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Biodiversity and Abundance of Various Fish Species of the Ennore Creek Tamil Nadu, India

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ABSTRACT

Background: The estimated biodiversity indices showed spatial and temporal variations in the biodiversity of finfish and shellfish among the three stations of Ennore Creek, from September 2018 to August 2019 and from September 2022 to August 2023 at fortnightly intervals.

Methods: A total of three sampling sites (S_1, S_2 and S_3) were chosen in Ennore Creek for the present research. Occurrence data of finfish and shellfish species caught using gill nets were collected at the three selected sites of Ennore Creek. PRIMER v7 (Plymouth Routines in Multivariate Ecological Research), a statistical software tool created at the Plymouth Marine Laboratory in the United Kingdom (Clarke and Gorley, 2006) was used.

Result: The findings showed that within the study area, there were more species, higher abundances, larger individuals and a higher percentage of Least Concern (77.6%), Not Evaluated (16.3%) and Data Deficient (6.1%). For every species of shellfish that has been documented, the IUCN classification is 100% not evaluated. But there are very few species of shellfish and finfish. Significant variations in fish abundance were found when the mean abundance of vulnerable, endangered and least concerned species for the assessed, unprotected areas were analysed.

Key words: Assessment, Biodiversity, Creek, Fishes.

INTRODUCTION

The Ennore Industrial Complex is located adjacent to Manali Industrial Complex. It includes wastes from petrochemical complex, thermal power plant, pharmaceuticals, chemicals, fertilizers; automotive manufacturing unit and a coal fired thermal electricity station-ETPS. Apart from this, NCTPS came to existence at a later stage. The present study was conducted to assess the impact of pollution in and around Ennore Estuary ecosystem (Chitrarasu *et al*., 2013). Tidal creeks and estuaries are crucial habitats for diverse marine flora and fauna and constitute a major source of biological productivity. In addition, tidal creeks are being used as navigational routes and also for tourism-related activities. Tidal creeks and their associated salt marshes are the interface between the local landscape and estuaries where freshwater from the land mixes with saline water from the estuary. The resulting tidal creek-salt marsh networks are renowned for their dynamic nature, ecological complexity, pollutant retention and processing, nursery functions, biological productivity and seafood production (Kneib, 1997; Sanger *et al*., 2015; Lerberg *et al*., 2000; Mallin *et al*., 2000; Holland *et al*., 2004). Creeks and estuaries are critical for the survival of many faunal and floral species. Tens of thousands of birds, mammals, fish and other wildlife depend on estuarine habitats to live, feed and reproduce. They provide ideal spots for migratory birds to rest and refuel during their long journeys. Many species of fish and shellfish rely on the sheltered waters of estuaries as protected places to spawn, thereby serving as nursery grounds. Hundreds of marine organisms, including many commercially valuable fish species, depend on estuaries at some point during their development. In addition, estuaries play an important role in a large number of coastal management activities. Coastal creeks are complex and dynamic aquatic environments. Estuaries and their associated habitats, such as mangroves and salt marshes, act as nurseries and feeding grounds for many commercially important species of fish, such as shellfish and finfish (Heck and Orth, 1980; Kathiresan and Bingham, 2001; Kennish and Paerl, 2010). Su *et al*. (2019) state that biodiversity is a multifaceted notion that includes a range of features, such as the quantity and diversity of species (taxonomic facet), the length of their evolutionary histories (phylogenetic facet) and the diversity of their functional attributes. Studies of taxonomic diversity or species richness should, to the maximum extent possible, be complemented by studies of ecological diversity, or the variety of biological communities in a particular location (Sarkar *et al*., 2010). The current study set out to provide

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current data on fish diversity regarding abundance, richness, relative abundance and diversity status of the reservoir system in the hopes of improving understanding of the fish diversity profile of Anjanapura reservoir and serving as a tool for conservation planning of aquatic environments in this region (Basavaraja *et al*., 2014).

MATERIALS AND METHODS

The Ennore Creek (13°13′54.48″N, 80°19′26.60″E) is located approximately 24 km in the northeastern part of Chennai City, Tamil Nadu and India at the coast of the Bay of Bengal. The creek or estuary is connected with Pulicat Lake in the north through Buckingham Canal and Kosasthalaiyar River in the northwest. A total of three sampling sites (S_1, S_2 and S_3) were chosen in Ennore Creek for the present research (Fig 1). Occurrence data of finfish species caught using gill nets mesh size of 24-36 mm with a hauling period of 2 hours and shellfish caught using bottom set gill net and dredges were used with a hauling period of 2 hours collected from the three selected sites of Ennore Creek with the help of fishermen from September 2018 to August 2019 and from September 2022 to August 2023 at fortnightly intervals. PRIMER v7 (Plymouth Routines in Multivariate Ecological Research), a statistical software tool created at the Plymouth Marine Laboratory in the United Kingdom (Clarke and Gorley, 2006) was used. Biodiversity indices such as Species richness (d), Species evenness (J′), Shannon-Wiener species diversity index (H′), Taxonomic diversity (Δ), Taxonomic distinctness index (Δ*), Average taxonomic distinctness index (Δ+), Total taxonomic distinctness (sΔ+), Variation in taxonomic distinctness (Λ+) and Total phylogenetic diversity (sPhi+), were calculated for all the three stations during all seasons of 2018-19 and 2022-23 using computer software package PRIMER version 7.0. The Spatio-temporal variability in the above indices was calculated to assess the ecosystem health of Ennore Creek. Research period is from September 2018 to August 2019 and from September 2022 to August 2023 at fortnightly intervals. The research work is carried out in Tamil Nadu Dr. J. Jayalaithaa Fisheries University, Dr M. G. R. Fisheries College and Research Institute, Ponneri.

