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A study on seasonal diversity of Penaeid prawn in Digha coast

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Abstract

The family Penaeidae is the dominated prawn community of the coastal habitat of Digha. A study on 3583 individuals belonging to 26 different species under 8 genera of penaeid prawn, revealed seasonal variation in the relative abundance and species diversity in the present investigation. The most abundant species of penaeid prawn is *Parapenaeopsis coromandolica* (14.42%), followed by *Metapenaeus lysianassa* (13.14%), *Helleropenaeopsis sculptilis* (10.21%), *Parapenaeopsis stylifera* (8.48%), *Metapenaeus brevicornis* (7.17%) and *Helleropenaeopsis hardwickii* (5.21%). Seasonal variations in relative abundance within the species has been observed. While diversity was found to be highest in the monsoon season and appeared to be influenced by the equitability of individuals among the species, highest speciesrichness was reported in the Digha during the monsoon and the lowest during the premonsoon. Temperature, Salinity, pH and dissolved oxygen affected positively both the abundance and the diversity of prawn in the Digha coast. Present study will be helpful to the prawn fishery managers and researchers of the study region.

Keywords: Diversity, Seasonal abundance, Equitability, Species diversity, Digha coast.

Introduction

India has many different kinds of aqua-ecosystems along its coast line. The length of the Indian coastline is 7500 km, of which 5700 km are on the mainland. The shoreline is spread out over nine coastal states, two groups of islands, and four union territories. The coastal plain of West Bengal is in the districts of Purba Medinipur and South 24 Parganas. It has 158 km of shoreline in West Bengal. Digha Coast is the most popular sea side in the West Bengal acclaimed for its expanded beaches which support diversity of animal life. It lies in Purba Medinipur district and at the northern end of the Bay of Bengal. It is located in latitude and longitude of 21°38'18"N 87°30'35"E.

Crustaceans play an important role in regulating the structure and function of tropical ecosystems in benthic communities (Hendricks X, 1995). Decapod is a major shellfish resource that also serves as a tropic connection between benthic microorganisms and higher vertebrates in the coastal food chain and food web (Trayer *et al.*, 1984, Huh and An 1997). Penaeidae prawns make up more than 70% prawn catch of the world, and their nutritional value helps a very large trade and export business (Guo *et al.*, 2008) in India. Penaeid prawns grow quickly and only live for a short time. Their life cycle can end in about a year. Most aquaculture is built on Penaeid prawns, especially those in the genus Penaeus, because they are easy to raise from eggs, grow quickly, and have large populations (Chanda 2016a). The Penaeid prawn is the backbone of the sea food export industry. It brings in the most foreign currency from the fishing industry, which is the main source of income for millions of people who work directly or passively in fishing. Some of the important Penaeid prawns that support industrial fishing along the Indian coast are also found at Digha coast (Chanda,2002 and 2014b). The fishing industry is an important part of the business and social growth of the fishermen community. Socioeconomic status is the best indicator of a people life (Kitagawa and Hauser, 1973; Marmot et al, 1987, Chanda, 2016b, and Tripathy and Chanda,2023). It shows the social, cultural, economic, and political characteristics of people, families, community groups, and organisations. The reproduction, seasonal variation and number of coastal Penaeid prawn are affected by many physicochemical parameters like temperature, salinity, dissolved oxygen, and pH. The Present study is conducted to investigate the seasonal diversity, abundance and population structure of the Penaeid prawn in Digha coast of West Bengal, India.

Methods

Study area: Digha Coast is located in Purba Medinipur district of West Bengal. It stretches between Udaipur to Shankarpur. The study has been conducted in four different study sites i.e., Udaipur 87° 29' 5.57" 21°37'0.994"N; Old Digha 87°31'24.95"E, 21°37'25.621"N; Digha Mohana

87°32'35.898"E, 21°37'48.21"N and Shankarpur 87°34'17.149"E, 21º38'29.327" were shown in the figure no. 1.

