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Studies On Orientation Pattern Of Pseudofecal Pellets of The Sand Bubbler Crab, *Dotilla Clepsydrodactylus,* Carbyns Cove, South Andamans

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Abstract

Sand bubbler crabs are small, intertidal inhabitants and feeds at low tide by scraping the sand surface and making pseudofaecal pellets after extracting organic detritus from the sand. *Dotilla clepsydrodactylus* is Indian sand bubbler crab. *D.clepsydrodactylus* was studied at Carbyns Cove beach area in Port Blair and to understand the feed activities and its relation with pseudofecal pellets. *Dotilla clepsydrodactylus* is an inhabitant of intertidal zone of sandy shores, and the pseudofecal pellets are always arranged towards one side of their feeding path, which also helps them to know which area is already utilized by them for feeding. *Dotilla clepsydrodactylus* are distributed evenly throughout the intertidal area, they all exhibit burrow pattern not a single igloo structure was observed in study area may be due to texture of sediment and water content. It is observed in the field that due to unavailability of space for feeding, crabs stops feeding and plug in to their burrow early, before flooding tide. Overlapping of feeding area also result in aggression behavior of sand bubbler crabs against neighbors, which has no relation with the size of crab. In the case of weight of the pseudofecal pellets produced by the crab and its morphometric measurements suggested that the smaller size crab eat more and large ones are lesser in eating. *Dotilla clepsydrodactylus* is the only species available at Carbyns Cove but they make concentric and spike patterns. They do not show any relation between directions of emergence with the pattern of pellet they form. The present study confirmed that there is much work to be carried out to understand the behaviour pattern of sand bubbler crab *Dotilla clepsydrodactylus* pseudofecal pellets formation in concentric and spike mode distribution.

Key Words: *Dotilla clepsydrodactylus*; Sand bubbler crab; Organic matter; Carbyns Cove; Port Blair; Andaman; India

Introduction

The family Ocypodidae under the order Decapoda of phylum Arthropoda, exhibited a species called as *Dotilla clepsydrodactylus* with a common name of sand bubbler crab found in the sandy beaches of Indian coast (Chavan *et al*., 1998). It lives in the burrows of upper tidal flat to water saturated area of the lower tidal flat. At low tide, it feeds detritus material deposited by the ebbing tide (Dray and Paula, 1998). During the activities of the feeding, it leaves its pseudofaecal pellets by the way of systematically bubble the sand after its consumption of detritus (Fielder, 1970 ; Ansell, 1988). While feeding, the crabs move along the trenches radiating from the burrow and produce pseudofaecal pellets which are amassed over the already excavated area. It feeds mainly upon the detritus organic material deposited at the uppermost part of the sand. The systematic method of expulsion of pseudofaecal pellets by the crab near its burrow has created an interest to go further to understand its behavior pattern as well as for its species specialization of this crab. This made an endeavor to study the pattern of pseudofaecal pellets organization in the vicinity of burrow. Earlier, Pandey (2008) studied this crab's behavioral pattern and its morphology in the Carbyns Cove location of the Andaman and Nicobar group of Islands. This present study planed to understand its pellets characteristic as well as pattern for organization of pellets.

D. clepsydrodactylus was firstly reported by Alcock (1900 and 1902) along Indian coast followed by Kemp (1915) reported them from East coast of India. Ravichandran *et al., (*2007) reported *D. clepsydrodactylus* in Pichavaram mangrove area. Mohan *et al*., (2011) reported occurrence of *D.clepsydrodactylus* from Andaman group of islands. Pandya and Vachharajani

(2013) reported the occurrence of *Dotilla intermedia* during brachyuran biodiversity studies from Kamboi along Mahi river coast of Gujarat. Till date, sand bubbler crabs are considered as of no economic value but they are the best bioturbators and consume the organic matter present in surface layer and make it suitable for feeding by other fauna (Dray and Paula, 1998). Fishelson (1983) reported that the burrowing activity result the oxidation of the anaerobic sediment. Lushi *et al.,* (1997) reported that orientation during short–range feeding in the crab *Dotilla wichmanni*. Gherardi *et al*., (1999) had provided a detailed description of burrow- oriented activities performed by *Dotilla fenestrata*. Takagi *et al*., (2010) gave an account on the role of *Dotilla myctiroides* in organic matter fate and food resources. Mohan *et al*., (2011) studied morphology and orientation activity of sand bubbler crab and found that disturbance and removal of pseudofecal pellets does not affect activity of crab, they start feeding from where they stopped before disturbance.

