Journal of Engineering and Applied Sciences 11 (6): 1349-1354, 2016
ISSN: 1816-949X

Improving the Survival Rate of Land Hermit Crabs Through Shell Ecology

[1]Rory Anthony Hutagalung, [1]Yosef and [2]Sylvain Mastrorillo
[1]Faculty of Biotechnology, Atma Jaya Catholic University of Indonesia, 12930 Jakarta, Indonesia
[2]Universite de Toulouse, Ecolab (UMR-CNRS 5245), Toulouse, France

Abstract: In addition to its success in evolving to live on land, Coenobita is a unique and interesting pet as it has no complete exoskeletons and uses gastropod shells to protect itself. However, the artificial shell is at the same time an obstacle as the crab has to adapt to the shell, especially in terms of osmoregulation. The aim of this study was to investigate how to improve the survival rate of hermit crabs (*Coenobita* sp.) in captivity through the ecological approach related to the artificial shell. The ability of the crabs to change the shell and their survival rate were analyzed by comparing natural shell change and human triggered shell change of *C. rugosus* and *C. perlatus*. Osmoregulation was analyzed through water consumption (fresh and salt) and the osmoregulator was used to separate the healthy hermit crabs from the weak ones. *C. rugosus* had a better ability to change its shell and had a higher survival rate than *C. perlatus*. In terms of water consumption, *C. perlatus* consumed more water than *C. rugosus* did, especially when the salt water was available. Selector osmosis successfully separated strong hermit crabs from the weak ones as shown by their survival rate. Indeed, the survival rate was correlated with the separated groups and was not related to species or media.

Key words: Land hermit crabs, water consumption, osmoregulation, shell replacement, survival rate

INTRODUCTION

Land hermit crabs (*Coenobita* sp.) are one of potential fishery products which can be traded as an exotic commodity, especially for export. The maintenance of land hermit crabs is very simple, due to their success to evolve from ocean ecosystems to terrestrial ecosystems. Furthermore, the relatively small size of land hermit crabs (8 cm maximum length) also contributes to the ease of maintenance of the animals in the house as pets (Burggren and McMahon, 1988).

In addition to color, shape or function, uniqueness is one of the conditions of animals or organisms to be regarded as pets. *Coenobita* sp. is a unique animal because it has no complete exoskeletons and uses gastropod shells as protection especially to protect its abdomen. Therefore hermit crabs have to change their shells to a larger one as their new home (Denny and Gaines, 2007). The growth, survival and fertility of land hermit crabs are affected by the size of the shell.

Indonesia has great potential to be the producer of the animals as they are abundant in nature, especially for *C. perlatus* whose distribution is limited because it is only found in Nias Island, Indonesia and in a small number of other countries. Despite its potential, the volume of trade of the species from Indonesia is relatively small compared to other exotic commodities because of high mortality of the animals in captivity (artificial habitat). *Coenobita* sp., particularly *C. perlatus* and *C. rugosus* are among the species that are very sensitive and often experienced sudden death in artificial habitat. The death of several individual crabs will trigger the death of others in a short time resulted in mass death. Mass death in the artificial habitat is allegedly linked to the ecological needs of hermit crabs. As mentioned previously, the special need is related to the artificial shell. Naturally, *Coenobita* sp., particularly *C. perlatus*, lives in coastal areas and frequently returns to the sea. The visit to the sea is related to the osmosis needs (osmoregulation). For this reason, osmoregulation ability is one of the factors that determine the survival of the hermit crabs.

In terms of business, especially for export, documents, freight and other transport expenses are the biggest cost and sometimes are higher than the price of the commodity itself. This explains why the selection of good quality products is important in order to ensure that the exported animals survive the destination. The relation of hermit crabs to their

Corresponding Author: Rory Anthony Hutagalung, Faculty of Biotechnology, Atma Jaya Catholic University of Indonesia, 12930 Jakarta, Indonesia

artificial shell, especially related to osmoregulation has great potential to be used for selecting healthier and stronger hermit crabs from weaker hermit crabs. Thus, the mass deaths can be prevented as early as possible and the hermit crabs shipped for export can be ascertained that they are the healthy and strong individual crabs.

