ARMY ON THE SANDY SHORE

A study on the locomotive abilities
to the successfulness of *Mictyris longicarpus*

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Abstract

Sandy shore is mostly regarded as a harsh environment. In order to survive, *M. longicarpus* acquires vary locomotive abilities that enable them to be a successful species in local sandy shore. We conducted an investigation on the locomotive ability, walking speed, burrowing behaviour and ability, of *M. longicarpus* with related to their size, at Starfish bay, Ma On Shan, which is a sheltered natural sandy shore in Hong Kong.

We found that *M. longicarpus* walk rather slow that it may not be fast enough to escape from their predators, birds, fish and crabs. However, they have developed several locomotive behavioural abilities towards their survival. Unlike other crabs that walk sideway, they can walk in all directions and allow them to escape from enemies quickly. They can also burrow down the ground surface to hide themselves in both clockwise and anticlockwise, which allow them to overcome the obstacles during the process. In our study, we found that the average vertical distance traveled by them is approximately 6 times of its average body size, the level of depth can protect them against predators both during high tide and low tide. Furthermore, their burrowing distance increase with their body size, this indicated that they are more able to escape from danger when they grow up. In conclusion, *M. longicarpus* are well adapted to escape from dangers by their excellent locomotive behavioural ability.

Introduction

On a typical sandy shore, which usually regards as a recreation venue, lives a large variety of organisms which show special features and adaptations to their habitat. Mobile and fine substrate particles, small slope and the little wave actions are the unique properties of a sheltered sandy shore. Its intertidal zone is paid particular attention to due to its high accessibility and rich biodiversity. This study, through investigations on a particular organism on the sandy shore, enables us to probe into the interesting facts around us and appreciate the beauty of nature.

There are few shelters in the sandy shore, the crabs are hard to escape from the predators and enemies. However, we can find a large population of *Mictyris longicarpus* on the sandy shore.

Table 1 Classification of *Mictyris longicarpus*

Kingdom: *Animalia*
Phylum: *Arthopoda*
Subphylum: *Crustacea*
Superorder: *Eucarida*
Order: *Decapoda*
Suborder: *Pleocyemata*
Infraorder: *Brachyura*
Family: *Mictyridae*
Genus: *Mictyris*
Species: *longicarpus* (Latreille, 1806)

Mictyris longicarpus, also known as “soldier crab”, is a brightly blue-coloured crabs. In Hong Kong, since *M. longicarpus* has a spherical body with a blue carapace, it is commonly known as “marble crab” by local villagers. Its classification is stated in Table 1. It is commonly found with a huge population size in the intertidal zone of some of the sheltered sandy shores in Hong Kong.

M. longicarpus is gregarious and will burrow into the sand when disturbed. These crabs will congregate on mud flats, beaches, sandy estuaries or mangroves and live in massive groups that seem to emerge from nowhere all at the same time. They filter sand or mud for microscopic organisms. They congregate during low tide, and bury themselves in the sand during high tide or whenever they are threatened. This is done in wet sand, and they dig in a corkscrew pattern, leaving many small round pellets of sand behind them. Their activities exert a particular fascination not only because of these huge "armies," but also because soldier crabs can walk forward but not only sideways.

Based on the above findings, it is believed that the large population of *M. longicarpus* is owing to its unique behaviour. In this study, the successfulness of *M. longicarpus* was investigated in the aspect of their strength to escape from the predators and enemies. We measured the distance they traveled underground when there is high tide, direction of burrowing, walking speed and walking direction.

Materials and methods

Site description

This study was carried out on Starfish bay in Wu Kai Sha, Ma On Shan, during low tide weekends of February and March 2011. Starfish bay is a typical sheltered sandy shore with a gentle slope and a large intertidal zone. This study was carried out during low tides because *M. longicarpus* emerge and move on the surface of the sand at that time to search for food or a mate. They were found in a large number during low tide which provides enough individuals for our investigation and experiments.

Fig 1. Our study site, Starfish Bay, which is indicated by a red cross.

Field Study Dates

The field study was carried out in two consecutive days during a low tide cycle. The first day was for the catching crabs and set the experiments, and the second day was for the measurements of the experimental results.

