

Cheliped morphometric differences in *Eurytium limosum* (Say, 1818) (Brachyura, Xanthidae).

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Abstract

Among crustacean species, cheliped morphology can vary greatly, and is commonly associated with their function. The occurrence of heterochely was investigated in the mud crab *E. limosum*. A total of 407 males and 457 females were collected in the Guaratuba mangrove (23°45'S and 45°53'W), São Paulo State, Brazil. The chelipeds were classified based on their teeth morphology. The carapace width and length, the propodus width and height of both chelipeds were measured. Chelipeds are dimorphic in this species, being one crusher and the other cutter. The major cheliped is positioned at the right side in the majority of the analyzed crabs. The proportion of right-handed crabs decreases with size, except for the largest individuals. Since *E. limosum* is an important predator of mollusks, right-handedness can be particularly suitable to its feeding habit, facilitating the consumption of asymmetric prey. Chelipeds were larger in males than in females, and presented a higher allometric level. In the former, however, the relative growth of chelipeds does not provide an adequate estimate of the size at the onset of sexual maturity for this species. Thus, the heterochely and handedness of *E. limosum* chelipeds is probably more related to its feeding habits than to its reproductive behavior.

Key words: morphometry, heterochely, handedness, mud crab, mangrove.

Introduction

The white-clawed mud crab *Eurytium limosum* (Say, 1818) belongs to the Xanthidae and is distributed in the Western Atlantic and Gulf of Mexico from South Carolina to Brazil. They usually live under rocks, fallen woods or in burrows excavated from the intertidal mud of salt marshes and mangroves swamps (Williams, 1984; Melo, 1996). Little is known about the feeding habit of *E. limosum*, except that it is thought to be a carnivorous, being identified as the most important secondary consumer in the Sapelo Islands salt marshes (Teal, 1962).

Differences of size, form, and function between right and left chelipeds are referred to as heterochely, and may vary widely among decapods (Hamilton *et al.*, 1976). Heterochely is verified in some brachyuran families, such as the Calappidae, Portunidae, Grapsidae, Ocypodidae and Xanthidae. Beyond morphological differences, the side at which crusher and cutter cheliped are located (handedness) is also an important point to be studied.

Among xanthid crabs, one of cheliped is usually stronger, bearing large blunt-tipped teeth. This appendage is named the crusher or major cheliped. The smaller one, presenting sharp-tipped teeth is named the cutter or minor cheliped (Hamilton *et al.* 1976; Góes and Fransozo, 1998).

Heterochely is often observed in both sexes, but in a few cases it is restricted to one sex (Hartnoll, 1982). In *Uca* species only males have dimorphic claws, being one cheliped remarkably larger than the other, which facilitates sexual identification.

This issue has been addressed for a number of species, e.g. *Ucides cordatus* (Linnaeus, 1763) by Alcântara-Filho (1978); *Eriphia smithi* MacCleay, 1838 by Vannini and Gherardi (1988); *Callinectes ornatus* Ordway, 1863 by Haefner (1990); *Carcinus maenas*, (Linnaeus, 1758) by Kaiser *et al.* (1990); *Arenaeus cribrarius* (Lamarck, 1818) by Pinheiro (1991); *Eriphia gonagra* (Fabricius, 1781) by Góes and Fransozo (1998); *Austinograea williamsi* Hesseler and Martin, 1989 by Tsuchida and Fujikura (2000) and, recently, *Panopeus austrobesus* Williams, 1983 by Negreiros-Fransozo and Fransozo (in press).

The aim of the present study is to describe the morphology of chelipeds and to classify handedness in *E. limosum*.

Material and Methods

The examined material was obtained at Guaratuba mangrove, Bertioga (SP), Brazil (23°45'9"S and 45°53'42"W), from December 1999 to November 2000. Collections were carried out at low tides at approximately, monthly, intervals.

After identification, the sex was identified based on the morphology of secondary sexual characters. The side at which the major and minor chelipeds occur was recorded, the following measurements were taken with a vernier caliper (precision 0.01mm) (figure 1):

- carapace width (CW) and length (CL);
- propodus of major cheliped width (MAW) and height (MAH);
- propodus of minor cheliped width (MIW) and height (MIH).

The relative frequency of right- and left-handedness was determined for each sex and size class. The percentages were compared between body side using the goodness-of-fit test (Zar, 1996).

