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RELATIVE GROWTH OF *Eriphia gonagra* (FABRICIUS, 1781) (CRUSTACEA, DECAPODA, XANTHIDAE) IN UBATUBA, STATE OF SÃO PAULO, BRAZIL

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ABSTRACT

Aspects related to relative growth of the Brachyura have been approached to document standard allometry, the puberty moult and the identification of the species, by the equation $y = a.x^b$ The relative growth of *Eriphia gonagra* has been analysed in order to infer about their puberty moult. This species lives in the intertidal zone, where it is found among rock stones and in burrows, from North Caroline (U.S.A) down to Santa Catarina (Brazil). The crabs were monthly collected between January and December, 1993, from Praia Grande beach, Ubatuba, São Paulo, Brazil. The independent variable used was the carapace width; 518 individuals were measured. In most relations, *E. gonagra* showed isometric growth, with the exception of the gonopod length in males and the abdomen width in females. We can suggest that sexual maturity for this species occurs at about 17 mm carapace width in males and 20 mm in females. Through this macroscopic study in connection with gonad histology, we could partly elucidate aspects of the species reproductive strategy.

Keywords: *Eriphia*, crab, relative growth.

INTRODUCTION

The stepwise growth of crustaceans (*cf.* Volpato, 1985) usually allows to correlate some specific moult with attaining sexual maturity and also to follow any allometry in development of various body parts.

The relation between one body dimension and the dimension of one appendage is considered as "relative growth", whereas during growth certain body dimensions may grow more than others (Hartnoll, 1974).

The first studies were carried out by Huxley (1931) and Teissier (1933). Relative growth in brachyurans can also be used for species identification (Barnes, 1968; Huber, 1985; Clayton, 1990) or to establish their sexual maturity (Haley, 1969; Finney & Abele, 1981; Du Preez & Mclachlan, 1984).

The relative growth is described by the function $y = a.x^b$ (Huxley & Teissier, 1936; Teissier, 1960), known as the equation of allometric growth, where a and b are constants. When the growth constant $b < 1$, there is negative allometric growth, when $b = 1$ isometry occurs, and when $b > 1$, it is considered positive allometric growth (Hartnoll, 1974, 1982).

In Brazil, a lot of studies focusing on relative growth in brachyurans have been performed such as those on *Hepatus pudibundus* by Mantelatto & Fransozo (1994), *Arenaeus cribrarius* by Pinheiro & Fransozo (1993), *Epialtus*

brasiliensis by Negreiros-Fransozo et al. (1994), and *Acanthonyx scutiformis* by Hiyodo & Fransozo (1995).

In brachyurans, aspects related to their growth have been approached, as well as the various morphometric relations used to evidence the pattern of allometry. These aspects can also be very important in sexual differentiation between the species, as well as in clarifying the passage from young to adult through the puberty moult evidences.

According to the observations *in loco*, *E. gonagra* inhabits the intertidal zone, where it can be found in rock gaps and in natural burrows created by the overlapping of rocks in the habitat. It is occasionally exposed by the tides, being also found in association with sand reefs formed by Polychaeta of the family Sabellariidae.

The geographical distribution of this species is restricted to the Western Atlantic, from North Carolina in the United States down to Santa Catarina, Brazil (Melo, 1985).

The objective of the present study is to analyse the relative growth of *E. gonagra*, focusing on the morphometrical relationship of carapace length (CL) and/or carapace width (CW) with the dimensions of other appendages. Analyses of these parameters enable characterisation of the levels of allometry as well as to make inferences about the sizes at which males and females reach sexual maturity, thus evidencing their puberty moult.

MATERIAL AND METHODS

The crabs used in this study were monthly collected from January to December, 1993, on the rocky shore of Praia Grande beach (23°28'02"S 45°03'35"W) in Ubatuba, State of São Paulo, Brazil. After collecting, the animals were separated, frozen, and transported to the laboratory on the Botucatu campus of São Paulo State University.

