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Full Paper

Feeding behaviour and feeding trench patterns of soldier crab (*Dotilla intermedia* De Man, 1888)

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Abstract: The feeding behaviour and sand-pellet trench patterns of soldier crab (*Dotilla intermedia* De Man, 1888) were observed the soldier crabs perform feeding activity only at daytime on low tide while during high tide they return to their burrowed area under the sand surface. The small-size soldier crabs live in the bottom low areas of the intertidal zone while the medium-and large-size crabs inhabit the upper areas of the intertidal zone. However, the density of the feeding crabs is highest in the middle intertidal zone. When they feed, the soldier crabs use their right and left pereiopods to drill the sediment and form a pellet at their mouthpart, after which the pellet is passed under its body. The feeding rates are 14-16 pellets/min. Feeding is performed in 2 directions, viz. clockwise and counterclockwise from the burrow. The feeding trench patterns come in 2 shapes: spikes and concentric rings. The trench length is 5-10 cm from the burrow entrance.

Keywords: *Dotilla intermedia*, feeding behaviour, feeding trench pattern, soldier crab

INTRODUCTION

Marine crustaceans present a variety of feeding modes that include deposit feeding, filter feeding, scavenging, predation, and suspension feeding. These feeding modes require

appropriate mechanisms to perform to be able to acquire and process food, as well as behavioural responses controlling such mechanisms [1]. Soldier crabs, classified under the crustacean groups, live in intertidal zones and sandy beaches and occur in massive groups that seem to emerge from nowhere at the same time and feed on deposited matter in the sand surface [2]. After the tide recedes, the soldier crabs emerge to feed on organic detritus from the surface layer of the sediment [3]. The spoon-shaped setae on their second maxillipeds enable the soldier crabs to sort organic matter from the sand [4]. *Dotilla* crab feeds by filtering the sand through their mouthparts, leaving behind balls of sand that are disintegrated by the incoming high tide [4]. Such pattern could imply that *D. intermedia* has a strict time feeding interval, i.e. during low tide like their relative *Dotilla fenestrate* [5], and that filter feeding also evolves independently in each group of crustaceans. Hence it is common that some differences could occur in the feeding behaviour and patterns among crustacean groups or even within a group [6].

Digging burrows within appropriate areas, where the sediment in terms of particle size as well as the organic and water contents of the intertidal zone is suitable, is also a significant aspect in the evolution of the *Dotilla* crabs [5]. The burrow has many functions and serves not only as an important refuge from predators but also as protection from environmental exposure such as heat irradiation and desiccation [7]. Moreover, the burrow also demarcates the territory of *Dotilla* and defends them against intrusion by con- and hetero-specific crabs [5]. Soldier crabs feed in a radial pattern centred on their burrows and always leave a path clear of feeding pellets to allow retreat into their burrows [8]. The burrowing and feeding activities of the crabs at low tide result in the rapid turnover of the sediment [9, 10], which has a significant effect on the meiofaunal community as this prevents colonisation of species, especially those that are not able to adapt to intense surface disturbance, and lowers the numbers of harpacticoid copepods [11].

A number of studies have been conducted on the feeding activities of *Dotilla* crabs, for example *D. stimpson* [4], *D. fenestrate* [5] and *D. wichmanni* [8] but not yet for *D. intermedia*. To fill the information gap, this study was carried out to gather information on the feeding activities of the soldier crab *D. intermedia* at Laem Son National Park, Prapas Beach, Ranong province, Thailand. The findings provide an insightful understanding of the unique feeding behaviour and feeding trench pattern of this soldier crab.

METHODS

The field study was conducted at Laem Son National Park, Prapas Beach, Ranong province, Thailand, from July 2018 to June 2019, from eight sampling stations (ST1–ST8, Figure 1). The beach area was divided into quadrats measuring 1x1 m^2, where sampling was carried out every month (once per month) throughout the year.

