SOMATIC GROWTH OF THE MUDFLAT FIDDLER CRAB *Uca rapax* (Smith, 1870) (Brachyura: Ocypodidae) FROM TWO SUBTROPICAL MANGROVES IN BRAZIL

CRECIMIENTO SOMÁTICO DEL CANGREJO VIOLINISTA *Uca rapax* (Smith, 1870) (Brachyura: Ocypodidae) DE DOS MANGLARES SUBTROPICALES DE BRASIL

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ABSTRACT. The crabs were collected monthly, from April 2001 to March 2002 in the mangroves of Itamambuca and Ubatumirim in Ubatuba, São Paulo, Brazil, using the procedure of catch per unit effort (cpue) during 15 minutes at low tide periods by digging the burrows. The sex and carapace width (mm) were recorded for each crab in a sample of 1 294 crabs in Itamambuca mangrove (667 males and 627 females) and 2 107 crabs in Ubatumirim (1 117 males and 990 females). The somatic growth herein described is based on analysis of frequency distributions in size classes using the von Bertalanffy's growth model. The growth curves based on the carapace width (mm) of males and females are described respectively by the equations: $Wt=23.9[1-e^{-0.21(t+0.87)}]$ and $Wt=23.8[1-e^{-0.16(t+1.18)}]$ in Itamambuca and $Wt=21.3[1-e^{-0.16(t+1.12)}]$ and $Wt=20.4[1-e^{-0..15(t+1.29)}]$ in Ubatumirim mangrove. The crabs from Itamambuca reached their maximum age in 1 620 days (males) and 1 800 days (females), while those from Ubatumirim, required 1 440 days (males) and 1 560 days (females).

Key words: somatic growth, *Uca rapax,* mangroves, age, subtropical region

RESUMEN. Los cangrejos se recolectaron mensualmente durante 15 minutos durante el período de marea baja, desde abril 2001 hasta mayo 2002, en los manglares de Itamambuca y de Ubatumirim, en Ubatuba, São Paulo, Brasil. El sexo y el ancho del caparazón (mm) fueron medidos para cada cangrejo en una muestra de 1 294 cangrejos in Itamambuca (667 machos y 627 hembras) y 2 107 cangrejos en Ubatumirim (1 117 machos y 990 hembras). El crecimiento somático fue determinado por medio del análisis de distribucion de frecuencias por clase de talla utilizando el modelo de crecimiento de von Bertalanffy. Las curvas de crecimiento obtenidas para machos y hembras fueron, respectivamente: $Wt=23.9[1-e^{-0.21(t+0.87)}]$ y $Wt=23.8[1-e^{-0.16(t+1.18)}]$ para Itamambuca y $Wt=21.3[1-e^{-0.16(t+1.12)}]$ y $Wt=20.4[1-e^{-0.15(t+1.29)}]$, para Ubatumirim. Los cangrejos violinistas de Itamambuca alcanzan su edad máxima a los 1 620 días (machos) y 1 800 días (hembras), mientras que los de Ubatumirim a los 1 440 días (machos) y a los 1 560 días (hembras).

Palabras clave: crecimiento somático, *Uca rapax,* manglares, edad, región subtropical

INTRODUCTION

Animal growth has been described as the measurable increase in weight or length. Such increase results from a balance of the anabolic and catabolic processes, being growth a phenomenon extremely heterogeneous and complex, widely dependent of external factors (von Bertalanffy 1938).

The relationship between a measure of length and age of individuals is described by a growth curve (Santos 1978). The determination of such a curve is of fundamental importance for the analysis of the population structure of species, as the parameters derived from the growth curve can provide information concerning the maximum size and age reached by the organisms, the growth rate and the reproductive period (Valenti *et al.* 1987). Also, the growth curves can help us to improve our understanding of some species life cycle patterns.

In spite of crustaceans have a tegument that facilitates the measurements, differences in growth between sexes and developmental phases (e.g. juvenile and adult) have been observed (Hartnoll 1978). Crustaceans lack structures allowing determining age marks as in other organisms (e.g. fishes, trees). Therefore, the interpretation of the trends of the size frequency distribution graphs and the shifts in time can be useful tools to estimate the growth, age and recruitment of individuals in a certain region (Pinheiro 1991). The model most commonly used to describe the crustacean growth was described by von Bertalanffy (1938), which showed the best fit to empiric data. As asserted by Munro (1982), the von Bertalanffy model can also show reliable results in relation to the body size-weight in function of age.

