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Architecture and Morphological Characters of the Burrows of Freshwater Crab *Barytelphusa Cunicularis* (Westwood, 1836)

KEYWORDS: Decapods, Crab burrows, burrow architecture, burrow morphology, burrowing activity, behaviour.

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ABSTRACT *Morphological characteristic and distribution ecology of burrows of the crab Barytelphusa cunicularis, found at Maroda Sector, Bhilai, India, were studied. Three different forms of burrows were witnessed in the study area. The openings of the single-, double- or tripled-mouthed (rare) burrows were ellipsoidal on the surface. Architecture of the burrows was investigated by in-situ casting using a mixture of plaster of paris and cement. Burrows were simple tunnels, descending downwards either straight or slightly slanted, with or without branches. The burrows exhibited L, S or Y like shapes. Observations during the casting and the study of the casts suggest that only one crab was normally resident in a burrow. The cross-sectional dimension of burrow varied throughout the depth of the burrow in no particular order. The depth of the burrow varied as per the size of opening of the burrow. Statistically significant linear relationship between the area of the burrow openings with respect to the carapace length and carapace width of the crabs was observed.*

Introduction

The design and architecture of the burrows of animals have always attracted attention of biologists, to examine the morphological patterns and structure of burrows using a wide variety of techniques. The structure of burrows plays a significant role and provides a morphological window in the life of an organism. By comparing the architecture and different patterns of burrows it may be possible to infer ecological differences between the concerned/ associated taxa and their interaction with the surrounding environment. (Atkinson &Taylor, 1988) reviewed a number of works dealing with the burrowing activity of the decapods. Burrows may also be of different shape and size, simple or complex, having many branches or a single opening depending upon the nature of the animals. Burrows are J-, U- or Y-shaped in *Scylla serrata* (Nandi & Dev Roy, 1991). Complex branched and multiple branched burrows are often found in thalassinids, living in marine and estuarine environments (Doworschak, 1983). (Suchanek, 1985) distinguished between the simple Y-shaped burrows of filter/suspension feeders and the deep-chambered burrows of rift catchers in the thalassinidean shrimp. (Deborah et al., 2005) conducted studies on morphology, impact of burrows and burrow casting in Chinese Mitten crab, *Eriocheir sinensis*. The activities of burrow construction promote the remobilization of sediment grains and nutrient cycling, thus changing the physical and chemical features of the local environment (Griffis & Suchanek, 1991). The burrow characters reflect the burrow morphology, general ecology, types and nature of burrows as well as feeding behaviour of its inhabitants. In *Uca uruguayensis* the morphology of the burrow plays a significant role in the sediment characteristics. As sediment thickness increases the burrows are found to be deeper, longer and more voluminous (Ribeiro et al., 2005).

A variety of techniques have been used by the biologists to determine the morphological patterns, and other environmental effects on the burrow architecture. Previously the moulds or casts of burrow were constructed using plaster of Paris or cement (Stevens, 1929). But recently the scientists have used resins to produce finely detailed reproduction of entire burrows (Shinn, 1968; Atkinson & Chapman, 1984; Dworschak, 2001). (Vaugelas, 1984) suggested the archaeological method of burrow excavation that involves direct observation of burrow features by carefully removing layer by layer of sediments and direct observation of burrow features, with or without cast.

Although extensive work has been carried out on the biology and fishery aspects of Brachyuran crabs, little is known regarding the burrow characteristics and burrowing behaviour in the Potamonide species, widely distributed in India. Therefore, in the present study, attempts were made to determine the characteristics of burrows of freshwater crab, *Barytelphusa cunicularis* (Potamonide).

MATERIAL AND METHOD

The Species and Study Site

All surveys and observations included in this paper were carried out at Maroda Sector, Bhilai (Lat.: 21° 13N; Long.: 81° 26E), Chhattishgarh, India (Fig. 1).

