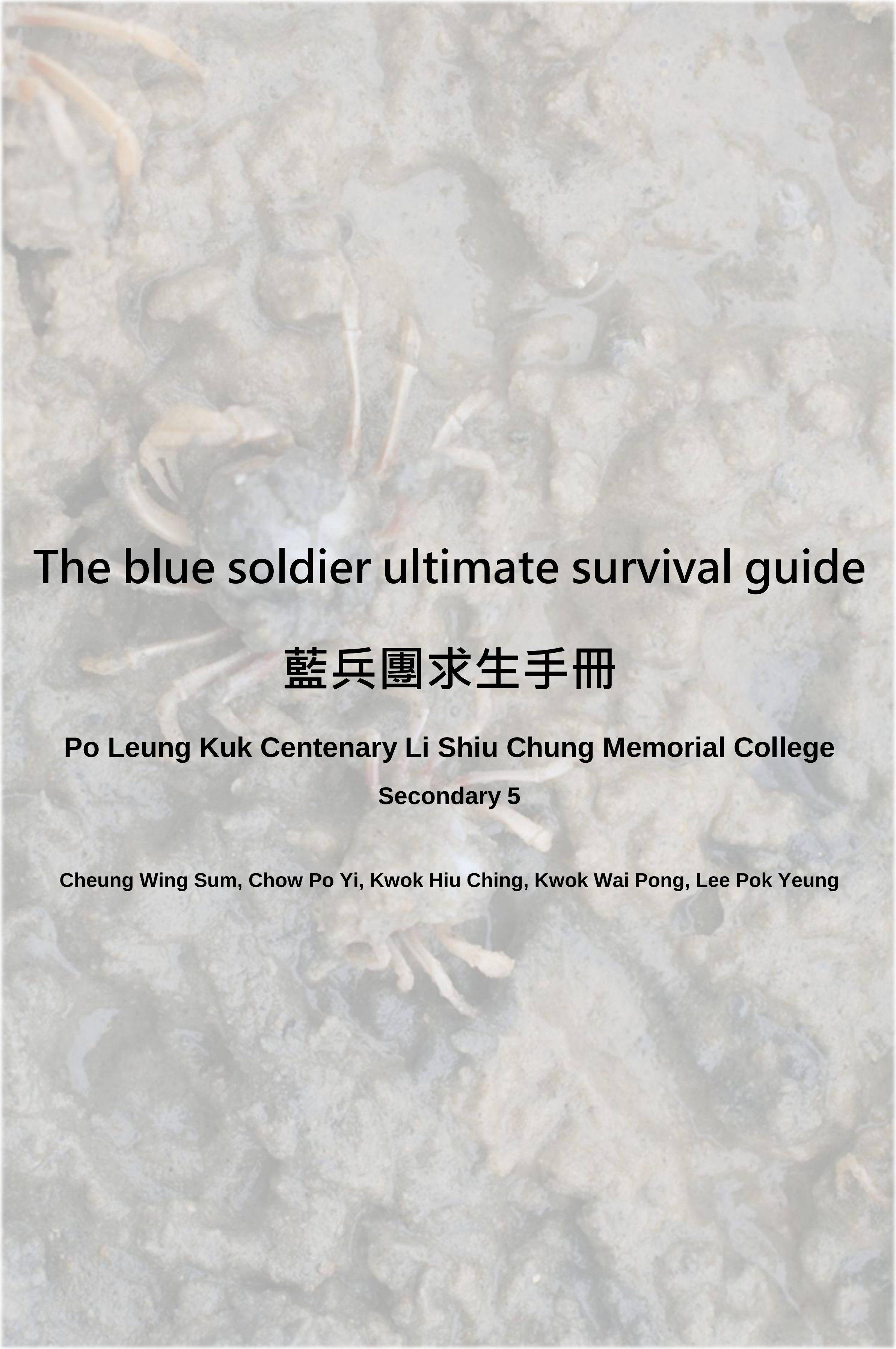


The blue soldier ultimate survival guide

藍兵團求生手冊

Po Leung Kuk Centenary Li Shiu Chung Memorial College

Secondary 5

Cheung Wing Sum, Chow Po Yi, Kwok Hiu Ching, Kwok Wai Pong, Lee Pok Yeung

Contents

Abstract p.3

Introduction p.4

Field works p.5-6

Part 1 p.7-10

Part 2 p.11-14

Part 3 p.15- 17

Conclusion p. 18

Limitation p.19

Significance p.19

Suggestions for further studies p.19

Bibliography p.20

Abstract

The main character of our investigation is soldier crab. Soldier crabs (***Mictyris brevidactylus)*** live in sandy and muddy shore with mangroves area where the salinity of water is really high, it fluctuates in mangrove area. Since the sand and mud is unstable with low oxygen content. Also it is the site where rivers and sea meets, this means the salinity changes along with the tide. Low salinity during low tide and high salinity during high tide makes this area changes its condition from one extreme to another in a short period of time every day. This area seemed not to be an ideal habitat for many organisms. But soldier crabs actually prefer to live in such environment.

