Environment and Natural Resources Journal

Volume 22
Issue 4
2024

Burrow Morphological Characteristics of Soldier Crab (*Dotilla myctiroides*) on the Libong Island, Koh Libong Subdistrict, Kantang District, Trang Province, Thailand

Pimonrat Thongroy, Supaporn Saengkeaw, Panjan Sujjaritthurakarn, Waewruedee Waewthongrak, Sukallaya Hemmanee, and Somsak Buatip*

Department of Science, Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani, Thailand

ARTICLE INFO

Received: 10 Nov 2023
Received in revised: 27 Apr 2024
Accepted: 8 May 2024
Published online: 10 Jun 2024
DOI: 10.32526/ennrj/22/20230316

Keywords:
Burrow/ Sandy beach/ Libong/ *Dotilla myctiroides*

*** Corresponding author:**
E-mail: somsak.bu@psu.ac.th

ABSTRACT

Dotilla myctiroides, the soldier crab, digs burrows in sand flats and extracts nutrients from sediment. The present study investigated the burrow morphology of this soldier crab, at Laem Juhoi Beach, Libong Island, Koh Libong Subdistrict, Kantang District, Trang Province, Thailand. Randomly selected burrows were examined by injecting molten paraffin into them. The crab found inside a burrow was collected and measured for its carapace length. The shapes of the complete burrow casts were identified, and various morphological characteristics of the burrow casts were recorded. A total of 84 burrows were identified, all of them were the I-shaped or single-tube burrows. The burrows were categorized into two groups based on the burrow opening diameter: the <12 mm group and the ≥12 mm group. The burrow opening diameter ranged from 7.50 to 20.10 mm while the end diameter at the burrow bottom ranged from 8.40 to 21.00 mm, and the total length of the burrows ranged from 27 to 206 mm. The carapace length showed a significant correlation ($p<0.05$) with the burrow opening diameter in both groups. Additionally, the burrow opening with a diameter <12 mm group had significantly greater hole distances than the burrow opening with a diameter ≥12 mm group ($p<0.05$). The observed variations in hole distances suggest potential differences in ecological and behavioral factors that influence the burrow morphology of *D. myctiroides* in distinct size categories.

1. INTRODUCTION

The burrow morphological characteristics of organisms are highly specific to their species, but their forms can change based on the physical and chemical characteristics of their habitats (Reise, 2002; Kristensen, 2008; Katrak et al., 2008). Some species may create or modify their burrow structures to adapt to the changing environmental conditions in their area (Griffis and Chavez, 1988; Griffis and Suchanek, 1991; Wolfrath, 1992). There have been several studies on the burrow structures of various crab species in different countries. For instance, a study was conducted in 2016, 2022, and 2023 on the burrow structure of *Ocypode ceratophthalmus* (Trivedi and Vachhrajani, 2016), *Dotilla blanfordi* (Upadhyay et al., 2022), *Austraca cryptica* (Min et al., 2023), and *A. sindensis* (Maheta and Vachhrajani, 2023) in India. Wang et al. (2015) also investigated the burrow structure of the *Macrophthalmus japonicas* and *Uca arcuate* in China. Additionally, Qureshi and Saher (2012) examined the burrow structures of several fiddler crab species, including *Uca* (*Paraleptuca*) *sindensis*, *U.* (*Paraleptuca*) *chlorophthalmus*, and *U. annulipes* in Pakistan.

Burrowing crabs are of great ecological importance. Soldier crabs belonging to the genus *Dotilla,* which are commonly found in the Indo-Pacific region, typically exhibit a preference for sandy substrates over muddy shores. They are generally observed inhabiting the lower regions of sandy shores

Citation: Thongroy P, Saengkeaw S, Sujjaritthurakarn P, Waewthongrak W, Hemmanee S, Buatip S. Burrow morphological characteristics of soldier crab (*Dotilla myctiroides*) on the Libong Island, Koh Libong Subdistrict, Kantang District, Trang Province, Thailand. Environ. Nat. Resour. J. 2024;22(4):301-309. (https://doi.org/10.32526/ennrj/22/20230316)

