The hermit crab's home

Gp.23 **St. Mark's School**

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Abstracts

The field site of this study is Tai Tam Bay. Over there a wide range of organisms were found and an interesting phenomenon was observed. In a particular area of the site, the percentage of hermit crabs which carried a spiral shape shell is much higher than the coiling shape ones.

Experiments had been done to find out the criteria that the hermit crabs use when selecting their shells and which shell do the hermit crabs prefer more. The result shows that the hermit crabs prefer the coiling shells more to the spiral shells. The advantages of using a coiling shell are that it has a wider canal, more space, and is lighter than spiral shells.

Fig. 1: The ground were left with empty and eroded spiral shells.

Fig.2: Photo of the field site of this study: Tai Tam Bay

Background

The Tai Tam Bay is a sallow bay, wave action is reduced and there is an accumulation of sand and detrital material. The backshore vegetation is dominated by *Hibiscus tiliaceus* and seaward sides have many patches of Zoysia grasses. It is a relatively unstable environment and the fauna is sparse. But the substrate stability allows for the development of a rich community for burrowing animals. Apart from the burrowing animals, mudskipper, ceriths and crabs are found abundantly in the site.

There is an interesting phenomenon that attracted our attention. In a particular area of the site, hermit crabs (*Clibanarius infraspinatus*) are found in a great amount. Among the hermit crabs, it is observed that the majority of the hermit crabs carried a spiral shape shell whereas the minority possessed a coiling shape shell.

We are questioned by ourselves why such phenomenon appears. Therefore further investigations of the hermit crab were taken.

Hermit crabs possess long soft abdomens which are protected from predators by the adaptation of carrying a salvaged empty seashell. The whole body of the hermit crab can retract into the shell. Most frequently hermit crabs utilize the shells of sea snails, marine gastropod mollusks. The tip of the hermit crab's abdomen is adapted to clasp strongly onto the columella of the snail shell. As the hermit crab grows in size, it has to find a larger shell and abandon the previous one.

Objectives

Fig. 3&4: The hermit crabs with coiling shell and spiral shell respectively

1. To investigate the preference for the two type of shells, the coiling one and the spiral one.
2. To investigate how the hermit crabs take advantage of the shell features in a bid to survive.
3. To contrast the advantages and disadvantages for the hermit crabs to possess each two type of shells.

General Information of the field trips

Date	Time	Purpose
08/03/2009	1200-1500	Trial
15/03/2009	1400-1700	Observation
20/03/2009	1430-1630	Taking Samples
29//03/2009	1300-1600	Returning Samples

