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Assessment of plankton diversity and physico-chemical characteristics for sustainable fish production in a tropical reservoir in South India

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Abstract

Plankton forms an important component of the aquatic ecosystem and act as indicators of fish diversity, pollution levels and environmental disturbances. They form an important natural fish food resource and play a vital role in the trophic structure of the ecosystem. In the present study a systematic assessment of the community distribution and diversity of plankton was conducted in the Karapuzha Reservoir in South India. Thirty six genera of phytoplankton belonging to 4 classes *viz,* Chlorophyceae, Bacillariophyceae, Dinophyceae and Myxophyceae were identified. Eleven genera of zooplankton belonging to four classes; Protozoa, Rotifera, Cladocera and Copepoda were also recorded. The Jaccard index of similarity showed that pre-monsoon and monsoon seasons shared a similar plankton composition. Diversity indices revealed the highest values during monsoon, while the Dominance index indicated the highest species dominance during post-monsoon (0.199) followed by pre-monsoon (0.1445) and monsoon (0.1417). Water quality parameters were found to have a significant correlation with plankton abundance in the reservoir. Shannon Weiner index indicated that the Karapuzha Reservoir ecosystem is moderately polluted. Seasonal variations in plankton composition showed the highest species abundance during the pre-monsoon followed by post-monsoon and monsoon seasons.

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Introduction

The role of plankton as ecological indicators of environmental health of a reservoir is determined by investigating their community structure, diversity, distribution and species richness. Environmental instability and spatio-temporal changes shape the community structure of plankton within the ecosystem (Chellappa *et al*., 2009; Bajpai *et al*., 2019; Liu *et al*., 2021; Parakkandi, *et al*., 2021). Seasonal changes in tropical regions, particularly precipitation induce changes in the abiotic factors of water which in turn influence plankton dynamics (Huszar and Reynolds, 1997; Figueredo and Giani, 2001; Almeida *et al*., 2012). Various aspects of plankton ecology have been studied globally and the plankton populations of numerous reservoirs in India have been documented by several authors (Mishra *et al*., 2010; Palaniswamy *et al*., 2015, Gogoi *et al*., 2019). The relationship between environmental factors and plankton communities has been reported by several researchers including, Salim and Ahmed (1985) in lakes of Nainital, India; Almeida *et al*. (2012) in Brazilian reservoirs; Bandelj *et al*. (2008) in the Venice Lagoon; Adebayo and Ayoade (2019) in an Ethiopian reservoir and Dirisu *et al*. (2019) in the Niger Delta.

Phytoplankton, the primary component of planktonic forms in aquatic ecosystems play an important role in primary production and serve as an important food source for herbivorous fishes. In tropical reservoir ecosystems, phytoplankton are essential for estimating potential fish yield (Hecky and Kling, 1981), assessing productivity (Park *et al*., 2003), monitoring water quality (Walsh and Wepener, 2009), understanding energy flow (Simciv, 2005), evaluating trophic status (Reynolds, 1999) and guiding ecosystem management (Beyruth, 2000). Plankton diversity studies are important chracterising ecological systems and can be useful tools for assessing ecosystem stability and resilience (Barnese and Schelske, 1994). As biological indicators, phytoplankton attract significant focus of research on eutrophication and its adverse impacts on aquatic ecosystems (Meshram and Dhande, 2000). Zooplankton play crucial role in energy transfer at secondary trophic level linking autotrophs and heterotrophs in aquatic food webs (Deivanai *et al*., 2004). The distribution and diversity of plankton in aquatic ecosystems are greatly influenced by the physico-chemical properties of water (Challouf *et al*., 2017).

Reservoirs in India generally have a diverse assemblage of planktivorous fish whose sustenance depends mainly on the plankton abundance. Panikkar *et al*. (2013) investigated the foraging habits of fishes in the Karapuzha Reservoir located in Wayanad District, South India and found that planktivorous fishes dominate the catch structure. Hence the composition of the plankton community can significantly influence the food-web dynamics of the ecosystem which could possibly affect the fishery to a large extent. Studies on feeding habits of fish provides insights into their food preferences or electivity for various food sources available in its surroundings. A quantitative analysis of food preferences is essential for understanding predator–prey interactions. This information will be helpful for stakeholders to plan stocking strategies for enhancing fish production from such water bodies. In many Indian reservoirs stocking fish seeds is adopted as a key management strategy to enhance fish production. The Karapuzha Reservoir is a very important reservoir due to its multipurpose utility and is also well suited for culture-based fisheries. The present study was undertaken to study the diversity and abundance of plankton in relation to selected abiotic parameters; to analyse the feeding preferences of commercially important fish species and to assess the physico-chemical properties of the reservoir water for its suitability in terms of drinking water and for supporting aquatic life. These objectives were pursued by analysing plankton composition, diversity indices of plankton population, water quality parameters, the correlation between water quality and plankton abundance as well as the electivity indices of important food fish species.

