UNIQUE SHELL UTILIZATION BY REEF-FLAT HERMIT CRABS IN GUAM, MICRONESIA*

With 2 Plates and 2 Tables

by

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グアム島 (ミクロネシア) 産ヤドカリの特異な貝殻利用について

図版 2, 表 2

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Abstract: *Calcinus latens* is the hermit crab widely distributed in the Indo-Pacific region. Many authors have reported that *C. latens* uses gastropod shells having regular whorls and showing regular conical shape, however I found in a coral reef of Guam that many individuals of *C. latens* used shells of irregular whorls or peculiar shapes, such as the shells of Vermetidae, Cypraeidae, Conidae and they are highly damaged. These shells are significantly heavier than the shells of normal type and sometimes their center of gravity is various. It has been reported that heavier shells influence the growth rate and clutch size of hermit crabs and that unbalanced shells restrict the locomotion ability of hermit crabs. Thus this condition is regarded as worse for *C. latens*, and may result from the scarcity of normal shells in the reef.

Introduction

Hermit crabs are unique among higher crustaceans, because they generally utilize gastropod shells as portable shelters. Gastropods have various forms of shells, but generally hermit crabs only use certain kinds, *i. e.* those which have regular coilings (whorls) and show regular conical shapes, such as the shells of the Trochidae, Turbinidae, Cerithiidae, and Muricidae. Their center of gravity is near the center axis

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of the shells, and hermit crabs can easily maintain their balance in the shell utilization.

However, gastropods having shells of irregular whorls or peculiar shapes are also known, and they are utilized by specific species of hermit crabs. For example, species of Conidae have a thick, heavy shell with a thin, elongated aperture. They have a very narrow inner space in relation to their weight. *Clibanarius eurysternus* utilizes shells of Conidae (MIYAKE, 1982); its body is dorso-ventrally flattened and fits the aperture of cone shells. Vermetid shells have sometimes irregular shapes of whorls and are cemented fast to rock surface. *Calcinus verrilli* specifically utilizes them (MARKHAM, 1977). Cowrie shells (family Cypraeidae) have no obvious whorl structure and are pouch-like. No hermit crabs use the cowrie shells specifically.

The hermit crab, *Calcinus latens* is the Indo-Pacific species, and generally uses shells having regular whorls (ABRAMS, 1981a, b; WOOSTER, 1978; ORIANI and KING, 1964; HAZLETT, 1970). However I found in the population of *C. latens* on Guam Island of Micronesia that many individuals used the shells of Conidae, Cypraeidae, and Vermetidae. In this paper I report the manner of utilization of such irregular-type shells in that population as well as the relationship between the weight of the crabs and that of their utilized shells.

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Methods

Samplings were done in Tuamon Bay of Guam Island, Micronesia, in June 1986. In the intertidal zone of this site, three hermit crabs commonly occur; *Clibanarius humilis* in the upper intertidal zone, *Calcinus latens* in the middle intertidal zone, and *Calcinus gaimardi* in the lower intertidal zone. At low tide of spring tide I collected hermit crabs there, randomly picking them up by hand. These hermit crabs were fixed by 10% formalin solution and brought to the laboratory. The hermit crabs and their shells were identified to species, dried up at 60°C for 120 hours, and weighed on a micro balancer.

In this paper I define the shells of Conidae, Cypraeidae, Vermetidae and highly damaged shells as the shells of peculiar type. Then I define the shells having regular whorls as the shells of normal type, which are used by most species of hermit crabs.

Results

Many examples of use of peculiar-type shells were found in *Calcinus latens*. In *Clibanarius humilis*, no individuals utilized the shells of peculiar type, and only one

case of the peculiar-shell use was found in *Calcinus gaimardi*. Thus I report about the cases of *C. latens*.

Fig. 1 (Pl. IV) shows vermetid shells utilized by *C. latens*. The shells had detached from the rock surface and were covered with a thick, calcareous substance. Since the shells have irregular whorls, it seems difficult for the hermit crabs to balance themselves. In the photographs, the major chelipeds of *C. latens* can be observed.

The utilization of cowrie shells by *C. latens* are shown in Fig. 2 (Pl. IV). The aperture is very narrow in relation to its inner volume, and only small crabs can get into the shells. In these photographs, individuals of *C. latens* retreated deeply into the inner part of shells in the fixation and can not be observed. The shells were covered sparsely with calcareous, polychaetous tubes and coralline algae.

Fig. 3 (Pl. V) shows the utilization of cone shells by *C. latens*. Only small crabs can get into the shells, because the shells have very narrow aperture.