Location: Tai Tam Bay on Hong Kong Island

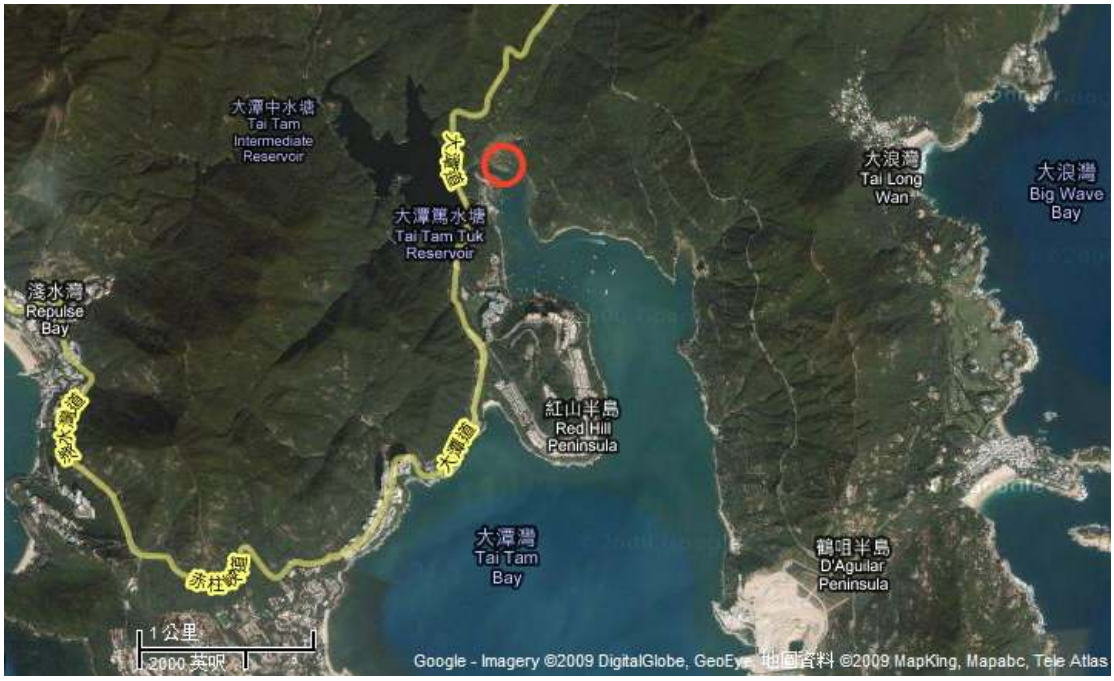


Fig. 5: Location of Tai Tam Bay on Hong Kong Island

The red circle indicates the location of study.

Fig. 6: Location where samples of hermit crabs were found

The red circle indicates the location where large amount of hermit crabs were found. Samples of hermit crabs and empty shells were taken there.

Methodology

Experiment 1

Aim:

To determine in what condition will stimulate the hermit crabs to abandon their original shell.

Background:

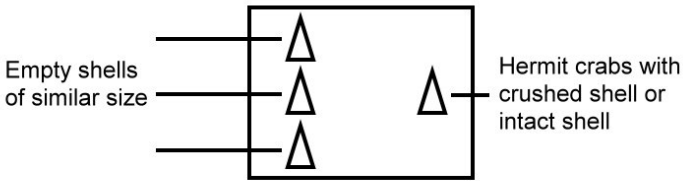
In this field trip report, the changing of shells of hermit crabs are going to be examined. In fact, the hermit crabs will change their shells only when they have grown to a size that their shells no longer suit them. Therefore, hermit crabs do not change their shells very often. Due to the limitation of time to do this report, we decided to stimulate the change of shells of the hermit crabs.

Procedure:

4 hermit crabs (in spiral shell) were obtained from the field site. (indicated as 'A') The shells of two of the samples taken were paralyzed by a pair of forceps and crashed by pliers. The remaining 2 were left intact.

The hermit crabs were kept in separate small boxes. 3 spiral shells of similar size were put beside each of them. The set up was placed on the window side. Also, the hermit crabs were fed once a day (cabbage).

Observations were carried out after 2 days (Table 1) .



Results:

Table 1: The stimulation of the change of shells of hermit crabs

Crab 1	Crab 2	Crab 3	Crab 4
In crashed shells		In intact shells	
Placed in water beside window and fed once a day			
Shell changed	Specimen died	Shell retained	Shell retained

Experiment 2

Aim:

To find out whether a spiral shape shell or a coiling shape shell is fitter for the crabs.

Background:

In Tai Tam Bay, only two types of shells in which the hermit crabs were carrying were identified. They were the spiral one and the coiling one. We observed that the majority of the hermit crabs carried a coiling shape shell whereas the minority possessed a spiral shape shell. It might be due to the fact that the hermit crabs tended to seek for a coiling shape shell rather than the spiral shape shell. In this experiment, we are going to determine the hermit crabs' preference on spiral or coiling shells.

Procedure:

4 hermit crabs were obtained from the field site. The shells of two of the samples taken were crashed by pliers in a similar way to experiment 1. The 4 hermit crabs were kept in separate small boxes.

28 empty shells (both coiling and spiral) were obtained from the field site. Their respective capacity were measured by immersing them in water, taking out and pouring the water inside into a measuring cylinder, 5ml. For each shell, the actions were repeated for 10 times. The capacity volumes were taken by dividing the resultant readings in the measuring cylinder by 10 (Chart 1). These shells were marked and divided in groups according to their capacities.

An empty spiral shell and a empty coiling shell of similar capacity volumes were placed and kept with the hermit crabs in separate box. The set up was placed on the window side. Also, the crabs were fed once a day.

Observations were carried out after 2 days (Table 2) .