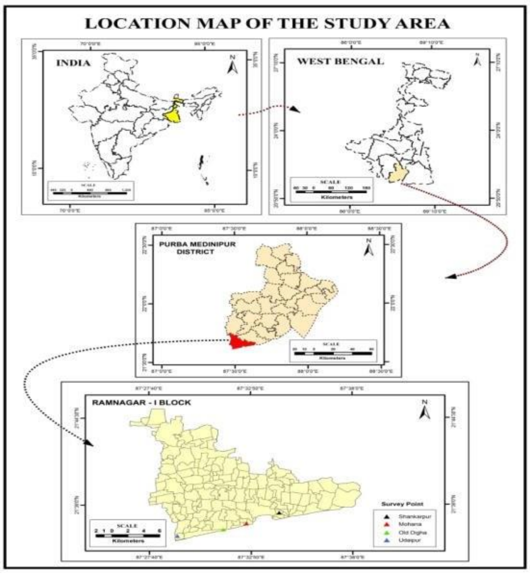

Fig 1: Study area and sampling station.

Specimen Collection: The sample were collected monthly during pre-monsoon, monsoon and post monsoon in the early morning time throughout the study periods (January 2022 to Janunary 2023). Prawn sample were collected from fisherman of each collection site. Prawn samples were collected in a fish basket containing 5 Kg of prawn specimen. Entire fish basket were identified up to the species level of the prawn sample. A total of 3583 penaeid prawn individuals were obtained for this study.

Preservation: The collected samples were preserved in 2-4% formalin solution with proper cataloging in laboratory of Raja N.L. Khan Women's College (Autonomous) for proper identification.

Identification: In the laboratory, the specimens were identified to species level, sexed, and measured. The total length was measured from the tip of the rostrum to the end of the telson, the carapace length was measured from the posterior margin of the orbit to the posterior margin of the carapace, and the total weight was measured as wet weight.

Water quality parameter analysis: Prior to prawn sampling dissolved oxygen, PH, salinity and temperature were measured in situ by water analyzer 371 (Systronics). These parameters were measured monthly for analysis of seasonal variation and a correlation were studied between water parameters and species composition.

Biodiversity assessment

The following diversity indices were used to calculate the prawn diversity:

1. The Shannon-Weiner index (H) (Shannon and Weaver,1948) measures the degree of order or disorder present in a given system. The quantity of each species observed individuals at the sample site defines this order. The following formula was used to calculate the Diversity index:

$H = - \sum Pi \ln Pi$

Where, Pi =the relative abundance (n/N), N = total number of individuals of all species, n =Number of individuals of each species.

Species diversity (D) $=1/\sum pi^2$

2. Equitability or evenness (J), (Pielou,1966) was calculated (range 0-1) according to the ratio: J = H / Hmax …

Where, H = observed species diversity, Hmax = species diversity under maximum equitability conditions and S = number of species in the community.

3. Species richness (0dum,1971) was calculated according to the formula: S = (S-1) logN …

Where, S = number of species present in community and N=number of individual in community.

4. The Simpson index (D) (Edward H.Simpson,1949) was derived by using the formula :

D = sum (Pi) 2

Where, Pi = the number of given species divided by the total number of prawn observed.

The Past software (Version 4.03) and Microsoft Excel 2019 were used for all statistical analysis. The statistical interpretation of water characteristics and the distribution of penaeid prawn species were resulted by cluster analysis (Dendrogram)

Results

Variations in temperature, salinity, pH, and DO across the seasons seemed to be related to where the prawn population was distributed. The mean temperature followed a usual seasonal trend, peaking in the summer (March to June) and falling in the winter (November to January).

Throughout the course of the study, the salinity showed notable monthly changes (ranging from 13.63 to 24.33 ppm). The pre-monsoon period (March to May) had the highest salinity, whereas the monsoon period (July to September) had the lowest salinity. Throughout the course of the investigation, average pH levels stayed very consistent (Fig. 2).