	Date	Duration
Observations and Trials	19/2/2011	1400 - 1700
	20/2/2011	1400 - 1730
Data Collection	5/3/2011	1300 - 1730
	6/3/2011	1330 - 1730
	20/3/2011	1230 - 1645
	21/3/2011	1545 - 1745

Vertical Distance traveled by the *M. longicarpus*

In order to measure the distance that the *M. longicarpus* traveled underground, 50 crabs were collected randomly on the shore. To each of the crab, a thread with diameter less than 1 mm, was attached to its carapace with AA glue. At the other end of the thread, a red tag was fixed as a mark for locating the crab on the shore for re-capturing on the next day. The treated crabs were returned to the shore before the rising tide. After the tide receded the following day, they were collected by spotting the signs of the red tags. Some blu-tacks were stuck to the thread to mark the ground level and then we dug out the sand and located the crabs. We measured the distance between its carapace and the blu-tacks on the ground level. In order to find out the relationship between the lengths of the *M. longicarpus* and the distance they traveled underground, their body length were also measured.

Threads and tags were of sharp colour so that they were easily spotted out from the sand flat on the next day. Also, the tags were small in size thus it minimized the hindrance posed on their locomotion. At the first time, threads of 100 cm long were used. When we collected the crabs on the next day, we realized that the threads were too long and it would obstruct the locomotion of them. Finally, we decided to use threads of 40 cm long instead.

Walking speed of *M. longicarpus*

For measuring the walking speed, 60 *M. longicarpus* were collected. During the measurement, a crab was placed on the cutting mat with squared lines. The walking of the crab was recorded by a live camera and the walking speeds were determined when playback the video by the computer. A transparency was placed on the computer screen and the walking trail was traced on the transparency. The length of the walking trail was measured. With the help of the scale on the cutting mat, the walking speed of the crab was calculated with the time spent shown on the video playback. The body sizes of each individual were also measured to find out the relationship between walking speed and body size.

Adaptations of Burrowing Behaviors of *M. longicarpus*

To investigate this aspect of adaptation, two approaches were used.

(i) Size of claw

The differences between the right claws and the left claws may result in the differences in their burrowing performances. In view of this, the differences of the two claws of 27 *M. longicarpus* were measured by using a caliper with scaled mark every millimeter.

(ii) Burrowing direction

In order to find out if there is fixed burrowing direction for an individual of *M. longicarpus*, 20 individuals of *M. longicarpus* were randomly caught and were placed on the sand to observe their burrowing actions. The direction of burrowing (i.e. anti-clockwise or clockwise) was recorded by a live camera. After the crab stopped burrowing, the individual was brought up to the ground surface again and the observation was repeated 10 times. The individual would be considered as "left-handed" or "right-handed" if no variations were found.

Walking Direction of *M. longicarpus*

In order to find out the walking direction of *M. longicarpus*, 10 crabs were caught and studied. The spontaneous walking direction of the crab was recorded by a live camera. To find out if the walking direction of the same crab was changed when threatened, a shovel is used to threaten the crab and the walking direction of the crab was recorded.

Results

Vertical Distance traveled by the *M. longicarpus*

Of the 50 *M. longicarpus* individuals marked, 37 survived individuals were found on the next day. As shown in Table 2, the vertical distance traveled by *M. longicarpus* varied from 12 mm to a maximum 122 mm. The vertical distance traveled by *M. longicarpus* increase with its body size (Fig. 2).

Body size (mm)	5	6	7	7	8	8	8	8	8	8
Distance travelled (mm)	39	12	42	60	17	24	40	46	54	59

Body size (mm)	9	9	9	9	9	10	10	10	10	11
Distance travelled (mm)	39	44	50	61	75	53	60	90	111	63

Body size (mm)	11	12	12	13	13	13	14	14	14	14
Distance travelled (mm)	77	45	53	36	72	110	60	62	68	70

Body size (mm)	14	14	15	15	16	16	16			
Distance travelled (mm)	82	107	55	113	80	85	122			

Table.2. The vertical distance traveled by *M. longicarpus* with its body size.