Pereira and Paulo (2000) found that trembling by humans does not affect the abundance and biomass of *Dotilla fenestrata* except that numbers of juveniles were decreased.

Study Area

Fig.1. Location of the Study Area

Field observations were done from December 2013 to March 2014 at Carbyns Cove beach of East Coast of Port Blair, Andaman ($11^0$38'28.3'' N and $92^0$44'47.4'' E). Even though, sand bubbler crabs are very common along the beaches of Carbyns Cove, Marina Park Sand Deposits, Chidiyatappu, Wandoor and Chatham but Carbyns Cove beach was selected based on the abundance of activities of this crab along with the presence of mangrove swamp in neighborhood and anthropogenic activities.Total 15 days, low tide, day time was used for this study among the four months duration.

Methodology

Understand the sand bubbler crab *Dotilla clepsydrodactylus* pseudofaecal pellets and their distribution mechanism in the sand surface the following methodology was adopted and the inferences were made.

Carbyns Cove beach a reference point was selected during the high tide period to measure the change in place of emergence of crab with tidal cycle. This reference point was marked 8 m away from the low water mark. A quadrate of $1m^2$ perpendicular to sea shore was placed randomly to know the distribution and abundance of crabs. Behavior of crabs was observed for their burrowing activity, feeding, digging and fighting by observing them for 15 minutes with 1-hour interruption. Main concern was given to territorial activity of crabs and influence of human activity on their emergence by observing them. Videos are recorded from emergence of crab up to 2-3 hours to know the activities performed by them and to know the relation between direction of emergence and pattern followed by them.

To know the relation between crab size, crab weight, feeding activity, and pseudo fecal pellets produced by them were collected and measured. Random samples were collected and their fecal pellets were counted and collected after every 10 minutes without disturbing the burrow. Crab size was measured and weight of crab was taken in laboratory with the help of electronic weighing balance.These above collected results were interpreted and discussed in detail.

Results and discussion

Dotilla clepsydrodactylus is an inhabitant of intertidal zone of sandy shores, below the high tide water level but sometimes they are present above high tide water level if

upper sandy area is not disturbed; that is sediment should not be loose. As tide recedes, after one or two hours *Dotilla clepsydrodactylus* emerge from their burrow below high tide mark but several *Dotilla species* (Vogel, 1984) was shown emerging at lower end of intertidal zone. The same place and time of emergence was found in *Scopimera gordone* (Bauchau and Elizabeth, 1981), *S. inflata* (Fielder, 1970) and *S. intermedia*. In beginning of feeding activity, crabs are confined around burrow then slowly start moving sideways away from burrow in a straight line. While feeding, crab spoon up the surface layer sediment with both chelipeds into mouth. The pseudofecal pellets produced after extracting organic content is removed by using both left and right cheliped simultaneously and passed backwards underneath the crab's body. There is no synchronization in the use of left and right chelipeds while passing the pseudofecal pellets backwards. The pseudofecal pellets are always arranged towards one side of their feeding path, which also helps them to know which area is already utilized by them for feeding. *Dotilla clepsydrodactylus* are distributed evenly throughout the intertidal area, they all exhibit burrow pattern not a single igloo structure was observed in study area may be due to texture of sediment and water content. Whereas, *Dotilla fenestrata* (Gherardi *et al*., 2002) and *Dotilla myctiroides* commonly exhibited burrow and igloo structure during their feeding time. Population of *D. clepsydrodactylus* comprises of wanders and sedentary crabs, wander are dominating towards low tide water level in water saturated area. After emergence, half of the population of *D. clepsydrodactylus* moves away from their normal zone of feeding, same behaviour was observed in less than 10% of *Scopimera inflata* population (Fielder 1970) and about 80% in *Dotilla fenestrata* population and many other crabs of Ocypodidae family like *Uca annulipes*, *Dotilla sulcata* (Fishelson, 1983), *Scopimera inflata*, *Scopimera globosa.* These wanders were found confined only towards the lower end of intertidal area.

Change in burrow position with respect to tide level

Sand bubbler crabs are filter- feeders normally found in intertidal region especially adjacent to mangrove area due to enrichment of organic content. Rhythmic shift of the burrows according to the high tide water line is been observed between the intertidal area during the study period. As the tidal level fluctuations increased (around 2 m) burrows shift more towards supra-littoral area and as tide level fluctuations is less (around 1.5 to 1.75 m) the burrow shift more towards the low tide water line (Table 1). This indicates that the movement of bubbler crabs within sediment happened during high tide and they never emerge at same place as water level changes. According to Fishelson (1983), *Dotilla clepsydrodactylus* shifts it direction of exposure according with the tidal level has been confirmed in this study.

