Diversity indices and distribution of brachyuran crabs found in the lagoon waters of Sonmiani, Balochistan

Noor Us Saher*[1], Nayab Kanwal[1], Muhammad Asif Gondal[2] Zunaira Amanat[1] & Naureen Aziz Qureshi[3]

[1]Centre of Excellence in Marine Biology, University of Karachi, Pakistan
[2]Department of Biosciences COMSATS Institute of Information TechnologyPark Road Islamabad, Pakistan
[3]Department of Wild life and Fisheries, Govt. College University Faisalabad, Faisalabad 38000, Pakistan

*[E.Mail: noorusaher@yahoo.com]

A total of 8 species of Brachyuran crabs was recorded,crabs belong to the family Portunidae were dominant and represented by 6 species. *Portunus pelagicus* and *Portunus sanguinolentus* were found throughout the years.Various ecological indices were calculated through the obtained data. The diversity ranged from 0.63 - 1.64, the richness varied from 0.84-1.76, the evenness ranged from 0.1- 0.35, the index of dominance varied from 0.36 - 0.73. Maximum diversity was recorded during Pre monsoon (yr. 2005-06). The ecological indices were positively correlated with environmental parameters.

Introduction

Species composition is fundamental key to understand the actual number of species present in the community[1]. Studies on the diversity of local fauna are vast significance as carry the different ecological processes and problems faced by ecosystem. These studies become effective to formulate strategies for the protection and preservation of diversity of faunal community and marine environment[2].Crabs belong to infra order Brachyura, the highly diverse group of decapoda and consist of approximately 700 genera with about 5,000 to 10,000 species worldwide [3-5]. Because of their diverse habitat and enormous abundance and distribution crab's considered as an important group in term of biomass and community structure [4].

Habitat complexity is the main factor that controls the brachyuran population quantitatively and qualitatively[6]. Change in climate is also an important aspect to determine the past and future distribution of crab biodiversity [7]. This suggests that diversity is dependent on environmental characteristics and consequently is affected by biological and ecological processes[8,9]. The crustaceans quickly and strongly response to their living environment, therefore, the physio-chemical parameters such as salinity, temperature, PH, and dissolved oxygen of coastal areas are vital environmental factors, as directly affects the abundance, diversity, metabolism, hormones, growth, moulting and survival of crustaceans [7].

The diversity of a particular group may be affected by the distribution of other organisms, as populations are composed of temporary, permanent and transitory residents [10]. Seasonal movements of commercially and economically species of different swimming crabs have been studied by various authors[11]. These seasonal movements of brachyuran crabs are mainly associated to diverse life stages such as mating, spawning, maturation, etc. [6, 12].

The loss in biodiversity caused by the human activities, dispersion of exotic species and global warming[13]. That's why in recent years, biodiversity has become a high concern on the international agenda [13, 14]. In Sonmiani bay area numerous fishery investigator reported diversity and distribution of different marine organisms[15-20]. In the present work crab community composition and distribution were studied to determine the crab's species assemblage in Sonmiani lagoon's waters. The stated information will describe the crab's diversity and local shellfish assemblage of the studied area.

Materials and Methods

The Sonmiani Bay or MianiHor is a lagoon (Figure 1), which is about 60km long and 7km wide convoluted and contorted water body, which is situated on the eastern part of Baluchistan coast and about 90km away from Karachi[20, 21]. Run off of fresh water from Porali and Windor rivers and mangrove diversity plays an important role in the productivity of Miani lagoon[20,22&23]. The sampling stations were located in between latitude 25. 27' 43" N and 25.27' 54" N and longitude 66. 33' 75" E and 66.33' 78" E.

Monthly faunal samples were collected during flood tide from a fishing boat through experimental designed gill net from May 2005 to April 2006. A Sample collected in each haul was immediately sorted (fish, crabs and shrimp species) and weighted then placed separately in a polythene bag and iced for later transfer to the laboratory for further analyses of samples. The fauna could not collect in April and June 2006 due

to unfavorable weather condition. Physical parameters such as Salinity, pH, atmospheric and water temperature were also noted in each month. In laboratory sample crabs were identified (up to species level) with the help of available taxonomic identification key [24]. Initially wet weight of each individual was noted and different parameters were measured e.g. carapace length, carapace width and Chela length for data analysis. To observe the seasonal variations the monthly data were divided into four seasons[25]. Where the March to May as Pre-monsoon, June to August as Southwest monsoon, September to November as Post-monsoon and December to February as Northeast-monsoon period. Seasonal abundance of crab species was also plotted. The Shanon-Wiever species diversity index (H'), was determined using the following formula:

$$H = -\sum (1-i)\ (Pi)\ (log2Pi)$$

Where, H' = Shannon-Wiever index, pi = the proportion of the total count arising from the *i*th species.

