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RESEARCH ARTICLE

Occupancy of gastropod shells by the hermit Crab *Clibanarius erythropus* (Crustacea, Anomura) inhabiting the Mediterranean Sea coast of Libya

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Abstract

The present study deals with the use of gastropod shells by the hermit crab *Clibanarius erythropus* (Decapoda: Anomura) inhabiting the Mediterranean Sea coast of Libya. Specimens of the crab were collected on 21 June 2014 from Misrata city, western Mediterranean Sea coast of Libya. A total of 260 individuals were collected which included 63 males (24.23%), 74 non-ovigerous females (28.46%) and 123 ovigerous females (47.31%). The study revealed that the crab occupied 11 gastropod shell species. The most common occupied shell species was *Pisania striata* (36%) followed by *Cerithium lividulum* (26%), *Cerithium vulgatum* (15%) and *Phorcus turbinatus* (8%). Shell utilization patterns appear to be determined by respective sex, size of hermit crabs and shell species. Male *C. erythropus* occupies the relatively large and heavy gastropod shell species (*Pisania striata* and *Phorcus turbinatus*). Small crabs occupy relatively larger shell species than large crabs. Positive relationships were recorded between the variables of the shells occupied and the hermit crabs size variables. The present study referred that the shell length and shell aperture width were the most important choice factors for the studied hermit crab.

INTRODUCTION

Empty shells of marine mollusks are often inhabited by the anomuran decapod crustaceans. Hermit crabs generally utilize gastropod shells because their abdominal exoskeleton lacks calcification. So gastropod shells are an indispensable resource for hermit crabs (Hasegawa *et al*., 2009). Shells of gastropods provide protection against predators (Vance, 1972 and Hazlett, 1990) and physical stress (Reese, 1969). Habitat partitioning has been demonstrated since closely related species show variable use of gastropod shells depending on the shell size, shape and availability (Teoh and Chong, 2014), while a more heterogeneous habitat provides more niches and ways to exploit the available resources (Bazzaz, 1975). The life cycle of hermit crabs depends mostly on the processes that make suitable gastropod shells (Hazlett, 1981). Studies on the utilization of gastropod shells by hermit crabs have been conducted by many authors like Fotheringham, (1976); Koutsoubas *et al*., (1993); Manjón-Cabeza and García Raso (1999); Martinelli and Mantelatto (1999); Botelho and Costa (2000); Mantelatto and Garcia (2000) Ateş *et al*. (2007) and Rodrigues and Rodrigo, (2009). No such study was done on the shell utilization by hermit crabs of the Mediterranean Sea coast of Libya.

The intertidal hermit crab *Clibanarius erythropus* (Latreille,1818) is a common species of Mediterranean shores and is also present along the Atlantic coasts from Brittany to the Azores (Zariqu.iey Alvarez, 1968 and Ingle, 1993). The present study was carried out to evaluate the utilization patterns of the gastropod shells by males, females and ovigerous females of C. *erythropus*; the most common species of hermit crabs found at Misrata city which lies on the western Mediterranean Sea coast of Libya.

MATERIALS AND METHODS

Samples were collected by hand from the shallow intertidal water from the public beach region of Misrata city (North 32° 25 , East 15° 02) Fig.1 on June 21th, 2014. This area is characterized by rocky shores and by a mixture of sandy and rocky soils. A total of two hundred and sixty specimens were collected and preserved in 10% seawater formalin, then transported to the laboratory. In the laboratory; crabs were removed carefully from their shells. Shells were labeled for identification. Crab specimens were classified into males, non ovigerous females and ovigerous females. They were measured for shield length (SL: measured from the tip of the rostrum to the midpoint of the posterior margin of the shield, providing an indication of animal size), carapace length (CaL: measured from the tip of the rostrum to the midpoint of the posterior margin of the carapace).

Size of the gastropod shells occupied by these hermit crabs were measured, including shell aperture length (SAL), aperture width (SAW) and shell length (ShL), by using calipers (precision 0.01mm). Also shell weight (ShW) was estimated after removing the crab. SPSS software package (version 21) (SYSTAT statistical program) and MS Excel were used for statistical analysis of the data.

