

Physiologic Sexual Maturity of the Fiddler Crab *Uca rapax* (Smith, 1870) (Crustacea, Ocypodidae) from Two Mangroves in Ubatuba, Brazil

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ABSTRACT

The gonad development of *Uca rapax* was studied to achieve the size at onset of its sexual maturity. Crabs were sampled from April/2001 to March/2002 in the Itamambuca and Ubatumirim mangroves in Ubatuba, São Paulo, Brazil. The specimens were grouped in 10 size classes. Juveniles and adult crabs frequencies were assessed for each class. The size of carapace width in which 50% of males and females were considered mature was 14.8 and 12.1 mm (Itamambuca) and 13.6 and 11.4 mm (Ubatumirim), respectively for males and females. Males matured at higher sizes than females, probably due to a major investment in their somatic growth, while females spend their energy in the reproductive process, saving energy for eggs' production.

Key words: Maturity, *Uca rapax*, Ocypodidae, mangroves

INTRODUCTION

The set of morphological and physiological transformations whereby juveniles or immature individuals reach the ability to produce gametes and to act directly on the population structure is considered as the sexual maturity (Mantelatto and Fransozo, 1996). The onset of sexual maturity is related to a certain individual size, which varies considerably among populations and also in specimens of a same species (Fontelles-Filho, 1989). According to Hines (1989) the size at maturity and growth rate are important sources of geographic variation in the life history and population dynamics of brachyuran crabs. Crustaceans, due to presence of a rigid exoskeleton, need to change periodically their

tegument allowing growth. During the ecdysis process, modifications at the animal body structure can occur and some changes are related with sexual maturity that will be reached at the pubertal ecdise. The size in which the crustacean attains the sexual maturity, based at the external morphological alterations has been published (Brown and Powell, 1972; Lewis, 1977; Haefner, 1977, 1990; Conan and Comeau, 1986; Choy, 1988; Mantelatto and Fransozo, 1996; Góes and Fransozo, 1997 and Negreiros-Fransozo et al., 2003; Masunari and Swiech-Ayoub, 2003; Benetti and Negreiros-Fransozo, 2004; Masunari and Dissenha, 2005; Masunari et al., 2005).

According to Fontelles-Filho (1989), the sexual maturity can also be determined through physiological modifications (microscopic and/or

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macroscopic gonad size), by means the immature crabs will produce gametes. The functional maturity is reached when there is an actual capacity to release gametes. The complete gonad development and gametes liberation occur only after the pubertal ecdysis in brachyurans. Thus, the crab size at the physiological maturity should correspond to the functional maturity.

The existence (or not) of the synchrony in the external morphological maturity with gonad development is an aspect extensively discussed. The determination of the size at onset of sexual maturity is engaged when only external morphological aspects are considered, because some variations in body structures can not inform in a very accurate way the exact moment when a crustacean reaches the sexual maturity. Sastry (1983), Conan and Comeau (1986) and Choy (1988) stated that morphological maturity not necessarily corresponded to physiological maturity, a fact observed mainly in males, where they could show external characteristics of adults and internally the gonads were not developed yet or vice-versa.

The reproductive capacity of a certain crustacean species can be assessed by the study of sexual maturity (Hines, 1982). The size at onset sexual maturity in brachyurans can be evaluated considering comparative studies about physiological (gonad development) and morphological aspects (analysis of the body shape and size of some parts of an animal body) as analyzed by several authors (Watson, 1970; Brown and Powell, 1972; Campbell and Eagles, 1983; Santos and Negreiros-Fransozo, 1996; López et al., 1997; López Greco and Rodríguez, 1998; Pinheiro and Fransozo, 1998; Reigada and Negreiros-Fransozo, 1999; Muñio et al., 1999; Castiglioni and Santos, 2000 and Flores et al., 2002).

