The improvement of survival rate of land hermit crabs *Coenobita* (Malacostraca: Coenobitidae) in artificial habitat through multispecies and niche heterogeneity approach

R A Hutagalung*, R Adrian and D Prasasty

Faculty of Biotechnology, Atma Jaya Catholic University, Jakarta, Indonesia

*E-mail: antoine455@gmail.com

Abstract. Land hermit crabs are invertebrates having a unique shell and attractive behavior. In their natural habitat, they live in a group with different species. Meanwhile in an artificial habitat, they are usually maintained solitary, even solitary that the necessities of social life are not fulfilled. This research was aimed to improve the survival rate of three species of hermit crabs (multispecies) through niche heterogeneity and to analyze their behaviors in an artificial habitat. Two treatments were evaluated including species types (multispecies combination) and habitat types (sand, hiding place, branch, open area). *Coenobita perlatus* preferred to climb and roam, especially at night, whereas *C. brevimanus* tend to burrow or hide while *C. violacens* preferred to hide. The highest survival rate was observed for *C. brevimanus* (91.66±0.143%) coexisted with two other species. *C. perlatus* showed the highest survival rate when they were mixed with *C. brevimanus* (83.61%±0.149). However, the survival was low when they were mixed with *C. violacens*. This result proved that hermit crabs need to coexist, but with the right species. The coexistence is possible by partitioning the resources.

Keywords: land hermit crab, multispecies, niche, resources partitioning

1. Introduction

Land hermit crabs have the potential to be kept as pets by their simple maintenance, their small size, and especially because of their uniqueness. The uniqueness of land crabs resides on their shell. They need to use another shell to protect themselves, especially for their abdomen. Hermit crabs change their shell as they grow (Wilkins 2011). The main problem of maintaining land hermit crab in an artificial habitat is their mortality. One of the causes is the lack of social need because they are often kept solitary in order to reduce the competition. The different behavior of different species cause competition on the availability of niche and inhibit cohabitation in artificial habitat (Abrams 1980, Busanto et al 1998). In nature, hermit crabs usually live in a group with other species (multispecies). The cohabitation is possible by the presence of different niches. The availability of different niches in an artificial habitat might facilitate the cohabitation.

The availability of these niches could be improved by imitating the ecological needs of hermit crabs in their natural habitats (Abdullah 2017). In the natural habitat, the niches are provided by sand for
burrowing, holes for hiding, and roots or branches for climbing. Moreover, hermit crabs health needs to be maintained by separating them from specks of dirt, such as food and metabolic waste (feces and urine) (Koswara 2018). Environmental variations (niches) and cage cleanliness allow several species to live together. Therefore, multispecies hermit crabs can coexist through resource partitioning patterns. This research was aimed to improve the survival rate of various species of hermit crabs through niche heterogeneity and to analyze their behavior in an artificial habitat.

2. Materials and methods

2.1. Materials

In this study, we used *Coenobita perlatus* (CP), *C. violacens* (CV) and *C. brevimanus* (CB). The samples were collected from Nias Islands (North Sumatra), Indonesia. The equipments used were 12 empty tubs of 52 cm x 32.5 cm x 30 cm, 24 water pallets (200 mL); sieve wire pedestal (1 cm x 1 cm in diameters); mangrove roots and sand set as complete terrarium (Hutagalung et al 2018). The tool used in this research was plant sprayer. This research was divided into three main steps, i.e., terrarium preparation, experiment design, and data collection analysis.

2.2. Methods

2.2.1. Terrarium preparation and experiment design. The experiment was to analyze the behavior and survival rate of each hermit crab species. A simple factorial design with two treatments was applied. The first treatment was based on species type (table 1). The behavior of CP was observed in treatment (T1-T4), while behavior of CV and CB were observed in treatment (T5-T8). The second treatment was based on habitat type, i.e., sand, hiding place, branch, open area. Each experiment was repeated three times. Each terrarium was filled by land hermit crabs (±5-10 g per individuals of each species) according to the treatments (table 1). The hermit crabs in the terrariums were kept and fed according to the method developed by Hutagalung et al (2017).

| Table 1. The number of each hermit crab species in each terrarium. |
|------------------|---|---|---|
| Treatment        | Species| CP | CV | CB |
| T1 (CP)          |      | 100|    |    |
| T2 (CP : CV)     |      | 30 | 75 |    |
| T3 (CP : CB)     |      | 30 | 75 |    |
| T4 (CP : CV : CB)|      | 30 | 50 | 50 |
| T5 (CV : CP)     |      | 30 | 75 |    |
| T6 (CB : CP)     |      | 30 | 75 |    |
| T7 (CV : CP : CB)|      | 30 | 50 | 50 |
| T8 (CB : CP : CV)|      | 30 | 50 | 50 |

2.2.2. Data Collection and Analysis

The variables measured in this research were the behavior and the survival rate. The behavior rate was observed by measuring the behaviours such as burrowing, hiding, climbing, and free of each species) for three days in a week at day and night. The survival rate was observed by measuring the mortality for each day. The mortality was then converted to the survival rate in units of percentage (%). The data were analyzed using a two-way factorial analysis of variance (ANOVA).

