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ABUNDANCE AND DISTRIBUTION PATTERN OF INTERTIDAL SHORE CRABS ON EXPOSED SANDY BEACHES OF BAKHALI, SUNDARBANS

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Abstract

Ecological survey of inhabited shore crabs was carried out at exposed sandy beaches of Bakkhali island (21°33'48"N and 88°15'34"E), located at southern proximity of West Bengal falling within Sundarban mangrove ecosystem. The main objectives were to analyse the across-shore distribution pattern of interspecific crabs by means of burrow counts and diameter of their openings and to identify their preferable zones and spatial segregation. To achieve the aims, quantitative transect and quadrat sampling was done to access the habitat distribution, their abundance and the relative density. The present survey reported the considerable interspecific variability in across-shore distribution pattern showing dominance of three brachyuran crabs of family Ocypodidae and Dotillidae. Niche segregation among the species had also been reported with two species more widely distributed, while one had restricted distribution. The Red ghost crab, *Ocypode macrocera* and Horned Ghost crab, *Ocypode cerathophthalmus* are typical predators, scavengers and deposit feeders, leaving huge amount of characteristic pellets on sandflats. Juveniles dig simple and shallower burrows towards seaward, while adults create deeper and complex burrows towards landward with great variability. Data revealed that *O. macrocera* were relatively abundant with greater population density (0.8 individuals/ m^2) preferring inhabiting almost dry supratidal, while *O. cerathophthalmus* only occurred at 0.3 individuals/ m^2. Distribution pattern of *O. macrocera* also varied greatly with maturity showing predominance of small burrows (1.5-2.5 cm) in diameter along transect T1and T2, inhabited by juvenile ones and by adult group (3.5-6.0 cm) within supratidal. The tiny spherical Soldier crab, *Dotilla blanfordi*, measuring upto 1 cm body width were important members of intertidal community occuring abundantly in moist sand of lower intertidal, with juvenile dominating towards waterline. The burrowing behaviour of shore crabs has been considered as one of the major bioturbations affecting the physical and chemical characteristics of the substratum, thereby promoting sediment turnover and biogeochemical cycling. They are excellent regenerators and transfer sediment from various depths to surface through frequent digging behaviour, thereby playing an important role in biomixing.

Keywords:

Ocypode macrocera;
Ocypode cerathophthalmus;
Dotilla blanfordi;
Distribution;
Abundance.

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1. Introduction

Study of distribution and abundance in a certain palace at a certain time refers to Ecology of a particular organism. The distribution of living organisms in a particular habitat may be affected by physical factors like temperature, amount of light, availability of water, nutrients and oxygen, pH, change in salinity etc. Ghost crabs, belonging to genera *Ocypode* (Family: Ocypodidae) are conspicuous inhabitants of tropical and subtropical sandy beaches worldwide. The crabs are dependent directly upon mangrove influenced coastal ecosystem for survival, feeding, predation and reproduction by constructing unique biogenic structures which influence the whole sedimentology and geochemistry of mangrove shore bed. The semi-terrestrial shore crabs, *Ocypode macrocera* (H. Milne Edwards, 1852), most commonly called 'Red Ghost crab' and *Ocypode cerathophthalmus* (Pallas, 1772) popularly known as Horned Ghost crab are largely distributed along the sandy shores of West Bengal, that faces daily tidal influences of Bay of Bengal. They are typical predators, scavengers and deposit feeders and play an important role in ecology of sandy beaches [9]. Ghost crabs are also able to take up water from damp sand via tufts of setae between the third and fourth periopods [16], [17]. All the *Ocypode* species construct deep, semi permanent, complex architectural burrows with opening surrounded by sand piles and leaving characteristic feeding pellets [3]-[5]. The burrow also provides shelter from adverse environment and space during mating period. Soldier crabs of genus *Dotilla* of Familly Dotillidae (Alcock, 1900) is widespread along the tropical sandy shores and prefers trooping in huge numbers on soft shores of lowermost intertidal. They have long slender pincers folded downward with claws pointing inward and possess special parts for absorbing air and water from sand.

Studies on burrowing behaviour and burrow morphology of shore crabs in specific ecosystem have gained attention over recent decades [3]-[5], [6], [8], but data regarding distribution pattern and population structure of shore crabs including *Ocypode* species are least. Hence, studies concerning ecology, behaviour and factors that govern the distribution of shore crabs are very essential, since they play structural and functional roles in maintaining ecology of sandy beaches of tropical mangroves. Bakkhali coastal area has been selected for study site, which is gaining much importance as tourist spot, being one of the deltaic islands across southern Bengal. As because of accelerated involvement of human for its residential, commercial, agricultural, industrial and tourism purposes, the habitats of shore crabs are being destroyed resulting in decrease of their population.

