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Environmental Influence on the Fish and Shellfish Biodiversity of Veli Lake in the Southwest Coast of India

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ABSTRACT

It is necessary to access the effects of the aquatic environment on species dominance, diversity and ecosystem functions as a measure to sustain aquatic resources at an optimum level. The present paper elucidates the status of fish and shellfish fauna and the correlation of the environmental factors of Veli Lake. The lake is situated 8 km north west of Trivandrum City at 8^o 28' N latitude and 76^o 57' E longitude. The system widens from the bar mouth to the eastern part and is 2 km long and 0.3 km broad. The biodiversity survey of fish and shellfishes of this lake was made for a period of one year(2009-2010).The available fishes of the concerned months were correlated with the physico-chemical parameters, nutrients of the water samples, carbon, nitrogen and phosphorous and heavy metals such as copper, lead, manganese, nickel and zinc of the sediments. A total of 31 species were reported during the whole year. All the fish and shellfishes showed seasonal influence with more fresh water species in monsoon months. The pre monsoon reported less percentage and non availability of most of the fish species in catches. The correlation analysis proved that, there is a relationship between environmental parameters and fish species in those ecosystems.

KEYWORDS: Correlation, Diversity, Heavy metals, Nutrients, shellfishes, and Sediment.

INTRODUCTION

The genetic diversity in a population is the result of the random occurrence of conservative replication of pre existing gene forms and combinations, sudden phenotypic differences due to mutation and recombination, the positive or negative selection enforced by external pressures and the random events affecting specific individuals during the origin of the particular group (Charrier *et al.*, 1996). Decisions regarding creation and management of various kinds of reserves are likely to be the key factors in determining the long term future of biodiversity. Ecological complexity enhances biodiversity through evolutionary and biogeographical processes and its degradation quickly causes the diversity in phenotypic and genotypic traits to decline (Karpinsky 2010).The dynamics of several environmental and oceanic factors such as monsoon, upwelling, currents and productivity influence the distribution, aggregation and abundance of fish stocks (Vivekanandan, 2001). Over fishing due to increased number of fishing vessels, sonar, spotter planes and other sophisticated fishing gears causes depletion of fisheries (Perez, 1996).

The four factors, namely, (1) biota, (2) sediment topography,(3) water flow such as tidal flow and waves and (4) the atmospheric processes (wind, rainfall etc), play important roles individually and in conjunction with others, forming and maintaining the ecosystem. Every factor interacts one of other factors (Mazda et al. 2007). Nutrients (primarily nitrate and phosphates) are often the major components of sewage load. High levels of organic pollutants can contribute to diseases, death and changes in the species composition. Metal pollution in the estuarine, harbor and coastal environment is usually caused by land run-off, mining activities and anthropogenic inputs. A large number of fishing vessels and trawlers that are engaged in fishing and landing operations use antifouling paints for their regular conditioning and protection from biofoulers like barnacle. Heavy metals like Zn, Cu and Pb being the principal ingredients of the antifouling paints often contaminate the ambient media. Because of their location at the interface between land and sea, mangroves are likely to be one of the first ecosystems to be affected by global changes. Most mangrove habitats will experience increasing temperature, changing hydrologic regimes (e.g., changes in rainfall, evapo-transpiration, runoff and salinity), rising sea level and increasing tropical storm magnitude and frequency. Reduced rainfall and runoff would produce higher salinity and greater seawater-sulfate concentrations (Chakraborty 2013).

In studies investigating diversity partitioning among sites, biodiversity indices are almost exclusively based on species composition even though the definition of biodiversity includes various facets of the diversity of life (Villeger *et. al.*, 2012). A variety of indices are available to measure the diversity of biological communities. These indices assume the biological diversity which can be satisfactorily described by two major components such as the number of species and their relative abundance. These indices treat all species as

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equivalent and ignore taxonomic, morphological or any such biological differences among species of a community (Ganeshaiah *et al*., 1997). Brian and Catherine (2000) reported evenness as a measure of diversity rather than richness because by varying evenness without changing species richness, it is possible to express that diversity was not effected by species identity. The biodiversity of inland is alarmingly declining primarily due to unsuitable and unethical fishing practices prevalent in the rivers and streams (Ababouch 2006). A variety of destructive type of fishing activities are being practiced in the inland water bodies of Kerala such as poisoning using chemicals, insecticides and seeds of plant origin, dynamiting, electric fishing etc. (Kurup *et al*., 1993). In order to prevent depletion of biodiversity due to environmental alterations or other ways, it is necessary to understand how the diversity of life particularly at the species level is maintained and it is equally necessary to know how the terminal extinction of species takes place under natural conditions. Hence, the present study aims to quantify the fish and shellfish resources of the Veli backwater to know the real stocks present in such environment.