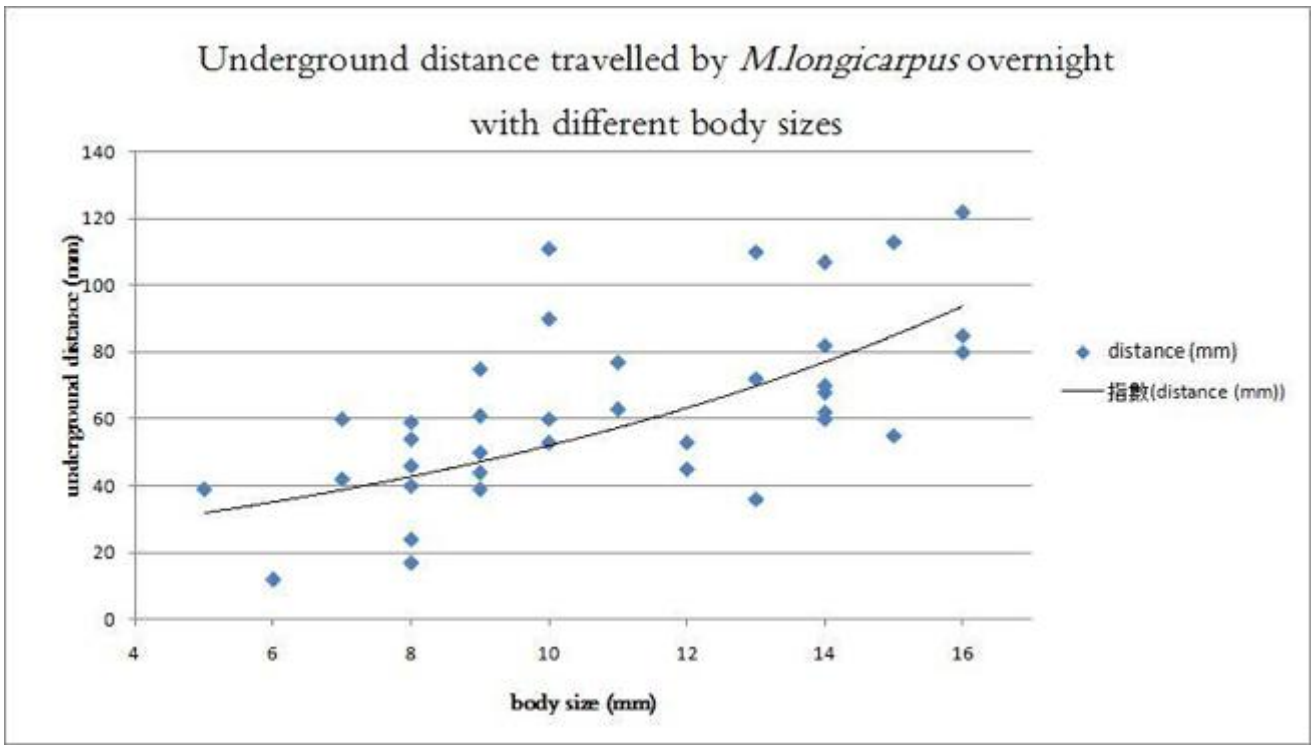

Fig. 2. The graph showing the relationship between the vertical distance traveled by *M. longicarpus* with their different body sizes.

Walking speed of *M. longicarpus*

The average walking speed of *M. longicarpus* was found to be 8.87 cm/s. The maximum walking speed can up to 14.29 cm/s. However, the walking speed of *M. longicarpus* seemed not related to their body size (Fig. 3).

Body size (mm)	10.4	10.6	10.7	10.8	10.8	11.2	11.8	12.5	12.5	12.7
Speed (cm/s)	7.39	11.03	8.57	9.00	10.27	7.81	7.48	9.22	8.75	9.21

Body size (mm)	12.7	12.7	13	13	13.2	13.2	13.2	13.2	13.3	13.5
Speed (cm/s)	9.06	8.92	9.85	7.75	7.52	10.48	7.84	9.33	9.02	7.95

Body size (mm)	13.5	13.6	13.7	13.7	13.8	14	14	14.2	14.3	14.4
Speed (cm/s)	7.63	14.18	6.64	6.09	7.67	7.77	8.65	8.41	6.64	9.34

Body size (mm)	14.4	14.4	14.4	14.8	14.9	15	15.1	15.3	15.3	15.4
Speed (cm/s)	14.29	5.00	8.55	10.54	7.03	6.33	7.63	5.70	11.28	7.14

Body size (mm)	15.4	15.4	15.6	15.7	15.7	16	16	16	16	16
Speed (cm/s)	7.19	6.78	7.65	8.87	10.10	10.42	10.76	7.69	12.86	13.25

Body size (mm)	16	16.5	16.7	16.7	16.7	17	17.3	17.4	17.7	18
Speed (cm/s)	11.07	6.97	10.83	9.05	7.75	9.74	7.95	10.58	10.42	9.42

