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Fish species diversity and their assemblages of Devi estuary in north east coast of India

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Abstract
Devi River Estuary of Odisha is one of the tributaries of Mahanadi reverine system which is the third river in India. It supports diverse fisheries to local communities as well as serves as the nursery ground for culture of important valuable estuarine fish *Mugil cephalus*. Present study was carried out to assess the fish diversity status and their assemblages in relation to some hydrological parameters. Fish samples were collected together with some water quality parameters from three sampling stations of Devi river estuary from May 2017 to October 2017. Diversity of fishes were analyzed using SPSS (16.0) software. Findings showed that highest Shannon-einner diversity value for pooled data was 1.970, Margalef species richness is 2.6876, Evenness index of 2.854. The major contributory species were *Mugil cephalus*, *Rastrelliger kangagurta*, *Alectis indica*, *Rhabdosargus sarba* and *Lutjjanus indicus*, *Eleutheronema tetradactylum* and *Alectis indica*.

Keywords: Devi estuary, assemblage, diversity, hydrological parameter

1. Introduction
Estuaries serve as a dynamic habitat for a large number of marine fisheries species during a part of their life span, which are characterized by a large fluctuations in environmental conditions as these are meeting place of freshwater from river and salt water from sea [1, 2].Their importance is best understood in many parts of the world as breeding and nursery grounds for a large variety of fishes and aquatic animals. For marine trophic chain nutrient in the dissolved state are the basic raw materials and their entry are from continental drainage through the estuaries [3, 4]. The nutrients supply is greater in estuaries due to entry of anthropogenic wastes and agricultural effluents and this causes several environmental modifications which may affect increase in productivity and fish yields [5-7]. But in recent years anthropogenic inputs causes frequent eutrophication in the aquatic environment specially in marine and estuarine regions which causes change in chemical characteristics of water quality and that lead to various changes in ecological consequences like composition of aquatic species, decrease in oxygen concentration and finally affecting marine live forms [8].
Odisha is traversed by several rivers which ultimately merge with Bay of Bengal forming estuaries. Devi estuary of Odisha is one of the tributaries of Mahanadi reverine system, the third largest river in India which meets Bay of Bengal at Nuagarh.
The diversity of natural population is partially dependent on the environmental variables of the estuary that effect competing populations [8]. Fish and shrimp assemblage structure in this estuary has not been well studied, although there are little works on different biological aspects of coastal esturine system of Odisha [9, 10]. It is also important to know the environmental conditions of coastal water from the Devi estuary as it is the place for the congregation of Olive ridley turtles during their arribada [9]. The morphological structure of this region is highly dynamic where active processes like erosion, accretion and deposition are active [9]. Along its course, the river receives effluents from different industries and urban areas such as Sambalpur, Cuttack, Chowduar, Jagatpur and Paradeep and also receives a large amount of agricultural run-off. Most of effluences are deposited at Devi river estuary and this may alter the environmental conditions of this estuary which provides a large number of aquatic organisms and also provides the breeding ground for Olive-ridley turtles. No detailed and comprehensive findings are available on biological and ecological aspect of the fisheries of Devi estuary and hence it needs to be monitored as priority basis.
Thus considering the above mentioned reason, present study is aimed to describe the finfish

assemblage structure at Devi river estuary in relation to some hydrological parameters of the river water.

2. Materials and Methods

2.1 Study area

Devi estuary (86º 23' E, 19 º 57' N) belongs to Mahanadi estuary in Odisha along the northeast coast of Bay of Bengal (Fig.1). Astaranga, the area of project is situated on the coast of Bay of Bengal near the mouth of river Devi. It is a fishing village and the community depends mainly upon fishing. The annual average rainfall in this area is 1600-1800 mm of which maximum of 70%during the southern monsoon (June-October). The mean annual temperature is about 20 °C with a summer maximum of 35 °C and winter minimum of 16 °C. The estuary is formed by the main branches of the Mahanadi River which meet the Bay of Bengal at Paradeep and Nuagarh (Devi estuary).The Mahanadi basin is one of the five sedimentary basins occurring along east coast of India.