Uca rapax (Smith, 1870) live in burrows in the mud or in the muddy-sand at the mangroves from the north littoral of the State of São Paulo, Brazil and distributed along Florida, Mexican Gulf, Antilles, Venezuela and Brazil (from Pará to Santa Catarina States) (Melo, 1996). Most of the papers dealing with *Uca rapax* have studied its behaviour or physiology (Salmon, 1971; Greenspan, 1980; McNamara and Moreira, 1983; Genomi 1985, 1991; Salmon and Kettler, 1987; Zanders and Rojas, 1996 a, b, c), being that few papers were developed about its biologic aspects (Castiglioni

and Negreiros-Fransozo, 2003; Castiglioni et al., 2004; Castiglioni and Negreiros-Fransozo, 2005).

In this study, macroscopic aspects of the masculine and feminine gonads of *Uca rapax* (Smith, 1870) from two Brazilian mangroves were analyzed to determine its size at onset of the sexual maturity.

MATERIAL AND METHODS

Crabs were collected monthly (from April/2001 to March/2002) by two people at mangrove of Cavalo river, Itamambuca (23°24'43"S and 45°00'73"W) and mangrove of Ubatumirim river (23°20'17,8"S and 44°53'22"W), both in Ubatuba, São Paulo, Brazil, using the procedure of capture per unit effort (cpue). Crabs were measured as for carapace width (CW) with precision calipers, with an accuracy of 0.01mm.

According to Colpo and Negreiros-Fransozo (2003), the Itamambuca mangrove typical vegetation is compounded only by *Laguncularia racemosa*. The trees density in Itamambuca reaches 1,250 trees/ha, with a mean height of 4.8 m and its mean diameter at breast height is 6 cm. By the other hand, as mentioned by Negreiros-Fransozo (pers. comm.), in Ubatumirim mangrove there is also *Avicennia shaueriana*, but in a lower frequency than *L. racemosa* (the Ubatumirim mangrove has 6,250 trees/ha, with a mean height of 10.6 m and its mean diameter at breast height is 4.7 cm). As Castiglioni (2003) assumed, the mangrove bottoms are composed predominately by median sand and very fine sand in Itamambuca and Ubatumirim, respectively and the organic matter content present in the sediments was higher in Itamambuca than Ubatumirim.

Crabs were dissected and the gonadal development was classified (Table 1). The coloration, shape and volume occupied by ovaries and testes in relation to hepatopancreas and thoracic cavity were also considered. Gonads were categorized in six developmental stages for females and five for males, following a modification of the procedures proposed by Haefner (1976), Choy (1988), Abelló (1989) and Negreiros-Fransozo et al. (2002) (Table 1). Data were arranged in two groups (juvenile crabs - specimens that showed immature gonads or rudimentary) and adult crabs (specimens with gonads at the stages classified as developing, developed, advanced or spent).

Crabs were separated in size classes of the carapace width, with 2.5 mm wide, for which the frequency of juvenile and adult crabs was obtained. For the physiological maturity analysis, the logistic equation was used at each size class: $y=1/1+e^{-r(LC-LC_{50})}$ as suggested by Santos and Negreiros-Fransozo (1996), Pinheiro and Fransozo (1998) and Reigada and Negreiros-Fransozo (1999). The adult relative frequency (%) and the

result of the logistic equation at each size class were obtained and plotted in graphs. The logistic equation variables were LC_{50} and r , where LC_{50} indicated the carapace width in which 50% of the crabs reached the sexual maturity and " r ", determined the curve inclination. The adjustment was assessed by the minimum square method (Aguillar et al., 1995; Vazzoler, 1996).

Table 1 - *Uca rapax*. Characterization of the gonad development in males and females.

STAGES	Characteristics
Males	
Immature (IM)	Testis could not be seen.
Rudimentary (RU)	Testis slightly visible with filamentous aspect. Coloration transparent.
Developing (DI)	Testis visible, winded and opaque coloration.
Developed (DE)	Testis attain it larger development, being a lot winded and white coloration.
Spent (SP)	Testis filamentous, thin and flaccid. Coloration transparent.
Females	
Immature (IM)	Ovary could not be seen.
Rudimentary (RU)	Ovary not developed with filamentous aspect, thin and transparent.
Developing (DI)	Ovary visible. Coloration of the ovary varies of the orange to orange-red. Ovary/hepatopancreas ratio about 1/10.
Developed (DE)	Ovary lobuled with red colored. Ovary/hepatopancreas ratio 1/2.
Advanced (AD)	Ovary larger than the hepatopancreas, occupying all cephalothoracic cavity and showing lobuled aspect and dark red coloration.
Spent (SP)	Ovary filamentous, thin and flaccid. Coloration transparent to orange. Ovary/hepatopancreas ratio about 1/10.

