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Article

Diversity and habitat preference of brachyuran crabs in Gulf of Kutch, Gujarat, India

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Abstract

The biodiversity of Gulf of Kutch is studied well with special reference to scleretinia and mollusca but the brachyuran crab taxa are rather neglected. Gulf of Kutch is very rich in floral and faunal diversity and comprises different types of communities and habitats like very unique coral reefs, mangroves, sandy shores, rocky shores and mudflats. Brachyuran crabs are the most diverse group among marine fauna having 5000 species world wide. Some studies on the intertidal fauna, including brachyuran crabs, have been carried out in Gulf of Kutch but the findings were not sufficient to draw out taxonomic diversity. Present work on Gulf of Kutch is an initiative to scan the entire coastal Gujarat and establish directory of brachyuran crab diversity. Since the Gulf habitat is diverse and distinct, eight different stations (16 sample sites) were sampled. The selection of the sample site was done on the basis of habitat type which included mangrove mudflats, open mudflats and rocky shores. A total of 19 species belonging to 8 families and 15 genera were recorded. Open mud flats were most preferred by the crabs followed by the mangrove mud flats and rocky shore.

Keywords brachyuran crabs; Gulf of Kutch; mangrove; mudflat; habitat preference.

1 Introduction

Studies on the local checklist of fauna are of great importance for the formulation of conservation polices (Fransozo et al., 1992; Hebling et al., 1994), because these studies lead to the best understanding of community structure, ecological processes and problem faced by ecosystem. The coastal or marine environs comprise some of the high biodiversity areas (Khan et al., 2005). The environs contain specialized habitats like salt marshes, coral reefs and mangroves and each habitat has their specific animal community. Crustaceans are the most crucial groups of tropical benthic communities. The larger and more abundant species are important for human consumption while the incredible variety of small species contribute importantly to the complexity and functioning of tropical ecosystems (Hendrickx, 1995); for e. g. on rocky shores, crabs are prime predators on molluscs, small crustaceans and other invertebrates, but on the other side they also provide prey base for fish, decapods and some terrestrial vertebrates (Siddon and Witman, 2004). So as a prey and predator they have potential influence on the behaviour, distribution and abundance of their own as well as neighboring communities (Seeley, 1986; Trussell and Nicklin, 2002). Among all benthic macro fauna which dwells in the intertidal zone, brachyurans are the most prominent because of great diversity, comprising of about 700 genera and 5000 species (Melo, 1996). Brachyurans are most important group for mangrove ecosystem because they

make 80% faunal biomass (Golly et al., 1962) and their density can reach up to 80-90 individuals per m^2 (Macintosh, 1984).

Gulf of Kutch, an indent to mainland of Gujarat is fourth major coral reefs areas of India. This area is geographically isolated from other reef areas of India; still it shows great varieties of marine habitats like coral reefs, mangroves, rocky intertidal zone and sea grass beds. The area is extensively explored by researchers as far as Scleracitnian and molluscs groups are concerned. Total 45 different species of hard corals (Dixit et al., 2010; Pillai and Patel, 1988) and 188 species of mollusc species were recorded in this area (Apte, 1998). Major mangrove forest cover of the state lies in the area and the mangrove ecology is well studied with reference to floral diversity but faunal component is least studied (Pandey and Pandey, 2010). Except few studies on marine fauna of the then Mumbai state (Chhapgar, 1957) no particular studies on brachyuran crab fauna have been done. So to generate the baseline picture of brachyuran crab diversity of Gulf of Kutch, the present study was carried out at eight different sites of Gulf of Kutch. The main aim of the study is to generate the information on brachyuran crab diversity and their habitat preference in selected habitats of Gulf of Kutch. However, the area of Marine National Park and Sanctuary was not included in the present study.

2 Materials and Methods

2.1 Study sites

Gulf of Kutch is the western proximity of Gujarat state and as stated earlier, it harbors huge variety of marine fauna. For the present study few locations of Gulf of Kutch (except Marine National Park and Sanctuary area) were selected (Fig. 1). The study sites were not within the Marine national Park, however, considering the legislative regulations collection, preservation or museum deposition of any specimen was not done.

