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Freshwater Zooplankton Composition in Relation to Physico-Chemical Parameters in Shanthi Sagara Lake of Davangere District, Karnataka, India

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Abstract: In the present investigation, diversity of zooplankton was correlated with physico-chemical characteristics of a fresh water perennial lake, Shanthi Sagara at Davangere district, Karnataka, India. In order to assess its suitability for fish culture, the study was conducted for a period of one year from February 2019 to January 2020 in three seasons, like rainy, summer and winter. A total of 29 zooplankton species were identified qualitatively, which includes 13 species of rotifera, 6 species of cladocera, 8 species of copepoda and 2 species of ostracoda. The mean population of each zooplankton groups from all the seasons were recorded in the following order, rotifers (988 o/l) >cladocerans (967 o/l) >copepoda (820 o/l) >ostracoda (317 ind./l). In this study, zooplankton productivity was maximum in summer. The population of zooplankton was positively correlated with various physico-chemical parameters, such as water temperature, pH, salinity, dissolved oxygen, total dissolved solids and electrical conductivity of the lake water. Species diversity indices were correlated with different zooplankton groups in various seasons. Since zooplankton, both in number of species and population was abundant in the Shanthi Sagara Lake, there is possibility for continuous utilization of this water body for inland aquaculture.

Keywords: Diversity, Rotifera, Cladocera, Copepoda, Ostracoda, Shanthi Sagara lake

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Introduction

The understanding of abundance, diversity and distribution of zooplankton is important in understanding trophodynamic and trophic progression of water bodies. Plankton undertake a journey from base to surface at the approach of darkness. Light force is considered as the main factor while, other factors like temperature, pressure, magnitude and predators also influence

this phenomenon (Sreelatha and Rajalakashmi, 2005; Pawar, 2015) . They serve as the production in forming major food source. Density of zooplankton is directly correlated with the fishery potential (Pawar, 2015).

Zooplanktons play a crucial position in water purification and serve as bio-indicator of water (Gannon and Stemberger, 1978; Gajbhiye and Desai, 1981; Saravana Bhavan *et al*., 2015). They mediate transfer of power from decrease to better trophic tiers in aquatic food chains and make contributions considerably to secondary manufacturing (Sharma, 1998). They are the intermediate hyperlink among the phytoplankton and larvae of aquatic organisms. Abundance of zooplankton (rotifers, cladocerans, copepods and ostracods) network relies upon the availability of bacterioplankton and phytoplankton as meals. The many of the larger types of secondary consumers feed on smaller zooplankton, a few of them are detritivorous, and feeding on the substrate linked organic depend, phytoplankton. Some of them are concentrating at the freely suspended natural ones lying on the lowest sediment. In a surroundings, the zooplankton responds to a big variety of disturbance such as nutrient loading, acidification and sediment of enter.

Zooplankton supports the fish population. Zooplankton is the major mode of energy transfer among the phytoplankton and the aquatic animals. Different environmental elements that decide the characters of water have splendid importance upon the bloom of zooplankton. The parameters and nutrient status of water play the most critical role in governing the production of planktonic biomass. But no records is available regarding the variant of zooplankton and their dating with the physico-chemical parameters of water in Shanthi Sagara Lake (Suresh *et al*., 2011).

The freshwater zooplankton performs a key position in renovation and protection of ecological balance. The physico-chemical and organic traits of water play an crucial feature in plankton productivity (Rahman and Hussain, 2008; Poongodi *et al*., 2009; Radhakrishnan *et al*., 2009; Shanthi *et al*., 2010; Manickam *et al*., 2012b, 2014; Saravana Bhavan *et al*., 2015). With the passage of time, aquatic bodies become polluted due to anthropogenic activities which incorporates entertainment. The sewage, home, enterprise and agricultural effluents with notably toxic substances reach the water bodies. Factors which includes slight intensity, meals availability, dissolved oxygen and predation have an effect on the populace dynamics of zooplankton, and pH and better salinity can lessen their range and density (Horne and Goldman, 1994). Therefore, physico-chemical parameters and kind of freshwater zooplanktons are vital. In order to evaluate the water pollutants and the suitability of the Shanthi Sagara lake, Karnataka, India, for inland aquaculture of fishes, it was aimed to assess the physico-chemical parameters and the variety of zooplankton of this lake.