Table 2 - *Uca rapax*: Mean (\pm sd), minimum and maximum values of the carapace width (mm) in each stage of gonad development.

STAGE OF GONAD	ITAMAMBUCA		UBATUMIRIM	
	Min - Max	Mean \pm sd	Min - Max	Mean \pm sd
Males				
Immature	4.0 - 11.4	7.2 \pm 1.7	3.5 - 12.4	7.0 \pm 1.8
Rudimentary	8.8 - 15.3	12.3 \pm 1.6	8.5 - 13.9	11.7 \pm 1.5
Developing	10.3 - 26.2	19.4 \pm 4.0	9.7 - 24.9	17.3 \pm 3.1
Developed	12.0 - 26.1	20.8 \pm 3.6	9.6 - 24.2	18.0 \pm 3.2
Spent	15.5 - 26.3	19.9 \pm 3.0	14.0 - 23.9	17.3 \pm 2.1
Females				
Immature	3.9 - 11.9	7.6 \pm 1.8	3.6 - 14.3	7.5 \pm 2.4
Rudimentary	9.3 - 12.4	11.1 \pm 1.0	8.3 - 11.4	10.3 \pm 0.9
Developing	9.2 - 24.2	16.9 \pm 4.5	8.4 - 22.5	15.6 \pm 2.9
Developed	10.5 - 25.0	18.5 \pm 4.5	10.8 - 20.6	16.6 \pm 2.5
Advanced	11.4 - 24.9	16.7 \pm 4.3	11.5 - 20.6	15.4 \pm 2.6
Spent	12.5 - 25.5	18.4 \pm 3.3	11.5 - 22.0	15.4 \pm 2.4