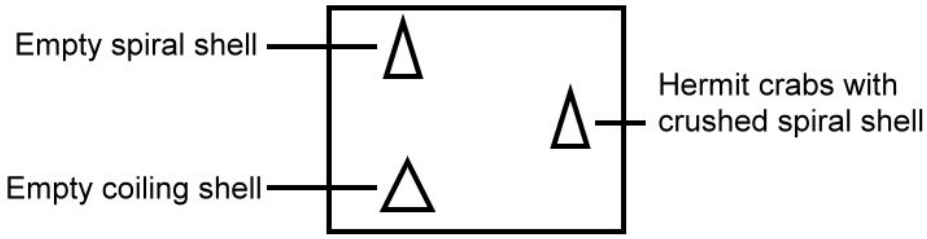


Fig. 7:The shell was cracked by a bonecutter

Results:

Chart 1: The capacity volumes of the spiral and coiling shape shells obtained

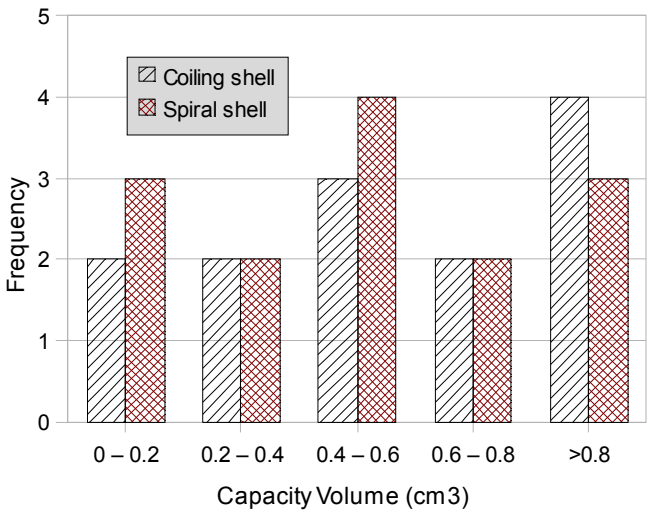


Table 2: The hermit crabs' choice on replacing their shells with spiral and coiling shape shells

Hermit crab no.		1	2	3	4
Treatment		Original shells(spiral) crashed			
Nourishment		Placed in water beside window and fed once a day			
New shell Capacity	Spiral shape	0.81 cm^3	0.85 cm^3	0.43 cm^3	0.56 cm^3
	coiling shape	0.98 cm^3	0.77 cm^3	0.46 cm^3	0.41 cm^3
New status		Moved to a coiling shell	Moved to a coiling shell	Moved to a coiling shell	Moved to a spiral shell

Fig. 8: The experimental set-up of experiment 2.

Experiment 3

Aim:

To find out the survivability and the behavior in competition for food of the two types of hermit crabs respectively: crabs carrying spiral shape shell and crabs carrying a coiling shape shell.

Background:

Since only little hermit crabs in spiral shells were found in the Tai Tam Bay, the survivability of the hermit crab in spiral shell was doubted. Tides in the bay caused the environment changing. Living in such a varying environment, the adaptive ability of organisms are very radical. Also, as the biological interaction among the hermit crabs community is competition, their behavior in competition for food is important. The criteria affecting the hermit crabs' preference on choosing shells might be the adaptivity of the shells, which in turn affects the organisms' behavior in competition. From the field site, hermit crabs were taken as samples and kept in the laboratory.

Procedure:

10 hermit crabs,with their size identified and classified into groups by comparing with the shells in experiment 2, were obtained from the field site. There were one spiral-shaped and one coiling-shaped shell hermit crab in each group. They were kept in a water tank in the laboratory. Water samples and sand samples were taken from the bay and poured into the water tank. To simulate the habitat of a sand bank, a slope was made artificially and water was added. The water level ranges from zero to 6 cm^3. A fan was installed near the water tank so as to speed up evaporation. The loss of water due to evaporation decreased the water level and stimulated the tide-out. Every day, sea water was added to compensate for the loss of water, stimulating the tide-in.

Fig. 9: The experimental set-up of experiment 3

On daily basis, a limited supply of food was given(only a small piece of cabbage was fed to each 2 hermit crabs) and the number of remaining hermit crabs were counted.