Materials and Methods

Lake:

Shanthi Sagara lake also called as Sulekere in Kannada, is the second largest built lake in Asia. It is located in Channagiri taluk of Davanagere District in Karnataka (Fig. 1). Shanti Sagara lake, created by an embankment with sluice outlets, was built in 1128. Lake has a history of 800 years. It took 3 years to construct the massive lake. It has a water spread of 6,550 acres (2,651 ha) and has a circumference of 30 km (19 mi). This lake has a entire drainage basin of 32,975 ha. The lake irrigates 4,700 acres (1,900 ha) of land and more than 170 villages are benefited by it (Chandran, Rahul , 2016).

Water analysis:

The surface water samples were collected in sterile polyethylene bottles and stored in an ice box and transported to the laboratory for the analysis of physico-chemical parameters. The water samples were collected during morning between 8.00 am to 10.00 am every month. Water temperature, pH, dissolved oxygen, electric conductivity and overall dissolved solids

Fig. 1: Different views of Shanthi Sagara lake.

were analysed by using the Water and Soil Analysis Kit.

The freshwater zooplankton samples were taken from a perennial lake at Shanthi Sagara (Fig. 1), Davangere, India, for a period of 12 months from February 2019 to January 2020 at 5 sites. The information were accrued on monthly basis and interpreted seasonal data, like monsoon, summer and winter. This lake is brought under the Department of Fisheries, Government of Karnataka and particularly used for aquaculture of carps, such as *Cyprinus carpio, Catla catla, Labeo rohita* and *Cirrhinus mrigala*. Some aquatic micro flora like algae and other water grasses are generally visible inside the lake.

Qualitative and quantitative evaluation of zooplankton:

For qualitative analysis of zooplankton, water samples were collected by the usage of towing plankton net (150 µm mesh) in zigzag fashion horizontally at a depth of 50 to 100 cm for about 10 min with a uniform velocity of boat. For the quantitative analysis of zooplankton 100 liter of water was filtered through a plankton net made from bolting silk (No. 10, mesh length 150 µm). Immediately after filtering out the water, the plankton biomasses have been transferred to containing 5% formalin (10 ml). Different zooplanktons, rotifera, cladocera, copepoda and ostracoda were segregated and separated under a binocular microscope by the usage of a needle and brush. Individual species of plankton was mounted on microscopic slides with a drop of 20% glycerin after staining with eosin and rose bengal. The identity of zooplankton was made by the standard manuals, text books and monographs (Edmondson, 1959; Sharma and Michael, 1987; Battish, 1992; Reddy, 1994; Murugan *et al*., 1998; Altaff, 2004). Photomicrographs were taken with the aid of microscope and camera.

1 ml of sample was poured into the Sedgwick-Rafter counter cell. After they settle a while they were counted. At least 5 such counting was performed for each group. The species, sex and the developmental stages of the plankton were taken into consideration. The average values were taken. Total variety of plankton present in 1 l of water was calculated (Santhanam *et al*., 1989) using the formula:

$$N = n \times v / V$$

Where, N = Total variety of plankton in 1l of water filtered ; n = Average of plankton in 1 ml; v = Volume of plankton in ml and V = total water filtered in liters.

The populace of every group of zooplankton was expressed in organisms per liter. The

information regarding zooplankton in relation to physico-chemical characteristics have been subjected to correlation and linear regression. The diversity indices which includes, species dominance (D), Shannon's diversity index (H'), species evenness and species richness have been calculated.

One way ANOVA and Tukey HSD data between season-wise fluctuation of physicochemical parameters and zooplankton population in the Shanthi Sagara lake was analyzed by using sociostatistics.com software.

Results and Discussion

The mean water temperature was maximum during summer season, followed by monsoon and winter (Table 1). Water temperature, EC, pH, and salinity were observed to be maximum in summer season while, dissolved oxygen (DO) and total dissolved solids (TDS) were highest in rainy season. Similar results in physico-chemical parameters of freshwater bodies have been reported by Manickam *et al*. (2012, 2014).

Water temperature is one of the maximum changeable environmental factors, since it impacts the growth and distribution of plants and animals. It influences upon the limnological phenomenon, along with stratification, solubility of gases, pH, conductivity and planktonic distribution (Singh *et al*., 1990). An increase in the temperature leads to the short chemical and biochemical reactions. The increase and decrease of micro-organisms, the kinetics of the biochemical oxygen demand is also regulated by water temperature (Khuhawar and Mastoi, 1995). The water temperature has shown to comply closely to the atmospheric temperature because of self-purification of the lake (Singhal *et al*., 1985). An increase in sun radiation and evaporation due to relatively longer day period may provide an explanation for gradual increase in both air and water temperature.

pH of water mainly depends upon the carbonic system and interplay among carbonates and bicarbonates. The natural water is commonly alkaline in nature due to the presence of CO_3. Generally, variant in pH is due to presence or absence of loose carbon dioxide and carbonates. The direct relationship of pH with CO_3 and an inverse relation with free carbon-dioxide has been reported (Jhingran, 1982). The pH is attributed to climatic elements, agriculture and activities associated with water bodies (Salam *et al*., 2000). Among biotic elements, high photosynthetic activity due to accelerated manufacturing of phytoplankton may additionally increase pH (Das and Srivastava, 1956). The pH is likewise attributed to washing of cloths by using detergents and sewage.