Measurement and calculation of area of Burrow Opening

The site of study was fenced grassland and therefore the burrows were largely undisturbed. The opening of each burrow was measured. The total number of burrows having single, double and triple opening on the surface was counted. The external opening of the burrows was ellipsoidal (Fig. 2). The length of major and minor axes was measured in order to determine the area of the burrow openings. The following formula was used to compute the area of each burrow opening:

$$\text{Area} = \pi \times a \times b / 4$$

Where, a = length of burrow opening, and

b = width of burrow opening

Calculation of mean shaft area:

For calculation of mean shaft area, the circumference of the cast was measured at every 20 cm depth of the burrow and following calculations were applied.

$$\text{Mean Circumference } C = (\Sigma C_n) / n$$

Where, C_n = circumference at the n^{th} point, and

n = total number of such points

Assuming the shape to be circular for simplicity, the mean shaft area was calculated as:

$$A = C^2 / (4 \times \pi)$$

In view of the assumption of circular shape, the area may not be exactly equal but is quite accurate and good enough for analysis purposes.

Burrow casting

Burrow structure of *Barytelphusa cunicularis* was investigated in situ. Only active burrows were chosen for casting and observations. The burrow activeness was observed visually by the excavated materials strewn around the burrow in the form of pallets. A total of 22 burrows were randomly selected with different size of mouth openings. Of these, 19 burrows had single-mouth openings, 2 had double-mouth openings and 1 with triple-mouth openings. Prior to casting, the burrow opening on the surface measured. The burrows were filled with thin slurry of cement and plaster of Paris in the ratio 7:3. The mixture was poured through the mouth of the burrow openings and was allowed to harden for 4-5 days (depending upon the environment conditions). The hardened cast of each burrow was excavated by carefully digging and removing sediments in layers to minimize damage to the burrow cast.

Burrow patterns and measurement

Burrows were simple tunnels, descending downwards either straight or slightly slanted. The burrows exhibited U, L, S or Y like shapes. The length and width of the carapace of the resident crab was measured using vernier calliper up to 0.01 mm accuracy. Measurement of total length of burrow cast was carried out using measuring tape. The circumference of burrow casts was measured at every 20 cm starting from the opening of the burrow and its mean shaft area was calculated.

RESULTS

Burrow morphology

Three different forms of burrow openings were witnessed in the study area - burrows having single-, double- or triple-mouth opening (Fig 3). A total of 98 burrows were examined, out of which 87 were with single opening, 9 had double openings and 2 were with triple openings.

Burrow dimensions

A frequency distribution of burrows was constructed as function of area of the openings (cm^2) (fig . 4). The average number of burrows in the area intervals of >30, 20-30, 10-20 and 0-10 cm^2 were found to be 11, 24, 49 and 27, respectively (fig . 4). The openings of the maximum number of burrows coincided with the area interval between 10-20 cm^2.

Burrow casts and in-situ characteristics

A total of 22 burrows were cast in-situ and the casts were recovered by careful digging. Some of the casts were incomplete due to rupture during digging or insufficient penetration of the mixture of cement and plaster of Paris. Morphological data of 10 casts were taken for observations that were complete and representative of particular burrow. Burrows of *Barytelphusa cunicularis* had very noticeable feature characterized by sandy sediments.

Burrows were found to be simple tunnels, either straight or curved, descending downwards and occurring with or without branches. Various patterns and shapes of burrows like L, S, and Y were observed from the casts. The shapes like L and S were observed in burrow cast (BC 1-9) in burrows with single opening, whereas Y like shape was observed (BC-10) in burrows with two openings. The study of cast of Y-shaped burrows revealed that though the burrow had two surface openings, the two openings connected to the same vertical structure known as shaft, near the middle of the full depth.

The number of crabs resident in a burrow is difficult to determine unless the crab comes from the burrow when the cast was poured or it gets entombed in it. Out of 22 cast study, in 13 casts the crab came out from the burrow as the casting slurry was poured in it, in 5 burrows the crab was embedded in the cast, while in rest of the 4 burrows the crab was not found. Observations during the casting and study of the cast indicate that only one crab was normally resident in one burrow.