Results:

Chart 2: The number of hermit crabs surviving with days passed

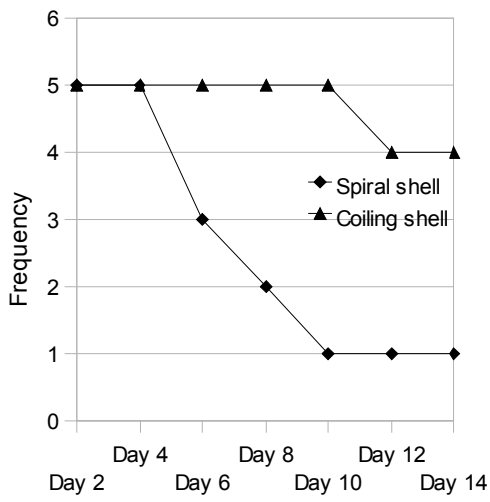


Table 3: The list recording the death of the hermit crabs

Crab no.	Day of death	Type of shell	Size
1	Day 6	Spiral	0 – 0.2
2	Day 6	Spiral	0.2 – 0.4
3	Day 8	Spiral	0.6 – 0.8
4	Day 10	Spiral	0.4 – 0.6
5	Day 12	Coiling	0 – 0.2

Experiment 4

Aim:

To investigate the adaptive features of spiral-shaped shell and coiling-shaped shell

Background:

Based on the assumption that the short of adaptive features may lead to death of the organism, the two types of shell should possess different adaptive features that allows the hermit crabs inside to be aware of the changing environment. We believed that the hermit crabs take advantage of the features in a bid to survive. In this experiment, the features of the two type of shells, spiral and coiling, are examined in the different aspects such as density, capacity volume per density and the tolerance to pressure,

Procedure:

3 empty coiling-shaped shell and 3 empty spiral-shaped shell was obtained to perform the following tests:

Test for mass

The shells were put on an electrical balance and the readings were recorded (Table 4).

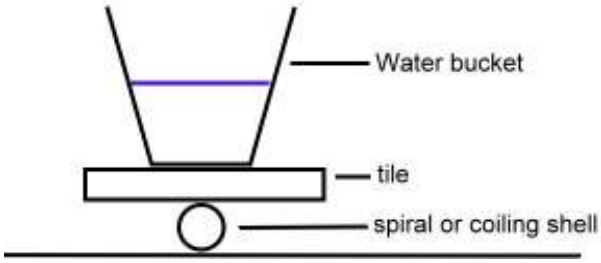
Test for capacity volume per mass

The shells was immersing them in a beaker of water. They were then taken out and the water inside was poured into a measuring cylinder, 5ml. Readings were taken (Table 4). The density per capacity volume was calculated by dividing the shell's weight by their respective capacity volume.

Test for the tolerance

A piece of tile was placed on the shell going to be tested. On the tile, a water bucket were placed in which water were slowly added into the bucket. When the

shell cracked, the total weight of the apparatus with the water added was recorded. The figure was then divided by the shell's mass(Table 4).



Results:

Table 4: The adaptive features of the both the spiral-shaped and the coiling-shaped shell

Shell type	Crab no.	Mass (g)	Capacity Volume (cm^3)	Capacity volume per mass (cm^3g^{-1})	Tolerance (Ng^{-1})
Spiral	1	0.41	0.07	0.1707	37685
	2	0.65	0.15	0.2308	12060
	3	0.69	0.08	0.1159	24137
coiling	4	1.18	0.82	0.6949	779
	5	1.50	0.85	0.5667	605
	6	1.68	1.10	0.6548	426