According to the problems and the solutions offered, the aim of this study was to analyze the specific needs of *Coenobita* sp., related to the artificial shell particularly the aspects of osmoregulation and the approach to utilize it to improve the survival rate of hermit crabs through osmosis selectivity.

MATERIALS AND METHODS

The main material used in this study was the strawberry hermit crabs (*C. perlatus*) originating from Nias Island, North Sumatra and *C. rugosus* from Bengkulu, Sumatra. While the main instrument used was a horizontal selector osmosis and vertical selector osmosis (Fig. 1). Horizontal selector osmosis consists of horizontal rectangular baskets dipped into a tub of water so that the half of the basket is submerged while the vertical osmosis selector consists of spherical aquarium measuring 20.5 lt (20 cm of diameter and 65 cm high). The selector equipped by 24 climbing poles consisting of aluminum coated rugged silicone.

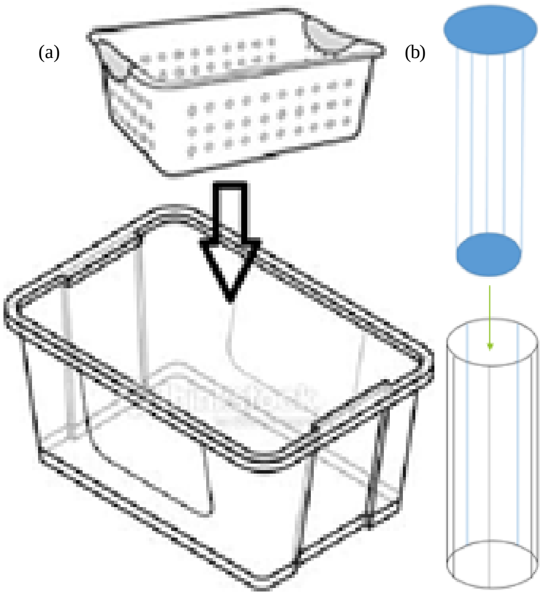

Fig. 1: Horizontal: a) and vertical and b) selector osmosis

Experimental design: The study was divided into 4 steps, namely total weight and body weight relationship, research on the shell replacement, water consumption and the selection of healthy hermit crabs. For the 3 last experiments, factorial design was applied.

Length weight relationship: In order to determine the body weight (without shell), the standard curve was defined for each species (*C. rugosus* and perlatus). Some 500 *C. rugosus* and 350 *C. perlatus* were selected to obtain the individual total weight (hermit crabs including the shell) and the body weight (hermit crabs without shell). The total individual weight was measured by weighting the hermit crabs together with the shell. Afterwards, the body weight was obtained by weighting the hermit crabs without shell. For this purpose the original shell of the hermit crabs was broken first using a vise.

Shell replacement: A 2×2 factorial designs was applied. The first treatment was type of species, composed by two factors (*C. perlatus* and *C. rugosus*) and the second treatment was shell replacement which also consists of two factors, namely natural and artificial. The natural shell replacement was the replacement by letting the hermit crabs replaces its shell while the artificial shell replacement was conducted by crushing the original shell and changed it to a new and bigger shell.

Water consumption: A 2×3 factorial design was applied. The first treatment was the species, consisted of two factors (*C. perlatus* and *C. rugosus*) and the second treatment was water type, i.e., fresh water, salt water and the combination of fresh and salt water. The variable measured was the water consumption per day per g (C) obtained by:

$$C=\frac{V_{-1}-V_0-E}{W\times D}$$

Where:

V_{-1} = Water volume in the previous day
V_0 = Water volume on theactual day of the experiment
E = Evaporation water (control)
D = number of the day from the previous day to the actual day of the experiment

Osmotic selection: The experiment consisted of 2 steps, namely horizontal osmotic selection and vertical osmotic selection. Horizontal osmotic selection was conducted by using 2×2 factorial designs with 4 replications. The first

Fig. 2: Oversized coenobita

Fig. 3: Vise used in the experiment

treatment was species types, namely *C. perlatus* and *C. rugosus* while the second treatment was media, i.e., fresh water and salt water.

The vertical osmotic selection was conducted by factorial experiment 2×5. The first factor is species types and the second factor was the water depth. The water depth was divided into 5 levels, i.e., 20, 30, 40, 50 and 60 cm. Each experiment was repeated for 4 times.