Regression analyses were conducted to establish relationship between area of burrow opening, burrow depth, carapace length, and carapace width of crab. Statistically significant linear relationship between the area of the burrow openings with respect to the carapace length and carapace width of the crabs was observed (Fig, 5 and Fig, 6). The total depth of the burrow was observed to be in proportion with the size of the burrow opening, i.e., greater the area of the burrow opening, higher the depth of the burrow (fig. 7).

Burrow shape and in-situ measurement

A linear correlation between the carapace width and length of the crab and total depth of the burrow cast was observed (fig. 8 and fig. 9).

The total depth of the burrow, in the burrow cast (BC-8) was 175 cm, having single opening and exhibited S shape. The area of the mouth of the burrow opening was 35.72 cm^2. The mean shaft area was 43.97 cm^2; the carapace length and width of the crab were 42.62 and 58.24 cm, respectively.

In the ten burrows for which the complete cast study was carried out, the burrow surface area opening ranged between 10.60 to 35.72 cm^2. The depth of the burrow varied from 70 to 175 cm. The width of the carapace ranged from 25.62 to 58.24 mm (Table 1). The depth of the burrow was strongly dependent on the animal size ($y = 0.31x - 11.74$, $R^2 = 0.86$).

Figure 1 Map of the study area

Figure 2 Ellipsoidal burrow showing length (a) and width (b)

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Figure 3 Burrows with single, double and triple openings

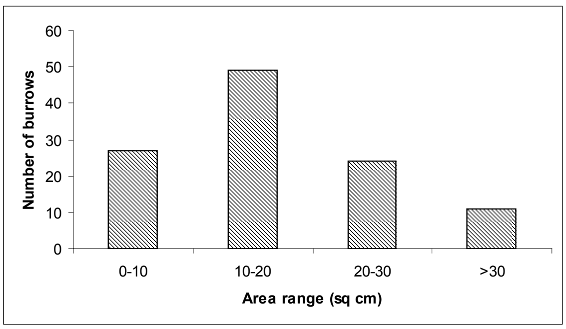

Figure 4 Distribution of burrows as per area of burrow opening

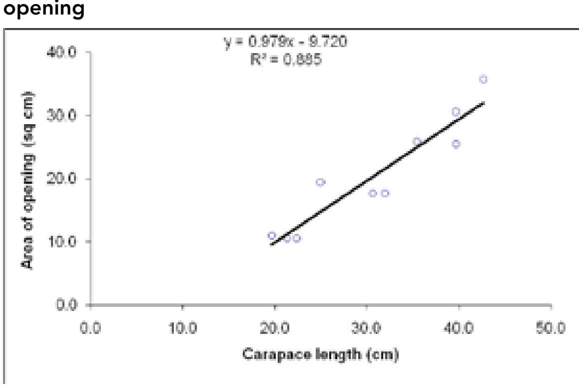

Figure 5 Relationship between carapace length and area of opening for cast burrows

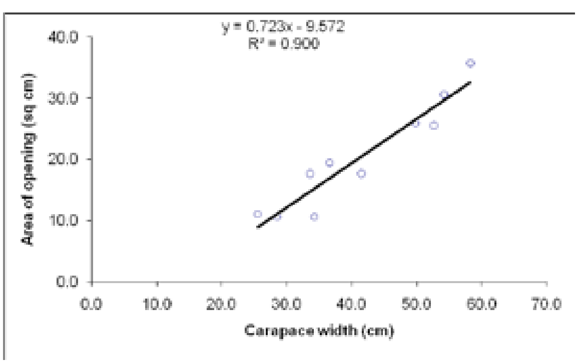

Figure 6 Relationship between carapace width and area of opening for cast burrows