Salinity is an important ecological factor for survival, metabolism and distribution of organisms such as plankton in freshwater ecosystem. It may also exert different ecological and physiological outcomes depending on the interaction with different elements like temperature, oxygen and ionic compounds (Odum, 1971). It influences organisms, especially through changes in osmotic pressure and density of the water. The majority of freshwater animals have a low tolerance to increase in salinity. An increase of salinity throughout summer time and decrease in winter has been reported (Kumar *et al*., 2002; Manickam *et al*., 2012, 2014). The increased salinity reported during summer season might be due to more evaporation due to high air temperature whereas, the decrease salinity noticed during monsoon months may be attributed to low temperature and higher influx of freshwater.

The oxygen content of natural water varies with temperature, salinity, turbulence, the photosynthetic activity and the atmospheric strain. The oxygen supply to the water specially comes from sources, atmospheric diffusion and photosynthetic activity. The amount of dissolved salts and temperature significantly influences the capacity of water to maintain oxygen. In this study, the maximum DO recorded in summer may be due to expanded photosynthetic activity. The minimum DO in monsoon season is due to usage for decomposition of organic matter and respiration of organisms.

Table 1: Physico-chemical characteristics of the Shanthi Sagara Lake water during February 2019 to January 2020

Physico-chemical Parameters	Winter *	Summer*	Rainy*
Air Temperature (ºC)	25.80±0.8	27.5± 1.52	24.75±1.05
Water Temperature (ºC)	24.75±1.32	26.59±0.84	23.68±0.72
pH	7.55±0.95	8.42±0.57	7.05±0.55
Salinity (ppt)	0.70± 0.38	0.95±0.25	0.86±0.12
Dissolved oxygen (mg/L)	6.94±0.78	7.24±0.82	7.8 ±0.70
Total Dissolved Solids (mg/L)	710±64	820±83	925±78
Electrical Conductivity (µS/cm)	1.02±0.08	1.28±0.22	0.89±0.05

*Each season-wise value is overall average of mean ± SD (n=10).

The enhanced TDS recorded was because of accelerated anthropogenic activities and stagnation of water, which hampered water (Manickam *et al*., 2012, 2014). In summer, maximum vegetation was decaying, so an upward thrust in TDS was natural (Narayan *et al*., 2007). The higher TDS recorded was due to evaporation of water as a result of higher temperature and inflow of drainage water containing huge amount of silt, clay and other materials. An excess quantity of TDS in water tends to disturb the ecological stability because of suffocation of aquatic fauna even the presence of sufficient quantity of DO (Trivedy and Goel, 1984). The most of salts dissolved in water are in ionic form via which water is able to accomplishing electric conductivity. Therefore, the EC of water relies upon the presence of ions. Natural water possesses low conductivity but infection will increase its level. EC is a superb indicator of the overall water satisfactory as for the pond and lake ecosystems are concerned. The modifications in EC of water followed the equal seasonal sample as that of salinity.

Table 2 depicts the species spectrum of zooplankton recorded in Shanthi Sagara Lake. An overall 29 zooplankton species were identified qualitatively, which includes 13 species of rotifera, 6 species of cladocera, 8 species of copepoda and 2 species of ostracoda. The mean population of each zooplankton groups from all the seasons were recorded in the following order, rotifers (988 o/l) >cladocerans (967 o/l) >copepoda (820 o/l) >ostracoda (317 ind./l). In this current study, zooplankton productivity was maximum in summer. Table 3 shows variation in density of zooplanktons (o/l) in the Shanthi Sagara lake . However, relation between seasonwise fluctuation of physicochemical parameters and zooplankton population in the present lake was depicted in Table 4.

Figure 2 highlights percentage composition of zooplankton groups in Shanthi Sagara lake. Rotifera showed maximum percentage with 44.83% followed by Copepoda (27.59%), Cladocera (20.69%) and Ostracoda with 6.9%, respectively.