Pielou's evenness (J') was calculated by using the following formula:

$$J = H/H_{max}$$

Where, H_{max}= Maximum number of species and is equal to log 2 S

Margalef's Index for species richness was calculated by using the method Margalef's Index of richness (Dmg)[26].

$$Dmg = (S-1) / log N$$

Where, S = total number of species, N = total number of individuals observed.

Simpson's [27]. index of dominance was calculated by the following formula.

$$D = \sum (Pi)^2$$
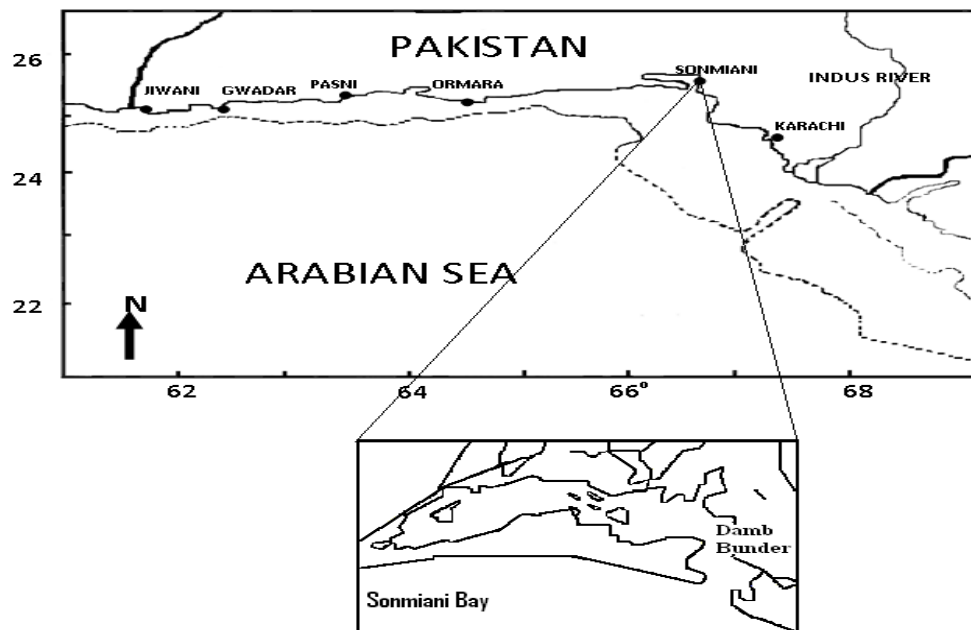
Where, D = Index of Dominance.

Figure 1. A Coastline map showing Sonmiani bay (MianiHor/lagoon).

Statistical analysis was performed using the Minitab software (Version 13.1). In order to ascertain whether the diversity indices exhibited seasonal cues, the data sets were analyzed for percent abundance, diversity (H'), equatibility (J'), species richness and index of dominance through one way ANOVA analysis. Pearson's correlation coefficient (r) was made in the statistical interpretation of the Physio-chemical parameters of water and crabs's diversity indices.

Results

In the present study monthly and seasonal variations in temperature were observed during the May 2005 to April 2007. The atmospheric temperature varied from 22.5ºC to 32.8ºC respectively, whereas minimum (22.5ºC) during the NE monsoon (yr.06-07) maximum (32.8 ºC) during Pre monsoon (yr.06-07). While the water temperature varied from 19.6ºC to 33.6ºC respectively, whereas minimum 19.6ºC water temperature was recorded during the NE monsoon (yr.05-06) and maximum 33.6 ºC was

recorded in Pre monsoon (yr.o6-07) (Figure 2). Salinity showed variation ranged between 33-43 ‰. Minimum (33 ‰) salinity was observed during the SW monsoon (yr.05) and maximum (41.3‰) during post monsoon (yr 06) (Figure 3). Surface water's pH remains slightly acidic to alkaline throughout the study period and varied from 6.8-8.5, and was observed minimum6.8 pH in SW monsoon (yr 06) and maximum 8.5 was in the Post monsoon (yr 05).