The references that describe growth in brachyurans are scarce with a few exceptions, namely D'Incao *et al.* (1993) for *Chasmagnathus granulata* Dana, 1852; Cracco and Fontoura (1996) for *Cyrtograpsus angulatus* Dana, 1851; Flores & Negreiros-Fransozo (1998) for *Pachygrapsus transversus* (Gibbes, 1850); Branco *et al.* (2002) for *Portunus spinimanus* (Latreille) and Lee and Hsu (2003) for *Portunus sanguinolentus* (Herbst, 1783).

The mudflat fiddler crab *Uca rapax* (Smith, 1870) is one of the most abundant species of the genus *Uca* inhabiting mud galleries and muddy sand in tropical and subtropical mangroves in South Western Atlantic coast. According to Melo (1996) this species is distributed from Florida, throughout Gulf of México, the Antilles, Venezuela and south of Brazil (from Pará to Santa Catarina State).

This study analyzes the somatic growth, the relation between size and age of *U. rapax*, from two mangrove forests of the São Paulo northern coast, Brazil, as a contribution to population dynamics of this species.

MATERIAL AND METHODS

The specimens of mudflat fiddler crabs were collected monthly by two people from April 2001 to May 2002 in the mangroves of the Cavalo river (Itamambuca beach) (23° 24'43"S and 45° 00'73"W) and the Ubatumirim river (Ubatumirim beach) (23° 20'17.8"S and 44° 53'22"W), using the procedure of catch per unit effort (cpue) during 15 minutes at low tide periods by digging the burrows.

The Itamambuca mangrove vegetation consists only of *Laguncularia racemosa* (Linnaeus). According to Colpo & Negreiros-Fransozo (2003) the tree density in Itamambuca reaches 1 250 trees/ha, with a mean height of 4.8 m and mean diameter at breast height 6 cm. In contrast (Negreiros-Fransozo, 2 003 pers. comm.), in Ubatumirim mangrove there is also *Avicennia shaueriana* Stapf. and Leech, but at a low frequency; this mangrove has 6 250 trees/ha, with a mean height of 10.6 m and mean diameter at breast height 4.7 cm.

The sex composition was recorded and carapace width of each crab was measured with a caliper (with a 0.1 mm resolution).

The carapace growth of males and females was estimated separately by means of the displacement of the modal frequencies obtained every two months of sample at the absolute frequency distribution by interval classes of carapace width (MacDonald & Pitcher 1979; MacDonald 1987). The modal values of the carapace width frequency distribution was calculated according to Spiegel (1979) by the equation Mode = $L_1 + (\Delta_1 / \Delta_1 + \Delta_2)$ C; where L_1 = inferior limit of modal class; Δ_1 = excess of modal frequency/inferior class; Δ_2 = excess of modal frequency/superior class; C = amplitude of the modal class interval.

The carapace width curve growth was described by the von Bertalanffy model (von Bertalanffy 1938) Wt = W∞ [1 Wt = W. [1-exp(-k(t + t_0))]; where Wt = median carapace width of crabs at age *t;* W∞ = asymptotic carapace width reached by crabs; e = natural logarithm; k = age-specific growth rate; t = age of crabs; t_0 = parameter related to the size of the crab at the birth.

The growth curves were fitted using the Ford-Walford method (Walford 1946) for equal time interval among samples. Through resultant linear regression the W∞, k e t_0 was calculated using the follow equations according to Fabens (1965): (1) $t_0 = k^{-1}$. ln (W∞ - W_0) / W∞, and (2) W∞ = a / (1-b); where k = - lnb and "a" and "b" are parameters of regressions transformed by Ford-Walford method (Walford 1946).

The growth curves obtained for males and females from both mangroves were linearized by method proposed by Allen (1976): Wt = a – b. r^t-, where a = C∞; b = C∞ . e $^{k.to}$; r median = (e^{-k} male + e^{-k} female) / 2. In such transformation, the dependent variable was calculated by means of carapace width and the straights of males and females of the same

mangrove and among the different mangroves was compared using a covariance analysis (ANCOVA; α=5 %) (Zar 1996).