The present study was undertaken to obtain a better ecological understanding of the species, their across-shore distribution pattern, abundance, relative density and extent of niche partitioning among inhabited interspecific shore crabs at the exposed sandy beach of Bakkhali coastal area. The study also aims to provide a detailed habitat distribution, their vertical distribution pattern on the shore in relation to varied degree of environmental parameters, along the variations of tidal zone. To achieve these aims, quantitative transect and quadrate sampling was done for quantitative estimation like population density, relative density and its abundance.

2. Research Method

Study was conducted during the month of December, 2017 at the sand flats of exposed sandy beach of Bakkhali island (21°33'48"N, 88°15'34"E), which continuously faces tidal influences of Bay of Bengal. Pilot survey and special considerations of study site determined the line drawing and placing of transects and quadrates respectively. High tide line (HTL) and Low tide line (LTL) were identified by deposition of litter. The number of transects varied according to the length of the beach. Two parallel random belt transects (T1 and T2) of 68 meters each were drawn across LTL and HTL with the help of measuring tape perpendicular to the shore line appropriately across the variations of the intertidal subzones. A total of 30 square quadrates, each measuring 2m x 2m, made of nails and ropes were placed at marked intervals along each transect and random counting was done from each quadrate considering each burrow being inhabited by a single crab. Similarly, randomly placed three transects (T3, T4 and T5) of 50 meters each from HTL to HHTL was used to determine the distribution of burrows across the supratidal zone. Mean density and diameter of burrows were analyzed by using quadrats (n = 10 per transect) across the distance from seaward to landward [10], [15]. The diameter of burrows was measured with the help of vernier calliper. To assess the population density of lowermost intertidal crabs, two transects each measuring 40 meters was stretched from LTL to waterline. The population structure was analyzed directly by measuring crab dimensions and indirectly by counting burrows and diameter of their openings. All numerical data are represented as the mean ± standard deviation (SD). The important physiochemical parameters of study site were measured using Digital pH meter and Digital TDS meter (Hanna, Taiwan make); Digital Salinometer (Erna, Japan make) and digital thermometer.

3. Results and Analysis

3.1 *Distribution pattern, number and size of burrows*

Two semi-terrestrial shore crabs of family Ocypodidae are typical inhabitants and predominant burrowing species along the coastal shoreline of Bakkhali Island, with periodical activity greatly influenced by tidal cycles. Within the study area, the number of crab holes and diameter of the burrows varied greatly among transects covering different zones (Figure 1). The distribution of crabs seemed to vary with the maturity from seaward to landward area. The density of burrows increased with distance from the shoreline towards landward. There were two distinct size groups of *O. macrocera*, the juvenile ones had burrow openings of diameter 1.5-2.5 cm inhabiting upper intertidal, whereas the larger adult group inhabited burrows measuring 3.5-6.0 cm in supratidal. Similar type of observation on *Ocypode macrocera* was demonstrated by Dubey *et al.*, 2013 at Sagar island of Indian Sundarbans. Burrow opening diameter of *O. cerathophthalmus* was found from 2.5 to 3.4 cm for adult ones, while juvenile burrow opening measured 1.0-1.5 cm in almost upper intertidal. A similar relationship was found between size of the crab and its position on the beach for *Ocypode cursor* population at northern Israel [11], [12]. The spherical soldier crab, *Dotilla blanfordi* were important members of intertidal sandy shore community and occurred abundantly in moist sand of lower intertidal towards shoreline. They build their burrows in the area from low tide level to just above mean sea level. As a result, their habitat is periodically flooded, leading to a continuous renewal of organic content in the uppermost sediment layer. Adult measured 0.5-1.0 cm of carapace length with female larger than males, while juveniles were tiny measuring upto 0.3 cm.