Fig. 4 (Pl. V) shows the utilization of highly damaged shells by *C. latens*. These shells had been broken and have holes of several size. Normally, hermit crabs mainly use the body whorl (the first whorl from the aperture) of the shell, however these crabs used the parietal whorl (the second whorl from the aperture) or the third (or more) whorls.

In this study area, the shell of normal type, *Canarium mutabilis*, dominated the molluscan fauna, and the hermit crab mainly used it. I measured the dry weight of the hermit crabs and *Canarium mutabilis* they occupied (Table 1). The ratio of the shell weight divided by the crab weight ranges from 10.802 to 40.556, and the mean value is 24.184 (s.d.=8.775). And I also measured this ratio in the utilization of shell of peculiar type; the shell of Conidae, Cypraeidae, and Vermetidae and highly damaged

Table 1. Use of shells of normal type (see definition in the methods) by the hermit crab, *Calcinus latens*; the relationship between dry weight of the crabs and that of their utilized shells.

No.	Shell species	shell weight in g [S]	crab weight in g [C]	[S]/[C]
1.	<i>Canarium mutabilis</i>	0.7959	0.0325	24.489
2.	"	0.6611	0.0286	23.115
3.	"	0.6352	0.0333	19.075
4.	"	0.5541	0.0513	10.802
5.	"	0.8666	0.0284	30.514
6.	"	0.6234	0.0336	18.580
7.	"	1.1582	0.0284	40.556
8.	"	1.1869	0.0327	36.297
9.	"	0.4597	0.0297	15.478
10.	"	0.8140	0.0355	22.930
				mean
				24.184
				s. d.
				8.775

Table 2. Use of the shells of peculiar type (see definition in the methods) by the hermit crab, *Calcinus latens*; the relationship between the dry weight of crabs and that of their utilized shells.

No.	Shell species	shell weight in g [S]	crab weight in g [C]	[S]/[C]
Conidae				
1.	<i>Virroconus coronatus</i>	3.5571	0.0394	90.282
2.	"	1.6324	0.0158	103.316
3.	"	3.2301	0.0515	62.720
4.	"	1.6351	0.0279	58.606
5.	<i>Puncticululus pulicarius</i>	1.0883	0.0060	181.383
6.	"	3.1618	0.0125	252.944
7.	"	6.2183	0.0449	138.492
8.	<i>Chelyconus catus</i>	4.1485	0.0245	169.326
9.	"	4.2858	0.0296	144.791
10.	<i>Conus miliaris</i>	2.5433	0.0154	165.149
				mean 136.701
				s. d. 56.827
Cypraeidae				
11.	<i>Monetaria moneta</i>	0.6062	0.0118	51.373
12.	"	1.0193	0.0147	69.340
13.	"	1.7316	0.0229	75.607
14.	"	1.2643	0.0061	207.262
15.	"	1.1333	0.0245	46.257
16.	"	1.6388	0.0129	127.039
17.	"	1.8241	0.0140	130.293
18.	<i>Ravitriona caputserpentis</i>	5.3376	0.0172	310.326
19.	"	5.3202	0.0400	133.005
20.	"	4.8267	0.0219	220.397
				mean 137.090
				s. d. 81.245
Vermetidae				
21.	<i>Vermetidae g. sp.</i>	5.2482	0.0395	132.865
22.	"	2.1763	0.1371	15.874
23.	"	1.8925	0.0667	28.373
24.	"	4.5826	0.2013	22.765
25.	"	2.0237	0.0701	28.869
26.	"	2.5784	0.0161	160.149
27.	"	2.9008	0.0517	56.108
28.	"	1.3643	0.0206	66.228
29.	"	2.7387	0.1184	23.131
30.	"	0.5678	0.0146	38.890
				mean 57.325
				s. d. 47.340

(continued)

No.	Shell species	shell weight in g [S]	crab weight in g [C]	[S]/[C]
damaged shells				
31.	<i>Drupa ricina</i>	2.6361	0.0125	210.888
32.	<i>Drupa morum</i>	7.0274	0.0580	121.162
33.	<i>Drupa glossularia</i>	0.5940	0.0035	169.714
34.	<i>Mancinella tuberosa</i>	5.1055	0.0418	122.141
35.	<i>Cararium mutabilis</i>	0.6869	0.0305	22.521
36.	"	0.6026	0.0166	36.301
37.	"	0.5233	0.0321	16.302
38.	<i>Cymatium</i> sp.	3.1086	0.0451	68.927
39.	"	1.6815	0.0380	44.250
40.	<i>Trochus nilotica</i>	2.4227	0.0226	107.199
				mean 91.941
				s. d. 62.158

