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Original Article

Construction of earthen structure as a sexual signals in the fiddler crabs

Noor Us Saher*[1], Naureen Aziz Qureshi[2]

[1]Centre of Excellence in Marine Biology, Karachi University, Karachi, Pakistan.
[2]Faculty of Science and Technology, Government College, University, Faisalabad, Pakistan.

Abstract: We studied the reproductive behavior and the construction of an earthen structure in the four species of fiddler crab with reference to their habitat. Males of the *Uca sindensis* and *U. iranica* inhibit on open mudflats, construct the pillar and semidome structures at or near to the burrows openings. These structures perform the function to attract females, who wandering on the surface between male burrows for mating as well as provide protection or hiding object against the avian predator to mates. There were no earthen structures were observed in *U. urvillie* and *U. annulipes*, which inhibit among the vegetation. The well-marked intersexual different arrangement of mudballs was observed in *U. annulipes*. The earthen structures (pillar and semidome) and mudballs arrangements help courting females to assess the quality of mate as well as internal conditions of the burrow.

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Introduction

It is a well-known phenomenon that adult males of some species of fiddler crabs belonging to the genus *Uca* construct an earthen structure at the entrance of the burrow (Crane, 1975). Von-Hagen (1968) listed twelve different species that construct such structures. Studies have shown that there are specific differences in size and shape of the structures. Crane (1975) reviewed these structures in fiddler crabs of the world. The males of 17 species have been reported to build an earthen structure as semidomes (shelter like structure), rims (a more delicate, vertical structure, which ranges from a tall, wide hood to a tall, narrow column or pillar) and chimneys next to their burrows during reproductive season (Christy, 1988a; Christy et al., 2001). Chimneys were found in some subgenera: *Australuca* (*U. elegans*), *Amphiuca* (*U. iranica*), *Boboruca* (*U. thayeri*), *Deltuca* (*U. dussumieri*, *U. arcuata*, *U. forcipata, U. coarctata*, and *U. urvillei*), *Celuca* (*U. cumulanta* and *U. stenodactylus*), *Minuca* (*U. vocator,* and *U. subcylindrica*) and *Thalassuca* (*U. tetragonon*) (Crane, 1975; George and Jones, 1982; Thurman, 1984).

The constructions of earthen structures have been shown to function for sexual attraction that build as pillars (Christy, 1988a, b), hoods (Zucker, 1974, 1981; Christy et al., 2002, 2003), mud balls (Oliveira et al., 1998) and chimneys (Shih et al., 2005). These earthen structures are useful to protect the fiddler crabs in different conflicting behavior such as fighting, burrow occupation and disturbance caused by neighbours (Zucker, 1974; Salmon, 1987; Oliveira et al., 1998; Wada and Murata, 2000; Shih et al., 2005), while some other studies have indicated usefulness of these structures in environmental regulation through hoods (Powers and Cole, 1976) and chimneys (Crane, 1975; Thurman, 1984) as well as in parental care (incubation of eggs) and protection from enemies through chimney (Shih et al., 2005). In many species, only reproductively active males build earthen structures and they have been supportive to reduce aggression behavior between neighbouring males (Zucker, 1974;

* Corresponding author: Noor Us Saher
E-mail address: noorusaher@yahoo.com

Clayton, 1988; Wada et al., 1994; Oliveira et al., 1998), attract females for mating (Crane, 1975; Christy, 1988a, b, 1995; Oliveira et al., 1998; Christy et al., 2001, 2002), and protection of gravid females after mating (Shih et al., 2005). In addition Kim and Choe (2003) and Kim et al. (2004) considered semidome to be, an indication of courtship activity. Kim et al. (2004) suggested that the semidome of *U. lactea* perform the function of reducing aggression or to attract females.

The objectives of this study were to study the appearance and the construction of earthen structure of fiddler species and the correlation of these structures with the breeding season.

