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3. DISCUSSION

1. Introduction

The Infraorder brachyuran contains 6,793 species in 93 families (Ng. et al., 2008). While Indian contributes about 705 species and in Gujarat 113 species were reported (Dev Roy, 2013; Trivedi et al., 2015). Out of 113species of brachyuran crabs reported from Gujarat, 100 species were reported from Gulf of Kachchh, 40 species are reported from Saurashtra coast and only 22 species are reported from Gulf of Khambhat (Trivedi et al., 2015). First comprehensive work on brachyuran crabs of Gujarat state was carried out By Chhapgar in different parts of Gujarat who has reported 42 species of brachyuran crabs from different sites like Okha, Kodinar, Umarsadi, Kolak and Udwada (Chhapgar, 1957; 1958). After that Chandy (1969; 1973) and Chhapgar & Mundkur (1995) have added few more crabs to the existing list of brachyuran fauna of Gujarat.

Recently, Trivedi et al. (2011) and Beleem et al., (2014) have worked on crab diversity in some selected sites in Gulf of Kachchh. Trivedi and Vachhrajani (2012; 2013) have studied the diversity and distribution of brachyuran crab at Saurashtra coast. Shukla et al. (2013) and Pandya & Vachhrajani (2013) have studied diversity of brachyuran crab at the estuarine area of Gulf of Khambhat. Dev Roy (2013) has provided checklist of marine brachyuran crab fauna of western coast of India where he listed occurrence of 62 species of brachyuran crabs form the coastal areas of Gujarat state. Recently, *Petrolisthes boscii* (Audouin, 1826), *Petrolisthes lamarckii* (Leach, 1820), *Scylla tranquebarica* (Forskal, 1775), *Scylla olivacea* (Herbst, 1796) and *Leptodius affinis* (De haan, 1835) have been recorded for the first time in Gujarat (Trivedi and Vachhrajani, 2013a; 2013b; 2014) where as *Macrophthalmus laevis* (A. Milne Edwards, 1867) and *Heteropanope glabra* (Stimpson, 1858) were recorded for the first time in India (Trivedi et al., 2014; 2015). A new species of brachyuran crab *Ilyoplax sayajiraoi* Trivedi, Soni & Vachhrajani 2015 has been described from study site (Trivedi et al., 2015). Many environmental variables are associated with spatio-temporal variations in the abundance and distribution of crabs, such as temperature, salinity, sediment texture and organic matter content and, indirectly, depth (Bertini and Fransozo, 1999; Bertini et al., 2001; Costa et al., 2005; Hiroki et al., 2011). The variation of these variables allows for the presence of organisms in the environment or not, depending on their tolerance to these variables (Lima et al., 2014). Thus, understanding the causes of such variation is fundamental to comprehend the distribution of a species (Mantelatto and Fransozo 1999, Lima et al., 2014).

Intertidal flats within an estuary exhibit significant variability in benthic macrofaunal species composition, density and biomass, and there is a long history of investigations in which this variability has been related to such environmental variables as salinity, sediment types and tidal depth (McIntyre, 1970; Key, 1983; Elliott and Kingston, 1987; Jones, 1988; Meire et al., 1991; Dauer, 1993; Beukema, 2002; Ysebaert and Herman, 2002; Ysebaert et al., 2003; Fujii, 2007; Pandya, 2011). Vertical zonation of marine organisms in the intertidal has yielded important insights into the role of interspecific interactions in community organization (Menge and Branch, 2001; Pandya and Vachhrajani, 2010). Estuarine intertidal areas have high abundance and diversity of macrobenthic invertebrates, attributable to a high concentration of organic matter and nutrients retained in the system (Atrill, 2002; Fujii, 2007). Sediment type and strata formation are some of the important features of habitat selection by different benthic animals (Snelgrove and Butman, 1994; Vachhrajani and Pandya, 2011). Pattern of intertidal habitat zonation has been of major concern for marine ecologist and there is considerable work on documenting the factors responsible for the vertical distribution of intertidal organisms. A general trend is a tendency for the upper limit of species to be determined by physical perturbations of the environment (e.g. desiccation and thermal stress) while lower limits are often the result of biotic interactions such as competition and predation (Cornell, 1961).

The general models to describe coastal assemblages of species have been based on the role of competition (Cornell, 1983) predation (Paine, 1974), disturbance (Sousa, 1980) and the role of the supply of larvae (Grosberg and Levitan, 1992). There is no doubt that the supply of larvae is a key factor, but once larvae arrive, the other factors are allimportant (Dayton, 1971; Menge, 1976; Underwood et al., 1983). However, competition for space and direct interference within and among species is usually weaker in three-dimensional soft-substratum habitats (Wilson, 1980; 1991), although competition for limiting food resources may be important (Iribarne et al., 2003; Martineto et al., 2007). Nevertheless, there are cases when the resource is space that competition becomes important (Wilson, 1991). Indeed, the few examples of competitive interaction among soft-substratum dwellers involve organisms that share access to the sediment such as gastropods (Levin, 1981) and suspension feeding polychaetes (Woodin, 1974, 1976), yet habitat displacement has been reported in a few cases (Peterson, 1977; Peterson and Andre, 1980; Wilson, 1980; Brenchley and Carlton, 1983).

Intertidal species are subject to a wide range of environmental variables (Chelazzi and Vanini, 1988) and Common responses of benthic organisms are rhythmic movements (vertical or horizontal), mainly related to the tidal cycle (Chelazzi and Vanini, 1988; Escapa et al.,, 2004). Vertical movements in response to tidal cycles are characteristic ofthis fauna, allowing them to remain in areas with good feeding conditions and minimizing the exposition to terrestrial and marine predators (Brown and McLachlan, 1990). Alternations in patterns of dispersion may be regular and include seasonal (Feare, 1971; Turchin, 1988), circadian and/or circatidal changes in behaviour (Moulton, 1962; Rhode and Sandland, 1975; Chelazzi and Vanini, 1988, Escapa et al., 2004). Alternatively, changes in behaviour may be determined by responses to environmental cues, such as exposure (Chelazzi et al., 1984), hot weather (Moran, 1985a), large waves, the previous history of emersion (Moran, 1985b) or desiccation (Cook, 1981) or the abundance of food (McKillup, 1983). Moran (1985b) found that alternation between aggregating anddispersing to feed in the whelk *Morula marginalha* was cyclical, but the timing of these cycles varied across the shore depending on local environmental conditions. Aggregation may provide different advantages to a species, including escape from parasitism or predation (Turchin and Kareiva, 1989), exploitation of resources (Stanton, 1983), mating (Scott, 1974) and protection from unfavourable conditions (Cook, 1981; Chapman and Underwood, 1996). Since the work of Naylor (1958) and Crothers (1968), who both demonstrated circatidal rhythmicity in the locomotors activity of the common shore crab, *Carcinus maenas*, with increased activity levels coincident with periods of high tidal elevation many papers have been published relating to the importance of tidal forcing on marine organisms. Rajan et al. (1979) and Williams (1985) have all reported endogenous cyclical changes in the haemolymphsugar concentrations of *C. maenas*, with peak concentrations occurring at low water.

At present study site, *Uca Annulipes* was distributed in the upper intertidal area where water inundate during specific spring tide days and during summer temperature is very high so desiccation play key role in the distribution and activity pattern of this species. *Ilyoplax sayajiraoi* covers mid intertidal area and water inundate regularly during whole tidal cycle hence condition are favourable here and intra and inter species competition for food and space play important role in density, distribution and activity. *Dotilla sp.* distributed homogenously at lower intertidal area. *Dotilla sp.* shows aggregation behaviour during recruitment season when density and distribution reaches at its peak. We aim to check the hypothesis (1) the substratum and species interactions play important role in the distribution pattern of macrobenthic assemblages on the intertidal mudflats and (2) Density, distribution and activity pattern of brachyuran crab are changes according to season and tidal cycle.

2 Result

2.1 Taxonomic Identification

Total 9 species of crab belong to 8 genuses to 8 families and 1 species of mudskipper were identified from the downstream of the estuary (Table 1). Sediment type and intertidal zonation were seen to be the governing factors in the brachyuran distribution. The planktonic diversity of the Mahi estuary included representatives of phyla Protozoa to Arthropoda. Total 40 planktonic organisms belonging to 21families to 13 orders to 6 Phyla were recorded from the downstream of the estuary (Table 3).

Taxonomic details of identified species of brachyuran crabs have been given in details:

1. ***Euricarcinus orientalis* A.** Milne-Edwards, 1867

Taxonomy

Kingdom: Animalia
Phylum: Arthropoda
Class: Malacostraca
Order: Decapoda
Family: Pilumnidae
Genus: Euricarcinus

Synonyms

Eurycarcinus orientalis A. Milne Edwards, 1867
Eurycarcinus orientalis de Man, 1892

Description

Carapace rather over two-thirds as long as broad, perfectly smooth, decidedly convex fore and aft and slightly so from side to side. Antero-lateral border cut into four thin shallow teeth, of which the first two are rounded and the last two are anteriorly acuminate, the first being the least prominent of all and the last being the smallest of all. The antero-lateral border is extremely short, a good deal less than two-thirds the length of the postero-lateral.Chelipeds markedly unequal, perfectly smooth, inner angle of wrist rather strongly pronounced.The legs and under surface of the body are covered with a dense, extremely short scurfy tomentum

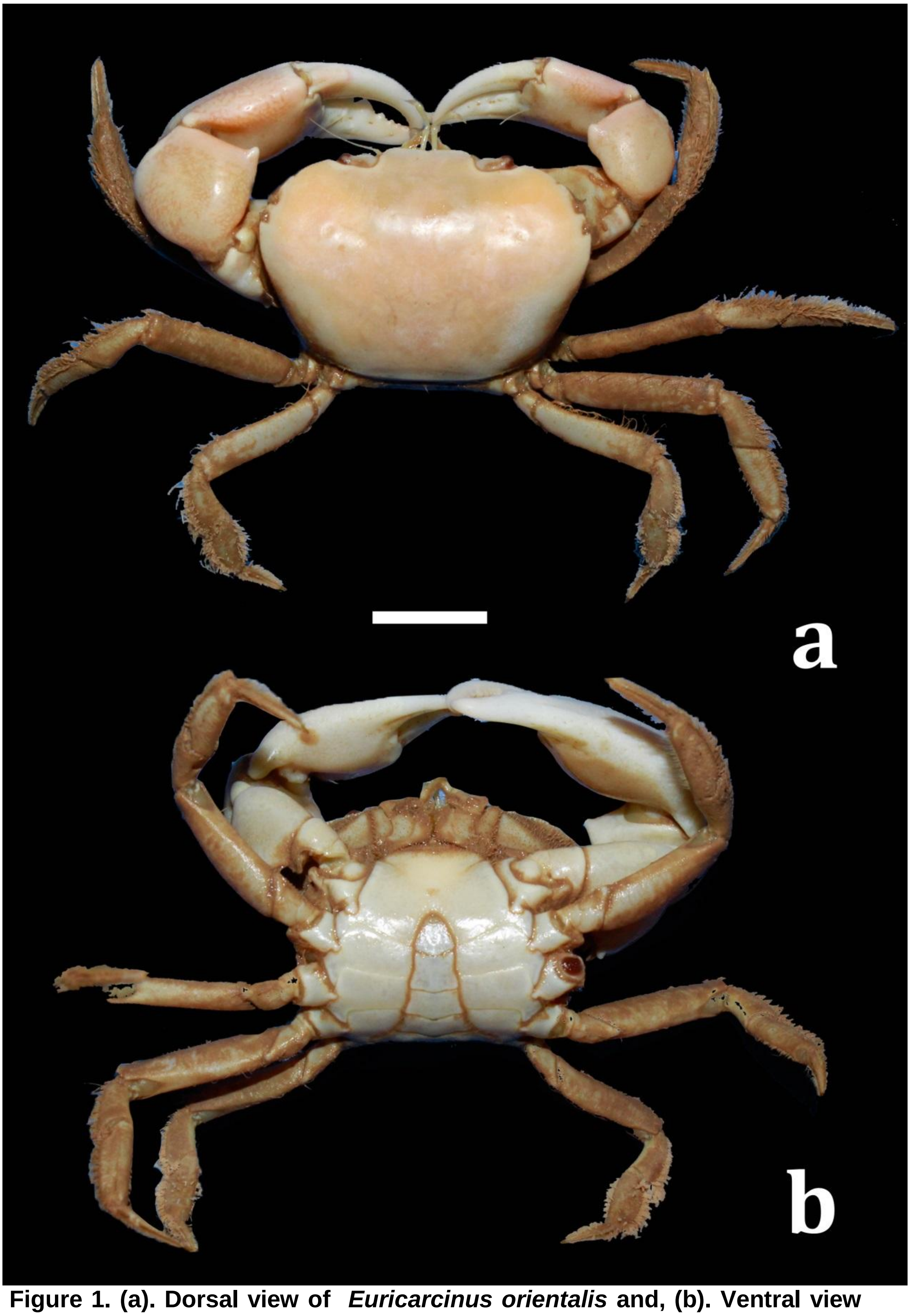

Figure 1. (a). Dorsal view of *Euricarcinus orientalis* and, (b). Ventral view of *Euricarcinus orientalis*.

2. *Uca (Austruca) annulipes* De Haan, 1835

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Ocypodidae

Genus: Uca

Synonyms

Uca lactea annulipes H. Milne Edwards, 1837

Ocypodelactea (De Haan, 1835)

Description:

Carapace with orbits moderately oblique; front broad, narrowest below eyestalk bases; antero-lateral margins approximately straight, converging, exorbital tooth acute and produced, directed antero-laterally. Palm of major cheliped finely granulate to tuberculate in the center of inner face, oblique ridge high and thin, tubercles largest on highest point of ridge; outer face with extremely minute tubercles, no depression at base of immovable finger; small cheliped in both sexes with merus not flattened posteriorly and not armed with a supra ventral row of tubercles, gape throughout about as wide as immovable finger, with weak serrations, which may be absent. Meri of fourth and fifth pereiopods narrow, fifth always strikingly slender. Horny terminal end piece of male first pleopod with strongly developed flanges; palp short.

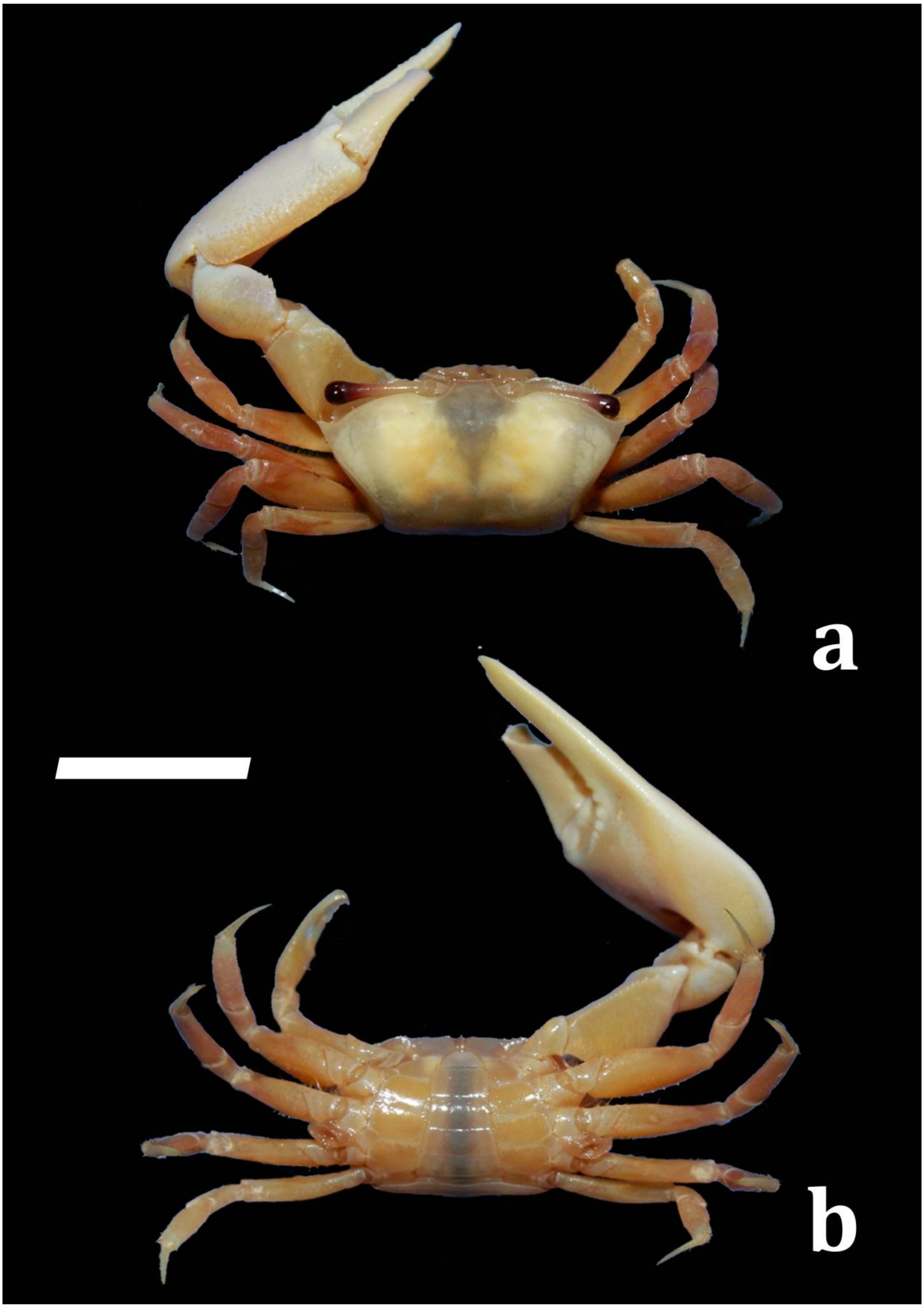

Figure 2. (a). Dorsal view of *Uca lactea* and (b). Ventral view of *Uca annulipes*.