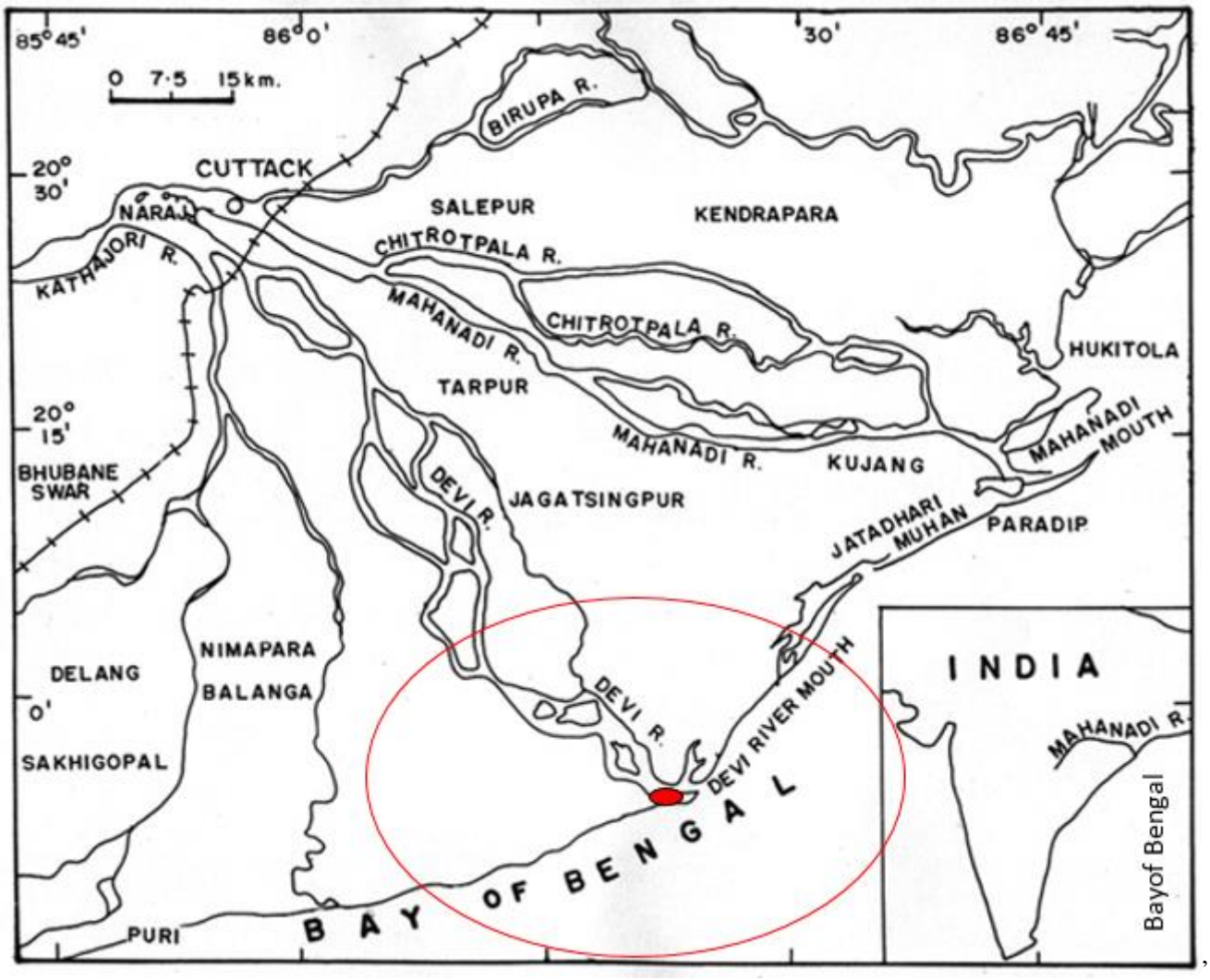

Fig 1: Red circle in Map showing path of flow of Devi River and study site at Nuagarh (Devi estuary)

The study area is divided into three sampling stations i.e. Nuagarh (st-1), Dakhinapantal (st-2) and Balipantal (st-3) for hydrological studies as well as finfish species collection. Data were collected fromMay-2017 to October-2017 as fishing is banned from November to April of every year for arribada of Olive ridley turtles. Water samples were collected from a depth of 30-35cm simultaneously with fish sampling at three sampling stations twice in every month. Fish samples were collected from previously contacted local fisherman. For laboratory study fishes were collected from each station during study period cleaned and frozen in icebox. In the laboratory samples were identified to species level [11, 12]. Temperature, salinity and pH of river water were determined using water analyzer (Systronic).

2.2 Data analysis

In the first stage of data analysis diversity of fish species and assemblage was quantified and then statistical analysis was done (Table-1). Species diversity was done using different ecological indices as Shannon-Wiener diversity, Evenness and Dominance indices in spatial and temporal spectrum. Shannon-wiener diversity considers both number of species and distribution of individuals among species [13, 14]. Margalef index (d) was used to measure species richness [15]. The dominance index was measured to determine whether or not particular fish species dominate in a particular aquatic system [16].

One way analysis of variance (ANOVA) was used for hydrological parameters. One way Analysis of similarities (ANOSIM) was done to test the significant difference among the stations and months [17, 18]. Similarity percentages analysis (SIMPER) was performed to observe the percentage of similarity among months and stations [17]. The hierarchical clustering was calculated to produce a dendrogram for investigating similarities among months and stations [18]. Canonical correspondence analysis (CCA) was calculated to

find out the association between species and environmental variables [19].

3. Result

The surface water temperature varied between 25.26 ˚C (in the month October at st-1) with a mean of 27.84 ˚C ±1.41˚C (Fig.2). No significant difference was observed in temperature between seasons (F=1.41 P≤0.01) and stations (F=0.98 P≤0.01).The highest pH value (8.29±0.38 at st-3) in May where as the lowest (7.54±0.39 at st-1) during September (Fig.3). No significant differences among months (F=0.59 P≤0.01) and seasons (F=0.66 P≤0.01) were calculated. The range of salinity varied from19.95% to 20.19 % (st-2 and st-1). No significant differences of the salinity values were observed between the stations (F=0.32 P≤0.01) (Fig.4).