(MacNae and Kalk, 1962; McIntyre, 1968; Hartnoll, 1973; Hails and Yaziz, 1982; Matsumasa et al., 1992; Darmarini et al., 2019). The soldier crab plays a crucial role in the sandy beach ecosystem, as they are commonly found in large numbers and have adapted to thrive on the sandy shore. They are characterized by having a streamlined body shape, long legs, and elongated eyestalks, allowing them to move quickly and efficiently. *Dotilla myctiroides* showcases a rounded or oval body shape with nearly equal length and width, small size, and a round body form. Dorsal part lacks sculpturing. Fresh specimen is grayish-brown coloration. It possesses four pairs of robust legs. This species features short antennae ranging from orange to brown, accompanied by elongated brownish-black eyes. (Darmarini et al., 2019). Soldier crabs can dig burrows and have curved, shovel-like appendages for scooping up food. They also have bristle-like structures in their mouthparts that help filter organic matter from sand grains (Warner, 1977; Ansell, 1988). The process of burrowing and feeding by the soldier crab group results in the decomposition of organic matter on the sand surface, leading to the cycling of nutrients and the flow of energy within the sandy beach ecosystem. This contributes to an increase in oxygen levels in the sand, creating a nutrient-rich sandy substrate suitable for small-sized animals as habitat. Additionally, it enhances the rate of decomposition within the sandy soil (Warner, 1977). *D. myctiroides* has been the subject of a study regarding burrow structures in Thailand, specifically found in the Phuket Province. The study examined the diameters of burrows and food pellets at Ao Tung Khen (Lee and Lim, 2004). Additionally, there has been research on the distribution and shape of burrows in the seagrass *Enhalus acoroides* area (Matsumasa et al., 1992). In summary, further studies on burrow morphology in this crab species are essential to enhance the researchers understanding while gathering more comprehensive data. The main objective of the study was to investigate how burrow morphological characteristics relate to crab size and determine their link with hole density and distances between burrows.

Libong Island is covering area as 34 km^2 island located on 3.5 km off the west coast of peninsular Thailand. Its landscape features a forested western area rising to 344 m, while the central part is populated by humans which is now dominated by rubber plantations. The eastern side is characterized by tidal mangroves forest and grassy clearings on raised sandy patches. Open coastal habitats include sandy beaches, rocky outcrops, and extensive mudflats. Declared as a non-hunting area by the Royal Forest Department in 1979, Libong Island is part of the restricted wildlife hunting zone in the Libong Island group. Home to diverse reserved wildlife, including critically endangered and endangered species, the existence of the island is crucial for migratory shorebirds and threatened birds that is at the verge of extinction such as Great Knot, Great Hornbill, Black-capped Kingfisher, Grey-headed Fishing Eagle, Eurasian Curlew, Black-tailed Godwit, Bar-tailed Godwit, Red-necked Stint, and Curlew Sandpiper. Recognized as an important habitat for avian species facing challenges, Libong Island plays a vital role in supporting wildlife conservation efforts and contributing significantly to the region's overall biodiversity (Eve and Ann-Marie Guigue, 1982; Swennen et al., 1987; BirdLife International, 2001).

2. METHODOLOGY

2.1 Study area

In this study (7°25'62" N, 99°44'86" E), the selected intertidal area for investigation is the sandy beach at Laem Juhoi Beach, situated at the eastern part of the island. During low tide, there is a large population of soldier crabs covering the area extensively (Figure 1).

2.2 Research methodology

The present study was carried out in March and October 2018. The burrows were selected randomly from lower to upper intertidal zone of the sandy shore. The study involved examining the burrow morphological characteristics by injecting molten paraffin into the crab burrows and allowing it to solidify. Once the paraffin had dried, the burrows were excavated and cleaned. If a crab was discovered inside a burrow, it was collected, and its carapace length (CL) was measured using digital vernier calipers (±0.01 mm; Pumpkin Model No. PTT-150VC01D). Subsequently, various measurements were taken, including the burrow opening diameter (B.O.D), end diameter at the burrow bottom (E.D), and the total length (T.L) using digital vernier calipers (±0.01 mm; Pumpkin Model No. PTT-150VC01D). The burrow shapes were also identified according to the modified method derived from Trivedi and Vachhrajani (2016) (Figure 2). These measurements and observations were conducted in a laboratory. In addition, random measurements of hole density (1×1 m^2) and the distance between holes.