Materials and Methods

Study site: Two sites, Sandspit and Korangi creeks, were selected for the fiddler crabs collection due to the presence of marked distinct distribution patches of fiddler crabs. The Sandspit backwaters mangrove area is located at south west of Karachi (24°50'N, 66°56'E). The backwater is connected to the Arabian Sea through the Manora Channel. The Sandspit beach is bifurcated by a dry strip of land, with mudflats and mangrove vegetation found on northern side and the sandy coast on its south. The dense vegetation is comprised of the monospecific stand of mangrove species, *Avicennia marina.* The second study site was located (24°79'N, 67°20'E) in the Korangi creek mangrove area near the salts works located in fishing village of Ibrahim Hyedri. The north most creeks of the Indus Delta are the Korangi and Phitti creeks of which Korangi creek is 12 km from Karachi Harbour and 9 km from Quaidabad. Korangi creek is connected at its northeastern end with Phitti creek and Kadiro creek, while at its southwestern end, it connects with open sea and with Gizri creek, and is bounded on its sides by extensive mangrove vegetation of *A. marina.*

Study fiddler crab species: The reproductive behaviour of four commonly distributed species of fiddler crabs was studied. *Uca urvillei* is the only narrow fronted species found in the shadow or canopy of the mangrove trees; *U. iranica* is the most frequently found species mostly distributed from low tide level to high tide level of sandy cum muddy areas; *U. annulipes* is mostly associated with fringing mangrove or among pneumatophores; *U. sindensis* is mostly found at the high tide level of muddy cum sandy area. *Uca iranica* and *U. sindensis* were usually distributed on the open mudflat areas adjacent to the mangrove vegetation.

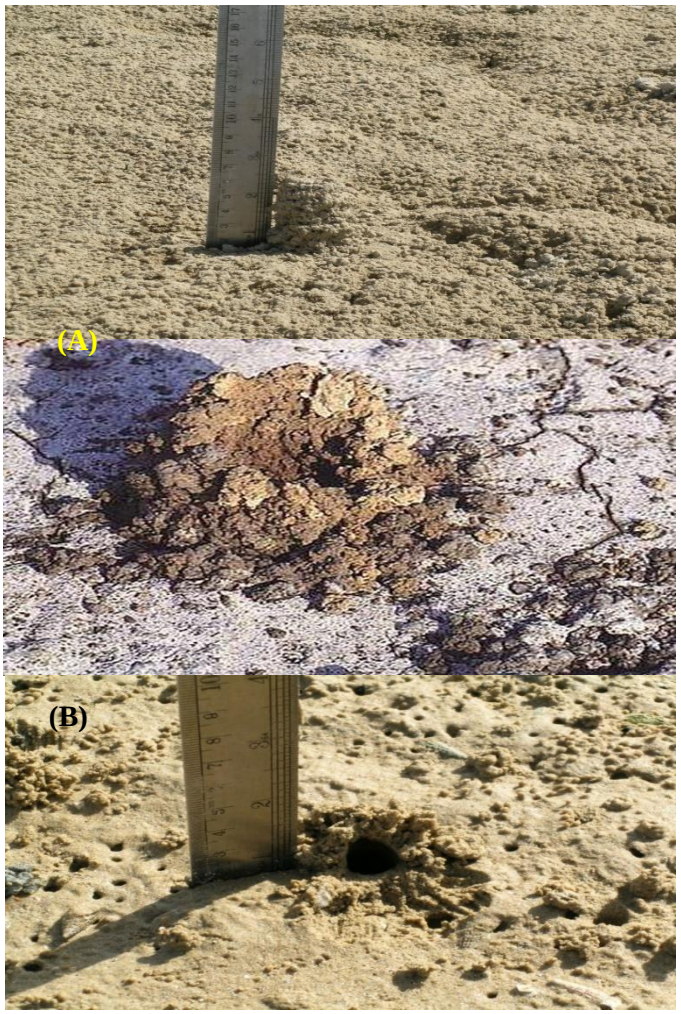

Figure 1. Earthen structures constructed by males of *Uca* species during breeding season. (A) Pillar constructed by male crab of *Uca sindensis* by bring the mud from inside the burrows and (B) Semidome structure constructed by the male crab of *Uca iranica* by scrapping the mud from opposite side.