RESULTS

Sorting of the collected 260 individuals of *Clibanarius erythropus*; the study revealed the presence of 63 males constituting (24.15 %), 74 non-ovigerous females, constituting (28.46%) and 123 ovigerous females constituting (47.33%). Sizes of *Clibanarius erythropus* (based on cephalothoracic shield length) ranged from 2.5 mm to 7mm (fig. 5). They occupied shells of 11 gastropod species (Fig 2-3) (Table1). The most commonly occupied shell species was *Pisania striata* which included 86 individuals constituting (33%) followed by *Cerithium lividulum* 75 (28%), *Cerithium vulgatum 40* (15%), *Phorcus turbinatus* 22(8%), *Columbella rustica* 9 (3.5%), *Conus mediterraneus* 7(2.7%), *Gibbula divaricata* 7 (2.7%), *Gibbula varia* 6(2.3%), *Muricopsis cristata* 5(1.9%), *Gyroscala lamellose* 2(0.8%) and *Fasciolaria lignaria* 1(0.4%) (Table1) (Fig 3)). Males (33%), non-ovigerous females (45%) and ovigerous females (75%) occupied the shells of *Pisania striata* at higher percentages (Fig 4)..

Fig (1): Showing the location of Misrata city on the Mediterranean Sea coast of Libya and the sampling site at Misrata (32° 25N, 15° 02E).

Figure (2): Shells used by *Clibanarius erythropus.* (a) *Pisania striata*. (b) *Muricopsis cristata.* (c) *Columbella rustica*. (d) *Cerithium vulgtatum.* (e) *Cerithium lividulum.* (f) *Gibbula varia*. (g) *Gyroscala lamellose*. (h) *Gibbula divaricata.* (i) *Fasciolaria lignaria.* (j) *Phorcus articulates* and (k) *Conus mediterraneus*.

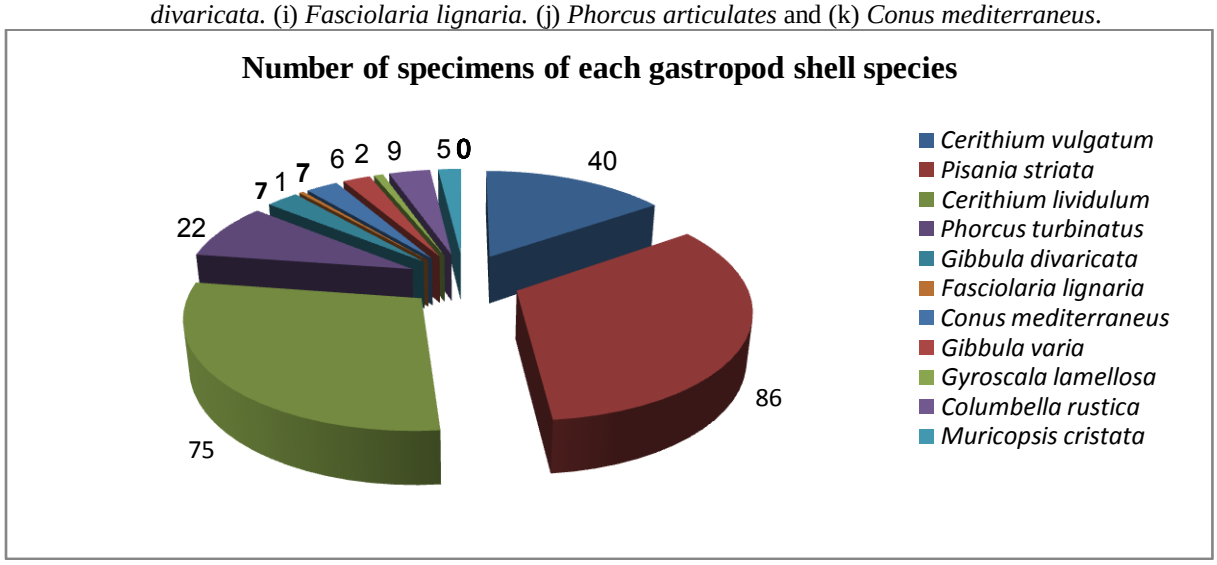


Figure (3): Number of specimens of each gastropod shell species occupied by *Clibanarius erythropus* at Misrata; western Mediterranean Sea coast.