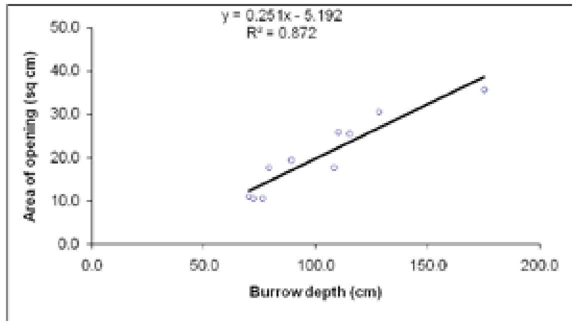

Figure 7 Relationship between burrow depth and area of opening for cast burrows

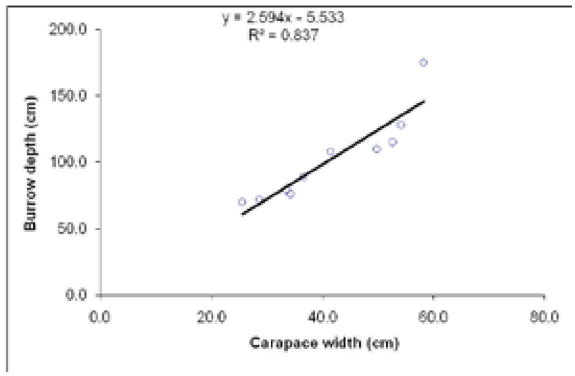

Figure 8 Relationship between carapace width and burrow depth for cast burrows

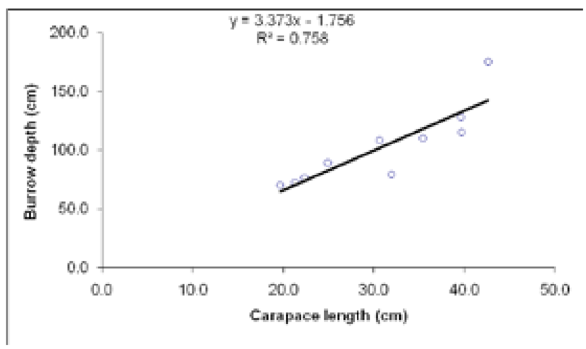

Figure 9 Relationship between carapace length and burrow depth for cast burrows

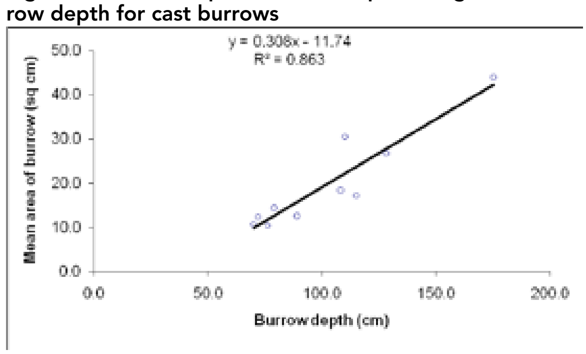

Figure 10 Relationship between burrow depth and mean area of burrow for cast burrows