Materials and methods

Study area

This study was conducted at Karapuzha Reservoir, (11°37'03.1350" N; 75°27'30" E) built across the River Kabini in Kerala, India. The area of the reservoirs is 855 ha at full reservoir level. The land adjoining the reservoir is primarily agricultural land with human settlements, hence the reservoir water is utilised for drinking water supply, irrigation and fisheries.

Sample collection and identification

For understanding the physical parameters and uniqueness of the reservoir, the sampling points (Fig. 1) were selected across three zones: (1) the riverine zone, where the river flows into the reservoir; (2) the lacustrine zone located near the dam and (3) the transitional zone situated between the riverine and lacustrine zones. These three zones were chosen to achieve maximum representation of the variation in the reservoir waters based on accessibility, depth profile and points of water influx. The data used for the present study was based on the sampling conducted month-wise for a period of one year (April 2009 to March 2010). The seasons in this region are distinguished by a marked temperature difference and also coincides with the, pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January) hydro-climatic regime of Kerala. Monsoons bring in around 60% of the average annual rainfall in this region and therefore have a significant impact on both water influx and dilution of reservoir water. Sub-surface (0.3 m below) water sample was collected from different zones on monthly basis. Water temperature was measured *in situ* using thermometer, pH as well as electrical conductivity (EC) were measured by EC-pH meter (Systronics). TDS (Total dissolved

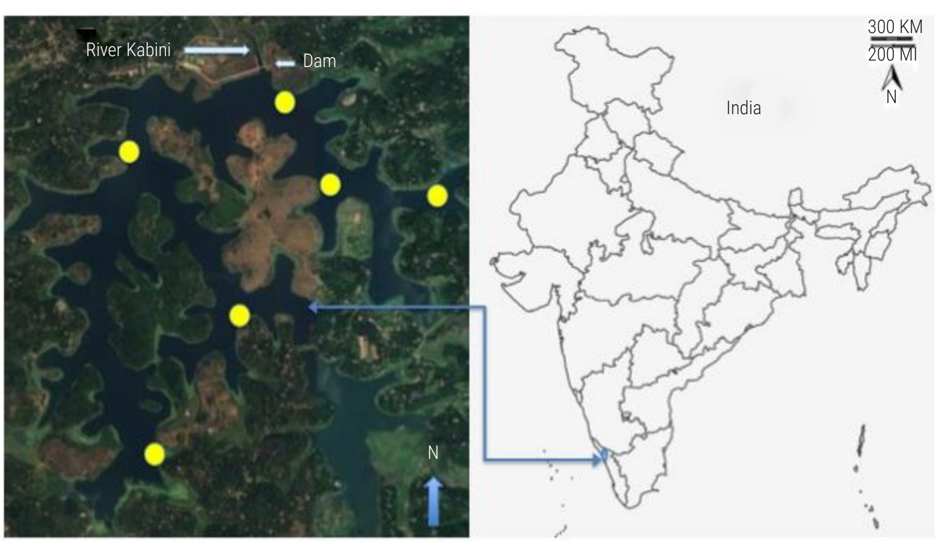

Fig. 1. Map of Karapuzha Reservoir with the sampling sites marked as circles

solids) were determined gravimetrically and dissolved oxygen (DO) was measured by Winkler's method. Sulphanilamide colorimetric method was used to determine the NO_3^--N. Phospho-molybdenum method was used to measure the phosphate-P (PO_4^{3-} P). Silicate (SiO_2) was measured colorimetrically by oxalic acid method (APHA, 2005).

