# GASTROPOD SHELLS USED BY HERMIT CRABS ON BUNAKEN ISLAND, SULAWESI, INDONESIA

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## ABSTRACT

The hermit crab, *Coenobita rugosus* Edwards 1837, were found abundantly on the dry upper part of the shore. The crabs were collected at night by transect and quadrant (100 $m^2$) sampling with 6 replications at 3 locations. The gastropod shells collected consisted of 26 genera and 19 were used by the crabs. The selective index (E) was positive for four gastropods shells: *Nassarius, Cerithium, Turbo,* and *Morula* (E = 0.54, 0.43, 0.33, 0.27 respectively). Frequency of occurrence of gastropod shells occupied by hermit crab, excluding the empty ones, was *Nassarius* > *Cerithium* > *Morula* > *Melanella* > *Liotina* >*Turbo* > *Drupella* > *Nerita.* Carapace width was strongly correlated with the width of gastropod shell aperture (r = 0.8889), and also animal and shell weight (r=0.7353). Hermit crabs are able to carry a shell more than ten times of their own weight. Adults were entirely found in *Turbo* shells, while juveniles occupied *Melanella* and *Nassarius* shells. Medium sized crabs inhabited *Morula, Drupella, Liotina, Nerita,* and *Cerithium* shells.

## INTRODUCTION

Shell selection by hermit crabs has been treated by a number of workers, *e.g.*, Bertness (1980), Spight (1977), and Reese (1963). However, the results may differ for different beaches since shell selection depends on the hermit crab species and type of gastropod shells available. The upper beach zone of Bunaken Island is rich in gastropod shells, and almost entirely inhabited by coenobitid hermit crabs. They are well known for their adaptation to life in an acquired shelter, usually in empty gastropod shells (Morgan 1990). Hermit crab behavior of entering and living in empty gastropod shells is first expressed by the coenobitid crabs at the post larval stage. The requirement of shell reflects adaptation to avoid desiccation, predation and reduce vulnerability during their life cycle (Reese 1968). Vance (1972) stated that predation is one force making shell use by hermit crabs necessary and probably plays an important role in the evolution of shell preference. Provenzano (1960) suggested that availability of shells may be a limiting factor for some species of hermit crabs. Reese (1968) reported that if there are no empty gastropod shells available, the young coconut crab, *Birgus latro* (Linnaeus, 1767) (Coenobitidae) will eventually die. According to Reese (1987), there are two major reasons why semiterrestrial marine crustaceans are tied to the sea: (1) release of fertilized eggs into the sea where they pass through the typical crustacean larval stages in the plankton, and (2) since their blood is isosmotic with sea water the animals must periodically have access to sea water to maintain this condition.

The aim of the present study was to investigate the biological importance of empty gastropod shells available on the beaches of Bunaken National Marine Park. I wanted to study if the hermit crabs select a specific type of gastropod shell, and if there is a relationship between shell shape and crab size.

## MATERIALS AND METHODS

Samples were collected at three stations on Bunaken Island (Fig. 1) in March 1994 (Boneka 1994). The hermit crabs were collected by hand in six replicated quadrants, each 100 $m^2$, during low tide at night. The quadrants were placed at random on three sections of the shore line: upper (edge of terrestrial vegetation), middle, and lower part. Empty gastropod shells were also collected outside the quadrants for statistical purposes. In the laboratory, the living crabs were removed after heating of the apex. The taxa were identified, shells and carapace of the crabs measured by caliper to the nearest 0.05 mm, crabs and shells weighed.

Correlation coefficients were used to study length-

weight relationships (Sokal & Rohlf 1981; Box 15.1). Selectivity was analyzed by means of the modified Ivlev Index (Krebs 1989, p. 394). $\chi^2$ test was used to test differences of hermit crab densities between stations. The relative abundance of gastropod shells was expressed as percentage of the total number collected.

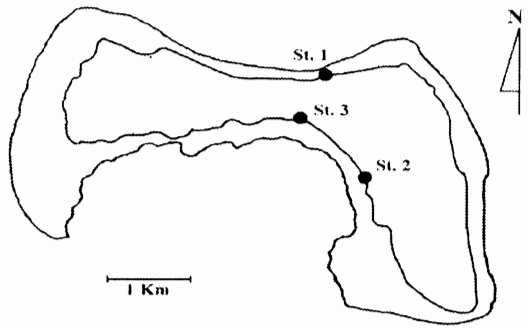


**Figure 1.** Bunaken Island, sampling locations (St.)

## RESULTS AND DISCUSSION

**Density of hermit crabs.** The hermit crab, *Coenobita rugosus* Edwards, is the most common crab on the upper shore of Bunaken Marine National Park. The crabs were found aggregated and abundant along most of the shore line. The $\chi^2$ test showed no significant difference between hermit crab density (ind./$m^2$) and sampling site ( $\chi^2 = 1.7214$; $P > 0.05$). During low tide some crabs invaded the lower wet sandy part of the shore searching for food. Only a few crabs were found at the middle and lower parts of the shore. The crabs are mainly scavengers. Wilson (*in* Reese 1987) demonstrated that they play an important role in reducing carrion and thereby potential fly breeding sites since flies lay their eggs in rotting organic material.