The abundance of Brachyuran crabs was recorded from May 2005 to April 2007 along the Sonmiani lagoon water Baluchistan coast. Distribution and abundance of brachyuran crabs showed fluctuation among seasons and years (Figure 4). A total of 1370 individuals was identified comprising 2 families (Matutidea and Portunidae). The eight crab species pertaining to five genera were identified, the six (6) species belonged to family Portunidae and only 2 species represent family Matutidae (Figure 4). Portunidae is an ecologically and commercially important group of brachyura, used as seafood and occurred with high diversity and abundance.
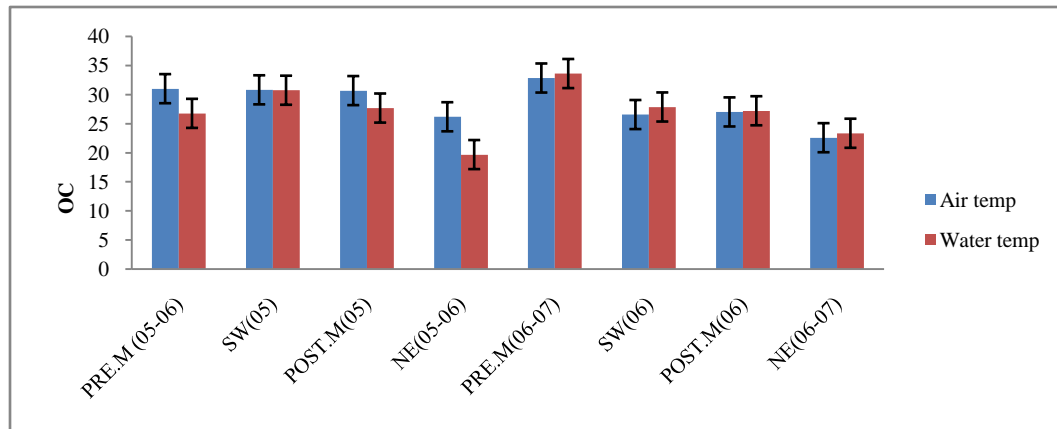
Figure 2. The mean Air & Water temperature variations in different seasons during the years 2005-2007.

Table 1. Summary of descriptive statistics for metric variables measured in crab species collected during May 2005 to April 2007.

Variables	Species	Female		Male	
		N	Mean ± SD(Range)	N	Mean ± SD(Range)
Weight (gm)	P. pelagicus	85	85.63±62.85(7.6-318.0)	85	77.45±68.28(3.5-316.0)
	P. sanguienolentus	27	51.7±56.7(6.4-275)	61	32.75±33.19(2.0-200.4)
	C. feriata	5	20.32±13.23(6.8-39.0)	6	42.0±41.4(5.0-96.0)
	C. callianassa	3	5.21±2.73(2.5-6.9)	5	20.28±15.63(3.75-45.2)
	C. cruciata	2	29.4±14.3(19.3-39.6)	3	18.13± 5.66(13.4-24.4)
	M. planipus	112	9.12±4.81(2.17-24.48)	459	35.1±385.5(1.4-8018.0)
	A. lunaris	140	12.69±1.98(2.71-39.90)	380	18.96±60.91(0.69-1190.0)
Carapace Length (cm)	P. pelagicus	85	5.10±1.26(2.5-8.1)	85	4.824±1.732(1.8-13.5)
	P. sanguienolentus	27	4.0 ± 1.3 (2.2-8.8)	61	4.1±3.7(1.7-31.0)
	C. feriata	5	10.9 ±17.2 (2.6-42.0)	6	4.3 ±1.1 (3.1-5.4)
	C. callianassa	3	2.57± 0.2 (2.4-2.7)	5	3.2 ± 0.9 (1.9-3.9)
	M. planipus	112	3.4±4.1(0.30-28.0)	459	4.1±5.3(0.80-33.0)
	A. lunaris	140	3.1±0.4 (1.10-4.5)	380	3.2±0.5 (1.50-5.0)
	C. cruciata	2	3.8 ±0.6 (3.4-4.2)	3	3.2 ±0.3 (2.9-3.5)
Carapace Width (cm)	P. pelagicus	85	10.4±2.7 (4.8-16.3)	85	9.6 ± 2.9 (2.9-15.8)
	P. sanguienolentus	27	8.6±2.3 (4.8-14.3)	61	9.7±10.7 (3.6-66.5)
	C. feriata	5	16.1±26.2 (3.0-63.0)	6	5.8 ±1.9 (3.9-8.6)
	C. callianassa	3	3.4 ± 0.3 (3.2-3.8)	5	4.6 ±1.5 (2.9-5.5)
	C. cruciata	2	5.6 ± 0.8 (5.0-6.2)	3	4.7±0.5(4.2-5.1)
	M. planipus	100	3.7±0.8(1.30-5.40)	434	4.3±2.03(1.20-42.0)
	A. lunaris	127	4.6±0.8(1.70-6.9)	343	4.7±0.8 (2.3-7.5)