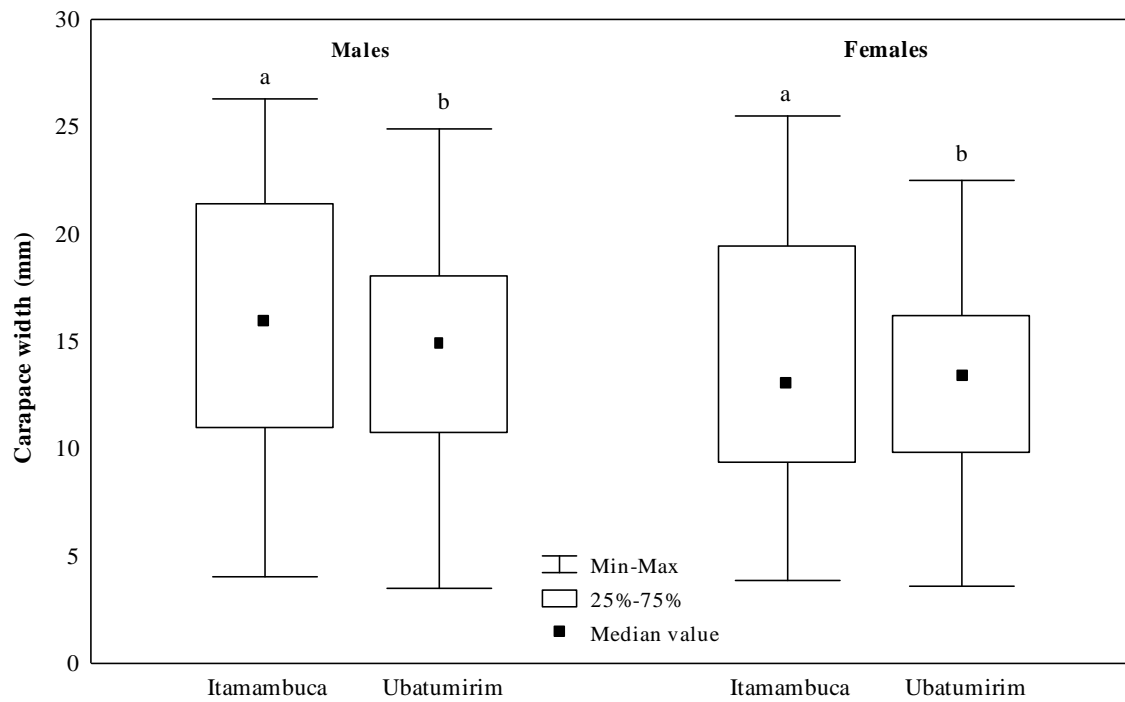


Figure 1 - *Uca rapax*. Comparison of the median size of each sex and site. Box with at least a same letter in common does not show significant statistical difference ($p > 0.05$).

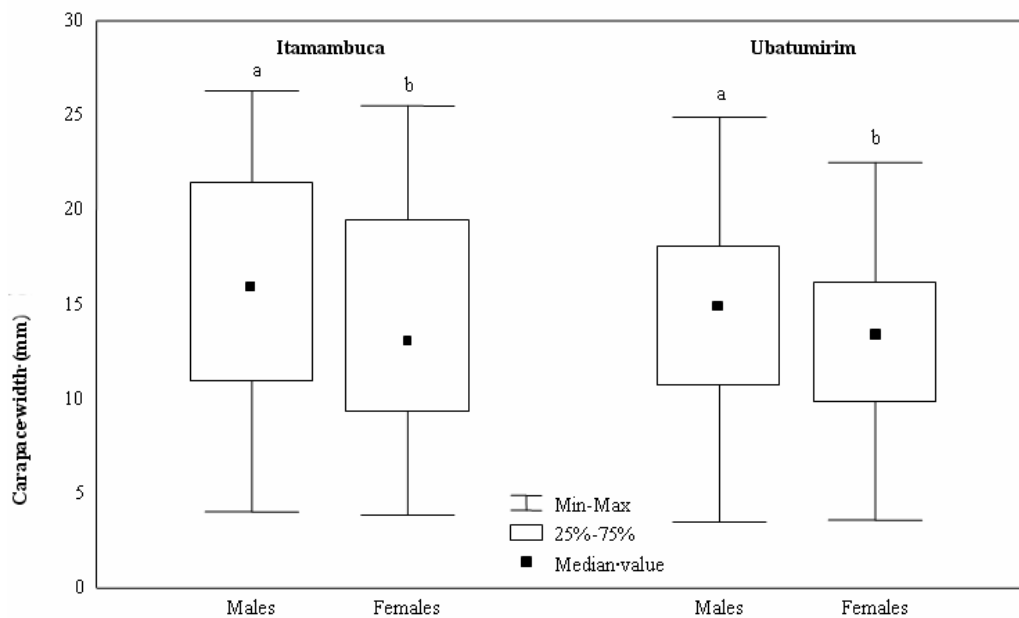


Figure 2 - *Uca rapax*. Comparison of the median size between males and females in each site. Box with at least a same letter in common does not show significant statistical difference ($p > 0.05$).