RESULTS AND DISCUSSION

Specimens of finfish and shellfish species were collected fortnightly from three selected sites in the Ennore Creek of Chennai coast from September 2018 to August 2019 and August 2022 to July 2023 by employing gillnet. A total of 49 species of finfish and 12 species of shellfish were recorded during the study period. The finishes recorded were found to belong to 11 orders with the dominance of the order Perciformes (16 families, 27 species), followed by Siluriformes (2 families, 3 species), Beloniformes (2 families, 5 species), Clupeiformes (3 families, 4 species), Carangiformes and Acanthuriformes (each 1 family, 2 species), Elopiformes (2 families, 2 species), Scombriformes, Mugiliformes, Gonorynchiformes and Pleuronectiformes (each 1 family and 1 species) (Fig 2 and 3). The IUCN status of recorded species was classified mostly as Least Concern (77.6%), followed by Not Evaluated (16.3%) and Data Deficient (6.1%) (Fig 4). The majority of the recorded shellfish (83.33%) were found to be commercially important.

The IUCN status of all the recorded shellfish species was classified as Not Evaluated (100%). However, only a small number of finfish and shellfish species were found in the current study, which may be related to pollution at the study site, as proposed by Plafkin *et al*. (1989). The current investigation concurs with Plafkin *et al*. (1989) in that a mere 49 finfish species and 12 shellfish species have been identified. The remaining fish species were uncommon in their occurrence (Goldin and Athalye, 2012). Our research is consistent with that of Azzuro *et al*. (2011), who found that sewage significantly altered the levels of specific species and the fish assemblage in Mediterranean waterways.

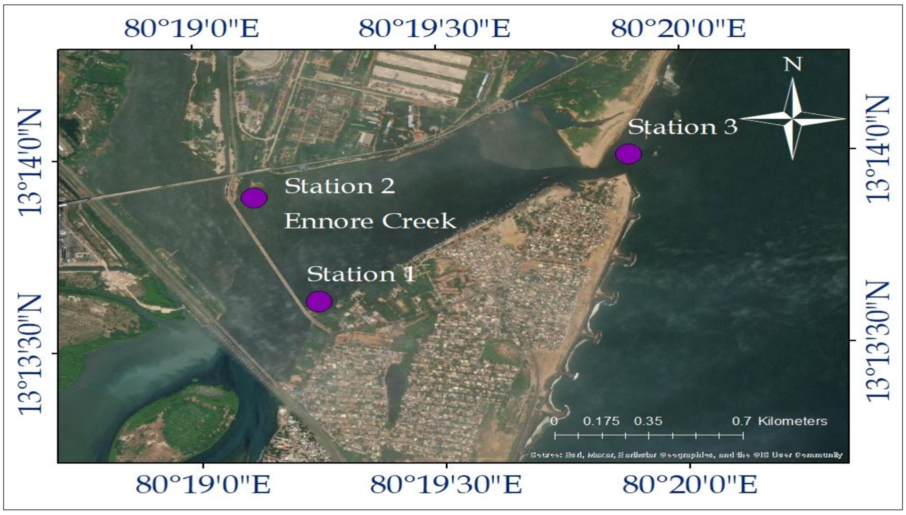

Fig 1: Sampling stations.

Species diversity (H′)

The spatial variation in Shannon-Wiener diversity (H′), value is given in Table 1. The highest (H′) value was observed at S_3 (4.022) and the lowest in S_2 (3.917) during 2022-23. On comparing the seasons, the highest (H′) value was observed in post-monsoon (4.027) and the lowest in monsoon (3.918) during the year 2022-23. The highest value (4.022) was observed in S_3 and the lowest value

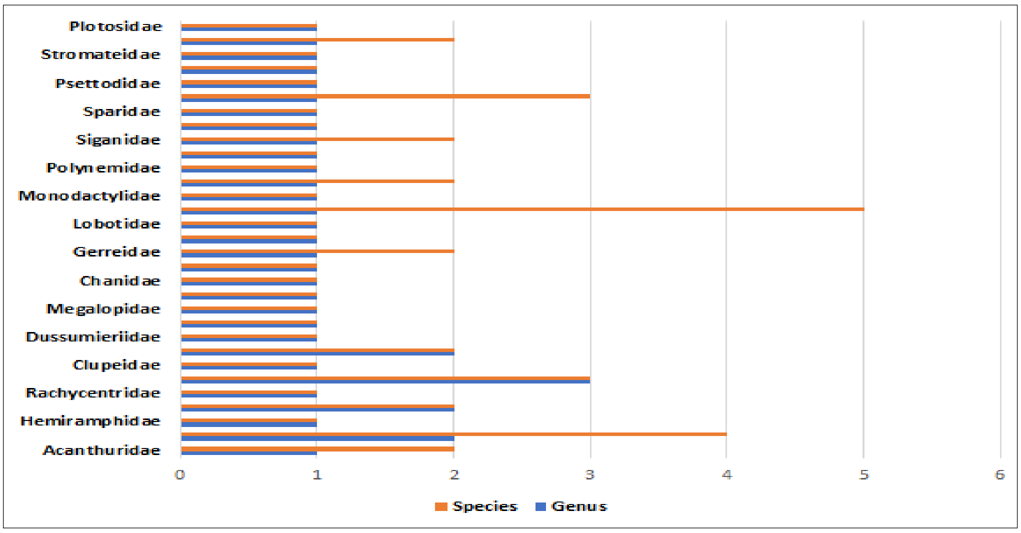

Fig 2: Family-wise representation of finfish diversity of ennore creek.