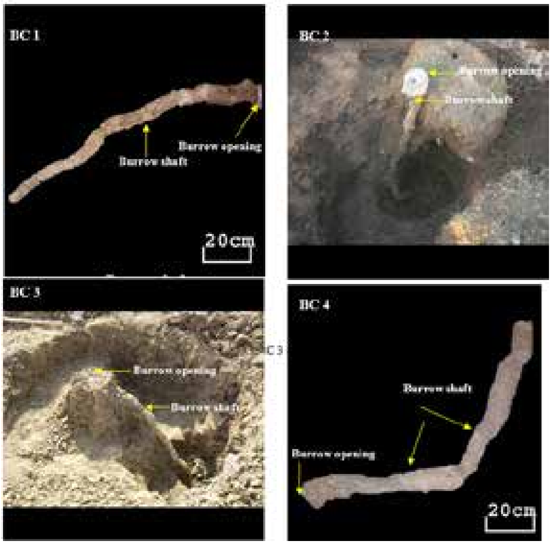

Figure 11 Cast of Burrows BC 1, BC 2, BC 3 & BC 4

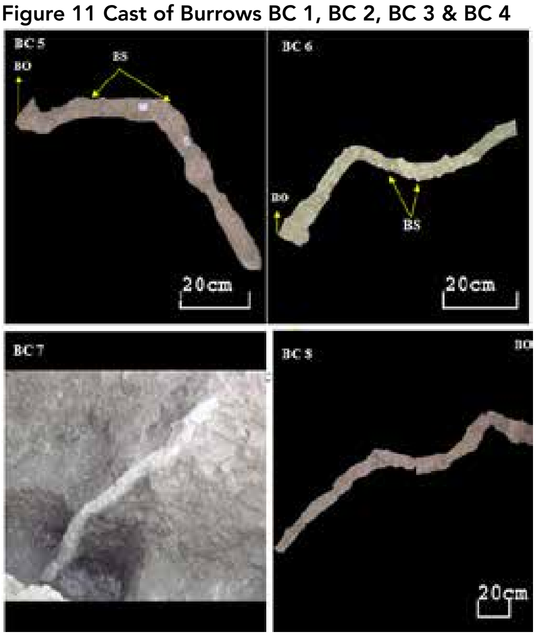

Figure 12 Cast of Burrows BC 5, BC 6, BC 7 & BC 8

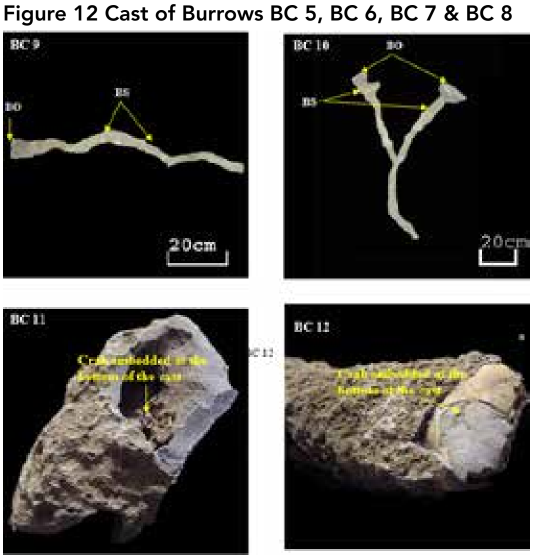

Figure 13 Cast of Burrows BC 9, BC 10, BC 12

BC 11 &

Table 1 Burrow characteristics and carapace measurements of *B.cunicularis*

Cast Number	Size of Burrow					Size of Crab	
	Opening (cm)		Surface Area of Opening (cm^2)	Depth (cm)	Mean Shaft Area (cm^2)	Carapace Length (mm)	Carapace Width (mm)
	Major axis	Minor axis					
BC 1	5	6.5	25.51	115	17.30	39.68	52.66
BC 2	3	4.5	10.60	76	10.53	22.36	34.28
BC 3	4.5	5	17.66	108	18.52	30.62	41.50
BC 4	6	6.5	30.62	128	26.84	39.62	54.20
BC 5	4.5	5.5	19.43	89	12.69	24.92	36.64
BC 6	3	4.5	10.60	72	12.44	21.32	28.64
BC 7	4	3.5	10.99	70	10.84	19.68	25.62
BC 8	6.5	7	35.72	175	43.97	42.62	58.24
BC 9	4.5	5	17.66	79	14.51	31.94	33.62
BC10 – a	5.5	6	25.91	110	30.59	35.42	49.84
BC10 – b	5	4.5	17.66	90	27.77		

10-a and 10-b are two openings of the same burrow. Common shaft depth was 40 cm. BC 11 and BC 12 show crab embedded in the cast.