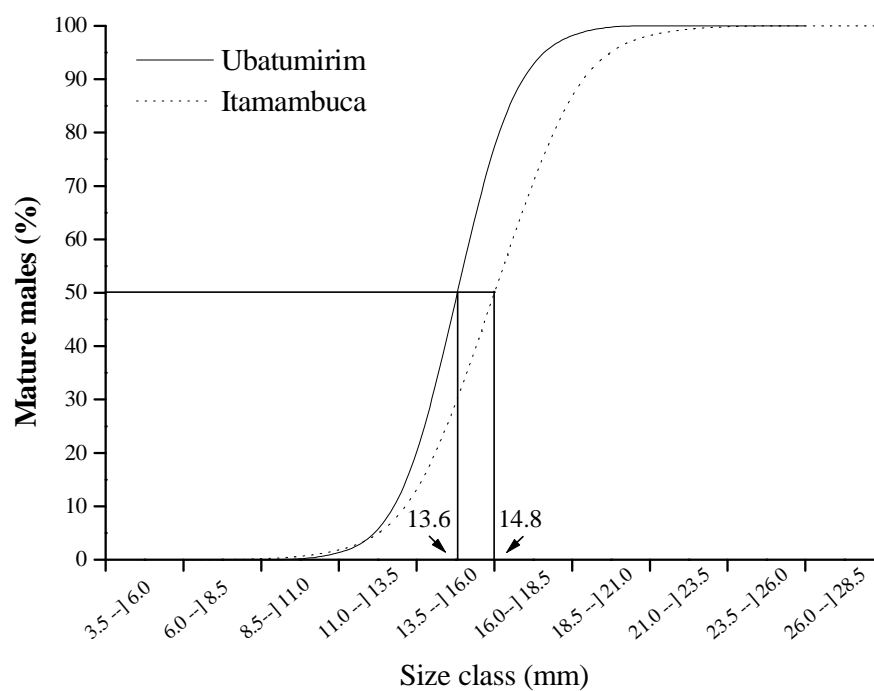


Figure 3 - *Uca rapax*. Cumulative frequency of the physiologic sexual maturity in males.

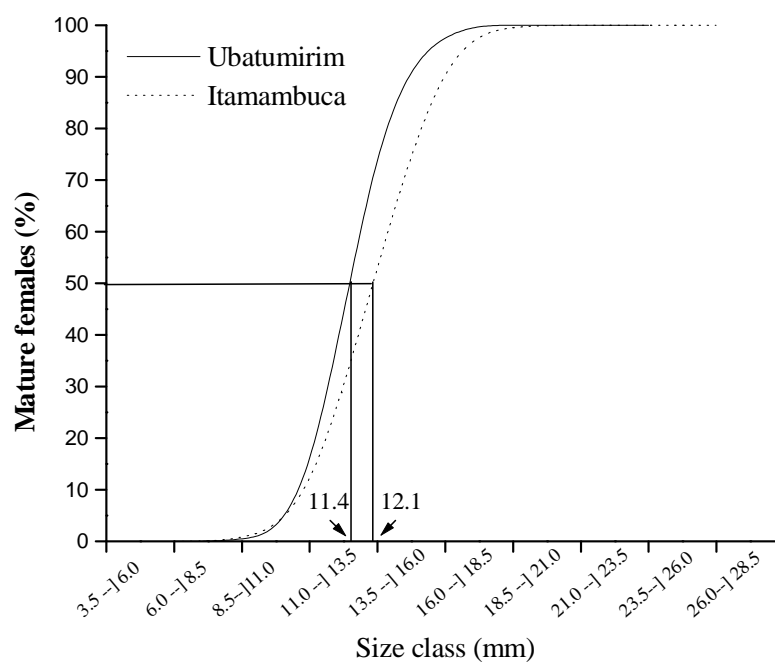


Figure 4 - *Uca rapax*. Cumulative frequency of the physiologic sexual maturity in females.

RESULTS

A total of 1,294 crabs were obtained (667 males and 627 females) from Itamambuca mangrove and 2,107 crabs (1,117 males and 990 females) from Ubatumirim. Crabs descriptive measures, for each sex and gonadal development stage are showed in Table 2. The smallest male and female individuals showed immature stages of gonad development in both mangroves. Animals with the greatest variation in size were found in DI (developing) and DE (developed) gonadal stages in Itamambuca and Ubatumirim. The mean size (carapace width – CW) of the analysed specimens were 15.2 ± 4.6 mm (males) and 13.8 ± 4.6 mm (females) for Itamambuca and 13.5 ± 4.8 mm (males) and 12.9 ± 4.4 mm (females) for Ubatumirim population. The Mann-Whitney test showed that median size of the crabs from Itamambuca mangrove was larger than Ubatumirim ($p < 0.05$) (Fig. 1). There was statistical difference in the median size ($p < 0.05$) between males and females from mangroves: males reached larger sizes than females (Fig. 2). The adjustment of maturation curve showed that size of carapace width in which 50% of the males were physiologically mature are 14.8 mm and 13.6 mm, in Itamambuca and Ubatumirim mangroves, respectively (Fig. 3). Such like values for females corresponded to 12.1 mm and 11.4 mm of carapace width (Fig. 4), respectively, in Itamambuca and Ubatumirim.