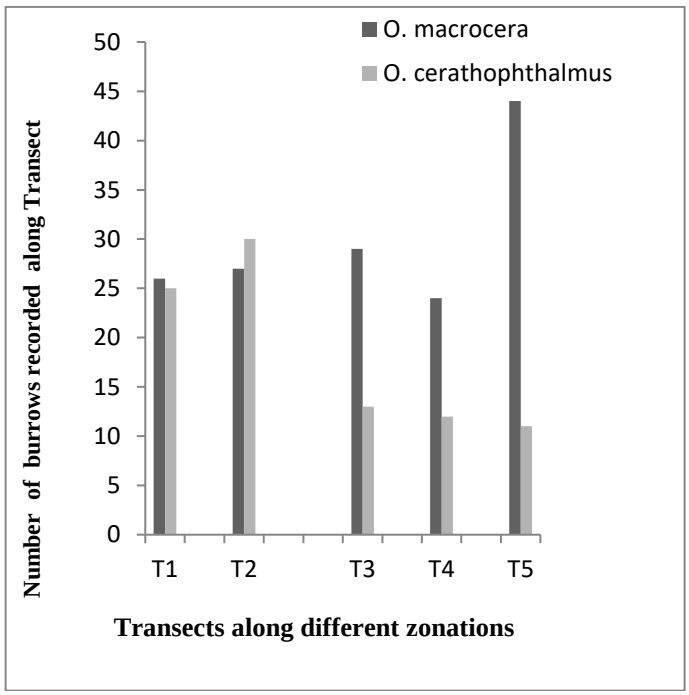


Figure 1. The number of burrows of *O. macrocera* and *O. cerathophthalmus* recorded in different transects of 68 m stretch (T1 & T2; n = 30) from intertidal and 50 m stretch (T3, T4 & T5; n= 10) from supratidal.

At the exposed intertidal sandflat along the transect T1 and T2 from LTL, average population density of *O. macrocera* reached 0.22 individuals/ m^2, while for *O. cerathophthalmus* only occurred at 0.2 individuals/ m^2. On transect further beyond the HTL (T3, T4 and T5), *O. macrocera* maintained an average density of 0.8 individuals/ m^2 and *O. cerathophthalmus* at 0.3 individuals/ m^2 (Table 1). Hence, data suggests that O. *macrocera* are relatively abundant and prefers inhabiting almost dry supratidal above the high tide level. Their activity in the lower intertidal mudflats below the HTM was related to feeding activity forming pellets (mud balls). The *O. cerathophthalmus* generally had maximum burrows in the upper intertidal zone closer to the high tide mark. High abundance of *O. cerathophthalmus* was reported by Trivedi and co-workers in Gulf of Kutch, Gujarat [13]. From the present investigation it is also suggested that habitat dependency of *O. macrocera* are related to several physiochemical parameters like air and water temperatures, different

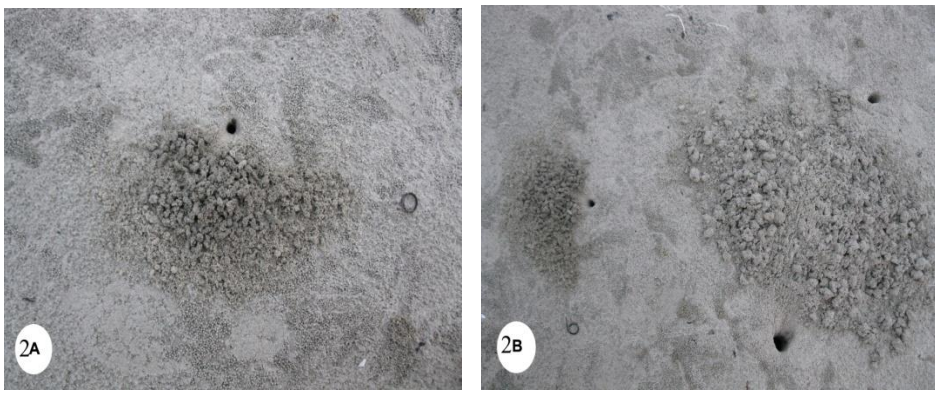
sediment conditions and varied salinity zonations due to tidal fluctuations. The average population density of *Dotilla blanfordi* reached 127.4 individuals/ m^2 along two transects at lowermost intertidal, which was mainly dominated by juveniles.

Table 1: Quantitative characteristics calculated on the basis of data shown in Figure 1 (n = number of quadrats).