Chela Length (CL)	P. pelagicus	85	5.9±1.6(3.1-10.2)	85	6.4±2.9(1.7-19.5)
	P. sanguienolentus	27	4.3±1.2 (2.4-7.6)	61	4.5±4.2 (1.6-36.0)
	C. feriata	5	11.5±18.7(2.6-45.0)	6	4.7±1.7(2.6-6.4)
	C. callianassa	3	2.3±0.1(2.3-2.5)	5	3.3±1.3 (1.5-5.0)
	C. cruciata	2	3.9±0.4(3.6-4.3)	3	3.3±0.4(3.0-3.8)
	M. planipus	100	1.7±0.4(0.6-4.9)	435	2.1±0.5(0.0-5.6)
	A. lunaris	127	2.1±1.3(0.7-17.0)	343	2.18±0.4(0.8-5.8)

More than 75% of crabs were belong to two portunid species as *Portunus pelagicus* and *Portunus sanguinolentus*. The size CW of female and male *P. pelagicus* ranged from 4.8 to 16.3cm and 2.9 to 15.8cm respectively, and the Carapace length of female and male *P. sanguienolentus* ranged from 2.2 to 8.8cm and 1.7 to 31.0cm respectively (Table 1). The seasonal abundance of Brachyuran crabs showed that the higher abundance200 was found in SW monsoon(yr 06) and low103.38 in NE monsoon(yr. 06-07).
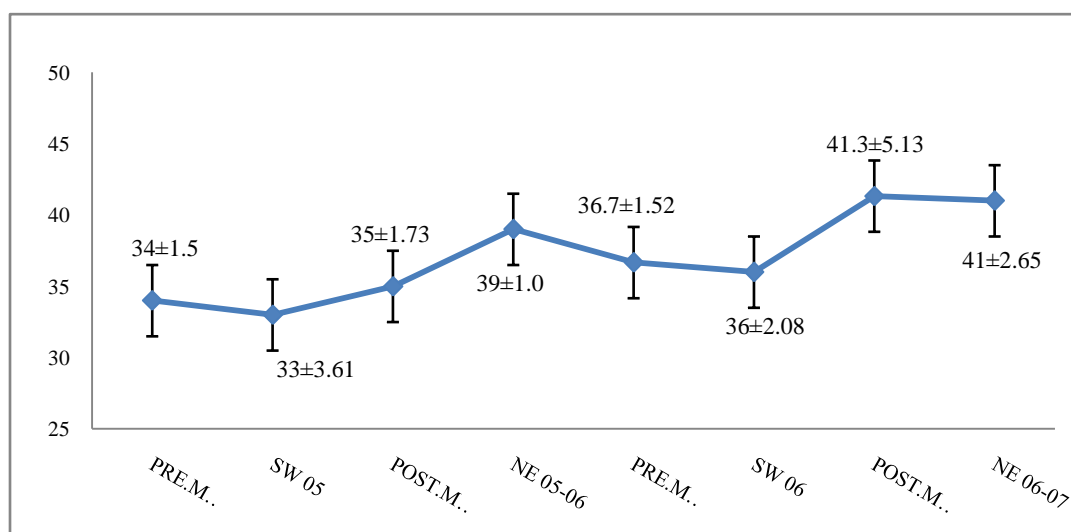

Figure 3. The mean (± standard deviation) salinity variations in different seasons of the years 2005-2007.

