## 7.1 INTRODUCTION

***"In the delicate ballet of survival, every foraging expedition becomes a chapter in the epic story of adaptation, written by the whispers of instinct and the choreography of necessity."***

**- Anonymous**

The biological disturbance of sediments, or "bioturbation" has a major impact on ecosystem functioning. The functioning of ecosystems is influenced by the presence of "Ecosystem engineers," specifically Grapsid and Ocypodid crabs (Kristensen, 2008). These crabs play crucial role in forming homes for a wide range of organisms, including microbial communities (Bertics and Ziebis, 2009), and macrobenthic populations (Widdicombe et al., 2000). Biogenic formations are by-product of the activities carried out by different organism on soil substrates. Previous studies showed construction of different types of biogenic structure by several organism such as rays creating feeding holes, polychaetes building galleries, crayfish building chimneys, and mudskippers creating burrow hills (Gregory and Ballanc, 1979; Dinh et al., 2014).

Several investigations have shown that different crab species have built a variety of mud and sand buildings. Such as, hoods (Zucker, 1981; Clayton, 1988), pillars (Christy, 1987), pyramids (Linsenmair, 1967), mounds (Wada et al., 1994), chimneys (Wada and Murata, 2000), and mudballs (Oliveira et al., 1998), are commonly seen in close proximity to the entrance of the crab's burrow. Mud balling is a widespread phenomenon in which resident crabs are observed to form tiny balls out of excavated soil from their surroundings, either during feeding or digging activities. Several studies have indicated that mudballs fulfil several purposes, including attracting mates, marking territories, and increasing the visibility of males (Oliveira et al., 1998). However, the precise importance of mudballs remains unknown and necessitates additional extensive examination.

Crabs found to construct their burrow in supratidal and high intertidal areas, traveling to forage in the mid to low intertidal zones during sediment exposure times. The feeding behaviour of these organisms involves the utilization of their minor chelae to transport small amounts of surface material to the buccal area. In this region, mouth appendages are responsible for processing the sediment by mechanically removing organic matters from the ingested material. The sediment that is not accepted accumulates at the base of the buccal region and is regularly expelled, being deposited on the sediment surface in the form of minute pellets. During a singular eating period, crabs have the capacity to digest approximately 50% of the surface sediment within their designated feeding zone (Oliveira et al., 1998). Crustaceans, specifically crabs, have the ability to significantly impact sediment dynamics and the availability of food resources for various communities within intertidal ecosystems. This is achieved through their activities related to burrow maintenance and feeding. Several studies have demonstrated the influence of crabs on sediment transport and mixing, as well as their consequential effects on microbial, faunal, and plant communities in these ecosystems (Fig. 7.1) (Botto and Iribarne, 2000; Botto et al., 2005; Kristensen and Alongi, 2006). The potential consequences of sediment disturbance caused by the feeding and burrowing behaviours of decapods can have both direct and indirect effects on macroinfauna and/or meiofaunal species (Botto and Iribarne, 2000).

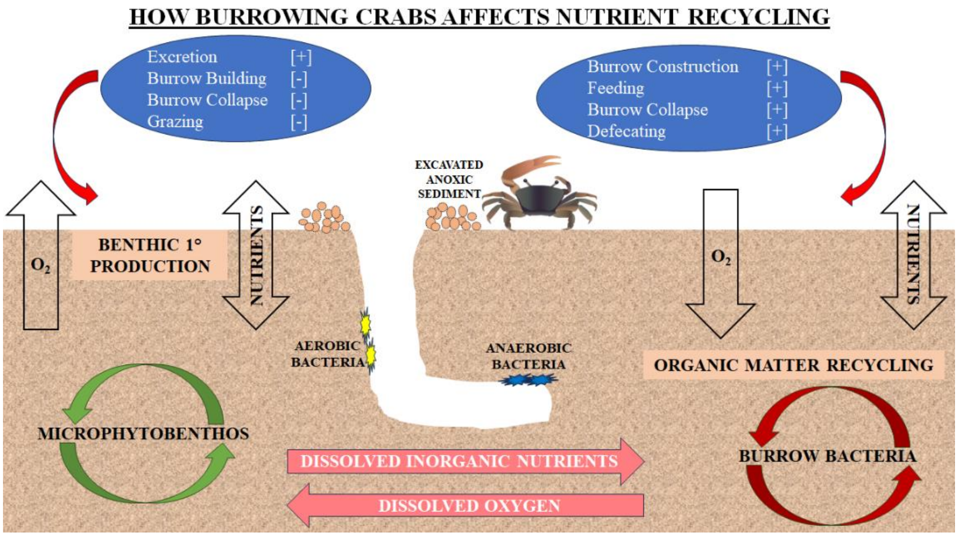


Figure 7.1: Representative illustration of the role of burrowing crab in nutrient recycling

***"With each meticulous movement, a crab becomes an architect of the seabed, its bioturbation dance rewriting the narrative of the ocean floor, a testimony to the subtle power that tiny pincers wield in sculpting the very essence of marine ecosystems."***

The feeding and burrow maintenance rates of particular crab species are influenced by many abiotic conditions, such as sediment grain size, cohesiveness, vegetation cover (Needham et al., 2010), and sewage influent (Bartolini et al., 2011). It is important to understand that these elements have the ability to not only alter the behaviour of individual crab species, but also influence the relationships between different species. This, in turn, may have implications for the overall functioning of ecosystems.

Organic detritus is a substantial constituent of sediments found in estuaries, playing an important part as an essential supply of nourishment in both estuary and coastal ocean. These investigations consistently indicate that detritus and its associated organisms, which are exported from the system frequently function as sources of organic matter. Nevertheless, the presence of invertebrates has a significant impact on the amount and ultimate destiny of detrital matter. For example, their feeding behaviours may encompass the ingestion of detritus or the promotion of detritus production. The contribution of burrowing organisms to the detritus pathway is substantial, as they enhance the decomposition of organic waste by bioturbation and irrigation. The burrows of these organisms serve as passive mechanisms for capturing sediment and organic matter (Botto et al., 2006) that are transported by bedload in both deep-sea and intertidal sediments (Botto and Iribarne, 2000).

