International Journal of Multidisciplinary Research and Development

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Volume: 2, Issue: 5, 368-371
May 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

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Biological reworking of sediment by crab in coastal area of West Bengal: Crab burrow morphology and related landforms

Ram Krishna Sen

Abstract
Burrowing by crabs is an important component of their functional role in coastal area. This study highlights to evaluate burrowing behavior and burrow morphology by using plaster of Paris casts. Five burrow morphology characters were measured (burrow number, depth, length, volume, and diameter of the burrow openings .The present study also emphasize on burrow landforms. The burrow morphology variations were correlated with the tidal level (distance from the water mark during low tide), porosity, percent organic matter, vegetation cover and structure of the sediments. Extensive burrowing activities, especially by typical sandy beach crab *ocypode sp.* Produce a characteristic bioturbated top layer (1-1.5m thick) having very high concentration (55-80sq m area) of interconnected complex burrow cavities, which weaken and divide the coherent layer into numerous small sediment blocks amenable to quick erosion by wave and tidal erosion.

Keywords: Burrows, Crab, Burrow morphology, Burrow landforms, Tidal height, Tidal erosion

1. Introduction
Coastal Zone represents the junction between the land and sea. The extent of coastal ecosystem is limited to that part of land which is influenced by adjoining sea and that part of the sea / estuary which is subjected to the impact of adjoining land. Crabs are semi-terrestrial organisms that may influence the sediment structure and other living communities mainly through their burrowing and feeding activities (Teal, 1958). Crabs construct their burrows actively in the intertidal zone from coarse beach sand to fine clay-rich marshy mud during low tide.Crabs are among the larger and more active burrowers in intertidal soft sediments. Consequences of this burrowing and bioturbation include increased vertical and horizontal movement of sediment and detritus (Rhoads & Boyer 1982, Takeda & Kurihara 1987a, Meadows & Meadows 1991), increased permeability of the sediment to water and air (Ridd 1996), stimulation of microbial activity (Montague 1981, AUer 1982, Andersen & Kristensen 1991) and the access of oxygenated water to areas of the substratum below the depth of the normal redox discontinuity layer (Wolfrath 1992). The digging of burrows begins when the crabs are very small (Hyman, 1922; Herrnkind, 1968). The digging behavior of crabs hasbeen described by various authors (Altevogt, 1955; Crane, 1975). These crabs are known to adjust their burrowing activities to a variety of conditions, such as stem density, root mat density, substratum, water, ground temperature, tidal periodicity, reproductive activity, threat by potential predators, seasons and mate display activities (Ringold, 1979; Bertness, 1985; Genoni, 1991). Faunally-mediated disturbancesof the physical, chemical and biological structure of the sediment are known as ‘bioturbation’.The architecture of the burrows plays an important ecological role in the life history of crabs as they are semi-terrestrial and active at low tide, returning to their burrows at high tide.

2. Aim and Objectives: The objectives of the study include:

- To identify the architecture of crab burrow.
- To demarcate the intensity of crab burrow and burrow ball characteristics.
- To identify changes in beach morphology created by crab.
- To identify the relationship between crab burrow intensity and coastal erosion.

3. Methodology:
I. At selected sites, counts of open burrows were first conducted as these indicate the number of burrows present beneath the surface. The burrow-opening density within the distribution area of each species was estimated by randomly locating 0.25 m2 quadrants (6 replicates). The total number of open burrows within each quadrant was counted.

In each quadrant three or four burrows were randomly selected for casts.

II. Aqueous solution of plaster of Paris was poured into the selected crab burrows with the help of a syringe until the burrows were completely filled, then allowed to dry for 3to 6 hours. The casts were then carefully dug up by hand, or with a spade in the case of hard substratum, then cleaned to remove as much sediment as possible from the surface of the cast. Each cast was separately placed in pre-marked poly bags and brought back for further analyses. After the casts were dug out, the area within each quadrant was excavated to a depth of 30 cm and the crabs were collected to calculate the relationship between the density of crabs and crab burrows.