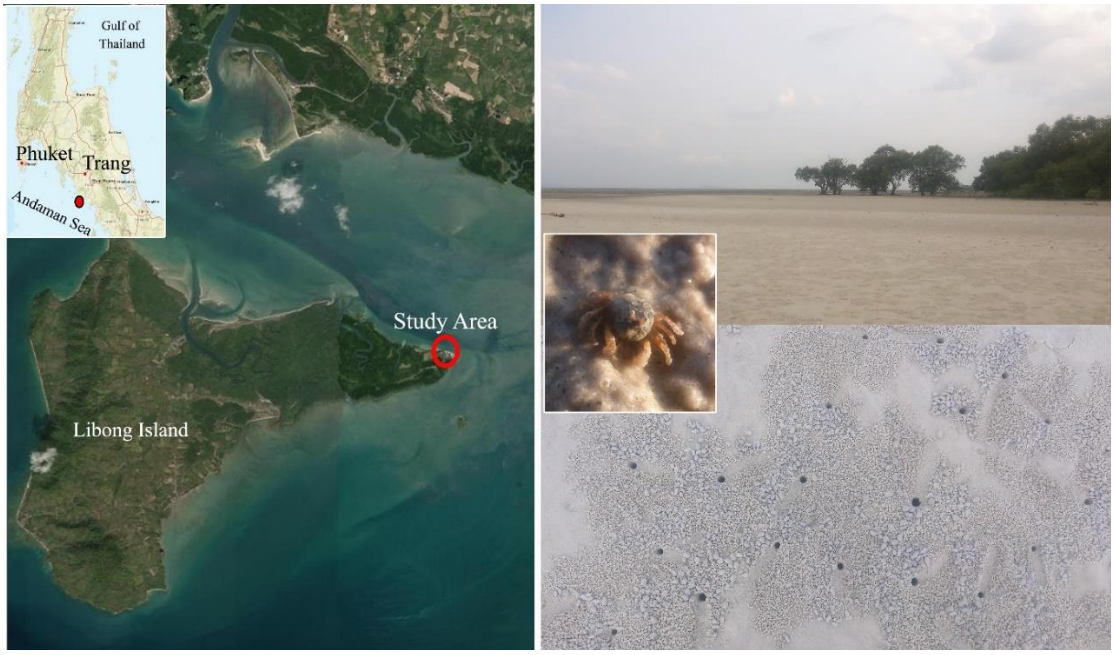

Figure 1. A map displaying the study area of Laem Juhoi Beach, Libong Island, Koh Libong Subdistrict, Kantang District, Trang Province

Figure 2. The method for measurements of the burrow morphological of soldier crab (*Dotilla myctiroides*)

2.3 Statistical analysis

The Pearson correlation coefficient was calculated to establish the relationship between morphological parameters of the burrow cast. While the crab size (carapace lengths) relationship between (1) burrow opening diameter (B.O.D), (2) end diameter at the burrow bottom (E.D), and (3) total length (T.L) were also analyzed. The hole distance was also compared using paired t-test. All of the statistical analysis was carried out using StatPlus in Windows 11.

3. RESULTS AND DISCUSSION

From the survey, it was found that soldier crabs are distributed across all of the sandy beach areas during the lowest tide periods. They share the area with fiddler crabs, ghost crabs, and sand bubbler crabs. Soldier crabs are predominantly found near the low tide zone. The soldier crabs are distributed approximately 6 m away from the shore to the low tide zone. Upon observation, two sizes of soldier crabs were identified. The distribution range of medium-sized soldier crabs start from approximately 6 m, while the larger soldier crabs start from approximately 16 m (Figure 3).

3.1 Burrow morphological characteristics

From a total of 84 burrow samples, it was found that all burrows exhibited an "I shape or single tube burrow". These burrows could be categorized into two groups based on the burrow opening diameter (B.O.D) namely: B.O.D<12 mm group (n=41) (Figure 4(a)) and B.O.D≥12 mm group (n=43) (Figure 4(b)).

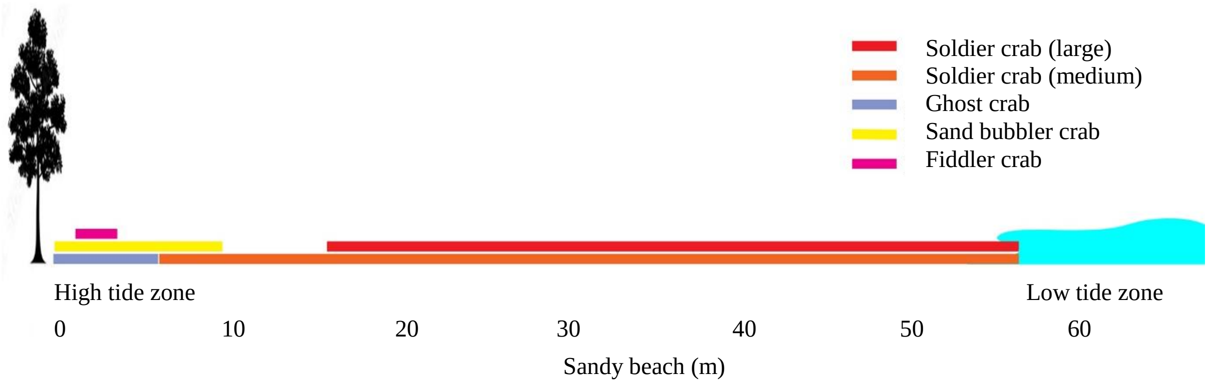

Figure 3. Distribution of soldier crab (*Dotilla myctiroides*) and other crabs on the sandy beach**,** Laem Juhoi Beach, Libong Island, Koh Libong Subdistrict, Kantang District, Trang Province