Body dimensions were measured with a pair of precision callipers, with an accuracy of 0.5 mm. A stereomicroscope with camera lucida was used to measure the small size class animals and the gonopods. The measurements included: carapace width (CW), carapace length (CL), abdomen width (AW) of the fifth somite of females and of the third somite of males, gonopod length (GL), the exopodite of the first pair of pleopods and length (MPL) and height (MPH) of the major propodus (Fig. 1).

Regressions were made in order to establish the level of allometry by using the $y = a.x^b$ and the program of Somerton (1980).

For values of b very near unity, the patterns established for isometry followed those used by Kurata (1962), Kuris & Carlton (1977), and Clayton (1990). Accordingly, values of b between 0.90 and 1.10 were considered isometric.

In all, measurements of 518 individuals were taken; their carapace width (CW) was token as the independent variable (X).

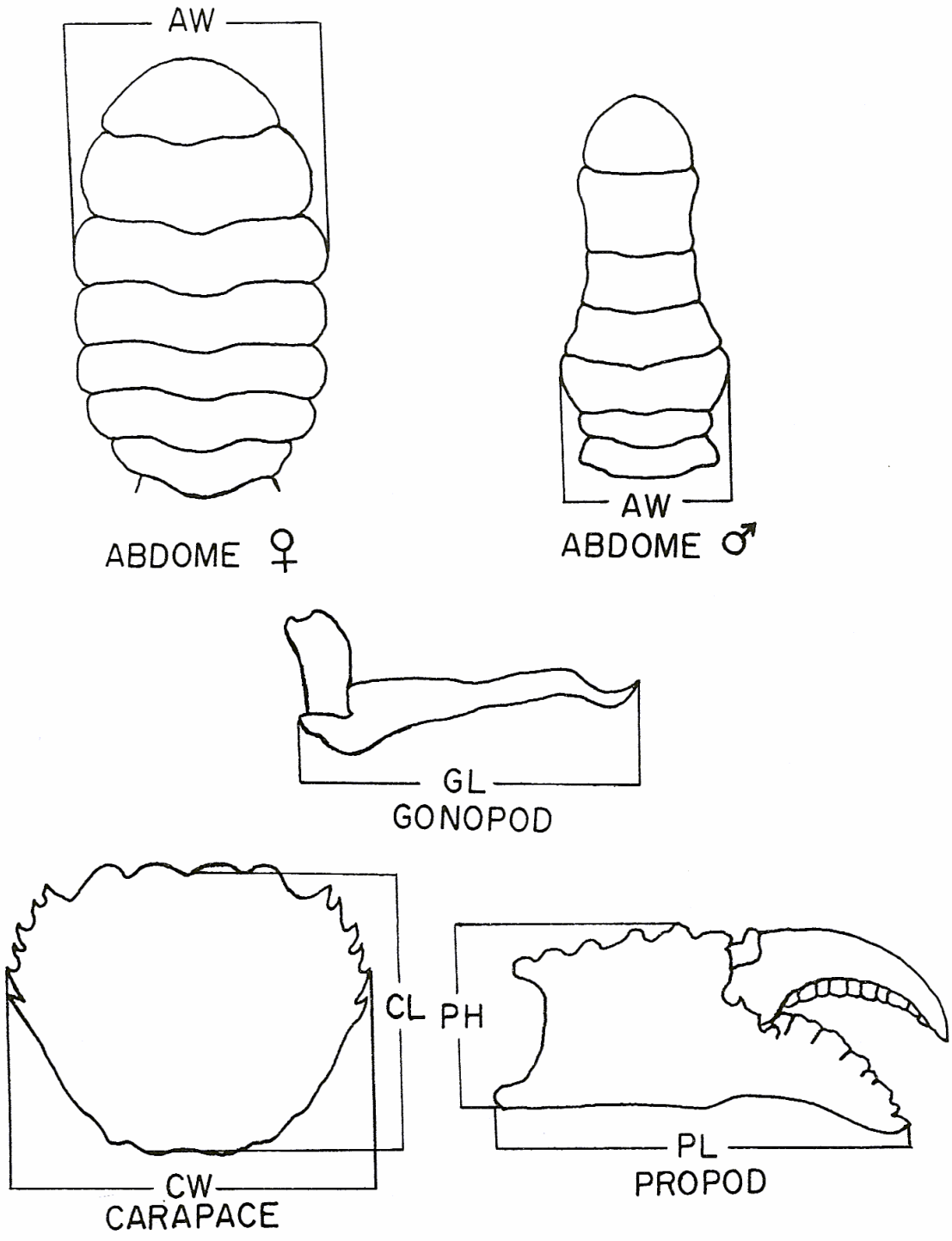

Fig. 1 - *Eriphia gonagra*. Position of the morphometric variables measured in the carapace (carapace width (CW) and carapace length (CL)), abdomen width (AW), gonopod length (GL) and propodus (propodus length (PL) and propodus height (PH)).