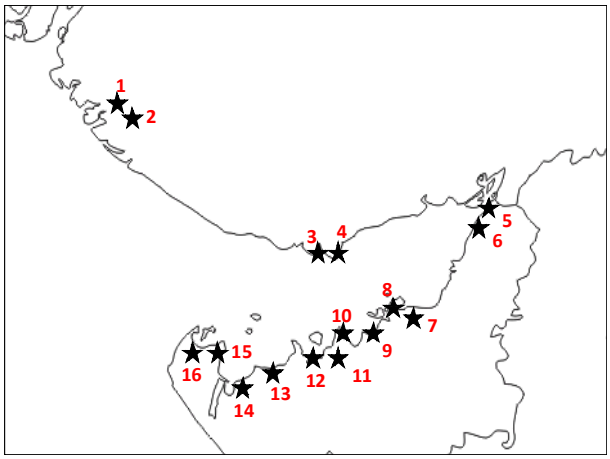

Fig. 1 Distribution of sampling sites in study area

The crab diversity was studied at eight different stations (Table 1). Selection of the stations was done on the basis of two parameters; one is habitat diversity (e.g. mangroves mudflats, open mudflats and rocky shores) and second is accessibility of the study site. The study area was classified in to three main habitat types; among the mud flats; area near the low tide mark and with no vegetation cover was considered as open mudflat, the mud flat which has mangrove canopy cover is considered as mangrove mudflats and the others included rocky shores. *Avicinia marina* makes the major canopy cover of mangrove mudflats of the study area while the canopy made by *Rhizophora mucronata* and *Ceriops tugal* were comparatively much sparse. Furthermore, the

detail profile of different marine habitats and their coverage area in each station was prepared. For detail study of brachyuran crab diversity and their habitat preference, each station was divided into two different sampling sites. Two different habitats which had maximum coverage area were surveyed as sampling site in each station (Table 1). Total 16 sampling sites were surveyed of which total 8, 6 and 2 sites were surveyed for mangrove mudflat, open mudflat and rocky shore, respectively.

Table 1 Study sites

Station	Sampling site	Site description
Nalia	1	Mangrove mudflat
	2	Open mudflat
Mundra	3	Open mudflat
	4	Mangrove mudflat
Jodia	5	Mangrove mudflat
	6	Open mudflat
Jamnagar	7	Mangrove mudflat
	8	Open mudflat
Sikka	9	Rocky
	10	Mangrove mudflat
Khambhalia	11	Mangrove mudflat
	12	Open mudflat
Bhatia	13	Mangrove mudflat
	14	Open mudflat
Poshitra	15	Mangrove mudflat
	16	Rocky

2.2 Sampling methods

Belt transect method was adopted for the study. Two belt transects (10x50m) were laid in each sampling site and whatever species encountered during the survey was collected. For the collection of wandering crabs handpicking method was used and for burrowing crab patient wait for the crab to come out of the burrow was the only option so as not to harm the crab while collection. The collected specimens were immediately photographed, sketched for noteworthy characters and identified tentatively in the field. After identification, all the specimens were released unharmed in their particular habitat. The identification was confirmed based on photographs, drawings and character description and comparing them with the illustrative keys (Sethuramalingam and Ajmal Khan, 1991, Jeyabaskaran, et al., 2000). For further conformation of species, all the details of the specimens were compared with the information available on Marine Species Identification Portal website (www.species-identification.org.com) and National Institute of Oceanography web site on Marine Fauna Information (Jeyabaskaran et al., 2002). The classification of brachyuran crabs was adopted from WORMS website (www.marinespecies.org). Bray – Curtis similarity percentage was calculated for each site and a dendrogram was drawn for grouping of similar sites.

3 Results

Total 19 species of brachyuran crabs belonging to 8 families and 15 genera were recorded from the study area where family Ocypodidae, Grapsidae and Portunidae contribute 4 species each (Fig. 2). Three species were belonging to family Xanthidae while rest of the families including Pilumnidae, Gecarcinidae, Goneplacidae, and Eriphiidae contributed only one species each. *Uca lactea annulipes*, *Parasesarma plictum*, *Scylla serrata* and *Cardisoma cranifex* were most dominant brachyuran crab species recorded from 13, 12, 11 and 9 different

sampling sites, respectively. Five species of crabs including *Charybdis acutifrons*, *Charybdis feriatus*, *Ocypode ceratopthelma*, *Atergatis integerrimus*, and *Atergatis subdentatus* were encountered only in one study site each. The maximum number of brachyuran crab species were recorded from Poshitra (11 species) followed by Mundra (9 species), Naliya (8 species) and Khambhaliya (8 species). Bhatia, Jodia and Sikka contributed same number of species (7 species) while minimum species diversity was recorded from Jamnagar (4 species). In sampling sites diversity, maximum diversity of brachyuran crabs was recorded from site number 2 while minimum diversity was recorded from site number 7 (Table 2, Figs 3 and 4).