RESULTS

A total of 1 294 specimens of *Uca rapax* was sampled in the Itamambuca mangrove during a year (April 2001 to May 2002), being 667 males and 627 females, while in the Ubatumirim mangrove 2 107 crabs, being 1 117 males and 990 females, were collected.

The carapace width ranged from 4.0 to 26.6 mm for males and from 3.9 to 25.5 mm for females in Itamambuca, while in Ubatumirim the males showed carapace width amplitude from 3.5 to 24.9 mm and the females from 3.6 to 22.5 mm. The median size of the analyzed specimens was 15.9 mm (males) and 13.0 mm (females) for Itamambuca and 14.9 mm (males) and 13.4 mm (females) for Ubatumirim populations. The Mann-Whitney test showed that median size of the crabs from Itamambuca mangrove was greater than from Ubatumirim (p<0.05). There was significant difference in the median size (p<0.05) between males and females from both mangroves: males reached larger sizes than females.

The frequency distributions in size classes at the Itamambuca and Ubatumirim mangroves are showed respectively, in Figures 1 and 2. In both frequency distributions a higher juvenile frequency in April-May 2001 was observed. In this sense, the growth was followed starting from such months.
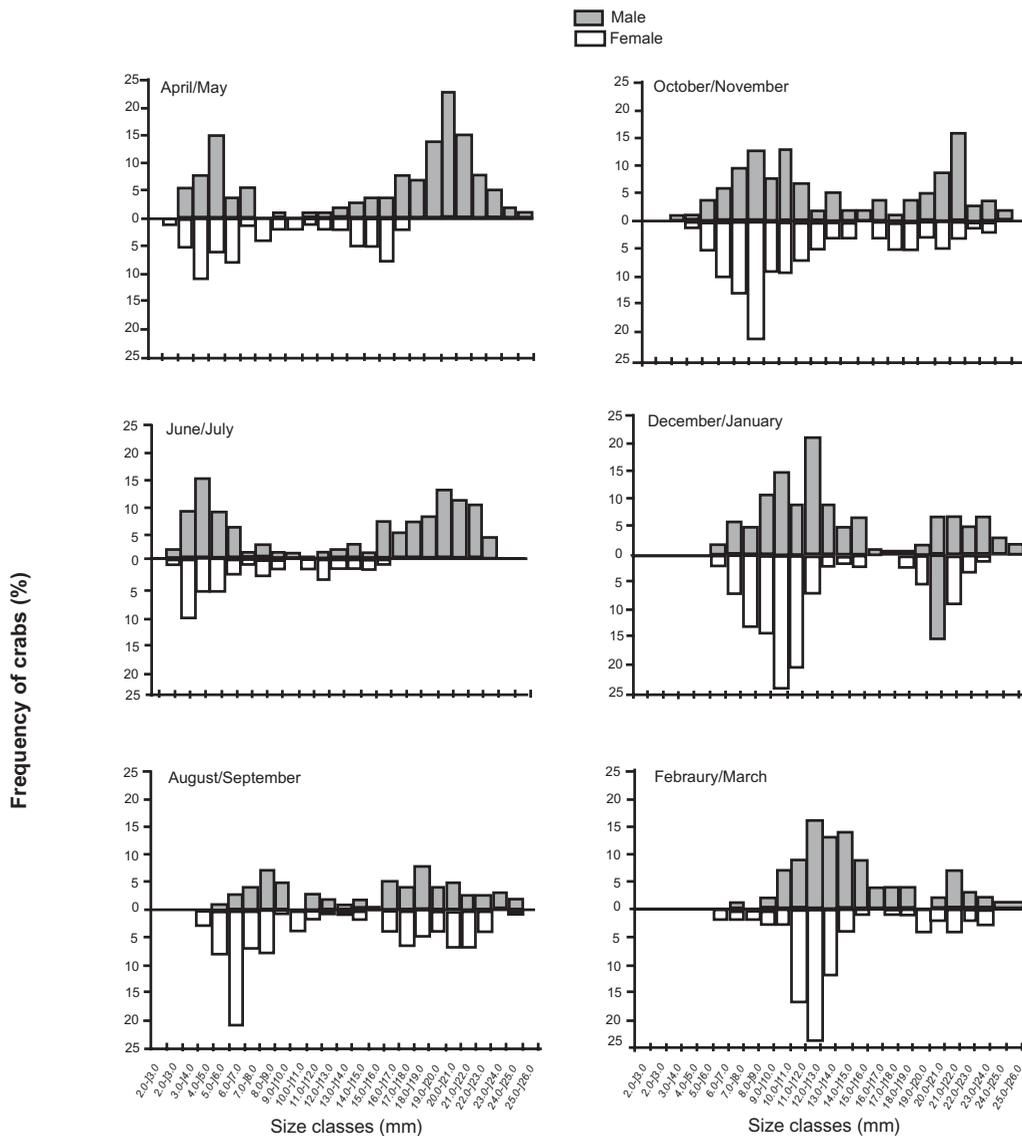