Figure 4. Burrow morphological of *Dotilla myctiroides*: (a) B.O.D<12 mm (medium) group, (b) B.O.D≥12 mm (large) group

In the B.O.D<12 mm group, the average burrow opening diameter is 10.08±1.17 mm while the average end diameter at the burrow bottom is 11.41±2.07 mm, and the average total length is 140.98±36.44 mm (Table 1, Figure 5(a)). In the B.O.D≥12 mm group, the average hole depth is less than B.O.D<12 mm group while the average burrow opening diameter is 13.74±1.74 mm with the average end diameter at the burrow bottom of 16.27±2.48 mm, and the average total length of 99.30±37.80 mm (Table 1, Figure 5(b)).

Table 1. Burrow morphological characteristics data of *Dotilla myctiroides*. (B.O.D: burrow opening diameter; E.D: end diameter at the burrow bottom; T.L: total length)

Parameters	B.O.D<12 mm group (n=41)			B.O.D ≥12 mm group (n=43)		
	B.O.D (mm)	E.D (mm)	T.L (mm)	B.O.D (mm)	E.D (mm)	T.L (mm)
Max	11.90	17.00	206.00	20.10	21.00	190.00
Min	7.50	8.40	58.00	12.00	12.00	27.00
Mean±SD	10.08±1.17	11.41±2.07	140.98±36.44	13.74±1.74	16.27±2.48	99.30±37.80

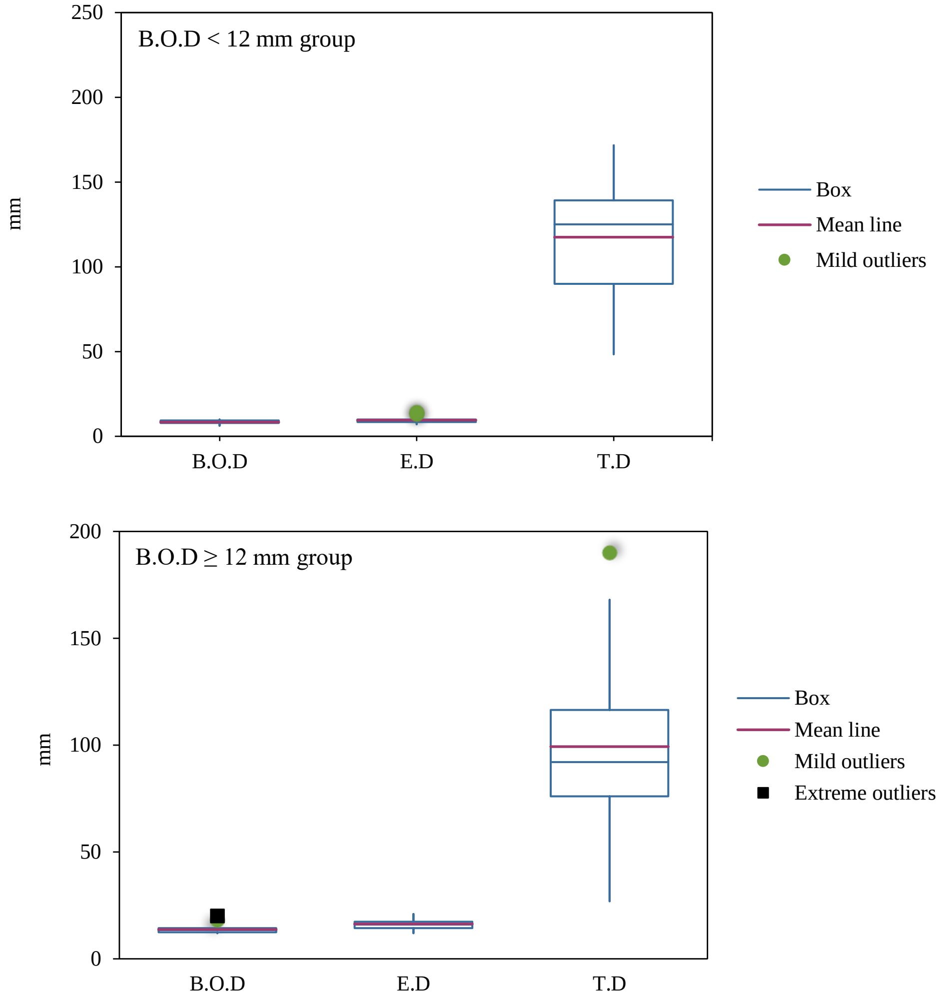

Figure 5. Boxplot: Burrow morphological characteristics of *Dotilla myctiroides*: (a) B.O.D<12 mm group, (b) B.O.D≥12 mm group

The analyzed data on the relationship between the morphological characteristics of the burrow using the Pearson Correlation Coefficient (r), found that only the T.L vs. E.D. within the B.O.D<12 mm group exhibited a non-significant correlation ($p>0.05$). In the B.O.D≥12 mm group, the sizes of B.O.D, E.D, and T.L showed a significantly correlated ($p<0.05$) situation. Specifically, B.O.D vs. E.D showed a positive correlation, while the B.O.D vs. T.L and T.L vs. E.D exhibited negative correlations (Table 2).

