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Improving the survival rate of land hermit crabs (*Coenobita rugosus*) through artificial habitat design

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Improving the survival rate of land hermit crabs (*Coenobita rugosus*) through artificial habitat design

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Abstract. *Coenobita rugosus* is one of the most popular hermit crab species traded as pets due to its attractive colors, easy maintenance, and especially by its uniqueness in using others' shells as their home. The aims of this experiment were to improve survival rate of hermit crabs by providing their ecological needs in artificial habitat and to observe their behaviour in the designed artificial habitat. The experiment was conducted by designing five types of terrarium i.e. empty terrarium as negative control (T_C); terrarium with separating system (T_1); terrarium with separating system, hiding, and climbing space (T_2); terrarium with separating system and burrowing space (T_3); and complete terrarium with separating system and all spaces mentioned (T_4). The best survival and growth rate were shown by T_4 followed by T_2 terrarium. T_2 and T_4 survival rate were significantly greater ($p < 0.05$) from the three other treatments. Despite the low survival rate, terrariums with separating systems could maintain the survival rate of land hermit crab in the first 6 weeks of the experiment compared to control terrariums. This proved that a separating system holds an important role in keeping terrarium's cleanliness thus decrease the mortality.

Keywords: behaviour, cage design, *Coenobita rugosus*, growth rate, survival rate

1. Introduction

Land hermit crabs (*Coenobita* sp.) is part of *Coenobitidae* family which succeeds to live in a terrestrial habitat. It can be recognized by a pair of *chela*, two pairs of visible walking limbs, and especially by its uniqueness in using other animal's shell to protect its soft abdomen. Futhermore, land hermit crab have many color variations such as purple, blue, red, pink, orange, black, white, grey, and brown [1]. This uniqueness lead the land hermit crab to become a valuable selling commodity as a pet kept in an artificial habitat called a terrarium. One of the problems in keeping land hermit crab in artificial habitats is the mortality rate which is very high. The cause of this mass death might be due to the lack of ecological needs in the artificial habitat, especially in terms of habitat heterogeneity. To this day, researches about hermit crabs are still limited to feeding method [2] and its osmoregulation [3].

Keeping land hermit crab in an artificial habitat needs compensation, such as imitating its natural habitat. Land hermit crabs needs burrowing space, climbing space, and hiding space. Burrowing space is needed to hide the land hermit crab from heat and to protect itself when it is molting [4]. Climbing space is also needed to search for food and rest. Hiding space is needed to avoid heat as well and protect itself from any other potential danger [5,6]. Aside from these three components, a separating system is needed inside a hermit crab's artificial habitat to separate hermit crabs from their feces and food crumbs. In an environment without a separating system, direct contact between feces and organism is inevitable and might lead to another problem. This research was aimed to increase survival rates of land hermit crabs, especially the rugosus hermit crab (*Coenobita rugosus*) through artificial habitat design.

2. Materials and Methods

2.1. Materials and tools

Materials used for this experiment were 3000 small land hermit crabs (*C. rugosus*) (± 5-7 grams per individual); 45 mangrove root stalks (± 30 cm long); 15 empty tubs of 52 cm x 32.5 cm x 30 cm in dimension; 30 water pallets (200 mL in volume); sieve wire (1 cm x 1 cm in diametres); freshwater; saltwater; and sand. Tools used in this experiment was a sprayer for keeping humidity in terrarium.

This research was conducted on November 2017 to June 2018 at Gang Delima V Street, No. 8, South Tanjung Duren. This research was divided into 3 major steps ie. terrarium preparation, experiment process, and data collection-analysis.

2.2. Terrarium preparation

A complete randomized design with five treatments and six repetitions was applied. The first treatment was negative control (T_C) ie. bare terrarium (without any additional habitat). The second was a terrarium with sieve wire as a pedestal/separating system (T_1) (figure 1). The third (T_2) was the same as T_1 plus mangrove roots serve as hiding and climbing space (figure 2).