Table. 1. Shift of burrows position with change in tide level
**** Low Water Mark to Reference Point is 8 M**

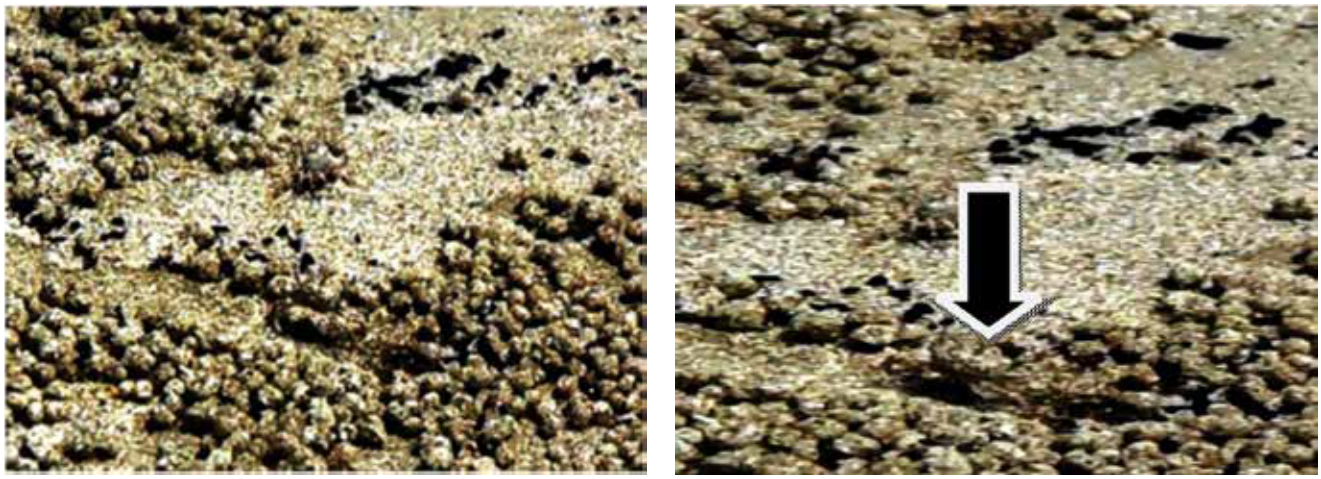
Date	Distance of 1st burrow from reference point	Tidal Fluctuation
13 January 2014	06.34 m	1.51 m
31 January 2014	04.00 m	2.05 m
14 February 2014	06.60 m	1.78 m
15 February 2014	06.64 m	1.87 m
28 February 2014	05.00 m	1.97 m
01 March 2014	04.00 m	2.11 m
10 March 2014	06.09 m	1.45 m
23 March 2014	05.50 m	1.84 m

High Density Effect

Dotilla clepsydrodactylus even though found in mangrove area where food distribution is not uniform they exhibit territorial behavior. They never dig another burrow once they have emerged which was reported in *Scopimera gordone* (Bauchau, 1981), *S. inflata* (Fielder, 1970) and *S. intermedia* but *Dotilla myctiroides,* (Vogel, 1984) was shown that they dig another burrow during their feeding cycle. Bubbler crabs are very abundant in Carbyns Cove area. Since, the organic content is not uniformly distributed on the surface of sand it directly affects the distribution of bubbler crabs. Sometimes, it is observed that a particular area is overcrowded by presence of 80 or above bubbler crabs present within 1m^2 areas. This overcrowding does not have any effect on pattern of feeding but effects feeding time. It is observed in the field that due to unavailability of space for feeding, crabs stops feeding and plug in to their burrow early, before flooding tide.

Overlapping of feeding area also result in aggression behavior of sand bubbler crabs against neighbors, which has no relation with the size of crab. If two crabs are of same size they just raise their cheliped up straight and jump to frighten the other. This behaviour is known as Hopping (Gherardi *et al*., 1999). Displaying (a way of expressing aggression) is also very commonly observed in two different sized crabs (Fig.2). After showing their aggression they just build a wall of bubbles between their feeding areas to make their territory. In *Dotilla fenestrata* (Gherardi at al., 2002) agonistic behavior was normally shown by the large size crabs mostly towards the smaller by-passers as compared to the neighbors. *Scopimera inflate* (Fielder, 1970) also exhibit aggressive behavior and the crabs were given name “rogues”.