**Taxa of gastropods.** The collected gastropod shells consisted of 26 genera where 19 were used by the hermit crabs. The present data do not encompass all gastropod taxa living in the area. For example, *Littoraria scabra* (L., 1758) and *Littoraria pallescens* (Philippi, 1846) were abundant in the mangroves (Boneka 1994), and their empty shells did not appear in the beach collections since the littorinid predators probably break the shells. Field observation indicated that grapsid crabs, portunid crabs, and the hermit crab *Calcinus* were the most important shell breaking predators in the mangrove of Bunaken.

**Utilization of shells.** Frequency occurrence (F%) of gastropod shells used by hermit crabs is shown in Fig. 2. Quantitatively, *Nassarius* shells constituted 29.7 % of total shells available (excluding the ignored ones, *e.g.*, *Cyprea*, *Trochus*), and 77.2 % of these shells were in use. About 87 % of the total crab population dwelled in shells of 6 gastropod taxa. The relative order of occupancy was *Nassarius* (44.1 %), *Cerithium* (10.6 %), *Morula* (6.8 %), *Melanella* (6.2 %), *Drupella* (6.1%), *Liotina* (5.6 %), *Turbo* (4.3 %), and *Nerita* (3.1 %). The F (%) value may indicate the crab's shell preference and reflect shell availability at Bunaken Island. The two genera *Nassarius* and *Cerithium* are obviously the important taxa in this region. The certain surplus of empty gastropod shells are necessary to support the process of shell exchange since hermit crabs must change to new shells as they grow. A crab requires several sizes of empty shells for completion of the life cycle. Many of the shells collected in Bunaken are worn and probably have been in use for a long time by several crab individuals. Vance (1972) found that there was no discrimination between used and unused shells occupied by the hermit crab, *Pagurus hirsutiusculus*. Although 19 taxa were inhabited by hermit crabs, apparently only four, namely *Nassarius* (E = 0.54), *Cerithium*, (E = 0.43), *Turbo* (E = 0.33), and *Morula* (E = 0.27), had a positive value of the selectivity index (Fig. 2), indicating preference, and reflecting competition for shells, since the three latter taxa were not found in significant numbers in the field. The shells of *Cyprea, Conus, Phytia,* and *Trochus* were not used by the hermit crabs. *Conus* and *Trochus* shells may be rejected by *Coenobita rugosus* due to the weight. However they were found inhabited by aquatic hermit crabs. At Eniwetak, *Trochus* shells were occupied by *Diogenes, Dardanus,* and *Calcinus* (Orians & King 1964). Some hermit crab taxa usually inhabit non-coiled shelters, *e.g.*, *Orthopagurus, Pylopagurus, Xylopagurus* and *Discorsopagurus* (Morgan 1990)

**Size-frequency relationships.** The present result agrees with Bertness (1980) and Reese (1963) who suggested that the size range of the shells used by hermit crabs always correspond to the size of the crabs. The relationship between carapace width (mm) and gastropod shell aperture width (mm) showed a positive strong correlation, r = 0.8889. Since the variety of shell shapes was great, the relationship between crab and shell weights (g) only gave a value of r = 0.7353. Data for *Drupella* showed that cabs can carry shells more than ten times of its their own body weight (Fig. 3). Although these r-values are just slightly different, they