Table 2. Relationship between the morphological characteristics of the burrow (B.O.D: burrow opening diameter; E.D: end diameter at the burrow bottom; T.L: total length)

Burrow group	VAR vs. VAR	R	N	p-value
B.O.D<12 mm group	B.O.D vs. E.D	0.7910	51	4.9670E-12*
	B.O.D vs. T.L	0.4487	51	0.0010*
	T.L vs. E.D	0.2670	51	0.0582
B.O.D≥12 mm group	B.O.D vs. E.D	0.7384	84	0.0000*
	B.O.D vs. T.L	-0.3933	84	0.0002*
	T.L vs. E.D	-0.4713	84	6.0504E-6*

Asterisks indicate significant differences (*=p<0.05)

A total of 41 burrow samples in the B.O.D<12 mm group, 9 crabs were found to have attached individuals burrow, carapace width average of 5.55±0.50 mm (5.00-6.30 mm), and carapace length average of 5.68±0.59 mm (5.00-6.70 mm). And 43 burrow samples of B.O.D≥12 mm group, 11 crabs were found, carapace width an average 7.73±0.80 mm (6.90-9.00 mm), and carapace length an average 8.10±1.00 mm (6.90-9.80 mm). The analyzed data on the relationship between the morphology characteristics of the burrow and crab size using the Pearson Correlation Coefficient (r), found that only the carapace length (CL) vs. burrow opening diameter (B.O.D) within both groups are significantly correlated ($p<0.05$) (Table 3).

Table 3. Relationship between the morphological characteristics of the burrow and crab size (CL: carapace length; CW: carapace width; B.O.D: burrow opening diameter; E.D: end diameter at the burrow bottom; T.L: total length)

VAR vs. VAR	B.O.D<12 mm group			B.O.D≥12 mm group		
	R	N	p-value	R	N	p-value
CL vs. B.O.D	0.8386	9	0.0047*	0.6721	11	0.0235*
CL vs. E.D	0.2692	9	0.4836	0.5991	11	0.0515
CL vs. T.D	0.0144	9	0.9706	-0.4661	11	0.1485
CW vs. B.O.D	0.6386	9	0.0641	0.4882	11	0.1276
CW vs. E.D	0.2157	9	0.5773	0.4303	11	0.1865
CW vs. T.D	0.1217	9	0.7550	-0.5397	11	0.0866

Asterisks indicate significant differences (*=p<0.05)

The burrow morphological observed in this study are predominantly of the I-shape or single-tube burrow type. This basic burrow shape is commonly found among various crab species, including sand bubbler crabs, fiddler crabs, and ghost crabs. Subsequently, several crab species were found to modify their burrows into J, L, and other shapes according to their functional needs. Current research has revealed that I, J, and L shapes are prominent among burrow structures. The branching of burrows is most likely a strategy to evade pressure from predators and to accommodate both juveniles and adults together. Furthermore, an increased number of openings in some crab species' burrows may enhance their ability to escape from predators more easily (Gillikin and Kamanu, 2005; Min et al., 2023). This finding is consistent with the study conducted on the south-eastern shore of Phuket Island, Thailand, within the seagrass *Enhalus acoroides* zone (Matsumasa et al., 1992) whereby it was observed that this crab species exhibited two types of burrows, namely: tube-type and "igloo"-type burrows. However, the igloo-type burrows were not observed in this current study. Therefore, the data of environmental factors, such as slope, grain size, vegetation type, might need to be considered to explain the issue. This difference could be due to the fact that this study was conducted in sandy habitats, mainly with sandy sediment types, while the study by Matsumasa et al. (1992) was conducted in a seagrass zone with muddy sand sediment. The type of sediment may have affected the burrow structure.