3. ***Ilyoplax sayajiraoi Trivedi***, Soni, Trivedi and Vachhrajani 2015

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Dotillidae

Genus: Ilyoplax

Description:

The carapace is transversely oblong, with the anterior breadth one and a half times the length; the upper surface of the carapace is slightly convex on both sides and moderately sculptured. The anterolateral border is slightly and evenly convex, the breadth in the middle decidedly larger than the breadth between orbital angles. A shallow depression is present parallel to the orbital region on both sides; the depression excavates near the median furrow. A sharp, perfectly transverse and straight ridge is present above the posterior carapace margin. The front is obliquely deflexed and the apex broadly rounded. Orbits are slightly oblique, not transverse. The outer orbital angle consists of an acute tooth directed outwards. A small notch is present behind the outer orbital angle, which runs down with a series of minute tubercles. The lateral margins are defined by a sharp crest bearing long setae.The chelipeds of the male are strong, slender, well developed and longer than the female chelipeds; the length of the chelipeds is less than twice the length of the carapace. In a large male, a dense patch of tomentum is present on the second walking leg extending from the middle of the carpus to the distal third of the propodus.The third walking leg is the longest at two and a half times the length of the carapace.The male G1 is slender, tapering distally.

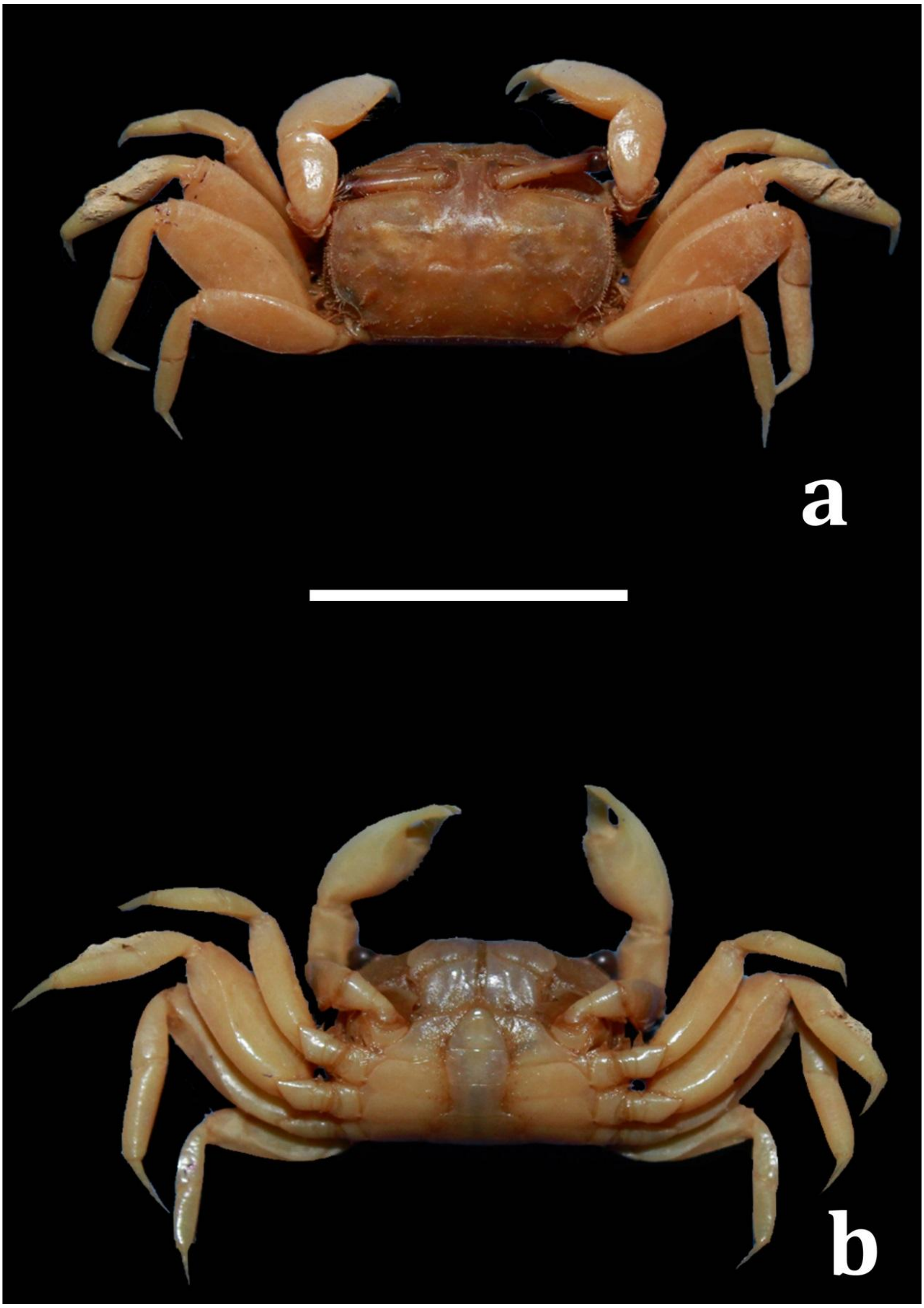

Figure 3. (a). Dorsal view of *Ilyoplax sayajiroai*and (b). Ventral view of *Ilyoplax sayajiraoi*.

4. *Metopograpsus messor* Forskal, 1775

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Grapsidae

Genus: Metopograpsus

Synonym:

Cancer messor Forskal, 1775

*Grapsus (Pachygrapsus) aethiopicus*Hilgendorf, 1869

Grapsusgaimardi Audouin, 1826

Description:

Lateral margins of carapace entire, distinctly converging backwards; free edges of the postfrontal lobes rounded and blunt, postfrontal region with distinct ridges or markings. Suborbital tooth acute strongly keeled from tip to base. Exposed surface of the base of the antenna not densely pubescent.Third and fourth pereiopods without pubescence on lower border; fifth pereiopod without a linear fringe of hairs on the upper margin of the propodus.Male abdomen with sixth segment shorter than fifth.Horny terminal endpiece of first male pleopod short.

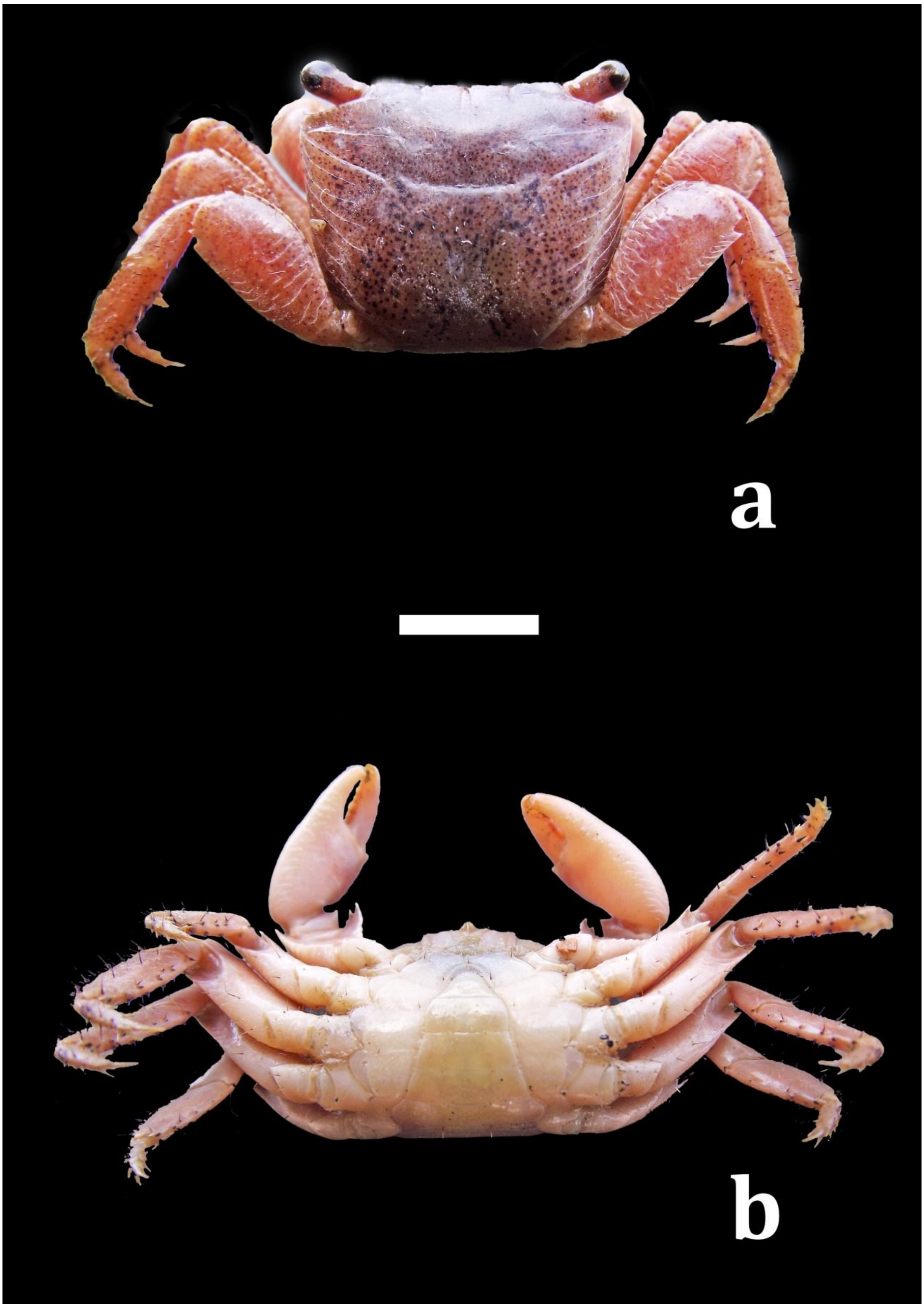

Figure 4. (a). Dorsal view of *Metopograpsus messor* and (b). Ventral view of *Metopograpsus messor*.

5. *Macrophthalmus sulcatus* H. Milne Edwards, 1852

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Macrophthalmidae

Genus: Macrophthalmus

Description

The eyestalks project slightly beyond the antero-lateral angles of the carapace. The true first tooth of the lateral border of the carapace belongs to the upper border of the orbit, and the antero-lateral angle of the carapace is formed by the true second tooth.

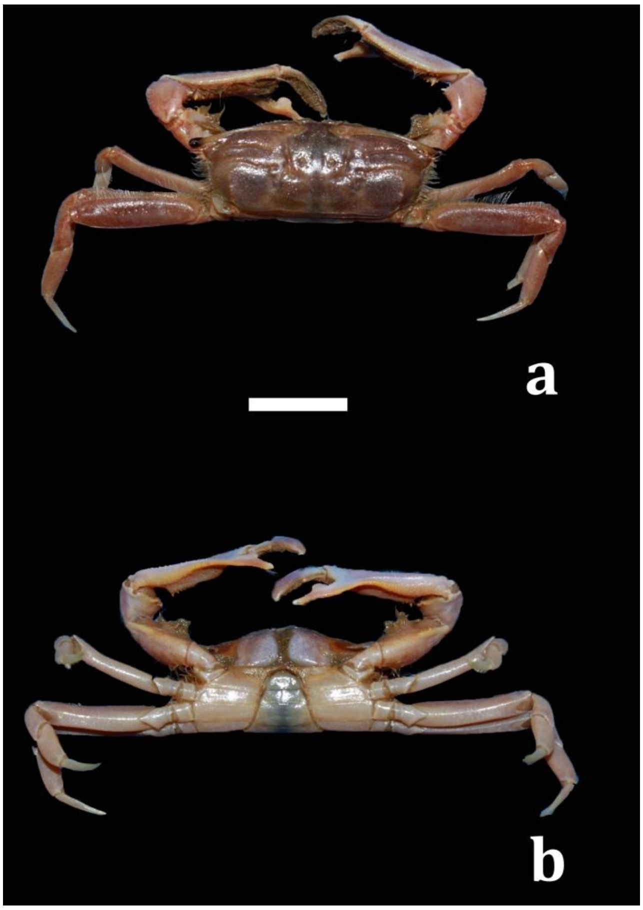

Figure 5. (a). Dorsal view of *Macrophthalmus sulcatus* and (b).Ventral view of *Macrophthalmus sulcatus*

6. *Scylla serrata,* Forskal, 1775

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Portunidae

Genus: Scylla

Synonym:

- *Achelous crassimanus*MacLeay, 1838
- *Cancer serrata* Forskal, 1775
- *Lupalobifrons* H. Milne Edwards, 1834
- *Scylla tranquebarica var. oceanic* Dana, 1852.

Description:

Carapace transverse, broad, moderately convex, perfectly smooth and unbroken except a curved transverse ridge; front four dentate, middle two teeth of equal length; antero-lateral borders cut into nine sharp acuminate teeth of almost equal size. Hands inflated and almost smooth; palm swollen and arm with three spines on the anterior border and two on the posterior border. Legs ambulatory and unarmed, last pair paddle-like and adapted for swimming. Abdomen of male broadly triangular, outer basal of the first pair of abdominal appendages more rounded in male with denser spinules. The anterior male abdominal appendages are elegantly bent and bear hairs along one border and spinules along the other. The tip is shaped like a scapel and bears a patch of spinules. Solitary, swimmers as well as burrowers.Adapted to salinities ranging from almost freshwater to that of seawater.