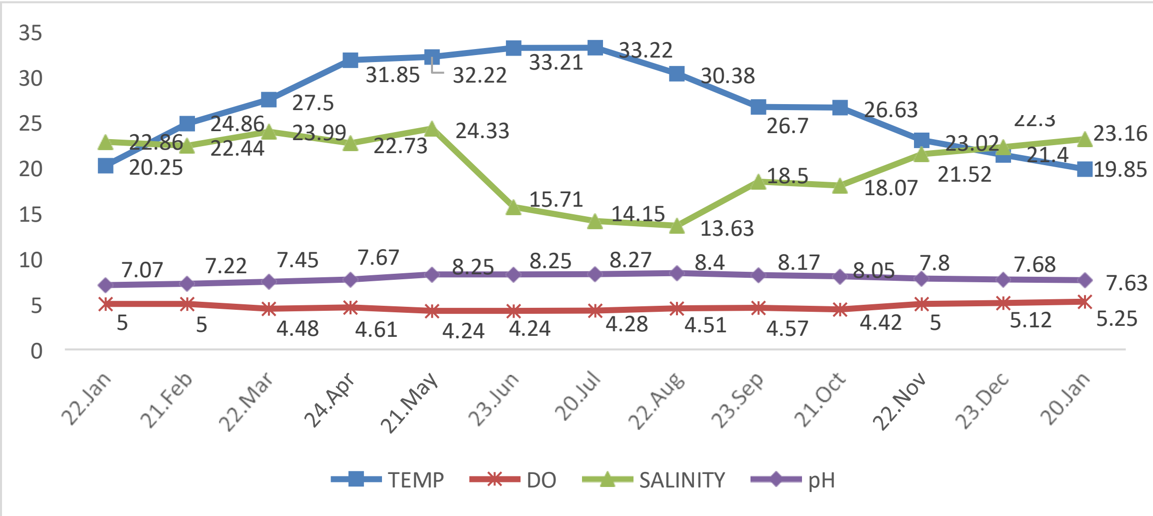

Fig 2: Monthly mean values of hydrographic parameters (temperature, salinity, pH, DO) in Digha coast.

The fluctuations of seawater salinity were negative correlated with temperature (-0.50102) and positively correlated with DO (0.5005). This was probably due to rainfall and evaporation. The fluctuations of seawater temperature were positively correlated with pH (0.67776) and negatively correlated with DO (-0.90874). This was probably due to warmer water holds less dissolved oxygen (Fig.3).