As stated earlier, the whole study area is divided into three different habitats including mangrove mudflat, open mudflat and rocky shore, where the area of rocky shore was very small as compared to others so only two sampling sites were surveyed for rocky shore crab diversity. The habitat preference of brachyuran crab was studied in these three habitats and maximum number of species was recorded from open mudflats followed by mangrove mudflats and rocky shore. Though the area of rocky shore was small still it supports comparatively good diversity.

Total 10 species belonging to 5 families and 8 genera were recorded from mangrove mudflat habitat (Tables 2, 3). The number of species recorded for family Grapsidae which is typically found in mangrove environment was three. Family Portunidae contributed three species in the species account followed by Ocypodidae (2 species), Gecarcinidae (1 species) and Goneplacidae (1 species). *Uca lactea annulipes* and *Parasesarma plictum* were recorded in seven different sites out of eight sites surveyed which makes them dominant species of the habitat. Other common brachyuran crab species of mangrove mudflat habitat recorded were *Scylla serrata* (5 sites) and *Cardisoma carnifex* (5 sites). Though family Grapsidae is very common in mangrove habitat still except *Parasesarma plictum* other species like *Grapsus intermedius* and *Grapsus albolineatus* were recorded from two and three different sites only, respectively. *Neoepisesarma tetragonum* belonging to family grapsidae was not recorded from mangrove mudflat.

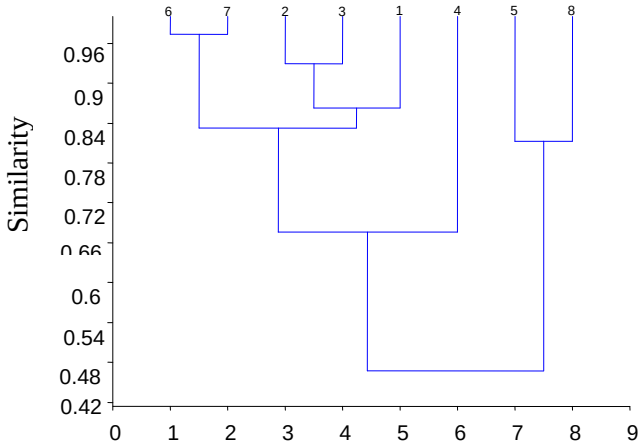

Fig. 2 Dendrogram of brachyuran crab diversity recorded from different station of Gulf of Kutch.

In open mudflat habitat total 11 species belonging to 6 families and 10 genera were recorded (Tables 2, 3). *Scylla serrata* and *Uca lactea annulipes* were the dominant species as they were found in all the sampling sites of open mudflat habitat while the other common species like *Macropthelmus pectinipes*, *Grapsus intermedius*, *Parasesarma plictum*, *Neopisesarma tetragonum*, *Cardisoma carnifex* were also recorded from the habitat.

Becides *Uca lactea annulipes*, another species *Uca dussumieri* belonging to family ocypodidae which mostly prefer muddy habitat was also recorded. Some species like *Portunus pelagicus*, *Grapsus albolineatus* and *Goneplex rhomboids* were recorded once in the habitat. Family Ocypodidae and Grapsidae were the most dominant families contributing 4 species each to the species account. Family Portunidae was contributing two species while family Gecarcinidae, Pilumnidae and Goneplacidae were contributing one species each to the species account. Among the 7 sites surveyed for open mudflat habitat site no 2 was having maximum diversity of brachyuran crabs (8 species) while site no 8 was having minimum diversity (4 species). Other sites were similar to each other in terms of brachyuran crab diversity.

Table 2 Diversity of brachyuran crabs at different stations of Gulf of Kutch (Fig. 3, 4)

Species and Family	**Stations and sampling sites**																
	Nalia		**Mundra**		**Jodia**		**Jamnagar**		**Sikka**		**Khambhalia**		**Bhatia**		**Poshitra**		**TR**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	
Portunidae																	
Scylla serrata	X	X	X		X	X		X		X		X	X	X	X		**11**
Charybdis acutifrons															X	X	**1**
Charybdis feriatus															X		**1**
Portunus pelagicus													X	X	X		**3**
Ocypodidae																	
Uca lactea annulipes	X	X	X		X	X	X	X		X	X	X	X	X	X		**13**
Uca dussumieri	X	X	X											X			**4**
Ocypode ceratopthelma												X					**1**
Macropthelmus pectinipes		X	X			X		X									**4**
Grapsidae																	
Grapsus intermedius	X	X		X	X	X						X					**6**
Grapsus albolineatus						X			X	X	X					X	**5**
Parasesarma plictum	X	X		X	X	X	X	X		X	X	X	X	X			**12**
Neopisesarma tetragonum		X	X									X		X			**4**
Xanthidae																	
Atergatis integerrimus																X	**1**
Atergatis subdentatus																X	**1**
Platypodia cristata									X							X	**2**
Pilumnidae																	
Pilumnus vesperitilio									X							X	**2**
Gecarcinidae																	
Cardisoma carnifex	X	X	X	X	X	X					X		X	X			**9**
Eriphiidae																	
Menippe rumphii									X							X	**2**
Goneplacidae																	
Goneplex rhomboides			X	X													**2**
Total species (Sample site)	**6**	**8**	**7**	**4**	**5**	**7**	**2**	**4**	**4**	**4**	**4**	**6**	**5**	**7**	**7**	**4**	
Total species (Station)	**8**		**9**		**7**		**4**		**7**		**8**		**7**		**11**		