In this project, we wanted to investigate what environmental conditions (presence of light, warmth, damp or dry soil etc.) are favorable to the livelihood of soldier crabs, we also analysed why and how the environment of muddy shore with mangroves being positive to the soldier crabs.

Since we have to separate different conditions apart and investigate them individually, we have set up variety of controlled experiments to achieve our goals of the whole project.

From vast number of experiments, we found out that they prefer environment with damp and fine sand and mud, presence of light and cold conditions. These are all the characteristics of their own original habitat.

我們這次探究的主角是短指和尚蟹。他們居住在紅樹林附近的泥灘上，該區域海水的鹽度非常高。不單如此，其鹽度會根據潮汐漲退而改變。時高時低的海水鹽度，加上不穩定的沙泥及低氧氣含量，令這個地區看似不適合各種生物居住。但這個地方居然是短指和尚蟹的棲息地。

在這個探究裏，我們想調查短指和尚蟹傾向選擇哪些環境條件作為棲息地，我們也分析了這些選擇背後原因。

因我們需要獨立調查短指和尚蟹對每種條件的選擇，我們設立了不同的實驗來進行探究。根據這些實驗，我們知道了短指和尚蟹傾向選擇潮濕及顆粒細小的泥沙，他們也較傾向有光及較冷的環境。這些都是他們的棲息地的環境條件。

Introduction

The objective of this project is to investigate what are the conditions that soldier crabs prefer to live, how do they survive in the intertidal zone of the habitat, and seek reasons behind the results.

Background information:

Light-blue Soldier crab (***Mictyris brevidactylus*):**

The soldier crab is nearly spherical, with an upright body (Brian Morton & John Edward Morton, 1983). They emerge to the surface a few hours before low tide, although some individuals may remain submerged for the entire tidal cycle (Ann M. Cameron 1966).

Soldier crabs are mainly found in Japan, China, Hong Kong, Taiwan, Singapore, and parts of Indonesia (Karakelong, Bawean and Ambon Island)[1]. They feed on small organisms in the sand (diatoms, gastropod eggs, nematodes etc.) and detritus (Ann M. Cameron 1966).

Soldier crabs are mainly found in sandy and muddy shores, and the shore near Sai Keng village is a muddy shore with a lot of mangroves.

From our observation, the Soldier crabs in Sai Keng emerged to the surface of the sand after the tide lowers. They will leave a small round pellets of sand around the holes they make.

Habitat:

The muddy shore near Sai Keng Village has shore with dense and fine sand, and they comes with large amount of organic mattes below the top soil.

---

[1] Resources from http://species-identification.org/species.php?species_group=crabs_of_japan&menuentry=soorten&id=1755

Field works:			
Venue	Muddy shore near Sai Keng Village		
Date and time	6/2 2:00pm-4:30pm 	15/2 10:00am-1:00pm 	18/2 12:00 noon-2:00pm 
Low tide	4:15pm	11:00am	at 2:15pm
High tide	11:25am	5:55pm	at 9:45am
Objectives	To find out whether the habitat has soldier crabs or not. Record the biodiversity of animals and physical factors of the muddy shore using transect.	To observe the activities of soldier crabs and record the abiotic factors of the habitat and design experiments to be carried out in laboratory afterwards.	To collect 30 soldier crabs for experiments and sand to recreate their habitat in the laboratory.

Field work equipment:

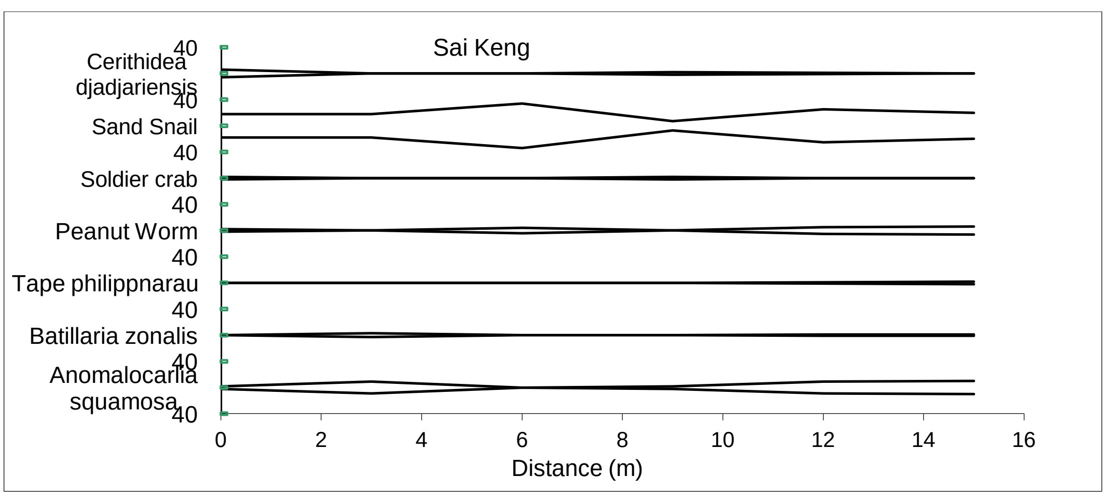
Item	Name	Quantity			
1	Transect	1	7	1 m Ruler	2
2	Spade	3	8	Sieve	2
3	Vial	10	9	thermometer	1
4	Plastic bag	10	10	Compass	1
5	Wind meter	1	11	Light meter	1
6	Salinity meter	1	12	Digital hydrometer	1