RESULTS

Throughout this investigation, *E. gonagra* showed, in most relations, an isometric pattern, as shown in table 1. From the graphs, it can be observed that the species does not present any remarkable difference in passing from the young phase into the adult, so for differentiation of growth stages the methodology of Somerton (1980) was employed.

Table 1 shows, that the only variables which present positive allometry are Gonopod Length (GL) for the males and Abdomen Width (AW) for the females.

For the males, an inclination of the straight line around 16.7 mm (Fig. 2) was found. For the females an overlap of the straight lines was indicated, determining a 17.3 to 24.6 mm range, with a 19.7 mm mid-point (Fig. 3). Acknowledge these results, other regressions were carried out based on the fact that males smaller than 16.7 mm were considered young, larger than that size considered adults. For females, 19.7 mm was the mid-point separating these two categories: specimens below this size were considered young and above that size adult.

DISCUSSION

It seems correct to assume that changes in growth rate do occur during maturation, because of the production and storage of reproductive products (Finney & Abele, 1981).

It is assumed that the relation CL x CW maintains the same isometry pattern for both growth phases in a large group of species, suggesting that this pattern is the most common among brachyurans (table 2). It is important to point out that for *Eriphia gonagra*, during its ontogeny, variations do occur when compared to the measurements of the length and the width up to the 5th juvenile stage. Only after this instar, these proportions stabilise, when the length corresponds to about 70% of the width (Fransozo & Negreiros-Fransozo, 1987).

In the current study, the growth phases reported by Hartnoll (1982) could only be evidenced with the program by Somerton (1980), as *E. gonagra* showed an isometric growth in most relations investigated.

For the females, the relation AW x CW indicates an overlap between the phases, determining a 17.3 to 24.6 mm range with a 19.7 mm mid-point. In a species where the puberal and post-puberal population are analysed independently, the discontinuity marks the puberty moult, ranging between the maximum and minimum size of the body in which the puberty moult occurs.

For the males, the growth pattern documented by GL x CW showed a distinct inflection among the points, indicating a puberty moult for *E. gonagra* around 16.7 mm CW, corresponding to 15th stage obtained by Fransozo (pers. comm.).

Under laboratory conditions, Fransozo (1987) detected a sexual differentiation in *E. gonagra* from the 4th juvenile stage onward through the phase in which secondary sexual characteristics become apparent. Using the mathematical model proposed by Negreiros-Fransozo & Fransozo (1991) for

Table 1. *Eriphia gonagra* - Regression analyses of morphometric data. Carapace width (CW) was used as the independent variable. (AW = abdomen width; MPL = length major propodus; MPH = height major propodus; gonopod length (GL) and carapace length (CL)).