Studies on zooplankton abundance and water quality parameters in Ayyanakere lake was studied by Thirumala *et al*. (2007). They have identified 10 genera of zooplankton. The data between zooplankton and water parameters were varied from area to vicinity relying upon the situation of the lake water. The genus *Keratella*, specially *K. tropica* represented a generally oligotrophic indicator (Sharma, 1992). Pejler (1983) stated that alongside a trophic scale, the number of planktonic rotifer species successively increased as much as mesotrophic circumstance and then the range declined till hyper eutrophic

degree.

The physico-chemical parameters and nutrient load in water play a enormous function within the distribution patterns and species composition of plankton (Horne and Goldman, 1994). In aquatic habitats, the physical properties of water, together with solubility of gases and solids, the penetration of light, temperature and density, the chemical factors, together with salinity, pH, hardness, phosphates and nitrates are very vital and dispersal of phytoplankton on which zooplankton and a few higher consumer depend for their existence. In this study, seasonal variation visible within the physico-chemical parameters can be definitely correlated with zooplankton populace density. Therefore, it is recommended that it should have impact on species composition, species variety, species evenness and species richness of zooplankton.

The temperature at some point of summer season become an essential thing, which is attributed to zooplankton production favorably due to availability of food in the form of bacteria, phytoplankton and suspended detritus which led to better production (Ramakrishnah and Sarkar, 1982; Kumar and Datta, 1994; Bais and Agrawal,

Table 2: List of zooplankton species recorded in Shanthi Sagara Lake during February 2019 to January 2020

Group (Phylum/ Class/ Order)	**Family**	**Genus**	**Species**
	Brachionidae	*Brachionus*	*Brachionus angularis*
			Brachionus calyciflorus
			Brachionus falcatus
			Brachionus quadridentatus
			Brachionus rubens
Phylum: Rotifera			
		Keratella	*Keratella tropica*
	Asplanchnidae	*Asplanchna*	*Asplanchna brightwelli*
			Asplanchna intermedia
	Filinidae	*Filinia*	*Filinia longiseta*
	Sididae	*Diaphanasoma*	*Diaphanasoma sarsi*
			Diaphanasoma excisum
		Daphnia	*Daphnia carinata*
			Daphnia magna
Class: Branchiopoda; Order: Cladocera	Daphnidae	*Ceriodaphnia*	*Ceriodaphnia cornuta*
			Ceriodaphnia reticulata
	Moinidae	*Moina*	*Moina brachiata*
			Moina micrura
		Moinodaphnia	*Moino daphnia*
	Macrothricidae	*Macrothrix*	*Macro thrix sp.*
Class: Copepoda Order: Calanoida	Diaptomidae	*Heliodiaptomus*	*Heliodiaptomus viduus*
	Cyclopoidae	*Eucyclops*	*Eucyclops speratus*
		Mesocyclops	*Mesocyclops hyalinus*
Order: Cyclopoida			*Mesocyclops leuckarti*
		Thermocyclops	*Thermocyclops hyalinus*
			Thermocyclops decipiens
	Cyprididae	*Cypris*	*Cypris protubera*
		Eucypris	*Eucypris bispinosa*
Class: Ostracoda; Order: Podocopida			
		Cyprinotus	*Cyprinotus nudus*
		Heterocypris	*Heterocypris sp.*

Table 3: Variation in density of zooplanktons (o/l) in the Shanthi Sagara lake during February 2019 to January 2020

Groups	Winter	Summer	Rainy
Rotifera	690±125	988±134	670±70
Cladocera	615±155	967±112	490±42
Copepoda	595±117	820±150	550 ±50
Ostracoda	119±52	317±38	210±32
Total	**2019**	**3092**	**1920**

Each season-wise value is overall average of mean ± SD (n=10)

Table 4: Relation between seasonwise fluctuation of physicochemical parameters and zooplankton population in the Shanthi Sagara lake

Physico-chemical Parameters vs Zooplankton density	Y data	R
Water Temperature	298.661 x-5955.19	0.910
pH	879.900 x-4666.40	0.952
Salinity	4200.314 x-1546.73	0.910
DO	655.612 x-2655.394	0.980
TDS	3050.570 x-850.295	0.920
EC	5700.170 x-2300.487	0.855

Table 5: Variation in zooplanktons diversity indices in the Shanthi Sagara Lake during February 2019 to January 2020