This was the abiotic factors we recorded during along the transect.

	Air Temperature °C	Relative humidity %	Light intensity *Lux*	Wind speed ms^{-1} & direction	Sand Temperature °C
Quadrat1 (open space)	16	55	22300	0	14
Quadrat 2 (open space)	17	54	22500	0	14
Quadrat 3 (open space)	16	40	16800	0	14
Quadrat 4 (open space)	15.4	40	21400	0	13
Quadrat 5 (open space)	15	40	21200	0	12
Quadrat 6 (open space)	16	40	21300	0	12
Under mangrove canopy	16.6	40	3530	0	13

Based on our measurement from field works, the salinity of sea water during ebb was 24.8 ppt. The pH of sand was in range of 7-8 and the sand was dark in color.

<u>Result of transect(kite diagram):</u>



Part 1:

Is grain size a factor affecting soldier crab’s choice of burrowing site?

method

Few sets of experiment were designed to study whether grain size of the sand is a factor affecting soldier crabs’ choice of burrowing site and try to explain it.

In order to study whether grain size of the sand is a factor affecting soldiers crabs’ choice of burrowing site,

1. A basket was modified to hold two different types of sand (shown in figure1a,1b), the sand was separated by an impermeable plastic sheet.The sand on the left was collected from Sai Keng and the right one was collected from Lung Mei. The sand of Sai Keng was mainly consisted of fine grained sand while the sand of Lung Mei was mainly consists of coarse grained sand. The amount of both sands used was roughly the same.

2. The soldier crabs were placed on the middle of the platform, and then they were allowed to move freely.

3. Two trials were carried out in total, 5 soldier crabs were allowed to choose their site for burrowing in each trial. Their movement were then observed and recorded.

Apparatus used:

Basket x1

Impermeable plastic sheet x4

Plastic bag x1

Hot glue x1

(top view)

figure1a

(Front View)

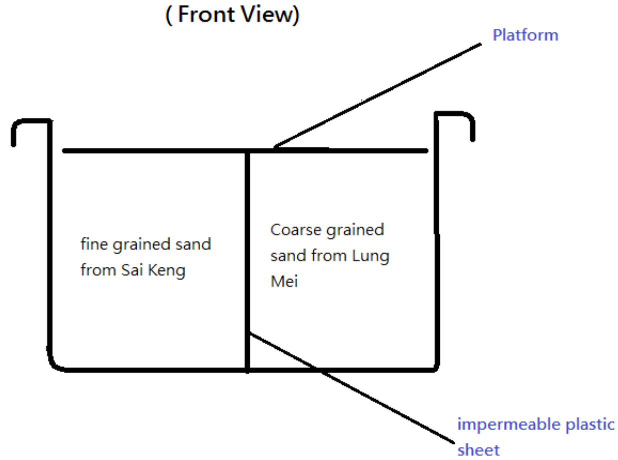


figure1b

Our hypothesis is that the grain size is a factor affecting soldier crab's choice of burrowing site(they prefer finer sand), and the reason behind that is because fine sand has better water retention and more organic matter for food.

Therefore the organic matter content and water retention of both types of substratum were also measured.

In order to find out the organic content of the two kinds of sand,

1. The soils were dried inside an oven for one day. The weight of the soil was recorded after they dried out.

2. The soil was then transferred to a crucible and burned by the blue flame of a Bunsen burner for 15 minutes to oxidize all the organic matter.

3. The amount of organic matter can be calculated by (weight of dried out soil – weight of dried out soil after being burned).