Table 3. The walking speeds of *M. longicarpus* with their body size

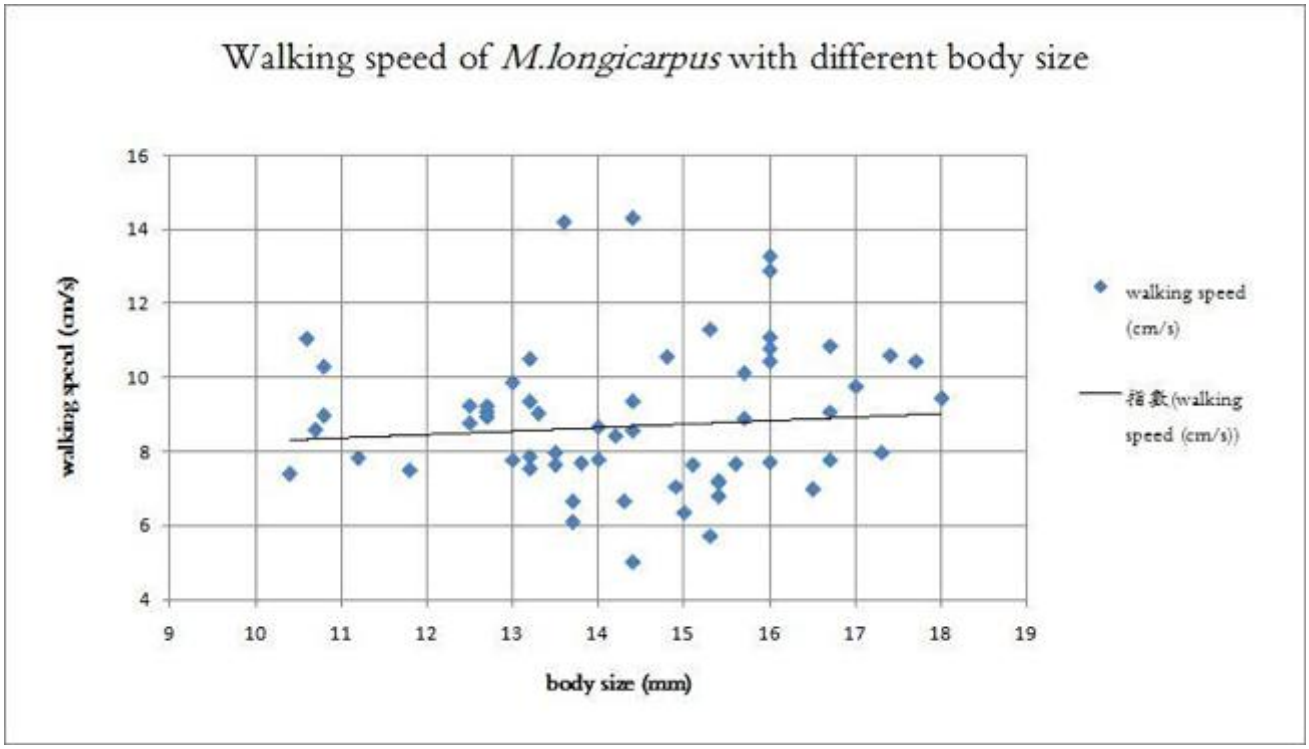

Fig. 3. The graph showing the relationship between the walking speed of *M. longicarpus* with their body sizes.

Adaptations of Burrowing Behaviors of *M. longicarpus*

(i) Size of Claws

Of the 27 *M. longicarpus* collected, none of them showed a difference between size of left claw and that of right claw. The differences in the sizes of their claws are said to be less than 0.5 mm which is the limitation of the measurement by the caliper.