Chart 3: The relationship between capacity volume and density

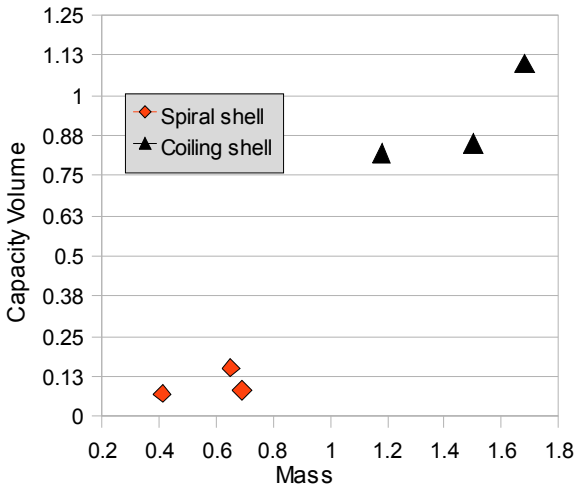


Chart 4: The relationship between density per capacity volume and density

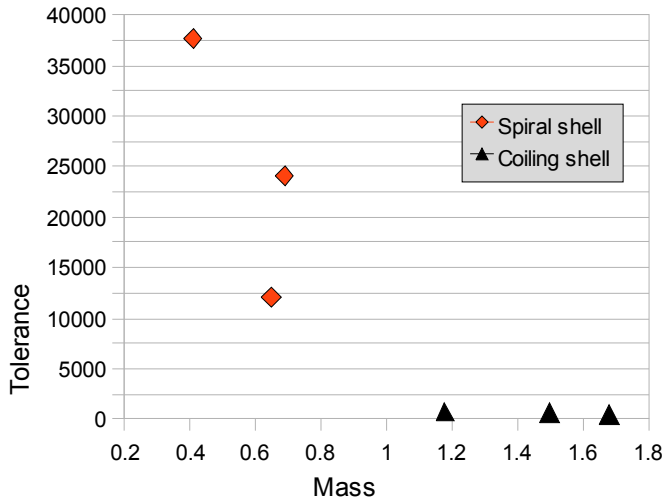


Chart 5: The relationship between tolerance to pressure and density

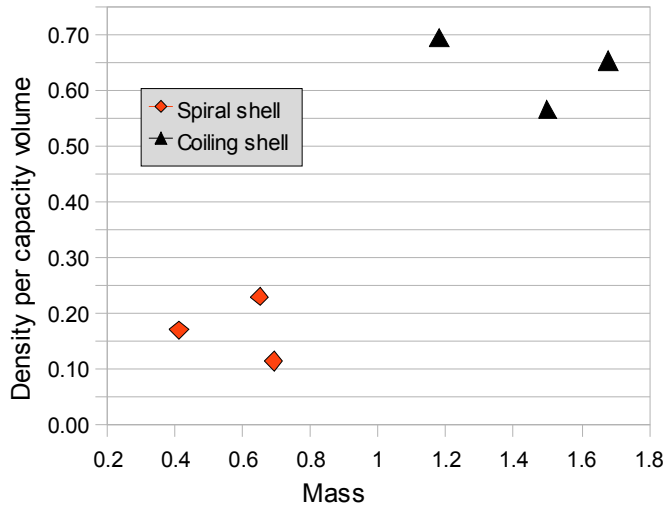


Fig. 10: The experimental set-up of experiment 4

Data Analysis

Experiment 1

The hermit crabs are likely to have intact shells instead of damaged ones.

Experiment 2

Most of the hermit crabs prefer coiled shell instead of spiral shell.

Experiment 3

Hermit crabs with coiling shell tend to survive for a longer time than the spiral shape.

Experiment 4

Coiling shells are generally less tolerant of mechanical damage caused by great force than the spiral shape.

Interpretation

Experiment 1

Two of the hermit crabs which their shells were crashed found new shells among the empty shells which were provided by us, while the other two hermit crabs which their shells were intact did not do so. This shows that the hermit crabs are likely to have intact shells instead of damaged ones. The result is quite understandable and expected .Damaged shell with holes expose the soft body of the hermit crab and they cannot be protected from the predators.

Experiment 2

Compared with spiral shells, coiling shells have relatively more space if the masses are the same (From the result of experiment 4). Thus, if the volumes are to be the same, coiling shells is relatively lighter. A lighter shell or a shell with more space inside probably suits hermit crabs more since they have faster locomotion. Also, they can hide more of their bodies into the shell. Predators such as birds with beaks and fish can hardly reach the crabs in the deep coiling shell. Most importantly, more space is provided to the hermit crabs so that it can grow into bigger size.

Fig. 11: The channel inside of coiling shape shell was broader

Fig. 12: The channel inside of spiral shape shell was narrower

Another possible reason for most of the hermit crabs to find coiling shells is that the spaces inside spiral shells are relatively narrow. That means although a coiling shell and a spiral shell has the same capacity inside, the spiral shell has more coiling and the canal is narrower. From our observation, since the hermit crabs can hardly reach the tapering end of the canal of spiral shells, some of the space is not occupied. And the actual capacity of the shell can be used by the hermit crabs is probably smaller. As coiling shells are less coiled and are wider, they are more preferable.

Fig. 13: Photo of the crashed shell

Experiment 3

Hermit crabs with coiled shell tend to be able to survive for a longer time. The crabs with coiled shells are generally stronger than those with spiral shells. From experiment 2, the hermit crabs tend to get the coiled shells instead of the spiral shells. Strong hermit crabs might obtain the coiled shells in the intraspecific-competition between the hermit crabs. Thus, the stronger hermit crabs are more adapted to the harsh environment with limited food resource as they are more likely to win the intraspecific-competition for the food. And that might be why hermit crabs with coiled shells can stand for a longer time.