MATERIAL AND METHODS

Monthly survey of fin fishes and shellfishes of Veli were carried out during early morning. Samples of fishes and shellfishes were preserved in 4% formalin for identification. Identification of fishes was carried out using standard keys which interpret the morphological features of each species (Jayaram, 1981; Munro, 1982; Talwar and Jhingran, 1991). All specimens were sorted at the species level and were counted and weighed on-board. Only fish were included in the analysis. The same net was used for all sampling; the mesh size for the net opening was 6.3 cm, the depth of the net opening was 6 m, the width of the net opening was 22.6 m, the mesh size of the cod end was 2 cm, and the trawling speed was approximately 4.82 km/h (2.6 knots).

The information on environmental parameters that affect the living organisms is vital. Hydrographical studies play an important role in understanding the various biological processes (growth, physiology, reproduction, etc.) and the general productivity of aquatic ecosystem. The physico-chemical parameters such as temperature, salinity, dissolved oxygen and nutrients are of profound biological significance and are used as population indicator. Temperature of surface and bottom water was recorded in the site itself using a high quality Celsius thermometer. The hydrogen ion concentration (pH) of water sample was measured in the laboratory using Elico-model L_1 – 10 pH meter. The Mohr-Knudsen titration method using potassium chromate indicator was followed to measure the salinity (Grasshoff, 1983).The alkalinity of the sample was estimated by back titration method of Gripenberg modified by Trivedy and Goel (1986). Dissolved oxygen was determined by classic Winkler’s titration method (Grasshoff, 1983).The determination of hydrogen sulphide by Lauth’s violet method equalent to methylene blue method was followed (Grasshoff *et al*., 1983). Estimation of ammonia was made by the Colorimetric method of steam distillation by microkjeldahl, distillation unit (Trivedy and Goel, 1986). The Photometric determination of nitrite was followed to estimate the nitrite nitrogen (Grasshoff *et al*., 1983).The estimation of Silicate silicon and inorganic phosphate in the water was made by following the modified method of Murphy and Riley (Grasshoff *et al*., 1983) and the optical densities were noted spectophotometrically.

The total organic carbon from sediment samples were estimated by the Walkley and Black method modified by Trivedy and Goel (1986).Total phosphorous by modified method of Murphy and Riley and the total nitrogen content was determined by microkjeldahl method (Grasshoff *et al.*, 1983). Heavy metals of the sediment were measured (May and Spears 2012) using atomic absorption spectrophotometer (GBC 932 AA).

In statistical surveys, when subpopulations within an overall population vary, it is advantageous to sample each subpopulation (stratum) independently. Stratified random sampling is a probabilistic sampling option. The first step in stratified random sampling is to split the population into strata, i.e. sections or segments. The strata are chosen to divide a population into important categories relevant to the research interest. Stratified random sampling method was followed to assess the count of each species (Krishnaswami, 1993). For investigating seasonal variations in premonsoon, monsoon and post monsoon, the survey study was carried out for a period of one year (April 2009 to March 2010).

Biodiversity is the variation of life forms within a given ecosystem, biome, or for the entire Earth. Biodiversity is often used as a measure of the health of biological systems. To understand different biodiversity indices used in the study, they are categorized as follows

Diversity Index: A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account. Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure.
Variables:

H Shannon's diversity index

S total number of species in the community

(richness)

p_i proportion of *S* made up of the *i*th species

E_H equitability (evenness)

The proportion of species *i* relative to the total number of species (p_i) is calculated, and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The resulting product is summed across species, and multiplied by -1:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Shannon's equitability (E_H) can be calculated by dividing *H* by H_{max} (here $H_{max} = \ln S$). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

Diversity Richness or Species richness**:** It is the simplest measure of biodiversity, and is simply a count of the number of different species in a given area. Species richness is also referred to as alpha-diversity. Species richness is commonly used, along with other factors, as a measure for determining the overall health of different biological ecosystems. High species richness for a given area indicates a high level of ecosystem stability, thus allowing the ecosystem to better withstand natural or anthropogenic disturbance.

Richness R simply quantifies how many different types the dataset of interest contains. For example, species richness (usually notated S) of a dataset is the number of different species in the corresponding species list. Richness is a simple measure, so it has been a popular diversity index in ecology, where abundance data are often not available for the datasets of interest. However, if true diversity is calculated with q = 0, the effective number of types (^0D) equals the actual number of types (R).

Species evenness: It refers to how close in numbers each species in an environment are. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically. The evenness of a community can be represented by Pielou's evenness index:

$$J' = \frac{H'}{H'_{\max}}$$

Where $H'$the number is derived from the Shannon diversity index and $H'_{\max}$is the maximum value ofH', equal to:

$$H'_{\max} = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S.$$

J' is constrained between 0 and 1. The less variation in communities between the species, the higher ***J'*** is. Other indices have been proposed by authors where $H'_{\min} > 0$e.g. Hurlburt's evenness index.**S** is the total number of species.