Soil animals play crucial roles in both aquatic and terrestrial ecosystems, serving a variety of activities like as consumption, decomposition of trash, and modification of habitats. These species are essential in the process of bioturbation, which involves the biological reworking of soils and sediments through their passive and/or active disturbance of the substrate. Bioturbation, which includes behaviours like as burrowing, foraging, and feeding, exerts significant impacts on fundamental ecological processes (Wang et al., 2010). Furthermore, the enduring effects of bioturbation are of utmost importance in diagenetic processes and contribute significantly to the establishment of unspoiled ecosystems (Wang et al., 2010). Crab burrowing is a commonly seen kind of bioturbation in coastal habitats. This activity not only facilitates the transportation of sediments but also brings about modifications in sediment texture. Consequently, the process of nutrient cycling within the ecosystem is expedited (Wang et al., 2010).

Fiddler crabs and ghost shrimp are recognized as prominent and widespread bioturbating macrofauna in coastal regions across the globe. The importance of their burrows lies in their recognition as vital pathways for chemical exchange between the water column and sediment. The activities of these crustaceans, as described by Bertics and Ziebis (2010), are intricately linked to crucial ecological processes including nutrient recycling, organic matter breakdown, and primary productivity.

Certain species within the Ocypodidae Rafinesque, 1815 have distinct behaviours pertaining to the construction of buildings through the utilization of excavated material. Male ghost crabs, namely *Ocypode saratan* (Forskål, 1775), engage in the construction of sand pyramids in close proximity to their burrows. These sand pyramids serve distinct purposes, including facilitating male territorial boundaries and enhancing female appeal (Linsenmair, 1967). In contrast, *Ilyoplax* Stimpson, 1858 crabs have been shown to construct diverse structures using mud obtained from their burrows, as evidenced by the studies conducted by Wada (1984, 1994), Takayama and Wada (1992), and Wada et al. (1994) (Oliveira et al., 1998).

*Scopimera crabricauda* Alcock, 1900 is a widely distributed burrowing crab species in India, often inhabiting sandy beaches and mudflat habitats in the state of Gujarat. According to the findings of Sana et al. (2017), *S. crabricauda* functions as a deposit feeder and exhibits diurnal activity patterns during low tides in estuary habitats characterized by sandy and restricted conditions. During periods of high tide, the crab seeks refuge in its burrow, resurfacing onto the sediment surface during low tide to engage in feeding and several other behaviours. Research findings have indicated that *S. crabricauda* demonstrates diverse mud balling patterns in the vicinity of its burrow entrances. Studies on the foraging behaviour of this particular species indicate that it obtains organic matter from the soil and generates pseudo-faecal pellets, as evidenced by the research conducted by Tweedie (1950), and Sana et al. (2017).

The assessment of sediment reworking by crabs in intertidal habitats, specifically in mangroves, has been given insufficient attention, despite its ecological importance. Previous research has predominantly concentrated on individual species, as highlighted by Iribarne et al. (1997), Botto and Iribarne (2000), Amouroux and Tavares (2005), Penha-Lopes et al. (2009), and Needham et al. (2010). Significantly, the research on mudball construction has predominantly centred on several species of fiddler crabs (Pardo et al., 2020). Currently, there is a lack of study examining potential variations in mud balling behaviour between male and female crabs in India, as well as a dearth of investigations comparing this behaviour to that of other crab species. The existing study vacuum underscores the necessity for additional investigation and comprehension of the many facets of crab behaviour within the Indian environment, as well as potential disparities across genders and species.

The habits and behaviour of shore crabs in the Indian subcontinent have received scant attention in previous literature, as evidenced by the published works of Henderson (1893), Alcock (1900, 1902), Kemp (1919), and Sewell (1922). Altevogt (1955) has made significant contributions to the field of ecology, biology, and ethology by conducting extensive research on shore crabs. Specifically, Altevogt's work has focused on fiddler crabs belonging to the genus *Uca* Leach, 1814 [such as *Austruca annulipes* (H. Milne Edwards, 1837), *Gelasimus vocans* (Linnaeus, 1758), *Uca nitida* (Desmarest, 1817) †, and *Austruca triangularis* (A. Milne-Edwards, 1873)] as well as the closely related genus Dotilla Stimpson, 1858 [including *Dotilla blanfordi* Alcock, 1900 and *Dotilla myctiroides* (H. Milne Edwards, 1852)] from India. These findings have been documented by Silas and Sankanrankutty (1965).

In consideration of the present discrepancy in understanding, the primary objective of this study is to do preliminary assessments on the foraging and bioturbation behaviour of *Austruca sindensis* (Alcock, 1900) and *Ilyoplax sayajiraoi* JN Trivedi, Soni, DJ Trivedi & Vachhrajani, 2015, which is a species that has been newly identified. The primary goal of the present research was to enhance comprehension of the behavioural characteristics exhibited by mud crabs and shed light on their ecological significance within the Indian coastal environment.

The detail methodology for data collection has been described in materials and methods chapter (page no. 32). Following flow chart shows summary of methodology used in the present chapter.

## Methodology: *Foraging Behaviour*

**200 Burrows were selected randomly of respective species and their opening diameter was recorded**

↓

**Photographs of selected burrows were captured**

↓

**Total area of foraging area was measured using DIGIMIZER Image Analysis Software**

↓

**Resident crabs were collected randomly form the selected burrows and their carapace length was measured.**

↓

**Mudballs were collected and their diameter were measured**

↓

**Then after mudball weight was measured**

↓

**Regression analysis was conducted to examine the relationship between the CL with BOD, TFA, TNM, TWM, ASM, and ADM.**

## Methodology: *Bioturbation*

**Quadrates (n=50) were laid randomly from upper intertidal to lower intertidal zone and Sub-surface temperature data of each quadrate was taken**