Experiment 4

The result shows that coiled shells are generally less tolerant of mechanical damage caused by great pressure. This may be due to the shape or thickness of coiled shells is not suitable for standing large force applying on it. Besides, it may be due to the difference in content of spiral and coiled shells such that the spiral shells are made up of materials with greater strength. However, the hermit crabs still have a higher tendency to choose the coiled shells than the spiral shells. It suggested that the advantages brought by the coiled shells overcame its disadvantages. In the soft shore, the tides normally are not as strong as in the exposed shore, which would not break the shells of the hermit crabs. So the strength of the shells is not a considerable factor for the hermit. On the other hand, the crabs in coiled shells are stronger and those shells enhance the growth of the crabs. Furthermore, the mature hermit crabs are not as much depending on the strength of shells as at the younger stage. At the younger stage, they cannot protect themselves, so a stronger shell is required for protection. In the mature stage, the hermit crab is strong enough to be self-defense by itself. As a result, the hermit crabs with coiled shells are stronger than the spiral ones.

Discussion

There are more spiral hermit crabs than the coiling hermit crabs. Moreover there are many empty spiral shells but no empty coiling shells. The spiral hermit crabs have a lower survivability. Thus the stronger spiral hermit crabs win the competition and get the coiling shells. The weaker one eventually dies and many empty spiral shells are found. All the coiling shells are obtained and therefore there are no such shells in the bay.

Errors and Improvements

Although trends can be observed from the result of the experiment, there are some errors or methods that are not very appropriate in the experiments.

Experiment 1

Only four hermit crabs were used. And the result may not be representative as we cannot tell whether some of the hermit crabs would prefer staying in the damaged shell. Assumption of all the hermit crabs change their shells are made. Hermit crabs with intact shells may comfort to their original shells, which they do not have the need to change their shells. Then no matter how many shells were put beside them, they would not find other ones. Therefore, one of the improvements can be done is to perform the experiment with more crabs and empty shells.

Experiment 2

The result shows that hermit crabs generally prefer coiled shell more. However, we had made an assumption that all hermit crabs had searched for all shells and chose the shell that suited them most. And we were not sure if the hermit crabs would go into whatever shell which is fit for them at once without searching for the others. To prevent this kind of problem, better shells (probably coiled shells) should be put further away from the hermit crabs and we should check if they would still prefer those shells or not.

On the other hand, there could be some other factors that accounted for the result which we did not consider much. For example, the size of the given empty shells (one coiled and one spiral for each hermit crab) might not be suitable. As a result, the hermit crabs chose the shell not because of the advantages that could be brought by that type of shell, but the unsuitable capacity of that another shell (i.e. the result is due to the capacity of the shell). Since the hermit crabs may be quite sensitive to the size of the shell, the error due to difference in sizes of shells should not be ignored.

Besides, there may be error due to problem of particular shells such that other factors lead to the result. For example, there might be some shells which have special internal structures (maybe thickness of the shell) so that the hermit crabs would not consider them. To make improvement, more empty shells can be provided to eliminate this kind of error.

The shells were crushed with holes were used in the experiment. This may forced the hermit crabs to leave their shells. We can have another investigation to find out whether a small damage to the shells (without even making holes) will cause the hermit crabs to move to new shells or not.

Experiment 3

There are some other factors that account for the trend of the survival of hermit crabs since the environment was not the natural one. We could not provide a more similar condition for them. They might not adapt to the change in the artificial condition and eventually die. For example, the wastes and bacteria accumulated in the water tank, which may caused disease to the crabs. So it is better to change the water in the tank every day. Besides, the hermit crabs were in different capacity of shells. The death of small hermit crabs may be due to their small size. The survivability of the hermit crabs might not relate to their shape of shells then (i.e. the result is caused by other factors). Thus, similar size of both hermit crabs with coiled and spiral shells should be used in this experiment.

Experiment 4

The way that we cracked the shell might not be very appropriate. Since the bucket of water was balanced by our hands, there may be some forces exerted by us which balanced some of the actual force adding on the shell. And this may lead to some errors in the weight of water required to crash the shell. Furthermore, shapes of the shells may lead to unfairness of the experiment as the orientations of the shells against the crush were different. For example, the tolerances are not the same on the posterior side as the anterior of the coiled shell. And this may lead to some errors in finding the force. The mass difference between the spiral and coiled shells was very large which leaded to a misleading result. Shells with similar mass and capacity are better to be tested. Nevertheless, since average reading can be found and the result is quite significant, we can deduce that spiral shells have greater tolerance.