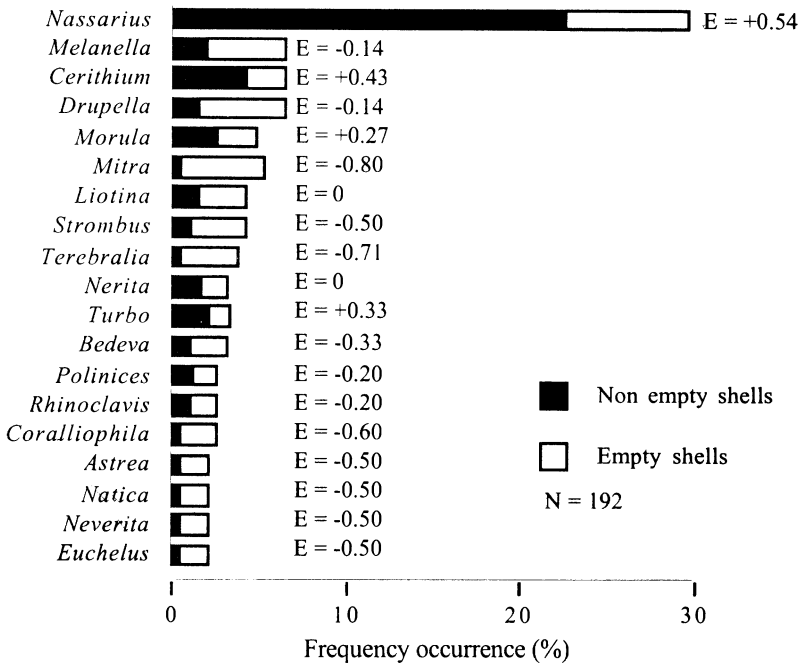


**Figure 2**. Frequency occurrence (F%) of gastropod shells used by the hermit crab, *Coenobita rugosus* Edwards, and Electivity Index (E); March 1994.

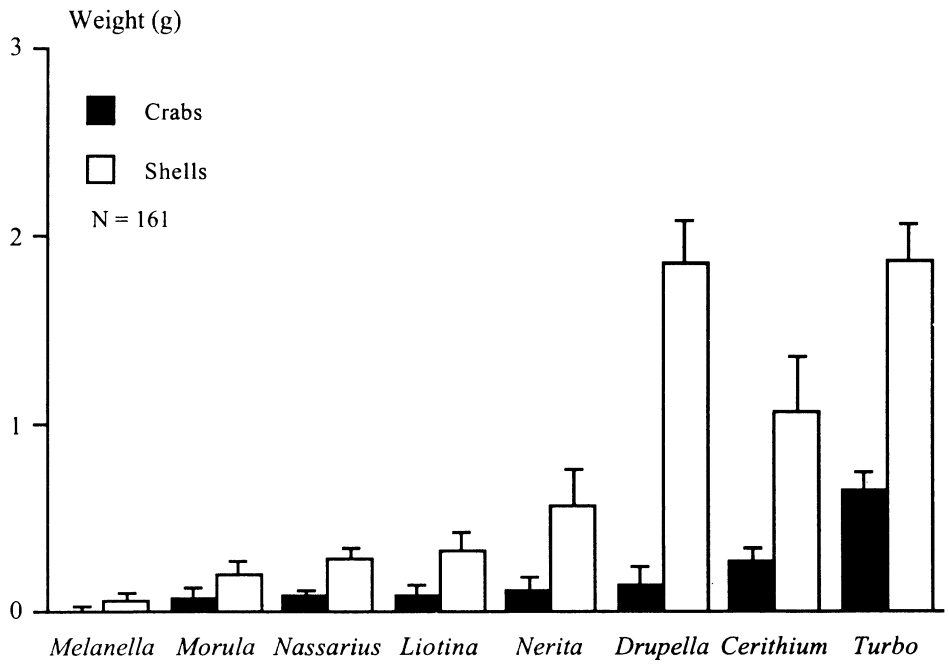


**Figure 3**. Average weight (g) + S.E. of crab, *Coenobita rugosus* Edwards, and gastropod shells; > 5 individuals were excluded. Bunaken, March 1994.

indicate that shell opening is more important than shell weight. Fig. 3 shows the mean weight of the collected shells and suggests that crabs choose shells according to the growth stage. The smallest size class of crabs were found in *Melanella* shells. The small to medium sized crabs (carapace width = 1.96 mm, Sd = 0.61) mainly occupied *Nassarius*. The medium sized crabs (carapace width = 2.93 mm, Sd = 1.18) dwelled in *Cerithium*, while the largest crabs were in *Turbo* shells.

**Conservation aspects.** Since October 1991, Bunaken Island together with other four other islands, Siladen, Mentehage, Nain, and Manado Tua have been classified by the Indonesian authorities as marine national parks. Since in the middle of 1980's, Bunaken Island has become one of the most popular and frequently visited tourist sites. By law, collection of living fauna is forbidden, but so far not collection of empty shells. Visitors coming to the islands may stimulate the shell business as observed in Thailand (Aungtonya 1994). The various empty gastropod shells available along the beaches do play a significant role for life history of the hermit crabs and contribute to the diversity of marine biota of the Marine National Park of Bunaken. Collection, or depletion of available empty shells is accordingly a threat to the hermit crab populations on the Bunaken Island. Reese (1968) demonstrated that glaucothoa of the coconut crab entered shells both in water and on land; they crawl out of the water with or without shells. But, the critical stage may occur when the crabs are looking for small shells, before moving onshore. In this respect, the availability of *Melanella* shells may play a significant role, even if E is negative (-0.14). There were shells available for the intermediate size of coenobitid crab. But, the larger crabs are most likely controlled by the availability of *Turbo* shells.

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