Zooplankton group	Diversity indices	Winter	Summer	Rainy
	Dominance	0.141±0.007	0.131±0.006	0.129±0.005
Rotifera (13 species)	Shannon	2.21±0.055	2.350±0.045	2.235±0.030
	Evenness	0.801±0.038	0.911±0.036	0.913±0.028
	Margalef	1.602±0.06	1.562±0.030	1.612±0.031
	Dominance	0.130±0.005	0.150±0.004	0.130±0.006
Cladocera (6 species)	Shannon	2.282±0.032	2.2005±0.02	2.201±0.030
	Evenness_	0.911±0.031	0.910±0.018	0.920±0.031
	Margalef	1.556±0.095	1.400±0.029	1.510±0.023
	Dominance	0.181±0.003	0.188±0.006	0.195±0.005
Copepoda (8 species)	Shannon	1.850±0.021	1.890±0.029	1.820±0.022
	Evenness_	0.896±0.018	0.930±0.025	0.880±0.014
	Margalef	0.977±0.048	0.925±0.040	0.970±0.020
	Dominance	0.240±0.031	0.185±0.005	0.197±0.019
Ostracoda (2 species)	Shannon	1.690±0.061	1.800±0.014	1.784±0.040
	Evenness_	0.900±0.055	0.983±0.013	0.982±0.029
	Margalef	1.125±0.180	0.945±0.034	1.099±0.073

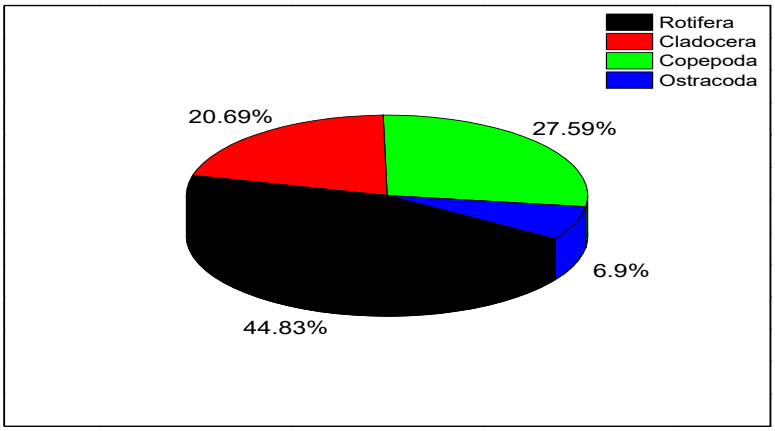

Fig. 2: Percentage composition of zooplankton groups in Shanthi Sagara lake.

Table 6: One way ANOVA data

	Winter Zooplankton (1)	Summer Zooplankton (2)	Rainy Zooplankton (3)	Winter water quality (4)	Summer water quality (5)	Total
N	5	5	5	5	5	25
∑X	4038	6184	3840	749.94	863.2	15675.14
Mean	807.6	1236.8	768	149.988	172.64	627.006
$\sum X^2$	5298872	12244586	4722000	504818.2186	673231.2446	23443507.4632
Std. Dev.	713.7547	1071.9392	665.7477	313.1837	362.0112	753.1906

Source	***SS***	***df***	***MS***	
Between-treatments	4291684.2879	4	1072921.072	F = 2.30156
Within-treatments	9323422.6145	20	466171.1307	
Total	13615106.9024	24		

The f-ratio value is 2.30156. The p-value is 0.094149. The result is not significant at $p < 0.05$.

1995; Poongodi *et al*., 2009; Radhakrishnan *et al*., 2009; Shanthi *et al*., 2010; Salve and Hiware, 2010; Manickam *et al*., 2014). This can be because of lenticness of the lake. While, in monsoon season, factors like lower water temperature, pH, salinity and TDS have been no longer in favour of growth and variety of zooplankton. This may be due to loticness of the lake, because of dilution effect and decreased photosynthetic interest by means of primary producers (Bais and Agrawal, 1993). This can also be because of over predation of zooplankton through the better trophic individuals, including planktonivourous fishes, which modify the zooplankton populace (Poongodi *et al*., 2009).