Execution of the experiment

Substitution shell: Hermit crabs used in the experiments were the oversized animals which were expected to replace their shells (Fig. 2). The oversized animals were divided into two groups (i.e., natural shell replacement and artificial shell replacement). Each group was then divided into 4 containers (replication) containing 50 *C. rugosus* per container or 30 *C. perlatus* per container. We had then 2 types of species (*C. rugosus* and *C. perlatus*) x 2 groups of replacement (natural and artificial), x 4 replications. For the natural shell replacement treatment, 50 bigger artificial shells for *C. rugosus* and 30 bigger artificial shells for *C. perlatus* were put on each container.

For the artificial shell replacement treatment, the original shell was replaced by breaking it using a vise (Fig. 3). Hermit crabs were removed from the broken shells with a stick by tickling their abdomens until they came out of their shells. The hermit crabs that were already out of their shells were placed in a container containing several suitable artificial shells (larger than the original shells). The bare hermit crabs were herded to enter a new shell. They were then kept in a container measuring 30×60×40 cm^3. The percentage of the replacement was counted until the 7th day. The survival rate of all experiment units was count daily during 30 days.

Water consumption: A 2×3 factorial design was applied. The first treatment was the species, consisted of two factors (*C. perlatus* and *C. rugosus*) and the second treatment was water type, i.e., fresh water, salt water and the combination of fresh and salt water. The variable measured was the water consumption per day per g (C) obtained by the following equation:

$$C = \frac{W_{-1} - W_0 - E}{Wb \times D}$$

Where:

W_{-1} = Water weight at the previous day (cc)
W_0 = Water weight at the day (g)
E = Evaporation water (g) (control)
D = Number of the day from the previous day to the actual day (day)
Wb = Weight of the hermit crabs (g)

Selection of hermit crabs through osmotic pressure approach: The experiment consist of 2 steps, namely horizontal osmotic selection and vertical osmotic selection. Horizontal osmotic selection was conducted by using 2×2 factorial design with 4 replication. The first treatment dealt with species types, namely *C. perlatus* and *C. rugosus* while the second treatment dealt with media, i.e., fresh water and salt water. The variables measured were the survival rate of hermit crabs until the 7th day after selection.

The vertical osmotic selection was conducted by factorial experiment 2×5. The first factor is species types and the second factor was the water depth. The water depth was distinguished into 5 levels, i.e., 20, 30, 40, 50 and 60 cm. Each experiment was repeated for 4 times.

RESULTS

Length weight relationship: The regressions between total weight and body weight for *C. rugosus* was