↓

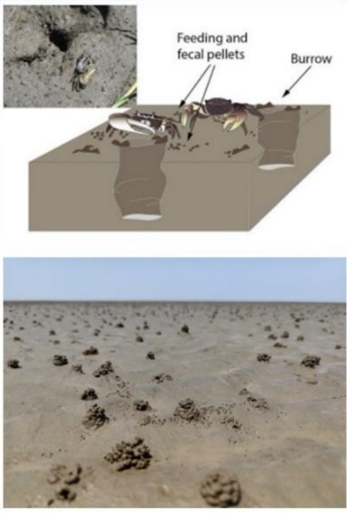
**Total number of burrows of respective species were counted and their opening diameters were recorded**

↓

**Mudballs of the individual burrow of respective species were collected, labelled in separate zip-lock bags and brought to the laboratory for further analysis**

↓

**Dry weight of the mudballs of each zip-lock bag were measured**



## 7.2 RESULTS

### *7.2.1 Foraging Behaviour*

In the current study, a total of 200 burrows inhabited by *A. sindensis* (55 males and 47 females), and *I. sayajiraoi* (59 males and 56 females), were examined for their foraging behaviour. The CL of *A. sindensis* showed positive correlation with mud balling metrics (Fig. 7.2, 7.3), including burrow opening diameter (BOD) ($R^2$=0.84), total foraging area (TFA) ($R^2$=0.26), total number of mudballs (TNM) ($R^2$=0.06), total weight of mudballs (TWM) ($R^2$=0.24), average mudball size (AMS) ($R^2$=0.16), and average distance between mudballs (ADM) ($R^2$=0.35), according to regression analysis. Regression analysis was carried out between CL of *I. sayajiraoi* and its mud balling metrics, where CL was positively correlated with BOD ($R^2$=0.72), TFA ($R^2$=0.27), TNM ($R^2$=0.17), TWM ($R^2$=0.32), AMS ($R^2$=0.12), and ADM ($R^2$=0.11) (Fig. 7.4, 7.5). In the current investigation, it was noted that male individuals had a more dispersed distribution of mudballs, characterized by more space between them. Conversely, females displayed a denser mud balling pattern, with much less spacing found between the mudballs.

### *7.2.1.2 Foraging behaviour of Austruca sindensis* (Alcock, 1900)

Mudballs were built by crabs using surrounding surface sand they used for feeding as well as sand that was dug out of their burrows. During this process, the crabs would carry a mudball using their walking legs on one side (specifically, the side opposite the major chela in males). Subsequently, the crabs would deposit the mudball on the substratum surrounding the mouth of the burrow which eventually considered its foraging area.

Present investigation reveals that, foraging rate of fiddler crabs (*A. sindensis*) not varied significantly between male and female (t=-0.12, p=0.45). For male and female burrows, the average foraging area was 425.36±285.35 and 438.26±198.79, respectively (Table 7.1). Male and female burrows had minimum foraging areas of 54.53 and 144.3 $cm^2$ and maximum foraging areas of 1053.89 and 1179.71 $cm^2$, respectively. In present study, CL of *A. sindensis* ranged from 2.89 to 11.06 mm, while the body size of male and female crabs varied between

2.34 to 11.35 mm and 3.40 to 9.39 mm, respectively. Both sexes created mudballs and positioned them in different places, but significant differences were recorded between them. Female individuals constructed more mudballs but size of mudballs is smaller as compared to male individuals. The mean number of mudballs deposited around female burrows was 416.16±172.40 (Table 7.1), with minimum and maximum numbers of around 913 and 203 respectively. Whereas for male burrows it was 304.68±179.13 (Table 7.1) with minimum and maximum number of mudballs observed around were 912 and 102, respectively.

Male and female mean diameter of mudballs were 1.59±0.62 and 1.57±0.53 mm, respectively (Table 7.1). The average distance between the mudballs was recorded at 4.26±2.64 and 4.04±0.75 mm for both burrows (Table 7.1), with the maximum distances being 9.27 and 5.36 mm. The minimum distance between two mudballs was 1.98 and 2.87 mm, respectively. Mean weight of mudballs found in the vicinity of male burrows was measured around 4.47±3.20 gm, while for female burrows it was recorded around 6.31±4.17 (Table 7.1). The maximum weight of mudballs observed for males and females were 14.53 and 11.37 gm, respectively. Conversely, the minimum weight of mudballs for males and females were 2.89 and 2.16 gm, respectively.

Table 7.1: Variation in foraging and mud balling pattern between different sexes of *Austruca sindensis* (Alcock, 1900). (BOD: burrow opening diameter; TFA: total foraging area; TNM: total number of mudballs; TWM: total weight of mudballs; AMS: average mudball size; ADM: average distance between mudballs; Sw: seaward; LW: landward)

| **Parameter** | **Male** | **Female** | **T-test** | **p-value** |
|---|---:|---:|---:|---:|
| BOD (mm) | 7.41±2.08 | 6.68±1.16 | 1.42 | 0.08 |
| TFA ($cm^2$) | 425.36±285.35 | 438.26±198.79 | -0.12 | 0.45 |
| TNM | 304.68±179.13 | 416.16±172.40 | 2.99 | $p< 0.001$ |
| AMS of 10 mudballs (mm) | 1.59±0.62 | 1.57±0.53 | -0.22 | 0.4135 |
| ADM (mm) | 4.26±2.64 | 4.04±0.75 | -0.81 | 0.2095 |
| CL (mm) | 6.57±2.01 | 5.86±1.20 | -1.38 | 0.0861 |
| TWM (gm) | 4.47±3.20 | 6.31±4.17 | -1.86 | $p< 0.05$ |
| Orientation of mud balling | 26 SW;29 LW | 17 SW; 30 LW | | |