DISCUSSION

The variation observed at the gonadal development stages, in relation to size of males and females in both mangroves, suggests that *U. rapax* shows a constant gonadal development during its life cycle. However, while a crab is preparing to molt the gonad cease their development. Only after molt, the gonad reactivates the development again.

The size in which the sexual maturity is reached and how it is determined are important aspects of the biological cycle of decapods and it can be determined through the study of reproductive aspects, whereas morphometric techniques can indicate allometric changes in size related with the external morphological maturity. Crustacean would be able to mate when attain such size. Traditionally two criteria have been utilized to

determine such size: the first was directly related with the reproduction as gonad development, spermatheca analysis, presence of ovigerous females and spermatophores in males (Wenner et al., 1974, Campbell and Fielder, 1986; Prasad and Neelakantan, 1990; Fernández et al., 1991; Freire et al., 1991) and the other was based on morphometric data (Campbell and Eagles, 1983; Haefner, 1990). Conan and Comeau (1986) assumed that these two kinds of determination of sexual maturity are coincident. As a result, only one technique is not enough to define the size at the sexual maturity, which is basically determined by genetics information of each species and influenced by environment factors in its distribution area (Hines, 1982).

According to González-Gurriarán (1985), it is necessary to compare different methods for the determination of sexual maturity to obtain more secure estimates. The accurate estimation of size of the sexual maturity should include examination of external morphological modifications and gonad development, since that the values are frequently different. Castiglioni and Negreiros Fransozo (2003), performed a study on the relative growth of two populations of *Uca rapax* to determine the size at onset sexual maturity morphologic, where was observed that males and females are mature, respectively at 15.2 and 12.1 mm CW in Itamambuca and 13.5 and 11.2 mm CW in Ubatumirim. If a crab becomes able to reproduce only when it acquires the morphological and physiological conditions, it can be inferred that the size (carapace width) in which such conditions were observed in *U. rapax* from Itamambuca mangrove was 15.3 mm for males and 12.1 for females. However, in Ubatumirim the size at which 50% of the males and females were mature is 13.6 and 11.4 mm of carapace width, respectively. These sizes were a valid mean estimates for the population, however it is possible to capture an specimen of a species refereed, whose size at onset of the sexual maturity can differ of this mean.

The values registered at the maturity for males and females of *Uca rapax* in both mangroves as much morphological analysis as the physiological were similar, indicating that gonadal development started probably at the same time when the crab begins to prepare for the adult life after the pubertal molt. This was observed by Perez (1990) in *Matuta lunaris* (Forsk., 1775); Haefner (1990) in males of *Callinectes ornatus* Ordway, 1863;

González-Gurriarán and Freire (1994) in *Necora puber* (Linnaeus, 1767); Santos and Negreiros-Fransozo (1996) in *Portunus spinimanus* Latreille, 1819; Reigada and Negreiros-Fransozo (1999) in *Hepatus pudibundus* (Herbst, 1785) and by Pinheiro and Fransozo (1998) in females of *Arenaeus cribrarius* (Lamarck, 1818).

Despite the close association between development of secondary sexual characters and physiological maturity, in some species these events are not synchronous as observed in *Cancer irroratus* Say, 1817 studied by Campbell and Eagles (1983); *Ovalipes stephensoni* studied by Haefner, 1985; *Liocarcinus holsatus* (Fabricius, 1798) and *Liocarcinus puber* (Linnaeus, 1767) studied by Choy, 1988; females of *Callinectes ornatus* studied by Haefner, 1990; *Scylla serrata* (Forsk., 1775) studied by Prasad and Neelakantan, 1990; males of *Arenaeus cribrarius* studied by Pinheiro and Fransozo, 1998 and females of *Liocarcinus depurator* (Linnaeus) studied by Muiño et al. (1999).