Plankton samples were collected from the same sites of water sample collection on monthly basis for a period of one year. Hundred litres of surface water were collected and filtered through plankton net (bolting silk No. 25) and the concentrated sample was transferred to an air tight bottle and preserved in 4% formalin solution. The systematic identification of plankton was made under an inverted microscope following standard keys (Needham and Needham 1962; Guiry and Guiry, 2020) and the quantitative estimation of algae was done using a Sedgwick-Rafter counting cell (Komarek, 2016) and expressed as number per litre; N= (A x 100) C/L, where N is the number of phytoplankton per litre of water; C is the volume (ml) of the concentrate; A is the average number of plankton in the counting cells and L is the volume of water passed through the plankton net.

Diversity analysis

Species richness index, diversity index and evenness index were analysed using PALEONTOLOGICAL STATISTICS (PAST) software. Species accumulation curves, together with the different estimators, were plotted for making comparisons between different estimators. And these curves were generated using the Estimate S (version5) software which uses Monte Carlo simulations of random samples drawn from the total set of samples for estimating the average species richness. Matrices of presence–absence data were used to analyse the differences in species composition based on seasons. This was measured using the Jaccard index of species dissimilarity.

Calculation of water quality index (WQI)

WQI as developed by different authors (Horton, 1965; Ott, 1978) was used in the present study. Weighted arithmetic index was used for calculation of WQI. Following formulae were used to calculate the WQI:

q_n=100 [Vn - Vi] / [Sn - Vi], where q_n denotes the quality rating of n^{th} parameter, V_n and S_n denotes the observed and permissible value, respectively for n^{th} quality parameters, whereas V_i indicates the V_n ideal value for n^{th} quality parameter of pure water which is 0 for all except pH and DO, where ideal values are 7 and 14.6, respectively. The unit weight (W_n) was calculated using the formula: Wn = k/s_n where, W_n is the unit weight of n^{th} parameter, S_n is the standard value of n^{th} parameter and K is the proportionality constant. Overall WQI was calculated using the formula, WQI = $\sum q_n W_n / \sum W_n$

The water quality index 0-25 indicates 'Excellent'; 26-50: 'Good': 51 to 75: 'Poor'; 76-100: 'Very poor' and >100"Unsuitable" for potability (Saha *et al.,* 2021).

Electivity index

The electivity index, also known as the selection index was calculated from the gut content analysis data of the planktivorous fish groups in the system. The electivity index of a predator for species i is calculated as the forage ratio (Si), as proposed by Chesson (1983), was used in this study.

S_i=(r_i/ P_i) $^n\Sigma_{n=1} r_n$/ $P_{n,}$ where ri is the relative biomass of prey in a predator's diet and Pi is the prey's relative biomass in the ecosystem. Si is scaled from -1 to 1. A value of -1 corresponds to total avoidance, Si = 0 represent non-selective feeding while a value of 1 corresponds to exclusive feeding on prey i.

Statistical analysis

Univariate Analysis of Variance ANOVA was performed for physico-chemical parameters and plankton abundance for the determination of homogeneity of samples based on temporal scale (or spatial variance equality). One-way ANOVA was performed to test the significance of difference in species richness, abundance and different indices based on seasons. ANOVA was performed using SPSS 16.0. Multivariate statistical analysis such as Canonical Correspondence analysis (CCA) was carried out to identify the important environmental parameters and its relation with plankton abundance using PAST software. Log transformation ln (x + 1) was carried out to normalise the water quality data.

Results

Water quality characteristics of Karapuzha Reservoir

The physico-chemical characteristics of water are presented in Table 1. The pH showed neutral to slightly alkaline status with lowest value in the month of September (7.0) and highest value during October (8.4). The water temperature plays a pivotal role in controlling the geochemical and eco-biology of aquatic ecosystem and it was lowest from December to March and highest during April to May. Average transparency values were lower in monsoon compared to the pre- and post-monsoon months. The dissolved oxygen (DO) value was lowest in March (5.9 mg l^{-1}) and highest in November (7.88 mg l^{-1}). Electrical conductivity (EC) and total dissolved solids (TDS) level was lowest in July (84 µS cm^{-1} and 53.8 mg l^{-1}, respectively) and the highest in August (217 µS cm^{-1} and 138.9 mg l^{-1}, respectively). The TDS indicates total dissolved salts in water and the values were below the permissible limit (1000 mg l^{-1}). Stoichiometry of inorganic macronutrients like nitrate nitrogen (NO_3^--N), phosphate-P (PO_4^{3-}P mg l^{-1}) and silicate (SiO_2) play an important role in controlling phytoplankton ecology of freshwater ecosystems (Panikkar *et al.,* 2022). SiO_2 content was higher in monsoon and post-monsoon months. Main source of NO_3^--N in water is chemical fertiliser and sewage. NO_3^--N concentration was high during August to December which is attributable to the monsoon rains that hastens the process of ammonification and its release from organic matter. PO_4^{3-} -P remained almost stable throughout the sampling period.