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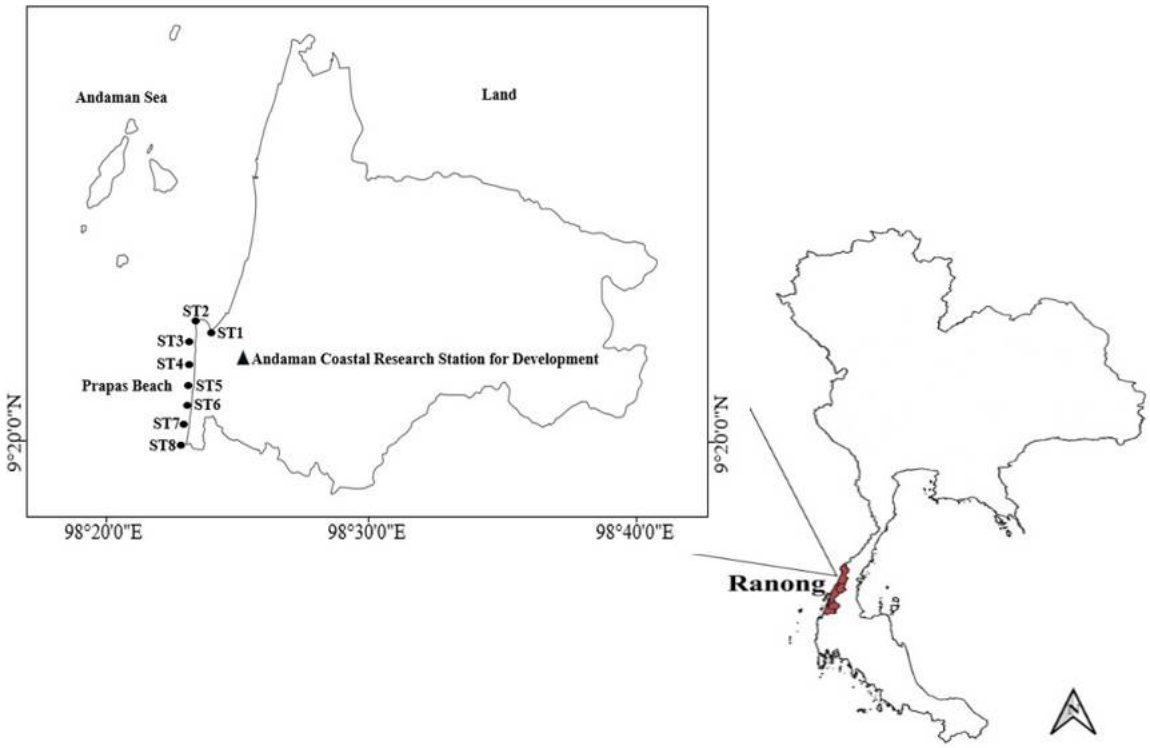

Figure 1. Sampling stations around Laem Son National Park, Prapas Beach, Ranong province, Thailand

Specimens of *D. intermedia* were collected and measured monthly at three areas of the intertidal zone, viz. low zone (nearest to the sea), middle zone and high zone, to observe the size and density of soldier crabs in each zone. The soldier crab samples were collected along the beach every 500-metre distance with three transects in each station. The feeding behaviour and feeding trench pattern of the soldier crabs were observed from a daily video recording at low tide in the daytime. The carapace (widest part) of the soldier crab was measured using a vernier caliper, as shown in the Figure 2. Differences in carapace width and carb density, among stations and among zones, were examined by Kruskal-Wallis test at $\alpha = 0.05$ and Dunn's post-test was applied where a statistical difference was found.

Figure 2. Measurement of carapace width (CW)

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RESULTS AND DISCUSSION

Statistics and Analysis

The result of Kruskal-Wallis test reveal that, among specimens of *D. intermedia* collected from each site and each intertidal zone, there is no significant difference among the sampling stations in crab density (P = 0.97) or in carapace width (P = 0.99). However, significant differences are noticed among the zones in both variables (P < 0.01) (Figure 3).