Several studies in various areas in India had found that the I shape or single tube burrows morphological were very prominent, such as *Dotilla blanfordi* with 7 burrow shapes. These include single tube burrows (predominant), single tube with branches, J, J shape with branches, U shaped with double openings, U shaped with a single opening, and bulb-shaped burrow (Upadhyay et al., 2022). Fiddler crab, *Austraca cryptica* exhibits only I shaped burrow, while *A. variegate* have J and I shaped burrow, *A. annulipes* have LL, Y, J, and I shaped burrow, and *A. occidentalis* exhibits JU, L, Y, and X shaped burrow (Min et al., 2023). In the case of *A. sindensis*, it exhibits 7 burrow shapes, including J shaped and single tube burrows predominantly, S, spiral, J-shaped with branches, U-shaped with single openings, and multi-branched burrow (Maheta and Vachhrajani, 2023). And ghost crab, *Ocypode ceratophthalmus* have 8 burrow shapes, including single tube burrow (predominant), J, Y, U, J-shaped with a branch at the base, bulb, multi-branched, and Y-shaped with double openings (Trivedi and Vachhrajani, 2016). In the case of *O. rotundata*, which was found on the Pakistan coastal belt, it exhibited 6 types of burrow shapes including single tube burrows (predominant), Y, C, L, J, and M shaped burrow (Odhano et al., 2022). The burrow shapes are typically specific to the species (Griffis and Suchanek, 1991; Wolfrath, 1992). However, modifications in burrow architecture may occur in response to variations in sediment type, grain size, average slope, average wave height, and vegetation, allowing the crabs to adapt to changing environmental conditions (Griffis and Chavez, 1988; Schlender et al., 2023).

In this study, it was found that carapace length (CL) showed a significant correlation with burrow opening diameter (B.O.D) in both groups, which is consistent with the findings of Lee and Lim (2004). In the case of other crab species, similar findings were found to be in line with the study on *Austruca sindensis*. However, in *A. sindensis*, crab carapace length demonstrated a significant positive correlation with total length, total burrow depth, and burrow volume (Maheta and Vachhrajani, 2023). In the case of *Ocypode ceratophthalmus*, crab carapace width showed a significant correlation with burrow opening diameter, total length, and burrow volume (Trivedi and Vachhrajani, 2016). And in the case of *Dotilla blanfordi*, these results emphasize the significant impact of crab body size on burrow morphology, a relationship that also varies across different life stages of the crab (Upadhyay et al., 2022).

3.2 Density and distance of the hole crab

Hole density was found to be between 50-85 holes/m^2 in the B.O.D<12 mm group, while the B.O.D≥12 mm group exhibited a hole density of between 53-119 holes/m^2

Hole distance was found to be between 3-18 cm with an average of 8.61±3.59 cm in the B.O.D<12 mm group (n=90), while the B.O.D≥12 mm group (n=60) had hole distances ranging from 2-12 cm with an average of 4.92±2.40 cm (Figure 6). Statistical analysis using t-test revealed that the hole distance in the B.O.D<12 mm group was significantly farther than the B.O.D≥12 mm group (t-statistic=7.5746, df=148, $p<0.05$).

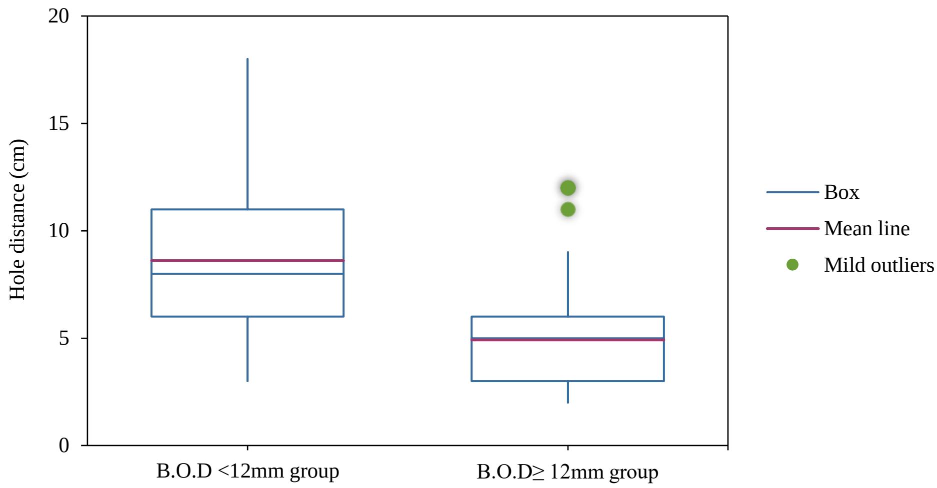

Figure 6. Boxplot: Hole distance of *Dotilla myctiroides* on Laem Juhoi Beach, Libong Island, Koh Libong Subdistrict, Kantang District, Trang Province