Water quality index (WQI)

The WQI with a mean value of 69.9 (Fig. 2) was found to be "Good" during monsoon. It is important to note that variables assigned with higher WQI values presented high levels during pre-monsoon and post-monsoon season. Our results clearly show poor water quality during the pre-monsoon and post-monsoon seasons. There

Table 1. Monthly variation in physico-chemical parameters of Karapuzha Reservoir

Month/ Parameters	Air Temp. (^{0}C)	Water Temp. (^{0}C)	pH	DO ($mg\ l^{-1}$)	Trans. (cm)	EC ($uS\ cm^{-1}$)	TDS ($mg\ l^{-1}$)	SiO_2 ($mg\ l^{-1}$)	NO_3^-N ($mg\ l^{-1}$)	$PO_4^{3-}P$ ($mg\ l^{-1}$)	Plankton abundance
Apr '09	27.3	29.3	7.94	6.93	190	135.4	86.7	7.3	2.3	1.80	2020
May	26.3	28.0	7.60	6.80	150	102.0	65.3	6.6	2.6	2.70	1130
Jun	25.8	26.3	7.07	6.56	130	118.6	75.9	8.5	3.4	2.30	122
Jul	23.5	24.5	7.50	6.8	120	84.0	53.8	12.2	4.0	1.70	2886
Aug	25.5	27.3	7.80	6.79	110	217.0	138.9	10.6	9.2	1.60	2178
Sep	25.7	27.6	7.00	7.30	250	88.6	56.7	6.4	10.0	3.33	192
Oct	26.6	27.3	8.40	7.66	110	91.2	58.4	11.8	15.0	12.27	140
Nov	27.2	28.7	7.90	7.88	175	93.0	59.5	11.6	16.0	2.93	203
Dec	24.7	26.4	7.21	7.53	180	113.7	72.8	10.6	12.0	4.20	1069
Jan'10	24.4	26.2	8.17	6.97	185	94.9	60.7	7.9	4.4	3.40	6087
Feb	26.5	27.6	7.80	7.25	220	99.2	63.5	8.8	5.3	3.30	17934
Mar	25.8	26.5	7.63	5.90	200	131.3	84.0	6.2	2.9	1.90	1180

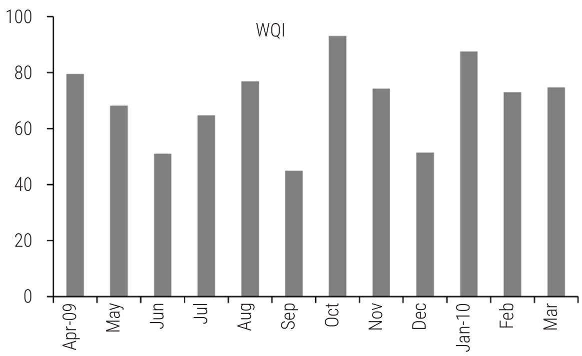

Fig. 2. Monthly variations of WQIs in the Karapuzha Reservoir during the study period

is strong evidence that precipitation driven water during monsoon diluted some important contaminants and thus improved the quality of water. The water quality index value of this study shows that the water body contains high organic matter leading to eutrophic conditions.

Plankton diversity

A total of 36 genera of phytoplankton (Table 2) under 4 different classes *viz.* Chlorophyceae (17 species)' Bacillariophyceae (13 species), Dinophyceae (one species) and Myxophyceae (two species) were identified. Phytoplankton belonging to Bacillariophyceae and Chlorophyceae dominated the plankton community. Bacillariophyceans were abundant in monsoon followed by pre-monsoon and post-monsoon season. The genera such as *Navicula, Nitzschia, Pleurosigma* and *Synedra* were present during all the three seasons, whereas *Amphora, Cymbella, Rhopalodia* and *Mastogloea* were observed mainly in monsoon. The zooplankton population were represented by Protozoa, Crustacea, Rotifera, Cladocera and Copepoda. Rotifers were represented mainly by *Brachionus, Keratella* and *Asplanchna.* The Cladocerans were represented by species of *Moina, Diaphanosoma, Notholca, Daphnia, Simocephalus* and *Ceriodaphnia*. Protozoans, Copepoda, and Crustacean larvae were encountered during all seasons, however Rotifers were recorded mainly during the monsoon months. Seasonal variation in plankton composition shows that the species abundance was highest during pre-monsoon (22264) followed by post-monsoon (7499) and monsoon season (5378).