Earthen structure construction behavior: Initially the data on the size of male crab and burrow diameter relationship were collected for the male crabs of the species. The construction behavior and appearance of the earthen structures in the species of fiddler crabs were studied. Data were collected from the visual field observations (Figs. 1 and 4).

Table 1. Summary of descriptive statistics for different parameters of the earthen structure constructed by three species of fiddler crab.

Species	Variable	n	mean ± SD	min	max
Uca sindensis	Burrow diameter (mm)	45	11.9±1.2	10.0	14.0
	Pillar height (mm)	45	90.0±16.0	50.0	125.0
Uca iranica	Burrow diameter (mm)	50	16.6±2.5	12.0	20.0
	Semidome height (mm)	50	60.0±6.0	50.0	75.0
	Semidome width (mm)	50	75.0±7.7	62.5	87.5
Uca annulipes	Burrow diameter (mm)	50	14.0±3.1	8.0	19.0
	Number of mudballs	50	24.0±5.9	13.0	38.0
	Farthest mudball distance (mm)	50	130.0±26.0	87.5	200.0

Results

Like most of the species of fiddler crabs, construction of earthen structures have been associated with reproductive season. The appearance of earthen structures starts with the initiation of breeding season.

Uca sindensis: The structures of this species start to appear from the end of February or beginning of March with increasing temperature and were observed up to July. The male crabs began to build a cylindrical structure, a pillar (with mean height of 90.0±16.0 mm) for an average burrow diameter (11.9±1.2 mm), with height range of 50-125 mm, next to the burrow opening south wards in the direction of low tidal level (Table 1). These pillars were composed of large wet soil pellets or mudballs (Fig. 1). The sediment material of mudballs is darker in color than the substratum and indicates it has been excavated and was carried up from inside the burrow. A linear relationship (r^2=0.694) between burrow diameter and pillar height (mm) was observed (Fig. 2). In addition, male crabs were observed to make definite waving display and waving increase (double than usual) in the presence of females. The underground mating was observed as during excavation of burrow, the presence of male and female crabs suggested the mating takes place within the burrow.

Uca iranica: The courting males of *U. iranica* build semidomes (or shelter like) structures on their burrows openings. These structures were observed from the month of May to September at the collection site of this species. To build the structure

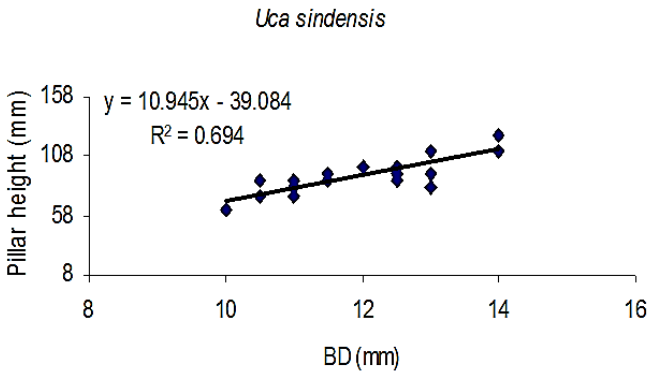

Figure 2. Linear relationship between burrow diameter and pillar height (mm) for *Uca sindensis*.

bits of mud from the substratum surface was scraped with the help of their walking and staked the similar material on the opposite side of burrow entrance with the help of his major claw (Fig. 1B). The size of burrows and the height and width of these semidomes structures showed the mean burrow diameter as 16.6 ± 2.5 mm with the mean height of 60.0±6.0 mm (Table 1). In addition, male crabs were observed to increase waving display of enlarge cheliped in the presence of females. The surface mating was also never observed and during excavation of burrows both, the presence of male and female crabs confirmed the underground mating. A good corresponding positive linear relationship was observed between Burrow Diameter (BD) and the width of semidome (r^2=0.57) and between BD and the height of semidome (r^2=0.64; Fig. 3).