Seasonal distribution of Portunid crabs showed that the most abundant species in the total annual catch in term of the number and weight were *P. pelagicus* and *P. sanguinolentus.* These two species were found in all seasons, but was abundant (mean abundance was 80 and 87.5 for *P. pelagicus* and *P. sanguinolentus*) in the SW monsoon (06) respectively (Figure 3). A distinct seasonal variation in values of diversity, species richness, evenness and index of dominance was noticed during two years. The H' value in Pre monsoon was the highest (>1.32) (Table 2), Although a wide range of H' (>1.5 in Post monsoon and <0.63 in SW monsoon) values were observed among seasons and seasonal variations within years was meager (Table 2). A similar trend existed relative to the J' values. The highest value of index of dominance was in SW (>0.45) with a range of (> 0.58 in post monsoon and <0.36 in NE monsoon). Similar mode were observed between species richness values (Table 2). The physical parameters showed strong correlation with each other (Table 3).
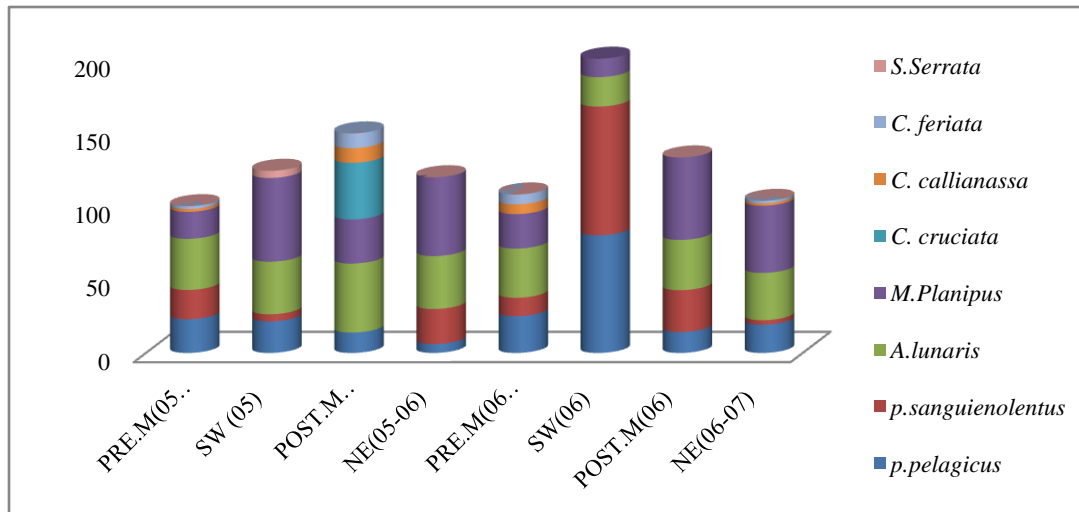
Figure 4. The Percent abundance of crabs collected in gill net during different seasons of the years 2005-2007.

Table 2. Mean seasonal diversity index values and the results of one way ANOVA between different seasons of the years 2005-2007. (Abn, abundance; Pre.M, Pre monsoon; SW, South west monsoon; Post.M, Post monsoon; NE, North east monsoon; 05-06, 2005-2006; 06-07, 2006-2007; DI,diversity index; H', Shannon-Weaver diversity index; J',evenness; ID, index of dominance; SR, species richness; df=degree of freedom).

Indices	PRE.M 05-06	SW 05-06	POST.M 05-06	NE 05-06	PRE.M 06-07	SW 06-07	POST.M 06-07	NE 06-07	One way ANOVA
Abn	171.5±155.2	28.6±23.1	11.5±6.81	72.3±51.5	118.6±40.9	6.5±4.04	38.6±30.1	69±15.62	Df=7, F=1.57
H'	1.64 ±0.97	1.34±0.47	1.57±0.94	1.41±0.40	1.32±0.07	0.63±0.37	1.03±0.40	1.61±0.14	Df=7, F=1.22
J'	0.35±0.21	0.29±0.10	0.34±0.20	0.30±0.08	0.28±0.01	0.13±0.08	0.22±0.08	0.35±0.03	Df=7, F=1.22
ID	0.38±0.22	0.45±0.11	0.58±0.22	0.37±0.08	0.47±0.02	0.73±0.42	0.58±0.19	0.36±0.06	Df=7, F=0.92
SR	1.07±0.64	1.76±0.98	1.45±0.64	0.88±0.25	0.84±0.06	1.10±0.65	1.21±0.85	1.02±0.25	Df=7, F=0.91

Correlation analysis showed a significant relationship between Brachyuran diversity indices and environmental variables (Table 3). Among the independent variables analyzed salinity indicated positive significant correlation with brachyuran crabs dominance(r^2= 0.409; p < 0.01), Diversity has a strong correlation with evenness (r^2 = 1.0; p < 0.01), pH has a positive correlation with the diversity and evenness (r^2 = 0.329; p <0.01) and finally the temperature has a positive correlation with dominance (r^2 = 0.305; p < 0.01).This analysis showed that single effect alone could not predict the seasonal variability in the distribution of brachyuran crabs and from the consequences it is evident that a minimum of two environmental aspects control significantly.