Figure 1. Absolute frequency distributions of carapace width of *Uca rapax* for males and females from Itamambuca mangrove.
Figura 1. Distribución de frecuencia del ancho del caparazón de *Uca rapax* paa machos y hembras del malglar de Itamambuca.
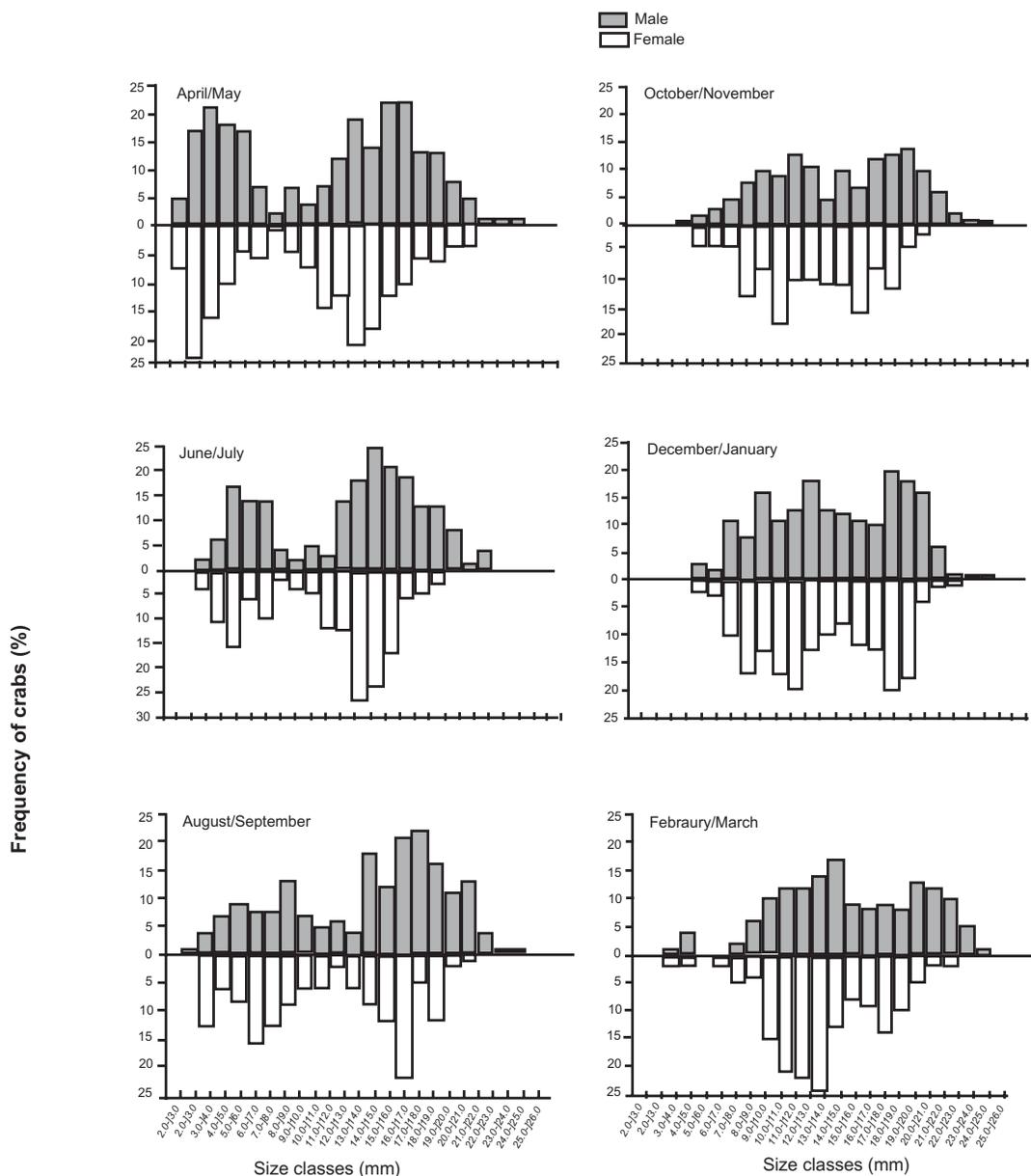
Figure 2. Absolute frequency distributions of carapace width of *Uca rapax* for males and females from Ubatumirim mangrove.
Figura 2. Distribución de frecuencia bi-mensual de la anchra del caparazón de *Uca rapax* para machos y hembras del manglar de Ubatumirim.