Uca annulipes: There were no special structures around the burrow, but markedly different arrangements of mudball sequence were observed during the month of September to November. The

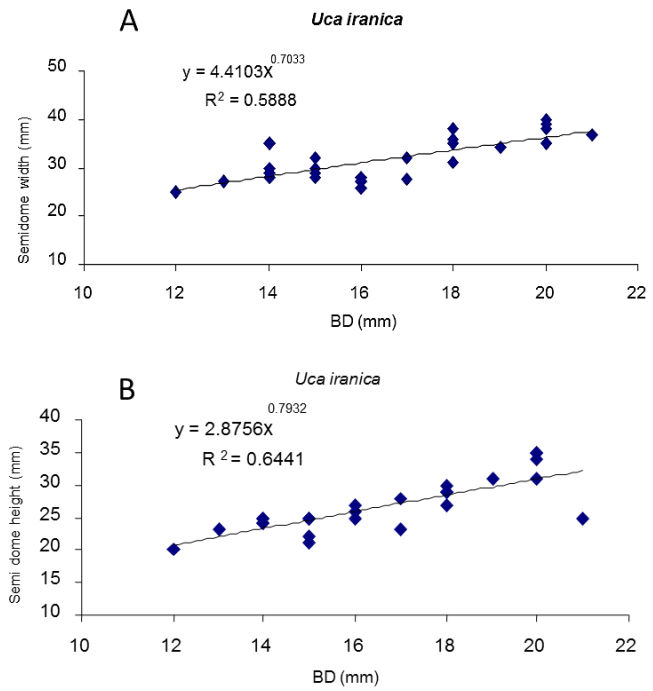

Figure 3. Linear relationship between (A) burrow diameter (mm) and semidome width (mm) and (B) burrow diameter (mm) and semidome height (mm) for *Uca iranica*.

mudball placement behavior was observed during the reproductive period for the male and female crabs. Apparently intersexual difference in the arrangement and number of mudballs were observed (Fig. 4). The male crabs placed more number of larger mudballs forming an arc (north wards mostly towards the high tidal level) around its burrow. The mean numbers of mudballs was 24.6±5.9 that were found and at the mean distance of 130.0±26.0 mm from the burrow opening with an average diameter of 14.0±3.1 mm (Table 1). Positive correlation was observed between BD and the number of mudballs adjacent to the burrows and the BD with the farthest placement of mudballs (r^2=0.52 and r^2=0.35) was observed (Fig. 5). There is no evidence for surface mating, thus the mating was underground or within burrows.

Uca urvillei: There were no special structure around the burrow nor were any marked arrangements of mudballs sequence observed. During field observation the surface mating was observed. In *U. urvillei*, male crabs do not construct the burrows and usually wandering on the surface within

Figure 4. The mouthball arrangement of *Uca annulipes* around the burrows. (A) Male and (B) female.

vegetation and at the time of the threat they escape in to the nearest burrow of other ocypodid or grapsid crabs.

Discussion

In present study, *U. sindensis* build a cylindrical pillar next to the burrow opening south wards in the direction of low tidal level these pillars were composed of large wet soil-pellets or mudballs and the courting males of *U. iranica* build semidomes (or shelter like) structures on the mouth of burrows openings by scraping the mud from the surface substratum towards the high tidal level. Like most of the species of fiddler crabs construction of earthen structures have been associated with reproductive behaviour. The appearance of earthen structures clearly coincides with the presence of ovigerous females and initiation of the breeding season. These structures likely increase the attractiveness of the mate for the sexual selection. Kim et al. (2004)