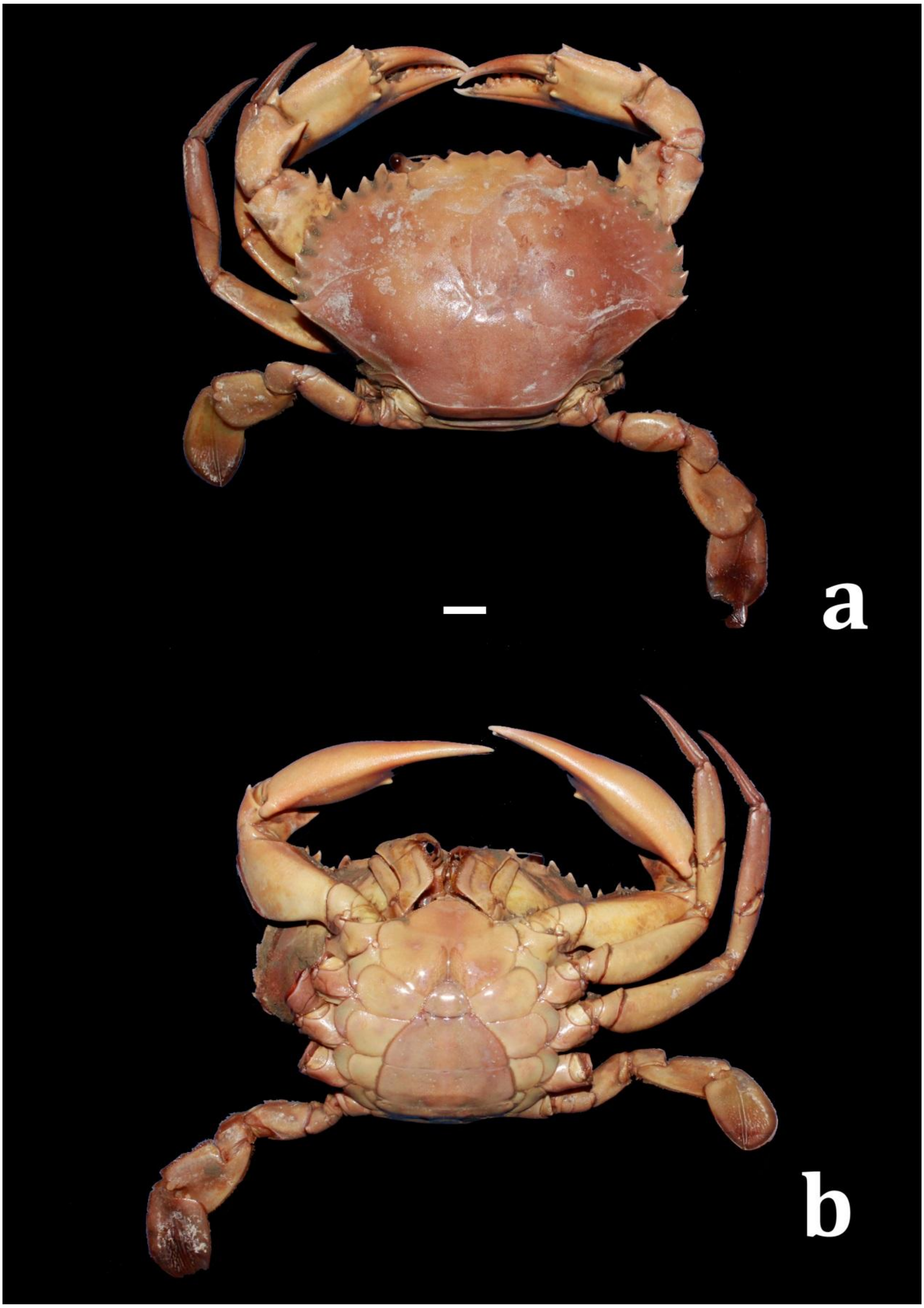

Figure 6. (a). Dorsal view of *Scylla serrata* and (b). Ventral view of *Scylla serrata.*

7. ***Ashtoret lunaris*** **Forskal, 1775**

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Matutidae

Genus: Ashtoret

Synonym:

- Cancer lunaris Forskal, 1775
- Matuta banksii *Leach, 1817*

Description:

Carapace sub circular, almost smooth with indistinct tubercles, somewhat depressed and with a prominent horizontal spine at the lateral apibranchial angle, on either side; postero-lateral borders sharply convergent; front wider than the orbit. Longitudinal ridge of dactylus of cheliped strongly milled; palm with spine-like teeth at the base of the lower outer angle near the wrist. Last four pairs of thoracic legs oar-shaped for swimming. The anterior male appendage straight, slender with arrowhead-like terminal portion bearing numerous blunt spinules, tubercles and hairs. This species is distinguished by the presence of a distinct spine at the angle of the hand where it comes in contact with the external angle of the arm. The length of the composite segment 3-5 in the male is greater than its breadth at the base, and the length of the terminal segment is considerably more than its posterior breadth. Differention in the direction of spines was observed, some pointing forward, some laterally and some even backward.

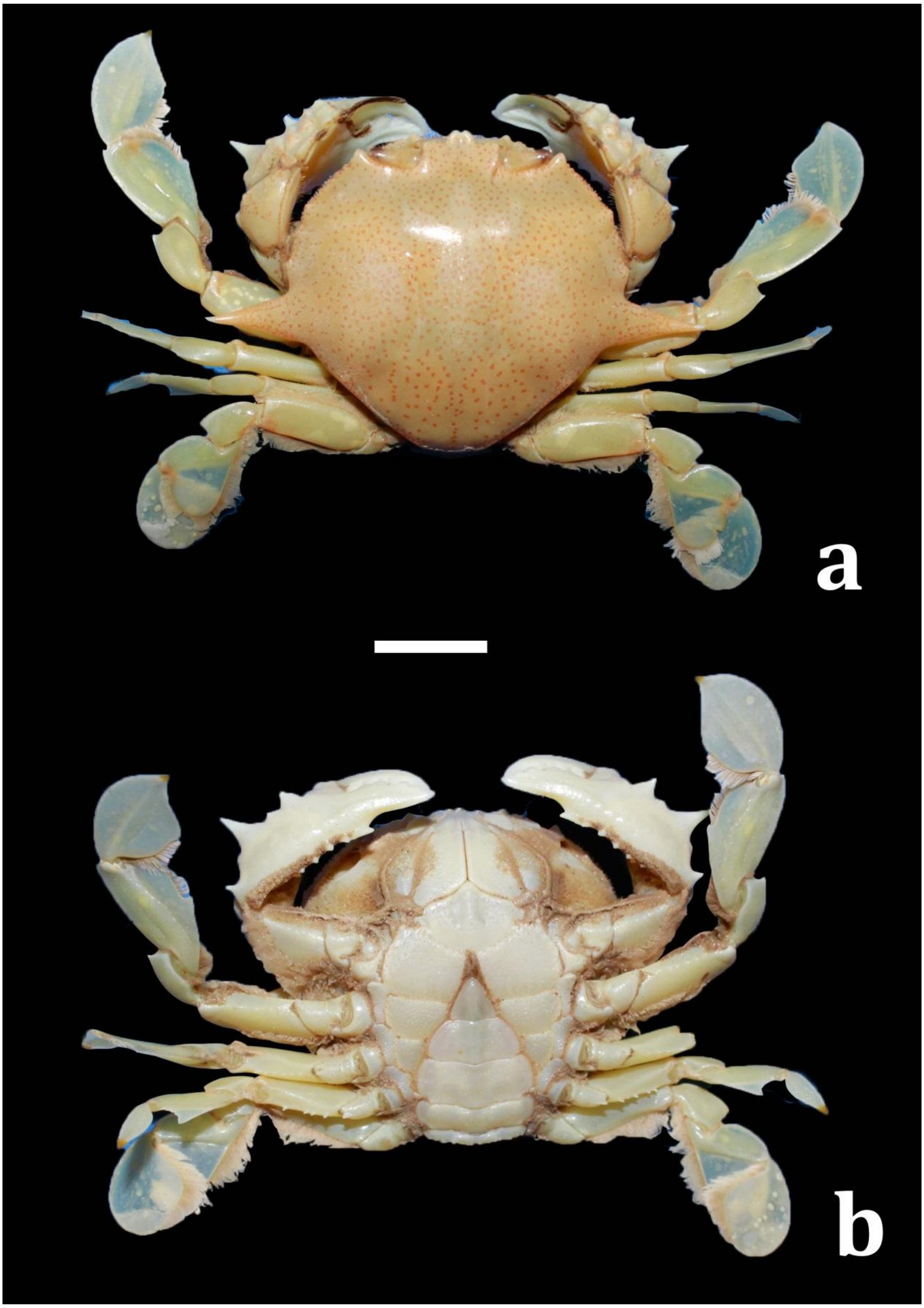

Figure 7. (a). Dorsal view of *Ashtoret lunaris* and (b). Ventral view of *Ashtoret lunaris*.

8. ***Parasesarma plicatum* Latreille, 1803**

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Sesarmidae

Genus: Parasersama

Synonym

- *Alpheus quadratus* Weber, 1795
- *Cancer quadratus* Fabricius, 1798
- *Ocypode plicatum* Latreille, 1803
- Sesarma plicatum Latreille, 1803

Description:

Lateral borders of carapace markedly concave in the middle, with an indistinct tooth behind the external orbital angle. The movable finger has a row of 8 to 9 "chiton-like" tubercles. No transverse ridges of granules not crest on the inner surface of palm.The merus of ambulatory legs very broad. Carapace hardly convex, decidedly broader than long, its length being about four-fifths its breadth between the antero-lateral angles, deep. There is no tooth on the lateral borders behind the orbital angle. The front is more than half the greatest breadth of the carapace. The inner border of the arm bears a large tooth at its distal end. On the upper surface of the palm are two oblique pectinated ridges, and the dorsal surface of the male finger is milled with 11 to 19 blunt transverse lamellae. The chelipeds differ in the sexes, being about 1¾ times the length of the carapace in the male and much more massive than the legs, but in the female hardly 11/3 times the length of the carapace and not more massive than the legs. The meropodites of the legs are foliaceous, their greatest breadth in the 2nd and 3rd pairs being more than half their length.

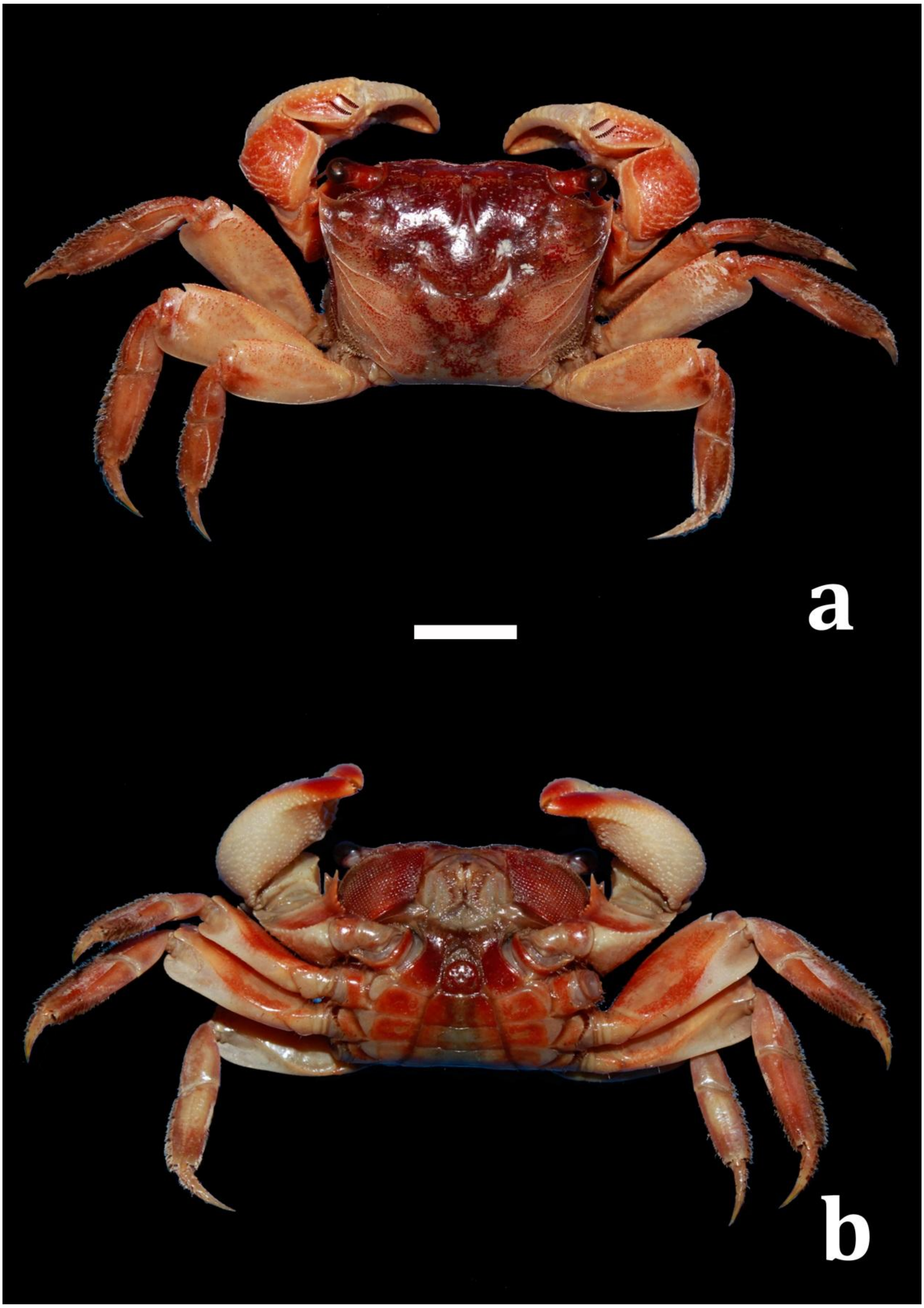

Figure 8. (a). Dorsal view of *Parasesarma plicatum* and (b). Ventral view of *Parasesarma plicatum*.

9. Dotilla sp.

Taxonomy

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Dotillidae

Genus: Dotilla

Description:

No brush of hair between bases of walking legs. Fourth segment of abdomen overlapping 5 with a thick brush of setae at its distal end in both sexes.Gastric and cardiac areas of carapace entire, not divided by a median longitudinal groove; transverse groove near posterior margin incomplete in the middle. No lobules isolated by grooves on gastric region. Adult male with a tooth below orbital angle and strong compressed tubercles on inner and proximal aspect of cheliped carpus.Tympana on all segments of sternum.

These are related to the so-called bubbler crabs. As they feed, their mouthparts sieve through the sand, filtering out the food particles. When finished, it discards the left-over sand as a ball on the ground. After several minutes of feeding, the ground is littered with dozens of closely packd balls. These are air-breathers and when the tide comes in; they retreat into their burrows, block the opening and ride out the high tide in a small air bubble.

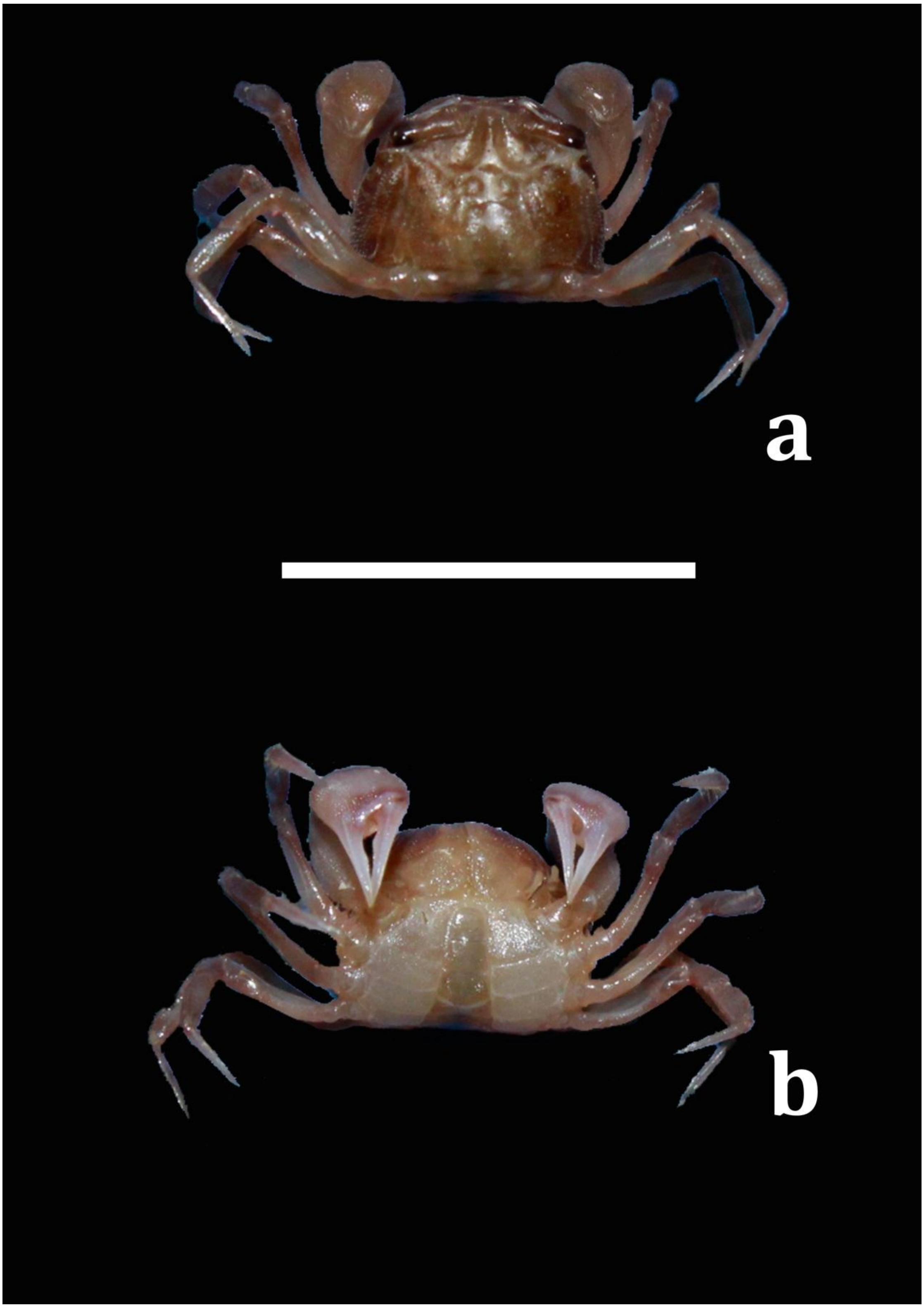

Figure 9. (a). Dorsal view of *Dotilla sp.* and (b). Ventral view of *Dotilla sp.*.