III. The morphology, size and structure of crab burrows were determined. The parameters measured for each burrow cast were: burrow diameter (BD), total burrow length (TBL), total burrow depth (TBD), and burrow volume
(BV). Volume was determined by weighing each cast (± 0.1g) and dividing the weight of the burrow cast by the density (2.2 g cm-3) of plaster of Paris (Chan et al., 2006). Only data for complete burrow casts were used for analyses.

IV. In four selected circular areas (radius 40 metres) ,the formation of burrow balls (sand balls) and erosion were observed and these burrow balls were collected to analysis.

4. Limitations

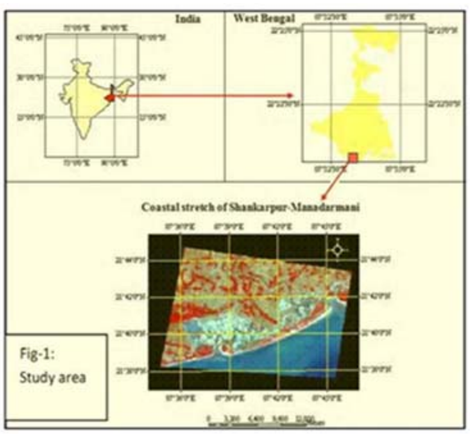

Fig-1: Study area

I) the study of erosion is largely based on secondary data owing to the constraints of time and resource. However, limited primary survey was undertaken as deemed necessary. II) Varity of crab species and their burrowing nature are not identified.III) Environment impact assessment has not been done. IV) It is not an intensive field survey.It based only some selected random samples.

5. Study Area: West Bengal has a substantially long coastline of almost 325 kilometers (including islands) characterized by high floral and faunal biodiversity, diverse geomorphic features and anthropogenic intrusions (Bhattacharya, 2001, Bhattacharya et al., 2003). The area selected for this study is the part of this extensive shoreline of Bay of Bengal along the West Bengal coast. The coastal stretch is about 50-60 km long extending from Talsari to Khejuri including Digha-Sankarpur tract, the Pichhabani inlet, Tajpur-Mandarmani coast, Dadanpatrabar-Junput sector and Hijili-Khejuri segment, which is known for straightness of the coastline, flatness and compactness of the each (Gupta, 1970).

6. Data Analysis and Results

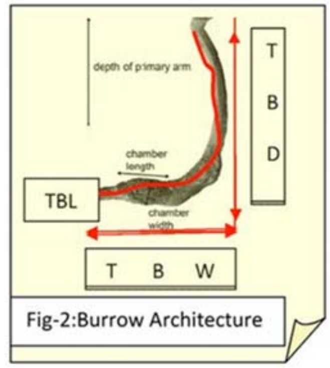

Fig-2:Burrow Architecture

I) Crab Burrow Architecture: Burrow architecture parameters, selected for analyses, were: Burrow diameter (BD) in mm, Total burrow length (TBL) in mm and total burrow depth (TBD) in mm.and total burrow width (TBW)

Table: 1 Data for Burrow Architecture

Average Burrow diameter (BD) in mm	**Average burrow length(TBL) in mm**	**Average burrow depth (TBD) in mm**	**Average burrow width (TBW)**	**Average Burrow Volume (BV) in cm-3**
38.2	86.25	56.12	76.4	227.32

Source: Field survey no of specimen were (31)

A total of 31 casts were made for the crab's burrow during the study period. The burrow cast variables (TCL, TBD, BD and BV) varied according to species, their distribution according to tide levels, and biotope characteristics. Burrows have one, two or three openings on the surface and exhibit J-, U- or Y-shapes. According to Iribarne et al. (1997) the shape of burrow varies as function of background areas. Y-shaped burrows had a mean opening diameter of 26.6 mm and Spiral burrows had a mean opening diameter of 32.6 mm.