Fig. 2. Crab showing aggression



Burrow and Feeding Activities

The studies on the species *Dotilla clepsydrodactylus* length, width, weight of the crab along with its burrow diameter and weight of the pseudofecal pellets were produced within three hours are presented in the Table 2. The present study suggested that there is not much relationship noticed with reference to length, width, and weight with the burrow diameter. Probably the diameter large with small size may be inferred that the sliding effect of sand during their activities. However, in the case of weight of the pseudofecal pellets produced by the crab and its morphometric measurements suggested that the smaller size crab eat more and large ones are lesser in eating. This has been evidenced by the production of pseudofecal pellets weight i.e. smaller crab (0.01 to 0.03 g) produce more weighted materials (10.11 – 19.02 g) than the larger size crab (0.12 to 0.23 g) with weight of 13.84 to 15.12 g pseudofecal pellets (Fig.3 and 4).

Fig. 3. Relation between carapace width and burrow diameter

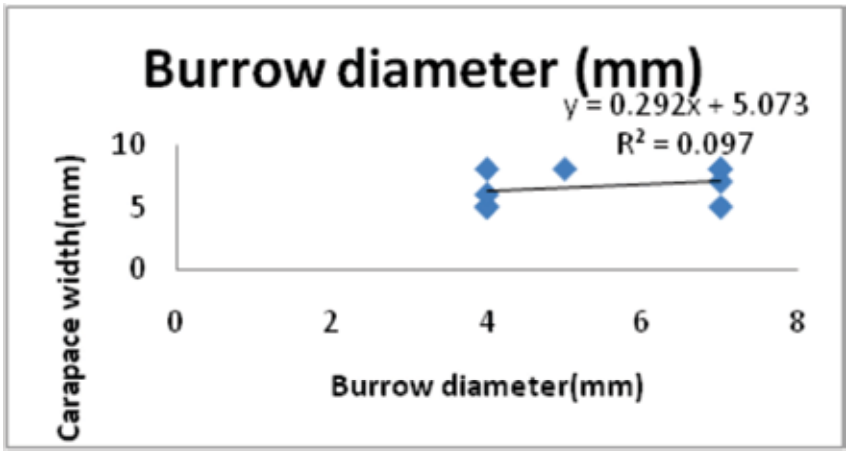
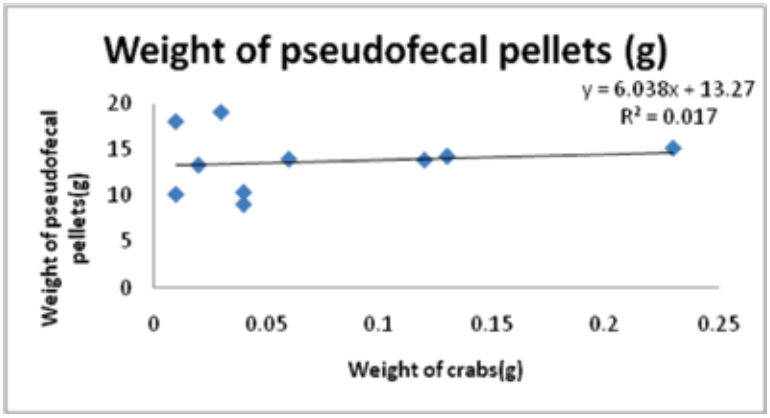


Fig. 4. Correlation between weight of crabs and weight of pseudofecal pellets



Trembling effect on sand bubbler crabs

Mangrove creek side of Carbyns Cove is highly disturbed area due to fishing and tourism. Walking of humans normally result in disturbance of the sediment on the beaches but this trembling has no affect on distribution and feeding activity of bubbler crabs. Trembled areas still showed emergence of bubbler crabs and resume their normal feeding (Fig.5). *Dotilla clepsydrodactylus* do not exhibit any change in the feeding activity and distribution due to human trampling like *Dotilla fenestrata* (Pereira *et al.*, 2000).

Fig.5. Feeding in trembled sediment

Table. 2. Crab *Dotilla clepsydrodactylus* size, weight, burrow diameter and its weight of pseudofecal pellets produced within 3 hours time.