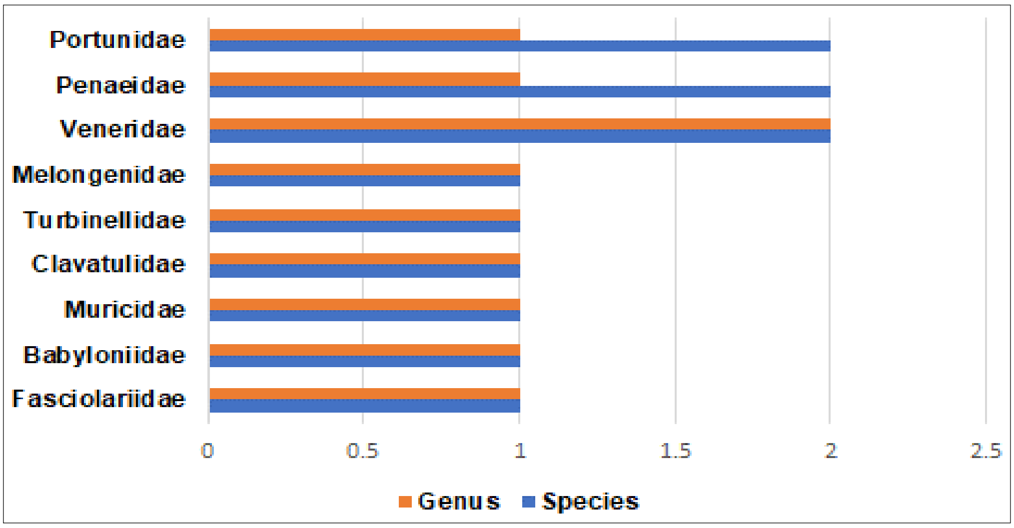

Fig 3: Family-wise representation of shellfish diversity of ennore creek.

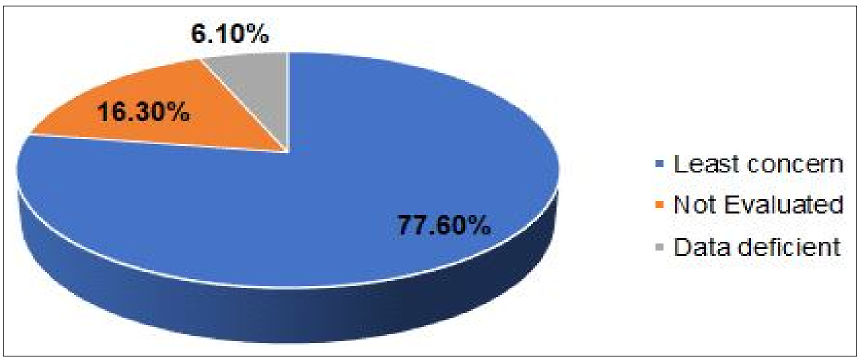

Fig 4: IUCN conservation status of finfish species recorded.

(3.917) was recorded in S_2. Similar results were observed in the Vellar estuary (4.52-5.81) by Murugan *et al.* (2014) and Nandini and Milton (2019) in the Adyar estuary (3.262-3.327). Observations were made by Bharadhirajan *et al.* (2015), at Coleroon Estuary, Murugan *et al.* (2014), at Vellar Estuary and Pavinkumar (2014), at Korampallam-thermal Estuary.

The diversity of fishes was calculated for each station following Shannon- Wiener index using the following formula,

$$H' = \frac{3.3219\ (N \log - \Sigma ni - \log ni)}{N}$$

Species richness (d)

Species richness for each station was calculated following Margalef index (d) using the formula,

$$d = \frac{S - 1}{\log e\ N}$$

The spatial variation in Margalef species richness (d) among different sites of Ennore is given in Table 2. The highest value was observed in S_1 (9171) and the lowest in S_2 (8.875) during the year 2022-23 (Table 1). The seasonal variation in Margalef species richness (d) is given in Table 2. The species richness "d" ranged from 8.718 to 10.06. Our study confirms with the study carried out by Plafkin *et al.* (1989) who opined that a community becomes more dissimilar as the stress increases and accordingly species diversity decreases with poor quality. The calculated d values of the present study lie more or less similar to that of Murugan *et al.* (2014) for the diversity of fishes of the Vellar estuary and Pavinkumar (2014), for the diversity of fishes of the Korampallam-Thermal estuary. Furthermore, when comparing the two years, 2022-23 exhibited higher Margalef species richness (10.86) than 2018-19 (10.75). This suggests a potential increase in species richness over time in the Ennore Creek region. However, the values of d were recorded for the ichthyofaunal diversity of the Thamirabarani River by Mogalekar (2019).

Taxonomic diversity (Δ)

This is a measure of average taxonomic distance between any two individuals chosen at random belonging to separate species. It was calculated using the following formula,

$$\Delta = [\Sigma \Sigma\ i< j\ wij\ xi\ xj] / [N\ (N-1)/2]$$

The estimated taxonomic diversity (Ä) values for the sampling stations are presented in Table 2. The highest taxonomic diversity value was observed at S_2 (85.29) during 2018-19 and the lowest value at S_3 (84.24). During the year 2022-23, the highest value (83.96) was observed at S_3 and the lowest at S_2 (83.64). The present seasonal taxonomic diversity values (83.33-85.37) are almost similar to the values reported by Jesintha *et al.* (2022) for the finfish and shellfish diversity of Pilicat Lake. Higher values of taxonomic diversity indices suggest that, on average; the species in the assemblage are not closely related, being higher biodiversity (Patricio *et al.*, 2009) shown in shade plots (Fig 5 to 7).

Species evenness (J′)

Evenness was calculated following Pielou's evenness (*j′*) using the formula,

$$J' = H'/\log_2 S \text{ or } H'/\ln_2 S$$

Pielou's evenness (J′) can be used to compute evenness, which describes how uniformly the individuals in a community were allocated among the various species. The highest value was observed at S_3 (0.9784) and the lowest was S_2 (0.9759) during 2018-19. According to Clarke and Warwick (2001), as the dominance of individual

Table 1: Spatial variations of biodiversity indices of ennore creek.

Sample	S	N	d	J′	H′ (loge)	Delta	Delta*	Delta+	sPhi+
S1-18-19	61	694	9.171	0.9769	4.016	84.31	85.88	87.08	3833
S2-18-19	61	480	8.718	0.9759	4.012	85.29	86.84	85.08	3533
S3-18-19	61	846	8.902	0.9784	4.022	84.24	85.8	87.08	3833
S1-22-23	61	553	9.524	0.9568	3.933	82.76	84.54	87.08	3833
S2-22-23	59	319	8.875	0.9606	3.917	83.64	85.35	86.28	3617
S3-22-23	61	863	10.06	0.9801	4.029	83.96	85.51	87.08	3833

Table 2: Seasonal variations of biodiversity indices of ennore creek.