The power equation ($Y=aX^b$) was used for relative growth analyses. In the first instance, a covariance analysis (ANCOVA) ($\alpha = 5\%$) was performed to compare the \log_{10} transformed equation ($\log_{10} Y = \log_{10} a + b \log_{10} X$) of the cheliped area (width x height) *vs.* carapace area (width x length) in order to verify if chelipeds of same shape present similar relative growth rate in crabs of each body side. After that, the straight lines of crusher and cutter chelipeds were compared between sexes.

The cheliped size of males and females was compared by means of a Student *t* test ($\alpha=0.05$) (Zar, 1996).

Results

A total of 407 males and 457 females was analyzed. The size of collected crabs ranged from 4.5 to 40.1 for males and 3.3 to 32.5mm CW for females. As expected, the chelipeds of *E. limosum* are strongly dimorphic, with distinct crusher and cutter chelipeds. No crabs with chelipeds of same shape were found.

Most of the analyzed crabs (male: $f=71\%$, $c^2=60.04$ and females $f=76\%$, $c^2=105.56$) bear the crusher cheliped on the right side. The relative frequency of right-handedness decreases as the size increases (figure 2).

The covariance analysis performed for the relationship of cheliped area (CHA) *vs.* carapace area (CA) did not present statistical differences between the relative growth of chelipeds of same shape in each body side, for both sexes. Then, other statistical analyses were performed grouping data based on the cheliped shape, disregarding side.

The power function (figure 3) fitted to the relationship of cheliped area (CHA) *vs.* carapace area (CA) indicates that the CHA shows a positive allometry for both sexes (Table I). However, coefficients of linear regression (slope and cutting point) differ statistically between sexes for both crusher and cutter chelipeds, suggesting that the relative growth rate of male chelipeds is higher than females.

The mean size of cheliped propodus width and height differ statically between sexes ($p < 0.05$) for all tested dimensions (table II), being the male claws larger than females.