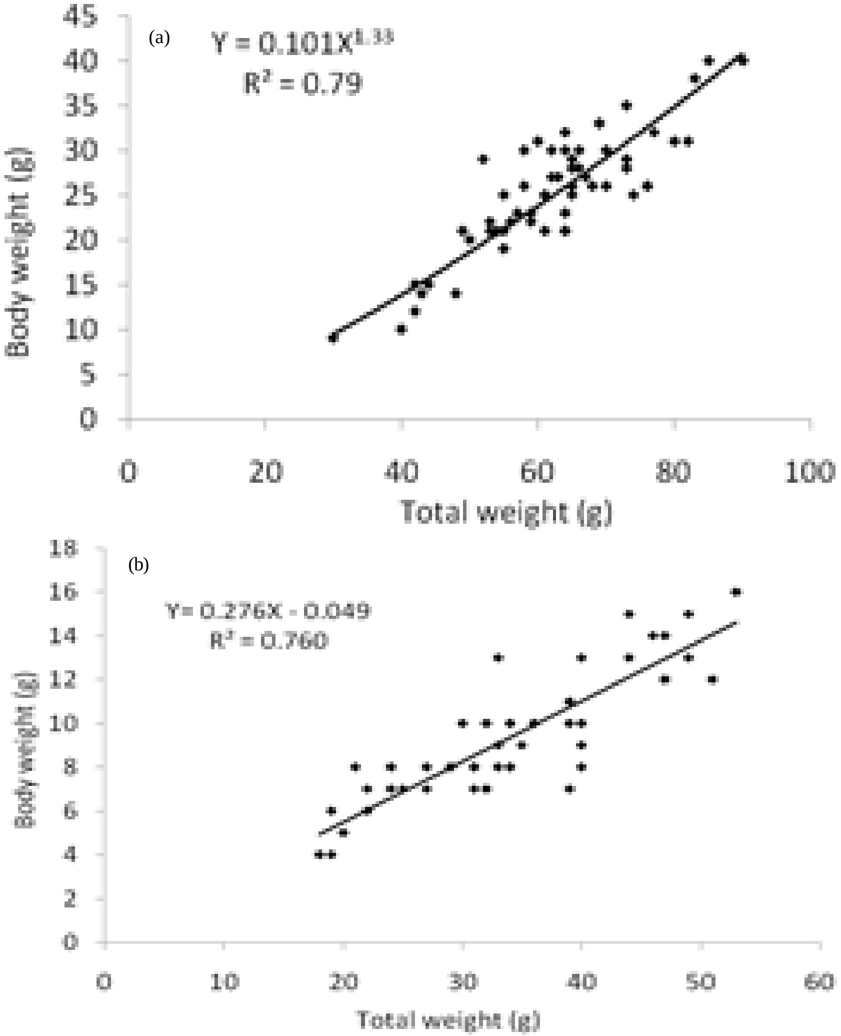

Fig. 4: Total weight (X) and body weight (Y) of *C. rugosus*: a) and b) of *C. perlatus*

Table 1: Number of shell replacement (of natural shell) and survival rate of hermit crabs according to species and shell treatment

Species	Shell	Shell replacement (%)	Survival rate (%)
C. rugosus	Natural	20.3±6.6	99±7.300
	artificial		95±12.20
C. perlatus	Natural	15.5±5.6	90.2±5.7
	artificial		98±13.50

$B = 1.01T^{1.33}$, ($R^2 = 0.76$). For *C. perlatus* it was $B = 0.276T-0.04$ g ($R^2 = 0.79$) (Fig. 4).

Shell replacement: For natural shell replacement, although not significantly different ($p > 0.05$), the number of natural shell replacement on *C. rugosus* was higher than *C. perlatus* (Table 1). About 20% of *C. rugosus* succeded to replace its own shell automatically and only 15% of *C. perlatus* did. In terms of survival rate, there was no any significant difference ($p = 0.50$) between the two species. However, *C. rugosus* could survive whether the shell was changed naturally or artificially. While for *C. perlatus*, some (10%) of the animal died when the shell was not changed artificially (Table 1).

Water consumption: Although, it wasn't significantly different ($p = 0.383$) *C. perlatus* consumed more water than *C. rugosus* (Fig. 5). Both species significantly consumed more sea water than fresh water ($p = 0.005$).

Osmosis selection: Using the horizontal osmosis selection, salt water media was more selective, either to *C. rugosus* or to *C. perlatus*. Only 14.5% of *C. rugosus* managed to handle osmotic pressure and came out of the water, compared to 85.5% of the sinking ones (Table 2).

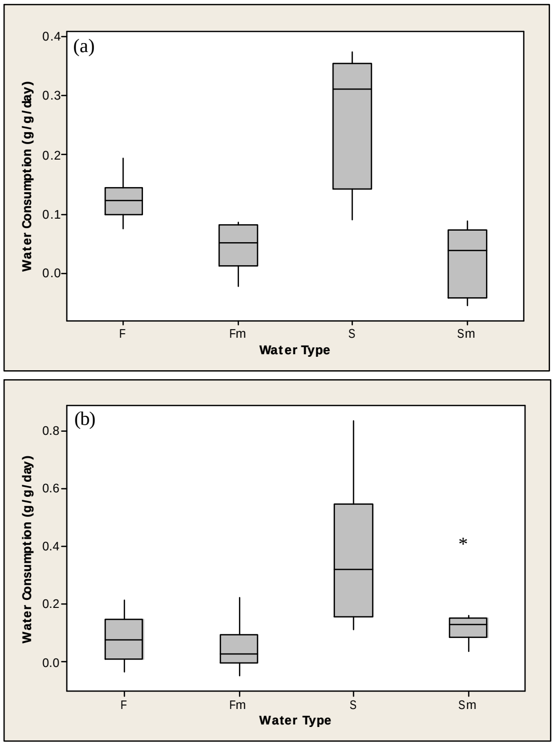

Fig. 5: Water consumption of *C. rugoses*: a) *C. perlatus* and b) (F: fresh water; Salt water on mixed treatment)

For *C. perlatus* the percentage was even smaller. Only 9.2% of the crabs manage to climb and the 90.8% others stay at the bottom. Using fresh water as selective medium 35.4 % for *C. rugosus* and 30.9% for *C. perlatus* were able to climb. As a whole only 22.5% of the hermit crabs climbed and the 77.5% of the rest could not manage to come out of the water (Table 3).