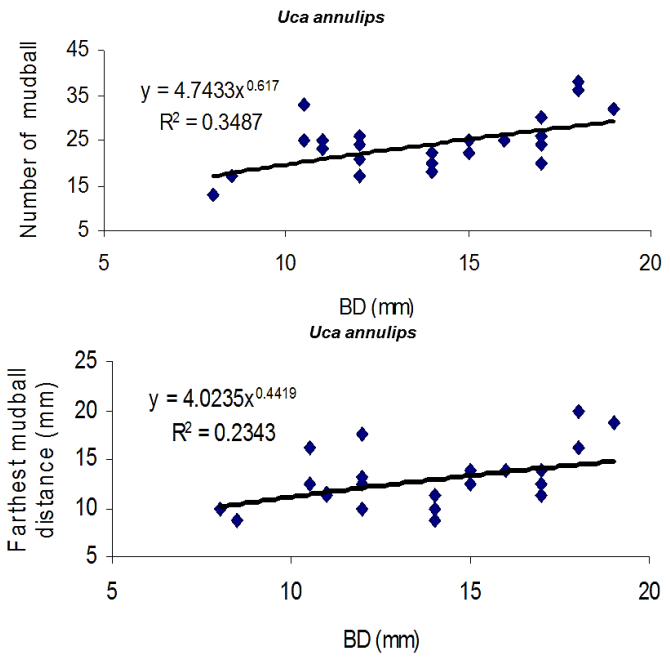

Figure 5. Linear relationship between (A) burrow diameter (mm) and the number of mudballs, and (B) burrow diameter (mm) and distance of farthest mudballs (mm) for *Uca annulipes*.

reported during mating season male crabs of *U. lactea* built semidomes at their burrow entrances to attract females for mating in the upper intertidal zone of mudflats, which were beyond the reaches of neap tides. Zucker (1981) suggested that male of *U. musica* build hoods to increase the time during mating and to reduce territorial overlap and aggressive interaction between neighbouring male crabs.

The pillar and hood building are condition dependent behaviours (Blackwell et al., 1995; Christy et al., 2001). The primary functions of these structures are related to courtship signaling but not to aggression between males (Christy, 1988; Kim et al., 2004). Male crabs of *U. beebei* also built pillars next to their burrow entrances for attracting mate searching female crabs (Christy et al., 2003). Christy et al. (2003) observed that females attracted to structure building males likely mate with superior males that may end in fitness benefits and reduce predation risks and thus ecological factors shape evolutionary patterns in different species. In *U. formosensis* chimney is built by male crabs after successfully luring the female into his burrow for underground mating (Shih et al., 2005). Shih et al. (2005) hypothesized chimney building of male *U. formosensis* before neap tides as a byproduct of excavation of the burrow that widens the shaft and deepens the burrow so that it reaches the water table and keeps the chamber, moist for female to incubate her eggs. In addition, the mudballs are piled to make chimney at burrow openings also serve as a refuge from enemies (Shih et al., 2005). The association of the claw-waving display with a defended territory and with earthen structures serves as a territorial advertisement signal to both receptive females and rival males (Brown, 1975; Crane, 1975; Weygoldt, 1977; Von-Hagen, 1993).

Mudball formation is a common characteristic feature of genus *Uca.* Oliveria et al. (1998) observed European fiddler crab *U. tangeri* both male and female crabs placed their mudballs around their burrow openings with major difference in mudballing behavior. They suggested that mudballs of females were the byproduct of burrow excavation and mudballs placement by males may exhibit dual function, to reduce the number and intensity of aggressive interactions between neighboring male crabs and to attract females. This type of mudballing behaviour has been observed in *U. annulipes* and was more evident during the reproductive season. There was no intersexual difference in the number of mudballs, but the placement and arrangement of mudballs was evidently different between sexes, this difference was more obvious during the breeding season and this difference indicated that mudball function in males spacing by making territories for attracting and copulatory activities.

The size of territory and number of mudballs helps the female to assess male quality as well as internal condition of male burrow. Some authors have noted that males of some species apparently increase their rate of waving when approached by either males or females (Doherty, 1982; Crane, 1975) although salmon, Stout (1962) demonstrated that male *U. pugilator* increased their waving rate when presented with females, but not with males.

The male crabs of *U. urvillei* usually does not construct their burrows (Data unpublished, observed

in field as well as in lab experiment) and they are usually wandering among the vegetation during the low tide period, when these crabs feel threats they immediately hide themselves in the nearest burrow of other crab or invade in soft mud. These crabs usually attract females by vigorously waving their enlarge cheliped in sun light. Some authors have noted that males of some species apparently increase their rate of waving when approached by either males or females (Doherty, 1982; Crane, 1975) although Salmon and Stout (1962) demonstrated that male *U. pugilator* increased their waving rate when presented by females, but not with males. The surface mating was observed in *U. urvillie*.

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