Parameters	Transect T1 & T2 (*n* = 30 each)		Transect T3, T4 & T5 (*n* = 10 each)	
	O. macrocera	*O. cerathophthalmus*	*O. macrocera*	*O. cerathophthalmus*
Population Density (individuals/ m^2)	0.22	0.20	0.80	0.30
Relative Density (RD) in %	51.4	48.54	72.93	27.06
Frequency of occurrence (%)	55	48	63	60
Abundance/quadrat	2.3	1.72	5.1	2.0

3.2 *Habitat preferance and behavioural observations*

The presence and abundance of crabs corresponds to daily influences of detritus based tidal action. During sampling, the mean air temperature was found to be 15.4 ºC, mean water temperature recorded was 22.2 ºC, salinity of 1.013 (dissolved), % ge =15 and Total dissolved solids as 3999 ppm. The major behavioral activities observed among *O. macrocera* were of feeding activity and pattern of burrow excavation. In the month of December, crabs seemed to be involved in burrowing activities in early hours of sunrise after receding the tides. They preferred inhabiting self constructed wide range of burrows, each occupied by single individual and deeper burrows being constructed by adults away from the shore above high tide mark. Burrows at supratidal were found to leave the dugout sand near the burrow opening to fo a mound where excavated sediments were piled in a single direction (Figure 2.A & B), whereas no lumps of substrate piles were observed around the opening of some burrows (Fig 2.C) near the vicinity of HTL. Sand piles near burrow openings had been reported for a number of species, like *O. mortoni*, *O. cursor* (Wong *et al*., 2012). Feeding behaviour observed among *O. macrocera* was of deposit feeding, leaving characteristic pellets on sand surface. Activities of *O. cerathophthalmus were* similar to that of *O. macrocera*, involved in searching of food, digging variable burrows and deposit feeding forming huge amount of small feeding pellets on sandflats (Fig 3.C & D). Burrow openings of *O. cerathophthalmus* with accumulated sand mounds had been reported by many workers [4], [16]. Juveniles of *O. cerathophthalmus* feed in vicinity of their burrows while adults move long distances in search of food. Juveniles were also found to move out of the burrows frequently to renew their respiratory water. They dig simple and shallower burrows in contrast to adults, which create deeper and complex burrows [3], [4].



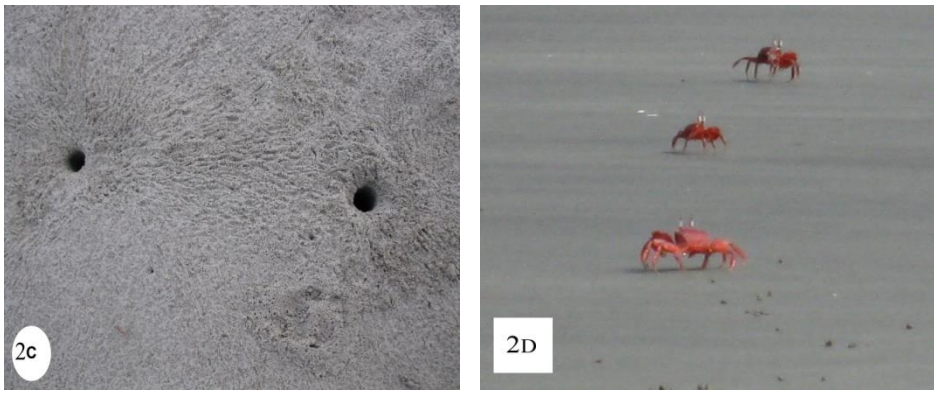


Figure 2. Burrow morphology of *Ocypode macrocera.* Note the variation of arrangements of sediment piles around the opening; A, Burrow opening showing bigger untidy sand balls piled in a single direction forming a hill in upper intertidal; B, leaving dug out sand near burrow opening of adult (larger one) and of juvenile (smaller) in lower intertidal; C, burrow opening with no sand piles left behind; D, Adult *O. macrocera* foraging for food.