Variable	Sex/ stage	N	Power Function $y = a \cdot x^b$	Logarithmic transformation $\ln y = \ln a + b \cdot \ln x$	r^2	Allometric Level
AW	JM	67	$AW = 0{,}247\ CW^{0{,}967}$	$\ln AW = -1{,}40 + 0{,}967\ \ln CW$	0,967	0
	AM	160	$AW = 0{,}256\ CW^{0{,}959}$	$\ln AW = -1{,}36 + 0{,}959\ \ln CW$	0,969	0
	MT	227	$AW = 0{,}243\ CW^{0{,}976}$	$\ln AW = -1{,}42 + 0{,}976\ \ln CW$	0,989	0
	JF	96	$AW = 0{,}0646\ CW^{1{,}47}$	$\ln AW = -2{,}74 + 1{,}47\ \ln CW$	0,955	+
	AF	176	$AW = 0{,}132\ CW^{1{,}27}$	$\ln AW = -2{,}02 + 1{,}27\ \ln CW$	0,964	+
	FT	272	$AW = 0{,}0633\ CW^{1{,}48}$	$\ln AW = -2{,}76 + 1{,}48\ \ln CW$	0,987	+
MPL	JM	71	$MPL = 0{,}648\ CW^{1{,}05}$	$\ln MPL = -0{,}433 + 1{,}05\ \ln CW$	0,988	0
	AM	138	$MPL = 0{,}597\ CW^{1{,}07}$	$\ln MPL = -0{,}515 + 1{,}07\ \ln CW$	0,973	0
	MT	209	$MPL = 0{,}661\ CW^{1{,}04}$	$\ln MPL = -0{,}413 + 1{,}04\ \ln CW$	0,993	0
	JF	91	$MPL = 0{,}710\ CW^{1{,}01}$	$\ln MPL = -0{,}342 + 1{,}01\ \ln CW$	0,979	0
	AF	157	$MPL = 0{,}757\ CW^{0{,}990}$	$\ln MPL = -0{,}278 + 0{,}980\ \ln CW$	0,933	0
	FT	248	$MPL = 0{,}747\ CW^{0{,}995}$	$\ln MPL = -0{,}291 + 0{,}993\ \ln CW$	0,989	0
MPH	JM	71	$MPH = 0{,}447\ CW^{0{,}987}$	$\ln MPH = -0{,}806 + 0{,}987\ \ln CW$	0,984	0
	AM	243	$MPH = 0{,}399\ CW^{1{,}01}$	$\ln MPH = -0{,}919 + 1{,}01\ \ln CW$	0,964	0
	MT	214	$MPH = 0{,}444\ CW^{0{,}988}$	$\ln MPH = -0{,}812 + 0{,}988\ \ln CW$	0,991	0
	JF	91	$MPH = 0{,}447\ CW^{0{,}985}$	$\ln MPH = -0{,}805 + 0{,}985\ \ln CW$	0,989	0
	AF	157	$MPH = 0{,}457\ CW^{0{,}972}$	$\ln MPH = -0{,}784 + 0{,}972\ \ln CW$	0,934	0
	FT	248	$MPH = 0{,}469\ CW^{0{,}965}$	$\ln MPH = -0{,}756 + 0{,}965\ \ln CW$	0,991	0
GL	JM	55	$GL = 0{,}0785\ CW^{1{,}54}$	$\ln GL = -2{,}54 + 1{,}54\ \ln CW$	0,959	+
	AM	162	$GL = 0{,}378\ CW^{0{,}982}$	$\ln GL = -0{,}973 + 0{,}982\ \ln CW$	0,983	0
	MT	217	$GL = 0{,}210\ CW^{1{,}16}$	$\ln GL = -1{,}56 + 1{,}16\ \ln CW$	0,977	+
CL	JM	73	$CL = 0{,}721\ CW^{0{,}996}$	$\ln CL = -0{,}326 + 0{,}996\ \ln CW$	0,988	0
	AM	162	$CL = 0{,}747\ CW^{0{,}980}$	$\ln CL = -0{,}292 + 0{,}980\ \ln CW$	0,994	0
	MT	235	$CL = 0{,}748\ CW^{0{,}980}$	$\ln CL = -0{,}291 + 0{,}980\ \ln CW$	0,997	0
	JF	99	$CL = 0{,}756\ CW^{0{,}979}$	$\ln CL = -0{,}281 + 0{,}979\ \ln CW$	0,991	0
	AF	175	$CL = 0{,}813\ CW^{0{,}953}$	$\ln CL = -0{,}207 + 0{,}953\ \ln CW$	0,990	0
	FT	274	$CL = 0{,}782\ CW^{0{,}964}$	$\ln CL = -0{,}246 + 0{,}964\ \ln CW$	0,997	0

JM = juvenile male; AM = adult male; MT = male total; JF = juvenile female; AF = adult female; FT = female total; N = number of individuals; 0 = Isometry; + = positive allometric.