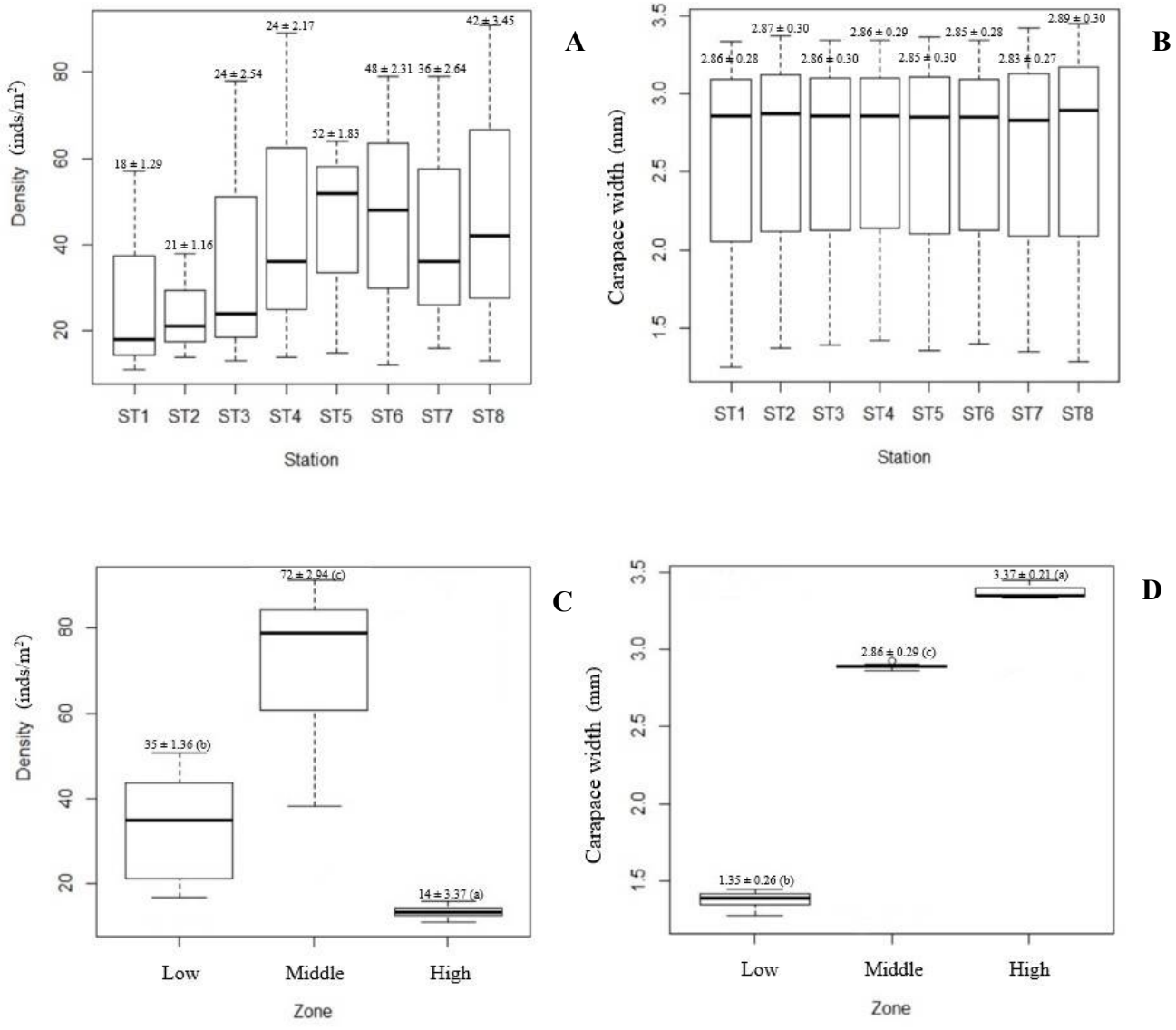

Figure 3. Boxplots of density and carapace width of *D. intermedia*: (A) density vs station (mean±SD), (B) carapace width vs station (mean±SD), (C) density vs zone (mean±SD), (D) carapace width vs zone (mean±SD). Different letters (a), (b), (c) in parenthesis indicate statistical difference at $\alpha = 0.05$.

From Figure 3 the middle intertidal zone has high density of soldier crabs. The density is lower on the outer sand waves (higher intertidal zone) where there is less competition for feeding space. A low density is presumably related to a less exposure time of the outer sand

wave area (the most seaward wave area) which is not exposed at all during neap tide, so the crabs must remain buried underwater for days during this part of the tidal cycle [13]. The study on fiddler crabs (*Uca tangeri*) showed that the crabs can live in the higher tidal zone because of the longer time available for making deeper burrows [14]. The optimum range of sand grain sizes on the shore is an important factor that controls the distribution and activity of the crabs [15-17]. However, their location on the shore (low, middle or high area) also determines the time available for feeding for the soldier crabs [9, 17].

A study on the ecological distribution of ocypoid crabs in the estuary found that their feeding behaviour may be related to the habitat occupied by each crab species [18]. Crabs of different sizes have different optimal living conditions, and larger crabs could outcompete smaller crabs for resources [14]. The effect of pollution could also make a behavioural change in soldier crabs, such as feeding rate as well as the depth and slope of their holes or burrows [19, 20]. The daily activities and substrate preference of soldier crabs (*Dotilla wichmanni*) have been described [21] and their feeding behaviour has been investigated [19].