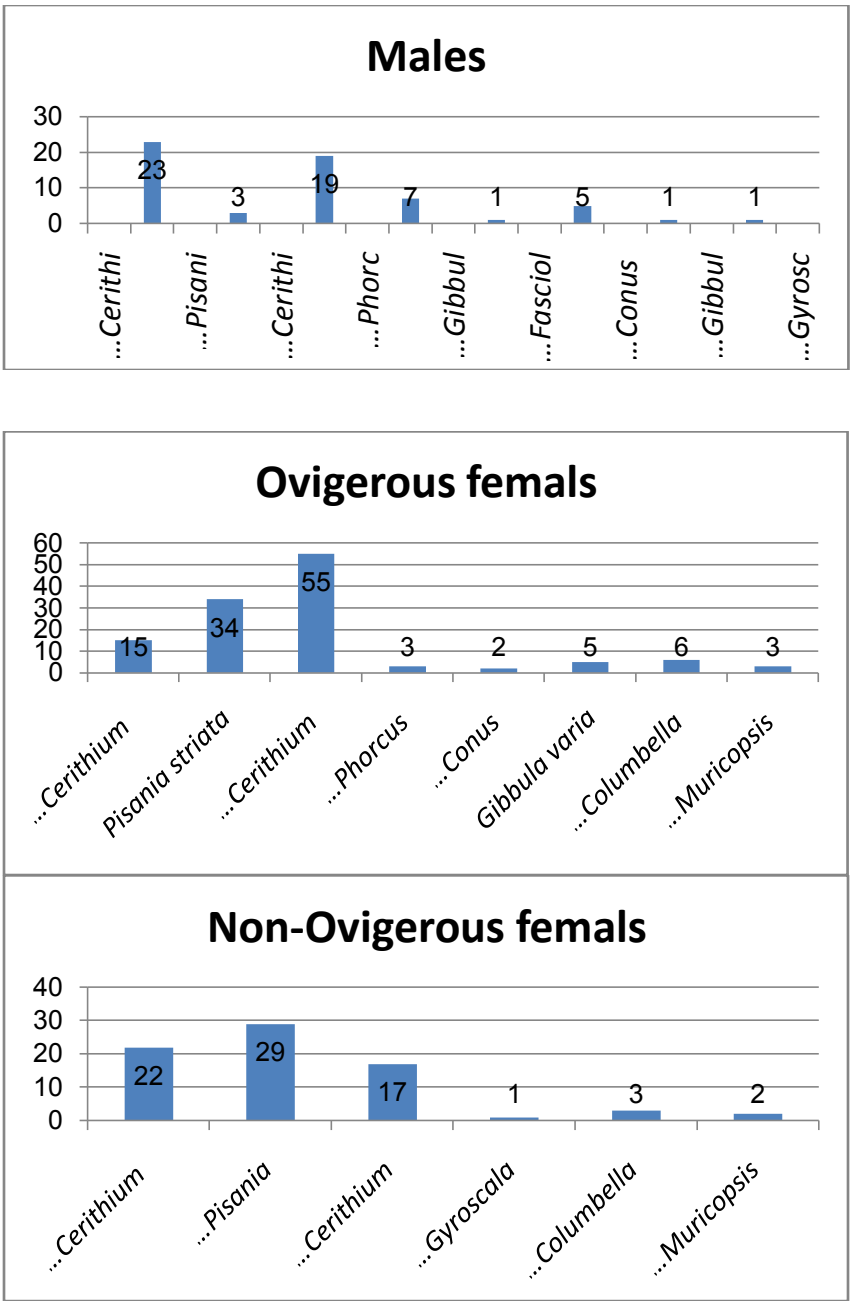
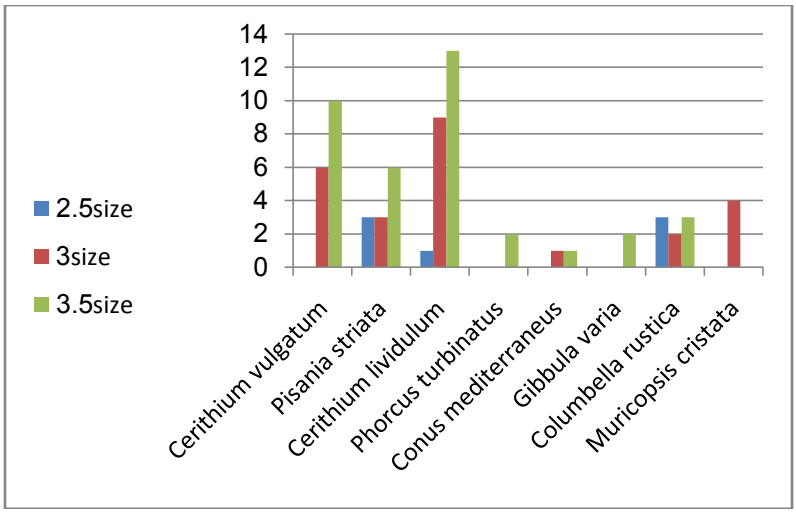