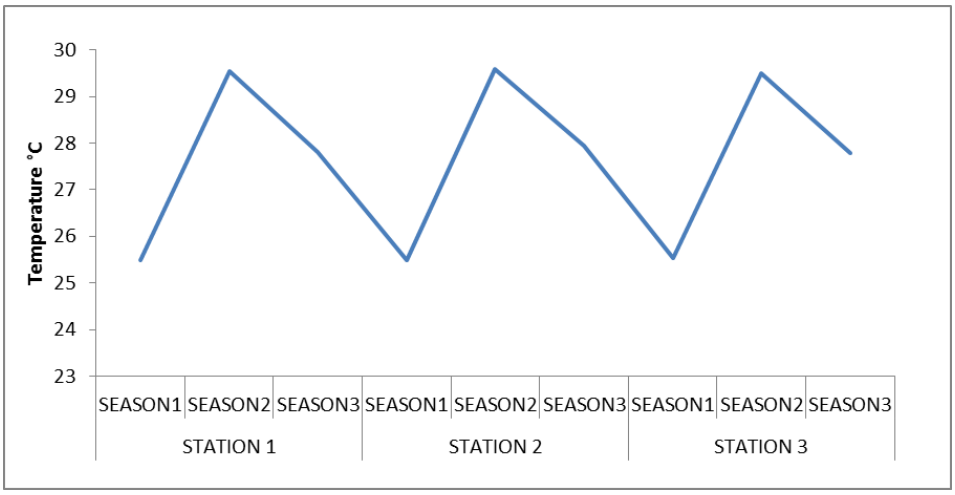

Fig 2: Variation of temperature in 2017

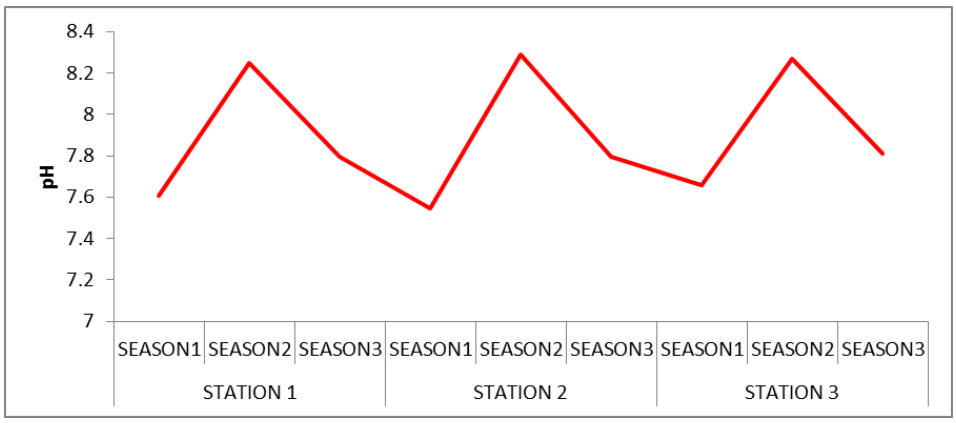

Fig 3: Variation of pH in 2017

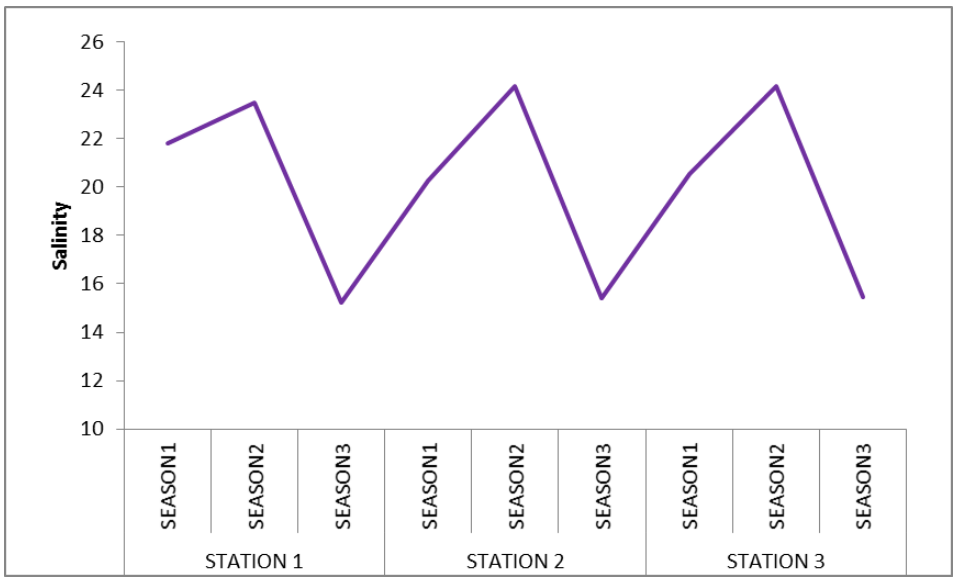

Fig 4: Variation of salinity in 2017

The Shannon-Weinner diversity value for pooled data was calculated to be 2.774 for st-1, 2.782 for st-2 and 2.820 for st-3 (Fig.5). The highest Shannon diversity of 1.970 was tabulated in the month of October (Fig.6). Margalef species richness for pooled samples were calculated to be 2.6876 (Fig.7).