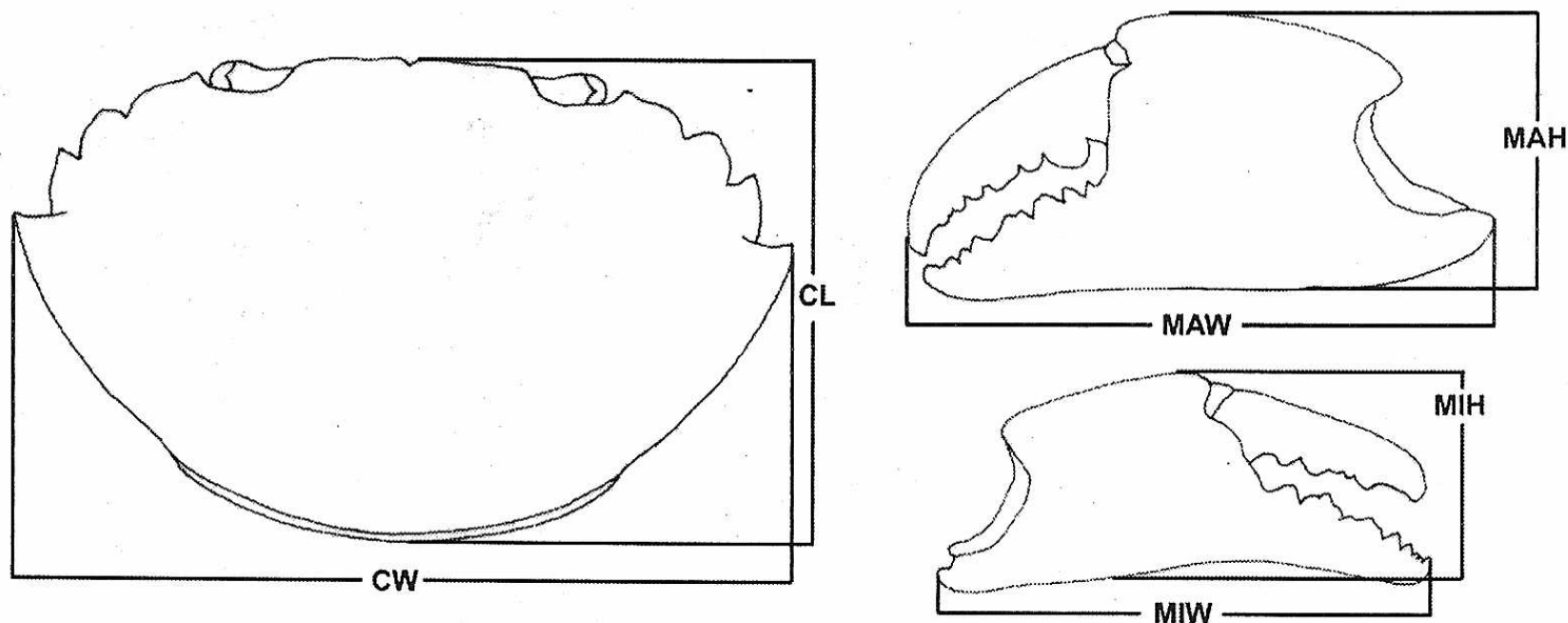


Figure 1: *E. limosum*: Schematic drawings of the measured body parts (CW = Carapace width, CL = Carapace length, PAW = Width of the propodus of major chelipeds, PAH = Height of the propodus of major chelipeds, PIW = Width of the propodus of minor chelipeds and PIH = Height of the propodus of minor chelipeds).

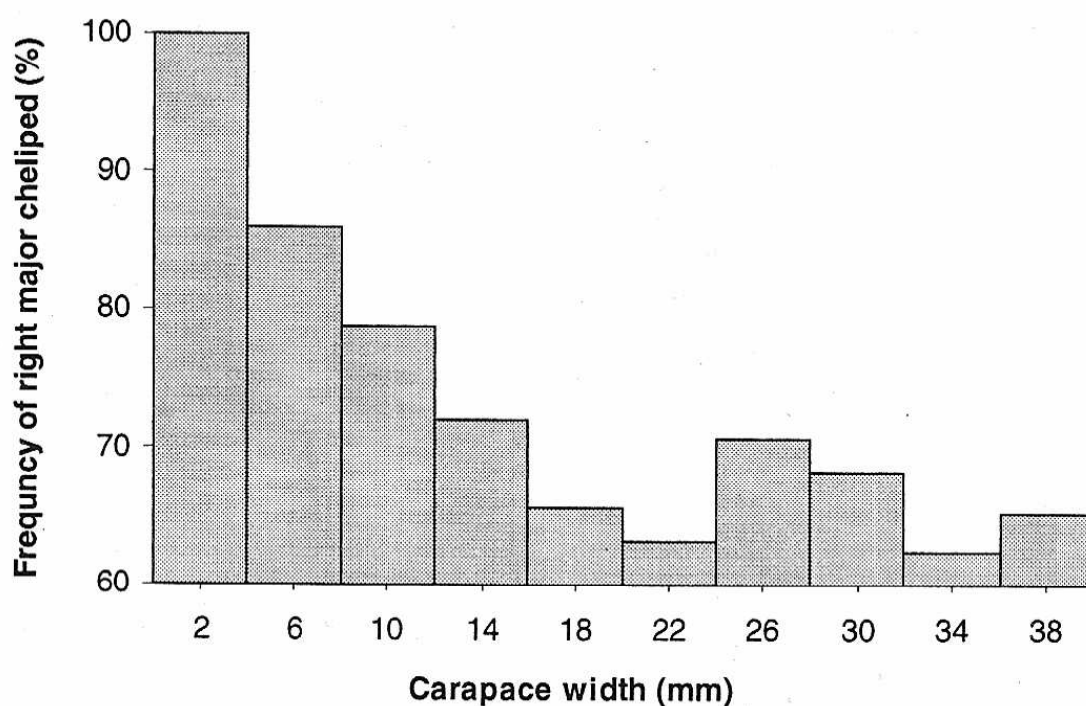


Figure 2: *E. limosum*: Frequency of right cheliped in crab size classes.