Discussion

Brachyuran crabs mainly decapods represent one of the biggest groups of Crustacea in terms of diversity; which represent more than a sixth of all crustacean species in the world [28]. Environmental change is a chief issue to determine the crab's biodiversity as crustacean's life patterns be effectively connected to environmental parameters[7]. The overall abundance of brachyuran crabs shows fluctuations in different season, the highest abundance was

found in southwest and post monsoon and low in the northeast and in the premonsoon. The high species diversity index and maximum species abundance in Sonmiani lagoon indicate the high productivity of the lagoon. Several biotic and abiotic factors such as fluctuation in temperature, salinity and dissolve oxygen as well as operational such as net length, mesh size and haul time are factors of variability in certain species become more or less catchable by gill net in the way of the year [29,30].

In the marine environment, many factors (adverse conditions, lack of food, competition and perhaps most important of all, predation) act to reduce survival rates of individuals in a population [31]. Coastal lagoons and estuaries showed an adverse habitat for marine species, turbidity and water temperature may increase significantly compared to adjacent coastal water, and many coastal lagoons incident strong tidal or seasonal salinity variation[32]. The environmental data showed large variation between seasons, however, some distinct spatial and temporal trends were observed. Salinity within the lagoon's ecosystem can fluctuate from almost fresh water to hypersaline depending upon the amount of rain and the exchange rate with adjacent sea water[32].During the study 6 species of crabs under the family Prtunidae (*P. pelagicus*, *P.*

sanguinolentus, C. feriata, C. callianassa, C. cruciata, S. serrata) two species under the Family Calapidae (*M. planipes* and *A. lunaris*) were identified. The variable seasonal conditions such as temperature, rainfall and salinity fluctuations following different season[33] affects the crab abundance and distribution. Salinity is an ecological factor in the distribution of marine organisms and production of the coastal ecosystem. Salinity was found to be high in the post monsoon and NE monsoon and low in the SW monsoon during the monsoon season this variation in salinity at study site is probably due to the runoff fresh water and rain. The pH is a major factor affecting cabs diversity and distribution in an ecosystem. Alkaline pH was found to be associated with the increasing number of crab species, however, increasing in pH the decreasing of the number of species has been reported[7]. Marine or aquatic organisms are pH dependent, optimal range of pH for sustainable life is 6.5 - 8.2 [34]. In this study hydrogen ion concentration (pH) in surface water remain slightly acidic to alkaline throughout the year. Usually the fluctuation in pH during different seasons of the year are affected to factors such as removal of CO_2 by photosynthesis, mixing or runoff of fresh water, reduction of temperature and salinity [4].

Table 3. Correlation relationship between environmental parameters and Brachyuran Crabs diversity indices (Where H'= Shanon diversity; ID=index of dominance; Even= evenness; SR= species richness).

	Air temp.	Water temp.	Salinity	PH	H'	ID	Even	SR
Air temp.	1.00							
Water temp.	0.865***	1.00						
Salinity	0.583***	0.470**	1.00					
PH	0.790***	0.652***	0.819***	1.00				
H'	0.326**	0.249*	0.279*	0.329**	1.00			
ID	0.236*	0.305**	0.409**	0.286*	0.04	1.00		
Even	0.326**	0.249*	0.279*	0.329**	1.0***	0.04	1.00	
SR	0.184	0.231*	0.135	0.243*	0.295*	0.14	0.295*	1.00

*Correlation is significant at the 0.05 level;

 ** Correlation is significant at the 0.01 level,

***Correlation is significant at the 0.001 level.

The water temperature ranged from 19.67ºC-33.6ºC, variation in temperature may result of the sun and atmospheric heat and fluctuation in water temperature allow well mixing of the water column. Abundance and distribution of portunid species did not show regularity during the study. Some crab species are exclusively observed from the study site, i.e two species under Family Portunidae (*P. pelagicus, P. sanguinolentus*) this could be attributed to its ability to tolerate a wide range of salinity and temperature, which influence the distribution, activity and movement of *P. pelagicus*[33]. Two species, each of Family Callapidae (*M. planipes* and *A. lunaris*) and *Scylla serrata* was poorly represented and it was only in the month of June (2005) while species of *Charybdis* were observed in different period of study. Several physiological and biological processes such as feeding habits, growth, reproduction and migration may influence the distribution in crabs [33].