(ii) Burrowing direction

Of the 19 successful observations, *M. longicarpus*, 9 of them were found to be usually left-handed, and 10 of them were found to be usually right-handed. However, several of them were found to have the ability to burrow in both directions. (Fig. 4)

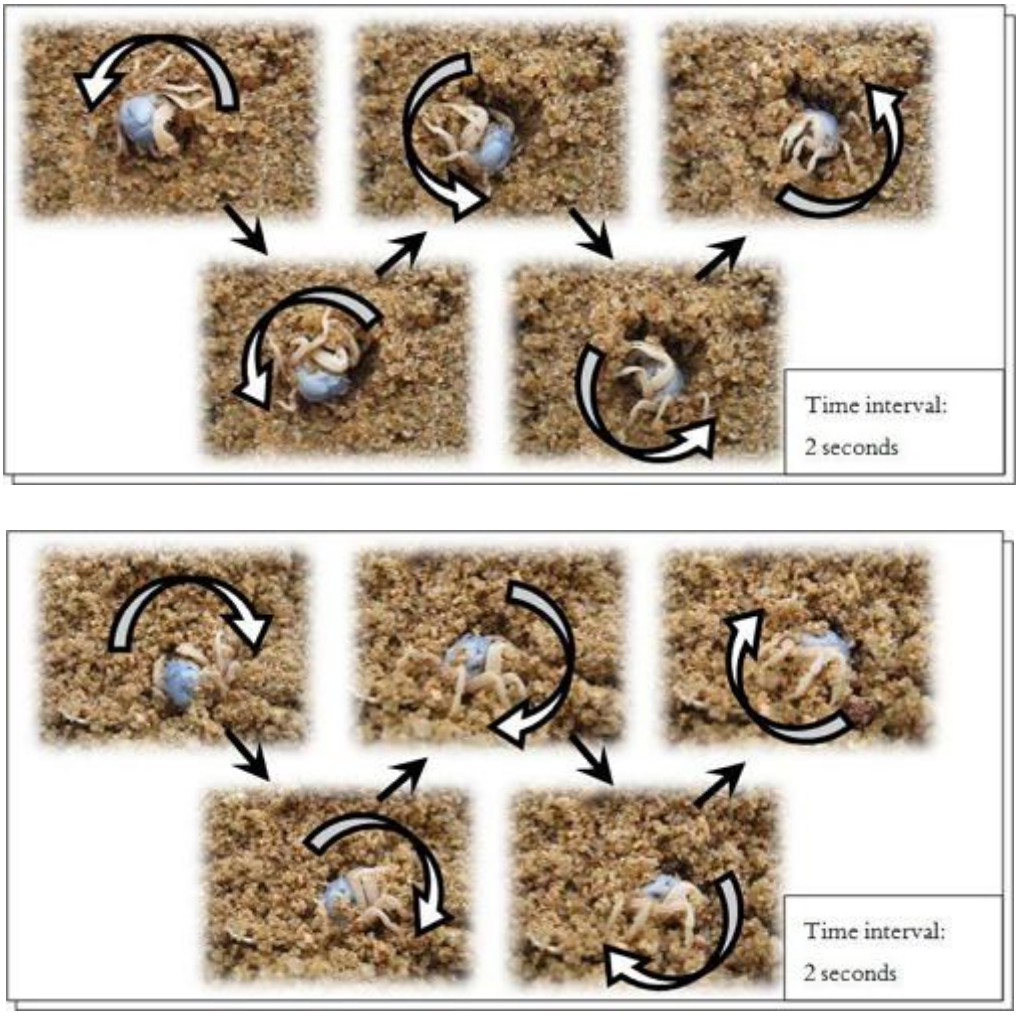

Fig. 4. A continuous capture of an individual *M. longicarpus* burrowing in anti-clockwise (upper) and in clockwise (lower)

Walking Direction

It was found that *M. longicarpus* has the ability to walk in all directions. They walked in all directions spontaneously. When threatened, they also showed a response by moving backward and away from the obstacle quickly.