3. Results and discussion

All treatments showed different survival rate for the three species, i.e., *C. perlatus*, *C. violacens*, and *C. brevimanus* (figure 1). *C. perlatus* showed the highest survival rate when they were mixed with *C. brevimanus* (83.61±0.15%). The same result was observed for *C. brevimanus*, where the highest survival
rate occurred when they were mixed with other species ($C. \text{brevimanus} + C. \text{violescens} = 92.99 \pm 0.15\%$, $C. \text{brevimanus} + C. \text{perlatus} = 91.66 \pm 0.15\%$). Based on those results, we can conclude that $C. \text{perlatus}$ and $C. \text{brevimanus}$ are social organisms and need to live with others. The cohabitation in artificial habitats as in the natural habitats was possible by the availability of different niches allowing resource partitioning (Abdullah 2017). Therefore, although the niche of the species overlaps, they still can live together by compromising their ideal needs on niches. However, when $C. \text{perlatus}$ were mixed with $C. \text{violacens}$, the survival rate decreased ($78.61 \pm 0.15\%$). The survival rate of $C. \text{violacens}$ was also decreased when they were combined with $C. \text{brevimanus}$ ($76.39 \pm 0.15\%$). These two cases suggest competition between $C. \text{perlatus}$ and $C. \text{violacens}$ and between $C. \text{violacens}$ and $C. \text{brevimanus}$.

![Figure 1](image1.png)

**Figure 1.** Land hermit crab multispecies survival rate ($T_1$: *Coenobita perlatus*, $T_2$: *C. perlatus* & *C. violacens*, $T_3$: *C. perlatus* & *C. brevimanus*, $T_4$: *C. violacens* & *C. brevimanus*, $T_5$: *C. violacens* & *C. perlatus*, $T_6$: *C. brevimanus* & *C. perlatus*, $T_7$: *C. violacens*, *C. perlatus* & *C. brevimanus*, $T_8$: *C. brevimanus*, *C. perlatus* & *C. violacens*).

![Figure 2](image2.png)

**Figure 2.** Behavior tendencies by different species of hermit crab.

Based on our observation on the behaviours of *Coenobita* species (figure 2), it seemed that mangrove root and sand were the two most favorite niches. Mangrove root was used for hiding (42.8%), while sand was used for burrowing (30.9%) during their resting time (immobile), especially during the day time. The immobility at daytime was shown by the number of hiding ($47.87 \pm 2.87\%$) and burrowing ($33.08 \pm 2.9\%$) that were higher than during the night ($38.01 \pm 2.87\%$, $28.68 \pm 2.9\%$, respectively) (table 2). The dormant or burrowing activities might be done to minimize the moisture loss from their abdomens.
(Voscojoli 2007) and to protect themselves from predators (Weis 2012). On the other hand, most of the hermit crabs were active at night, showed by the number of roaming (22.12±2.96%) and climbing (11.2±1.56%) compared to the number of both activities during the day (10.17±1.15% and 8.85±1.4%, respectively). Our results corroborated Wilkins (2011) that hermit crabs are active at night looking for food to survive. Thus, hermit crabs are nocturnal animals.

Habitats influenced the behaviours of the hermit crabs (p<0.05) (table 3). *C. perlatus* has the highest percentage on climbing and roaming, especially when they were mixed with *C. brevimanus* (T1) or with two other species (T1). This behavior of *C. perlatus* might be related to the strategy of finding the space when the density is high due to the presence of other species. In this case, *C. perlatus* applied habitat segregation (Ruckstuhl and Neuhaus 2005) by using their climbing ability. Meanwhile, *C. violacens* has the highest percentage of hiding behavior (60.4±4.65%). *C. brevimanus* has the highest percentage on burrowing, especially when it was mixed with two other species (60.01±3.84%). This behavior showed that *C. violacens* and *C. brevimanus* are passive crabs. They tend to burrow or to hide all the time. Burrowing or hiding activities are useful for keeping their abdomens humid from high temperature at daytime (Voscojoli 2007).

### Table 2. Behavior tendencies by different species of hermit crabs based on time

| Time  | Hiding (%) | Burrowing (%) | Roaming (%) | Climbing (%) |
|-------|------------|---------------|-------------|--------------|
| Daytime | 47.87±2.87 | 33.08±2.9 | 10.17±1.15 | 8.85±1.4 |
| Night  | 38.01±2.87 | 28.68±2.9 | 22.12±2.96 | 11.2±1.56 |

The higher survival rate on multispecies proved that hermit crabs are social organisms, but need to coexist with the right species. The coexistence is possible by partitioning the resources. *C. perlatus* can coexist with *C. brevimanus*, but need to be facilitated with mangrove roots in artificial habitat. By providing mangrove roots, the survival rate of *C. perlatus* increased. In terms of behavior, *C. brevimanus* preferred to burrow or to hide, and the presence of other species stimulated *C. brevimanus* to be active. *C. perlatus* managed to avoid direct competition by applying resources partitioning.

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