10. Boleophthalmus dussumieri

Taxonomy

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order:Perciformes
Family:Gobiidae
Genus: *Boleophthalmus*

Synonyms:

*Boleophthalmus dentatus*Valenciénnes, 1837
*Boleophthalmus chamiri*Holly, 1929

Descriptions:

Total elements in second dorsal fin D2 24- 28; caudal fin length (CL) 21.9 t 25.3% of total fish length (SL); total elements in caudal fin 24-27; longitudinal scale count 103-185; predorsal scales 48-56; head length (HL) 23.6 to 28.7% of total fish length (SL); first elements of D2 unsegemented and unbranched; lower jaw teeth notched; the three canines in the upper jaw near both symphysis elongated and protruding; height of D1 more in males and largercanine teeth; Dorsum and flank bluish grey to light brown in color in fresh specimen; numerous dark brown speckelson dorsal side of head, gill cover, chicks, muscular portion of pectoral fins; ventral portion of body pale in color; D1 light grey with numerous dark spots on the interradial membrane, D2 gray in color column of pale blue spots on the interradial membrane, caudal fin with gray to blackish rays; body color light brown, grayish blue or purplish in preserved specimens.

Figure 10. (a). Lateral view of *Boleophthalmus dussumieri* and (b). Ventral view of *Boleophthalmus dussumieri*.

2.2 Diversity of Brachyuran crab and planktonic along downstream of Mahi estuary

Kamboi, mouth of the Mahi estuary, contain vast intertidal area and mosaic of microhabitat and hence comprise rich diversity of brachyuran crabs whereas Sarod represent comparatively less intertidal area and being effluent release site retain low diversity of brachyuran crabs. All the 9 brachyuran crab recorded at downstream were found at Kamboi whereas only 3 species found at Sarod (Table 2).

Dabka being midstream of estuary comprises both, freshwater and marine, planktonic form hence highest 26 planktonic organisms were recorded. Kamboi, being marine site comprises 19 marine planktonic organisms and 13 planktonic organisms were recorded from Sarod (Table 4).

2.3 Distribution of macrobenthic assemblages along the intertidal mudflat at Kamboi:

Total 10 species of Macro benthic fauna, 9 brachyuran crabs and 1 Mudskipper, were identified from the study area which shows their affinity to particular microhabitat or zonation. A specific pattern in distribution was observed in Kamboi from upper intertidal zone to lower intertidal line.

Overlapping benthic communities was also observed in different zones, especially in an interface between two zones.

Mudskipper (*Boleophthalmus dussumieri*) shared watery substrata of Z4 (Lower part) and Z5 (upper part). Burrows of *B. dussumieri* were found mostly in Z4 but they were foraging in Z3 within runnel, and they used Z3 vigorously as a foraging ground during juvenile recruitment.

Euricarcinus orientalis showed a distribution range in Z2. Gradually it decreases from upper to lower part of Z2. Species showed sparse and isolated distribution. Though they share Z2 with *Uca annulipes*, their distribution never overlapping with *Uca annulipes* and no competition for space or burrow found, they found active during evening time.

Uca annulipes showed distribution in lower part of Z2 and upper part of Z3. It is dominant species in Z2 and initial part of Z3. In the initial part of Z3 competitions for space and food is found with *Ilyoplax sayajiraoi*. It is found active during low tide of day time for 3-4 hours.

Ilyoplax sayajiraoi showed distribution in Z3 and Z4. It is dominant species in Z3 and Z4. In the lower part of Z4 competition for space found with mudskipper (*B. dussumieri*). During the juvenile recruitment period of mudskipper and *Dotilla sp.* heavy intraspecific competition observed for space in Z3 and Z4.

Metopograpsus messor was recorded in muddy substratum of Z3 and Z4, it's an occasional species recorded at few instances only during the study periods.

Macrophthalmus sulcatus was confined to the lower intertidal zone towards low tide line in Z5. The species preferred fine sandy substratum and formed inclined burrows, found nocturnal at low tide. The crab was not seen in compact densities but found in homogenously adequate distribution.

Dotilla sp. is dominant species in Z5, showed rich congregation towards the initial part of Z5 and showed homogeneous distribution till the lower tide line. During juvenile settlement their density and distribution increase vigorously and reached upper intertidal area up to Z3.

Scylla serrata showed isolated distribution especially in form of under the hard substratum in Z4 and Z5. It is an occasional species recorded only two times during the study periods.

Ashtoret lunaris was distributed in lower intertidal range in Z5 with fine sandy substratum. It showed predatory behavior and does not showed a burrowing behavior and found active during night time in low tide.

Parasesarma pictum was recorded from hard substratum of upper part of Z5 and confined to the specific area.

2.4 Distribution of Brachyuran crab along the intertidal mudflat at Sarod:

Sarod, being effluent release site, very less diversity of crabs was found. Total 3 species of brachyuran crabs and were recorded from Sarod. A specific pattern in distribution was observed from upper intertidal zone to lower intertidal line.

Uca annulipes showed distribution in upper part of Z1. It is dominant species in Z1 and competitions for space and food is found with *Ilyoplax sayajiraoi*during specific recruitment season.

Ilyoplax sayajiraoishowed distribution in lower part of Z1 and upper part of Z2 and it is dominant species in Z2.

Dotilla sp. showed very spars distribution in Z3 except their recruitment period when they showed rich congregation towards the initial part of Z3 and showed homogeneous distribution in the Z3.

2.5 Annual density of dominant brachyuran crab at Sarod and Kamboi

Brachyuran crab quantification, using line transect in different predefined zones revealed that density of the crab varied from 0 to 128 individuals per linear meter along the transect all over the above described zones at intertidal zone at kamboi. Quadrate analysis showed that the mean annual density of brachyuran crab was, *Uca annulipes*: 8.89 ±2.26 / m^2, *Ilyoplax sayajiraoi*: 48.73 ±8.53 / m^2, *Dotilla sp.*: 51.92 ±12.50 / m^2 (Table 5).

Sarod, being effluent release site, very less density of brachyuran crabs was found. Quadrate analysesshowed that mean annual density of brachyuran crab was, *Uca annulipes*: 1.10 ±0.75, *Ilyoplax sayajiraoi*: 1.92 ±1.05 and *Dotilla sp.*: 2.84 ± 1.54 (Table 5).

2.6 Month wise density and distribution of dominant macrobenthos at Kamboi

Among the 10 macro benthos species 4 species are dominant and covered most of the intertidal area of Kamboi where other 6 species are isolated and rare.

Uca annulipes*:* Its density was found 2 to 16 individual / m^2. Average month wise density remains 6 to 9 individual / m^2 (Table 6). In the month of November density decreases up to 6 individual / m^2 otherwise during all the month density did not change much but the distribution patch differ season wise according to biotic and abiotic factors (Figure 11). Ingeneral,*Uca annulipes* distribution patch found 40 meter, 30 meter in the lower part of Z2 and 10 meter in upper part of Z3 (Figure 12).

Ilyoplax sayajiroai: Density of *I. sayajiroai* found 21 to 98 individual / m^2. Average monthly density remains 31 to 77 individual / m^2 (Table 6). From August to December average density remains below 40 individual / m^2 but from January to July density increases with the two peaks during February and April (Figure 11). In general, distribution of*Ilyoplax sayajiroai* found in 55 meter patch, 50 meter in Z3 and 5 meter in upper part of Z4 (Figure 12).

Boleophthalmus dussumieri (Mudskipper): Density of *B. dussumieri* remain almost constant with the 2 individual / m^2 exception of three month period, during which density reach up to 7 individual / m^2 during November and 6 individual / m^2 during October and December (Table 6). Distribution patch of *B. dussumieri* remain 10 meter in the Z4. But during the three month period of juvenile settlement it increases 30 meter covers the 10 meter area of Z4 and 20 meter lower part of Z3 (Figure 12).

Dotilla sp.: Density of *Dotilla sp.* remains nearby 40 individual / m^2 during the period of six months from August to January (Figure 11). From late January their density increases with the peak at May (110 individual / m^2) and gradually decreases during Jun and July (Table 6). It showed rich congregation towards the initial part of Z5 and showed homogeneous distribution till the lower tide line during six month from August to January. From late February their juvenile settlement periods start and distribution increases towards upper part and in Apr and May it covers up to upper part of Z4 (Figure 12). In May distribution patch found almost up to zone 3 gradually synchronize during Jun and July (Figure 13).

2.7 Effect of recruitment of Juvenile mudskipper:

Recruitment of juvenile *B. dussumieri* is seen primarily during October and November and then continues till December. During this period, they cover almost 30m patch in Z4 and Z3, so overlapping of 20m area with *I. sayajiroai* at upper part of Z3 which leads to competition for food and space. Due to foraging and wandering behaviour of *B. dussumieri* this part contain more water pool and become muddier which affect the feeding behaviour of *I. sayajiroai*. Schematic diagram shows the increased distribution of *B. dussumieri* in upper intertidal zone (Figure 12). Due to disturbance of *B. dussumieri*, *I. sayajiroai* starts feeding early as tide resides, and close their burrows within 1-2 hours during low tides. With the disturbance to *I. sayajiroai* in Z3, the distribution of *I. sayajiroai* is shifted towards upper side which leads to interspecific interaction increases with *U. annulipes*, and *U. annulipes* also shifted towards upper side, where desiccation is limiting factor which affect the density of *U. annulipes*. Density of *I. sayajiroai* decreases during October and density of *U. annulipes* decreases during November.

2.8 Effect of Juvenile *Dotilla sp.* and *I. sayajiraoi* recruitment:

Density of *Dotilla sp.* increases as juvenile recruitment of *Dotilla sp.* initiated from February at that time density of *I. sayajiroai* is also increases. Density of *Dotilla sp.* increases from 37 individual / m^2 to 52 individual / m^2 and density of *I. sayajiroai* increases from 51 individual / m^2 to 57 individual /

m^2during January to February. *Dotilla sp.* covers the lower 70 meter patch of Z5 and its distribution reach up to upper part of Z4 while distribution of *I. sayajiroai* reach up to upper part of Z5 in February and March (Figure 12). Density of *Dotilla sp.* reached to 104 individual / m^2 and covers around 140 m total area, almost all the area of Z4 and Z5 and also reached till Z3 in April. During this period chimney building by *Dotilla sp.* observed in three meter belt of *I. sayajiraoi* distribution patch in Z3 which affects distribution of *I. sayajiraoi* adversely (Figure 13). Very less Burrows of *I. sayajiraoi* were found in Z5 from February to May. Interspecific competition for space reaches up to maximum during this period between *Dotilla sp.* and *I. sayajiraoi*. Density and distribution of *Dotilla sp.* and *I. sayajiraoi* gradually decreases during June and July (Figure 12) and found in their defined distribution patch in August.

2.9 Impact of lunar cycle and seasons on density of brachyuran crabs

The lunar cycle provides a strong, predictable set of environmental cues for marine species. Environmental cycles (e.g., tidal water movement, moonlight) entrain endogenous reproductive cycles, synchronizing gamete release within a population and ensuring that movement, feeding and reproduction occur under favourable conditions (Taylor, 1984; Omori, 1995; DeBruyn, 2001).Lunar synchronized spawning, for example, is commonly documented for species of shallow waters with large tidal fluctuations (Korringa, 1947; Taylor, 1984). Reef fishes often mass in spawning aggregations on a specific lunar and seasonal cycle (Robertson et al., 1990). In addition, lunar cycles have been detected in spawning and settlement of intertidal (Taylor 1984) and pelagic-spawning fish and invertebrates (Crabtree, 1995; Robertson et al. 1999). Lunar cycles in fish behaviour have long been recognized and exploited by artisinal and commercial fisheries (Parrish, 1999; Nishida et al., 2006). It was hypothesized that lunar cycle has impact on activity pattern of brachyuran crabs at study site. As the crab species distributed along the intertidal area, the impact of tidal cycle varies along the intertidal area. The sampling strategy of the present workwas directed to in situ observations of species' density during various tidal cycle days.

Ilyoplax sayajiraoi distributed at mid intertidal area in Z3 and water inundate varies along the tidal cycle in this area. During monsoon, burrow count recorded maximum after 3 hours of water inundate with exception of 8^{th} day of lunar cycle where it was recorded higher after 2 hours of water inundate (Figure 14). Highest burrow count was recorded during 23^{rd}day of lunar cycle (61.33 ±8.08 count / m^2) followed by 27^{th} day and 8^{th} day of lunar cycle (50.33 ±8.08 count / $m^2$and 50.00 ±4.00 count / m^2) (Table 7). Neap tide condition found to be favorable for *Ilyoplax sayajiraoi* during monsoon. We can assume that spring flood with rain made substratum watery which affects the feeding activity of crabs and hence density recorded higher during neap tide in monsoon.

During winter, burrow count recorded maximum after 3 hours of water inundate (Figure 15). Highest burrow count was recorded during 23^{rd}day of lunar cycle (92.33 ±3.06 count / m^2) followed by 15^{th} day and 8^{th} day of lunar cycle (90.33 ±8.08 count / $m^2$and 73.00 ±7.21 count / m^2) (Table 8).
During summer, burrow count recorded maximum after 3 hours of water inundate (Figure 16). Highest burrow count was recorded during 8^{rd}day of lunar cycle (27.33 ±1.53 count / m^2) followed by 27^{th} day and 4^{th} day of lunar cycle (25.67 ±4.16 count / $m^2$and 24.67 ±2.52 count / m^2) (Table 9).

Overall scenario was observed that density of *I. sayajiraoi* recorded high during neap tide compared to spring tide. Highest density recorded during winter followed by monsoon and very less density recorded during summer.
*Uca annulipes*accommodate at upper intertidal area where water inundates during spring tide days and desiccation risk is high during summer. During monsoon, burrow count recorded maximum after 3 hours of water inundate with exception of 8^{th} day of lunar cycle where it was recorded higher after 2 hours of water inundate (Figure 17). Highest burrow count was recorded during 30^{th} day of lunar cycle (5.67 ±0.58 count / m^2) followed by 12^{th} day and 15^{th} day of lunar cycle (5.00 ±1.00 count / $m^2$and 4.67 ±0.58 count / m^2) during monsoon (Table 10). During winter, burrow count recorded maximum after 3 hours of water inundate with exception of 12^{th}, 19^{th} and 23^{rd} day of lunar cycle

where it was recorded higher after 2 hours of water inundate (Figure 18). Highest burrow count was recorded during 19th day of lunar cycle (9.33 ±0.58 count / m^2) followed by 23rd day and 15th day of lunar cycle (9.00 ±1.00 count / m^{2}and 8.67 ±1.53 count / m^2)during winter (Table 11).