shells (Table 2). The mean values of the ratio are significantly higher than that in the shell use of the normal type; 136.701 in Conidae ($p < 0.0001$, $U = 0$, one-tail Mann-Whitney's U-test), 137.090 in Cypraeidae ($p < 0.0001$, $U = 0$, one-tail Mann-Whitney's U-test), 57.325 in Vermetidae ($p < 0.05$, $U = 25$, one-tail Mann-Whitney's U-test) and 91.941 in damaged shells ($p < 0.025$, $U = 14$, one-tail Mann-Whitney's U-test). Very high values are observed in the utilization of Cypraeidae, such as 310.326 and 220.397 in *Ravitriona captuserpentis* and 207.262 in *Monetaria moneta*, and in the utilization of Conidae, such as 252.944 in *Puncticulus pulicarius*, as well as in the utilization of damaged shells, such as 210.888 in *Drupa ricina*.

Discussion

The shells utilized by *Calcinus latens* have been frequently reported: *Trochus niloticus*, *Drupa* sp., *Natica* sp., *Strombus* sp., and *Cypraea* sp. at Pago Bay and Agat Bay of Guam Island (WOOSTER, 1982); *Clypeomorus morum*, *Strombus gibberulus luhuanus*, *Cerithium* sp., *Monetaria moneta*, and *Conus* sp., etc. in Enewetak Atoll and Guam Island (ABRAMS, 1981a); *Planaxis planicostatus*, *Cerithium* sp., *Nerita* sp., *Turbo* sp., *Trochus* sp., etc. at One Tree Island, Australia (ABRAMS, 1981b); *Ergalatax constrictus* and *Reishia luteostoma* at Shirahama, Japan (MIYAKE and IMAFUKU, 1980).

These suggest that *C. latens* mostly uses and prefers the shells of normal type. Though WOOSTER (1982) and ABRAMS (1981a) reported that in a few cases this species of the hermit crab also uses the shells of Cypraeidae and Conidae. ABRAMS (1981b) reported in a *C. latens* population in the tropical Pacific that the frequencies of *Monetaria moneta* (Cypraeidae) and *Conus* sp. occupied 2.49% and 4.58% respectively in the shells utilized by them.

In this study area, most individuals of *C. latens* use shells of normal types such as *Trochus niloticus* and *Canarium mutabilis*, although they also use the shells of Vermetidae, Conidae, and Cypraeidae and highly damaged shells. The utilization frequencies of them are considered to be nearly the same as those in ABRAMS (1981b). These shells are heavier in relation to the body weight of hermit crabs (Table 2) than the shells of the normal type (Table 1). BERTNESS (1981) reported that hermit crabs which use shells of heavier weight and lower internal volume have lower growth rates and lower clutch sizes. Thus the use of shells of the peculiar type can be regarded as a worse condition for the hermit crab from the view point of shell weight.

Since the positions of center of gravity are various in vermetid shells, the crab cannot balance himself easily. This decreases the locomotion ability of the crab and, perhaps, causes serious problems, because locomotion plays an important role for hermit crabs in their acquisition of new shells and food (HAZLETT, 1983) and in their avoiding predation and dessication (REESE, 1969). CONOVER (1978) reported that the alteration of the angle of the shell axis and the position of the shell's center of gravity resulted in an aversion to altered shells by hermit crabs.

Nevertheless, *C. latens* in the Guam population sometimes uses the shells of peculiar type. This may be because the normal shells are very scarce in the reef and the crab are forced to use "worse" shells, as many authors have suggested in several locations (HAZLETT, 1981).

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要 約

ツマジロサンゴヤドカリ *Calcinus latens* は、普通、規則正しく層の巻かれた巻貝を利用しているが、グアム島において多数の個体が特殊な形態の貝、オオヘビガイ科・タカラガイ科・イモガイ科の貝や、破損の大きな巻貝の貝殻を利用しているのを観察した。これらは形態が特異な上、貝殻内の体積に比べ貝殻の重量が大きく、ヤドカリにとって種々の不都合をもたらすと推測された。

Fig. 1. Utilization of shells of Vermetidae (unidentified species) by *Calcinus latens*.

Fig. 2. Utilization of shells of Cypraeidae by *C. latens*. *Monetaria moneta* (left) and *Ravitronea caputserpentis* (right).

Fig. 3. Utilization of shells of Conidae by *C. latens*. *Chelyconus catus* (left) and *Virroconus coronatus* (right).

Fig. 4. Utilization of broken shells by *C. latens*. *Cymatium* sp. (left) and *Canarium mutabilis* (right).