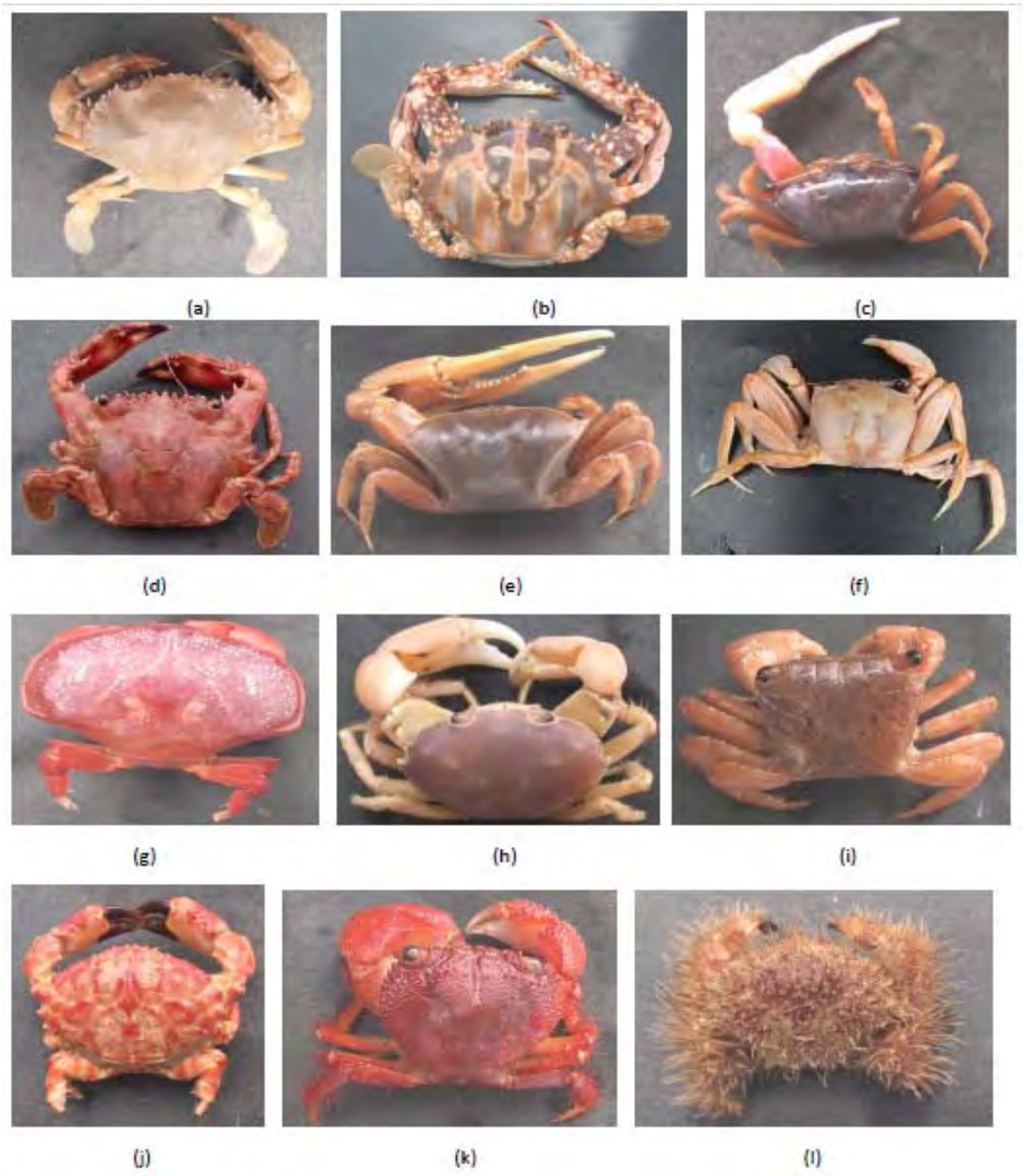

Fig. 3 (a) *Scylla serrata* Forskal, 1755; (b) *Charybdis feriatus* de Man, 1879; (c) *Uca lactea annulipes* H. Milne Edward, 1837; (d) *Charybdis acutifrons* de Man, 1879; (e) *Uca dussumieri* H. Milne Edward, 1852; (f) *Ocypode ceratopthelma* Pallas, 1872; (g) *Atergatis integerrimus* Lamarck, 1801; (h) *Cardisoma carnifex* Herbst, 1796; (i) *Parasesarma plictum* Latrille, 1803; (j) *Mennipe rumphi* Fabricius, 