During summer, burrow count recorded maximum after 3 hours of water inundate with exception of 12th and 19th day of lunar cycle where it was recorded higher after 2 hours of water inundate (Figure 19). Highest burrow count was recorded during 30th day of lunar cycle (6.00 ±1.00 count / m^2) followed by 8th day and 15th day of lunar cycle (6.00 ±1.73 count / m^{2}and 5.33 ±1.53 count / m^2) during summer (Table 12). Overall scenario was observed that density of *U. annulipes* recorded high during spring tide compared to neap tide. Highest density recorded during winter and less density recorded during summer and monsoon. Distribution of *Dotilla sp.* was foundat lower intertidal area where water inundates during all tidal days. During monsoon, burrow count recorded maximum after 2 hours of water inundate with exception of 12thand 30th days of lunar cycle where it was recorded higher after 3 hours of water inundate (Figure 20). As lower intertidal area flooded equally with all the tidal cycle days no significant difference recorded in density of burrow count with reference to tidal cycle in monsoon (Table 13).

During winter, burrow count recorded maximum after 3 hours of water inundate with exception of 12thand 30th days of lunar cycle where it was recorded higher after 2 hours of water inundate (Figure 21). Density of *Dotilla sp.* increased as tidal cycle progress (Table 14) but it may be relate with initiation of juvenile recruitment season in post winter and no relation with tidal cycle. During summer, burrow count recorded maximum after 3 hours of water inundate (Figure 22). Same scenario observed like winter that Density of *Dotilla sp.* as tidal cycle progress (Table 15) and it was due to peak of juvenile recruitment season during April-May and no relation with tidal cycle.

3 Discussion

Planktonic organisms clearly reflect the estuarine gradient in downstream of estuarine region. Highest, 26 planktonic organisms (mostly freshwater) reported from Dabka as most of the water is freshwater. 19 marine planktonic organisms reported from Kamboi as this site contain marine water during both the tides. Lowest, 13 planktonic organisms reported from Sarod, it was may be due to mixing of fresh water and marine water and effluent release (Table 4). As per sediment composition Sarod intertidal area contained three zones whereas Kamboi intertidal area contained five zones so high microhabitat variation along the inter tidal present at Kamboi and brachyuran diversity recorded high at Kamboicompared to Sarod (Table 2). Density of brachyuran crabalso recorded very low at Sarod compared to Kamboi that is because of heavy pollution load at Sarod due to effluent release.

Worldwide many studies are done on distribution of decapods (crustacean) in relation to environmental factors. The salinity and substratum characteristics are the most important factors that can influence the spatial distribution of brachyuran crabs (MacIntosh, 1989). In the intertidal zone, sediment composition is a major factor affecting spatial distribution of brachyuran crabs. In present study site this phenomena is reveal and we found *U. annulipes* and *Euricarcinus orientalis*prefers loamy composition in upper intertidal area in spite of low water expose and high desiccation risk. Distribution of*Ilyoplaxsayajiraoi*found in muddy substratum whereas *Dotilla sp.*, *Ashtoret lunaris* and *Macrophthalmus sulcatus*distributed in sandy substratum. The similar kind study carried out byBezerra et al. (2006) and reported that distribution of four species of *Uca* with respect to sediment composition. Distribution patch and diversity of *Boleophthalmus dussumieri* increased during October and November due to juvenile recruitment period. Continuous surfing of juvenile mudskipper disturbed the upper layer of substratum and made it more muddy and watery which adversely affect the feeding habit of *I. sayajiraoi*. During this period distribution patch of *I. sayajiraoi*displace towards upper intertidal area and increased the interspecific competition for food and space with *U. annulipes*. Due to high competition with

I. sayajiraoi, Distribution of *U. annulipes* also displace towards upper intertidal area where desiccation risk is very high. Due to this cascade of effect density of *I. sayajiraoi* recorded low during the month of October and November whereas density of *U. annulipes* was recorded lowduring November. Similar kind of habitat displacement was described by Iribarne et al. (2003) in two common soft-bottom SW Atlantic intertidal crabs.

During February, March and April density and distribution patch of I. sayajiraoi increased whereas during March, April and May Density and Distribution patch of *Dotilla sp.* increased due to due to juvenile recruitment period. Competition for food and space reached at its peak during this period between this species. Increase in density during juvenile recruitment periods in *Scopimera crabricauda* Alcock, 1900and DotillasulcataForskall, 1775 described by Clayton and Al-Kind (1998) in an estuarine habitat in Oman.
Cardoso et al. (2010) explained the migration pattern along the tidal cycle, with individuals tending to burrow deeper in sediment in low tide. This behaviour can be interpreted as an escape to surface adverse environmental conditions induced by desiccation. This pattern was stronger in springtide, when water levels have more abrupt and contrasting variations. We also observed a persistent density decrease with advancing high tide in *I. sayajiraoi* and density increases with advancing high tide in *U. annulipes*. These data are in line with observations made under laboratory conditions, where Ostracoda exhibited active emigration from the sediment (Armonies, 1988a, b), resulting in short-term temporal variations in abundance and population structure. This type of migration can be a dispersion strategy to maximize foraging opportunities.

Similar emergence patterns during tidal cycle have also been described for benthic copepods by Palmer and Brandt (1981), whose results suggested that behaviour plays, indeed, a role in the tidal patterns.Although we detected differences in densities between neap and spring tides, In *I. sayajiraoi*activity found higher during neap tide whereas in *U. annulipes* activity recorded high during spring tide. During spring tide difference between high tide line and low tide line is less which is perfect condition for *I. sayajiraoi.* Similar kind of explanation was given by Cardoso et al., (2010) for high activity pattern in gastropod*H.ulvae*duringneap tide. Activity of *U. annulipes* reported high during spring tide and during summer density was recorded comparatively low clearly suggest the desiccation risk is the key in density and activity pattern in this species as it is distributed in upper intertidal area.

In spite of several available studies on the distribution of intertidal brachyuran crabs (Bacon, 1971; Griffin, 1971; Hartnoll, 1975; Jones, 1976; Wada, 1983, Augusto 2001), there are no conclusive models explaining population density as a function of key environmental factors related to desiccation potential. Such factors are known to constrain the intertidal distribution of sessile invertebrates in which comprehensive descriptive models have been proposed and reviewed (Little and Smith, 1980). Mobile fauna, however, may behave so as to minimize harsh environmental conditions. In addition to the remarkable osmoregulatory capacity of certain crab species (Gross, 1964; Barnes, 1967; Schubart and Diesel, 1998), locomotion may also allow the exploitation of different shelter resources (Cannicci et al., 1999), which may obscure eventual zonation patterns of these organisms. As for sessile forms, most discussion has centered on the nature of limiting factors that set the upper and lower boundaries of a given species distribution. In this sense, it has been argued that tidal exposure time (McLay and McQueen, 1995) and substrate type (Menendez, 1987; Ysebaertand Herman, 2002; Fujii, 2007; Pandya and Vachhrajani, 2010) may be the major factors causing zonation in brachyurans.

Recruitment of young crabs during recruitment seasons seems to be the main factor contributing to the population increase in particular seasons. Present study suggests that all four dominant macrobenthos species have well defined distribution pattern but juvenile recruitment of one species leads to cascade of disturbance to nearby living species and affect the density and distribution of all interacting species. The study also suggests that abiotic factors regulate the distribution pattern of macrobenthic fauna however; also the biotic factor like recruitment pressure further control the distribution pattern and temporary alter the existing distribution pattern.

Table 1. List of brachyuran crab recorded at lower estuarine area

Order	**Family**	**Genus**	**Species**
Decapoda	Pilumnidae	*Euricarcinus*	*Orientalis*
	Ocypodidae	*Uca*	*Annulipes*
	Grapsidae	*Metopograpsus*	*Messor*
	Macrophthalmidae	*Macrophthalmus*	*Sulcatus*
	Portunidae	*Scylla*	*Serrata*
	Matutidae	*Ashtoret*	*Lunaris*
	Sesarmidae	*Parasesarma*	*Pictum*
	Dotillidae	*Ilyoplax*	*Sayajiraoi*
		Dotilla	*sp.*
Perciformes	Gobidae	*Boleophthalmus*	*Dussumieri*

Table 2. Diversity of crab at Kamboi and Sarod

Sr no.	Brachyuran crab	Kamboi	Sarod
1	*Euricarcinus orientalis* A. Milne-Edwards, 1867	+	-
2	*Uca (Austruca) annulipes* De Haan, 1835	+	+
3	*Ilyoplax sayajiraoi* Trivedi, Soni, Trivedi, Vachhrajani, 2015	+	+
4	*Metopograpsus messor* Forskal, 1775	+	-
5	*Macrophthalmus sulcatus* H. Milne Edwards, 1852	+	-
6	*Scylla serrata,* Forskal, 1775	+	-
7	*Ashtoret lunaris* Forskal, 1775	+	-
8	*Parasesarma plicatum* Latreille, 1803	+	-
9	*Dotilla sp.,* Alcock, 1900	+	+

Table 3. List of planktons recorded at lower estuarine area

Phylum	Class	Order	Family	Genus
Sarcomastigophora	Mastiogophora	Zoomastiginia	Euglenidae	Euglena
		Phytomonadina	Volvocaidae	Volvox
		Chyromonadina	Chyrosomonadidae	Chilomonas
			Silicoflagillidae	Dictyoca
				Distephanus
	Lobosa	Testacealobosa	Arcelidae	Amoeba
				Arcella
				Chlorella
				Closterium
				Tetraspora
				Hydrodictyon
				Phacotos
				Navicula
				Aphanizomenm
				Ankistrodesmus
	Actinopoda	Heliozoa	Actinophyrydae	Actinophyrys
Ciliophora	Ciliata	Spirotrichida	Stentorida	Stentor
		Perichida	Vorticellidae	Vorticella
			Vaginicolidae	Cothurina
Cnidaria	Hydrozoa		Hydroidae	Hydra
Rotifera	Seisonidae	Bdelloida	Philodinidae	Philodina
				Rotaria
	Monogononta	Ploima	Brachionidae	Brachionus
				Notholca
				Kerallatella
Annelida	Polychaete			Trochophore larvae
Arthropoda	Crustacea	Cladocera	Daphnidae	Moina
				Diaphanosoma
			Chydoridae	Chydorus
			Macrothricidae	Macrothrix
		Ostracoda	Cypridae	Cypris
		Copepoda	Calanidae	Labidoceras
				Paracalanus
				Nannocalanus
				Heliodeaptomus
				Glaucothoe
			Cyclopidae	Cyclops
			Sapphirinidae	Copilia mirabilis
		Decapoda		Zoea of Brachyuran
			Penaeidae	Larvae of Penaeus

Table 4. Comparison of plankton diversity at downstream of Mahi estuary

Plankton	Dabka	Sarod	Kamboi
Euglena	+	-	-
Volvox	+	-	-
Chilomonas	+	-	-
Dictyoca	+	-	-
Distephanus	+	-	-
Amoeba	-	+	+
Arcella vulgaris	+	-	+
Chlorella	-	-	+
Closterium	-	+	+
Tetraspora	-	-	+
Hydrodictyon	-	+	+
Phacotos	-	-	+
Navicula	+	+	+
Aphanizomenm	-	-	+
Ankistrodesmus	-	+	+
Actinophyrys	+	-	-
Stentor	+	-	-
Vorticella	+	-	-
Cothurina	+	-	-
Hydra	+	-	-
Philodina	+	-	-
Rotaria	+	-	-
Brachionus	-	+	-
Notholca	+	-	-
kerallatella	+	+	-
Trochophore larvae	-	+	+
Moina	-	+	+
Diaphanosoma	+	-	+
Chydorus	+	-	-
Macrothrix	+	-	-
Cypris	-	+	+
Labidoceraspavo	-	-	+
Paracalanusparvus	+	-	+
Nannocalanus mirror	+	-	-
Heliodeaptomusvidutus	+	-	-
Glaucothoe	+	-	-
Cyclops	+	+	+
Copilia mirabilis	-	+	+
Larva of *Paeneusindicus*	+	+	+
Zoea of crab	+	+	-

Table 5. Annual mean burrow count of brachyuran crab at two sites

Site	*Uca Annulipes* (Burrow count / m^2)	*Ilyoplax sayajiraoi* (Burrow count / m^2)	*Dotilla sp.* (Burrow count / m^2)
Kamboi	8.89 ±2.26	48.73 ±8.53	51.92 ±12.50
Sarod	1.10 ±0.75	1.92 ±1.05	2.84 ± 1.54

Table 6. Month wise density (Burrow count/m^2) of dominant macrobenthos at Kamboi

	Uca Annulipes		*Ilyoplax sayajiraoi*		*Dotilla sp.*		*Boleophthalmus dussumieri*	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Aug-10	9	1.01	44	3.11	29	3.24	2	0.96
Sep-10	9	1.28	44	2.93	26	1.91	2	0.72
Oct-10	8	1.45	31	2.79	24	2.78	6	1.50
Nov-10	6	1.21	33	2.71	24	2.74	7	1.18
Dec-10	8	1.39	37	4.14	28	2.30	5	1.43
Jan-11	9	1.38	60	3.92	33	4.90	2	0.85
Feb-11	9	0.92	77	6.04	53	3.54	2	1.00
Mar-11	9	1.34	55	4.08	76	6.16	2	0.76
Apr-11	8	1.08	61	5.79	104	10.42	2	0.84
May-11	8	0.82	54	3.93	111	18.29	2	0.65
Jun-11	8	0.77	50	6.07	66	9.20	2	0.53
Jul-11	9	0.93	48	5.66	52	9.56	2	0.66

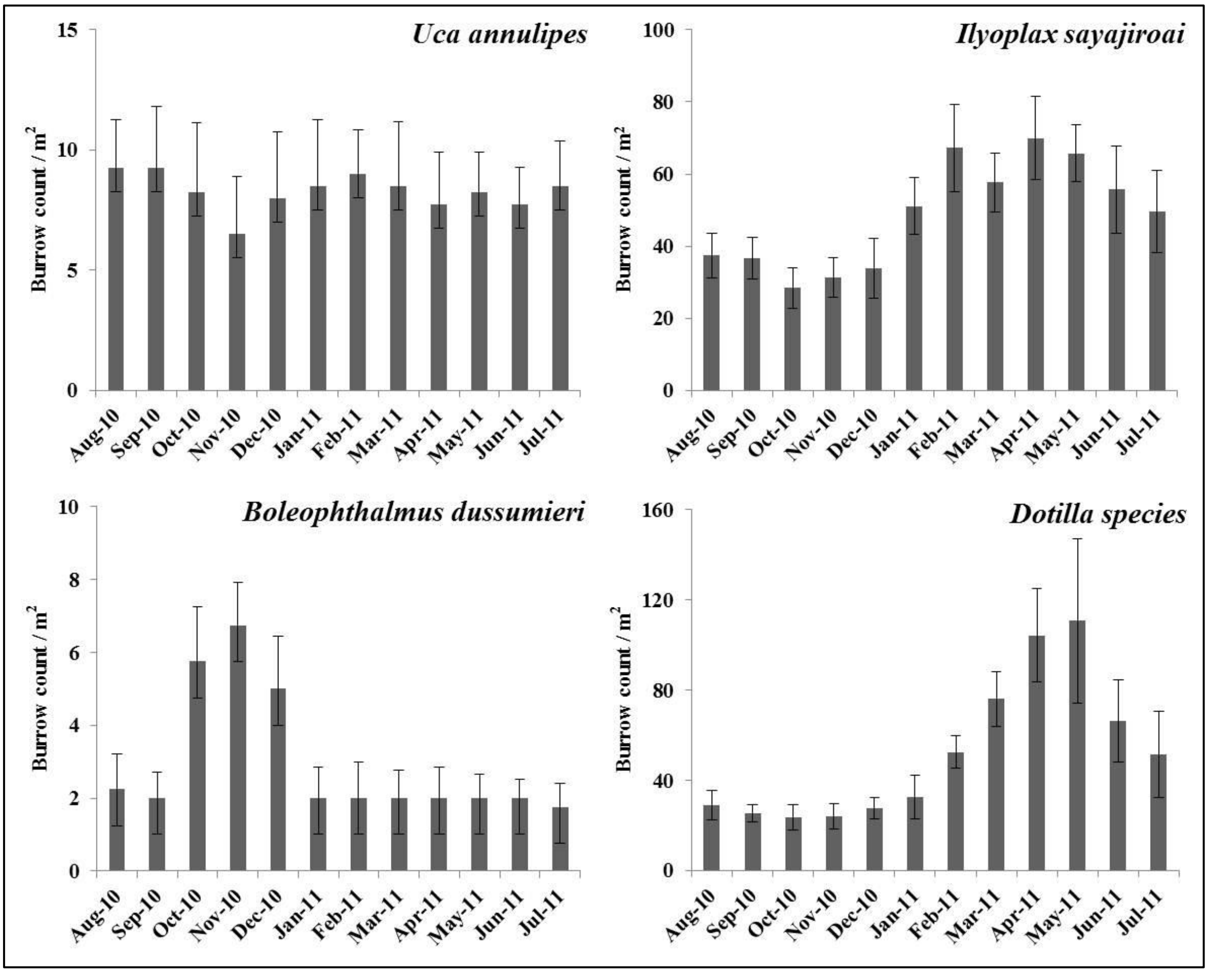

Figure 11. Monthly burrow count / m^2 for the dominant four species of macrobenthos at Kamboi