Sample	S	N	d	J′	H′ (loge)	Delta	Delta*	Delta+	sPhi+
M-18-19	58	601	8.908	0.9845	3.997	85.37	86.92	87.41	3633
PoM-18-19	61	592	9.398	0.9796	4.027	84.22	85.73	87.08	3833
S-18-19	61	607	9.363	0.9764	4.014	84.38	85.94	87.08	3833
PrM-18-19	61	590	9.404	0.9769	4.016	83.77	85.31	87.08	3833
M-22-23	57	449	9.171	0.9691	3.918	83.3	85.02	87.49	3600
PoM-22-23	61	514	9.611	0.9733	4.001	83.12	84.68	87.08	3833
S-22-23	61	584	9.418	0.9746	4.006	84.13	85.7	87.08	3833
PrM-22-23	61	592	9.399	0.9768	4.015	83.74	85.28	87.08	3833

species increases, the level of species evenness decreases (Fig 5 to 7). The values of species' evenness vary from 0 to 1, where a value of zero represents no evenness and a value of one represents complete evenness. The above concept holds well in the present study. Pielou's evenness calculated in the present study

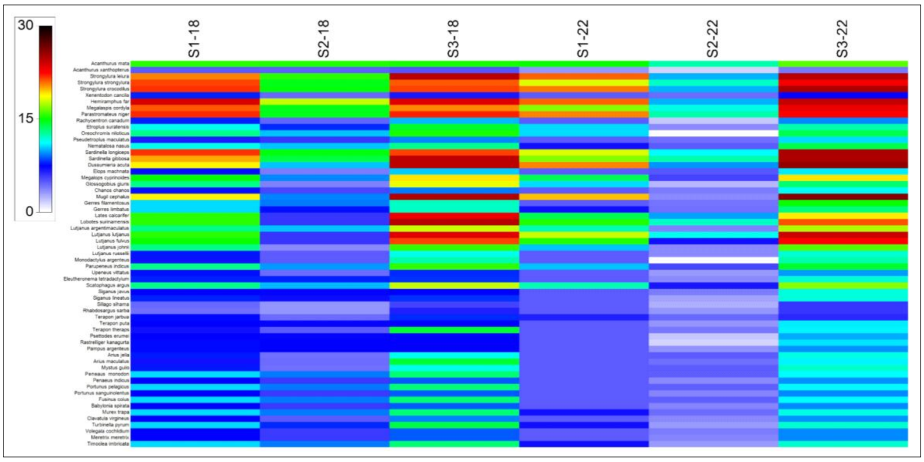

Fig 5: Site-wise shade plot for the species recorded during the present study.

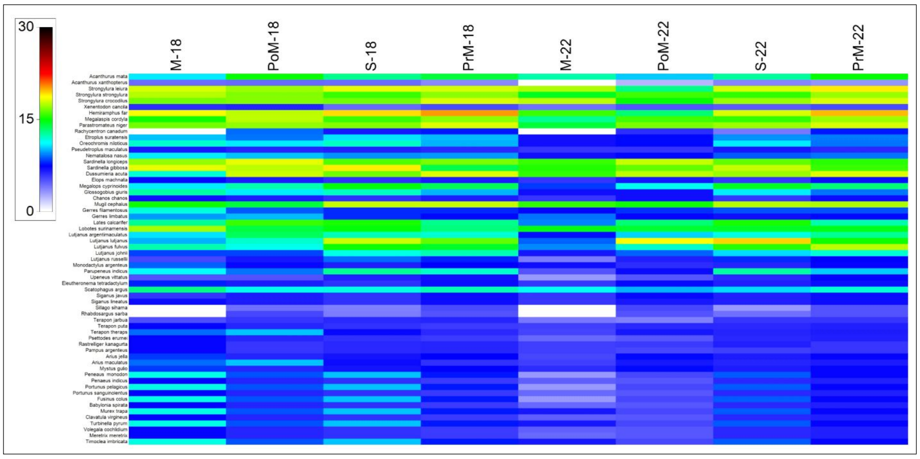

Fig 6: Season-wise shade plot for the species recorded during the present study.

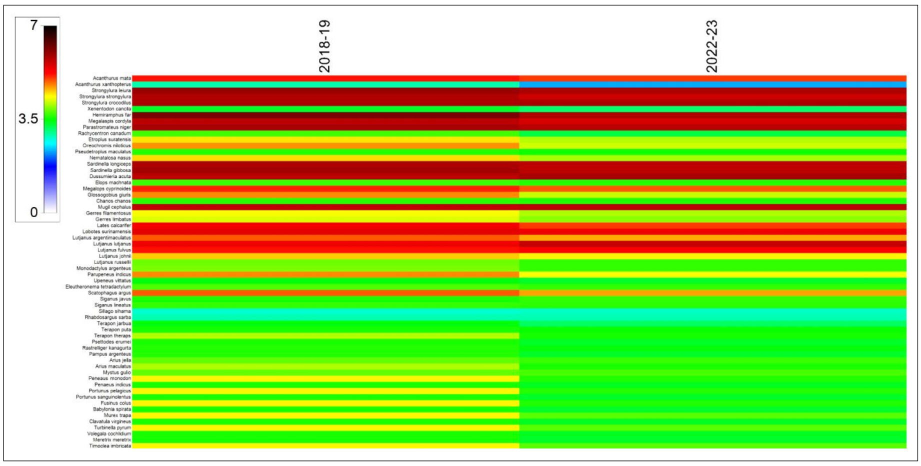

Fig 7: Year-wise shade plot for the species recorded during the present study.

was relatively higher in the range of 0.9568-0.9801. This indicates that the distribution of individuals among species in the community was more uniform in 2018-19 compared to 2022-23 (Table 3). Mogalekar (2019) reported the average. The evenness value calculated for Pulicat Lake is higher which shows that the fish communities in the lake are not under stress (Jesintha *et al*., 2022).