Biodiversity dominance or Simpson's dominance index: It measures biodiversity based on the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). Simpson's dominance index ranges from 0 (all taxa are equally present) to 1.0 (one taxon dominates the community completely).The percentage of the species and correlation between the environmental parameters and each species were analyzed by Karl Pearson Correlation Coefficient (Kapur, 1981). Statistical analysis for diversity index, diversity richness, evenness and biodiversity dominance were carried out to count the biodiversity criteria.

RESULTS

In Veli Lake, a total of thirty one species were recorded from the present study. The monthly occurrence of each species in percentage and their correlation significance are presented in Tables 1, 2, 3 and 4.The percentage of *Oreochromis mossambica* showed a significant negative correlation with hydrogen sulphide and highly significant positive correlation with organic carbon and sediment phosphorus. The occurrence of *E. maculatus* species showed significant positive correlation with temperature, pH, ammonia nitrogen and nickel, highly significant positive correlation with nitrite nitrogen, silicate silicon and zinc and highly significant negative correlation with lead and manganese. The percentage of *Caranx sehfsciatis* showed significant positive correlation with copper and negative significance with ammonia nitrogen and phosphate phosphorus. The percentage of *C. ignobilus* showed significant negative correlation with ammonia nitrogen, phosphate phosphorus and nickel.

The percentage of *Mugil cephalus* showed significant negative correlation with alkalinity and organic carbon.The percentage of *Channa marulius* showed a significant positive correlation with DO and total nitrogen. The percentage of *C. striatus* showed a positive significance with salinity and DO and negative significance with zinc.The occurrence of *Megalops cyprinoides* showed significant negative correlation with DO. The percentage of *Gerrus filamentosus* showed significant positive correlation with temperature, pH and organic carbon and negative correlation with manganese and highly significant positive correlation with nitrite nitrogen and silicate silicon. The percentage of *Puntius filamentosus* showed significant negative correlation with pH, hydrogen sulphide, ammonia nitrogen, phosphate phosphorus and significant positive correlation with organic carbon.

The percentage of *Anabas testudineus* showed significant negative correlation with temperature and alkalinity and positive significance with salinity and dissolved oxygen. The percentage of *Mystus gulio* showed significant positive correlation with hydrogen sulphide, phosphate phosphorus and negative significance with organic carbon. The percentage of *Arius arius* showed positive significance with hydrogen sulphide and phosphate phosphorus. A highly significant negative correlation was observed with DO. The percentage of *Tachysurus subostratus* showed a positive significance with salinity and copper. A negative significance was noticed with alkalinity and organic carbon. The percentage of *Valamugil cunnaecius* showed negative significance with pH, ammonia nitrogen and phosphate phosphorus. A positive significance was observed with copper. The percentage of *Hyphoramphus improvis* showed positive significance with salinity and copper. A negative significance was noticed with alkalinity and organic carbon. The percentage of *Periophthalmus weberi* showed a significant negative correlation with pH and phosphate phosphorus. The percentage of *Anguilla bengalensis* was 0.2 in November, 0.16 in December and 1.04 in August. *Austroglossus pectoralis* showed negative significance with pH was observed.

The percentage of *Metapenaeus brevicornis* showed negative significance with pH, ammonia nitrogen, phosphate phosphorus and positive significance with copper. The percentage of *Macrobrachium idella* showed significant negative correlation with hydrogen sulphide, ammonia nitrogen, phosphate phosphorus and nickel. The percentage of *Scylla serrata* showed positive significance with alkalinity, negative significance with hydrogen sulphide, ammonia nitrogen and highly significant positive correlation with Organic carbon. A negative significance with *Penaeus monodon* was noted with alkalinity. The percentage of *P. indicus* showed a negative significance with total nitrogen, highly significant negative correlation with DO, highly significant positive correlation with hydrogen sulphide, phosphate phosphorus and total phosphorus. In Veli lake Diversity index ranged from 0.64 in October to 2.01 in December. Species richness ranged from 0.001 in January and May to 0.0036 in December. The species evenness ranged from 0.23 in October to 0.64 in December. The diversity dominance ranged from 0.24 in December to 0.79 in October (Table 5).

DISCUSSION

Estuaries play a significant role as nursery grounds for fishes and prawns in view of their high productivity and also shelter to the juveniles. Due to slow changes in climatic and coastal geomorphic conditions, the estuarine systems have undergone some changes, particularly with regard to sedimentation and sand bar formation (Campagna *et al.*, 2011). Most of the fish species collected from the environments are transient forms inhabiting the estuarine and riverine environments. Few species are riverine while others are marine forms (Butchart *et al.*, 2010). The commercially important groups which contribute to the major catches belong to the estuarine habitat are highly seasonal, since the catches depend upon the adjacent sea and river.