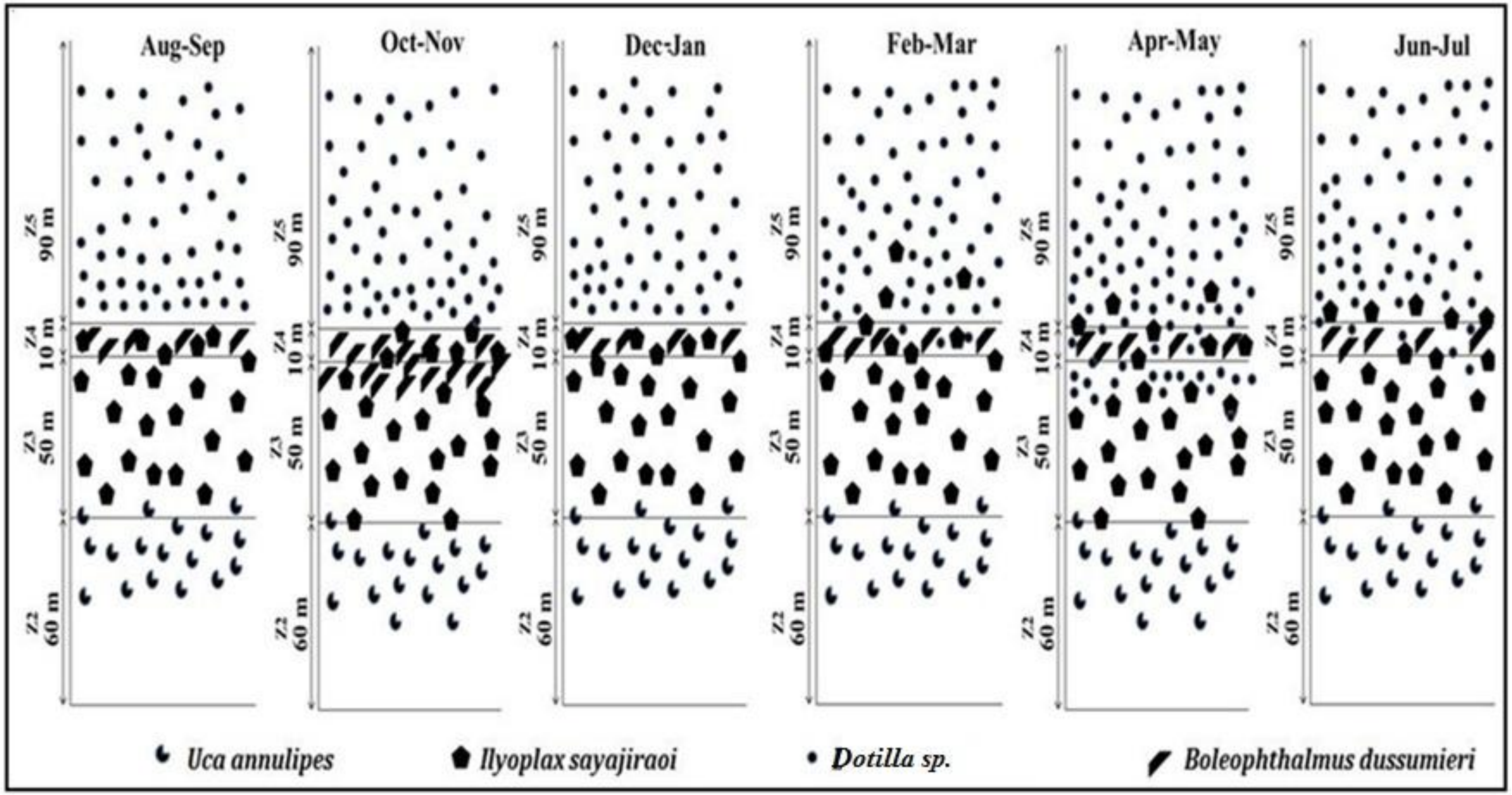

Figure 12. Monthly distribution of dominant four macrobenthos in Kamboi

Figure 13. Three meter belt of chimney made by *Dotilla sp.* at zone 3

Table 7. Mean burrow count / m^2 of *Ilyoplax sayajiraoi* at diiferent time lapse during low tide along the tidal cycle in Monsoon

Monsoon	After 1 hr		After 2 hr		After 3 hr		After 4 hr		After 5 hr	
Tidal Cycle day	Mean	Stdv	Mean	Stdv	Mean	Stdv	Mean	Stdv	Mean	Stdv
4th	19.00	2.00	24.00	2.65	29.33	2.52	21.33	1.53	9.33	0.58
8th	44.00	6.08	50.00	4.00	41.67	2.52	33.67	1.53	20.33	2.08
12th	19.67	1.53	25.00	2.00	33.67	1.53	23.33	4.04	16.67	5.77
15th	26.00	2.65	34.33	2.08	40.00	2.65	25.67	1.53	20.67	2.52
19th	21.67	1.53	33.33	4.93	38.67	3.51	35.00	2.00	18.00	1.00
23rd	43.67	12.01	50.67	6.43	61.33	8.08	30.00	2.00	12.67	3.06
27th	23.33	2.08	37.00	4.00	50.33	7.37	38.67	5.86	19.33	1.53
30th	10.33	1.53	26.00	5.29	35.33	3.06	13.67	1.53	9.67	0.58

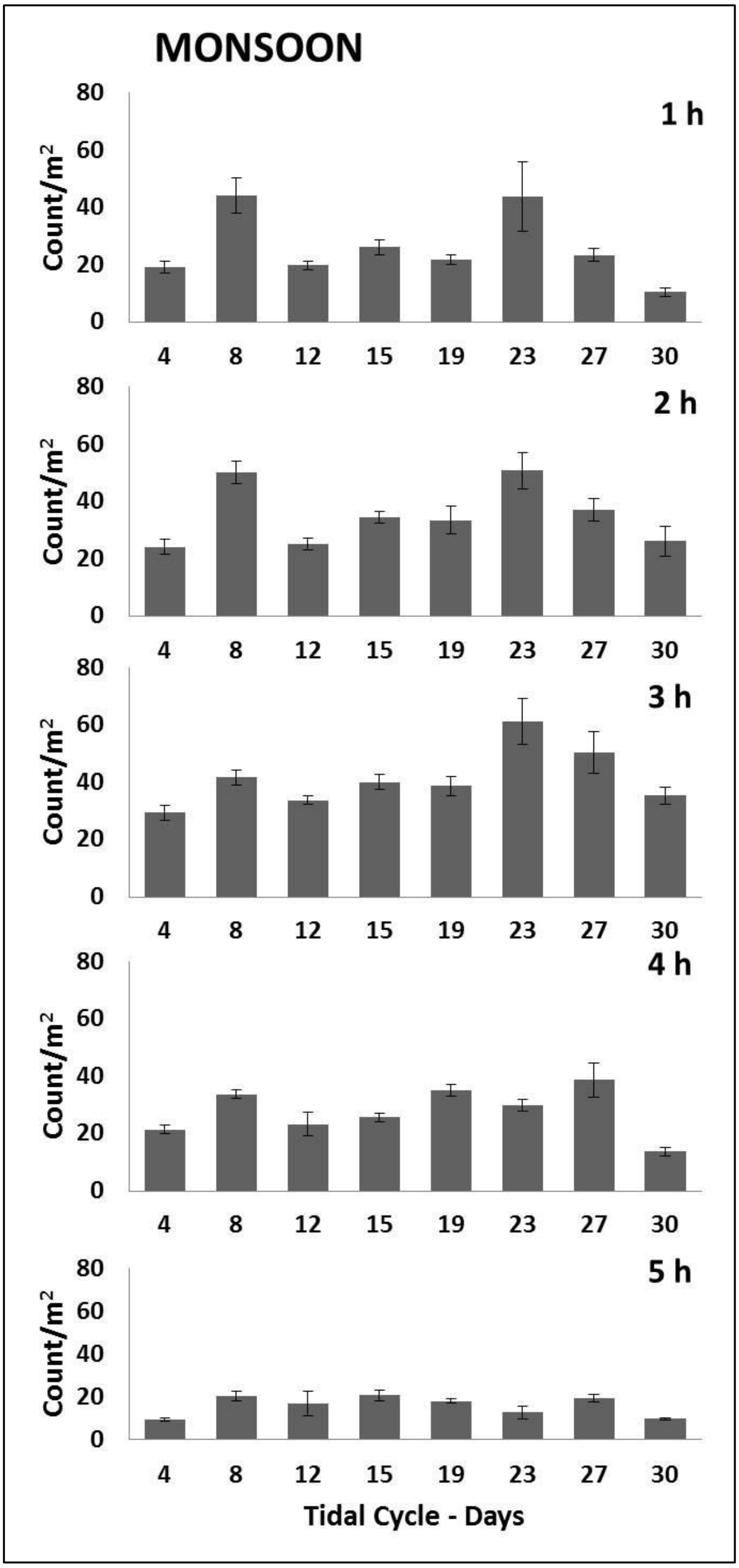

Figure 14. Mean burrow count / m^2 of *Ilyoplax sayajiraoi* at diiferent time lapse during low tide along the tidal cycle in Monsoon

Table 8. Mean burrow count / m^2 of *Ilyoplax sayajiraoi* at diiferent time lapse during low tide along the tidal cycle in Winter

Winter	After 1 hr		After 2 hr		After 3 hr		After 4 hr		After 5 hr	
Tidal Cycle day	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**
4th	23.00	2.00	43.00	4.58	48.67	6.51	29.33	2.52	14.00	2.00
8th	41.67	9.50	65.00	7.00	73.00	7.21	54.33	5.13	25.67	5.51
12th	32.33	9.29	52.00	20.88	66.67	12.06	39.00	19.00	23.00	1.00
15th	66.33	4.93	87.00	7.00	90.33	8.08	70.67	10.26	37.33	4.16
19th	34.33	6.81	56.67	5.03	58.67	4.04	42.33	3.51	25.33	5.86
23rd	47.00	6.24	72.00	4.00	92.33	3.06	53.00	9.54	29.67	8.02
27th	34.00	5.00	44.67	1.53	70.33	1.53	31.67	2.52	20.33	2.08
30th	24.33	1.53	44.33	1.53	54.33	3.21	42.00	3.61	20.00	2.65

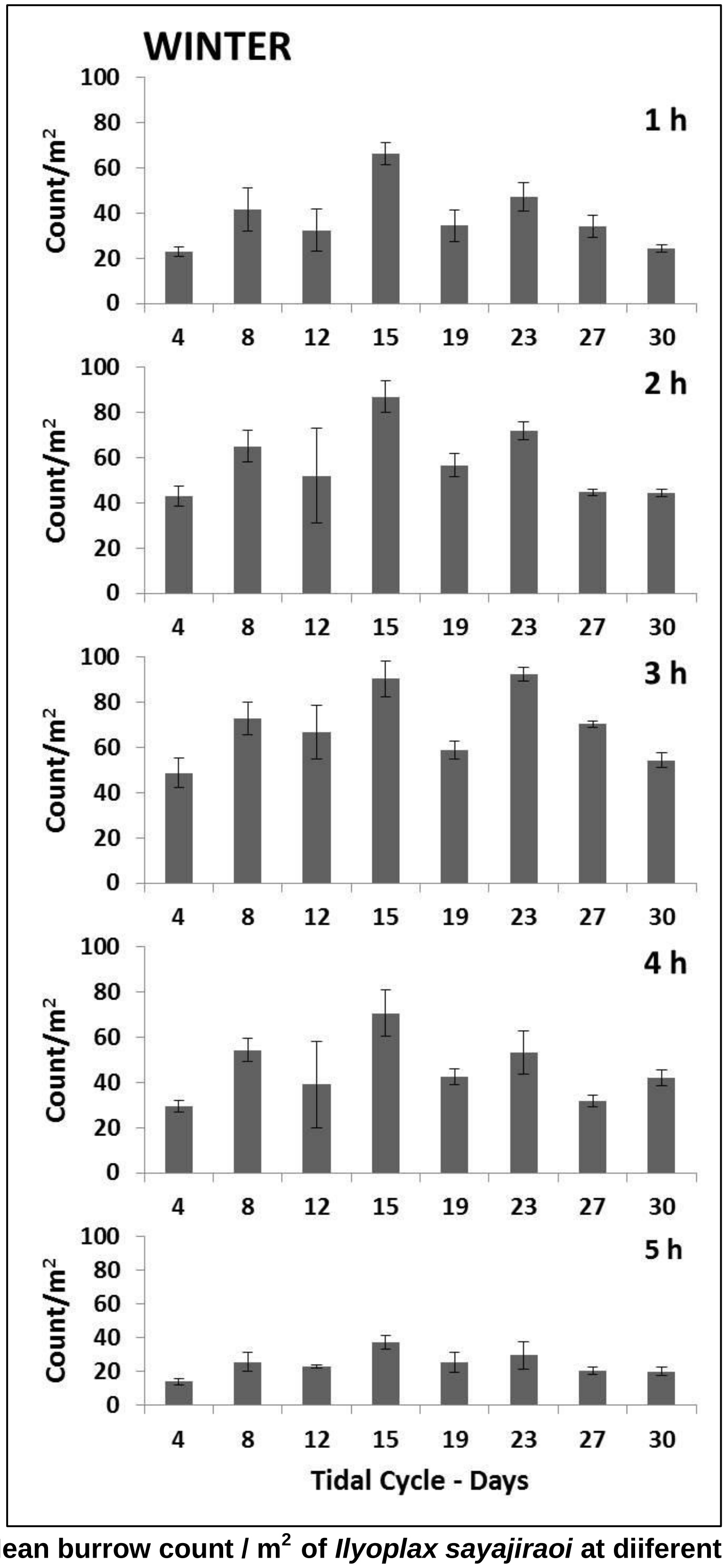

Figure 15. Mean burrow count / m^2 of *Ilyoplax sayajiraoi* at diiferent time lapse during low tide along the tidal cycle in Winter

Table 9. Mean burrow count / m^2 of *Ilyoplax sayajiraoi* at diiferent time lapse during low tide along the tidal cycle in Summer

Summer	After 1 hr		After 2 hr		After 3 hr		After 4 hr		After 5 hr	
Tidal Cycle day	Mean	Stdv	Mean	Stdv	Mean	Stdv	Mean	Stdv	Mean	Stdv
4th	12.67	2.08	17.33	2.52	24.67	2.52	26.00	3.46	24.33	4.51
8th	17.00	2.00	21.33	1.15	27.33	1.53	28.00	5.29	27.00	2.00
12th	12.67	1.15	17.00	3.46	17.67	2.52	17.33	2.52	21.67	1.53
15th	13.33	1.53	13.67	1.53	21.00	1.00	15.33	3.51	18.33	3.06
19th	13.67	1.53	13.67	2.52	19.00	2.00	23.33	1.53	23.67	2.52
23rd	12.67	1.15	18.67	2.52	21.00	2.65	24.67	2.52	24.00	1.73
27th	20.33	3.06	23.33	1.15	25.67	4.16	25.67	0.58	29.00	2.00
30th	10.33	1.53	13.00	2.00	16.67	2.52	20.33	1.15	22.00	2.00