Phytoplankton community characteristics such as species richness, evenness and diversity were studied. The Dominance index indicated the highest dominance during post-monsoon (0.199) followed by pre-monsoon (0.1445) and monsoon (0.1417). Simpson's index values ranged from 0.801 to 0.86 suggesting that the species are not evenly distributed. Shannon and Weiner index represents entropy and is a useful index in determining the pollution status of a water body and the recorded values indicated that the reservoir is moderately polluted. The ANOVA for different indices with respect to seasons showed no significant differences ($p<0.05$).

Canonical correspondence analysis (CCA) was used to characterise the relationship between physico-chemical parameters and the plankton abundance during different seasons in the reservoir (Fig. 3). Certain genera of phytoplankton *viz*, *Navicula, Ulothrix, Scenedesmus, Microcystis, Nitzschia, Closteriopsis* and zooplankton forms like *Ceriodaphnia, Calanus* and *Simocephalus* were found during all the seasons. The CCA plot revealed that the genera such as *Cosmarium, Closterium, Desmidium* and *Staurastrum* are closely influenced by water conductivity. Water quality parameters such as temperature and pH showed positive association with plankton abundance, mainly *Ulothrix* sp., *Pleurosigma* sp., *Scenedesmus* sp., *Nitzschia* sp. and *Ceriodaphnia* sp. There was also a positive association between DO and plankton genera such as *Pediastrum, Diaphanosoma, Simocephalus* and Protozoa.

The important water quality parameters *viz*, temperature, dissolved oxygen, pH and conductivity showed negative correlation with species abundance. The univariate analysis of variance for water quality parameters and plankton abundance showed that there was no significant difference.

Electivity index

The planktivorous groups and their components are presented in Table 3. The electivity index presented in Fig. 4 shows that Mozambique tilapia, a highly detritivore fish exhibited no preference for zooplankton. There were indications of preference for both phytoplankton and zooplankton in major carps. Minor carps exhibited very low electivity for zooplankton, but showed considerable preference for phytoplankton. Barbs showed

Table 2. Variations in plankton composition during different seasons

Group	Genus		Monsoon	Post-monsoon	Pre-monsoon
Phytoplankton					
Chlorophyceae	*Ankistrodesmus*		+	–	+
	Botryococcus		+	–	++
	Closteriopsis		++	++	++
	Closterium		++	+++	++
	Coelosphaerium		–	++	–
	Cosmarium		++	++	–
	Crucigenia		–	–	–
	Desmidium		++	++	–
	Micractinium		+	–	–
	Pediastrum		+	+	++
	Spirogyra		+	–	++
	Spirotaenia		++	–	–
	Staurastrum		++	+++	–
	Trebauria		–	+	+
	Ulothrix		+++	++++	++++
	Xanthidium		+	–	–
	Scenedesmus		+	++	++
Bacillariophyceae	*Amphora*		+	–	–
	Asteroinella		+	++	+
	Cosmarium		–	–	+
	Cymbella		++	–	–
	Diploneis		–	–	+
	Gomphonema		–	–	+
	Gonatozygon		+	+++	–
	Navicula		+++	+++	++++
	Nitzschia		+	+++	++
	Ophiocytium		–	+	–
	Pleurosigma		+	++	++
	Trebauria		+	–	–
	Rhopalodia		+	–	–
	Surirella		++++	–	+++
	Mastogloea		+	–	–
	Synedra		+	++++	+
Myxophyceae	*Merismopedia*	MER	+	–	++
	Microcystis	MIC	++++	++++	++++
Dinophyceae	*Ceratium*	CER	+	–	+
Zooplankton					
Copepoda	*Calanus*	CAL	++++	++++	++++
	Cyclops	CYC	+++	+	++
Protozoa	*Vorticella*	PRO	++	+	++++
Crustacea	*Nauplius*	NAU	+++	++	++
Cladocera	*Ceriodaphnia*	CER	++	++++	++++
	Diaphanosoma	DIA	+	+	++++
	Simocephalus	SIM	+	+	++
	Notholca	MOT	+	–	+
	Asplanchna	ASP	+	–	–
	Keratella	KET	+	–	+
Rotifera	*Brachionus* sp.	BRS	+	–	–
	B. forficula	BFO	+	–	–