To find out the water retention capacity of the sand,

1. The two kinds of sand were filled into two filter funnels respectively.

2. 50ml of water was then poured into the funnels. (Figure 1)

3. The time needed for dripping to stop was recorded and the volume of water collected in the beakers was measured.

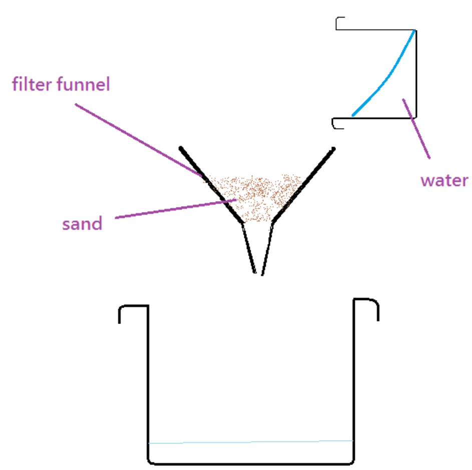


Figure1c

Experiment result and analysis

For the experiment which studied whether grain size is a factor affecting soldiers crabs' choice of burrowing site, (Table 1) 5 soldier crabs were tested in each trial. The result shows that the majorities of soldier crabs prefer fine sand to coarse sand.

	Number of soldier crabs	
Trial	Coarse sand	Fine sand
1	2	3
2	1	4

(5 soldier crabs were tested in each trial) Table 1

In table 2, it was found out that fine sand had a higher organic matter content than coarse sand. As fine sand has larger surface area, it can provide attachment for more organic matter. Besides, the lower layer of fine sand collected in Sai Keng contains more organic matter. As a result, soldier crabs are usually found in the lower layer of fine sand in favor of higher organic matter content for more food.

		Oxygenation	Organic matter content
Fine sand	Collected in Sai Keng	Upper Layer (greater exposure to oxygen , lighter in color)	1.2%
		Lower Layer (Lack of oxygen, darker in color)	1.9%
	Collected in Lung Mei	Upper Layer	1.2%
		Lower Layer	1.2%
Coarse sand	Collected in Lung Mei	/	0.4%

Table 2

Table 3 shows that the water retention capacity of fine sand is better than that of coarse sand. As a result, fine sand can keep moist even when low tide and maintain a constant humidity to prevent dehydration. Besides, Water can reduce the friction between sand granules, which facilitates the action of burrowing of soldier crabs.

		Water retained on sand per 50ml water	Time needed for dripping to stop
Fine sand (Sai Keng)	1st trial	34ml	6 minutes 17seconds
	2nd trial	30ml	6 minutes
Coarse sand (Lung Mei)	1st trial	10ml	1 minute 35 seconds
	2nd trial	13ml	1 minutes 42 seconds

Table3

Overall, it is concluded that grain size of the sand is a factor affecting soldier crabs' choice of burrowing site as grain size determines both organic matter content and water retention of soil. Fine sand has higher organic matter content and better water retention capacity than that of coarse sand. Fine sand can provide a more favorable living condition for soldier crabs. By choosing fine sand over coarse sand, soldier crabs can have a higher chance of survival.

Part 2:

How the soldier crab respond to certain stimulus which may help them to survive ?