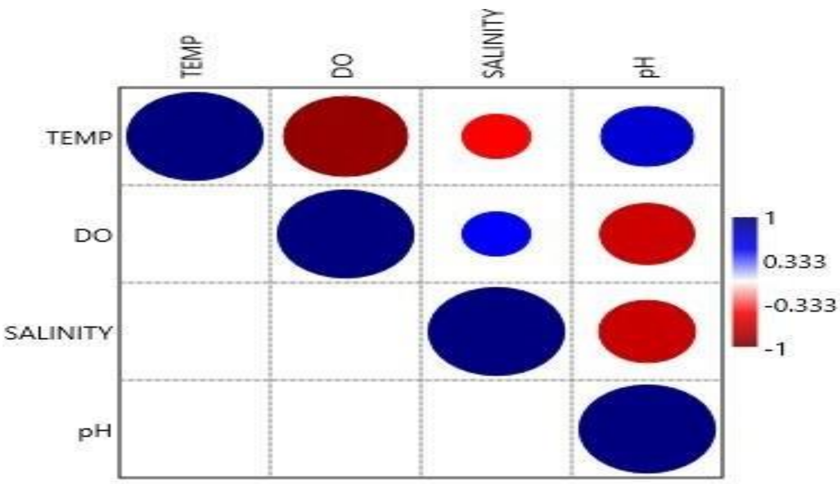

Fig3: Pearson's correlation with significant marks

Table 1 shows the abundance and biomass composition of penaeid prawn species in the Digha coast during the present study. Twenty-six penaeid prawn species from eight genera were identified, with *Parapenaeopsis coromandolica* (Alock,1906), *Metapenaeus lysianassa* (De Man,1888*)*, *Helleropenaeopsis sculptilis* (Heller,1862), *Parapenaeopsis stylifera* (H. Milne Edwards, 1837*)*, and *Metapenaeus brevicornis* (H.Milne Edwards,1837*)* being the most abundant species. Other species present included *Helleropenaeopsis hardwickii* (Miers,1878), *Kishinouyepenaeopsis maxillipedo* (Alock,1905), *Megokris granulosus* (Haswell,1879*)*, *Metapenaeopsis toloensis* Hall,1962, *Metapenaeus dobsoni* (Miers,1878*)*, *Metapenaeus elegans* De Man,1907, *Metapenaeus ensis* (De Haan,1844*)*, *Metapenaeus stebbingi* Nobili,1904, *Penaeus monodon* Fabricius,1798, *Penaeus japonicus* Spence Bate,1888, *Penaeus semisulcatus* De Haan,1844, *Penaeus latisulcatus* Kishinouye,1896, *Penaeus indicus* H.Milne Edwards,1837, *Penaeus merguiensis* De Man,1888, *Alockpenaeopsis uncta* (Alcock,1905), *Metapenaeus monoceros* (Fabricius,1798), *Metapenaeus affinis* (H. Milne Edwards,1837), *Metapenaeus stridulans* (Alock,1905), *Kishinouyepenaeopsis cornuta* (Kishinouye,1900), *Penaeus penicillatus* Alock,1905, *Penaeus canaliculatus* (Olivier,1811). The most numerous species on the Digha coast was *Parapenaeopsis coromondolica*, which accounted for 14.42% of total prawn counts and 5.86% of total prawn biomass. *M. lysianassa* was the second most abundant species, accounting for 13.14% of the total number of species and 4.69% of the total biomass. *H. sculptilis* was the third most abundant species, accounting for 10.21% of the total number of species and 3.36% of the total biomass. *P. stylifera* and *M. brevicornis* were the fourth and fifth most abundant species on the Digha coast, accounting for8.48% and 7.17% of the total number of species and 1.61% and 12.24% of the total biomass and so on.

Table 1 — Total abundance, percent abundance, mean total length, range of total length, mean wet weight, range of wet weight, total biomass, and percent biomass of prawn species collected from Digha coast in the period January 2022 to January 2023 prawn species.

Species	**Abundance**		**Total length(cm)**		**Mean wet weight(g)**		**Biomass**	
	N	**%**	**Mean±SD**	**Range**	**Mean±SD**	**Range**	**g**	**%**
Helleropenaeopsis sculptilis **(Heller,1862)**	366	10.21	9.98± 3.44	5.6-14.5	3.37 ±0.31	16.5-17.2	1233.42	3.36
Helleropenaeopsis hardwickii **(Miers,1878)**	187	5.21	8.78 ± 3.9	4.7-13.2	10.8± 0.88	9.5-11.9	2019.6	5.50
Parapenaeopsis coromandolica **(Alock,1906)**	517	14.42	6.12 ± 1.88	4.1-8.9	4.16± 0.55	3.5-4.9	2150.72	5.86
Parapenaeopsis stylifera **(H.Milne Edwards, 1837*)***	304	8.48	5.14 ± 1.55	3.2-7.5	1.95 ±1.45	0.9-3.8	592.8	1.61
Kishinouyepenaeopsis maxillipedo **(Alock,1905)**	37	1.03	10.2 ± 1.50	8.9-12.5	16.42 ±1.03	15.1-17.5	607.54	1.65
Megokris granulosus **(Haswell,1879*)***	75	2.09	11.88 ±0.61	9.1-10.6	9.58± 1.21	8.7-11.7	718.5	1.95
Metapenaeopsis toloensis **Hall,1962**	67	1.86	1.22 ± 0.13	1.1-1.4	5.74± 0.52	4.9-6.2	384.58	1.04
Metapenaeus lysianassa **(De Man,1888*)***	471	13.14	1.5± 0.15	1.2-1.6	3.66± 0.84	2.7-4.7	1723.86	4.69
Metapenaeus brevicornis **(H.Milne Edwards,1837*)***	257	7.17	12.16± 0.97	10.6-13.1	17.48± 0.95	16.1-18.4	4492.36	12.24
Metapenaeus dobsoni **(Miers,1878*)***	58	1.61	10.22± 0.23	10.1-10.5	6.72± 0.68	5.5-7.1	389.76	1.06
Metapenaeus elegans **De Man,1907**	15	0.41	7.32 ±0.96	6.0-8.5	3.12± 0.37	2.5-3.5	46.8	0.12
Metapenaeus ensis **(De Haan,1844*)***	63	1.75	9.66± 1.71	5.4-9.9	3.58 ±1.81	1.1-5.8	225.54	0.61
Metapenaeus stebbingi **Nobili,1904**	14	.39	6.68 ±0.68	5.9-7.5	2.7± 0.65	2.1-3.8	35	0.095