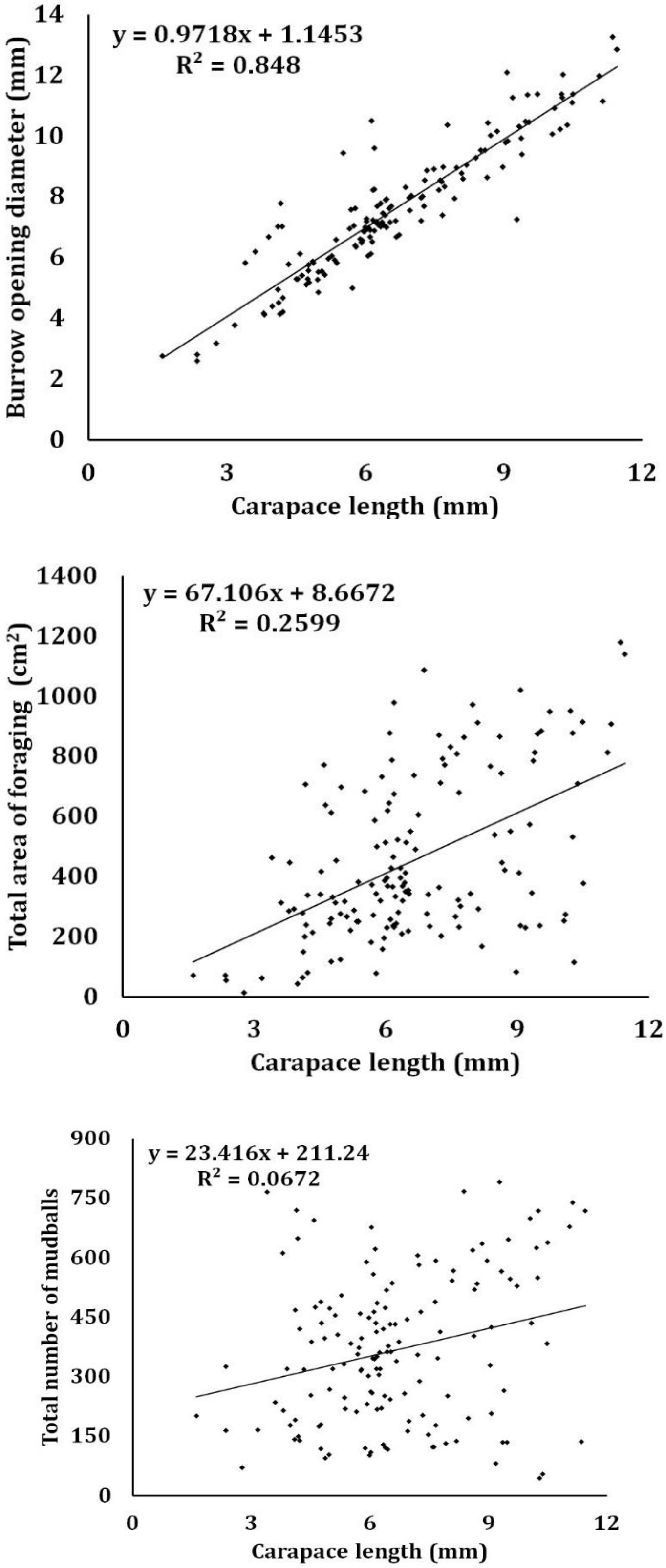


Figure 7.2: Regression analysis for the relationship of crab Carapace Length (CL) with burrow opening diameter, total area of foraging, and total number of mudballs of burrows of *Austruca sindensis* (Alcock, 1900).

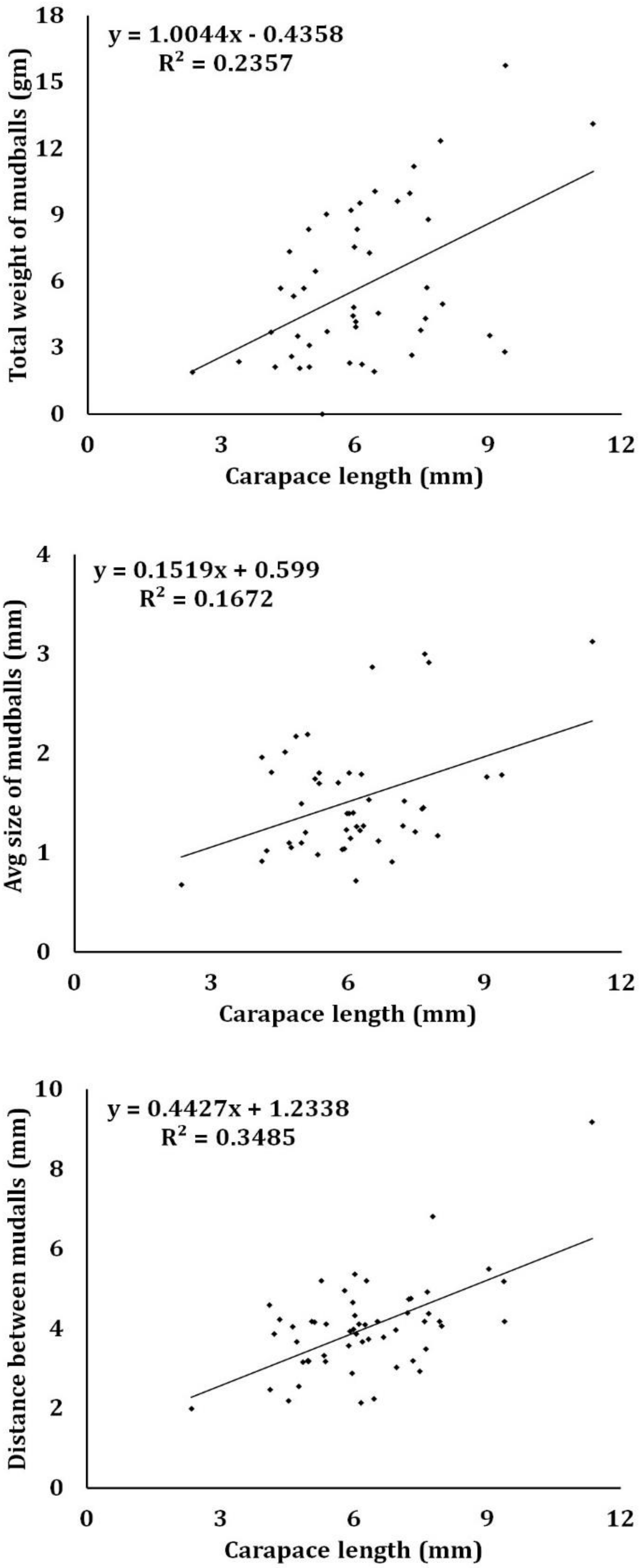


Figure 7.3: Regression analysis for the relationship of crab Carapace Length (CL) with total weight of mudballs, average size of mudballs, and distance between mudballs of burrows of *Austruca sindensis* (Alcock, 1900).