Feeding Behaviour

The soldier crab (*D. intermedia*) feeds only during the daytime at low tide and between the intertidal zones. It starts feeding by using its right and left pereiopods to touch and drill the sediment and uses its claws to begin the excavation activities (Figure 4A). The sand sediment is sent to the mouthpart to form a pellet and during such activity the soldier crab sorts out the organic matter from the sand sediment. After the sediment is sorted, it picks the sand pellet off and passe it under its body, and then all walking legs push the sand pellet towards its posterior (Figure 4B).

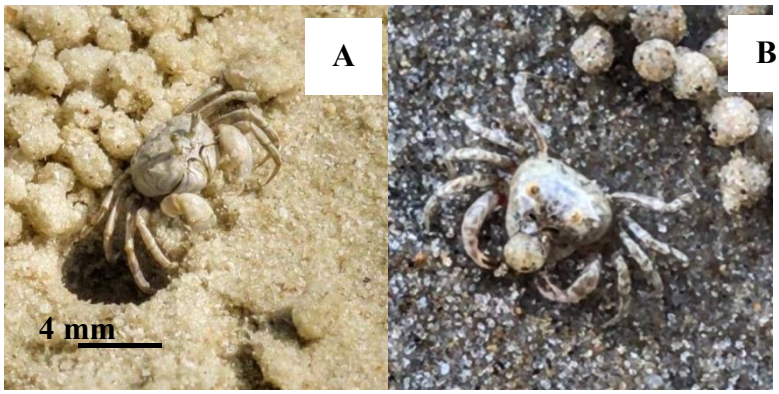

Figure 4. Feeding behaviour of *D. intermedia*: (A) start of feeding by using right and left pereiopods to touch and drill sediment; (B) sand sediment is sent to mouth to form sand pellets.

The soldier crabs (*D. intermedia*) usually submerge under the sediment surface during high tide and come out again at low tide during the daytime. Their feeding activities can be easily observed from the large numbers of sand pellets produced on the sand surface, the feeding rate for each crab of all sizes being between 14-16 pellets/min. The number and size of sand pellets are related to the size of carapace as large crabs create sand pellets the size of

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which is bigger than those made by the small-size soldier crabs. The sizes of the sand pellets are between 1.50-3.28 mm.

The position of the crabs on the shore is determined by the time available for feeding [14, 22]. Sediment with nutrients on the beach is replenished by tidal water [17]; then the crab density (as indicated by the number of burrow entrances) is highest in the intertidal zone. Additionally, the differences between crab distribution and behavioural pattern as recorded in previous studies probably were also the results from local differences in biological as well as physical factors. For *Uca tangeri* [14], an optimal strategy was found that encompassed many biological factors (e.g. predation and reproduction as well as feeding) that could determine the distribution of crabs on a beach. Also, it was found that crabs of different sizes have different optimal living conditions, and that larger crabs could outcompete smaller crabs for resources [14]. However, a strategy found effective in one locality may not be optimal in another, as evident from the daily activities and substrate preference when the feeding behaviour of *Dotilla wichmanni* in Koh Samet, Rayong province was investigated [19, 20]. The number of sand pellets and their sizes were greater in beaches that were not affected by oil spill [20]. At the same time, the quantity and size of the sand grains were less and smaller in oil-spilled areas than in areas not affected by oil spill. Results of studies on the ecological distribution of ocypoid crabs in estuaries also show that their feeding behaviour (e.g. number of sand pellets/ball, grain size) is related to the habitat occupied by each species of crabs [18].

Feeding Direction

A *D. intermedia* crab starts feeding from the burrow entrance by moving sidestep from the burrow for 5-10 cm, then turns back to the burrow and, upon reaching the burrow, makes a new trench for feeding again starting from the burrow (Figure 5). The sand pellets are placed in such a way that a straight path is formed along the trench. This is essential for the soldier crab to retreat to the burrow in case of external disturbance or danger. Consequently, as the feeding progresses radially in a line-by-line pattern, the lines rotate around the burrow entrance just like the hands of a clock. It was observed that the feeding direction could occur in two ways: clockwise or counterclockwise with the burrow entrance as the centre (Figure 5).