DISCUSSION

Burrows can be of different shape and size, simple or complex, having many branches or a single opening depending upon the nature of the animals. In the present study the burrows of B. cunicularis were found to have ellipsoidal openings on the surface. Casting and excavation of burrows, however, revealed that burrows were simple, sometimes branched either straight or slightly slanted descending downwards. The burrows with single opening had straight branch, and exhibited S, J or L shape whereas burrows having two or three openings on the surface had branches with interconnections between them and exhibit U or Y shapes. The S shaped burrow may be unique to B. cunicularis as no earlier reference to it could be located in the available literature for the fresh water species. Morphology of the burrows has been investigated in the marine crab, Scylla serrata (Nandi and Dev Roy, 1991), using mixture of plaster of Paris and cement. Burrows have one, two or three openings on the surface and exhibit J-, U- or Y-shapes. Complex branched and multiple branched burrows have been often observed in thalassinids (Dworschak, 1983; Nash et al., 1984). The burrows of two species of crab Ocypoda have been studied on the sandy beach of western Sunderban, Bengal delta (Baksi et al., 1980). According to Iribarne et al. (1997) the shape of burrow varies as function of background areas. In the vegetated area the burrows are straight and nearly vertical, but in mud flats the burrows are oblique to vertical with funnel-shaped entrance and larger diameter. Chan et al. (2006) examined that the difference in the burrow architecture of ghost crab, Ocypode ceratophthalma appears to be related with the crab age and behaviour. The juveniles produced shallow J-shaped burrows, and the larger crabs have Y-shaped and spiral burrows. Burrows of Upogebia noronhensis, a thalassinidean shrimp showed a typical Y-shaped burrow pattern in about 70% of the cases, the remaining 30% comprised U-shaped burrows (Candisani et al., 2001). Dworschak (2001) using resin casting observed that the burrows of Lepidophthalmus louisianensis (the shafts and chambers) follow the spiral shape.

Burrow sizes vary, depending on season and carapace size of the crab. In the present study, a total of 98 burrows were examined, out of which 87 were with single opening, 9 had double openings and 2 were with triple openings. Most of the burrows of B. cunicularis had single openings. This finding corroborates the results of an earlier study Nandi and Dev Roy (1991) of burrow casts of Scylla serrata. They reported that 94% burrows had single external opening, 5% with two openings and 0.83% had triple burrow openings. Similar pattern was observed in the present study.

Observations while casting the burrows of B. cunicularis indicated that normally one crab occupies one burrow. Always a solitary crab came out from the burrow, while the slurry of cement and plaster of Paris was being poured into 13 burrows out of a total of 22. In the cast of 5 burrows, the crab was found to be embedded in the cast. In the remaining 4 burrows no crabs were observed either coming out of the burrow or embedded in the cast. One burrow cast presented two openings on the surface but only one crab was entrenched in the cast. This indicates that though the burrows have V- or Y-like configuration, they are occupied by single organism. The number of observations may not be statistically significant and hence it can be a subject for further study. Griffis and Suchanek (1991) observed the burrow morphology in thalassinidean shrimp having a simple Y-shaped pattern with two surface openings with one occupant per burrow.

In Barytelphusa cunicularis the area of the burrow opening varied from 10.6 to 35.72 cm^2. The depth of the crab varied from 72 to 175 cm, where as the carapace length and width of the crab were in the range of 19.68 to 42.62 and 25.62 to 58.24 mm, respectively. This indicates that possibly the larger crabs create deeper and more complex burrows for mating and refuges and can tolerate prolonged periods without renewing their respiratory water. In contrast, the Juvenile crabs have smaller gill areas and move out of the burrows regularly to renew their respiratory water and as a result they do not have deep burrows. According to Nandi and Dev Roy (1991) the longest diameter of the burrows of Scylla serrata varied from 53 to 117 mm, occupied by the crabs of carapace width 40 to 112 mm. Stieglitz et al. (2004) investigated the mean and maximum tunnel diameter of the crustaceans' burrows; which was 7 cm and 11 cm, respectively. Candisani et al. (2001) reported that in thalassinidean shrimp the internal diameter of the burrow strongly depended on the size of the animal with most of the burrows being as wide as the animal carapace.

Burrows provide crabs with protection from particularly high temperature, desiccation and predators while maintaining tolerable conditions with respect to other essential parameters. It has functional attributes and is associated with reproduction, behavioural, or physiological characteristics of the species. All these evidences suggest that crab burrow architecture may have adaptive significance in several ways, which merit further studies.