positive selection for phytoplankton and detritus with slightly less preference for zooplankton. Minnows exhibited a slightly higher preference for phytoplankton when compared to zooplankton. Crustaceans positively selected detritus followed by zooplankton and phytoplankton.

Discussion

Phytoplankton form the foundation of the aquatic food web and are crucial for the production of organic matter in the aquatic ecosystems. Most reservoirs require a substantial abundance of

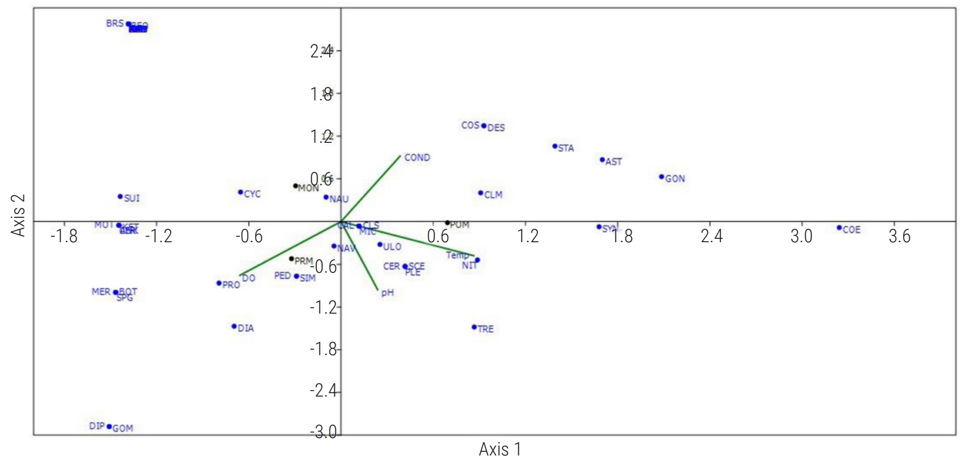

Fig. 3. CCA biplot of the plankton abundance along with the environmental parameters

Table 3. The planktivore fishes in Karapuzha Reservoir

Groups	Components
Major carps	*Catla catla, Labeo rohita, Cirrhinus mrigala*
Minor carps	*L. fimbriatus, L. bata, C. cirrhosus*
Barbs	*Puntius wynaadensis, P. ticto, P. sarana, P. sophore*
Minnows	*Barilius bakeri, Rasabora daniconius, Aplocheilus* spp., *Ambassis* spp., *Chela* spp.,
Mozambique tilapia	*Oreochromis mossambicus*
Crustaceans	*Macrobrachium rosenbergii, Paratelphusa* sp.

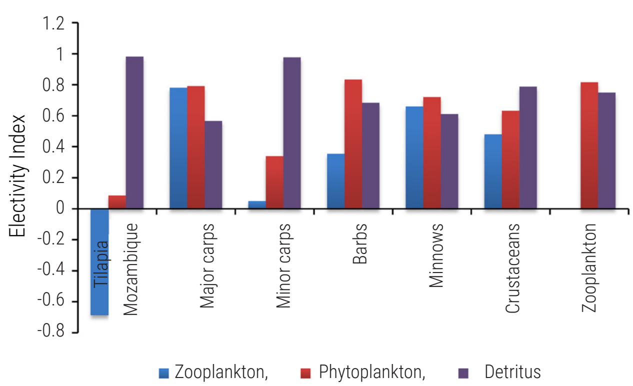

Fig. 4. Electivity Index of fish groups in Karapuzha Reservoir

phytoplankton to support productive and sustainable fisheries. The interplay of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblage (composition, distribution, diversity and abundance) is also structured by these factors. Thus any perturbations in these factors may affect the phytoplankton assemblage which could have a significant impact on water quality and fisheries of reservoirs. In a productive aquatic ecosystem, the biomass of phytoplankton is expected to be high as reported by several authors (Cloern *et al*., 2014; Dalu *et al*., 2016; Dirisu *et al*., 2019). The Karapuzha Reservoir ecosystem also had high species diversity and abundance of phytoplankton which indicates that this is a healthy ecosystem. Chlorophyceae was highest in number closely followed by Bacillariophyceae. Similar findings were reported by Das *et al*. (2018) from a freshwater ecosystem in India where Chlorophyceae contributed to the highest percentage in the phytoplankton community.