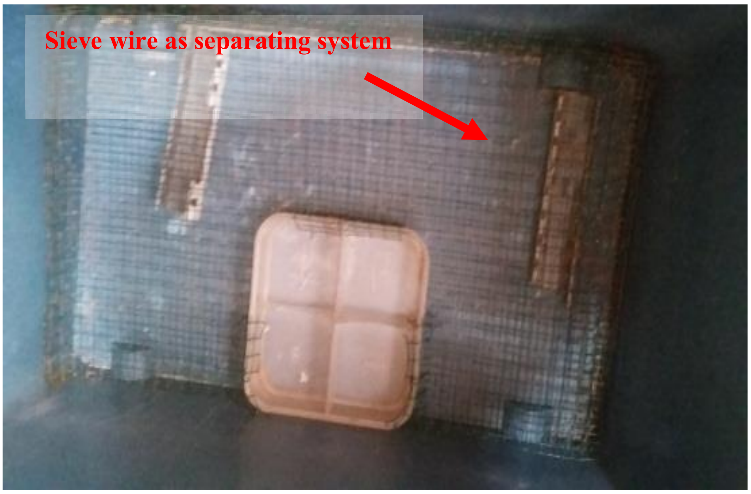

Figure 1. T_1 terrarium design.

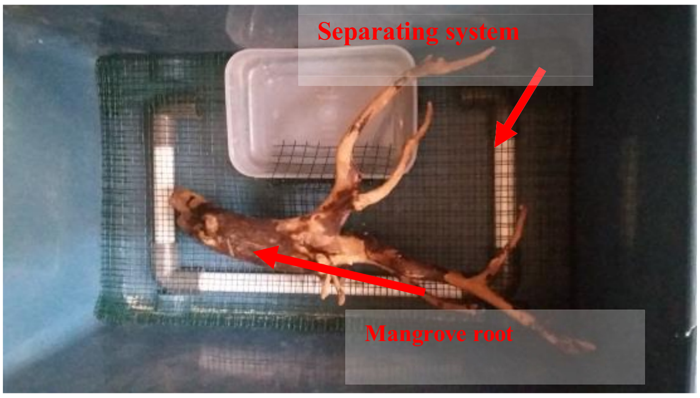

Figure 2. T_2 terrarium design.

The fourth design (T_3) was the same as T_1, added with sand serve as substrate for burrowing space (figure 3).

Figure 3. T_3 terrarium design.

The last design (T_4) was a terrarium with sieve wire pedestal added with mangrove roots and sand (figure 4).

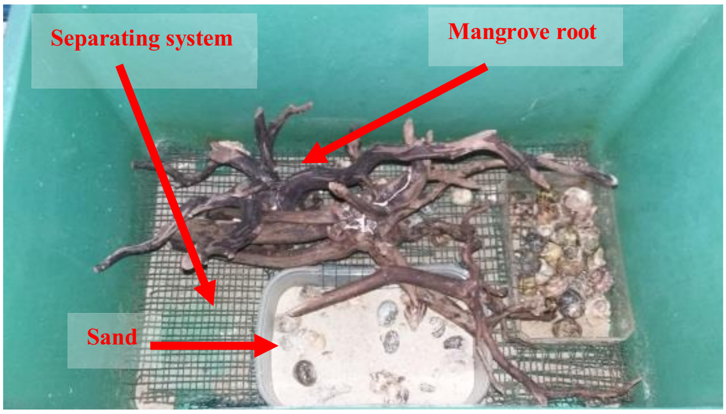

Figure 4. T_4 terrarium design.

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Each terrarium was filled by 100 land hermit crabs (*C. rugosus*) and kept for 4 months. The land hermit crabs (*C. rugosus*) originated from Nias Island, Indian Ocean. All terrariums were sprayed daily with water every morning and evening to maintain its humidity and fed with apple, jicama, and corn according to [2].

2.3. Data collection-analysis
The variables measured were survival and growth rate. The survival rate was measured by counting the number of land hermit crabs that survived and was summarized every two weeks. The growth rate was measured every two weeks by calculating the average weight of 15 representative of *C. rugosus* of every terrarium. *C. rugosus* behaviour was also observed once a week at noon and night. One way ANOVA analysis was done for analyzing difference of survival rate and growth rate. Univariate test was calculated for analyzing difference of behaviour and correlation between time and behaviour.