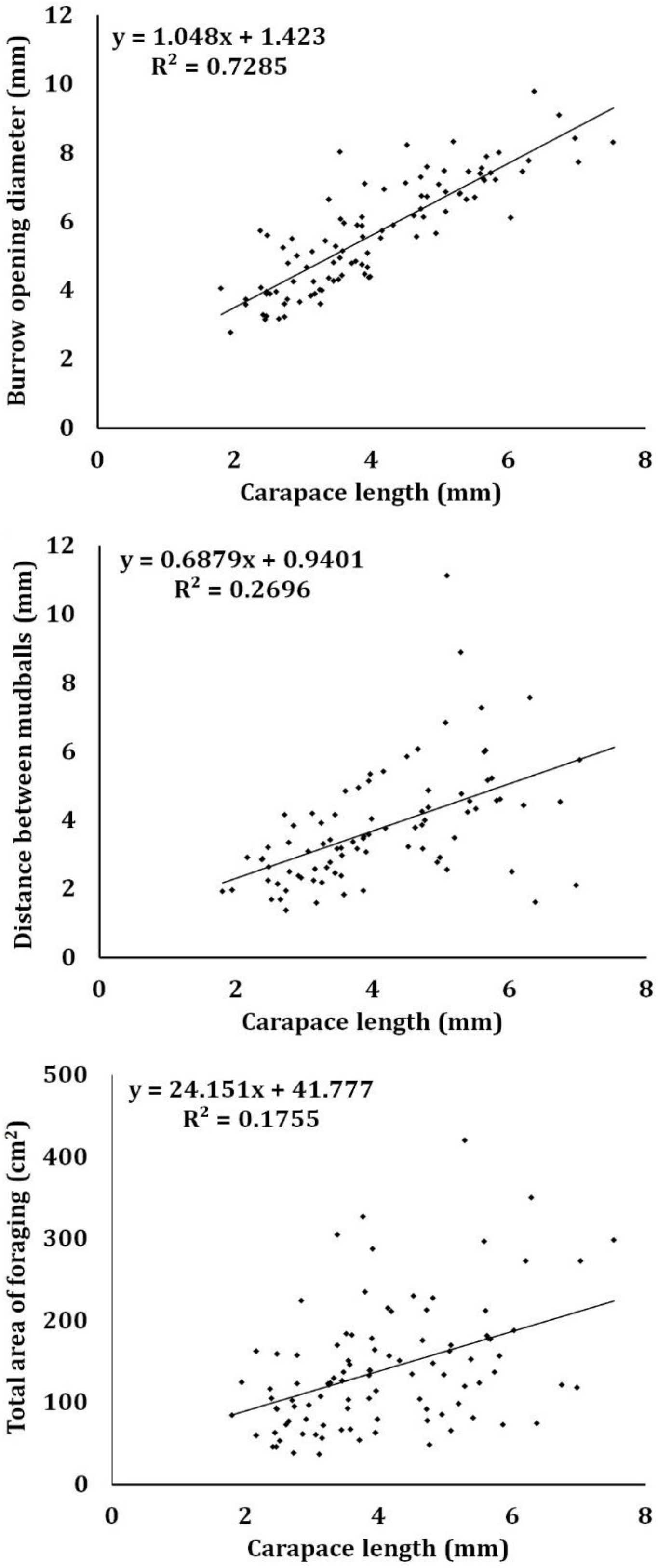


Figure 7.4: Regression analysis for the relationship of crab carapace length (CL) with burrow opening diameter, total area of foraging, and total number of mudballs of burrows of *Ilyoplax sayajiraoi* Trivedi, Soni, Trivedi & Vachhrajani, 2015.