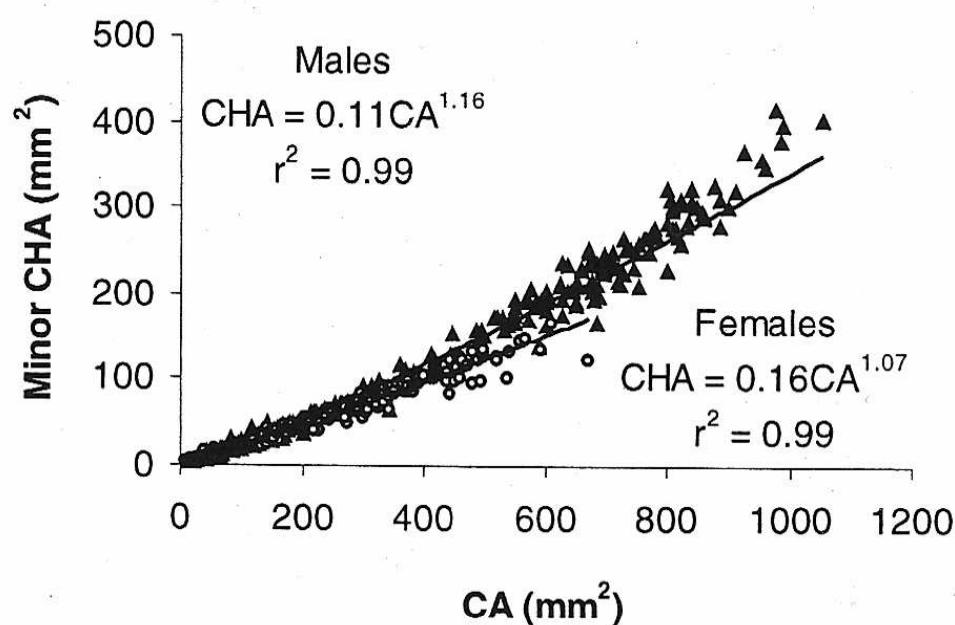
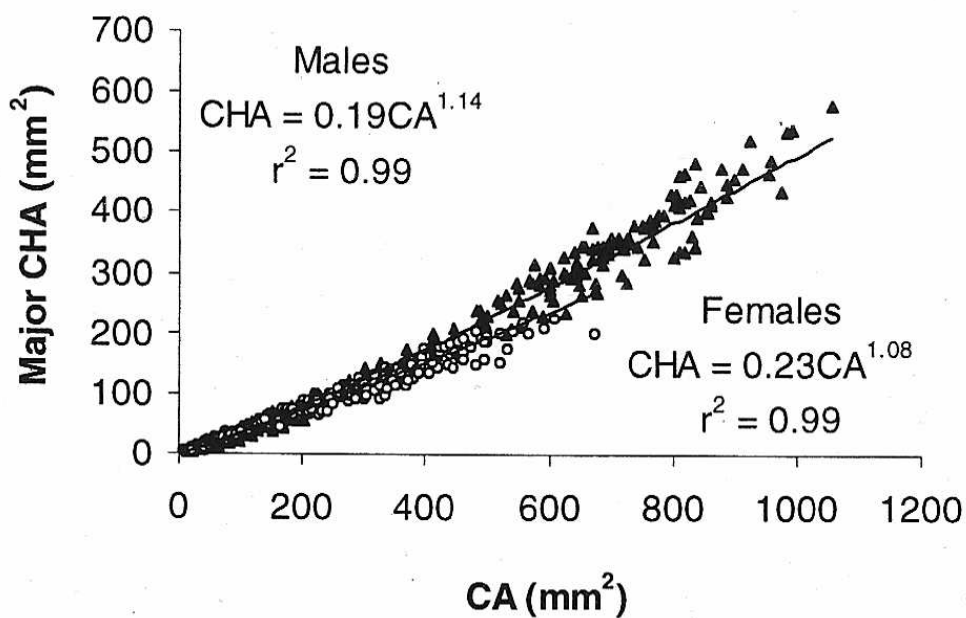


Figure 3: *E. limosum*: Relationships between cheliped area (CHA) and carapace area (CA) (scatter plot of empirical data).

Table I: *E. limosum*: The relative growth equations for major and minor chelipeds, for each sex.

Relationships	Sex	Linear regression	r ²	t	Allometric coefficient
Major CHA vs. CA	Male	LogCA = 1.14LogCHA-0.73	0.99	21.10*	+
	Female	LogCA = 1.08LogCHA-0.63	0.99	10.35*	+
Minor CHA vs. CA	Male	LogCA = 1.16LogCHA-0.95	0.99	26.94*	+
	Female	LogCA = 1.07LogCHA-0.80	0.99	10.47*	+

r² = determination coefficient;t = t-test for H₀: b=0 *p>0.05Table II: *E. limosum*: Mean size of major and minor cheliped compared between sexes by Student t test (α=0.05).