method

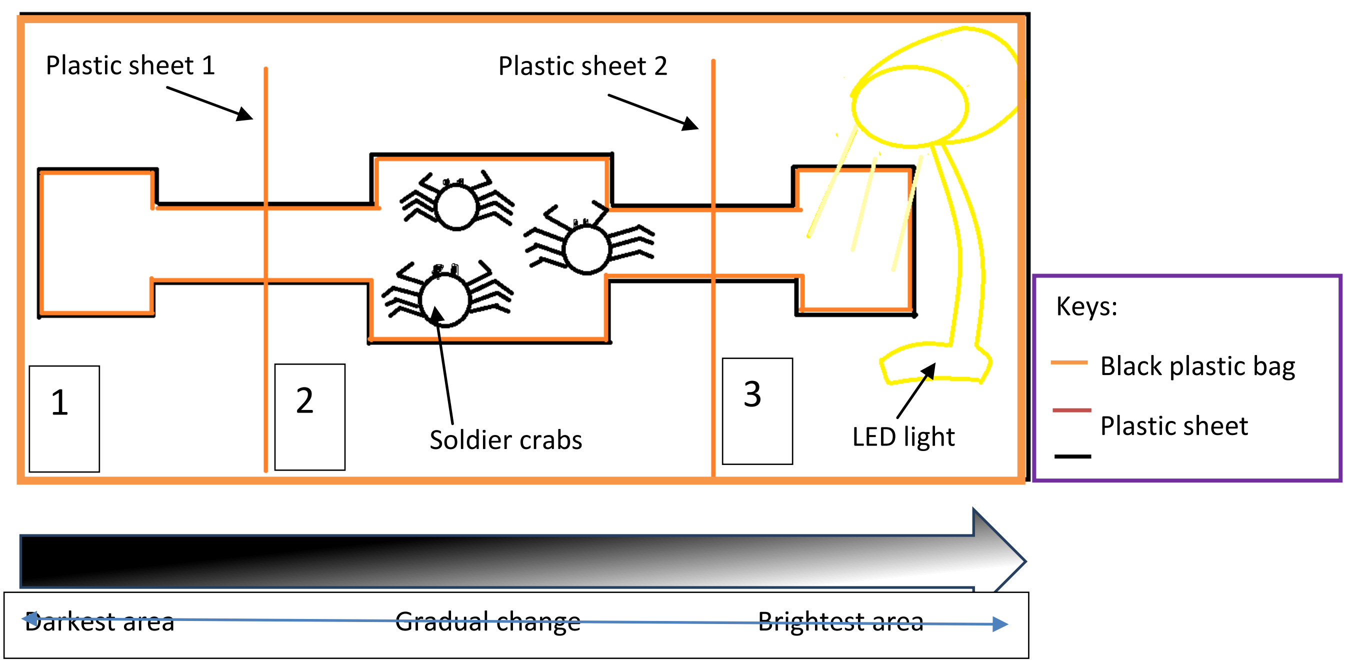
Experiment 1

Aim:

To find out the relationship between the light intensity and the distribution of the soldier crabs

Set-up:

1. LED light
2. Styrofoam
3. Black plastic bag x1
4. Soldier crabs x15
5. Plastic sheets (avoid the soldier crabs climbing out of the styrofoam)



Control condition:

The size of the crab (Use crabs of similar size for the experiment)

Steps:

1. Plastic sheet 1 and plastic sheet 2 were put into the styrofoam for avoiding the soldier crabs moving to the two sides,
2. 15 soldier crabs were put into 2 and was covered with the black plastic bag. And had to wait for 3 minutes.
3. After 3 minutes, the LED light was turned on and the plastic sheet 1 and plastic sheet 2 were taken out.
4. The black plastic bag was used to cover it again and waited for ten minutes.
5. The result was recorded after ten minutes.
6. Steps 1-5 were repeated for three times.

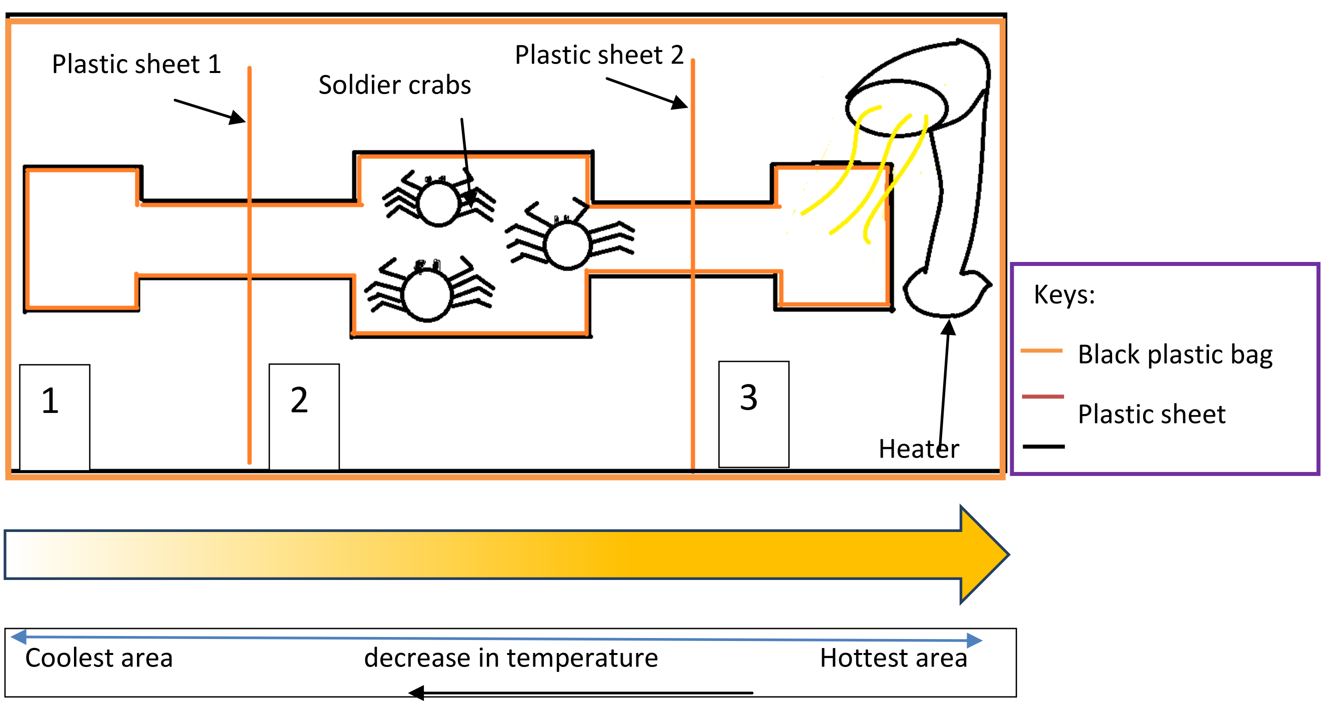
<u>Experiment 2</u>

Aim:

To find out the relationship between the temperature and the distribution of the soldier crabs

Set-up:

1. Heater
2. Styrofoam
3. Black plastic bag ×1
4. Soldier crabs ×15
5. Plastic sheet



Control condition:

The size of the crab (Use crabs of similar size for the experiment).