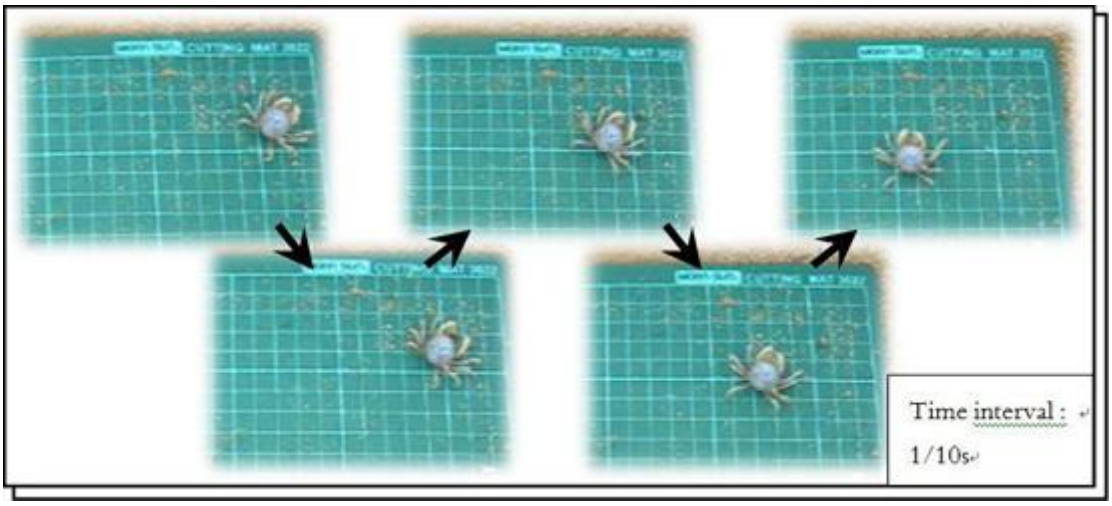

Fig. 5. A continuous capture of an *M. longicarpus* individual moving backward spontaneously

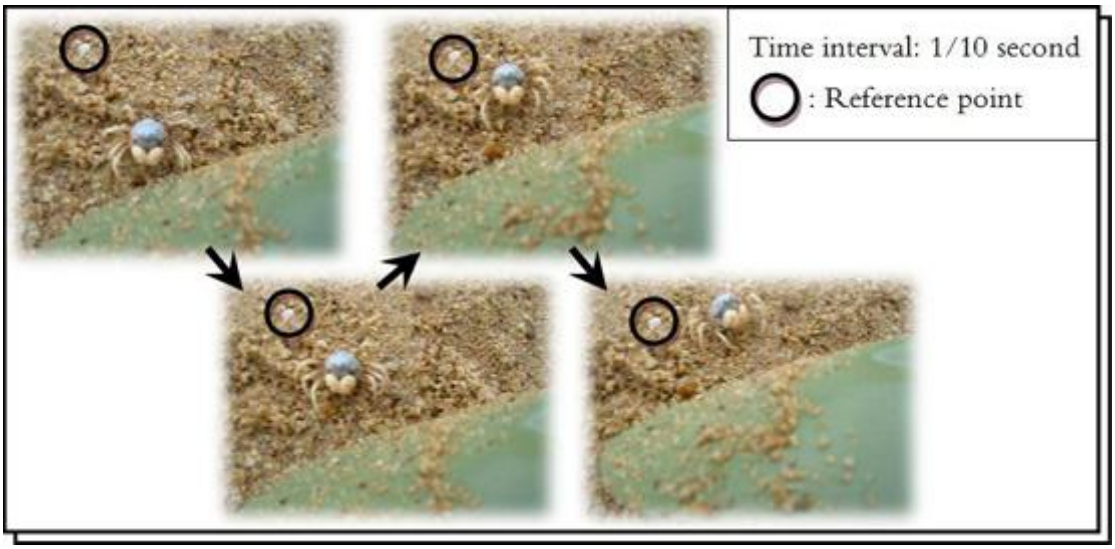

Fig. 6. A continuous capture of an *M. longicarpus* individual moving backward when threatened by a shovel

Discussion

In our study, different approaches were used to find out how the behaviors of *Mictyris longicarpus* help to lead to the successfulness of its large population, including the walking speed, walking direction, burrowing direction and the vertical traveling distance.

The aim of the first approach for our study is to investigate the walking speed of *M. longicarpus* as the walking speed is thought to be an important factor for survival to most of the organisms. For no obvious physical adaptive features which were related to their walking speed were found, we can conclude that the speed of *M. longicarpus* is slow with their small body size. Their average speed is 8.87 cm/s which is not a fast speed with comparison to its predator mainly birds and fishes. Thus, the walking speed is not a suitable way to escape from enemies successfully. However, the value obtained of the average speed of *M. longicarpus* may had errors as the routes they took might not be horizontal or linear, and individual variations might happen during our observation, these errors are not able to be avoided.

For the walking ability of *M. longicarpus,* the possible walking direction is also one of our major concerns. Ability in walking in different direction allows an organism to escape from enemies and overcomes the barriers. We found that *M. longicarpus* can walk in all directions as the sandy shore is a spacious area where dangers will come from all directions, it is important for them to be able to react with these situations. With the information on the web, we know that *M. longicarpus* is able to walk forward, while our results showed that *M. longicarpus* can walk in all directions, including walk forward instead of the typical sideways motion of crabs and also walk backward without rotating their bodies. This will help them to give immediate response when facing enemies. The ability can be explained by their spherical body shape and limbs which are nearly evenly distributed on its body, which is a unique body features among crabs. This special body feature enables them to walk in all directions and achieve the aim which is to escape from enemies quickly.