The frequency distribution histograms based on carapace width of crabs from both populations showed marked modes for the age groups along the sampling period. Two age groups were evidenced from April-May, 2001, which represented a new generation of juvenile crabs (recruitment) and other with the adult crabs. The juvenile frequencies decreased throughout the year period, while the adult frequencies maintained the same pattern. The modes of the frequency distributions used for the calculation of growth curves of males and females are show in Table 1.

The growth curves (Figure 3) in carapace width for males and females are described in the following equations:

Table 1. Modes (mm) of *Uca rapax* used in the estiration of the growth curves for males and females from Itamambuca and Ubatumirim mangroves.
Tabla 1. Modas (mm) de *Uca rapax* utilizadas en el cálculo de las curvas de crecimiento de machos y hembras de los manglares de Itamambuca y Ubatumirin.

Itamambuca		Ubatumirim	
Males	Females	Males	Females
6.39	4.66	5.57	4.69
9.5	7.48	6.78	6.33
12.7	9.4	9.45	7.73
14.5	11.71	12.66	11.5
16.4	13.37	13.5	12.3
		14.27	13.26

* Itamambuca:
  Males: $Wt = 23.9[1-e^{-0.21(t+0.87)}]$
  Females: $Wt = 23.8[1-e^{-0.16(t+1.18)}]$

* Ubatumirim:
  Males: $Wt = 21.3[1-e^{-0.16(t+1.12)}]$
  Females: $Wt = 20.4[1-e^{-0.15(t+1.29)}]$

The values of "k" showed that males' grow more than females (males: k=0.21; females k=0.16), but attain similar size (W∞) in Itamambuca (males: 23.9 mm; females: 23.8 mm) (Table 2). However, males and females grow with the same intensity (males: K=0.16; females: K=0.15), but the males attain higher sizes than females in Ubatumirim (males: 21.3 mm; females: 20.4 mm) (Table 2).
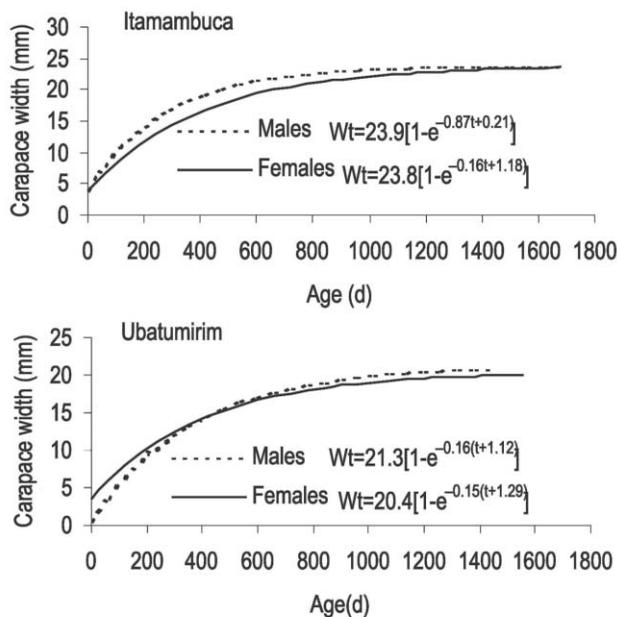

Figure 3. Growth curve in carapace width of *Uca rapax* crabs from the Itamambuca (A) and Ubatumirim (B) mangroves (Wt= median carapace width of the crabs at the age.
Figura 3. Curva de crecimiento de *Uca rapax* basada en el ancho del caparazón para cangrejos de los manglares de Itamambuca y Ubatumirim (Wt = ancho medio del caparazón de cangregos de la edad t).