Taxonomic distinctness index (Δ*)

Taxonomic distinctness (Δ*) was calculated using the following formula,

$$\Delta^* = [\Sigma \Sigma i< j\ wij]/[S(S - 1)/2]$$

Spatial variation in average taxonomic distinctness (Δ*) is represented in Table 2. The comparison between the two years revealed that 2018-19 (86.66) had a slightly higher average taxonomic distinctness than 2022-23 (86.24). However, our present results are contrary to the taxonomic diversity index of freshwater fish in Guangxi, China, which falls within the range of 42.8 to 43.2 (He *et al*., 2022), showing that the diversity of fish species in the Ennore Creek is relatively good.

Variation in taxonomic distinctness index (Δ^+)

Average taxonomic distinctness index (Δ^+) was calculated using the formula,

$$\Delta+= [\Sigma \Sigma i< j\ (wij - \Delta+)\ 2] / [S(S-1)/2]$$

The spatial variation in taxonomic distinctness (Δ+) among the studied sampling sites (Table 1) is in the following ascending order. The study also examined the variation in taxonomic distinctness (Δ+) for each year and found that the values for 2018-19 and 2022-23 were both equal, with a value of 87.08. Jiang *et al.* (2020) assessed the effects of anthropogenic impacts (loss of river-lake connectivity and deterioration of water quality) based on the presence/ absence data of fish assemblages from the floodplain lakes in the Yangtze River Basin, China.

Total phylogenetic diversity (sPhi+)

Total phylogenetic diversity (sPhi+), which vouches safe for the taxonomic breadth for the fishes present in various sampling stations, was calculated by finding out cumulative branch length of the full taxonomic tree drawn using the Linnaean classification.

The total phylogenetic diversity (sPhi+) had the highest value at $S_1$and S_3 (3833) for the two corresponding years 2018-19 and 2022-23 and the lowest value at S_2 (3533) during the years 2018-19 and S_2 (3617) during the year 2022-23 (Table 1). In a healthy environment, due to rich faunal assemblages, (taxonomic breadth) the total phylogenetic diversity and average phylogenetic diversity are always higher (Khan *et al*., 2005; 2008). The values obtained in the present study are higher than those obtained by Pavinkumar (2014) for the diversity of fishes in the Korampallam Thermal, Punnaayal and Manakudy estuaries; Murugan *et al.* (2014) for the diversity of fishes in Vellar estuary.

K-dominance curve

Chandran *et al*., (2022), stated that K-dominance curve was plotted season-wise. Cumulative relative abundances were higher in monsoon followed by winter and summer. The month-wise D dominance plot showed that the cumulative abundance was rich during August, 2019 and September, 2019 and poor during February, 2020. The spatio-temporal variation in the K dominance plot among the sampling stations indicated that the flow of cumulative abundances is the flow of station 1>2>3>4>5. The seasonal variation recorded for Gorai Creek resulted in high during monsoon, 2019 and less during summer, 2020. To examine the dominance of individual species across stations, dominance plots were created by ranking the species in decreasing order of abundance. Among the sampling sites, in 2022-23, S_2 had a relatively more significant cumulative abundance than the other sites and in 2018-19, no significant difference was observed in the species abundance. The Spatio-temporal variation and the seasonal variation in the dominance plot among the sampling sites at Ennore Creek, Chennai are presented in Fig 8 to 10.

Analysis of similarity

Bray-Curtis similarity helps to quantify the compositional similarity between two sites/ seasons/ years, based on counts at each location. The calculated values are presented in Fig 11 to 13. While analyzing the spatial variability in the BC similarity index for individual sampling sites, it was higher (94.24%) between S_2-22 and S_2-18; and 82.67% between S_2-18 and S_1-18 with high positive Cophenetic correlation (0.8473). Contrary to this, the lowest similarity (64.24%) has been observed between S_2-22 and the combination matrix of other sites (Clarke and Warwick, 1999).

nMDS plot

According to our dissimilarity analysis, 2017 and 2018 shared 80% of the species recorded in the study, which is also consistent with the similar temperatures and diversity values recorded in both years. In addition, average taxonomic distinctness also shows 2017 and 2018 as highly similar years. According to Ruiz-Campos *et al*., (2010), the fish species that inhabit the intertidal rocky areas of the West coast of the Baja California peninsula have a greater affinity for the Mexican and Cortes zoogeographic provinces, with the family Pomacentridae recording the highest number

Table 3: Year-wise variations of biodiversity indices of ennore creek.

Sample	S	N	d	J′	H′ (loge)	Delta	Delta*	Delta+	sPhi+
2018-19	61	266	10.75	0.9949	4.09	85.44	86.6	87.08	3833
2022-23	61	251	10.86	0.9938	4.085	85.09	86.24	87.08	3833

of species, particularly *A. declivifrons* and *A. troschelii.* This is consistent to that reported by Cota-Ortega *et al*., (2022), who also mentioned these species as the most abundant. A simulation test performed on average taxonomic distinctness using a funnel showed all the values for spatial abundance for two-year sampling (2018-19, 2022-23) falling within the 95% confidence limit. Values for the spatial abundance fell exactly on the mean (Δ+, 87.08; λ+, 139.15),

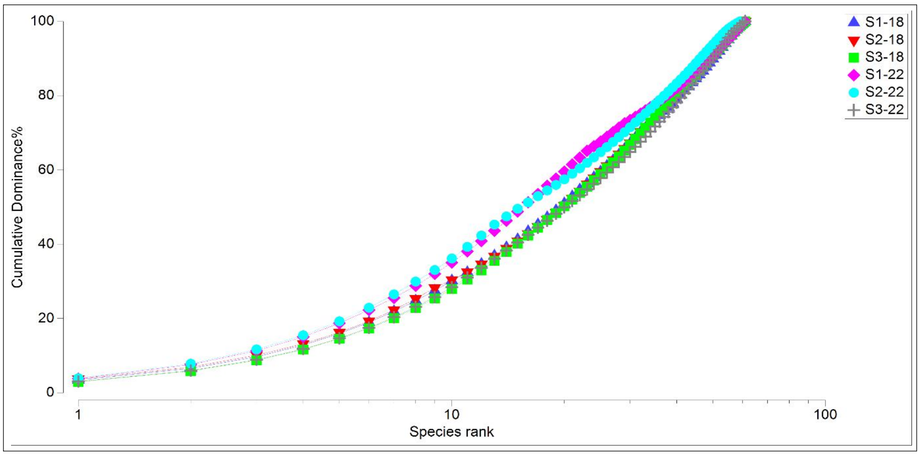

Fig 8: K-dominance plot depicting fishes recorded for the three sites along ennore creek.