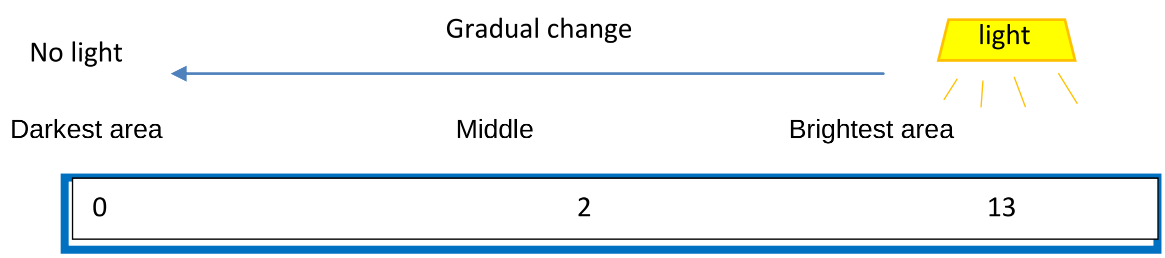
Steps:

1. Plastic sheet 1 and plastic sheet 2 were put into the styrofoam for avoiding the soldier crabs moving to the two sides
2. 15 soldier crabs were put into 2 and was covered with the black plastic bag. And had to wait for 3 minutes.
3. After 3 minutes, the heater was turned on and the plastic sheet 1 and plastic sheet 2 were taken out.
4. The black plastic bag was used to cover it again and waited for ten minutes.
5. The result was recorded after ten minutes.
6. Steps 1-5 were repeated for three times.

Experiment results

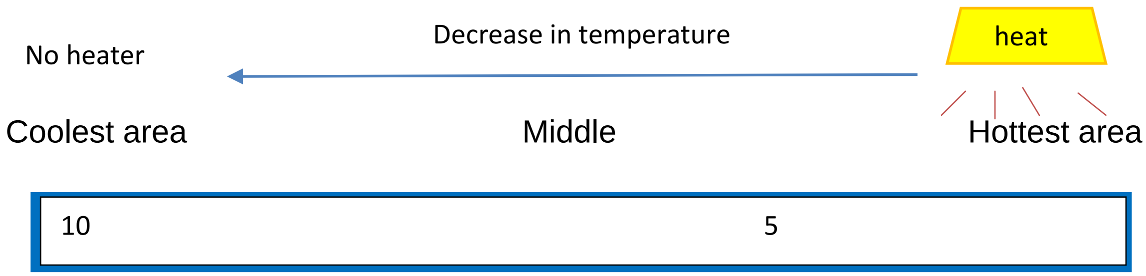
Experiment 1

	Darkest area	Middle	Brightest area
1st time	0	2	13
2nd time	1	2	12
3rd time	0	1	14
Average	0	2	13



Experiment 2

	Coolest area (20°C)	Middle	Hottest area(40°C)
1st time	10	0	5
2nd time	9	2	4
3rd time	11	0	4
Average	10	1	4



Analysis

From experiment 1, through repeating the experiment three times, we found that there are no soldier crab going to the dark area. There were 2 soldier crabs staying in the middle and 13 of them going to the bright area. It showed that the soldier crabs like going to the bright area rather than dark area. We thought the reason was because when the soldier crabs were in their holes, they would be attracted towards the bright area which indicates direction of sand surface so they could go out to breathe the fresh air. Since their holes were dark, they would know that there would have air in the bright area. Therefore, they could find out the direction of leaving the substratum.

From experiment 2, through repeating the experiment three times, we found that there were 10 soldier crabs going to the coolest area. There was only 1 soldier crab staying in the middle and 4 of them going to the hottest area. It showed that the soldier crabs like going to cool area rather than hot area. We thought the reason is the evaporation rate would increase if it was hot, and it would lead to dehydration. The water potential of the cells in their bodies would change. When it lost water, the cells of it would shrink and become wrinkled.

Part 3: How does soldier crab's unique spherical body help them to survive in the intertidal mudflats?

Method:

In this section the behaviour of soldier crabs was observed and a hypothesis is suggested to explain how the crab's spherical body gives them a better chance of survival in intertidal mudflats. Behaviour of crabs without spherical bodies--Sand bubbler crabs *(Scopimera globosa)* and grapsid crab *(Parasesarma pictum)*) were also observed and compared to that of soldier crabs for evidence to support our hypothesis.
The observations are carried out on-site during field trips.