The density of burrows and the distances between them, as observed in the study, revealed that larger soldier crabs tend to create burrows in a denser arrangement compared to smaller soldier crabs. This also results in shorter distances between burrows, which could be attributed to variations in population size and the size of crabs in different age groups. Based on the study results, larger soldier crabs tend to have a narrower distribution range near the lowest water level, whereas smaller soldier crabs can spread out over a wider area (Figure 3). In contrast, it has been observed that the fiddler crab (*Uca bengali*) exhibited differences in behavior. Specifically, there is a dense distribution of larger-sized crabs in areas away from the water level, exhibiting a distinct pattern of dispersion (Tina et al., 2015). Larger soldier crab populations are generally more numerous than smaller ones. Furthermore, the distribution patterns differ among different-sized soldier crabs, with medium-sized soldier crabs establishing their burrows at approximately 6 meters apart, whereas larger soldier crabs start their burrows at around 16 meters apart. This leads to the larger soldier crabs being clustered closer together than the smaller ones. Hence, there would be a possibility that these differences might have been influenced by various factors, such as feeding behavior and food preferences, which are typically not explainable by a single mechanism. In addition, the profiles and natural characteristics of the beach environment may also play a role in shaping these patterns (Fisher and Tevesz, 1979; Milne and Milne, 1946; Turra et al., 2005; Branco et al., 2010; Gül and Griffen, 2018). Therefore, further research is needed to gain a deeper understanding on all factors related to these crab species.

4. CONCLUSION

The burrows of soldier crabs (*Dotilla myctiroides*) exhibited only an I-shaped (or single-tube structure). Based on the burrow opening diameter, the burrows were of two types namely, B.O.D<12 mm group and B.O.D≥12 mm group. There was a non-significant correlation between total length and end diameter within the group of burrow opening diameter was less than 12 mm. However, a significant correlation was found between carapace length and burrow opening diameter in both groups. Hole density was found to be between 50-119 holes/m^2 while the hole distance was between 2-18 cm. Future studies need additional factors, such as feeding behavior, food preferences, slope, as well as the physical and chemical characteristics of the beach environment. For the protection and management of the area, the responsible authorities should track and monitor those areas accessed by tourists and local fishermen so as to ensure that they benefit responsibly. This study suggested that there should be continuous monitoring to observe changes in the population or burrow structure of these crabs on the beach, which can easily assess environmental changes.

REFERENCES

Ansell AD. Migration or shelter? Behavioral options for deposit feeding crabs on tropical sandy shores. In: Chelazzi G, Vannini M. editors. Behavioral Adaptation to Intertidal Life. New York: Plenum Press; 1988. p. 15-6.

BirdLife International. Threatened Birds of Asia: the BirdLife International Red Data Book. Cambridge, UK: BirdLife International; 2001.

Branco JO, Hillesheim JC, Fracasso HAA, Christoffersen ML, Evangelista CL. Bioecology of the ghost crab *Ocypode quadrata* (Fabricius, 1787) (Crustacea: Brachyura) compared with other intertidal crabs in the Southwestern Atlantic. Journal of Shellfish Research 2010;29:503-12.

Darmarini AS, Soewardi K, Prartono T, Hakim AA, Nursiyamah S, Wardiatno Y. New distribution record of the soldier crab, *Dotilla myctiroides* (Milne-Edwards) from Lubuk Damar Coast, Aceh Province, Indonesia. AACL Bioflux 2019; 12(1):289-97.

Eve R, Ann-Marie Guigue AM. Birds on Ko Libong, Southern Thailand. Natural History Bulletin of the Siam Society 1982;30(2):91-104.

Fisher JB, Tevesz MJS. Within-habitat spatial patterns of *Ocypode quadrata* (Fabricius) (Decapoda Brachyura). Crustaceana Supplement 1979;5:31-6.

Gillikin DP, Kamanu CP. Burrowing in the East African mangrove crab, *Chiromantes ortmanni* (Crosnier, 1965) (Decapoda, Brachyura, Sesarmidae). Crustaceana 2005;78(10):1273-5.

Griffis RB, Chavez FL. Effects of sediment type on burrows of *Callianassa californiensis* Dana and *C. gigas* Dana. Journal of Experimental Marine Biology Ecology 1988;117(3):239-53.

Griffis RB, Suchanek TH. A model of burrow architecture and trophic modes in thalassinidean shrimp (Decapoda: Thalassinidea). Marine Ecology Progress Series 1991; 79:171-83.

Gül MR, Griffen BD. Impacts of human disturbance on ghost crab burrow morphology and distribution on sandy shores. PLoS ONE 2018;13(12):e0209977.

Hails AJ, Yaziz S. Abundance, breeding and growth of the ocypodid crab *Dotilla myctiroides* (Milne-Edwards) on a West Malaysian Beach. Estuarine and Coastal Marine Science 1982;15(2):229-39.