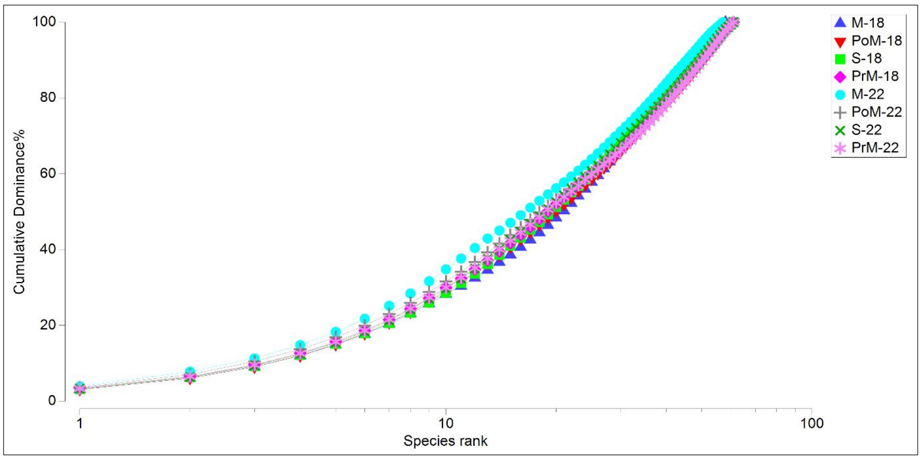

Fig 9: K-dominance plot depicting fishes recorded for various seasons along ennore creek.

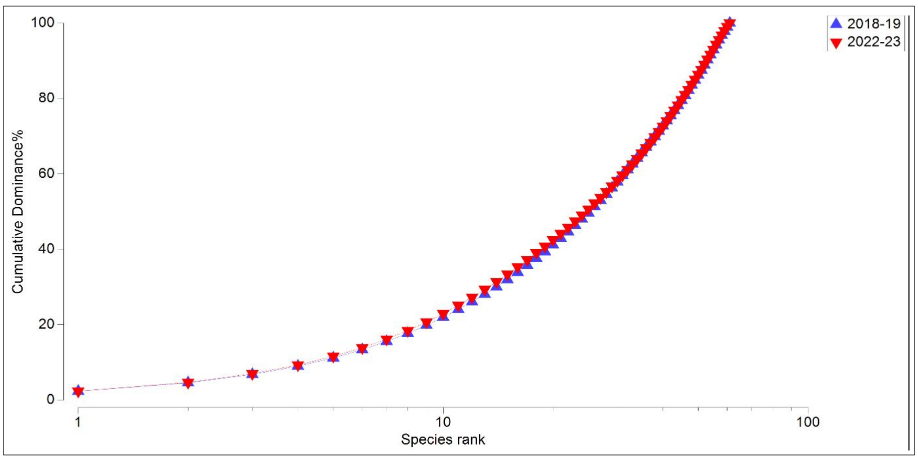

Fig 10: Year-wise representation of K-dominance plot depicting fishes recorded along ennore creek.

while for the S_2-22 it varied slightly from the mean (Δ+, 87.28; +, 140.78) with significance of (Δ+) 59.3% and (+) 63.3%, respectively. A simulation test performed on average taxonomic distinctness using a funnel showed all the values for seasonal abundance for two-year sampling (2018-19 and 2022-23) falling within the 95% confidence limit (Fig 14 to 17).

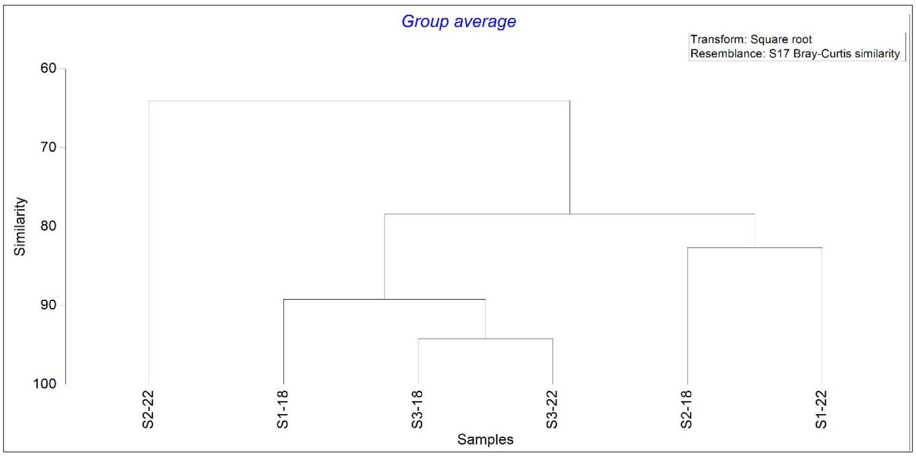

Fig 11: Dendrogram representing the fish diversity for three sampling sites of ennore creek.

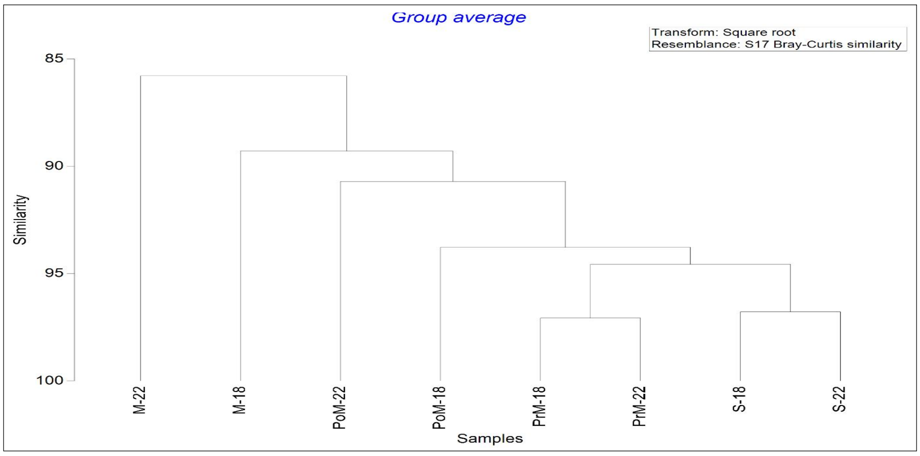

Fig 12: Dendrogram representing the fish diversity for different seasons of ennore creek.