II) Intensity of Crab Burrow and Burrow Ball Characteristics: Three different forms of burrow openings were witnessed in the study area - burrows having single-, double- or triple-mouth opening .A total of 71 burrows were examined, out of which 57 were with single opening, 12 had double openings and 2 were with triple openings. A frequency distribution of burrows was constructed as function of area of the openings (cm2). The average number of burrows in the area intervals of 00-10, 10-20,20-30 and 30-40 cm2 were found to be 19,35,22and 9 respectively . The openings of the maximum number of burrows coincided with the area interval between 8-15 sq cm. The burrow ball's diameters are varied from 0.1 mm -12.25 mm.

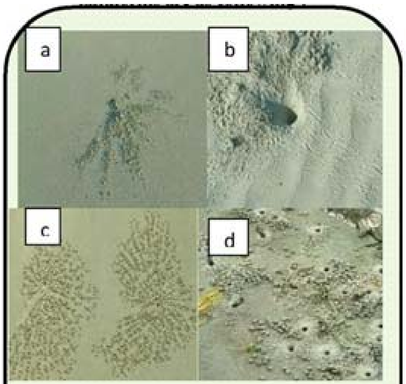

Fig 3: Development of burrow balls in different stages respectively

III) Beach Morphology Created by Crab: Crabs could be the work of a talented artist with far too much time on his hands. But these spectacular sculptures are in fact created by dozens of sand bubbler crabs as they tunnel into the beach. The intricate patterns form when the tiny crustaceans sift through the sand in search of microscopic food before gathering what's left into a sphere and throwing it behind its legs .The stages of evaluation of crab burrow landforms are as following:

a) Initial stage: In this stage new burrows are opened by the crabs. A few no of burrows are opened in this stages. The burrow ball (sand ball) texture is very light and their diameter may be found 0.5-2mm.

b) Primary stage: In this stage, no. of burrows are increased and the diameter of burrow balls are also developed rom 2-4mm.It takes 1.30-2hours.

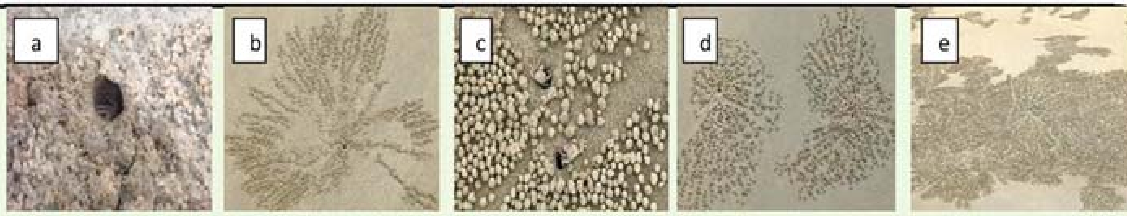

Fig-4: The landforms developed by crabs :a) Sand loose burrow, b)Micro burrow ball, c)Macro burrow ball, d)Micro pattern ground, e)Macro pattern ground

c) Juvenile stage: In this stage, burrow density is increased and also diameter of burrow balls are increased (4-8mm).It takes 2-4 hours.

d) Mature stage: in this stage, a high density of burrows are found .The diameter of the burrow ball turned into >8mm.It takes >5hour

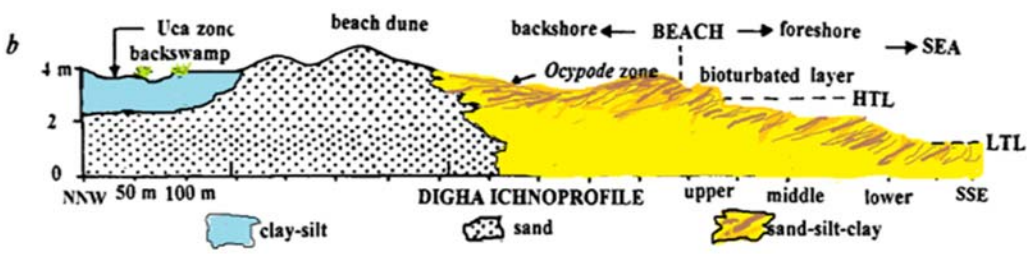

Fig: 5 Digha Beach Profile (after De.C,GSI)