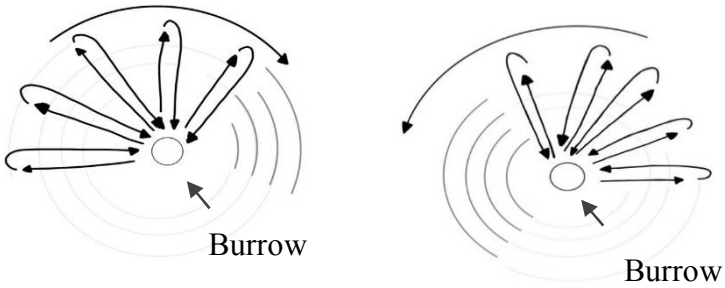

Figure 5. Feeding direction of *D. intermedia* crabs: (A) clockwise; (B) counterclockwise

The soldier crabs are extremely perceptive to movements and rapidly escape to the burrow when there are external movements, although they may re-emerge and resume

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feeding later. Then they may or may not continue along the trench last used before the escape. Soldier crabs possess remarkable orientation ability that allows them to resume in the direction along the feeding trench, even in the absence of visual clues in the trench. Finally, they stop feeding when the tidal current starts to submerge their feeding area.

Trench Patterns

As mentioned above, soldier crabs feed in a radial pattern centred round the burrow with straight-line trenches radiating from the burrow and sand pellets produced along the paths, which end at a distance not far from the burrow (5-10 cm from the burrow entrance). A short-trench path can help the crabs escape from their predators. The trench patterns are found to be in 2 shapes: spike shape or concentric-ring shape (Figure 6).

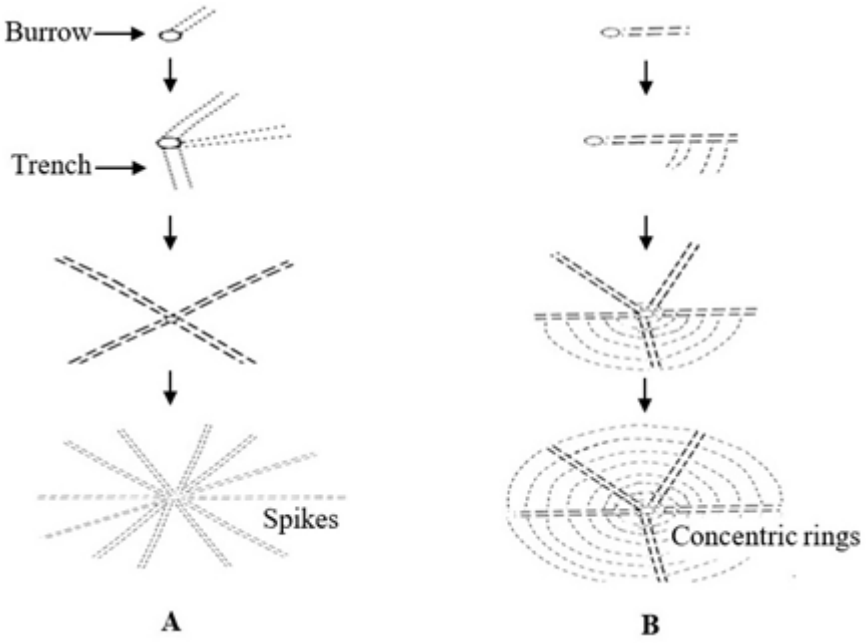

Figure 6. Trench patterns: (A) spike shape, (B) concentric-ring shape

The different shapes of the trench patterns could be owing to 1) crab density (trench pattern is spike-shaped when the feeding crabs are of low density, while the shape becomes concentric rings when there is a high density of crabs); 2) sediment colour (trench pattern appears like spikes when the sediment is brown in colour and is ring-shaped when the sediment is dark brown or black in colour, meaning that the amount of nutrients in the brown sediment is low and the crabs must move to longer distances to feed); and 3) predators (if the feeding area has few predators, the trench pattern appears in spikes shape and the length of the trench is greater from the burrow). However, both trench patterns can also be found together in the same feeding area and the reasons for that should be examined further.

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CONCLUSIONS

The feeding behaviour of *D. intermedia* soldier crab around Laem Son National Park, Prapas Beach, Ranong province, Thailand has been established from this study, which complements current limited information on the feeding activities of *Dotilla* soldier crabs.

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