***Penaeus monodon* Fabricius,1798**	148	4.13	23.34± 5.60	19.2-32.2	40.76± 11.13	21.5-48.0	6032.48	16.44
***Penaeus japonicus* Spence Bate,1888**	131	3.65	12.9± 0.90	11.5-13.8	13.28± 0.26	12.9-13.5	1739.68	4.74
***Penaeus semisulcatus* De Haan,1844**	133	3.71	12.4± 0.35	11.9-12.8	14.44± 0.47	13.7-14.9	1920.52	5.23
***Penaeus latisulcatus* Kishinouye,1896**	30	0.83	7.02 ±0.58	6.9-7.6	3.04± 0.20	2.7-3.2	91.2	0.24
***Penaeus indicus* H.Milne Edwards,1837**	172	4.80	10.72±0 .73	9.5-11.3	6.74± 0.38	6.1-7.1	1159.28	3.16
***Alockpenaeopsis uncta* (Alcock,1905)**	110	3.07	12.5± 0.84	11.5-13.5	17.96±0.60	17.1-18.8	1975.6	5.38
***Penaeus merguiensis* De Man,1888**	75	2.09	19.96±1.05	18.5-21.0	46.4±4.20	38.9-48.7	34.80	9.48
***Penaeus penicillatus* Alock,1905**	71	1.98	20.32± 0.85	19.6-21.3	48.9±5.82	39.5-54.1	3471.9	9.46
***Metapenaeus monoceros* (Fabricius,1798)**	135	3.76	8.12± 0.89	7.1-9.1	5.6±0.75	4.9-6.7	756	2.06
***Metapenaeus stridulans* (Alock,1905)**	53	1.47	6.08± 0.49	5.5-6.7	2.68±0.41	13.7-14.9	710.2	1.93
***Kishinouyepenaeopsis cornuta* (Kishinouye,1900)**	1	0.02	5.3	5.3	2.2	2.2	2.2	0.005
***Metapenaeus affinis* (H. Milne Edwards,1837)**	92	2.56	7.8 0.2	7.5-8.0	4.3±0.31	3.9-4.7	717.6	1.95
***Penaeus canaliculatus* (Olivier,1811)**	1	0.02	4	4	8	8	0.8	0.002
Total	3583						36677.94	

One-way ANOVA showed that F value of 0.416839 is less than the F critical value of 2.497129, so the null hypothesis cannot be rejected and P value is greater than the α / significance value (0.05), so the null hypothesis cannot be rejected. There was no significance difference between seasons.

Table 2: One-way ANOVA testing of seasonal prawn species variation in Digha coast.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Pre-monsoon	26	933	35.88462	1872.906
Monsoon	26	1372	52.76923	1956.985
Post-monsoon	26	1334	51.30769	4139.902

ANOVA

source of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between group	4550.846	4	1137.712	0.416839	0.795981	2.497129
With in group	199244.8	73	2729.381			
Total	203795.7	77				

During the study period, a seasonal monthly fluctuation was observed. Fig: 4 (a) and (b) demonstrate the monthly and seasonal species distribution. The seasons were divided into three periods: pre-monsoon, monsoon, and post-monsoon. Seasonality and abundance fluctuation of penaeid species observed on the Digha coast.