Sl. No.	Carapace length (mm)	Carapace width (mm)	Burrow diameter (mm)	Weight of crab (g)	Weight of pseudofecal pellets (g)
1	**4**	**7**	**5**	**0.03**	**19.02**
2	**3**	**4**	**5**	**0.01**	**18.01**
3	**3**	**4**	**5**	**0.01**	**10.11**
4	**3**	**4**	**6**	**0.04**	**09.02**
5	**4**	**5**	**8**	**0.06**	**13.92**
6	**6**	**7**	**8**	**0.23**	**15.12**
7	**5**	**7**	**8**	**0.12**	**13.84**
8	**3**	**4**	**8**	**0.02**	**13.28**
9	**5**	**7**	**7**	**0.13**	**14.24**
10	**4**	**5**	**7**	**0.04**	**10.32**

Associates

During the study period several associated fauna were observed inhabiting in the nearby colonies of bubbler crab. Commonly found associates were crabs of genus Ocypodid, *Uca (Celuca) lactea annuplies* and hermit crabs of species *Coenobita spinosus* and *Coenobita rugosus.* Genus ocypodid is found associated only with sand bubbler crabs. They basically do not have any effect on bubbler crabs but many times it was observed that either they intrude in their burrows and affect their normal behavior or they just burry them in their burrows by putting the bubbles on them. Uca crab and hermit crabs were identified using published keys. They do not have any effect on the distribution and activity of bubbler crabs. Gherardi *et al.*, (2002) has reported that *Uca annuplies* was found associated with *Dotilla fenestrata.*

Table. 3. Relation between direction of emergence and pellet pattern formed

Sl. No.	Direction of emergence	Pattern Type
1		Concentric
2		Concentric
3		Concentric
4		Spike
5		Concentric
6		Concentric
7		Concentric
8		Concentric
9		Spike
10		Spike

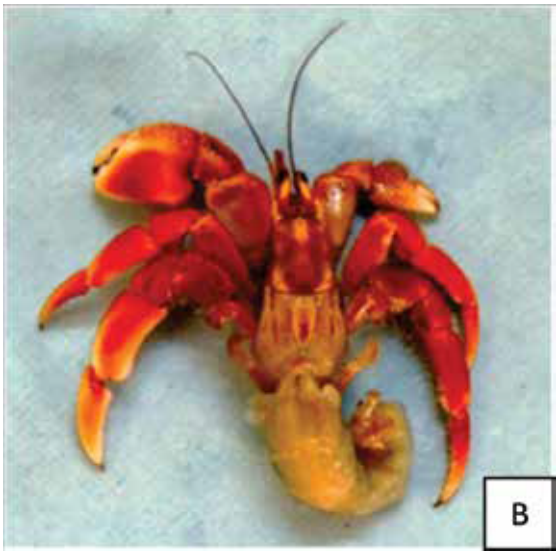
*Upper portion of the circle is denoting the seaward side and lower portion towards supra littoral. Direction of arrow indicates the face of crab at the time of emergence.

Dotilla clepsydrodactylus is the only species available at Carbyns Cove but they make concentric and spike patterns. It was observed that even though they have many direction of emergence, there is no relation between their direction of emergence and the pattern they form. But it was clear that where they emerge, they start feeding from that point. They do not show any relation between directions of emergence with the pattern of pellet they form. Pandey (2008) while working on *Dotilla clepsydrodactylus* showed that they exhibited spike and concentric pattern.

Experimental Studies

During the study period, an experimental set up was established to study the behavior of the crab in laboratory conditions. Crabs were kept in three different boxes of different height i.e. 10cm, 20cm and 30cm and filled with sediment. In the first box, three crabs of 3mm carapace width were put and kept undisturbed in laboratory. At the time of high tide, water was sprinkled over the sediment filled in the box. Next day, two of the crabs emerge at the time of low tide and start wandering but they do not display any feeding. After that they went back to the burrows. In 20cm height box, two crabs of 3mm carapace width are put and observed for two days. They just emerge from their burrows at the time of low tide but no feeding was observed. In last observation, two crabs of 4mm carapace width were put in 30cm height box. Till five days, no emergence was observed. After fifth day only one of the crabs emerges and starts wandering. They did not emerge till five days because it may be inferred that they might get sufficient feed inside the burrow itself, due to the mixing of sand with good amount of height. Further, as reported by Sassa and Watabae (2008) the negative pore water pressure may be needed to come out from the burrow which was not available in the present experimental set up.

Another set of experiment was performed on the field. Crabs of different size were collected and then released back in field to know there behavior after disturbance. It was observed that crabs never go back to their own burrow instead they go into some others burrow. They specially prefer the burrow of large size crab and start feeding from there. The large size crab extrude the existing crab of small size from their burrow and make the hole more broaden by digging and starts feeding there. Over and above, out of ten numbers of crabs seven went in the new burrow and not expelling the old one and living with them.