Table 1: Fish specimen identified from different stations of study site 2017

Sl. No	Species	Code
1	*Sphyraena jello*,Cuvier,1829	C1
2	*Sardinella longiceps* Valenciennnes,1874	C2
3	*Gudusia chapra* (Hamilton,1822)	C3
4	*Gonialosa manmina* (Hamilton,1822)	C4
5	*Pellano ditchella* Valenciennnes,1874	C5
6	*Ophisthopterus tardoore* (Cuvier,1829)	C6
7	*Stolephorous indicus* (Vanttasselt,1823)	C7
8	*Thryssa mystax* (Bloch & Schneider,1801)	C8
9	*Lutjanus indicus* (Vanttasselt,1823)	C9
10	*Secutor insidator* (Bloch,1787)	C10
11	*Gerres selifer* (Hamilton,1822)	C11
12	*Rhabdosargus sarba* (Forsskal,1775)	C12
13	*Harpodon nehereus* (Hamilton,1822)	C13
14	*Trichurus lepturus* Linnaeus,1758	C14
15	*Eleutheronema tetradactylum* (Shaw,1804)	C15
16	*Xenentodon cancila* (Hamilton,1822)	C16
17	*Sillago sihama* (Forsskal,1775)	C17
18	*Tachysurus arius* (Hamilton,1822)	C18
19	*Rastrelliger karanguta* (Hamilton,1822)	C19
20	*Chelon parsia* (Hamilton,1822)	C20
21	*Mugil cephalus* Linnaeus,1758	C21
22	*Lates calcarifer* (Bloch,1790)	C22
23	*Alectis indica* (Ruppell,1830)	C23
24	*Carangoides malabaricus* (Bloch &Schneider,1801)	C24
25	*Johnius dussumierie* (Cuvier,1830)	C25

The highest value (2.9894) was observed for the month of May where as the lowest (2.8615) for October (Fig-8). The highest value of dominance diversity index was calculated to be 0.0921 in st-1 and lowest 0.892 in st-3 (Fig.9). Highest dominance diversity index value was 0.0258 in the month of May and lowest value o.0221 during September (Fig.10)

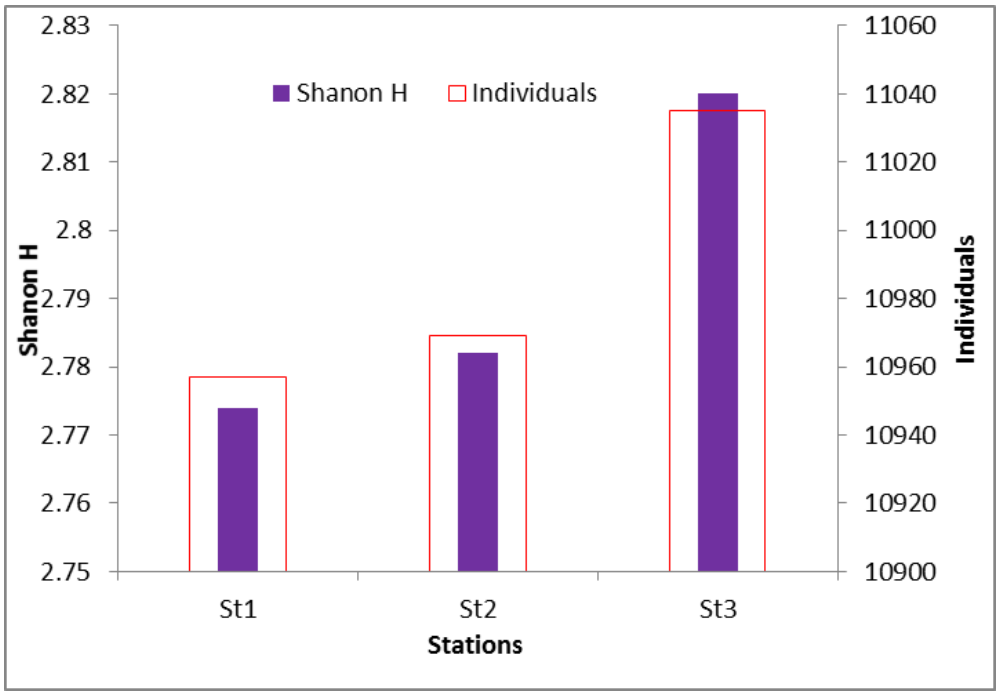

Fig 5: Shannon diversity indices for different stations (2017)