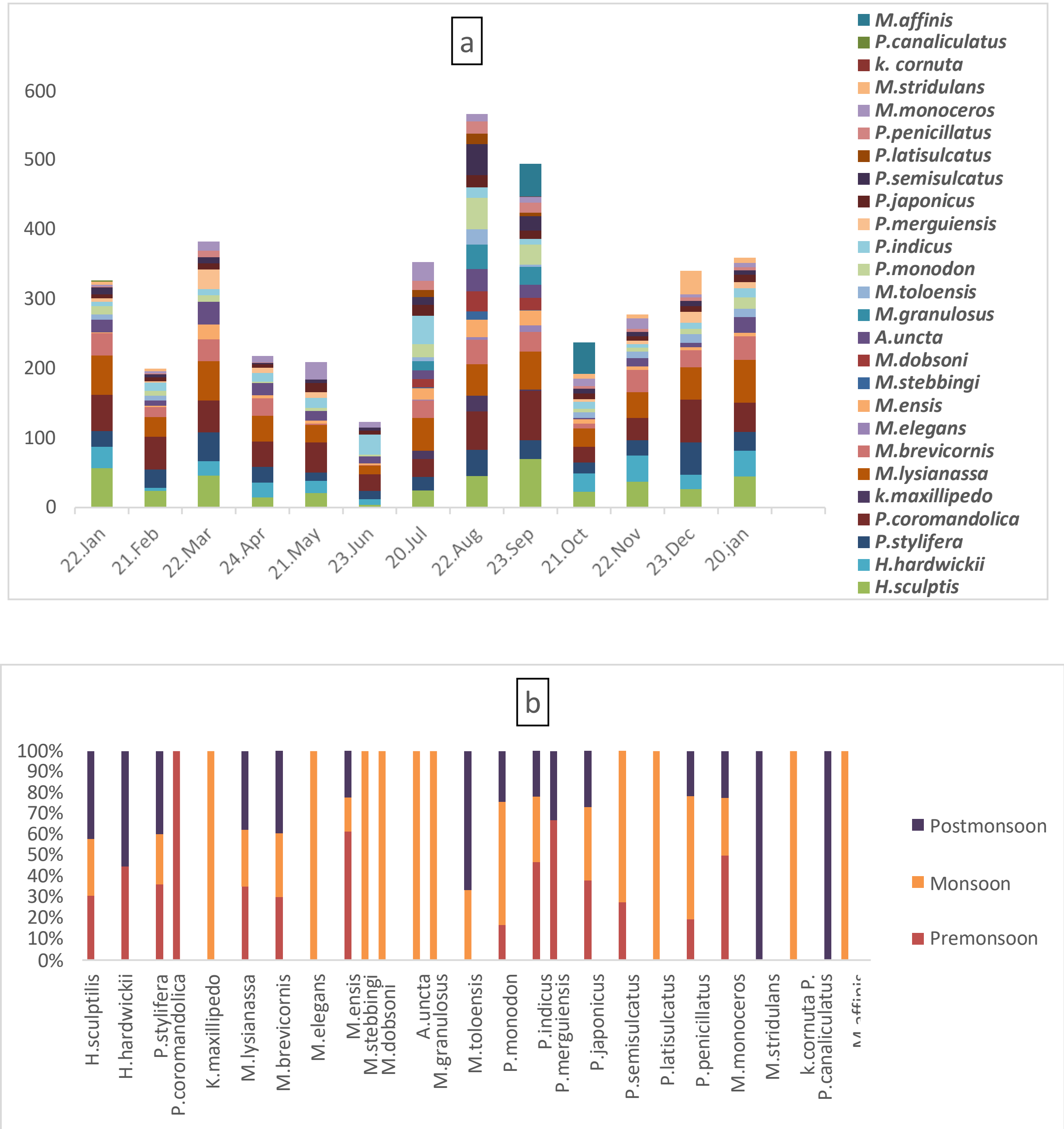

Fig4: (a) Monthly and (b) Seasonal – distribution of prawn species from Digha coast.

The highest Shannon-Weiner index (H) was observed in the monsoon season (9.55) and the lowest in the pre-monsoon season (2.35), while equitability or evenness (J) was highest in the post-monsoon (3.27) and lowest in the pre-monsoon (0.86). Species richness (S) was highest during the monsoon season (6.69) and lowest during the pre-monsoon season (4.72), whereas the Simpson index (D) was highest during the post-monsoon season (0.105) and lowest during the monsoon season (0.05). D was highest during the monsoon season (19.23) and lowest during the post-monsoon season (9.52) (Fig.5).