The experiment were continued with vertical osmosis selector to find out the effect of water depth on selectivity between strong and weak hermit crab. For *C. rugosus* depth of water affected the percentage of climbing hermit crabs. Deeper water has fewer climber. On the contrary, for *C. perlatus*, the depth of water did not affect the capability of hermit crabs to climb. The percentage was stable at about 40%. Regardless the water depth, the percentage of the climbing *C. perlatus* was higher than *C. rugosus* (35% compared to 25%). There were no any differences in survival rate (7 day after the selection) according to the species nor to the types of water used for osmosis selection. But the survival rate was highly related to the group of the hermit crabs after the selection, where the survival rate of the climbing hermit crabs was significantly higher ($p = 0.002$) than the sinking one (95.0% compared to 79.4%) (Tabel 3).

Table 2: Percentage of sinking and climbing hermit crabs and survival rate using horizontal osmotic selector

		Percentage		Survival rate after 7 days	
Species	Treatment	Sinking	Climbing	Sink (%)	Climb (%)
C. perlatus	Fresh w.	69.2	30.9	73.2	91.0
	Sea w.	90.8	9.2	85.1	97.1
	Average	80	20.05	79.15	94.1
C. rugosus	Fresh w.	64.6	35.4	69.6	93.1
	Sea w.	85.5	14.5	89.8	98.6
	Average	75.05	24.95	79.7	95.9
Average (general)		77.5	22.5	79.4	95

Tabel 3: Percentage of sinking and climbing hermit crabs and the survival rate using vertical osmotic selector

		Percentage		Survival rate after 7 days	
Species	Depth	Sinking	Climbing	Sinking (%)	Climbing(%)
C. rugosus	20	63.0	37.0	74.5	98.0
	30	69.4	30.6	82.7	94.3
	40	74.8	25.2	85.1	94.2
	50	81.3	18.7	78.4	96.1
	60	86.8	13.2	77.8	96.7
	Mean	75.1	24.9	79.7	95.9
C. perlatus	20	49.0	41.0	74.6	96.8
	30	49.4	49.2	87.1	91.3
	40	50.4	48.4	82.2	92.2
	50	49.1	44.4	73.4	93.3
	60	53.7	46.6	78.4	96.7
	Mean	50.3	45.9	79.1	94.1
Mean (general)	62.7	35.4	79.4	95.0	

DISCUSSION

From regression equation, we can define the body weight of hermit crabs through the total weight. Both species showed different regression equations. For *C. rugosus* the regression was linear ($B = 0.276T-0.04$ g) while for *C. perlatus* it followed a power regression ($B = 1\text{-}101X^{1.33}$). The different on type of regression can be attributed to different in sample weight being used. The one of *C. rugosus* was relatively smaller (18-53g with an average of 34.54 g) while the one of *C. perlatus* was bigger (30-90 g with an average of 62.22 g). The sample of the first species consisted only the young animal which was probably in the lag phase. While the second species included the adults whose growth has entered the log phase. From statistical perspective, data which more aligned with scatter plot is considered as linear model and data which more aligned with log-log plot is considered a power model (Chow and Liu, 1992).

The ability of *C. rugosus* to change the shell naturally was higher than *C. perlatus* and had higher survival rate. For *C. perlatus* when the shell of the oversized crabs was not changed artificially, some of them (around 10%) died. The mortality could be attributed to stress due to narrow space of the shell. Sometimes, stressed hermit crabs may hide in their shell by lowering their activity (Pavia, 2006). The shell artificial change is then advised for the oversized *C. perlatus* to avoid any mortality due to narrow space of the shell.