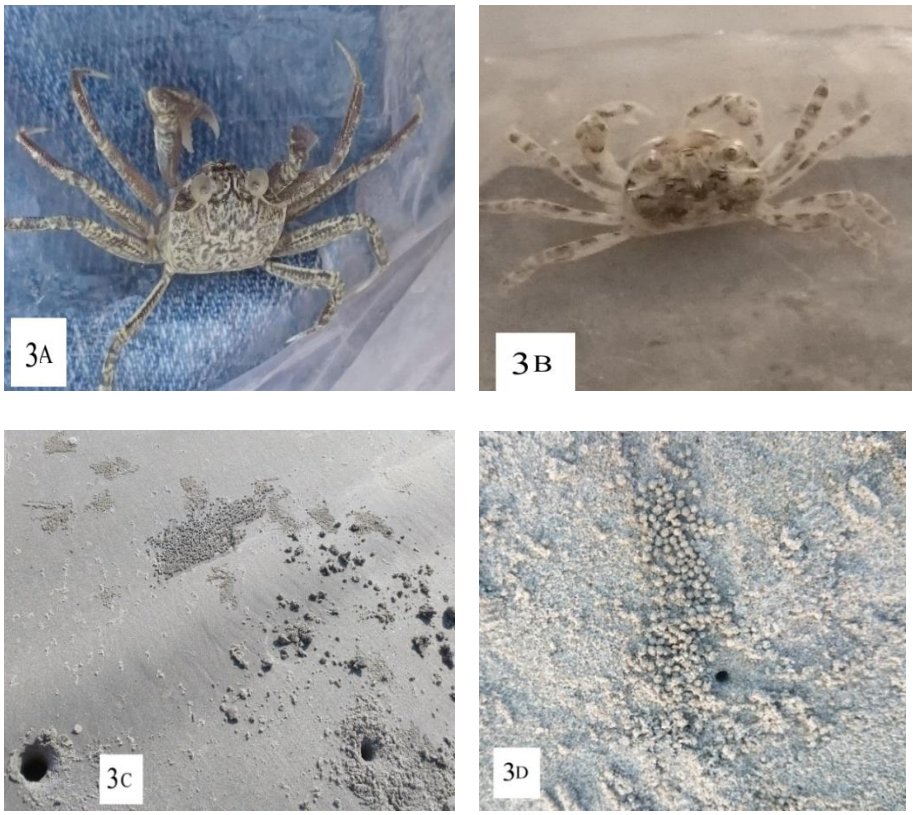


Figure 3. A & B, Adult male and Juvenile (magnified) of *Ocypode cerathophthalmus*; C, Burrow opening at upper intertidal depicting *sediment* piles and left over feeding balls; D, Burrow made by juvenile surrounded by feeding pellets.

The lower intertidal shore crabs, *Dotilla blanfordi* remained in burrows during high tide by plugging their openings and trooped in numbers during low tide eating thin layer of organic matter by scrapping on sand grains. Juveniles usually wondered not very far from their burrows and covered the entire lower intertidal by inflated pellets within several minutes. Huge amount of pelletization made by juveniles was seen during low tide at lower intertidal towards shoreline (Fig 4. C). They showed unique feeding activity, working radially from the entrance to their burrows forming "feeding lines" of sediment pellets radiating from the opening (Fig 4. D). Hence, ecologically they are playing important role as deposit feeders and bioturbators thereby affecting the productivity of sandy shores.

Figure 4. A, Adult male of *Dotilla blanfordi*; B, Juvenile in the process of plugging holes of their burrows before onset of high tide; C; Huge pelletization covering lower intertidal; D, *Dotilla* feeding in circular patterns around their burrows proceeding in one direction.

Burrowing of shore crabs in particular ecosystems as one of the major bioturbations have received increasing attention over the recent decades. The burrowing behaviour has been found to affect the substratum in which they live, thereby affecting the physical and chemical processes in ecosystem [7], [15]. The bioengineering processes exhibited by shore crabs on sandflats and resulting into varied biogenic structures, control various ecological processes for maintaining the stability within marine ecosystems. Through feeding activity they scrap the upper organic rich layer of the sediments regulating the organic content and the algal covering, on the other hand their byproduct from gut enriches the sediments with minerals like N and P [1]. The crabs are excellent regenerators which continuously dig burrows and transfer sediment from various depths to surface, thereby playing an important role in bio-mixing (bioturbation). Their digging activity enhances nutrient recycling, oxygenation in the sediments, decomposition of organic materials and facilitates entrapping the sediments and mangrove seedlings [2]. Thus, brachyuran crabs serving at different trophic levels in the food web of marine ecosystem could be used as key bioindicators of human impact on benthic communities. Hence, periodic assessment and biological monitoring of burrowing shore crabs on exposed sandy beaches may be a useful tool for anthropogenic impact and ecosystem assessment.

4. Conclusion

The crabs are dependent directly upon mangrove influenced coastal ecosystem for survival, feeding, predation and reproduction by constructing biogenic structures. They dig unique architectural burrows along the variations of tidal zone thereby reflecting non-competitive habitat distribution pattern. The niches of all coastal inhabited species were segregated using restricted ecological niches often with much overlap, as shown by *O. macrocera* and sympatric *O. ceratophthalmus* along the variations of tidal and salinity zones. Hence, crabs showing huge diversity and density and serving at different trophic levels of marine food web could be used as a bioindicator species for the health of substratum. The present investigation conclusively opines that biological monitoring of coastal sandy beaches and periodic assessment of population density and abundance of burrowing inhabitants may be a useful tool for anthropogenic impact assessment on exposed sandy beaches.

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