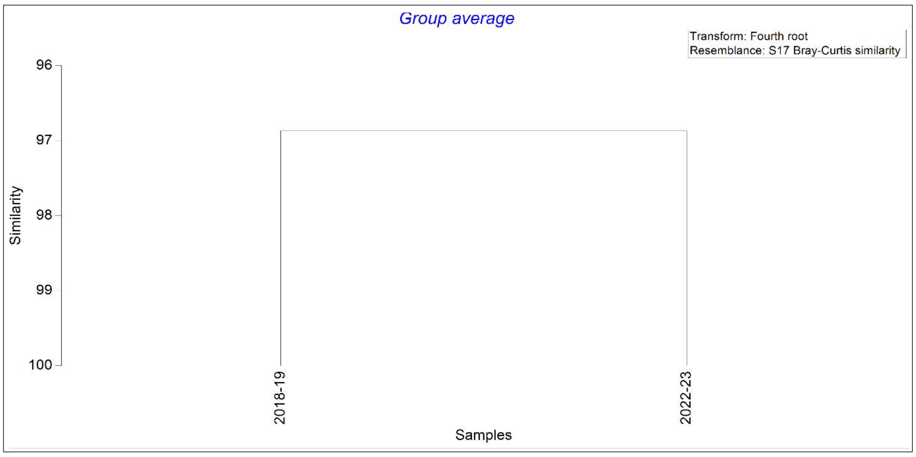

Fig 13: Dendrogram representing the year-wise similarity of fish diversity in ennore creek.

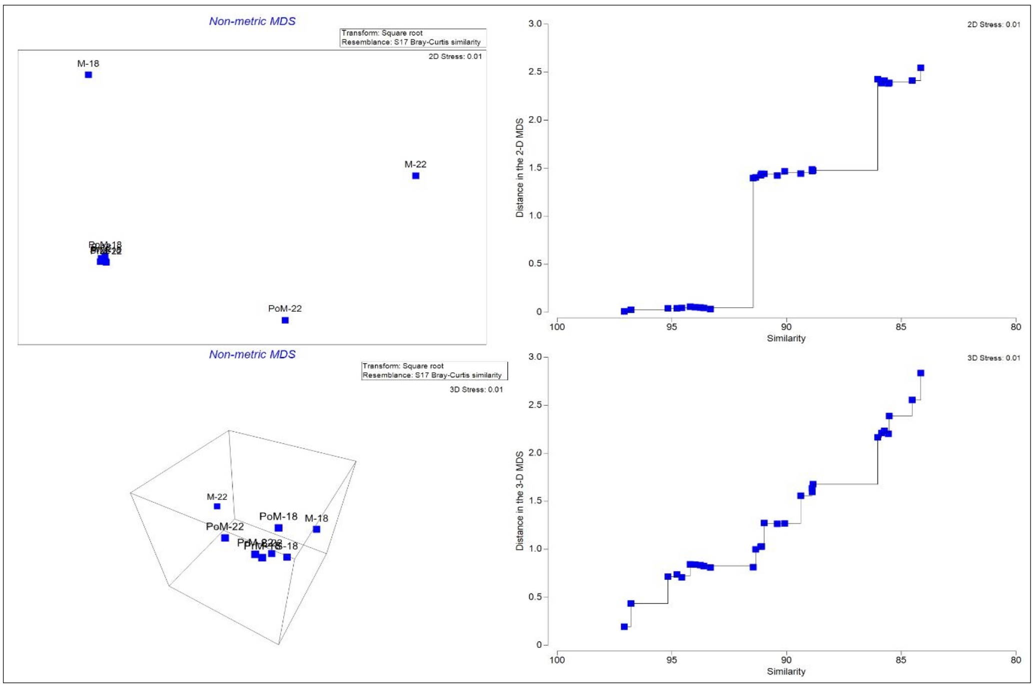

Fig 14: nMDS ordination multiplot for the fish assemblages during seasonal abundance in ennore creek.

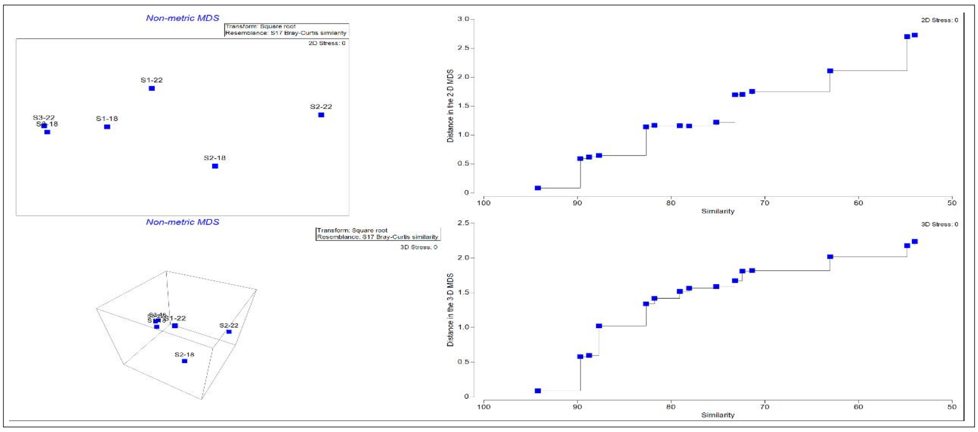

Fig 15: nMDS ordination multiplot for the fish assemblages during spatial abundance in ennore creek.