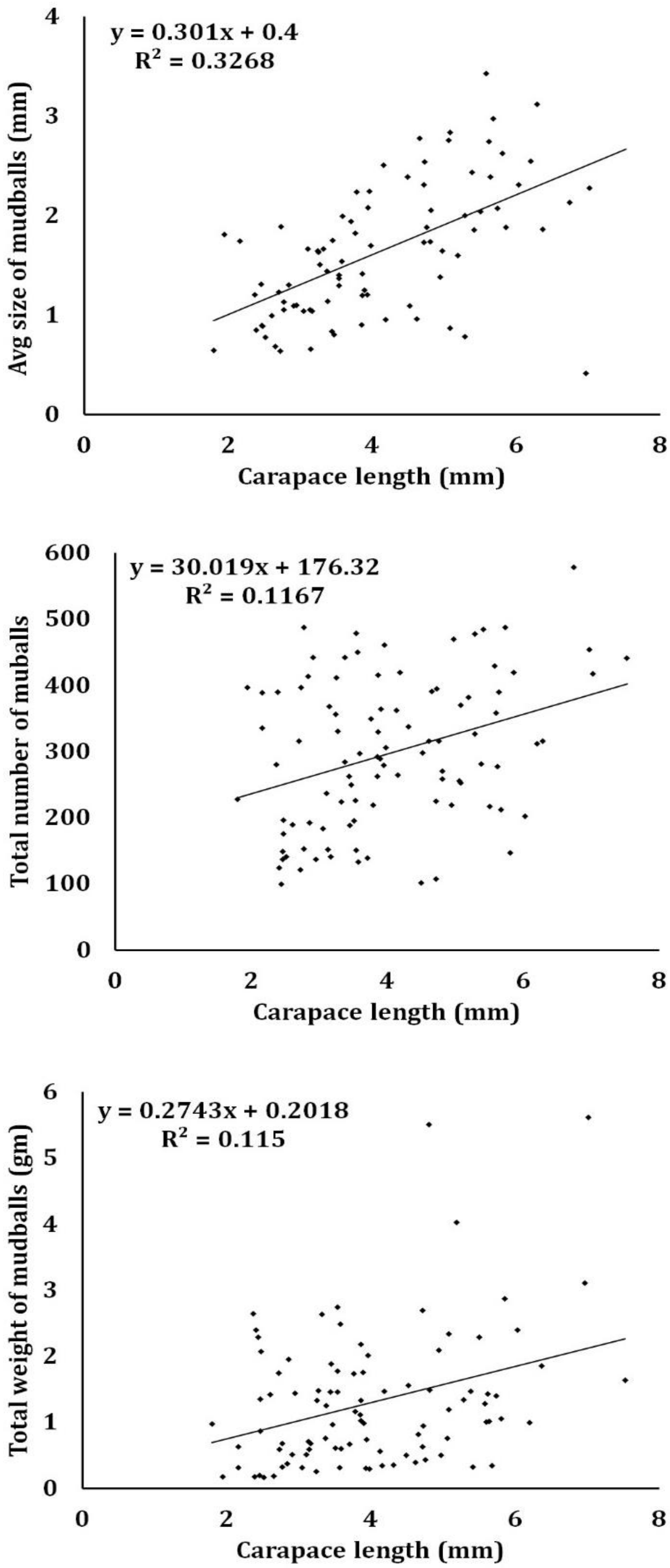


Figure 7.5: Regression analysis for the relationship of crab Carapace Length (CL) with total weight of mudballs, average size of mudballs, and distance between mudballs of burrows of *Ilyoplax sayajiraoi* Trivedi, Soni, Trivedi & Vachhrajani, 2015.

### *7.2.1.2 Foraging behavior of Ilyoplax sayajiraoi* Trivedi, Soni, Trivedi & Vachhrajani, 2015

There was observed a difference in the foraging rate between male and female individuals of *I. sayajiraoi* (t=1.31; p=0.096). The mean foraging area for males was recorded around 130.50±65.62 cm$^2$, while for females it was measured 150.03±80.74 cm$^2$ (Table 7.2). The male burrow showed the largest and smallest foraging range of 296.86 and 36.59 cm$^2$, respectively. Present study revealed that female burrows exhibited a variety of foraging distances, with the minimum and maximum measurements being 45.42 and 420.49 cm$^2$, respectively. The findings of this study indicate that female individuals exhibited a greater foraging area in comparison to their male counterparts.

The mean CL of male *I. sayajiraoi* individuals was measured in the range of 4.19±1.29 mm, while females had a CL of 3.90±1.25 mm (Table 7.2). Male and female minimum lengths were measured around 1.80 and 1.94 mm while maximum lengths were measured around 7.53 and 7.02 mm. The mean number of deposited mudballs near male and female burrow entrances was 310.54±114.45 and 288.74±110.53, respectively (Table 7.2). The minimum number of mudballs were recorded 99 and 157 surround the male and female burrows respectively. The maximum number of mudballs seen was approximately 487 and 419 for male and female burrows, respectively.

The study recorded the sizes of mudballs, differentiating between genders, as 1.59±0.64 mm for males and 1.68±0.64 mm for females (Table 7.2). The dimensions of mudballs found in male burrows were observed to range from approximately 0.41 mm to 3.43 mm. In contrast, the observed diameters of mudballs in female burrows ranged from around 0.64 to 3.11 mm. The measurements of the distance between the mudballs in both burrows were recorded at 3.71±1.55 mm and 3.90±1.76 mm, respectively (Table 7.2). The greatest distances observed were 8.91 mm and 7.59 mm. The minimal distance between two mudballs was measured to be 1.37 mm and 1.62 mm, respectively. The average weight of mudballs collected near the vicinity of male burrows was observed to be around 1.38±1.20 gm, but for female burrows, it was found to be around 1.23±0.73 gm (Table 7.2). The observed maximum weight of mudballs for males and females were 4.03 and 2.86 gm, respectively. In contrast, the minimal weight of mudballs for males and females was recorded as 0.68 and 0.16 gm, respectively.

Table 7.2: Variation in foraging and mud balling pattern between different sexes of *Ilyoplax sayajiraoi* Trivedi, Soni, Trivedi & Vachhrajani, 2015. (BOD: burrow opening diameter; TFA: total foraging area; TNM: total number of mudballs; TWM: total weight of mudballs; AMS: average mudball size; ADM: average distance between mudballs; Sw: seaward; LW: landward)

| **Parameter** | **Male** | **Female** | **T-test** | **p-value** |
|---|---:|---:|---:|---:|
| BOD (mm) | 5.46±1.59 | 5.91±1.45 | 1.44 | $p < 0.05$ |
| TFA ($cm^2$) | 130.50±65.62 | 150.03±80.74 | 1.31 | 0.096 |
| TNM | 310.54±114.45 | 288.74±110.53 | -0.95 | 0.17 |
| AMS of 10 mudballs (mm) | 1.59±0.64 | 1.68±0.64 | 0.61 | 0.27 |
| ADM (mm) | 3.71±1.55 | 3.90±1.76 | 0.51 | $p < 0.05$ |
| CL (mm) | 4.19±1.29 | 3.90±1.25 | 1.09 | $p < 0.05$ |
| TWM (gm) | 1.38±1.20 | 1.23±0.73 | -0.70 | 0.09 |
| Orientation of mud balling | 36 SW; 23 LW | 31 SW; 25 LW | | |

### *7.2.2 Bioturbation*

In the present study the correlation status was checked between opening diameter and dry weight of mudballs of individual burrow in *A. sindensis* and *I. sayajiraoi*. A strong positive correlation was recorded in both the species between the studied parameters (Fig. 7.6, Fig. 7.7).

One of the main ways of assessing an organism's capacity for bioturbation was the excavation of burrows by that species. The calculation of bioturbation performed by a single species on a daily basis per square meter was derived from the analysis of the observed burrows in the study. In terms of individual species, *A. sindensis* had the maximum turnover rate at 126g/m$^2$/day, whereas *I. sayajiraoi* demonstrated a bioturbation rate of approximately 45g/m$^2$/day (Fig. 7.8).