Species diversity is a simple and useful tool to measure the relationship in the biological communities. In this study the correlation between diversity indices and physical parameters (salinity, temperature and pH) was strong $p > 0.01$ but a weak correlation was observed between species richness, Dominance with water temperature $p > 0.05$[4] found a high level of connection between the environment and species diversity. Species diversity is controlled by fluctuation in the environment, hence a measure of species diversity is an ecologically and biologically powerful tool. In the present study H' values from 0.63 - 1.645 was observed. Only in SW monsoon the H' value inferred[1] (Table 2). High value in the pre monsoon due to the influx and availability of nutrients in sea water. With the exception the species richness and dominance were high in southwest monsoon likely due to the runoff of fresh water and rainy season. The seasonal variations of diversity H reflected the seasonally high numerical abundance of a few dominant species of family portunidae such as *P. plagicus* and *P. sanguinolentus.* Fluctuation in the values of species diversity and dominance is recognized to changes in rainfall pattern and associated with the influx of floodwaters[35].Low diversity can be effect of diverge variable environmental conditions in the lagoons during different season, which can possibly act as a natural stress which results in a decrease in the variety of species and an increase in the abundance of individual of the species.

References

1. Iszak J & Papp, L, A link between ecological diversity indices and measure of biodiversity. *Ecol. model*, 130 (2000) 151-156.
2. Trivedi J N, Gadhavi, M K,&Vachhrajani, K D, Diversity and habitat preference of brachyuran crabs in Gulf of Kutch, Gujarat, India. *Arthropods*, 1(2012) 13-23.
3. Ng P K L, Guinot, D & Davie, P J F,SystemaBrachyurorum: Part I. An annotated checklist of extant brachyuran crabs of the world. *Raffles Bull. Zool*, 17(2008) 1-286.
4. Satheesh Kumar P, Mangrove vegetation and community structure of brachyuran crabs as ecological indicators of Pondicherry coast, South east coast of India.*Iran. J. Fish. Sci*, 1 (2012) 184-203.
5. Sakthivel K, & Fernando, A, Brachyuran crabs diversity in MudasalOdai and Nagapattinam coast of southeast India.*Arthropods*, 1(4)(2012)136-143.
6. Kumar A AJ, &Wesely, S G, Spatio-temporal distribution of assemblages of brachyuran crabs at Laamu atoll, Maldives. *Atoll Research bulletin,*588(2010).
7. Varadharajan D, Soundarapandian, P,&Pushparajan, N,Effect of Physico Chemical Parameters on Crabs Biodiversity.*J. Mar. Sci. Res. Dev*, 3(2013) 1.
8. Brown JH, Morgan-Ernest, S K, Parody, J M, Haskell, JP, Regulation of diversity: maintenance of species richness in changing environments. *Oecologia,* 126(2001)321–332.
9. Gutiérrez-Estrada By J C, Vasconcelos, R,& Costa, M J, Estimating fish community diversity from environmental features in the Tagus estuary (Portugal): Multiple Linear Regression and Artificial Neural Network approaches. *J. Appl. Ichthyol*, 24(2007) 150–162.
10. Myers AA, Biogeographic barriers and the development of marine biodiversity. *Est. Coast. Shelf Sci*, 44(1997)241–248.
11. Le VayL, Ngoc, Ut,& Jones, D A, Seasonal abundance and recruitment in an estuarine population of mud crabs, *Scylla paramamosain*,

in the Mekong Delta, Vietnam. *Hydrobiologia*, 449(3)(2001) 231-239.

12. Stone R P, Clair, C E O,&Shirley, TC, Seasonal migration and distribution of female red king crabs in a southeast Alaskan estuary. *J. Crust. Bio*, 12(4)(1992) 546-560.

13. Nøhr A A, The Governmentality of Biodiversity in the EU's Common Fisheries Policy. *JIS,* 7(1)(2011).

14. Queffelec B, Cummins, V,&Bailly, D, 'Integrated management of marine biodiversity in Europe: Perspectives from ICZM and the evolving EU Maritime Policy framework'. *Mar. Policy*, Vol. 33(6) (2009) 871-877.

15. Ahmed M,&Ayub, Z, First report on the penaeid shrimp population from MianiHor lagoon in Balochistan, *Pakistan. Pak. J. Zool*, 28 (1996) 331-334.

16. Ahmed M, Rizvi, N, &Moazzam, M, The distribution and abundance of intertidal organisms of some beaches of Makran coast in Pakistan (Northern Arabian Sea). *Pak. J. Zool*, 14(1982) 175-184.