1798; (k) *Platypodia cristata* A. Milne Edward, 1837; (l) *Pilumnus vespertilio* Fabricius, 1793

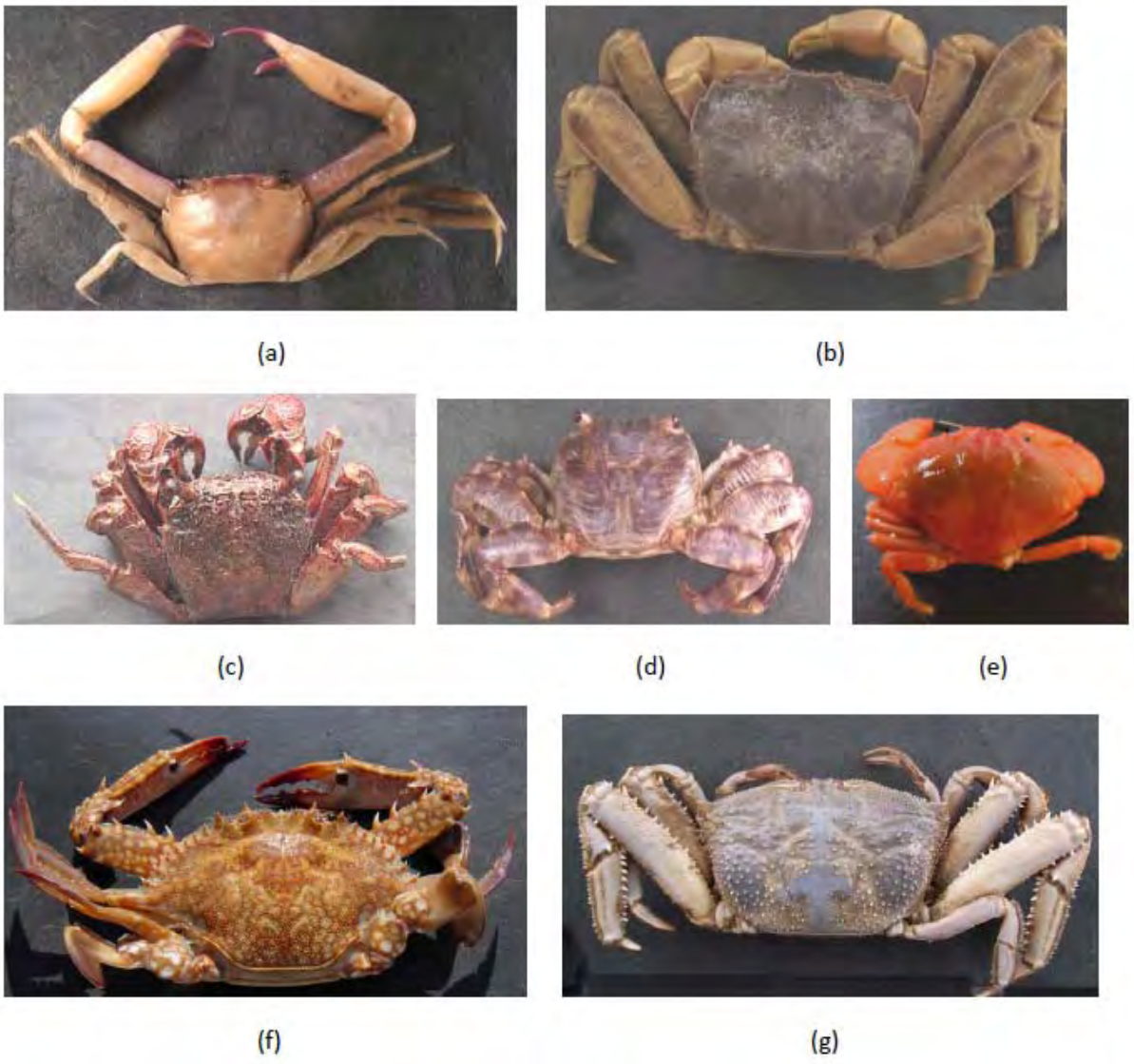

Fig. 4 (a) *Goneplex rhomboides* Linnaeus, 1758; (b) *Neopisesarma tetragonum* de Man, 1887; (c) *Grapsus intermidius de* Man, 1888 ; (d) *Grapsus albioneatus* Lamarck, 1818 (e) *Atergatis subdentatus* de Haan, 1835; (f) *Portunus pelagicus* Linnaeus, 1758; (g) *Macropthelmus pectinipes* Guerin, 1839