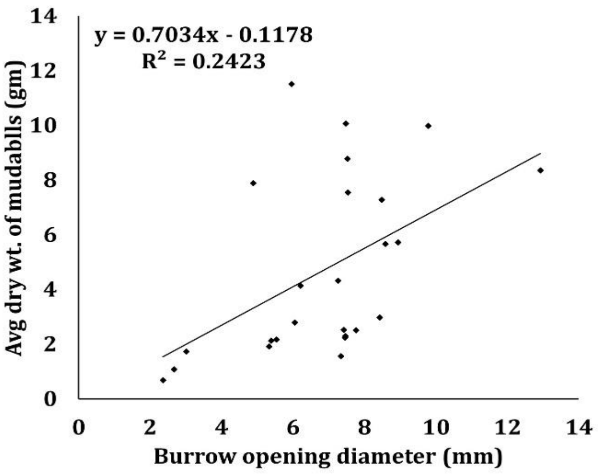


Figure 7.6: Regression analysis for the relationship between Burrow opening diameter and Dry weight of Mudballs of the individual burrow of *Austruca sindensis* (Alcock, 1900).

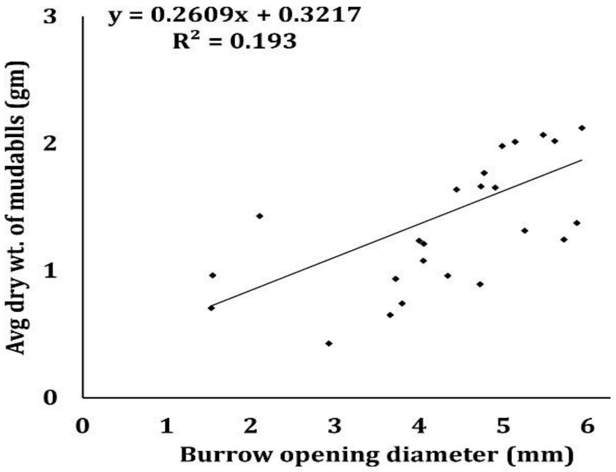


Figure 7.7: Regression analysis for the relationship between Burrow opening diameter and Dry weight of Mudballs of the individual burrow of *Ilyoplax sayajiraoi* Trivedi, Soni, Trivedi & Vachhrajani, 2015.

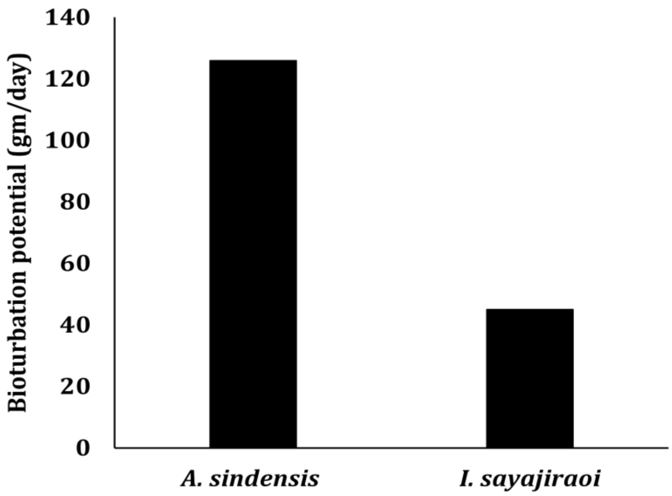


Figure 7.8: Average daily output of bioturbation potential of different crab species per square meter

## 7.3 DISCUSSION

Acquiring nutrients for development and reproduction is a vital factor in the success of any consumer species, regardless of whether it is native or invasive. Decades of research have shown that there are significant variations in the foraging methods of various species, in addition to dietary differences within species (carnivores, herbivores, detritivores, etc.). The variations in foraging behaviour may ultimately dictate the ability of a species to effectively establish, proliferate, and thrive in a new ecological setting.

Members of the Ocypodidae and Dotillidae families use their chela to collect sand from their surroundings during feeding (Miller, 1961). Mud balling is an exceptional behavioural trait exhibited by brachyuran crabs during their feeding and burrowing activities. During occurrence of low tide, fiddler crabs exhibit a behaviour where they emerge from their burrows and engage in activities such as clearing and digging their burrows, foraging and feeding as well as strategically arranging mudballs around the entrance of the burrow (Oliveira et al., 1998; Burford et al., 2001). Nonetheless, significant differences occurred in the mud balling behaviour exhibited by two distinct families of crabs, namely Ocypodidae (*A. sindensis*) and Dotillidae (*I. sayajiraoi*). The production of mudballs in the case of Ocypodidae was a result of both burrow excavation and feeding activity. On the other hand, mudballs produced by Dotillidae were formed from the sand excavated during their feeding process (Oliveira et al., 1998). As per the findings of Wolfrath (1993), *Afruca tangeri* (Eydoux, 1835) species in Portugal exhibited a pattern of surface activity characterized by an initial period of intensive feeding lasting for 1-1.5 hours, followed by around 1 hour of engaging in burrow-related activities.

The current study demonstrates prominent variation in the TFA of both investigated species (Table 7.1; Table 7.2). The feeding activity may vary with species to species, sex and size of brachyuran crabs. These factors may affect the sensitivity of crab species towards the food supply as well as it can be attributed to alterations in foraging efficiencies, food assimilation rates, food requirements, or the potential limitation of food availability (Crane, 1975).

Here, CL of *A. sindensis* and *I. sayajiraoi* were positively correlated with BOD, TFA, ADM, TWM, as well as the TNM and AMS (Fig. 7.2-7.5). Lee and Lim (2004) carried out research on *Dotilla myctiroides* (H. Milne Edwards, 1852) to check relationship between BOD and feeding pellet diameter with CL of resident crab, which indicated both burrow diameter and food pellet diameter were closely related to the size of the crab, especially CL. These parameters could be used as an estimate to the size structure of the population, without massive excavation and undue disturbance to the habitat (Lee and Lim, 2004).