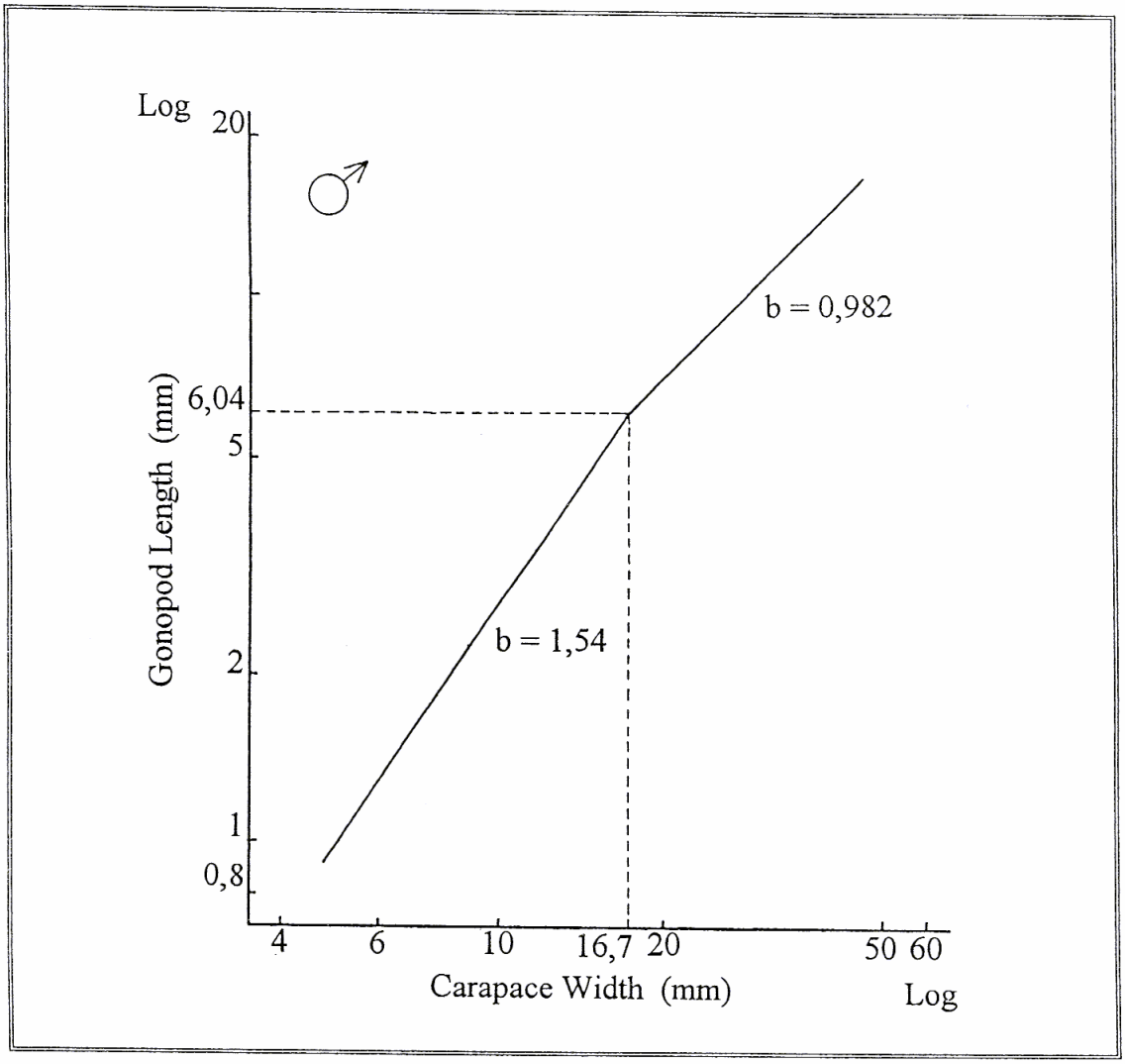

Fig. 2 - *Eriphia gonagra*. Male morphometric relation between gonopod length (GL) and carapace width (CW); total males (N = 217).