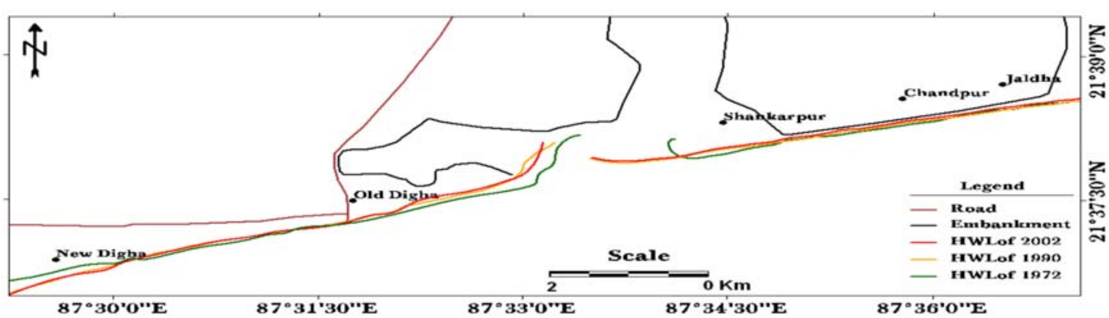

Fig: 6 Changes of shoreline over time from 1972 to 2002 (Derived from SOI Toposheet and Sateilite imagery

IV) Relationship Between Crab Burrow Intensity and Coastal Erosion: It is notoriously difficult to estimate the intensities of crabs in relation to burrows. Burrow intensities are related to surface activities, which are related to biotic functions such as feeding, availability of food, reproductive activities, agonistic behaviour, predation and recruitment. They are also related to abiotic features such as substratum preference, harsh conditions (rise and fall in temperature), tidal periodicity etc., and can result in spatial and temporal variability and over-estimates of crab densities (Skov & Hartnoll, 2001). In the present study we observed higher densities of burrows than crabs in all species. Lim & Diong

(2003) further hypothesized that deeper burrows in the high intertidal areas might help fiddler crabs to maintain lower burrow temperature during ebb tides. They also observed that burrows in anoxic sediments had significantly shorter depths, which would help to improve aeration. The various combinations of sediment type and presence of vegetation as well as other environmental variables, such as inundation levels, result in burrows of different structure .Extensive burrowing activities, especially by typical sandy beach crub produce a characteristic bioturbated top layer (1-1.5 m thick) having very high concentration (55-80 m-2 area)of interconnected complex burrow cavities, which weaken and divide the coherent layer into numerous small sediment blocks amenable to quick erosion by wave and tidal actions. Repetition of this process over the years has been significantly enhancing long term erosion of Digha-Sankarpur beach.

7. Conclusion: In conclusion, our results show that *crubs* display significant interspecific variation in their burrow morphology in relation to the biotic and abiotic factors of their biotopes, such as sediment composition, substratum hardness and root-mat density of the surrounding vegetation. The sediment characteristics (percent organics,composition) and vegetation cover influence the morphology of crab burrows. More work is required to determine the extent of the impact of these environmental factors on burrow morphology, burrow ball landscape and its relation with coastal erosion.

8. **Acknowledgement**
I express my profound gratitude to Prof. Arunabha Misra (VEC), Dr. Nitai Kundu (IWMED), Sandipan Das and ,Jayanta Mondal,. There have been many unmentioned names that have been a part of this paper. Yet, it does not belittle their contribution of this work, nor my gratitude towards them.

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