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REFERENCE

1. Atkinson RJA, Chapman CJ, 1984. Resin casting a technique for investigating burrows in sublittoral sediments. Progr. Underwat. Sci., 10:109-115. | 2. Atkinson RJA, Taylor AC, 1988. Physiological ecology of burrowing decapods. In Fincham, A.A. and Rainbow, P.S. (eds): Aspects of Decapod Crustacean Biology. Symposia of the Zoological Society of London 59, Clarendon, Oxford, 201-226. | 3. Baksi SK, Ray TK, De C. 1980. On the workings of some crabs on the sandy beach of Western Sundarbans, Bengal delta, India. J. Geol. Soc. India, 21: 184-187. | 4. Candisani CL, Sumida PYG, Pires-Vanin AMS, 2001. Burrow morphology and mating behaviour of the thalassinidean shrimp Upogebia noronhensis. J. Mar. Biol. Ass. U.K, 81: 799-803. | 5. Chan BKK, Chan KKY, Leung PCM. 2006. Burrow architecture of the Ghost crab Ocypode ceratophthalma on a sandy shore in a Hong Kong. Hydrobiologia. 560: 43-49. | 6. Deborah AR, Valerie C, Vincent HR. 2005. Morphology and impacts of the burrows of chinese mitten crab, Eriocheir sinensis H. Milne Edwards (decapoda, Grapsoidea), in South San Franciso Bay, California, U.S.A, Crustaceana. 78, 787-807. | 7. Dowrschank PC. 2001. The burrows of Callianassa tyrrhena (Petagna 1792) (Decapoda: Thalassinidea). P.S.Z.N: Marine Ecology 22. 155-166. | 8. Dowrschank PC. 1983. The biology of Upogebia pusilla (Petagna) (Decapoda, Thalassinidea). The burrows of Marine Ecology. 4: 19-43. | 9. Griffis RB, Suchanek TH. 1991. A model of burrows architecture and trophic modes in thalassinidean shrimp (Decapoda: Thalassinidea). Mar. Ecol. Prog. Ser. 79: 171-183. | 10. Iribarne O, Bortolus A, Botto F. 1997. Between-habitat differences in burrow characteristics and trophic modes in the South western Atlantic burrowing crab Chasmagnathus granulata. Mar. Ecol. Prog. Ser. 155: 137- 145. | 11. Nandi NC, Dev Roy MK. 1991. Burrowing activity and distribution of Scylla serrata (Forskal) from Hooghly and Malta estuaries, Sundarban, West Bengal, India. J. Bom. Nat. Hist. Soci. 88: 167-171. | 12. Nash RDM, Chapman CJ, Atkinson TJA, Morgan PJ. 1984. Observations on the burrows and burrowing behaviour of Calocaris macandreae (Crustacea: Decapoda: Thalassinoidea). J. Zool. 202: 425-439. | 13. Ribeiro PD, Iribarne OO, Daleo P. 2005. The relative importance of substratum characteristics and recruitment in determining the spatial distribution of the fiddler crab Uca uruguayensis, Nobili. J. Exp. Marine Biol. 314: 99-111. | 14. SHINN, E.A., 1968. Burrowing in recent lime sediments of Florida and the Bahamas. J. Paleont., 42: 879-894. | 15. STEVENS, B.A., 1929. Ecological observations on Callianassidae of Puget sound. Ecology., 10: 399-405. | 16. STIEGLITZ, T., P. RIDD & P. MA LLER, 2004. Passive irrigation and functional morphology of crustacean burrows in a tropical mangrove swamp. Hydrobiologia., 421: 69-76. | 17. SUCHANEK, T.H., 1985. Thalassinid shrimp burrows ecological significance of species-specific architecture. In Delesalle B (ed) Proceedings of the 5th international Coral Reef Congress, Tahiti. Antenne Museum, Ephe, Moorea, French Polynesia., 27: 205-210. | 18. VAUGELS, J.V.De., 1984. Preliminary observations on two types of callianassids (Crustacea, Thalassinidea) burrows, Gulf of Aqaba (Red Sea). In Proc. First Int. Symp. Coral Reef Environ. Red Sea., 1: 520-539.