3. Results and Discussion

3.1. Result
For survival rate, terrarium with hiding, climbing, and burrying space (T_4) showed the best result (21.50% ± 0.05) followed by terrarium with separating system, hiding, and climbing space (T_2) (17.67% ± 0.02). These results were significantly ($p < 0.05$) greater compared to terrariums without hiding and climbing space i.e. T_C, T_1 , and T_3 from the 6th week until 14th week of the experiment (figure 5).

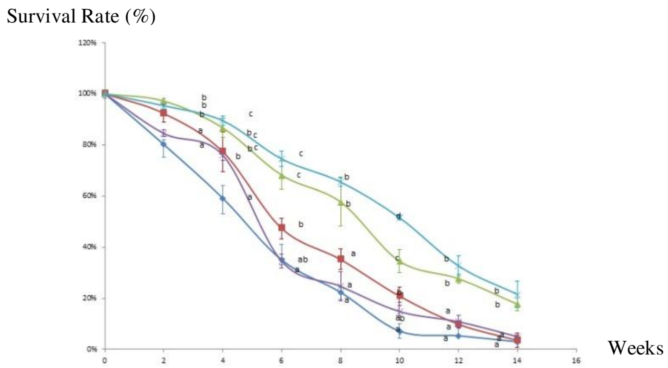

Figure 5. Land hermit crab (*C. rugosus*) survival rate (■:T_C, ■: T_1, ■: T_2, ■:T_3, ■ :T_4).

For growth rate, all treatments performed positive growth, except for negative control where *C. rugosus* weight declined. However, the difference growth rate among the treatments was not significant ($p > 0.05$).

In terms of behavior, the majority of *C. rugosus* preferred gathering around freshwater supply to saltwater supply. By gathering near freshwater supply, *C. rugosus* was presumptively filling their shell water with fresh water. This observation was also supported by previous study that *C. rugosus* preferred freshwater to saltwater [6].

There was no significant behaviour difference during day and night. *C. rugosus* tend to show the same behaviour during both times. Thus, there was no correlation between observation time and behaviour. *C. rugosus* preferred hiding below mangrove roots (figure 6) to climbing or burrowing in the sand.

Figure 6. *C. rugosus* hiding below mangrove roots.

Hiding *C. rugosus* (83.00% ± 0.03) at day and (80.80% ± 0.03) at night were significantly ($p < 0.05$) greater than the other behaviors. Following hiding, as the most favorite behavior, was burrowing behavior. Climbing was the least favorite choice for *C. rugosus* in the artificial habitats which significantly differed from free (figure 7). Free *C.rugosus* might be caused by insufficient burrowing, climbing, or hiding space instead of walking free willingly. This assumption needs to be confirmed in further study.

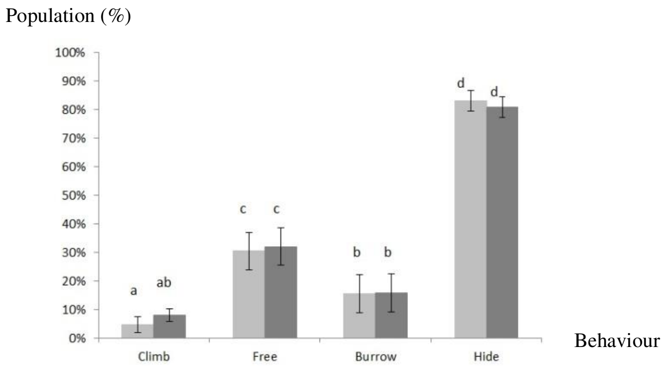

Figure 7. *C. rugosus* behaviour (■ : day, ■ : night).

3.2. Discussion

Control terrarium (T_C) and terrarium with separating system (T_1) had low survival rate compared to other treatments. However, T_1 successfully maintained *C. rugosus* population for 6 weeks of experiment while T_C declined since the beginning of the experiment. The difference between these two treatments were related to cleanliness where the feces and food crumbs were clearly separated from the organism by the separation system (sieve wire) (figure 8).