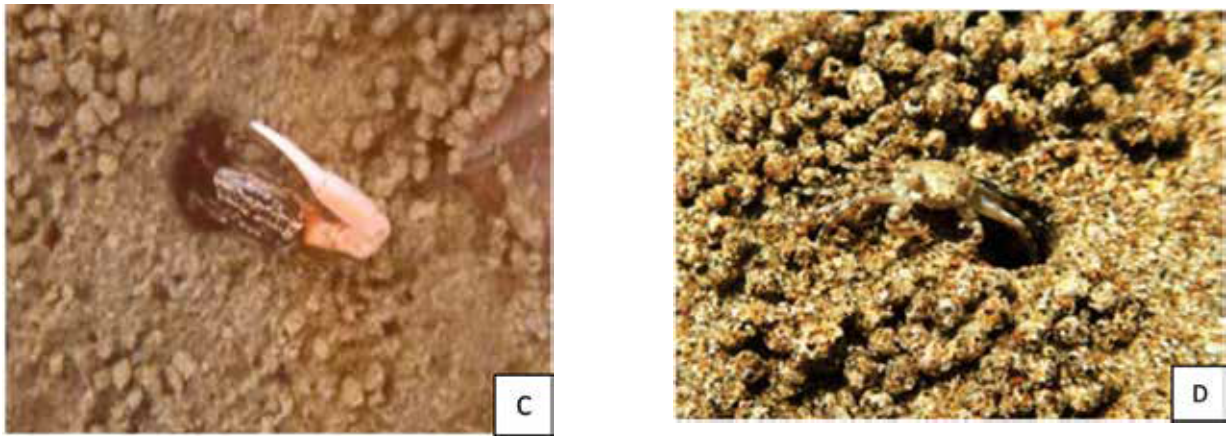


Fig. 6. Associates of *Dotilla clepsydrodactylus*: *A.Coenobita rugosus*, B. *Coenobita spinosus* C. *Uca (Celuca) lactea annuplies D. Genus Ocypodid*

Conclusion

Sand bubbler crabs are small, intertidal inhabitants of tropical and sub-tropical regions commonly found on sandy beaches and muddy region. *Dotilla clepsydrodactylus* is Indian sand bubbler crab. The pseudofecal pellets produced by the crab are always arranged towards one side of their feeding path, which also helps them to know which area is already utilized by them for feeding.

Rhythmic shift of the burrows according to the high tide water line has been observed between the intertidal area during the study period. As the tidal level fluctuations increased (around 2 m) burrows shift more towards supra-littoral area and as tide level fluctuations is less (around 1.5 to 1.75 m) the burrow shift more towards the low tide water line

The overcrowding of crab does not have any effect on pattern of feeding but effects feeding time. Overlapping of feeding area also result in aggression behavior of sand bubbler crabs against neighbors, which has no relation with the size of crab.

The present study suggested that there is not much relationship noticed with reference to length, width, and weight with the burrow diameter. However, in the case of weight of the pseudofecal pellets produced by the crab and its morphometric measurements suggested that the smaller size crab eat more and large ones are lesser in eating. Humans activity has no affect on distribution and feeding activity of bubbler crabs. Trembled areas still showed emergence of bubbler crabs and resume their normal feeding.

Genus ocypodid is found associated only with sand bubbler crabs. They basically do not have any effect on bubbler crabs. *Dotilla clepsydrodactylus* is the only species available at Carbyns Cove but they make concentric and spike patterns. They do not show any relation between directions of emergence with the pattern of pellet they form.

During the study period, an experimental set up was established to study the behavior of the crab in laboratory conditions suggested that they did not emerge till five days because it may be inferred that they might get sufficient feed inside the burrow itself, due to the mixing of sand with good amount of height.

Another set of experiment was performed on the field. Crabs of different size were collected and then released back in field to know there behavior after disturbance. It was observed that crabs never go back to their own burrow instead they go into some others burrow. They specially prefer the burrow of large size crab and start feeding from there. The large size crab extrude the existing crab of small size from their burrow and make the hole more broaden by digging and starts feeding there. Over and above, out of ten numbers of crab seven went in the new burrow and not expelling the old one and living with them.

The present study confirmed that there is much work to be carried out to understand the behaviour pattern of sand bubbler crab *Dotilla clepsydrodactylus* pseudofecal pellets formation in concentric and spike mode distribution.

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