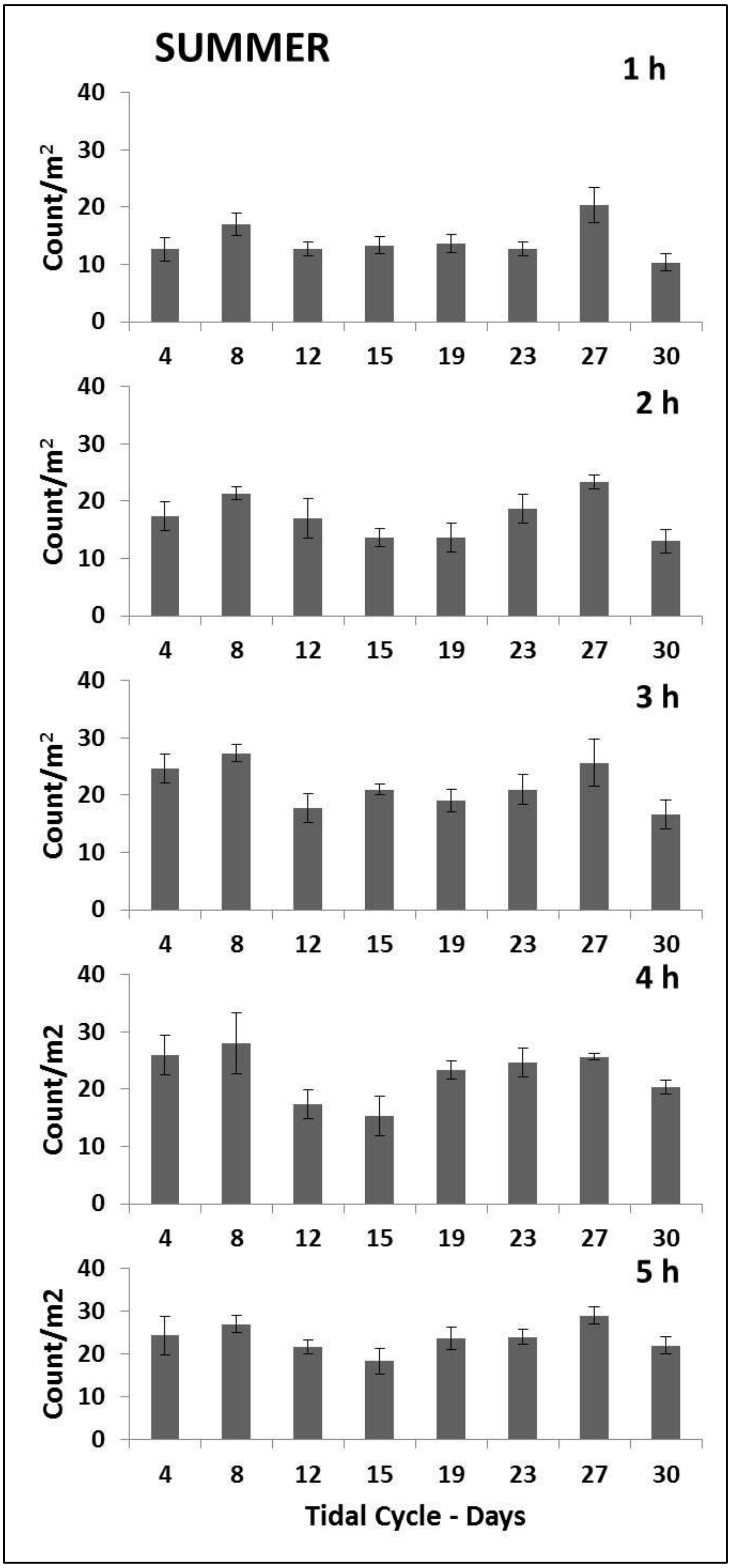

Figure 16. Mean burrow count / m^2 of *Ilyoplax sayajiraoi* at diiferent time lapse during low tide along the tidal cycle in Summer

Table 10. Mean burrow count / m^2 of *Uca annulipes* at diiferent time lapse during low tide along the tidal cycle in Monsoon

Monsoon	After 1 hr		After 2 hr		After 3 hr		After 4 hr		After 5 hr	
Tidal Cycle day	Mean	Stdv	Mean	Stdv	Mean	Stdv	Mean	Stdv	Mean	Stdv
4th	3.33	1.53	3.33	0.58	3.67	1.15	5.33	0.58	5.33	1.53
8th	3.33	1.53	4.67	1.53	4.33	2.52	4.00	1.00	4.33	1.53
12th	4.67	0.58	3.67	1.15	5.00	1.00	4.33	1.15	5.33	1.53
15th	5.00	1.00	4.67	0.58	4.67	0.58	4.67	0.58	5.00	1.00
19th	1.00	1.00	2.67	0.58	3.00	0.58	3.67	1.53	3.33	0.58
23rd	2.67	1.53	3.00	2.00	3.67	1.53	4.00	1.00	3.67	1.53
27th	2.67	0.58	4.33	0.58	4.33	1.53	3.00	0.00	3.00	1.00
30th	4.67	0.58	4.00	0.00	5.67	0.58	5.67	2.08	4.67	1.53

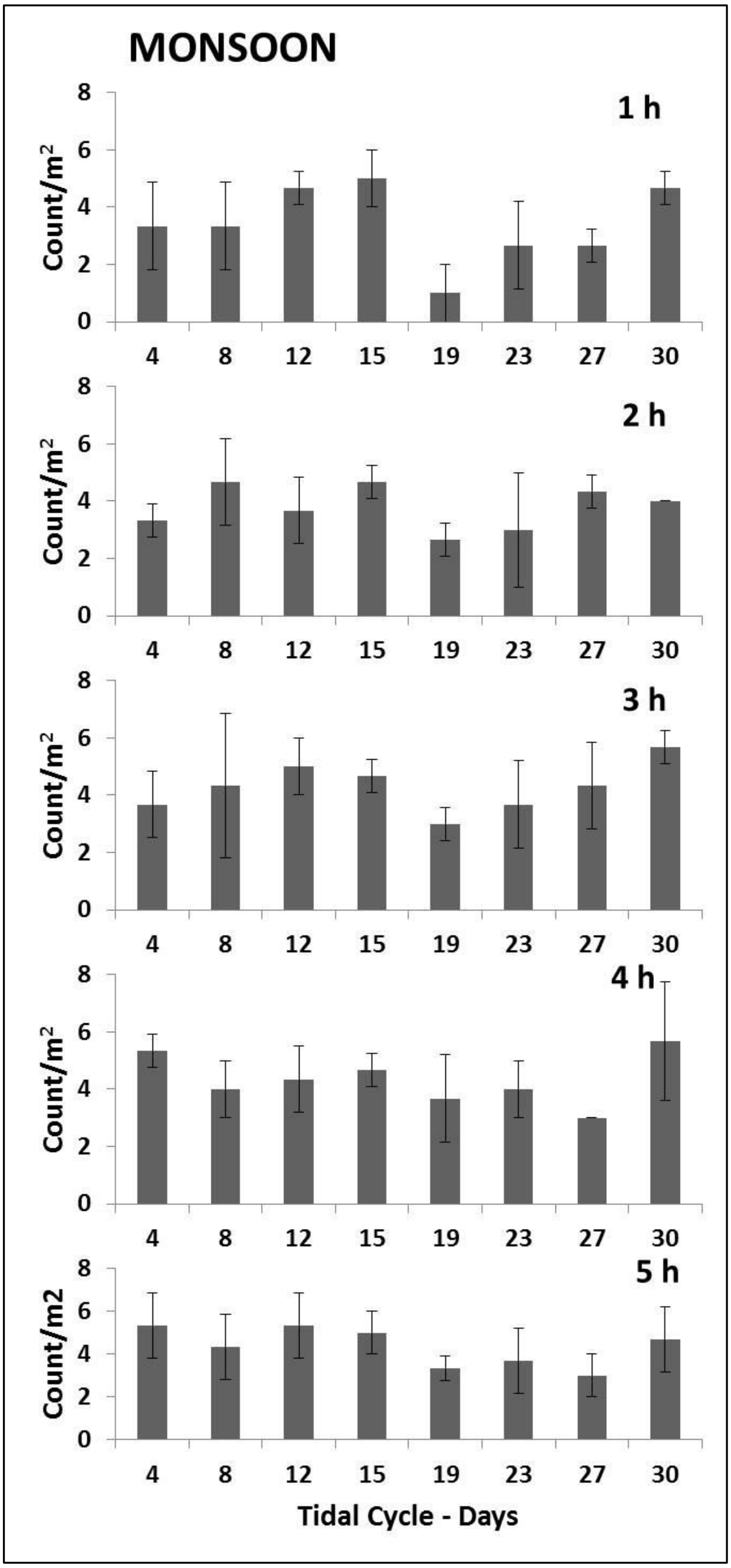

Figure 17. Mean burrow count / m^2 of *Uca annulipes*at diiferent time lapse during low tide along the tidal cycle in Monsoon

Table 11. Mean burrow count / m^2 of *Uca annulipes* at diiferent time lapse during low tide along the tidal cycle in Winter

Winter	After 1 hr		After 2 hr		After 3 hr		After 4 hr		After 5 hr	
Tidal Cycle day	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**
4th	6.00	2.00	6.00	1.00	8.00	1.00	8.00	1.00	6.33	0.58
8th	6.00	1.00	5.00	1.00	7.00	1.00	8.00	1.00	5.33	0.58
12th	4.33	2.31	7.00	2.65	6.33	2.08	4.33	1.53	5.00	2.00
15th	5.67	2.08	6.67	2.08	8.67	1.53	7.00	2.00	6.33	1.53
19th	8.00	0.00	9.33	0.58	8.67	0.58	9.67	0.58	8.00	1.00
23rd	5.33	1.53	9.00	1.00	7.67	1.53	6.67	1.53	6.67	1.53
27th	5.33	1.53	4.67	1.53	5.33	1.15	5.33	1.53	4.00	0.00
30th	4.33	1.15	5.67	1.53	6.00	2.00	5.33	1.53	4.33	0.58

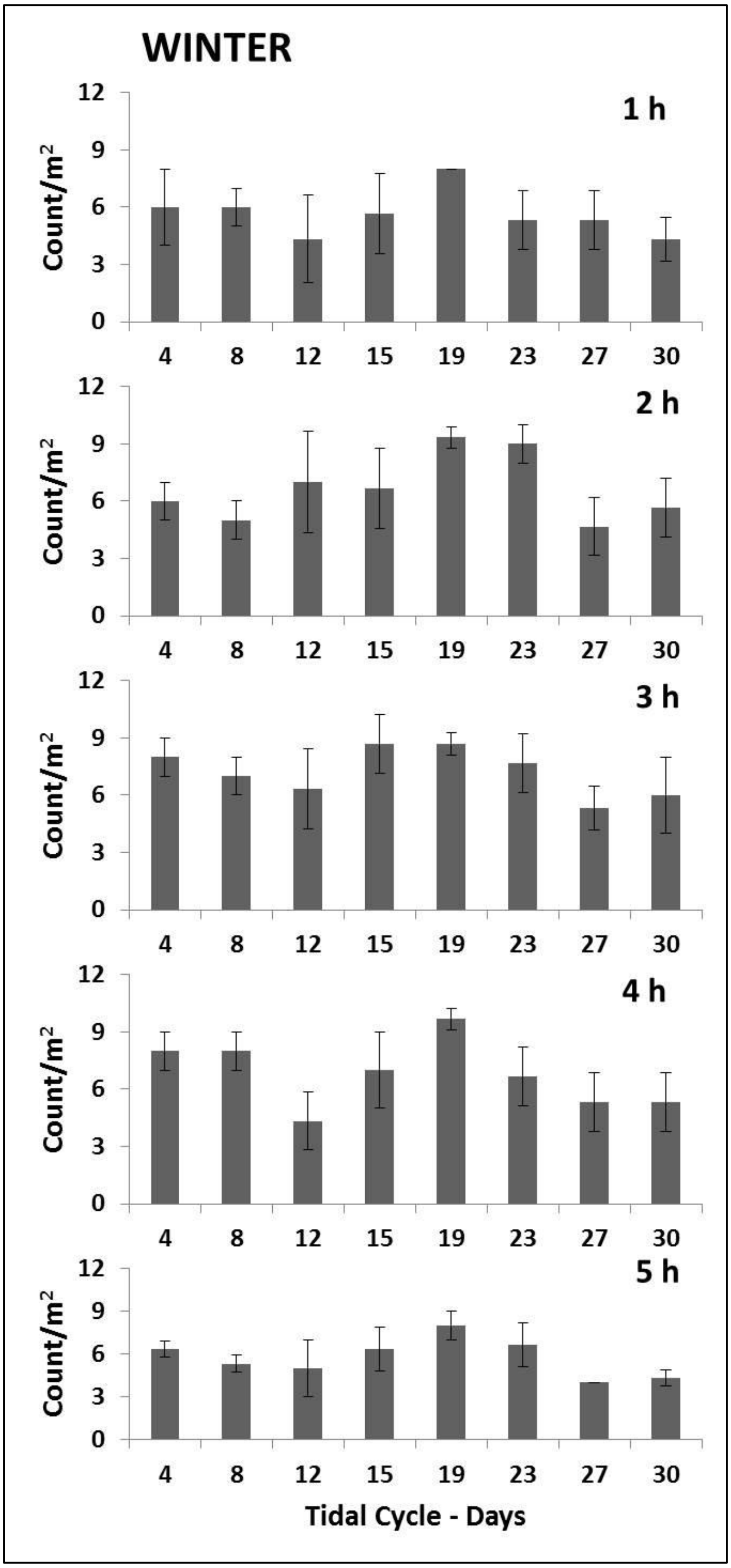

Figure 18. Mean burrow count / m^2 of *Uca annulipes* at diiferent time lapse during low tide along the tidal cycle in Winter

Table 12. Mean burrow count / m^2 of *Uca annulipes* at diiferent time lapse during low tide along the tidal cycle in Summer

Summer	After 1 hr		After 2 hr		After 3 hr		After 4 hr		After 5 hr	
Tidal Cycle day	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**
4th	3.67	1.53	4.67	0.58	4.67	1.15	5.67	1.53	5.33	0.58
8th	4.67	0.58	5.33	1.53	6.00	1.73	6.67	2.08	5.67	0.58
12th	2.00	1.00	4.67	1.15	4.33	1.15	4.67	0.58	4.00	1.00
15th	4.33	1.15	5.00	1.00	5.33	1.53	4.67	0.58	5.00	1.00
19th	3.33	1.53	4.67	0.58	4.33	1.53	5.67	0.58	5.00	1.00
23rd	3.00	1.00	3.33	1.53	4.00	1.00	4.33	1.53	5.33	0.58
27th	3.33	1.53	5.00	0.00	5.00	1.00	5.33	0.58	5.33	1.53
30th	4.00	1.00	4.33	1.53	6.00	1.00	6.33	1.53	5.67	1.15