Fig. (4): Numbers of males, non ovigerous females, ovigerous females, in the different occupied shell species.



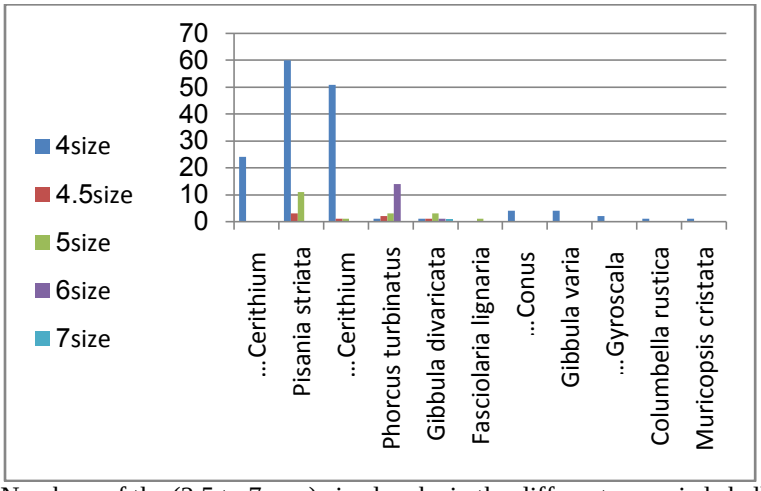


Fig. (5): Numbers of the (2.5 to 7 mm) sized crabs in the different occupied shell species.

Table. (1): Frequency and percentage of the different eleven species of gastropod shells occupied by *Clibanarius erythropus*

variables	Shield length		Carapace length	
	r	Sig.	r	Sig.
Shell length	0.335	**	0.352	**
Aperture length	0.496	**	0.529	**
Aperture width	0.768	**	0.761	**
Shell weight	0.744	**	0.716	**

Table 2: Correlation coefficients for association between *Clibanarius erythropus* crab sizes variables and occupied shell size variables (r= correlation coefficient, Sig.=significant, **= statistically significant at 0.01, N=260).

No.	Name of shell species	Frequency	% of the total occupied shells
1	*Cerithium vulgatum*	40	15.4
2	*Pisania striata*	86	33.1
3	*Cerithium lividulum*	75	28.8
4	*Phorcus turbinatus*	22	8.5
5	*Gibbula divaricata*	7	2.7
6	*Fasciolaria lignaria*	1	0.4
7	*Conus mediterraneus*	7	2.7
8	*Gibbula varia*	6	2.3
9	*Gyroscala lamellosa*	2	.8
10	*Columbella rustica*	9	3.5
11	*Muricopsis cristata*	5	1.9
Total		260	100

Table 3: Regression equations for the relations between *Clibanarius erythropus* crab sizes variables and occupied shell size variables (SL = Shield length, CaL = Carapace length, ShL = Shell length, SAL = shell aperture length, SAW= SAL = shell aperture width, ShW = Shell weight, N=260).