Brachionus species are very common in

temperate and tropical waters (Hutchinson, 1967) which indicates alkaline nature of water. Rotifers are considered as indicators of water quality assessment (Berzens and Pejler, 1989). It is assumed that rotifers utilize the nutrients as well as phytoplankton more rapidly to build up their population. This may be the reason for the worldwide distribution of rotifers (Pennak, 1978). Sakhre and Joshi (2006) reported 8 species of rotifers in Yeldari reservoir, India. Madhusudhana Rao *et al*. (2014) recorded 9 species of Rotifers from perennial pond at Lake Kolleru Region of Andhra Pradesh. In their study the genus *Brachionus* was the dominant group. Hence, our findings are similar to the study of Sakhare and Joshi (2006). The present investigation also supports the findings of Sharma and Capoor (2010). Harish Kumar and Kiran (2015) have studied the water quality status of Jannapura tank near Bhadravathi town, Karnataka as assessed by rotifers. A total of 5 genera and 8 species of Rotifera belonging to 4 families were recorded by them.

Veerendra *et al*. (2012) have studied the

Table 7: Tukey HSD data for between seasonwise fluctuation of physicochemical parameters and zooplankton population in the Shanthi Sagara lake

Pair-wise Comparisons		$HSD_{.05}$ = 1292.1802 $HSD_{.01}$ = 1616.2710	$Q_{.05}$ = 4.2319 $Q_{.01}$ = 5.2933
T_1:T_2	M_1 = 807.60 M_2 = 1236.80	429.20	Q = 1.41 (p = 0.85496)
T_1:T_3	M_1 = 807.60 M_3 = 768.00	39.60	Q = 0.13 (p = 0.99998)
T_1:T_4	M_1 = 807.60 M_4 = 149.99	657.61	Q = 2.15 (p = 0.56036)
T_1:T_5	M_1 = 807.60 M_5 = 172.64	634.96	Q = 2.08 (p = 0.59207)
T_2:T_3	M_2 = 1236.80 M_3 = 768.00	468.80	Q = 1.54 (p = 0.81172)
T_2:T_4	M_2 = 1236.80 M_4 = 149.99	1086.81	Q = 3.56 (p = 0.12642)
T_2:T_5	M_2 = 1236.80 M_5 = 172.64	1064.16	Q = 3.49 (p = 0.13913)
T_3:T_4	M_3 = 768.00 M_4 = 149.99	618.01	Q = 2.02 (p = 0.61582)
T_3:T_5	M_3 = 768.00 M_5 = 172.64	595.36	Q = 1.95 (p = 0.64746)
T_4:T_5	M_4 = 149.99 M_5 = 172.64	22.65	Q = 0.07 (p = 0.00000)

relationship between zooplankton abundance and water quality parameter in Mani reservoir between January and December 2008. In their investigation, 10 genera of zooplankton were identified. Zooplankton and water quality parameters were varied from aquatic habitat depending on the condition of the reservoir water. The maximum populace of Cladocera in winter season may be due to favorable temperature and availability of food in the form of microbes, plankton and suspended matter. DO, water temperature and turbidity also play an important role in controlling the density of Cladocerans (Edmondson, 1965; Pullie and Khan, 2003; Deepthi and Sadanand Yamakanamardi, 2014). Parveen and Mola (2012) reported the diversity of zooplankton in two perennial ponds in Aligarh of Uttar Pradesh of India. They reported a large quantity of Cladocera during winter season. Mondal *et al*. (2013) studied the diversity of Cladocerans of Mirik Lake in Darjeeling and they reported that temperature adversely affect Cladoceran abundance and they were more abundant during winter season. Sitre (2012) studied the seasonal variation of zooplankton in Ambazari lake of Nagpur, Maharashtra and recorded maxium Cladocera during winter season.

The Tukey's HSD (honestly significant difference) procedure facilitates pair wise comparisons within ANOVA data (Table 6). The F statistic indicated whether there is an overall difference between sample means. Tukey's HSD test (Table 7) allows to determine between which of the various pairs of means - if any - there is a significant difference.

Conclusion

In this study, no bloom of zooplankton group seen and no seasonal variations were noticed. The favorable increase of zooplankton was found in summer season. Variety of various species of zooplankton and their overall populace density confirmed their abundance because of occurrence of favorable conditions, they disappeared in unfavourable conditions and reappeared during favorable conditions. Thus, it is cautioned that proper control measures may be followed to preserve the lake unfastened from over pollutants for attractive non-stop, healthful and sustainable aquaculture practices. Present study revealed that the Physico chemical parameters of this lake was found to be almost suitable for domestic and aquatic life form. Many parameters are found within the permissible limit. Information on environmental circumstances and on the structure and functioning of plankton communities is used in preparing management plan and minimizing adverse effects of unsustainable development and pollution. Conservation on water bodies is basically more complex than on land because of the much greater degree of inter connectedness and lack of plain borders. So this work will help in the management plans.

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