		Males		Females		t-test for differences of means ⁽¹⁾
		$\bar{x} \pm sd$	Ranges	$\bar{x} \pm sd$	Ranges	
Major cheliped	Width	14.1±8.64	2.8-34.4	11±5.03	2.1-22.8	6.24*
	Height	7.03±4.47	1.5-16.9	5.3±2.44	1.1-10.5	6.78*
Minor cheliped	Width	12.7±7.96	2.5-31.5	9.70±4.54	2.1-20.5	6.44*
	Height	5.26±3.41	1.1-13.7	3.89±1.80	0.8-8.1	7.05*

⁽¹⁾ H₀: b=0 *p<0.0001

Discussion

The cheliped is a multifunctional organ that is mainly used on foraging, agonistic interactions and courtship behavior (Tsuchida and Fijikura, 2000). The cheliped structure and size of a particular species seem to be a result from the joint action of three broad selection pressures related to reproduction, agonistic behavior and food (Lee, 1995).

Several authors have attempted to associate cheliped morphology with specific adaptations related to feeding habit. The claws can be specialized for scraping algae from rocky shores, break mollusk shells, or carrying the sediments to the bucal cavity (Warner, 1977). Predators that prey only one type of food often possess more specialized feeding structures than predators with broader diets (Yamada and Boulding, 1998)

Abby-Kalio and Warner (1989) suggested that in most predatory brachyuran crabs, the crusher cheliped is on the right one. The mud crab *E. limosum* is an important predator of mollusks (Lee and Kneib, 1994), and the right handedness may facilitate handling of asymmetric prey, such as dextrogyrous gastropods (Vermeij, 1975; Lee, 1995). Similar results had already been obtained by Savage and Mcmathan (1968) for *M. mercenaria*, by Skilleter and Anderson (1986) for *O. truncatus*, by Vannini and Gherard (1988) for *E. smithi*, by Góes and Fransozo (1998) for *E. gonagra*, and by Negreiros-Fransozo and Fransozo (in press) for *P. austrobesus*.

Guimarães (2002) observed that the cheliped shape of *E. limosum* can be clearly distinguished after the 4th juvenile stage under laboratory conditions and found that most crabs were right handed. In this study, it was found that the incidence of right handed crabs decreases with increasing size, suggesting that handedness may be associated to age. Hamilton *et al.* (1976) had also observed this pattern in *C. sapidus* and pointed that these ontogenetic differences in cheliped laterality may be associated to a reversal caused by autotomy and regeneration, or merely due to spontaneous reversal at molting. Simonson (1985) observed in crabs reared from eggs that when their crusher chelipeds were experimentally removed, 88% of juvenile *Menippe mercenaria* reversed handedness within the first regenerative molt. Among larger crabs in natural populations, the variation of handedness incidence is most likely dependent on the

ability of individuals to survive without a crusher cheliped (Haefner, 1990).

The functional significance of morphological traits evolved with the reproductive process has been extensively used in the relative growth studies. According to Hartnoll (1974, 1982), allometric changes are related to some ontogenetic events, usually coinciding with the maturation of gonads. The cheliped allometry is one of the parameters commonly used for relative growth analyses, because some species show a discontinuity in cheliped allometry caused by the puberty molt (Haley, 1969; Lewis, 1977). However, the allometry growth of chelipeds in *E. limosum* does not allow to identify the size at sexual maturity (Guimarães and Negreiros-Fransozo, 2002).

The *E. limosum* sexual dimorphism based on chelipeds is restricted to the size, with differential growth rate between male and female chelipeds. According to Hartnoll (1974), the chelipeds allometry can be related to their function. Probably, the absence of allometric evidence, indicating the occurrence of the puberty molt is because in *E. limosum* the cheliped function is not closely related with reproduction as in other species. Therefore, the cheliped sexual dimorphism in *E. limosum* can be more related to their feeding habit, rather than reproductive traits.

Kneib and Weeks (1990) studied the feeding habit of *E. limosum* at a Sapelo Island salt marsh. They found that dimorphism is restricted to size, not to shape. Therefore, detailed behavioral studies should be performed to explain this sexual dimorphism.

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