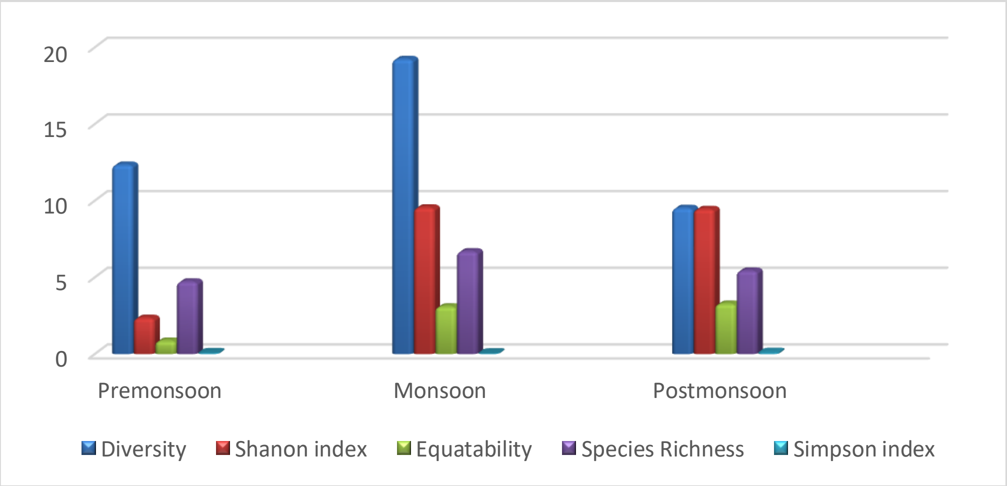

Fig5: Seasonal variation in the diversity indices (Diversity, Shannon index, Equatability, Species Richness and Simpson index) of Penaeid prawn from Digha coast.

The dendrograms produced by cluster analysis of penaeid prawn species with environmental parameters (temperature, salinity, pH, and DO) for the Digha coast show similarities to each other (Fig.6). Cluster analysis (Dendrogram) demonstrating the link between water parameters and the abundance of the identified species. The proximity of among different groups were adjudged by calculating the Bray-Curtis distance through ward linkage using Past-4.0.3 software. The identified species i.e, *M. ensis M. monoceros, M. stebbingi, M. stridulans* were placed in a same cluster. The second sub group have demonstrated pair wise clustering between the species like *M. dobsoni , K. cornuta, , H. hardwickii ,P. monodon A. uncta, P. canaliculatus, M. granulosus, M. affinis, M. toloensis, H. sculptilis.* The third sub group have demonstrated pair wise clustering between the species like *P. coromandolica, P. merguiensis , k. maxillipedo, P. japonicus P. stylifera, P. indicus*. The fourth sub group have demonstrated pair wise clustering between the species like *M. lysianassa, P. semisulcatus, M. brevicornis, P. latisulcatus, M. elegans, P. penicillatus.* Cluster analysis revealed that the water parameters such as salinity, Temperature, pH and Dissolve oxygen (DO) were showing similarities to each other (Fig. 6).

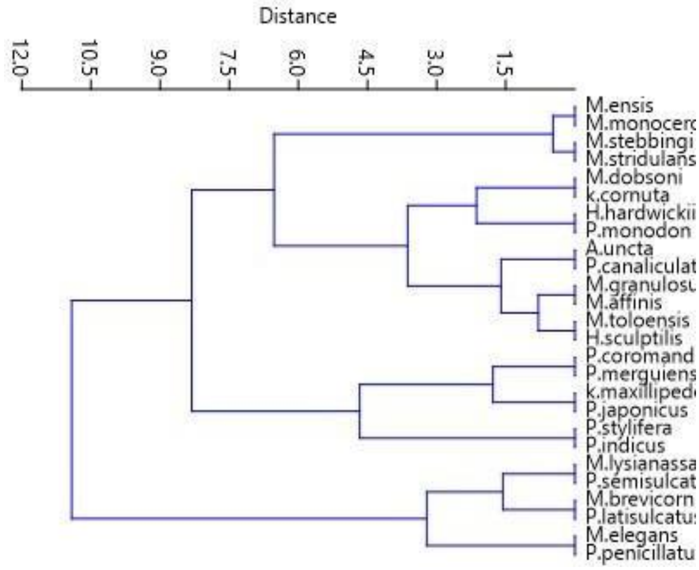

Fig 6: Hierarchical cluster analysis (Dendrogram)