17. Van Zalinge N P, Khaliluddin, M,& Khan, W, Description of the shrimp fishery including a stratified sampling scheme for shrimp landings and effort at Karachi fish harbour. *FAO, FI: DP/PAK/77/033 FIELD Document*, 7(1987)56.

18. Jahangir S, Siddiqui, G, Moazzam, M,&Ayub, Z, Clams of the families Tellinidae and Veneridae and blood cockle of family Arcidae from Phitti creek and Sonmiani along the coast of Pakistan (Northern Arabian Sea). *Pak. J. Zool*, 44(2012)259-266.

19. Afsar N, Siddiqui, G,& Ayub, Z, Update of records of selected Prosobranch gastropod species found along the coasts of Sindh and Balochistan, Pakistan. *Pak. J. Zool*, 44 (2012) 267-275.

20. Gondal M A, Saher, N U, & Qureshi, N A, Diversity and biomass distribution of intertidal fauna in Sonmiani bay (MianiHor), Balochistan (Pakistan). *Egypt. Acad. J. Biolog. Sci*, 4(1) (2012)219-234.

21. Saifullah S M,&Rasool, F, A preliminary survey of Mangroves of Balochistan. WFF Pakistan project, (1995) 99.

22. Rasool B, Arif, J, Hameed, M,& Nadeem, S, Field performance of Trichogrammachilonis against Helicoverpaarmigera under varying sowing time and varieties of cotton. *Int. J. Agric. Biol,* 4(2) (2002)113-114.

23. Saifullah SM, Ismail, S, Khan, S H, & Sleem, M, Land Use- Iron pollution in a mangrove habitat of Karachi. Indus Delta. *Earth Interactions*, 8(17) (2004) 1-9.

24. Tirmizi, M N, & Kazmi, B Q, Marine fanua of Pakistan: 6. Crustacean: Brachyura, Brachyncha part II (Portunidae). Marine Reference Collection and Resource Centre. University of Karachi, Pakistan.(1996).

25. Naz S, Javed, M. Tahir, A, &Azmat. H, Impact of Physico-Chemical Variables of test media on growth performance of metal stressed major Carps.*Pak. J. Zool*, 44(5) (2012) 1291-1296.

26. Magurran A E, Ecological diversity and its measurement.Princeton, NJ: Princeton University Press.(1988).

27. Simpson EH, (1949). Measurement of diversity. *Nature*, 163-688.

28. Kumar A B, Kumar, M S, Raffi, S M,& Khan, S A,Diversity of brachyuran crabs associated with trawl by-catch in Kerala coast, India. *Ind. J. Fish*, 54(3) (2007) 283-290.

29. Olin M T M, & Ruuhijarvi, J, Gillnet catch in estimating the density and structure of fish community - Comparison of gillnet and trawl samples in a eutrophic lake. *Fish. Res*, 96 (2009) 88-94.

30. Dimitra B C, & Ioanna, S, Seasonal variation of fish abundance and biomass in gill net catches of an East Mediterranean lake: Lake Doirani. *J. Environ. Biol*, 31(6) (2010) 995-1000.

31. Safaie M., Bahram, K, Jamileh, P,& Shokri, R M, Growth parameters and mortality rates of the blue swimming crab, *Portunussegnis*(Forskal, 1775) in coastal waters of Persian Gulf and Gulf of Oman, Iran.*Indian J. Fish*, 60(1) (2013)9-13.

32. Hendrickx ME, Studies of the coastal marine fauna of southern Sinaloa, Mexico. n. The Decapod crustaceans of Estero El Verde. An. Inst. Cienc. Mar y Limnol. Univ. Nal. Autón. México. 11(1984) 23-48.

33. Hosseini M, Vazirizade, A, Parsa, Y,&Mansori,A, Sex Ratio, Size Distribution and Seasonal Abundance of Blue Swimming Crab, *Portunus pelagicus* (Linnaeus, 1758) in Persian Gulf Coasts, Iran. *World App. Sci. J*, 17 (7) (2012) 919-925.

34. Adeyemo O K, Adedokun, A O, Yusuf, R K, &Adeleye, E A, Seasonal changes in physico-chemical parameters and nutrient load on river sediments in Ibadan city, Nigeria. *Global NEST J*., 10(3) (2008)326-336.

35. Onuoha GC, Ekpo, EI,Chude, LA,&Isangedighi, I A, Composite preliminary ichthyo faunal survey of NtakInyang Stream, Ikpa River, Nigeria. *Nigerian J. Agri. Food Environm, 6 (2010) 82-89.*