However, from the result, we can only deduce that spiral shells can withstand a greater force when the shells are lying on the ground normally. Whether this is an adaptive feature or not highly depends on real situation. The tolerance to withstand great force can be a feature that protects the hermit crab from being trampled by other organisms (for example human). However, whether the shell is tolerant to the erosion due to sea wave cannot be deduced by the experiment. According to some internet resources, it was said that some of the spiral shells (擬蟹守螺) usually have the tapering ends eroded. And this shows that the spiral shells are not necessarily stronger and difficult to damage.

Explanation of some of the methods used

In the experiments, spiral hermit crabs instead of coiling hermit crabs were cracked. This is because of hermit crabs were seldom able to hide deep in the shell (about two turns only). And it is easier to crack the shells without hurting the hermit crabs.

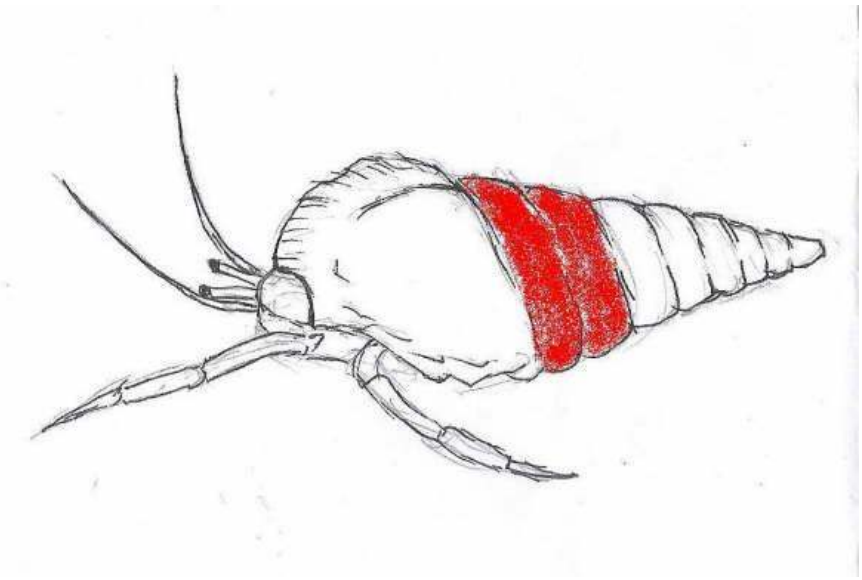


Fig. 14: The red region indicates where the hermit crab's abdomen occupies

On the other hand, we carried the experiment out near the window so as to simulate the condition as the natural one with day time and night time.

Further investigation

Investigation of resistance of different shells

In experiment 4, we can only find the tolerance of shells towards the mechanical force. And it might not be very critical for the shells. So we may investigate the resistance of the shells in particular environments. Those environments can be water with fixed salinity, pH, etc.

This can be done by putting different shells into the same solution. Then by finding the change of mass, we may calculate the percentage changes in mass and find the erosion to each shell. And we may be able to find the resistance to those environments of each shell.

Besides, we can even investigate which conditions cause more erosion to the shells.

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As a result, the effect of the waste water discharge by the factor and farmland to the hermit crabs shells can be found. The relationship between human activity and the hermit crabs can be discovered.

Investigation on the pattern of the choice of shells by different species of hermit crabs

Due to the limitation of time, we had only arrived one field site of soft shore and identified one type of hermit crab. Identifying more species of hermit crab, we can perform experiments to investigate the choice of selecting specific shell by different species. Thus, the wider relationship between the hermit crabs and the shells can be known.

Conclusion

1. The hermit crabs prefer the coiling shells more to the spiral shells.
2. If the shells for hermit crabs have more space, they may be able to hide deep inside against predator and grow better. If the canals of the shells are wider, hermit crabs can occupy more space so more capacity can be used. If the shells are harder, hermit crabs can avoid being broken by trample of animals. If the shells have lower density, hermit crabs can have faster locomotion. All these are important for the survival of hermit crabs.
3. For spiral shells, they have advantages such as harder shells. But spiral shells do not have the advantages of coiling shells, such as wider canals, more space, and lighter shell.

Reference

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