In the case of rocky shore habitat only two sampling sites were surveyed and total 7 species belonging to 5 families and 7 genera were recorded (Tables 2, 3). Family Xanthidae was dominant family on rocky shore which contributed three species followed by Eriphiidae, Pilumnidae, Grapsidae and Portunidae which contributed one species each to the species account. Genus *Atergatis* was dominant at both the sites. Species like *Atergatis integerrimus*, *Atergatis subdentatus*, *Platypodia cristata*, *Pilumnus vesperitilio* and *Menippe rumphii* were recorded only from rocky shore habitat. The sampling site no. 16 which falls in Poshitra study station was more diverse than sampling site no. 9 of Sikka (Table 3).

Table 3 Habitat preference of brachyuran crab species

Species	Habitat type															
	Mangrove mudflat								Open mudflat						Rocky shore	
	Sampling sites															
	1	4	5	7	10	11	13	16	2	3	6	8	12	14	9	15
Scylla serrata	X		X		X		X		X	X	X	X	X	X		X
Charybdis acutifrons								X								
Charybdis feriatus																X
Portunus pelagicus							X							X		X
Uca lactea annulipes	X		X	X	X	X	X		X	X	X	X	X	X		X
Uca dussumieri	X								X	X				X		
Ocypode ceratopthelma													X			
Macropthelmus pectinipes									X	X	X	X				
Grapsus intermedius	X	X	X						X		X		X			
Grapsus albolineatus					X	X		X			X				X	
Parasesarma plictum	X	X	X	X	X	X	X		X		X	X	X	X		
Neopisesarma tetragonum									X	X			X	X		
Atergatis integerrimus								X								
Atergatis subdentatus								X								
Platypodia cristata								X							X	
Pilumnus vesperitilio								X							X	
Cardisoma carnifex	X	X	X			X	X		X	X	X			X		
Menippe rumphii								X							X	
Goneplex rhomboids		X								X						
Total species (Sample site)	**6**	**4**	**5**	**2**	**4**	**4**	**5**	**4**	**8**	**7**	**7**	**4**	**6**	**7**	**4**	**7**
Total species (Habitat)	**10**								**11**						**7**	

Table 4 Bray-Curtis similarity for brachyuran crabs collected from different stations

Station Name	Nalia	Mundra	Jodia	Jamnagar	Sikka	Khambhalia	Bhatia	Dwarka
Nalia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mundra	85.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jodia	86.7	92.9	0.0	0.0	0.0	0.0	0.0	0.0
Jamnagar	56.0	69.6	72.0	0.0	0.0	0.0	0.0	0.0
Sikka	35.7	46.2	50.0	52.2	0.0	0.0	0.0	0.0
Khambhalia	78.8	83.9	90.9	71.4	58.1	0.0	0.0	0.0
Bhatia	76.5	81.3	88.2	69.0	56.3	97.3	0.0	0.0
Dwarka	29.4	37.5	41.2	41.4	81.3	54.1	57.9	0.0

The similarity in species diversity and composition between different sites was ranging from 29.4% to 97.3% (Table 4) with an average similarity percentage of 64.1. For further analysis of site similarity, the dendrogram was drawn and it revealed separate grouping of similar stations. Stations 6 and 7 formed a group with maximum similarity percentage of 97.3. Stations 2 and 3 formed a group with similarity percentage of 92.9 to which station 1 has got linked at 85.7%. Stations 1, 2 and 3 which represent mangrove mudflat and

open mudflat areas have got similar kind of diversity and this group got linked with the group of stations 6 and 7 at 83.9%. Station 4 which also represent mangrove mudflat, but has less diversity, got linked with main group with similarity percentage of 69.0. Stations 5 and 8 which represent rocky shore habitat formed a separate group with similarity percentage of 81.3. The major two groups including rocky shore as one and the second including both the mangrove and open mudflat habitat linked with each other with the similarity percentage of 46.2 only.