Hypothesis : The spherical body gives soldier crabs more directions of movement so they can seal up their burrows, thus creating an air pocket underground for breathing during high tide and hide from predators.

Observation :
Soldier crabs:
Burrowing:
The soldier crabs are observed to self-rotate (some rotate clockwise and some anticlockwise) while digging and use one of their cheliped to remove mud from below. The other cheliped will then pass the mud to the sand surface. A circle of mud is formed around their burrow and the top of hole become smaller and smaller as they continue to rotate and push mud out. They then turn over themselves to seal up the top of the burrow. When a pair of forceps is used to stir the mud at the sealed part, air bubbles appeared which indicates that air is trapped in the burrow.

Fig. 3.1: soldier crab digging burrow

Walking:
Soldier crabs are observed to walk in almost every direction.

Crabs without spherical body:

-Sand bubbler crabs (*Scopimera globosa*)

Fig. 3.2, a sand bubbler crab

Burrowing:

The burrowing of sand bubbler crabs (*Scopimera globosa*, which have a rectangular and flattened body) is also observed. They use their walking legs on either their left or right side to dig mud from below and continue digging in one direction. Their burrow's opening left a hole on the ground surface that can be clearly seen.

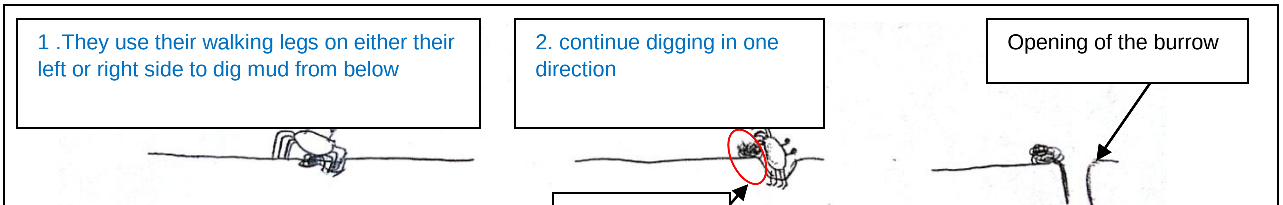


Fig. 3.3: simplified drawing showing the burrow digging process of sand bubbler crabs

Walking:

They are observed walking sideways only.

-Grapsid crab (*Parasesarma pictum*)

Fig.3.4: a *Parasesarma pictum*

Burrowing :

Not observed.

Walking:

Sideways only.

Analysis :

The spherical body of the soldier crabs provides a more curved surface for attachment of legs so that the legs are arranged in more directions. This enables movements in more directions. According to our observation, the crabs can walk in almost every direction and self-rotate. In contrast, the other two crabs' legs grow closely on two sides due to its rectangular body shape. This greatly restricted their directions of movements. They are observed walking sideways only and no self-rotation. This proves that a spherical body is related to the movement of self-rotation. As self-rotation is a crucial process in sealing off the burrow to create igloo (a burrow structure in which the burrow is sealed with air trapped inside), having a spherical body that can self-rotate enables soldier crabs to form igloos. By being able to build igloos, soldier crabs, which are air-breathers, can have sufficient air supply when the mudflat is submerged in high tides. Besides, by sealing off the burrows they can hide from predators and have better protection. More directions of movement help them escape from predators by making their escape path more unpredictable. Their chance of surviving can be raised.

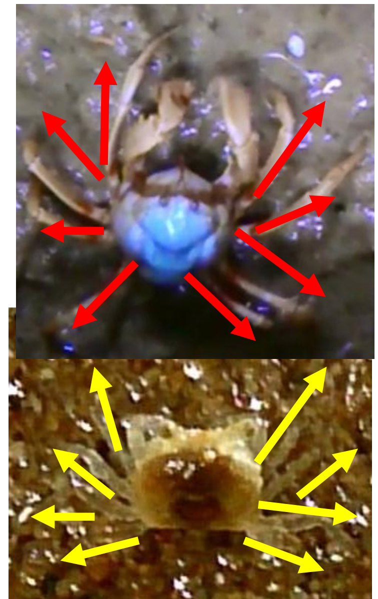


Fig3.5: directions of movement in soldier crabs (upper) and sand bubbler crabs (lower)

Conclusion

Through our field trips, the soldier crabs are found to be the dominant species in the foreshore in the Sai Keng mudflat. As the grain size of sand gradually changes on the shores, we investigated whether grain size is a factor affecting soldier crabs' choice of burrowing sites by experiment. From the result we can see that the crabs prefer finer mud to coarse sand and thus we can draw a conclusion that grain size is indeed a factor affecting their choice of burrow sites. We have two hypotheses to explain why the crabs like fine mud more: fine sand has a higher water retention which helps maintain a constant humidity to prevent dehydration and has a higher surface area for the attachment of food (organic matter like algae and bacteria). From the experiments, fine mud is found to retain more water than coarse sand. The organic matter content of find mud is also found to be higher, which means more food supply to the crabs when they carry out underground foraging in their burrows. Therefore grain size of the sand will affect the crabs' choice of burrowing site.