Dependent Variable	Selected variable	P value	R	Regression equations
Shield Length	**Constant**	< 0.001	0.808	SL=2.333 + 0.107 ShL +0.533SAW+0.279ShW
	Shell Length	0.019		
	Aperture Width	< 0.001		
	Shell weight	< 0.001		
Carapace Length	**Constant**	< 0.001	0.801	CaL=2.294+0.187ShL+ 0.141SAL+ 0.660SAW
	Shell Length	< 0.001		
	Aperture Length	.002		
	Aperture Width	< 0.001		

DISCUSSION

The present study revealed that *Clibanarius erythropus* inhabiting the Mediterranean Sea cost of Libya at Misrata city occupied 11 gastropod shell species. The most commonly occupied shells included: *Pisania striata*, *Cerithium vulgatum, Cerithium lividulum* and *Phorcus turbinatus*. Similar previous studies showed that hermit crabs and closely tied to a high proportion of the total gastropod shells present eg. Lewinsohn (1982),

Reay and Haig, (1990) Gherardi and McLaughlin (1994), Hogarth *et al.* (1998), Botelho and Costa (2000), Barnes (2003), Terossi *et al*. (2006), Michelle (2010), Abd El-Wakeil *et al*. (2010) and Tahir *et al*. (2013).

The present study reported that there was a close relationship between the crab size and the size of the occupied shell. Similar relationship was recorded for other *Clibanarius* species from different areas. *C. erythropus* from São Miguel (Azores) (Botelho and Costa, 2000) and *C. virescens* from South Africa (Reddy and Biseswar, 1993). The small hermit crabs occupy larger shells to allow their future growth (Dominciano and Mantelatto, 2004). This might give the chance for smaller crab to choose from a wide range of gastropod shells between adequate shell size and larger shell for future growth.

In the present study *C. erythropus* size variables were positively correlated with all of the measured shell variables. This indicated the effect of the measured variables of shell size on crab size, this means that shells affect growth of the crab. Many authors reported the effects of shell on crab growth (Markham, 1968; Fotheringham, 1976b; Bertness, 1981; Turra and Leite, 2003; 2004; Abd El-Wakeil *et al*., 2010). It is also known that hermit crab growth is slowed by occupation of a small shell (Hazlett, 1981; Lancaster, 1988; Botelho and Costa, 2000).

Multiple regressions for the present data show that shell length and shell aperture width were the selected shell features characterized the association between crab size (shield length) and the occupied shells.

The degree of importance for several morphological shell characteristics was always debatable (Floeter *et al.*, 2000). Previous studies have shown that the most important variables in shell occupation by hermit crabs are shell aperture width, shell weight and internal volume (Botelho and Costa, 2000; Floeter *et al*., 2000; Garcia and Mantelatto, 2000; Mantelatto and Meireles, 2004; Dominciano and Mantelatto, 2004; Terossi, *et al*. 2006 Abd El-Wakeil *et al*., 2010).

The above-mentioned results mean that hermit crabs are searching for adequate shell, which has suitable shell aperture and shell weight. Since the shell aperture is the main entrance for the crab, it should provide enough space to accommodate crab size and can close well to confer protection against desiccation. While the shell should be heavy enough to increase the crab resistance against the water current (Garcia and Mantelatto, 2001) and predators (Floeter *et al*., 2000), its weight should be suitable to minimize the energetic cost of carriage (Osorno *et al.*, 1998). Therefore, it can be concluded that the shell weight and shell aperture are the most important choice factors for hermit crab.

Shell use in nature was also demonstrated to be dependent on hermit crab species. Also, shell use is dependent on a combination of site-specific features such as wave energy, predators, habitat complexity, shell availability, and shell use history, which may or may not differ among areas (Dominciano *et al*., 2009).

As a conclusion, gastropod shells preferred by hermit crabs depend on the region and site features. It was found out that exotic gastropod shells are mostly preferred along the Libyan Sea coast. Monthly or seasonal studies are required to be done along this coast determined whether there is a variation in utilized of this shells by juvenile or adult hermit crabs and whether exotic gastropod shells are occupied by hermit crabs through their lives only for certain stages or their life**.**

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