Generally, in tropical reservoirs, Chlorophyceans reach their highest levels during the onset of summer, which could be attributed to the availability of high allochthonous organic matter with high nutrient concentration brought in during the monsoon season, favouring the growth of the phytoplankton (Mishra *et al*., 2010). Bacillariophyceans represented mainly by *Navicula, Nitzschia* and *Surirella* exhibited highest density during the post-monsoon months, which is in conjunction with the earlier reports (Rishi and Kachroo, 1981; Mishra *et al*., 2010) as this group require less light and temperature for their growth. Cyanophyceans are common in many of the reservoirs in India and some of them cause algal blooms in eutrophic waters. The occurrence of the Cyanophyean *Microcystis aeruginosa*, was recorded throughout the year in Karapuzha Reservoir. Hulyal and Kaliwal (2009) reported a positive correlation between Cyanophyceae and increase in DO and conductivity in Almatti Reservoir in India. Harikrishnan and Abdul-Azis (1989) reported a direct positive association of cyanophycean abundance with pH. A higher concentration of Bacillariophyceae population and its association with high DO values was observed in the present study which is in conjunction with the findings of Arumugam *et al*. (2015) in a tropical water body of India. Dinophyceans represented by *Cymatium* sp. was observed during pre-monsoon months. CCA plot revealed positive association between DO and pH with species abundance. Similar findings were reported by Baruah and Kakati (2012). Among zooplankton groups, rotifers were found to be abundant during the monsoon months. The contribution of rotifers varied during different months as reported in reservoirs of Brazil by Tundisi and Tundisi (2005) and in India by Mishra *et al*. (2010). Rotifers are abundant in systems specifically with reduced dissolved oxygen concentrations and these are indicators of high pollution levels. The reservoir ecosystem under study did not have high abundance of rotifers which shows that the reservoir is not highly polluted. Rajsekhar *et al*. (2010) reported the impact of seasonal variation on zooplankton community in a reservoir in Karnataka, South India. Bhivgade *et al*. (2010) and Shinde *et al*. (2012) have documented the zooplankton as biological indicators of water quality and eutrophication. Cladocerans constituted a significant part of the zooplankton community and showed decline in monsoon months which could be attributed to the inflow of allochthonus nutrients. Similar observation was recorded by Mishra *et al*. (2010) in Uttarakhand reservoirs. The diversity indices calculated for the reservoir indicate moderate richness of plankton in the reservoir. The highest dominance index during post-monsoon season could be attributed to the abundance of Bacillariophyceae owing to higher levels of silicate content as reported by McNair *et al.* (2018). The Shannon Weiner index which reveals the pollution level of a water body categorise Karapuzha system as moderately polluted. Changes in plankton community due to pollution stress can cause decrease in species diversity (Mishra *et al*., 2010).

Physico-chemical parameters as observed in Karapuzha Reservoir indicated that most of the parameters were significantly different in the months of April to June/July and July/August to September, however the parameter remains stable in post-monsoon. This indicates that rainfall and temperature and thus season are the prime factors that control concentration of the observed parameters. Along with this, anthropogenic factors also played an important role. pH was lowest in monsoon month which could be due to the leaching of acids from the precipitaion. Low pH value may have negative impact on fish community and may disturb the aquatic ecosystem (Spyra, 2017). The pH variation was within the permissible limit as prescribed by Bureau of Indian Standards (BIS, 2012). Tolerable temperature range for fishes is 30-35^{o}C (Delince, 1992), while the optimal temperature for most of the fishes range from 24-30^{o}C (Bhatnagar *et al*., 2004; Santhosh and Singh, 2007; Saha *et al*., 2021) which indicates that Karapuzha Reservoir water temperature was suitable for fishes. Lower value of transparency in monsoon months may be due to the deposition of colloidal and suspended particles brought from the adjacent catchment area through rain water. Settlement of suspended particles in pre- and post-monsoon period resulted in higher values for transparency. Similar trend was also observed in other freshwater reservoir of India (Thirupathaiah *et al*., 2012; Patil *et al*., 2013) DO is an important parameter for management of aquatic habitat quality and value below certain level may be harmful for aquatic life (Chambers *et al*., 2000) and thus imparts a direct and immediate impact on fishes. However, the DO content in Karapuzha Reservoir was higher than the different eutrophic freshwater bodies of Kerala, India (Ray *et al*., 2020) and suitable for freshwater fishes throughout the study period.