Previous studies had indicated a favourable association between body size and the quantity of mudballs excavated by both female and male individuals of *A. tangeri* (Oliveira et al., 1998; Latruffe et al., 1999). This phenomenon can be attributed to the fact that larger-sized crabs require a greater quantity of food to meet their metabolic requirements, resulting in the expansion of their foraging area. In addition, it has been shown that male mudballs may attract females for mating. Specifically, females tend to exhibit a greater inclination to approach a male burrow that contains a larger quantity of mudballs, as opposed to a male burrow with a smaller quantity of mudballs (Oliveira et al., 1998). According to Latruffe et al. (1999), the quantification of mudballs surrounding a male's burrow may serve as a means for females to evaluate the quality of the burrow without entering inside burrow. Because male burrows with mudballs could be a fertile arena for female mate preference. Mudballs around male burrows might provide a mating opportunity for males by increasing their chance of encountering females.

The current study revealed, a notable difference was observed in CL of male and female individuals of both the species, with males exhibiting bigger body size than females (Table 7.1; Table 7.2). According to Chan et al., (2006), it has been observed that males generally exhibit larger body sizes in comparison to females. This difference can be attributed to the increased energy expenditure in physical growth among males, whereas females allocate a significant portion of their energy into egg development and reproduction. Lim (2006) discovered that the diameter of the burrow opening was larger in male individuals compared to females. This difference can be attributed to the higher body size of males, which enables them to travel more easily across the burrow opening.

Though males were larger, current investigation showed that females of both species exhibited a greater foraging range in comparison to males. Dudiya et al. (2023) observed similar findings during their investigation on the mud balling behaviour of *Scopimera crabicauda*. However, a study conducted by Patel et al. (unpublished data) revealed contradictory results for *D. blanfordi* (Dudiya et al., 2023), where males exhibiting a higher mud balling area as compared to females. This may be because, males exhibit active participation in male-male conflict, mating behaviours, and territorial marking, which may result in reduced activity in covering larger areas with high mud balling and constructing a greater number of mudballs (Oliveira et al., 1998).

In *A. sindensis*, female burrows had more amount of mudballs as compared to males, (Table 7.1). Similar studies were carried out on *A. tangeri* [Initially recognized as *Uca tangeri* (Eydoux, 1835)] and *A. annulipes* where males had constructed a greater number of mudballs as compared to females (Oliveira et al., 1998; Tina et al., 2018). Conversely, for *I. sayajiraoi*, males were seen to produce a greater number of mudballs compared to females, as shown in Table 7.2. There could be one possible reason behind this, as males build longer and deeper burrows than females, they consequently dig more mud and thus have to make more mudballs.

Furthermore, it was observed that the mean distance between the mudballs exhibited higher values among male individuals in comparison to female individuals for both species (Table. 7.1; Table. 7.2). In addition, it was observed that female individuals tend to position substantial mudballs in close proximity to their burrow entrance, whereas male individuals exhibit a preference for placing larger mudballs at a greater distance from the burrow mouth. Both male and female individuals were seen to consistently deposit mudballs of almost identical size at the central area of the mud balling pattern. The mud balling behaviour exhibited by male individuals is characterized by the placement of mudballs at a larger distance from the burrow opening. This behaviour is likely influenced by the male's role in mating attraction and the establishment of territorial boundaries (Oliveira et al., 1998; Chatterjee et al., 2014).

Because of foraging and digging activity, the sediment is significantly influenced by burrowing macrofauna. The activity of organisms has an impact on the environmental conditions in their burrows as well as the surrounding surface sediment. Crabs have a major impact on the composition of sediment, the structure of the habitat, and the benthic animals, much like other burrowing crustaceans like *Callianassa* Leach, 1814 (Dworschak, 2001) and *Upogebia* Leach, 1814 (Kinoshita et al., 2003). The grapsid crab *Chasmagnathus granulatus* Dana, 1851 [*Neohelice granulata* (Dana, 1851)] has been found to exert a significant influence on the distribution of meiofauna, the amount of organic matter, and the loading of nitrogen in sediment (Botto and Iribarne, 2000; Botto et al., 2005, 2006). According to Bruno (2012), there is evidence to suggest that the feeding activity of *Uca uruguayensis* Nobili, 1901 [*Leptuca uruguayensis* (Nobili, 1901)] and *Uca (Minuca) rapax* (Smith, 1870) [*Minuca rapax* (Smith, 1870)] leads to sediment bioturbation, resulting in alterations to both the granulometric composition and organic content. The feeding behaviour of *L. uruguayensis* and *M. rapax* leads to bioturbation within the mangrove sediments, resulting in alterations to both the size-class distribution and organic content of the sediment after processing.

Present study revealed that, the dry weight of mudballs showed positive correlation with BOD of both the species which suggest that larger crabs required more food and larger burrow as compared to smaller one. Which in turn imparts more bioturbation potential to respective crab species. Pandya (2010), studied bioturbation potential of three brachyuran crab species *Uca lactea*, *Dotilla crepsydrodactyla* and *Macrophthalmus depressus* (Presently identified as *A. sindensis*, *D. blanfordi* and *I. sayajiraoi*) species and their contribution to the prevailing habitat/environment from lower estuarine region of mahi river. Where they have recorded highest turnover with a rate of 11.43kg/crab/year followed by 7.2kg and 3.9kg per year respectively for above mentioned species. In present study also, it was observed that *A. sindensis* has higher bioturbation potential as compared to *I. sayajiraoi* (Fig. 7.8). Similar study was carried out on *Ucides* *cordatus* (Linnaeus, 1763) which resulted mean excavation rate in the young mangrove becomes 9.1±7.6 g $m^{-2}$ $day^{-1}$ (Adélaïde et al., 2016). Variations in sediment reworking rates are neither related to changes in species nor in functional richness area but rather depend on the presence of an individual species or a specific burrowing behaviour. These findings add weight to the recognition of the importance of species or functional identity in controlling ecosystem processes (Mermillod-Blondin et al., 2005).