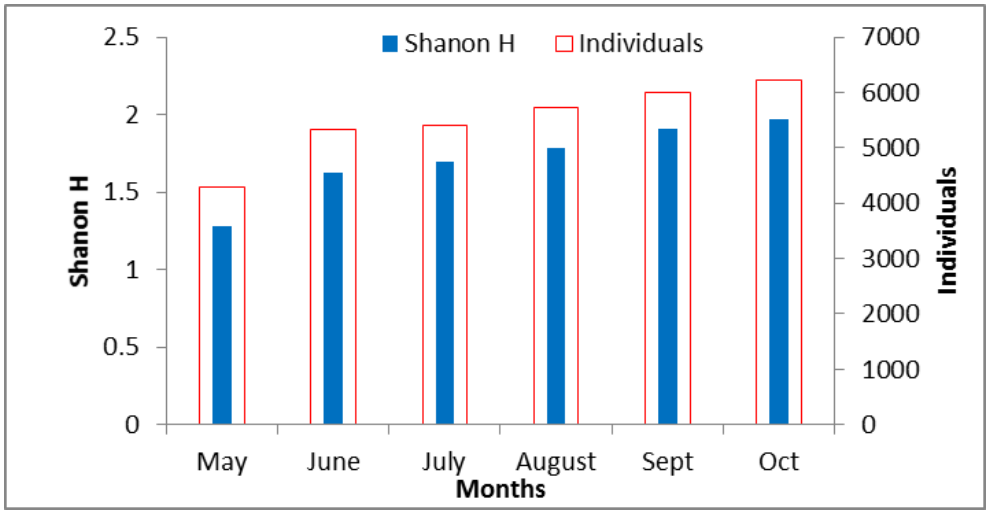

Fig 6: Shannon diversity indices for different months (2017)

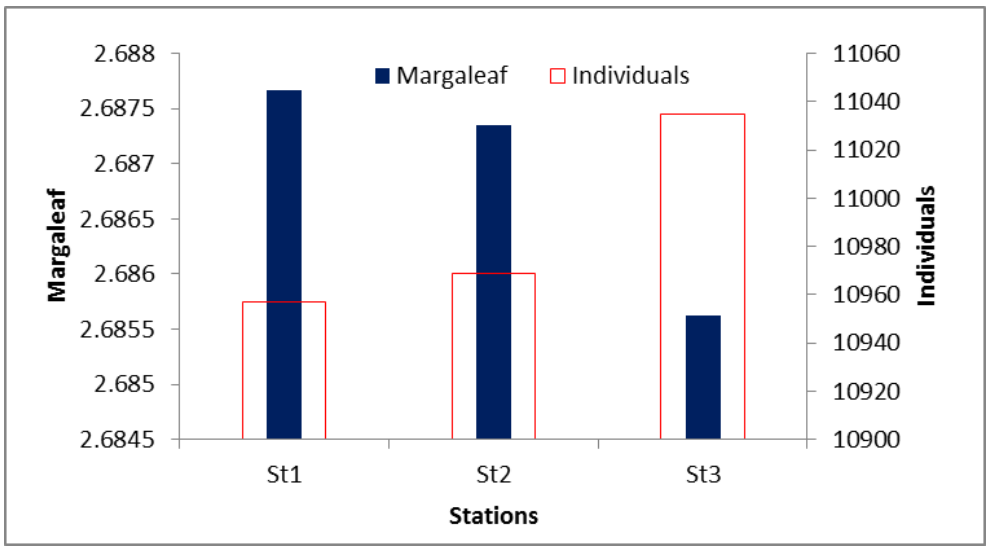

Fig 7: Margalef indices for different stationsat Devi Estuary (2017)

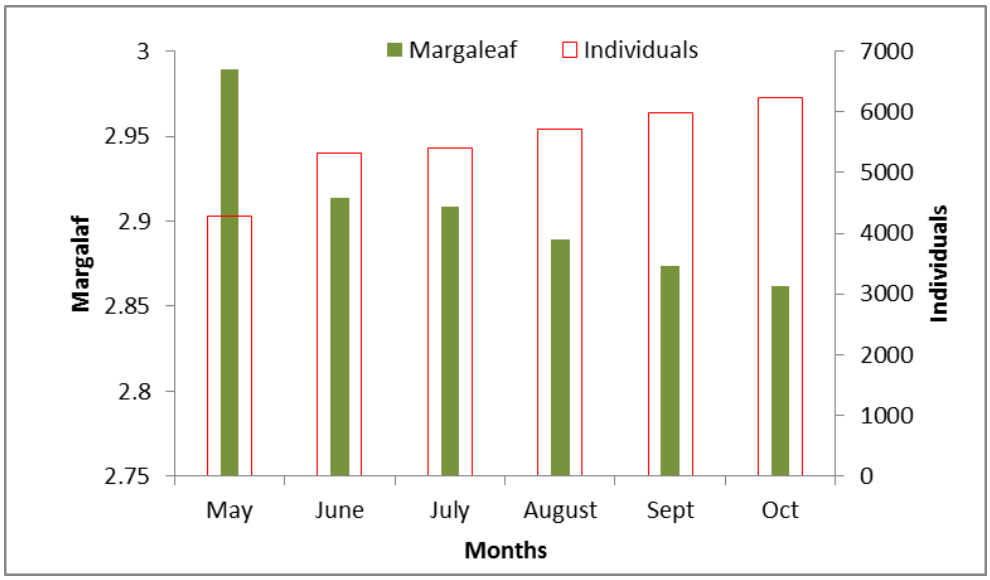

Fig 8: Margalef indices for different months Devi Estuary (2017)