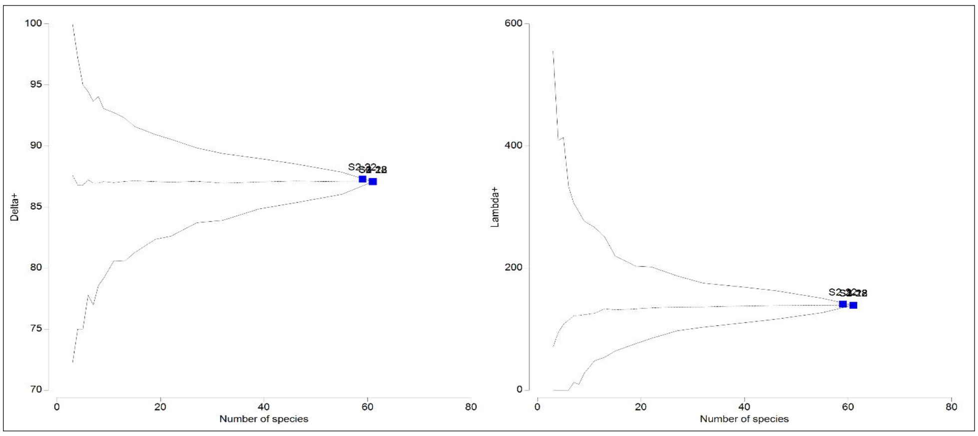

Fig 16: Ninety-five percent confidence funnel for Delta+ and Lambda+ values recorded for spatial abundance.

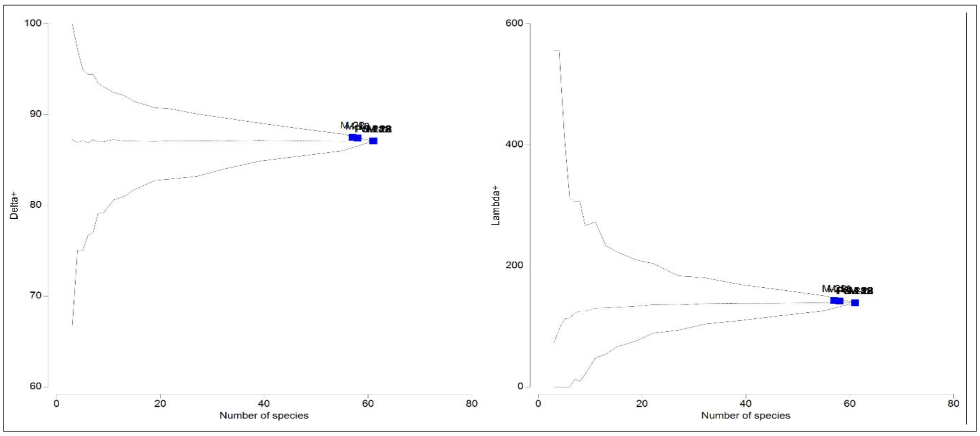

Fig 17: Ninety-five percent confidence funnel for Delta+ and Lambda+ values recorded for seasonal abundance.

Table 4: Water quality parameters of Ennore, 2018-19 and 2022-23.

Year	2018-19			2022-23		
Parameters	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Temperature	28±0.1	27±1	26±0.5	28±0.5	27±0.4	26±1.1
pH	6.79±0.4	6.79±0.4	6.79±0.7	6.89±0.3	6.79±0.2	6.39±0.7
Ammonia mg/l	0.45±0.3	1.03±0.34	1.01±0.6	1.03±0.3	1.01±0.1	1.01±0.1
Do mg/l	4.9±0.5	4.4±0.5	4.3±0.07	4.8±0.6	4.4±0.5	4.3±0.6
BOD mg/l	4.05±3.8	37.5±3.8	37.5±2.2	27±0.2	25.9±0.3	23±10.3
COD mg/l	246±10.5	239±10.5	230±10.5	248±9.01	239±9.03	230±4.5
Salinity	26±0.7	24±0.7	25±1.7	26±0.7	25±0.4	24±1.7

Physico-chemical properties of seawater

Water is one of the most important compounds to the ecosystem. Physico-chemical and micro-biological characteristics may describe the quality of water (Priyanka *et al*., 2019). The marine environment, as a complex system is mainly influenced by various physical, chemical and biological processes. Estuaries aid creeks play an important role as nursery grounds for fishes and prawns. However, they are vulnerable to anthropogenic activities, as they are being used as dumping grounds for domestic and industrial wastes. Short term and long-term studies of the hydrological parameters can provide firsth and information about the chemical interactions taking place in an aquatic ecosystem (Quadros *et al*., 2001).

The study reveals water quality parameters of Ennore estuary showed that concentrations of nutrients were above the coastal water level due to continuous discharge of domestic sewage and industrial effluents and the estuary is severely polluted (Table 4). The continues discharge of effluents to the estuarine ecosystem is vulnerable to all compartments of the food web. Awareness has been created if not immediate, definitely block or alert the input from industrial area. Estuaries are extremely exploited ecosystems, due to their proximity to major civilization throughout the globe. There is an urgent need to control or restore the discharge of domestic sewage and other industrial effluents to restore breeding ground of finfish and shell fish, secondary and tertiary productivity in the estuarine water body for the benefit of Chennai coast.

CONCLUSION

On the basis of present research finding and other similar studied of recent times, it can be concluded that Ennore creek has been losing its biological productivity under the influence of natural as well as human interference and hence it is recommended to invite more attention towards conservation and management of ichthyofaunal diversity in Ennore creek. In the current study, finfish and shellfish species composition, in Ennore Creek was investigated. A total of 49 species of finfish and 12 species of shellfish were recorded during the study period. It has been discovered that protected areas along creeks frequently lead to higher fish populations for threatened species, which is crucial for the preservation and management of biodiversity. According to our observations, these places inside the creek can be used for both freshwater and marine purposes, provided that further precautions are taken to safeguard these aquatic resources from real dangers. Hence, intensive research would be needed in fish stock assessment and suitable management plan is of paramount importance for conservation of creeks biodiversity and its ecosystem.

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Conflict of interest

All procedures followed were in accordance with the ethical standards of the responsible, the authors declare that they have no conflict of interest.

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