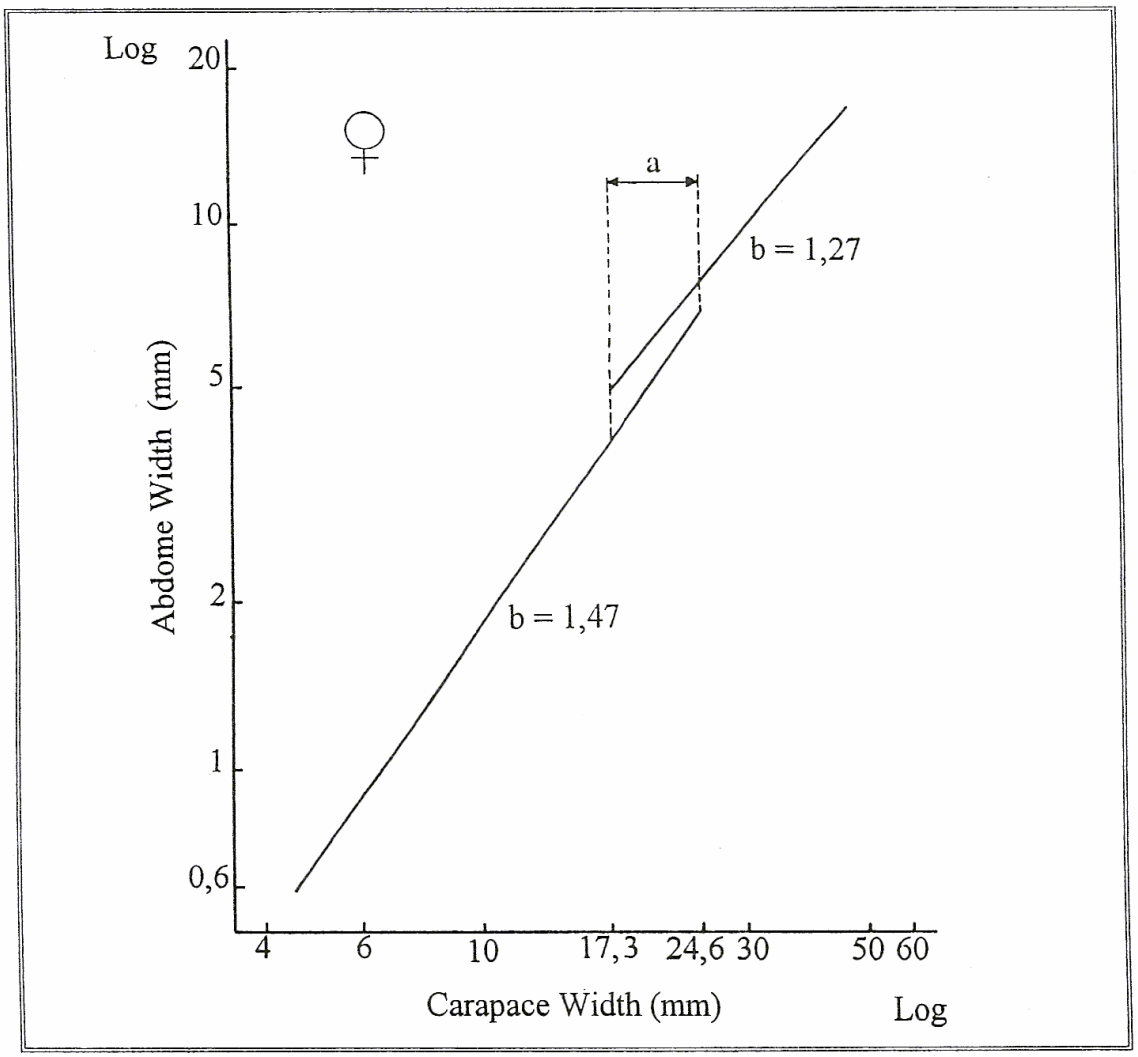

Fig. 3 - *Eriphia gonagra*. Female morphometric relation between abdomen width (AW) and carapace width (CW); total females (N = 272); a = puberty moult.

Table 2. *Eriphia gonagra*. Growth constant values ("b") between carapace length (CL) and carapace width (CW), for some brachyuran species.