The fact that males of *Uca rapax* were mature with higher size than females should be probably due to the lower energy investment by females at the growth, because they spend their energy in the reproductive process. Thus males probably reach higher size than females with the same food resource and, consequently, the sexual maturity was achieved in higher sizes than females. This result was also observed in others ocypodid crabs, such as *Uca leptodactyla* (Masunari and Swiech-Ayoub, 2003) and *Uca burgersi* (Benetti and Negreiros-Fransozo, 2004).

According to Hines (1989), some factors as food supply, population density or subtle changes in substrate can regulate the size of sexual maturity and the variation of such factors can generate different size that are more important at the variation of the size maturity than latitudinal factors in some species as *Hemigrapsus oregonensis* (Dana, 1851) and *Scyra acutifrons* Dana, 1851. If a population lives in a rich environment of food resources, its individuals probably will grow more quickly rather than in a severe environment. This difference can cause discrepancy at the size in which the animals reach sexual maturity (Wenner et al., 1974). Other factors that can determine differential size rates among crabs and, consequently, different sizes at the sexual maturity are variations in molt increment or in the number of molts to maturity (Hines, 1989).

Hines (1989) studying five brachyurans species observed that four species showed geographic variation in size at sexual maturity, that can caused by temperature and temperature-photoperiod interactions, producing latitudinal clines in metabolic rates, growth and size, resulting in slower growth to larger, older individuals and delayed maturity at higher latitudes. Jones and Simons (1983), studying the grapsid *Helice crassa* Dana, 1851, also observed latitudinal variation in maximum size of crabs, at the size at sexual maturity of females and at the eggs number exteriorized for females, where these values increased at high latitudes.

The divergent environment conditions, under which populations of *Uca rapax* live, probably produce distinct growth rates, promoting variations at the size onset of sexual maturity. The crabs from Itamambuca mangrove reached the maturity in a higher size than crabs from Ubatumirim, when in this mangrove the food supply was lower, because it had less organic matter amount in the sediment (Castiglioni, 2003). This result was also observed by Benetti and Negreiros-Fransozo (2004) in *Uca burgersi* in these same mangroves.

The Itamambuca mangrove is a young ecosystem, with primary production increasing and with a high organic matter drift in the substratum (Colpo and Negreiros-Fransozo, 2003). This mangrove contributes to the crabs growth that can reach larger sizes and, consequently can attain the sexual maturity in higher sizes when compared to the crabs from Ubatumirim. This fact was already observed by Colpo (2001) for other ocypodid crab, *Uca vocator* (Herbst, 1804) that reached the morphological sexual maturity in a higher size at the Itamambuca mangrove, when compared to the Indaia and Itapanhaú mangrove populations, São Paulo State, Brazil.

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RESUMO

A determinação do tamanho em que os caranguejos atingem sua maturidade sexual é um importante instrumento em estudos da dinâmica populacional e na determinação do potencial reprodutivo de uma espécie. O objetivo deste estudo foi analisar aspectos fisiológicos como o desenvolvimento gonadal para a determinação do tamanho na primeira maturação de *Uca rapax*. Os caranguejos foram coletados durante um ano (abril de 2001 a março de 2002) nos manguezais de Itamambuca e Ubatumirim, Ubatuba, SP. Os exemplares capturados foram mensurados quanto à largura da carapaça e o sexo e os estágios de desenvolvimento gonadal registrados. Os caranguejos com gônadas imaturas e rudimentares foram considerados jovens e os caranguejos nos demais estágios gonadais foram classificados como adultos. Os exemplares foram separados em 10 classes de tamanhos, sendo que para cada classe foram obtidas as frequências de caranguejos jovens e adultos. A determinação da maturidade sexual foi obtida através de equação logística e o ajuste desta equação foi efetuado pelo método dos mínimos quadrados. O tamanho da largura da carapaça no qual 50% da população de *Uca rapax* foi considerada madura foi de 14,8 mm para machos e 12,1 mm de LC para fêmeas em Itamambuca e 13,6 mm para machos e 11,4 mm de LC para fêmeas provenientes do manguezal de Ubatumirim. O fato dos machos maturarem com tamanhos superiores ao das fêmeas, deve-se ao maior investimento em crescimento somático por parte desse sexo, sendo que as fêmeas investem mais em processos reprodutivos.

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