Discussion

Among the total twenty-six species, collected during the present study from the Digha coast, *P. coromandolica* was found to be the most dominant prawn species (14.42 %), it suggests that its coastal water is ideal for this species, which is followed by *M. lysianassa* (13.14%), *H. sculptilis* (10.21%), *P. stylifera* (8.48%), and *M. brevicornis* (7.17%) and so on as in table-1. Luchmann *et al*., (2008) in his study also found similar seasonal changes for two penaeid prawn species that were present throughout year, but *Farfantepenaeus paulensis* being more abundant in summer and *F. brasiliensis* being more abundant in autumn. The seasonal distribution of prawn species suggests an approach for reducing potential interspecific differentiation. In the present study, Twenty six penaeid species of eight genera were identified, of which *P.coromandolica, M. lysianassa , H.sculptilis, P. stylifera, M. brevicornis* were the dominant species during the study period. The seasonal peaks vary in strength depending on environmental conditions and suitable habitats (Sparre *et al.*, 1989). Temperature, salinity, DO, and pH are all environmental factors that influence the reproduction and abundance of marine penaeid prawns. Salinity is one of the most critical environmental elements influencing marine prawn growth, survival, and development. Penaeid prawns live in saline water with salinities ranging from 15 to 50 ppt, however salinity tolerance is usually greater in adults than in juveniles or larvae (Dall *et al*., 1990). Adults are almost invariably restricted to sea water with a salinity of 33 - 36 ppt (Dall *et al*., 1990). (1953) asserted that freshwater and marine creatures coexist in estuarine environments up to salinities of 3.5 ppt, and that it is inaccurate to claim that marine species exist at these salinities. Temperature increase is one of the factors known to influence penaeid prawn migration (Joubert and Davies,1966)**.** Temperature, salinity, and lunar phase are among the variables that appear to have an impact on the process (Subramaniam, 1990). Many research on the quantity and distribution of penaeid prawns in marine environments with respect to temperature, salinity, DO, and pH have been published (Turner 1977, Minello and Zimmerman 1991, Mayer 1985)**.** Zupanovic (1971) investigated the distribution and quantity of penaeid shrimps along coast of Pakistan, specifically the Balochistan and Sindh coasts, with the primary locations being Pasni, the Sonmiani Bay, and the Karachi coast. He discovered *P. merguiensis* to be the dominating species in these locations throughout the months of January, February, and April, while *P. penicillatus* was abundant near the Karachi shore. Gololobov and Grobov (1969) discovered that the species, *P. merguiensis*, was caught between Sonmiani Bay and Karachi in July and August, but lower numbers of *P. penicillatus* were caught to the southeast of Karachi, which is partially consistent with the findings of the present study. Because penaeid prawns are short-lived animals that spend their juvenile stage in extremely changeable inshore environments, and they are frequently vulnerable to considerable environmental variability in recruitment and stock size (Garcia, 1984). The present investigation also discovered that *P. coromandolica* is the most abundant species on the Digha coast.

Conclusion

The community of crustacean in coastal Digha is significantly impacted by abiotic sources. Penaeid prawns are the most economically significant species in estuaries and coastal waters of fauna, and they are essential in controlling the structure and function of tropical ecosystems. The prawn fishery contributes significantly to fishing industry of the nation in terms of gross output, gross revenue profits and export. Many water physicochemical parameters influence prawn species distribution and migration. The present investigation identified 26 Penaeidae species from 8 genera. The present study has revealed that *P. coromandolica*, *M. lysianassa,* *H. sculptilis, P. stylifera M. brevicornis* were the most dominant prawn species in the coastal waters of Digha. The present study regions socioeconomic status is strongly reliant on fishing, which is one of the most important sources of income for residents of the Digha coastal belt and its surrounding area. Capture fisheries, especially the Penaeid fishery, are critical to the livelihood process. There has been no previous research on the seasonal abundance and species diversity of penaeid prawns on the Digha coast. As a result, this study adds to the current data on the family Penaeidae in order to control the culture of penaeid prawn species on the Digha coast. This data will be critical in developing a long-term development strategy for fishing business of the Digha.

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Conflict of interest

There are no conflicts of interest with the present research work.

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