In the second section, we tried to investigate the crabs' response to two stimulus commonly found on the shores: heat and light. Our set up is a Styrofoam platform with a gradual change in the intensity of these two stimuli (separately in two set-ups). Most crabs are found in cooler area and lighter area in the experiments with changes in heat and light respectively. We believed that the crabs like cooler area as lower temperature means lower evaporation rate and they are less likely to dehydrate and maintain a constant water potential in their bodies. They are attracted by light as light is a sign to help them find their way out of the mud and obtain fresh air.

We tried to suggest a reason to explain how the soldier crabs benefit from their spherical bodies in the third section. We observed and compared the behaviour and structural differences between the soldier crabs and crabs without a spherical body. From our observation, we concluded that the spherical body help them to self-rotate, a motion not observed in other crabs, and facilitate their building of igloos which help them to survive underwater in high tides. Being able to move in various directions due to the spherical bodies also help to escape from predation.

Limitation

1. In order to protect the ecosystem, we only used a small number of crabs for experiments which may affect the accuracy of results. (All crabs and material collected are return to their original places after experiments)
2. In the experiment investigating whether grain size is a factor affecting the distribution of crabs, the mud and sand used are in their natural conditions. Some conditions other than grain size that may also affect the distribution of crabs are impossible to remove like the composition of mud.
3. In the part 2, the crabs' response to the stimulus may not reflect their original response as they are psychologically stressed (being in a foreign environment of the testing platform). We have allowed them to settle and calm down for 3 minutes to reduce their stress but the result may still be affected by their frightened psychological state.
4. In part 3, it is impossible to modify the body shape of soldier crabs (the independent variable). We can only compare them with crabs without a spherical body to prove how the spherical body benefit them.

Significance

From the results we can understand the importance of fine mud to soldier crabs. To protect the fine mud at natural habitats, coastal protective measures can be implemented to reduce the loss of fine mud due to coastal erosion and ensure that the shore inhabited with soldier crabs can continue to be favourable for them. Turning mudflats into beaches with coarse sand must be given a second thought as the area may no longer favourable to soldier crabs.

By knowing how the crabs response to different stimulus , we can reduce human activities which may produce these kinds of stimulus to avoid

disturbing the life of soldier crabs.

Suggestions for further studies

1. From our observation, after the tide water retreated, the former igloos formed by soldier crabs exposed again as hummocks. Studies on the changes of burrow underground after the high tide can be carried out.
2. Other than grain size, factors like salinity can also be investigated in future studies.
3. The crabs seem to be more active in bright light and tend to dug burrows when in dark. The effect of light on the crabs can be further investigated.

Bibliography

Websites:

1. Marine species identification portal (retrieved on 2/3/2015)
http://species-identification.org/species.php?species_group=crabs_of_japan&menuentry=soorten&id=1755
2. Redcliffe Environmental Forum- notes on soldier crab (retrieved on 2/3/2015)
http://www.redenviroforum.org.au/Links/Notes%20on%20the%20Soldier%20Crab.pdf
3. AUSECO- SOLDIER CRABS (retrieved on 2/3/2015)
http://www.auseco.com.au/index.asp?pagename=eco+updates+soldier+crabs
4. 短指和尚蟹成群在泥灘上覓食
http://www.greenpower.org.hk/html/download/pdf/wild_stars_6_2010.pdf
retrieved on 28th February, 2015

5. Soldier Crab Queensland Museum
http://www.qm.qld.gov.au/Find+out+about/Animals+of+Queensland/Crustaceans/Common+marine+crustaceans/Crabs/Soldier+Crab
Retrieved on 28th February, 2015

6. 波子蟹 多面睇
http://www.hkwildlife.net/Forum/viewthread.php?tid=15753&highlight
Retrieved on 28th February, 2015

Publications:

1. Benny K.K. Chan, Kevin J. Caley (2004). Hong Kong Field Guides : Sandy shores. Wan Li Book Co., Ltd. 115 pp.

2. Satoshi Takeda & Minoru Murai (2005), "Microhabitat used by the soldier crabs, Mictyris brevidactylus : interchangeability of surface and subsurface feeding through burrow structure alteration ", Journal of Crustacean biology Vol. 24, No.2 (May 2004) pp 327–339

3. Pat Willmer, Graham Stone, Ian Johnson(2005). Environmental Physiology of Animals. Blackwell Publishing.

Videos:

1. Soldier crabs ecology

https://www.youtube.com/watch?v=njsAEaiWVxk&feature=player_embedded

Retrieved on 28th February, 2015