Family / Species	Author	Males			Females		
		Juvenile	Adult	Total	Juvenile	Adult	Total
Portunidae							
Callinectes ornatus	Haefner (1990)	---	---	1,03	---	---	1,02
Arenaeus cribrarius	Pinheiro & Fransozo (1991)	1,02	0,98	1,00	0,99	0,98	1,02
Portunus spinimanus	Santos et al. (1995)	0,94	0,94	0,95	1,05	0,95	0,99
Majidae							
Acanthonyx scutiformis	Hiyodo & Fransozo (1995)	---	---	0,99	---	---	0,98
Xanthidae							
Trapezia ferruginea	Huber (1985)	---	---	0,977	---	---	1,027
Trapezia corallina	Huber (1985)	---	---	0,892	---	---	0,942
Trapezia formosa	Huber (1985)	---	---	0,977	---	---	1,043
Eriphia smithii	Vannini & Gherardi (1988)	0,996	0,942	---	1,068	0.949	---
Eriphia gonagra	(present study)	0,996	0,980	0,980	0,979	0,953	0,964

juvenile growth of *E. gonagra*, it can be inferred that, on an average, 16.7 mm CW males are 441 days old, enough for their sexual maturity to have been reached. Nevertheless, it is believed that males of this species do not take so long (about 1.2 years) to reach their sexual maturity under natural conditions, as laboratory conditions become limiting from a certain phase and data can not be compared.

For females, the overlapping range of the straight line from 17.3 to 24.6 mm is an indicator that females have their sexual maturity very near the size obtained for males, as the smallest ovigerous female found reached 20.20 mm CW. Based on the principle that the average moult increment obtained by Negreiros-Fransozo & Fransozo (1991) for *E. gonagra* was established as 15.56%, the smallest ovigerous females found had around 17.5 mm CW, just before their puberty moult.

In this study, *E. gonagra* showed positive allometric growth for the young and an isometric growth for the adults for GL x CW, something very similar to the results obtained by Hartnoll (1965a) for *Aratus pisonii* and different from *E. smithi* studied by Vannini & Gherardi (1988), as shown in table 3. Crabs commonly present remarkable abdominal growth during their ontogeny, since in females this structure functions for carrying/protecting eggs, whereas in males it is merely a protection for the gonopods (Mackay, 1943).

Table 3. *Eriphia gonagra*. Growth constant values ("b") between gonopod length (GL) and carapace width (CW), for some brachyuran species.

Family/Species	Author	Males		
		Juvenile	Adult	Total
Ocypodidae				
Ocypode quadrata	Haley (1969)	---	1.06	---
Grapsidae				
Aratus pisonii	Hartnoll (1965a)	1.5	0.96	---
Xanthidae				
Eriphia smithi	Vannini & Gherardi (1988)	2.037	1.168	---
Eriphia gonagra	(present study)	1.54	0.982	1.16

Concerning the abdomen of *E. gonagra* males, this growth pattern was not apparent. Whereas in the females an abdominal size change was observed, presenting a much higher positive allometry in young than in adults. Differently from the males, the females have four pairs of pleopods that need to grow in the maturity phase to attach the eggs to; therefore it can be suggested that the continuity of the positive allometry in the adult phase in females is related to this aspect.

E. gonagra females kept the same pattern when compared with other species. In most cases, they showed a high positive allometry in the young phase and less evident allometry or isometry when adult (table 4).

In both sexes and growth phases of *E. gonagra* the relations with the propodus tend to isometry. When males are compared, it can be noted that this growth occurs differently from that of other brachyurans. In literature, only *Ocypode saratan* follows the same pattern as the here studied species (table 5). For the females, the established isometry is common in most cases. Therefore, it can be concluded that for *E. gonagra* the dimensions of the propod are not a good indicator of the puberty moult.

Concerning the beginning of their sexual activity, it can be inferred that the males of this species reach the puberty moult around 17 mm CW, characterising a morphological maturity, but not necessarily a physiological one. The females can be morpho-physiologically mature around 19 mm CW. Because of the protection, courting, agonistical behaviour, etc., it is believed that males reach their maturity before females. Therefore, it can be suggested that morphological maturity is attained around 17 mm CW for males and 19 mm for females, corroborating the study of Vannini & Gherardi (1988) which settled sexual maturity for *E. smithi* around 19 mm CW for both sexes. Such inference is based on the biometric analysis, which can only be confirmed after macroscopic and/or histological study of the gonads.