4 Discussion

Monitoring and baseline surveys are of great importance to know the present status of native and invading species (Melo, 1996). Along the sea coast of Gulf of Kutch base line surveys for species diversity of coral and mollusca are recorded but the studies on brachyuran crabs are sparse and non definitive (Dixit et al., 2010). In the present study we recorded 19 species of brachyuran crabs from selected areas of Gulf of Kutch. By comparing different kinds of habitats like open mudfalts, mangrove mudflats and rocky shore, one can postulate the species dominancy on the habitat. Maximum diversity of brachyuran crab was recorded from open mudflat followed by mangrove mudflat and rocky shore. Open mudflats provide unique kind of habitat to several species of brachyuran crabs. 11 species of brachyuran crabs have been recorded from open mudflat of Mahi river estuary (Pandya, 2011). Open mudflat habitat is a dominant habitat type in Mahi estuary and species like *Uca lactea annulipes, Macropthelmus depressus, M.dilatatus* were dominant. Here, in Gulf of Kutch, *Uca lactea annulipes, Scylla serrata* and *Parasesarma plictum* were dominant species while the density of *Macropthelmus pectinipes* was also good.

Mangroves provide extra ordinary habitat for brachyuran crabs as well as for other benthic fauna. However, the diversity was comparatively less than the open mud flat habitats. Few families like Sesarmidae, Grapsidae, Ocypodidae and Xanthidae make most of the brachyuran crab diversity of mangroves. Among the entire benthic fauna that dwells in mangroves, grapsid crabs are most important in terms of species diversity and density (Daudouh – Guebas, et al., 1997). In the present study we recorded 10 species of brachyuran crabs in mangrove mudflats. Family Grapsidae and Portunidae were dominant in mangrove mud flats contributing three species each. *U. lactea annlipes* and *P. plictum* were recorded from all the stations surveyed. Khan et al. (2005) has recorded 38 species of brachyuran crabs from Pichavaram mangroves amongst them 18 species belonged to family Grapsidae while 8 to the family Ocypodidae. Davie (1982) has recorded 32 species of brachyuran crabs from mangroves of Hong Kong and Australia while Tan and Ng (1994) found 51 species of Grapsids from mangroves of Peninsular Malasia. All above records show higher diversity of crabs as compared to the present study. Crabs play important ecological role in mangrove forest. They decompose the leaf litter and increase the availability of nutrient for other fauna and flora. Crabs always change the substratum profile as bioturburator which drives the nutrient cycling in mudflats and mangroves (Pandya and Vachhrajani, 2010, 2011). The species diversity of brachyuran crabs in mangroves depends on the density and species diversity of the mangroves and prevailing hydro biological conditions (Davie, 1982).

Rocky shores are amongst the most dynamic habitats found along the sea coast of the world. Many factors play important role in determining the nature of rocky shore communities. Abiotic factors like wave action, slope and salinity of water are vital and cause direct effect on diversity and distribution of floral and faunal communities inhabiting rocky shore habitat. The animal species which live in rocky shore habitat have to develop specific kind of adaptations for the harsh conditions especially against wave or tide action because the high force of waves can detach or tare the animal from their home and it can take them to the subtidal zone of the ocean. Pohle et al. (2011) have recorded 32 species of decapods crustaceans from Atlantic coast, Szechy et al. (2001) have recorded 12 species of brachyuran crab from the rocky shore of Rio de Janeiro and Sao Paulo

of Brazil and Flores and Paula (2001) have recorded 7 species of brachyuran crabs from rocky shore of central Portugal. In the present study, we recorded 7 species of brachyuran crabs from two different stations surveyed. Amongst the two sites, the rocky shore of Poshitra was highly diverse then the rocky shore of Sikka.

Of the total 19 species recorded in present studies, the preference for mud flats was more visible. However, since only two locations were analyzed for rocky shore, the data may be insufficient to conclude about over all species diversity.

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References

Apte D. 1998. Book of Indian shells. Bombay Natural History Society, Mumbai, India

Chhapgar BF. 1957. Marine Crabs of Bombay State. Contribution No. 1 of the Taraporevala Marine Biological Station. Marine Biological Station, Department of Fisheries, Mumbai, India

Dahdouh – Guebas F, Verneirt M, Tack JF, et al. 1997. Food preference of *Neosermatium minerti* de Man (Decapoda: Sesarminae) and its possible effect on the regeneration of mangroves. Hydrobiologia, 347: 83-89

Davie PJF. 1982. A preliminary checklist of Brachyura (Crustacea: Decapoda) associated with Australian mangrove forest. Operculum, 5: 204 – 207

Dixit AM, Kumar P, Pathak KD, et al. 2010. Economic Valuation of Coral Reef Ecosystem in Gulf of Kachchh. Gujarat Ecology Commission, Ghandhinagar, India