On the other hand, *M. longicarpus* acquires the ability to burrow down the ground surface. At the earlier stage of our investigation, we came up with an idea of measuring how much time is needed for *M. longicarpus* to bury themselves completely into the sand. However, the burrowing process may not be a continuous one as they often paused. Hence, we changed our mind to investigate the efficiency of their burrowing process.

In order to find out how their burrowing habits can adapt to the environment, we had another approach to find out whether they are able to choose their burrowing direction. Before we conduct the investigation, we thought that the crab may only be able to burrow in one direction only. It was similar to the “left-handed or right-handed” principle of other creatures such as human-being, i.e. the direction of burrowing of a certain *M. longicarpus* will only be clockwise, or anti-clockwise. According to the results we found, although most of them seem follow our hypothesis, we can also found that the same individual of *M. longicarpus* is able to have a clockwise and anti-clockwise burrowing direction at different time.

As written in the previous section describing the walking speed of *M. longicarpus*, it is not a good method to escape from enemies around its habitat. This habitat, the sandy shore, provides no shelter for them to escape from enemies. Therefore, the immediate burrowing skills can increase their survival chances by providing ways for them to hide from nature enemies. At the same time, the direction of burrowing was not limited for each *M. longicarpus* so that they are able to make their choice to an easier option and escape quickly in case of facing barrier at one side of it. By putting the ease of burrowing as their first priority, they can also make their choice by considering the condition of sand around it and also the original body posture. Hence, this adaptation leads to a faster burrowing speed and thus increasing the chance of hiding from the enemy.

By observation, the two front claws were the major tools during burrowing process. Therefore we decided to study the difference between the level of development of their claws. In this study, the length of its claw was used to determine the level of development. If there are any differences between the left claw and right claw, the performance of burrowing in clockwise direction will be different from that of anti-clockwise direction. With no observable difference between the left claw and the right claw of *M. longicarpus,* this allows their inborn physical adaptation of burrowing at both directions. Therefore their performance of burrowing will not be affected by using different claws.

Another approach of us to find out how *M. longicarpus* overcomes the environment of sandy shore with frequent tidal movements is to find out how deep it can travel underground. Sufficient burrowing skills are important to *M. longicarpus* as it reduces the chances of being brought away by the tidal movement or eaten by its potential enemies

which come along with the high tide. With reference to the results we found, the average vertical distance traveled by them is 63.135 mm which is approximately 6 times of its average body size. This level of depth provides them not only a sufficient shelter below the ground surface during high tide, but also a quick access to the ground during low tide when they have to search for food. *M. longicarpus* also showed a steady increase in the vertical traveled distance with increase in body size, which means the ability of burrowing increase with its size, together with the survival chances. It is understandable that the individuals with longer limbs can burrow deeper, as the size of sand is relatively smaller comparing to its body size. However, the method we applied may lead to errors that the thread and the tag may lead to a pulling force on the crab which may change the actual distance and direction of the crab burrowed. Thus, the real distance may not be indicated.

Among the investigation we conducted, possible source of errors was brought up by the environment. As stated before, field studies were carried on different days. There were different in temperature between days and slightly different in temperature between hours. Being a cold-blooded animal, variations in performance will happen on *M. longicarpus* owing to the natural rising or dropping of temperature. Since temperature at different time will cause the variation in performance, so if our measurement can all be carried at the same period of time, it will lower the errors of walking speed, and the impact of temperature on the crabs.

However, there are some desirable approaches that were not done in this investigation due to the limited apparatus and time of study. A further study is recommended to investigate how the size of grains relates to its burrowing rate by measuring the grains size in different zones. This may be able to further explain the variations of the results we had in the burrowing experiments. However, our school laboratory did not have the equipment for measuring the grain size that we can’t measure it in this study. Besides, winter may not be the best time for this study as they were not active enough. A further study in summer may give a comparable result to this one for their burrowing speed and walking speed.

References

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Classification of *Mictyris longicarpus* : http://australianmuseum.net.au/Soldier-Crab