Jayasree (1995) suggested that *Etroplus spp.* and mullets are the most abundant forms having considerable economic importance and contribute appreciably to the catch composition. But such a trend was not observed during the present study. *Etroplus spp.* once found abundantly in this estuary is no longer available in good numbers. The available reports suggest that the population of *Etroplus spp.* was greatly reduced due to environmental degradation. A declining catch trend of catfishes was observed in the present study. Gopi (2000) also reported that certain catfishes were vulnerable to extinction.Chandrashekariah *et al*. (2000) reported that the fish *Glossogobius giuris* in the Western Ghats were threatened and the present study also showed that they were very less. Among the mullet species, *Mugil cephalus* and *Liza parasia* contributed considerably to the fishery (Uriarte and Borja 2009). In the present study also these fishes were recorded more or less in higher numbers. Although there was no evidence to prove that the decline of penaeid prawns and crabs was due to intense seed collection and wide spread aquaculture, the reasons for the decline of such species can very well be related to intensive coir retting process and the disposal of city sewage through canals in the environment (Bijoy Nandan, 1991).The extent of onshore migration of fish and shellfish are dependent on their extreme tolerance level of the environmental parameters (Whitfield *et al.*, 1981; Claridge and Potter, 1983). The significance level tested by Karl Pearson correlation coefficient (5% level) also proves the above statement.

Different physicochemical parameters displayed a wide range of temporal and spatial variation. Water temperature, salinity, pH, conductivity, turbidity, dissolved oxygen (DO), and biochemical oxygen demand (BOD) were found to be higher during pre-monsoon, while, silicate, phosphate phosphorous, nitrite nitrogen, ammonical nitrogen, and nitrate nitrogen were maximum during monsoon. The post-monsoon season was characterized in having lowest temperature, moderate salinity, and other parameters. Soil temperature, salinity, organic carbon, and sand content were found to be higher during premonsoon, while available potassium, available nitrogen, and available phosphorous were maximum during monsoon. The post-monsoon season was characterized in having lowest temperature, available phosphorous, available potassium, available nitrogen, and moderate level of other parameters (Chakraborty 2013). According to Cai *et al*. (2012) heavy erosion and high sedimentation with heavy siltation altered the fisheries both in the newly created lacustrine environment and downstream areas. The immeasurable quantities of organic wastes added to these water bodies increase the BOD and caused depletion of dissolved oxygen levels. The high level of phosphate and nitrates present in domestic sewage and agricultural run off accelerated the process of eutrophication (Abery *et al*., 2005). Heavy siltation, drastic reduction in water volume and loss of breeding grounds are the major factors responsible for the decline in fisheries (Lotze 2010). In the present study the distribution of fish showed an inverse relationship with increased concentration of heavy metals, hydrogen sulphide and ammonia, which not only cause stress to aquatic organisms, but also disturb the migratory pattern of the fish (May and Spears, 2012).

The diversity index of Veli (2.01) suggests that extreme climatic variations may results in an alteration of fauna of different origin and increase the global temperature may also results in loss of freshwater species (Beard et al., 2011).The factors related to zoogeography such as restricted distribution, wider-distribution with preferential mass migration to selected localities and less conducive biotopes can also cause rarity of species (Devaraj *et al*., 1994). The species richness was high in Veli (0.0036) reveals that the number of the particular species which encountered their limits at the particular ecosystem (Albaret, 1999). The high species richness of Veli was due to two antagonistic hydrological processes such as penetration of fish fauna from marine or freshwater origin and permanent resident species which make up the bulk of the catches.

The low evenness recorded in Veli was due to the dominance of certain species which reduced the chances of survival of more species because of the non-availability of feeding and breeding grounds for all the inhabitants and due to pollution stress. Relationships between biomass and evenness varied and depended on the identity of the dominant species. Brian and catherine (2000) reported that changes in evenness occur with little or no changes in species richness and this point out the importance of evenness as a component of diversity. Reduction in evenness occurs due to the response of environmental changes which produces indirect effects on estuarine productivity. Biodiversity dominance was high in Veli lake (, 0.78) shows an inverse relationship with evenness of the species (Baran, 2000). The fittest species such as *Oreochromis mossambicus* and *Penaeus indicus* resist the environmental degradation up to an extreme extent and supports the diversity dominance of the ecosystem and replaces the sensitive species (May and Spears, 2012). It is known that species become rare before coming extinct and once rare; they are vulnerable to disappearance (Butchart *et al*., 2010). So rarity should not be ignored. Future efforts to protect species and to prevent rare ones from slipping into extinction will depend on a deeper understanding of the biology, rarity and extinction. The sense of protection by optimum exploitation maintains a stable ecosystem in a near future.

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