During the months of September to February, the EC and TDS were found to be stable due to low temperature. EC is an important parameter that determine the quality of water for various uses like irrigation and potability (Sharma *et al*., 2012). Source of EC and TDS in aquatic systems is the mineral dissolution which is influenced by environmental parameters like temperature and pH and also the anthropogenic sources like agricultural runoff, sewage and detergent as well as organic material degradation (Kumar *et al*., 2020) The main contributing factors in changing the value of EC and TDS in the reservoir water may be temperature and rainfall.

High amount of nitrogen and phosphorus indicates the eutrophic nature of water bodies. NO_3^--N in Karapuzha water are comparable to the Peechi and Pothundi reservoirs, in Kerala (Paul *et al*., 2017), but fairly higher than eutrophic freshwater bodies of Kerala, India (Ray *et al*., 2020). PO_4^{3-} -P enters into the aquatic body through domestic wastes, fertilisers and industrial wastes and their concentration at 0.03 mg l^{-1} is sufficient for algal bloom formation (Sheela *et al*., 2011). Based on WQI value, Karapuzha Reservoir water is categorised as "good" and is suitable for drinking purpose (Etim *et al*., 2013; Saha *et al*., 2021, 2023).

Pre-monsoon season had high abundance of plankton followed by post-monsoon and monsoon season. However, during post-monsoon, the turbidity of water declined gradually and the phytoplankton population showed an increase. Similar observations were made in the wetlands of Jharkhand by Bohra and Kumar (2004). The influence of environmental parameters on the plankton composition was investigated exhaustively by different authors (Sharma and Singh, 2013; Suresh *et al*., 2013) for proper understanding of the dynamics of an ecosystem (Parakkandi *et al*., 2021). The results obtained reveal the importance of environmental parameters and the influence of seasons on characterising the plankton structure of an aquatic ecosystem. Such studies help in predicting the biotic succession on a spatio-temporal scale and the functioning of the plankton community.

Electivity index can help to discern and quantify broad patterns in the feeding ecology of fish groups and to draw inferences on the feeding preferences and that of the reservoir's principal food fishes offer information on the preferred food from the vast range accessible in the ecosystem. The trophic guilds of fishes with respect to feeding habits were dominated by planktivores. Ramya *et al*. (2021) reported a similar kind of dominance in a large reservoir in the region. The value of the electivity index for these organisms in the reservoir ecosystem contributes to the assessment of plankton's significance in the diets of economically significant fish groups (Lazzaro *et al*., 1992). Lazzaro *et al*. (1992) investigated the impact of two species of filter feeding fish that used different trophic cascade pathways and found that fish biomass was more important in regulating plankton structure. The Karapuzha Reservoir is a productive reservoir that can support the growth and production of many economically important fishes.

From all these observations, it is very clear that the diversity of plankton population, density and number of species varies during different seasons and such studies help in identifying the fish species to be stocked based on the plankton composition. The WQI vlues indicated that reservoir water is in "poor" category, but with proper treatment it can be used for drinking purposes. This reservoir was found to be moderately polluted probably due to the surface runoff from the adjoining human settlements in the vicinity of the reservoir. It is therefore suggested to regulate the anthropogenic activities around the reservoir. Since plankton forms the base compartment of a trophic pyramid, proper utilisation of this group through appropriate management strategies can help in improving fish production on a sustainable level from such reservoirs. This reservoir is being stocked by the local fisheries department on a regular basis with fast growing carps which feed low in the food chain. Hence it is recommended that suitable ecosystem-based management protocols be formulated and implemented to effectively utilise these biological resources. The findings of the study provide baseline information on water quality index, plankton diversity and food selection index of the fishes which could be utilised for further research on ecosystem health assessment and for effective fishery development programs.

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