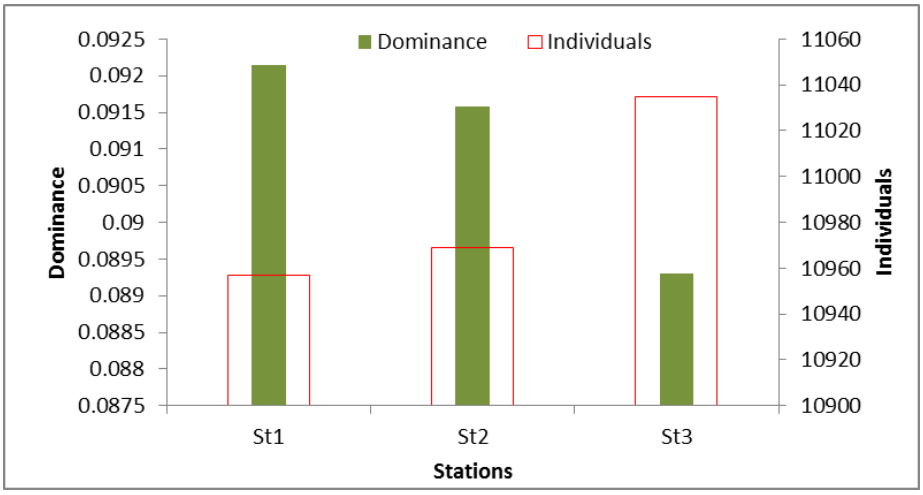

Fig 9: Dominance indices for different Stations

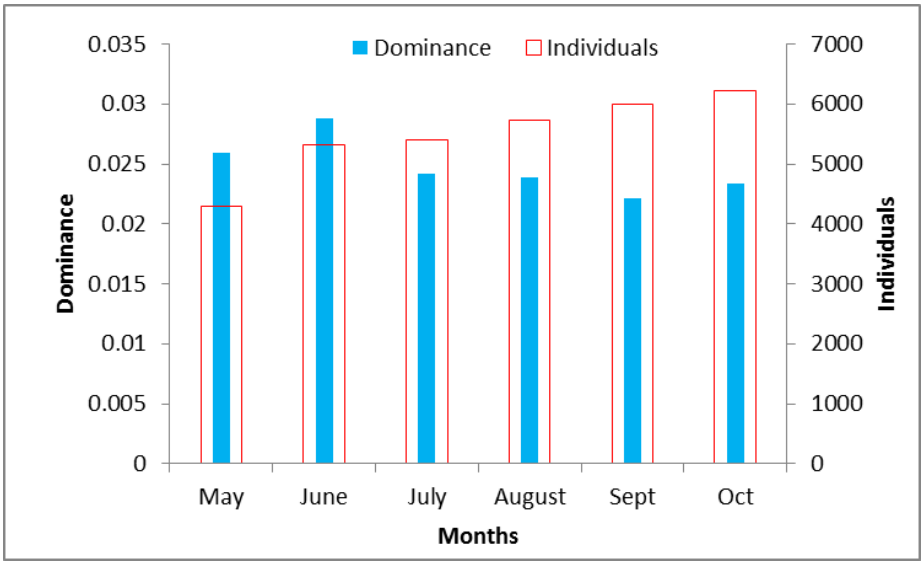

Fig 10: Dominance indices for different months

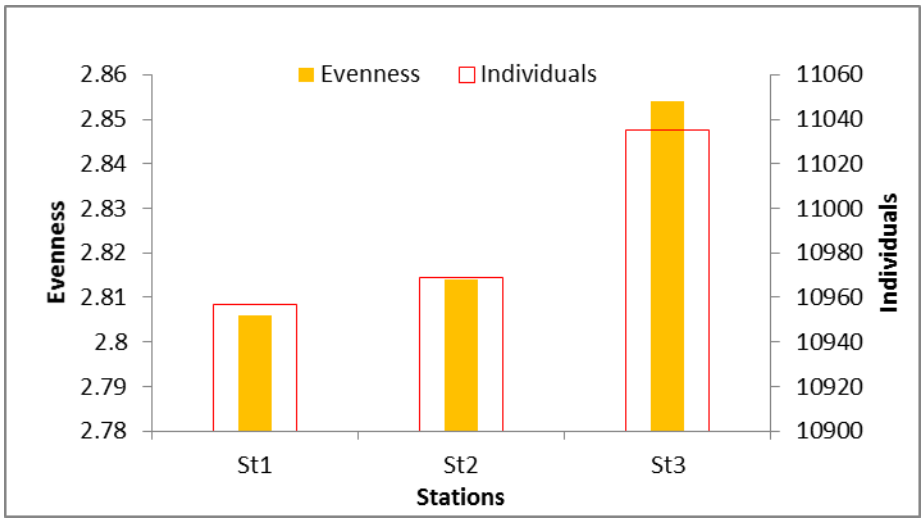

Fig 11: Even-ness indices for different Stations

Evenness indices are different for different stations (Fig.11). The highest value 2.854 is marked for station -3 where as the lowest 2.806 of station-1.October shows highest value 1.874 for evenness and May of lowest value 1.168 (Fig.12).