Hartnoll RG. Factors affecting the distribution and behaviour of the crab *Dotilla fenestrata* on East African shores. Estuarine Coastal and Marine Science 1973;1(2):137-43.

Katrak G, Dittmann S, Seuront L. Spatial variation in burrow morphology of the mud shore crab *Helograpsus haswellianus* (Brachyura, Grapsidae) in South Australian saltmarshes. Marine and Freshwater Research 2008;59(10):902-11.

Kristensen E. Mangrove crabs as ecosystem engineers; with emphasis on sediment processes. Journal of Sea Research 2008;59:30-43.

Lee S, Lim SS. Do diameters of burrows and food pellets provide estimates of the size structure of a population of *Dotilla myctiroides* at the sand-flats of Ao Tung Khen. Phuket Marine Biological Center Research Bulletin 2004;65:55-60.

MacNae W, Kalk M. The fauna and flora of sand flats of Inhaca Island, Mocambique. Journal of Animal Ecology 1962; 31(1):93-128.

Maheta NP, Vachhrajani KD. Burrow characteristics of the fiddler crab - *Austruca sindensis* (Alcock, 1900) from mudflats of Gulf of Khambhat, Gujarat, India. Arthropods 2023;12(1): 37-56.

Matsumasa M, Takeda S, Poovachiranon S, Murai M. Distribution and shape of *Dotilla myctiroides* (Brachyura: Ocypodidae) burrow in the seagrass *Enhalus acoroides* zone. Benthos Research 1992;43:1-9.

McIntyre AD. The meiofauna and macrofauna of some tropical beaches. Journal of Zoology 1968;156:377-92.

Milne LJ, Milne MJ. Notes on the behavior of the ghost crab. American Naturalist 1946;80(792):362-80.

Min WW, Kandasamy K, Balakrishnan B. Crab species-specific excavation and architecture of burrows in restored mangrove habitat. Journal of Marine Science and Engineering 2023;11:Article No. 310.

Odhano S, Saher NU, Rosenberg MS, Hassan MF, Soomro H. Burrow construction morphology of *Ocypode Rotundata* Miers 1882 (Ocypodidae: Brachyura) from the Sandy Coastal Areas of Karachi, Pakistan. Oceanography and Fisheries Open Access Journal 2022;15(4):Article No. 555917.

Qureshi NA, Saher NU. Burrow morphology of three species of fiddler crab (Uca) along the coast of Pakistan. Belgian Journal of Zoology 2012;142(2):114-26.

Reise K. Sediment mediated species interaction in coastal waters. Journal of Sea Research 2002;48(2):127-41.

Schlender K, Corte G, Durdall A, Habtes S, Grimes KW. Urbanization driving *Ocypode quadrata* burrow density, depth, and width across Caribbean beaches. Ecological Indicators 2023;153:Article No. 110396.

Swennen C, Ruttanadakul N, Ardseungnurn S, Howes JR. Foraging behaviour of the Crab Plover *Dromas ardeola* at Ko Libong, Southern Thailand. Natural History Bulletin of the Siam Society 1987;35:27-33.

Tina FW, Jaroensutasinee M, Sutthakiet O, Jaroensutasinee K. The fiddler crab, *Uca bengali* Crane, 1975: Population biology and burrow characteristics on a riverbank in southern Thailand. Crustaceana 2015;88:791-807.

Trivedi JN, Vachhrajani KD. On burrow morphology of the ghost crab, *Ocypode ceratophthalmus* (Decapoda: Brachyura: Ocypodidae) from sandy shore of Gujarat, India. International Journal of Marine Science 2016;6(15):1-10.

Turra A, Gonçalves MAO, Denadai MR. Spatial distribution of the ghost crab *Ocypode quadrata* in low-energy tide-dominated sandy beaches. Journal of Natural History 2005;39(23):2163-77.

Upadhyay KS, Patel KJ, Prajapati JM, Rabari VM, Thacker DR, Patel HV, et al. Burrow morphology of Brachyuran Crab *Dotilla blanfordi* Alcock, 1900 from Gulf of Khambhat, Gujarat, India. International Journal of Zoological Investigations 2022;8(2):251-61.

Wang J, Bertness MD, Li B, Chen J. Plant effects on burrowing crab morphology in a Chinese salt marsh: Native vs. exotic plants. Ecological Engineering 2015;74:376-84.

Warner GF. The Biology of Crabs. Great Britain: Paul Elek (Scientific Books) Ltd.; 1977.

Wolfrath B. Burrowing of the fiddler crab *Uca tangeri* in the Ria Formosa in Portugal and its influence on sediment structure. Marine Ecology Progress Series 1992;85:237-43.