Flores AAV, Paula J. 2001. Intertidal distribution and species composition of brachyuran crabs at two rockyshores in central Portugal. Hydrobiologia, 449: 171-177

Fransozo A, Negreiros-Fransozo ML, Mantelatto FL, et al. 1992. Composição e distribuição dos Brachyura (Crustacea,Decapoda) do sublitoral não consolidado na Enseada da Fortaleza, Ubatuba (SP). Revista Brasileira de Zoologia, 52(4): 667-675

Golley F, Odum HT, Wilson RL. 1962. The structure and metabolism of Puertrican and mangrove forest in May. Ecology, 43: 9–18

Hebling NJ, Mantelatto FL, Negreiros-Fransozo ML, et al. 1994. Levantamento edistribuição de braquiúros e Anomuros (Crustacea, Decapoda) dos sedimentos sublitorais da região da Ilha Anchieta, Ubatuba (SP). Bolm. Inst. Pesca, 21, 1-9

Hendrickx ME. 1995. Checklist of brachyuran crabs (Crustacea: Decapoda) from the eastern tropical Pacific. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique Biologie, 65: 125-150

Jeyabaskaran RS, Wafar M. 2002. CD on Brachyuran Crabs of West Coast, India. National Institute of Oceanography, Dona Paula, Goa, India

Jeyabaskaran R, khan AS, Ramaiyan V. 2000. Biodiversity Project on Gulf of Mannar Biosphere Reserve. Centre of Advanced Study in Marine Biology, Annamalai university, Parangipettai, India

Khan AS, Raffi SM, Lyla PS. 2005. Brachyuran crab diversity in natural (Pichavaram) and artificially developed mangroves (Vellar estuary). Current Science, 88(8): 1316-1324

Macintosh DJ. 1984. Ecology and productivity of Malaysian mangrove crab populations (Decapoda: Brachyura). 354-377, Proceedings of the Asian Symposium on Mangrove Environmental Research and Management, University of Malaya, Kuala Lumpur, Malaysia

Marine species identification portal developed by ETI bioinformatics. www.species-identification.org.com

Melo GAS. 1996. Manual de identificação dos Brachyura (caranguejos e siris) do litoral brasileiro. Editora Plêiade, São Paulo, Brasil

Pandey CN, Pandey R. 2010. Study of Pollination Biology and Reproductive Ecology of Major Mangrove Species of Gujarat. GEER foundation, Gandhinagar, India

Pandya PJ. 2011. Benthic community structure of Mahi River estuary with special reference to animal-sediment relationship. PhD Thesis, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, India

Pandya PJ, Vachharajani KD. 2010. Spatial distribution and substratum preference of brachyuran crab *Macrophthalmus depressus* (Decapoda: Ocypodidae) along the lower estuarine mudflats of Mahi River, Gujarat, India. Crustaceana, 83: 1055-1067

Pandya PJ, Vachharajani KD. 2011. Life under ecological stress: An estuarine case study. In: Animal Diversity, Natural History and Conservation (Vol. 1) (Gupta VK, Verma AK, eds). 427-436, Daya Publication House, New Delhi, India

Pillai CSG, Patel MI. 1988. Scleracitnian corals from the Gulf of Kutch. Journal of Marine Biological Association of India, 30: 54-74

Pohle G, Iken K, Clarke KR, et al. 2011. Aspects of benthic decapode diversity and distribution from rocky near shore habitat of geographically widely dispersed sites PLoS ONE, 6(4): e18606

Seeley RH. 1986. Intense natural selection caused a rapid morphological transition in a living marine snail, Littorina obtusata. Proceedings of the National Academy of Sciences of USA, 83: 6897-6901

Sethuramalingam S, Khan AS. 1991. Brachyuran Crabs of Parangipettai, Centre of Advance Study in Marine Biology, Annamalai University, India

Siddon CE, Witman JD. 2004. Behavioral indirect interactions: multiple predator effects and prey switching in the rocky subtidal. Ecology, 85: 2938-2945

Szechy MTMD, Veloso VG, Paula EJD. 2001. Brachyura (Decapoda: Crustacea) of phytobenthic communities of the sub littoral region of rocky shore of Rio de Janeiro and Sao Paulo, Brazil. Tropical Ecology, 42(2): 231-242

Tan CGS, Ng PKL. 1994. An annonated checklist of mangrove brachyuran crabs from Malaysia and Singapore. Hydrobiologia, 285: 75-84

Trussell GC, Nicklin MO. 2002. Cue sensitivity, inducible defense, and trade-offs in a marine snail. Ecology, 83: 1635-1647

World register of marine species. www.marinespecies.org