Table 2. Maximum asymptotic carapace width (W∞ - mm) and growth rate parameter (k) of *Uca rapax,* for males and females from Itamambuca
Tabla 2. Asintota máxima del ancho del caparazón y parámetro de la tasa de crecimiento (k) de *Uca rapax* para machos y hembras de los manglares de Itamambuca y Ubatumirim.

| Mangroves | Males | | Females | |
	W∞	k	W∞	k
Itamambuca	23.9	0.21	23.8	0.16
Ubatumirim	21.3	0.16	20.4	0.15

The analysis of comparison of the growth linearized curve show that through modal progression it may be perceived a differentiated growth among individuals from different sex and such to treat the male and female growths in distinct curves (p<0.05). It was also observed that males and females show different rates of growth (k) for each mangrove population, with males and females from Itamambuca attaining larger sizes than Ubatumirim mangrove (p<0.05).

DISCUSSION

The higher body dimensions showed by males and females of *U. rapax* in Itamambuca are probably due to the fact this mangrove presented a high productivity and high organic matter drift at the substratum (Castiglioni & Negreiros-Fransozo, *in press*). Thus, the Itamambuca mangrove contributes to the fiddler crabs species, which live in this mangrove to attain great sizes due to the high food availability, once, that this species feed on organic matter available in the sediment, which is a result of the decomposition of plants and animals.

Growth curves analysis revealed that males and females from Itamambuca population live nearly four years and five months (1 620 days) and five years (1 800 days), respectively. At the mangrove of Ubatumirim males live four years (1 440 days), while females four years and three months (1 560 days). Montague (1980) observed that fiddler crabs from temperate zones rarely live more than two years, but *U. pugnax* (Smith, 1870) may live for more than four years.

The individuals of a population grow in an asymptotic way, with a dependent somatic growth rate resultant of the molts during ontogeny, what could be different for each sex (Vazzoler 1982). Analyzing the growth curves of *Uca rapax* it was observed that males and females attained similar sizes in Itamambuca mangrove, while males reached larger sizes than females in Ubatumirim. However, females presented higher longevity than males in both mangroves, which was also observed for the estuarine grapsid, *Chasmagnathus granulata* by D'Incao *et al.* (1983). The fact that *U. rapax* females presented higher longevity than males might be related to males behavior, since they remain more time exposed in the surface feeding, disputing territory and courtship the females (Christy & Salmon 1984, Caravello & Cameron 1987, Backwell *et al.* 2000) and in this way stand more susceptible to environment adversity and to predators. The sexual differences in age of such organisms can be also related to the habitat quality, food availability and physic or physiological stress (Bond & Buckup 1983).

The growth in crustaceans is usually similar between sexes until maturity (Hartnoll 1982). After that, the growth becomes slower in females than males due to an increasing of the intermolt period and a lower increment in size during the molts due to the process of production and incubation of

eggs, which has been recorded for *Chasmagnathus granulata* by D'Incao (1983), *Macrobrachium acanthurus* by Valenti *et al.* (1987) and *Portunus sanguinolentus* by Lee & Hsu (2003). However, in some Decapoda any growth after the molt that happens just before spawning (Mauchline 1977) is not observed. In the case of *Aegla platensis* Schmitt, they attained higher sizes than males probably due to the fact of the males migrate for other sites in the river (Bueno *et al.* 2000). The different growth between males and females of *U. rapax* can be due to higher investment in somatic growth for males, while the females spend an important account of their energies by the reproductive purpose. Consequently the males attain greater sizes than females as it was observed in this paper.

According to Hyman (1922) and Crane (1975) male and female crabs cannot be equally sensible to food supply due to the differences at the efficiency of foraging, assimilation or application of food or due to dominance of males or big crabs that can limit the availability of food resources to another crabs, doing with that a sex, consequently, attain higher dimensions that the opposite sex.

The different environment conditions which are subjects *U. rapax* populations, mainly organic matter content in the sediment, river and burrow water salinity and granulometric composition of the substrate (Castiglioni & Negreiros-Fransozo, *in press*) appear to act direct or indirectly in the population aspects, mainly in the growth, promoting variations in such process for different investigated populations.

ACKNOWLEDGEMENTS

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