E. gonagra shows isometric growth for most of the analysed relationships. However, in the analyses of the gonopod and the abdomen, remarkable changes during the ontogeny were observed, indicating that their growth is closely connected to reproductive aspects. The size of sexual maturity of individuals is merely an estimate, as the procedures used are not adequate predict maturation more precosely . Only the examination of the reproductive system and the use of production rates, will allow to infer more about the significance of size in establishing their sexual maturity (Finney & Abele, 1981).

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Table 4. *Eriphia gonagra*. Growth constant values ("b") between abdomen width (AW) and carapace width (CW), for some brachyuran species.

Family / Species	Author	Males			Female		
		Juvenile	Adult	Total	Juvenile	Adult	Total
Portunidae							
Portunus pelagicus	Prasad & Tampi (1954)	0,99	0,99	---	1,21	1,52	---
Arenaeus cribrarius	Pinheiro & Fransozo (1993)	1,05	0,98	0,99	1,33	1,18	1,74
Portunus spinimanus	Santos et al. (1995)	0,71	0,60	0,64	1,12	1,47	1,63
Calappidae							
Hepatus pudibundus	Mantelatto & Fransozo (1994)	0,95	1,15	1,12	1,38	1,33	1,52
Majidae							
Acanthonyx scutiformis	Hiyodo & Fransozo (1995)	---	---	---	1,31	0,91	1,93
Epialtus brasiliensis	Negreiros-Fransozo et. al. (1994)	0,890	0,893	---	1,70	1,03	---
Grapsidae							
Aratus pisonii	Hartnoll (1965a)	---	---	---	1,4	1,0	---
Ocypodidae							
Ocypode quadrata	Haley (1969)	---	---	---	1,37	1,44	---
Xanthidae							
Eriphia smithii	Vannini & Gherardi (1988)	0,999	0,935	---	1,194	1,715	---
Eriphia gonagra	(present study)	0,967	0,959	0,976	1,47	1,27	1,48

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Table 5. *Eriphia gonagra.* Growth constant values ("b") between propodus length (PL) and carapace width (CW), for some brachyuran species.

Family / Species	Author	Males			Female		
		Juvenile	Adult	Total	Juvenile	Adult	Total
Portunidae							
Portunus pelagicus	Prasad & Tampi (1954)	1,16	1,59	---	1,06	1,03	---
Arenaeus cribrarius	Pinheiro & Fransozo (1993)	1,09	1,26	1,20	1,10	1,09	1,08
Portunus spinimanus	Santos et al. (1995)	1,19	1,54	1,46	1,12	1,02	1,06
Calappidae							
Hepatus pudibundus	Mantelatto & Fransozo (1994)	0,85	1,25	1,17	0,94	1,03	1,08
Majidae							
Macrocoeloma trispinosum	Hartnoll (1965b)	1,30	1,42	---	1,08	0,95	---
Microphrys bicornutus	Hartnoll (1965b)	1,20	1,47	---	0,97	0,95	---
Mithrax sculptus	Hartnoll (1965b)	1,27	1,37	---	---	---	---
Stenorhynchus seticornis	Hartnoll (1965b)	1,40	1,65	---	1,25	1,17	---
Acanthonyx scutiformis	Hiyodo & Fransozo (1995)	1,15	1,03	1,47	---	---	---
Ocypodidae							
Ocypode saratan	Sandon (1937)	1,04	1,04	---	---	---	---
Ocypode quadrata	Haley (1969)	---	1,3	---	---	1,1	---
Grapsidae							
Sesarma bidentatum	Hartnoll (1964)	1,20	1,65	---	1,11	1,20	---
Sesarma ricordi	Hartnoll (1965a)	1,25	1,3	---	1,2	0,97	---
Xanthidae							
Eriphia gonagra	(present study)	1,05	1,07	1,04	1,01	0,990	0,995

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