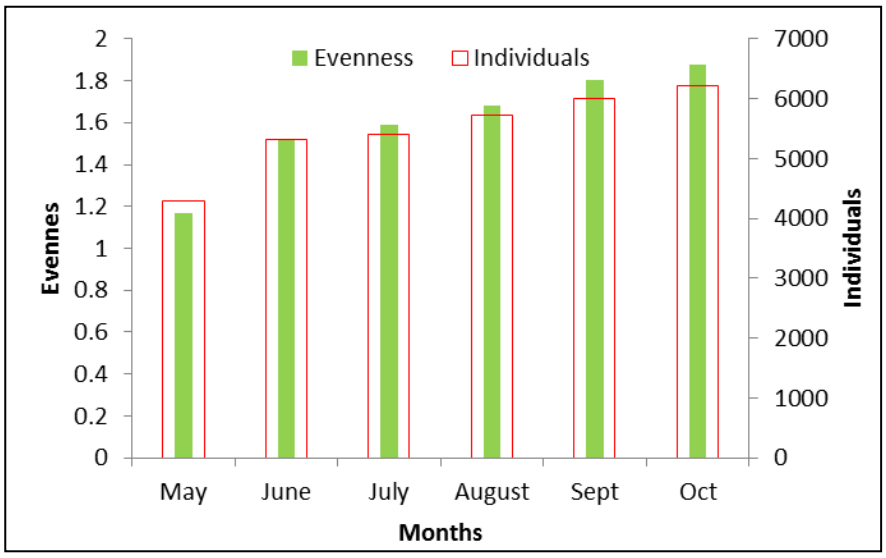

Fig 12: Even-ness indices for different months

The species assemblage was observed through SIMPER analysis. The overall average dissimilarity %was 87.90 among different months (Table-2). Three clusters were identified (Fig-13) which showed more than 75% similarity. The clusters indicated that there was high level similarity in the occurrence and abundance of species between months. CCA Eigen values for hydrological parameters in the first three axes were 0.130, 0.0004, 0.000.The vector length of a given variable in CCA analysis indicated the influence of that variable in species distribution (Fig. 13, 14). Temperature has the longest vector and was significantly correlated with season-1 and season-2. Occurrence of species *L. indicus*, *H. nehereus*, *O. tardoore*, *M. cephalus*, *R. kanagurta* were associated with higher values of temperature. Higher salinity values were associated with *S. indicus*, *G. selifer*.

Table 2: Simper analysis

Taxon	Average Dissim.	Contrib. %	Cumulative %	Mean 1	Mean 2	Mean 3
SP11	8.96	80.04	80.04	245.00	3960.00	248.00
SP4	0.39	3.45	83.50	2290.00	2330.00	2190.00
SP18	0.27	2.43	85.92	268.00	370.00	267.00
SP21	0.19	1.71	87.63	548.00	526.00	596.00
SP12	0.13	1.20	88.83	343.00	388.00	366.00
SP7	0.13	1.17	90.00	1600.00	1580.00	1550.00
SP8	0.11	0.95	90.96	144.00	130.00	170.00
SP13	0.09	0.83	91.79	452.00	432.00	467.00
SP10	0.09	0.80	92.59	734.00	703.00	712.00
SP15	0.09	0.76	93.35	121.00	127.00	152.00
SP19	0.08	0.68	94.03	113.00	114.00	139.00
SP23	0.07	0.61	94.64	1080.00	1080.00	1060.00
SP25	0.07	0.59	95.23	251.00	239.00	264.00
SP20	0.06	0.56	95.79	598.00	580.00	575.00
SP14	0.05	0.49	96.28	368.00	355.00	374.00
SP9	0.05	0.48	96.76	182.00	188.00	201.00
SP16	0.05	0.44	97.20	189.00	177.00	195.00
SP17	0.05	0.43	97.63	253.00	266.00	270.00
SP1	0.05	0.41	98.04	287.00	282.00	272.00
SP5	0.05	0.41	98.44	226.00	243.00	236.00
SP6	0.05	0.40	98.85	126.00	128.00	142.00
SP22	0.04	0.32	99.17	185.00	184.00	173.00
SP24	0.03	0.31	99.48	178.00	173.00	186.00
SP3	0.03	0.28	99.76	83.70	84.00	94.30
SP2	0.03	0.24	100.00	154.00	152.00	146.00