Figure 8. Feces separated from *C. rugosus* by sieve wire.

On the contrary, T_C terrarium let *C. rugosus* live along with its feces and food crumbs thus causing high mortality. This condition was worsen by the absence of their ecological needs (figure 9).

Figure 9. Direct contact between feces and *C. rugosus.*

This proved that separating system role in keeping terrarium's cleanliness was important. Direct and prolong contact between organism (land hermit crab) and its feces and food crumbs may lead to dangerous pathogenic agents infecting the organism [7]. However, a massive population decrease in T_1 was observed after the 4^{th} week. This may be caused by the increasing stress to *C. rugosus* by the absence of their other ecological needs i.e. burrowing space [8], climbing space [9], and hiding space [10].

A massive mortality in T_3 (terrarium with burrowing space) was observed on the 6^{th} week (figure 5). The carcasses were mostly found inside the sand. This mortality might be related to the disability of C. *rugosus* to climb out of the sand and consequently, the crabs were trapped inside. This disability may be caused by the sand type used in this experiment, soft sand from shore, whose particles may be too small for *C. rugosus* to climb on. This presumption needs to be investigated in further study. Spraying water into the terrarium may worsen the condition as the wet sand trap *C. rugosus* further. For this problem, solutions suggested were to change sand type for burrowing substrate and keep the sand area as dry as possible.

T_2 had the best survival rate followed by T_4 terrarium. These two treatments had two things in common i.e. climbing space and hiding place. According to the behaviour observation, most of the land hermit crabs preferred hiding below the mangrove roots to climbing and to burrowing. This may prove that *C. rugosus* main ecological needs in the artificial habitat were hiding (figure 6).

Along with survival rate, T_4 and T_2 treatments showed higher growth rate than other treatments. The presence of *C. rugosus*' hiding needs may cause less stress thus promoting growth rate. However, the difference was not significant. The non significant difference might be related to high variations. A bigger sample was needed to confirm the difference.

Concerning the behavior, *C. rugosus* tended to avoid to burrowing in the sand. This was supported by their behaviour data where free *C. rugosus* was significantly greater than burrowing *C. rugosus* (figure 7). Free *C. rugosus* tended to gather around the water supply. This behavior might be related to *C. rugosus*' need to keep their abdomen humidity [8] (figure 10). Further study is needed to confirm this presumption.

Figure 10. Free *C. rugosus* gather around water supply.

Burrowing *C. rugosus* may be suitable for those who were ready to molt. Land hermit crabs needed a substrate, such as sand, to burrow when they were molting [4]. Another use of sand was to keep osmotic pressure in land hermit crabs. However, this use could be ignored because of routine water spray to the terrarium. Thus, the cause of burrowing *C. rugosus* was molting which unfortunately was not successful. Most of the molting *C. rugosus* were found inside the sand. Those who avoided the sand may not ready to molt. This presumption needs further study.

The preference of gathering around fresh water compared to salt water might be related to the nature of *C. rugosus*. *Coenobita* spp. is known to be one of the crustacean successfully evolve to terrestrial life and *C. rugosus* is the one which is able to advance far enough from sea to vicinity [9].

4. Conclusion

A separating system (sieve wire) facilitated a clean environment for *C. rugosus*, thus promoting health. However, a separating system alone was not enough as there was ecological needs to fulfill. From four ecological needs, the main requirement for *C. rugosus* was hiding space which could be facilitated by mangrove roots. This was supported from behavior observation where hiding below the mangrove roots was the most favorite behavior. Having their main ecological need fulfilled, terrariums with mangrove roots also performed the best survival rate significantly ($p < 0.05$). Growth rate in these terrariums were also the highest although statistically was not significant from other treatments. Sieve wire and mangrove roots had an important role for *C.rugosus* in captivity. These two elements were needed in order to increase their survival rate and facilitate their freedom to express their behavior.

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