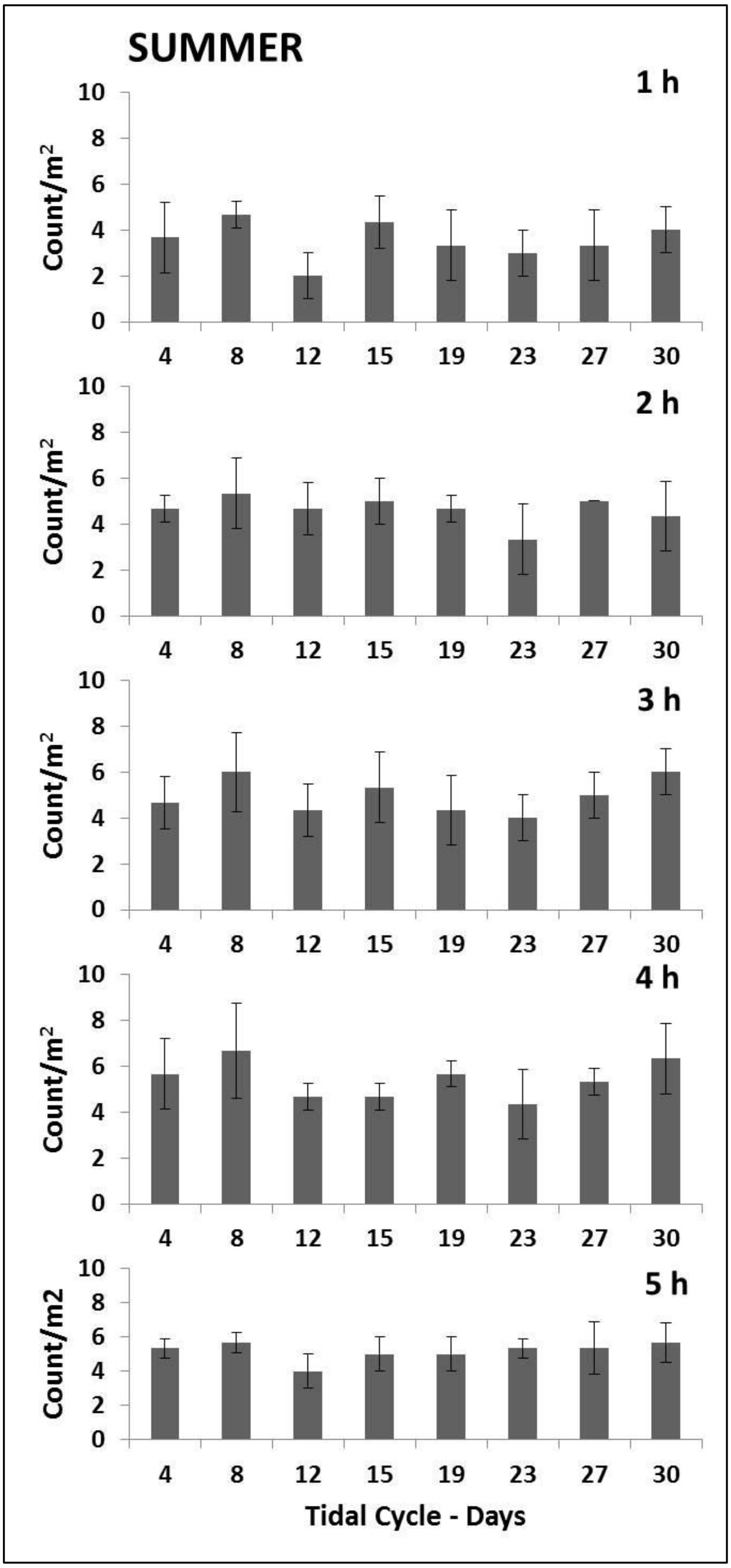

Figure 19. Mean burrow count / m^2 of *Uca annulipes* at diiferent time lapse during low tide along the tidal cycle in Summer

Table 13. Mean burrow count / m^2 of *Dotilla sp.*at diiferent time lapse during low tide along the tidal cycle in Monsoon

Monsoon	After 1 hr		After 2 hr		After 3 hr		After 4 hr	
Tidal Cycle day	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**
4th	13.33	1.53	27.33	1.53	22.33	1.53	22.00	1.53
8th	11.67	2.00	24.00	1.53	24.00	1.15	24.67	1.00
12th	12.00	3.79	23.67	1.53	25.67	1.15	25.00	0.58
15th	13.00	3.21	28.00	3.51	28’00	3.46	28.33	2.08
19th	14.67	2.08	24.00	2.52	22.33	2.00	22.33	2.08
23rd	14.00	3.21	28.67	6.43	28.33	5.29	26.00	3.61
27th	18.33	2.52	29.00	3.00	29.00	1.73	28.67	1.00
30th	12.33	3.51	26.33	4.93	28.67	4.73	27.00	4.16

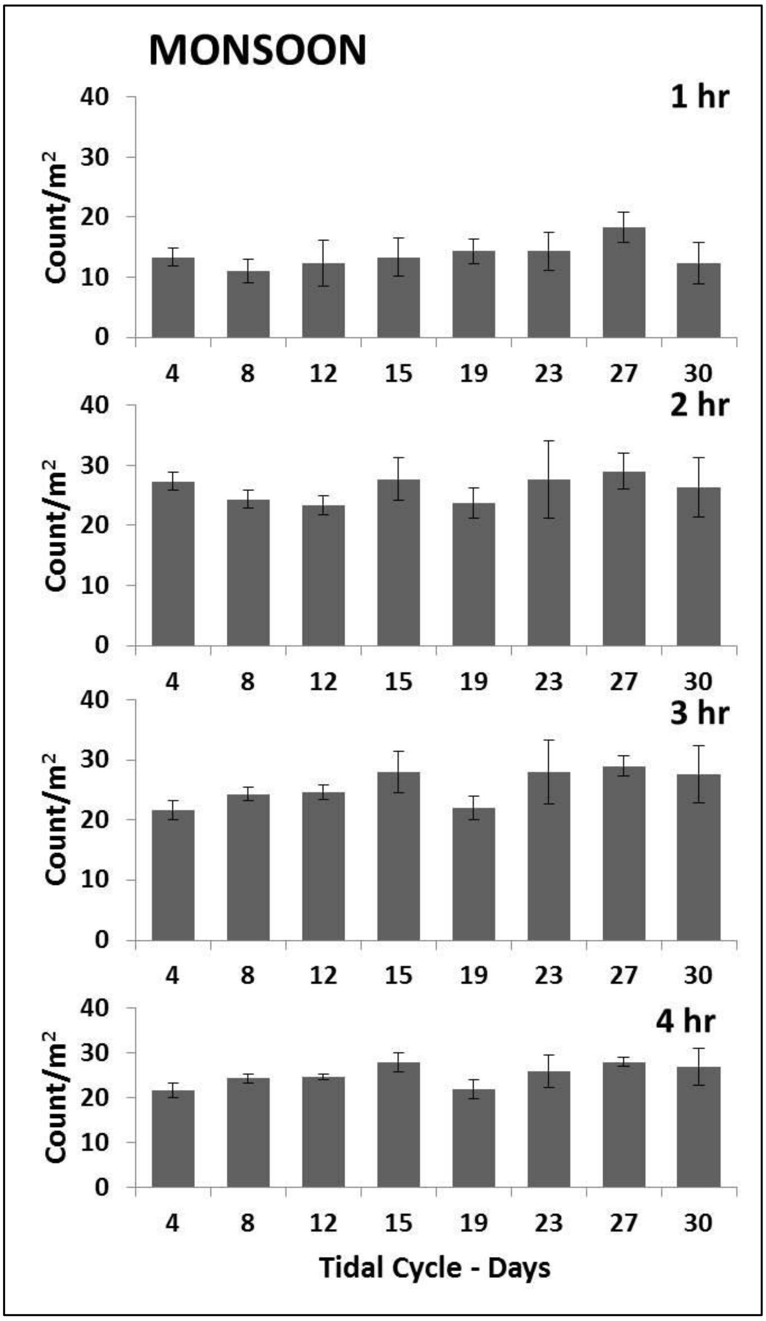

Figure 20. Mean burrow count / m^2 of *Dotilla sp.* at diiferent time lapse during low tide along the tidal cycle in Monsoon

Table 14. Mean burrow count / m^2 of *Dotilla sp.* at diiferent time lapse during low tide along the tidal cycle in winter

Winter	After 1 hr		After 2 hr		After 3 hr		After 4 hr	
Tidal Cycle day	Mean	Stdv	Mean	Stdv	Mean	Stdv	Mean	Stdv
4^{th}	19.33	1.53	30.33	1.53	32.00	2.00	34.33	0.58
8^{th}	18.67	3.06	32.33	1.53	35.67	1.15	35.00	1.00
12^{th}	20.33	3.06	33.00	5.57	34.00	3.61	34.00	2.00
15^{th}	25.33	2.08	41.67	3.06	43.67	0.58	43.00	2.00
19^{th}	30.33	4.04	44.33	3.21	46.67	2.08	48.67	2.08
23^{rd}	33.67	9.61	48.33	5.51	51.00	6.24	54.00	6.24
27^{th}	37.00	5.57	57.33	4.16	58.00	5.29	58.00	3.61
30^{th}	29.00	7.00	57.00	8.19	60.67	7.57	61.33	8.14

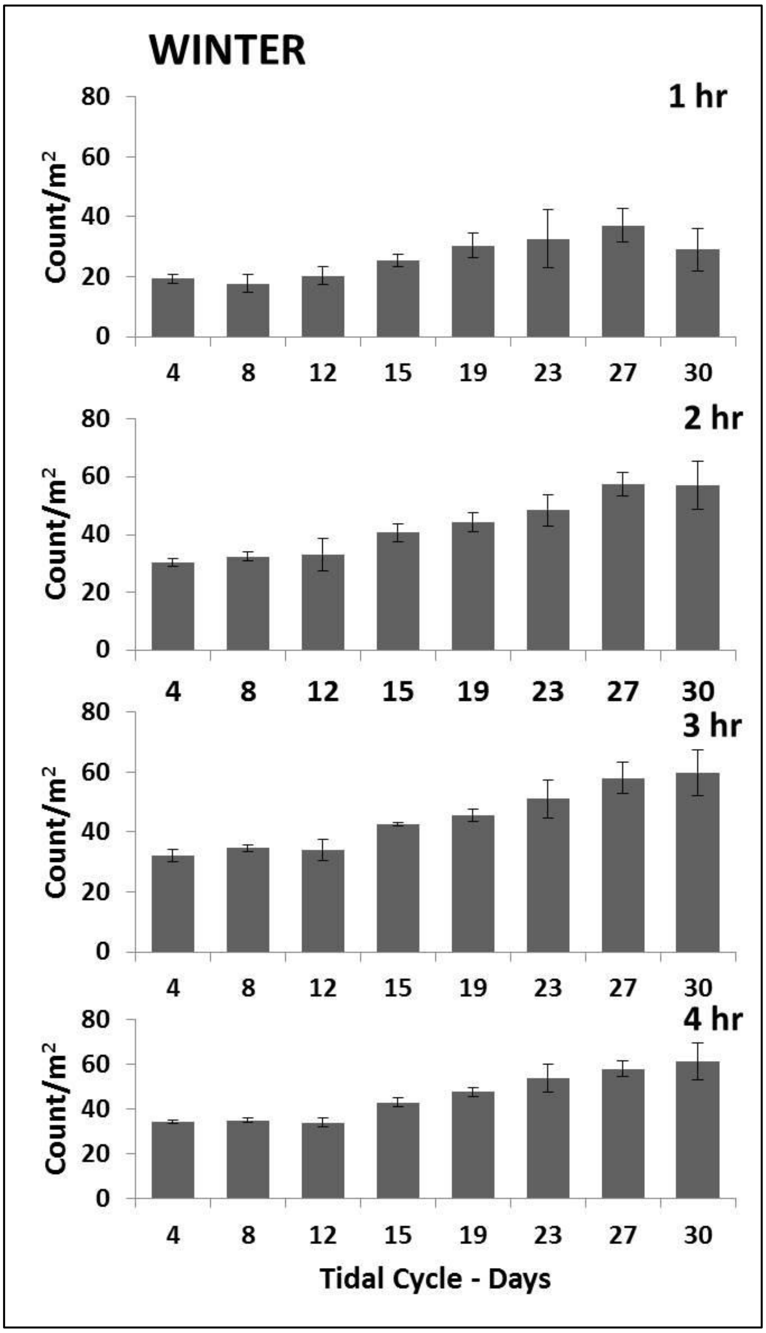

Figure 21. Mean burrow count / m^2 of *Dotilla sp.* at diiferent time lapse during low tide along the tidal cycle in winter

Table 15. Mean burrow count / m^2 of *Dotilla sp.* at diiferent time lapse during low tide along the tidal cycle in Summer

Summer	After 1 hr		After 2 hr		After 3 hr		After 4 hr	
Tidal Cycle day	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**	**Mean**	**Stdv**
4th	39.67	8.02	85.00	8.19	85.67	6.66	91.67	11.68
8th	45.33	7.51	93.67	8.02	98.33	13.05	110.00	12.53
12th	51.00	7.00	104.00	9.85	106.67	7.77	109.67	12.06
15th	53.00	11.14	113.00	18.73	115.00	14.93	124.00	6.93
19th	54.67	9.02	109.00	18.68	111.33	12.58	115.00	13.53
23rd	62.33	8.50	116.33	9.29	115.67	7.51	116.33	13.20
27th	50.00	8.19	110.33	13.61	112.33	20.23	122.67	15.31
30th	59.33	7.77	118.00	13.45	128.00	12.12	131.00	7.21

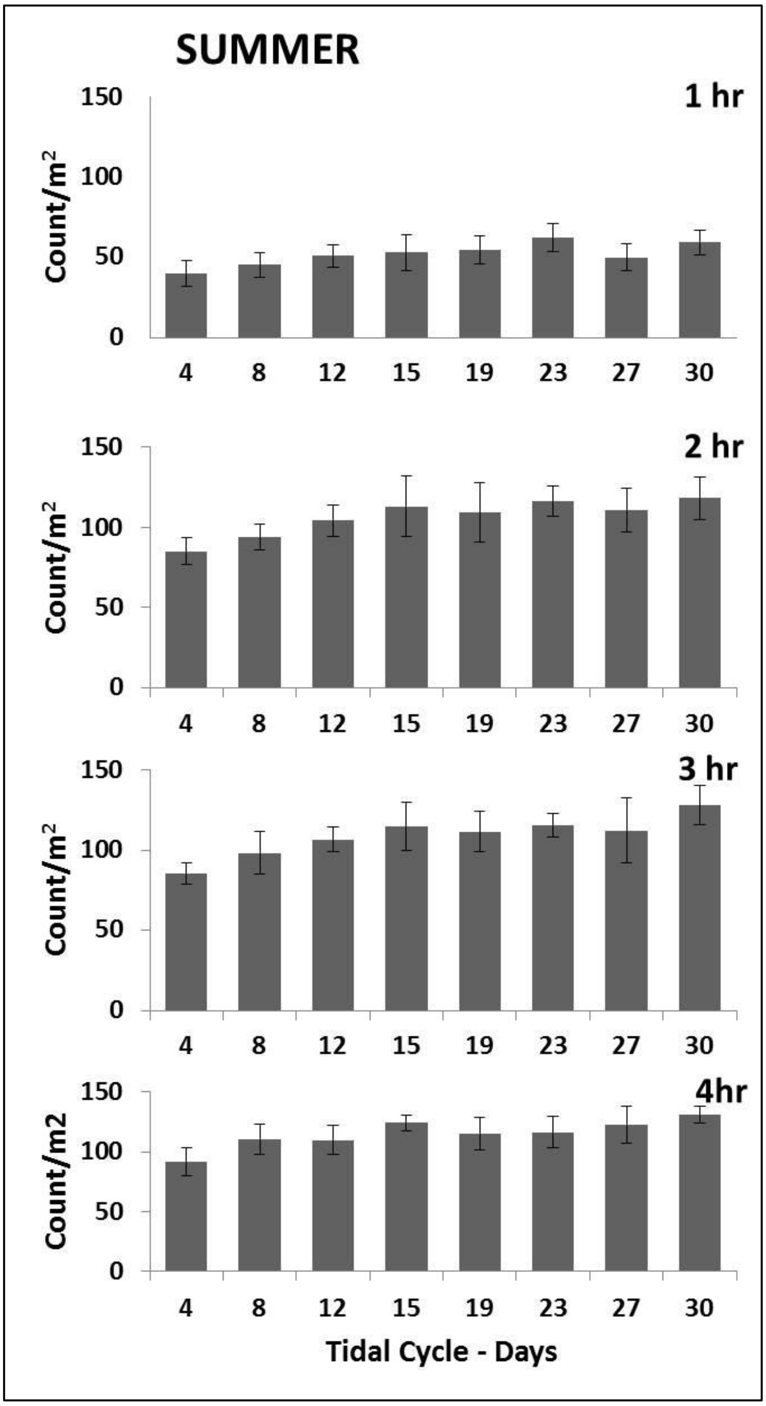

Figure 22. Mean burrow count / m^2 of *Dotilla sp.* at diiferent time lapse during low tide along the tidal cycle in Summer