Overall average dissimilarity = 12.10%

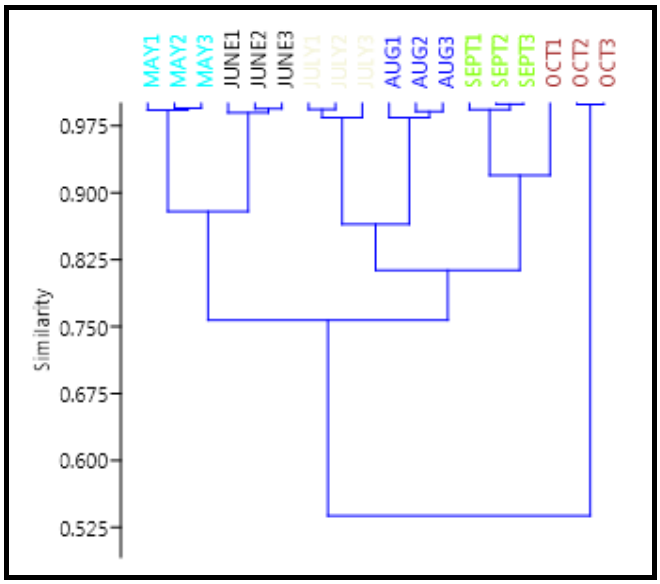

Fig 13: Cluster showing similarity between months

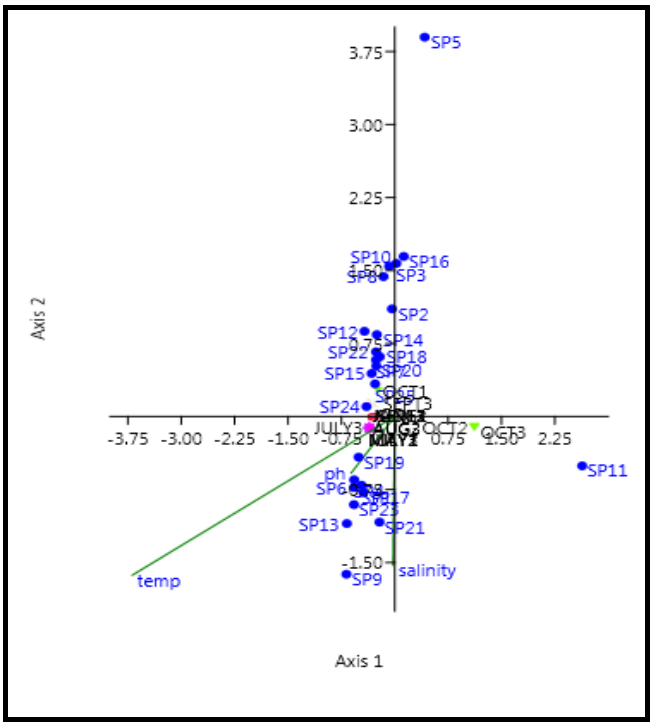

Fig 14: CCA for fish species and hydrological parameters for 2017

4. Discussion

During the present study no significant spatial variation was observed for temperature and pH. This may be due to heavy fresh water discharge from surrounding land area and also a function of annual rainfall pattern. Further in flow of the freshwater from Mahanadi riverine system makes the area low saline zone. pH value was almost constant in all stations and this might be due to runoff process and human interference with domestic waste disposal [8]. Present study emphasized only on 25 species from Devi estuary which contributed higher availability. Out of these almost all showed high abundance value which includes both adults and juveniles. The species abundance found in Devi estuary is composed of small numbers of species with high contribution % is a common feature of estuarine faunal populations [8, 20-23].

Devi estuary is a positive estuary which showed high dominance of marine species as compared to brackish and fresh water species. The species diversity involves number of species or richness and distribution of individuals among species where the measurement of species richness is complex [8]. The Shannon index in present observation is within the range of (2.774-2.820) which indicated that this estuary is less polluted as in a Shannon-Weinner legislation, the aquatic environment of soil and water is divided as good when H 74, good quality is 4-3,moderate 3-2,poor quality 2-1 and very poor if H<1. The high Shannon diversity index involved with low individuals and low diversity involved with more number of individuals [1].

Moreover each estuarine and coastal ecosystem may have a different abiotic environment resulting from tidal range, fresh water input, geo morphology and human pressure which also effects species abundance [24, 25]. Lower number of fishes in Devi estuary was due to consideration of only commercially valuable, edible fishes of the estuary and use of same type net which catches similar type of fishes. Another reason may be short period of study and unidentification of all the available fishes. The consistent occurrence of *M. cephalus* an estuarine species shows completion of their life cycle in this estuarine condition [8, 26].The biodiversity index (H) obtained from present study is not so high and they do not show many differences among stations. The reason for showing lower species diversity is that fishing gears used have high selectivity effect [27]. The main causes of the differences in the biodiversity indices are mainly monthly variations of nutrients at the ecosystem and seasonal fish migrations [8].

5. Conclusion

Thus the findings demonstrated that Devi estuary is dominated by the families *Clupidae*, *Engraulidae* etc. The present findings contributed additional knowledge of estuarine fish diversity than qualitative and quantitative aspects as little was known about the estuaries and bays of the Indian coast. And the Bay of Bengal at Devi estuary offered high species richness with rich diversity. The conclusions were drawn however based on the data of one year only thus require further study.

6. Acknowledgement

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