For water consumption, high sea water consumption on hermit crabs, especially *C. perlatus*, can be explained by its habitat. It lives in coastal areas where sea water is more readily available than fresh water. Even for the inland hermit crabs (such as *C. rugosus*) which lives far from coastal area, the availability of brackish water is more important than pure fresh water. Inland hermit crabs tend to live far from area with high fresh water concentration. It is because salt has function in active water transport. Hermit crabs is interested in fresh water in an arid area where the water is limited (Wilde, 2013). Moreover in its natural habitat, *C. perlatus* keeps the sea water inside the shell in order to maintain osmotic pressure, because sea water contains an osmotic concentration similar to its blood, thus preventing dehydration during evaporation (Greenaway, 2003) and to be sluggish (Pavia, 2006).

For osmotic selection, salt water was more selective than fresh water either for *C. rugosus* or *C. perlatus* and the osmotic selector could clearly separate the healthy crabs from the weak ones. Osmotic pressure provoked by the water might trigger the crabs to come out of water. The strong or healthy crabs could manage to come out while the weak ones sank. The stress crabs tend to have lower activity (Pavia, 2006). The osmotic pressure in the hermit crabs body change according to water osmotic concentration in the shell. When the water osmotic pressure on the shell is lower the osmotic concentration on the body is hypertonic and vise versa. In normal condition osmotic pressure on the blood is a little bit more hypertonic than the shell water (Wilde, 2013). In this experiment, the salinity of salt water used was 30 per mil which probably could provoke high osmotic pressure that separated the strong or healthy crabs from the weak one, better than fresh water.

For the vertical osmotic selection, the deeper the water the less the climbing crabs for *C. rugosus* but for *C. perlatus*, the water depth did not affect the percentage of the climbing crabs. This might due to the size of the sample used. The sample of *C. perlatus* used was much bigger than *C. rugosus*. The bigger is the animal the stronger the ability to manage the stress (Wellock *et al*., 2006). That might be also related to the ability of *C. perlatus* to adapt to salt water condition. After all, the osmotic selector had successfully separated the strong ones from the weak ones, proven by much higher survival rate. It is then recommended to use the osmotic selector to choose the healthy individual before export.

CONCLUSION

The total weight-body weight relationship can be used to estimate the body weight (B) of hermit crabs through the total weight (CT). For *C. rugosus* the regression equation was $B = 0.276T-0.04$ g ($R^2 = 0.7585$) and for *C. perlatus* it was $B = 1.01T^{1.33}$ ($R^2 = 0.79$). In captivity, *C. rugosus* could change its shell easier than *C. perlatus* and the oversized hermit crabs could die when the shell was not changed artificially. Both species consumed more sea water than fresh water, especially *C. perlatus*. This species consumed 0.316±0.057 g g^{-1} body weight/day of sea water and consumed only 0.102±0.197 g g^{-1} body weight/day of fresh water. The osmotic selector was able to separate the strong hermit crabs from the weak one and in term of media, sea water was more selective than fresh water for both species. The survival rate of strong hermits crabs was significantly higher than the weak one (95% compared to 79.4% for both species).

REFERENCES

Burggren, W.W. and B.R. McMahon, 1988. Biology of the Land Crabs. Cambridge University Press, Cambridge, England, pp: 479.

Chow, C.S. and J.P. Liu, 1992. Design and Analysis of Bioavailability and Bioequivalence Studies. Marcel Dekker, New York.

Denny, M.W. and S.D. Gaines, 2007. Encyclopedia of Tidepools and Rocky Shores. University of California, Los Angeles,.

Greenaway, P., 2003. Terrestrial adaptations in the anomura (Crustacea: Decapoda). Mem. Mus. Victoria, 60: 13-26.

Pavia, A., 2006. Hermit Crab: Your Happy Healthy Pet. Wiley-Blackwell, Hoboken, New Jersey,.

Wellock, I.J., G.C. Emmans, I. Kyriazakis, E. Kebreab and J. Dijkstra *et al*., 2006. Modelling the effects of environmental stressors on the performance of growing Pigs: from individuals to populations. Nutr. Digestion Util. Farm Anim. Modell. Approaches, 1: 229-239.

Wilde, E., 2013. On the Ecology of Coenobitaclypeatus in Curacao: With Reference to Reproduction, Water Economy and Osmoregulation in Terrestrial Hermit Crabs. Springer, Dordrecht, Pages: 136.