Reproductive ecology of *Armases rubripes* (Sesarmidae) from mangroves of southeastern Brazil

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Abstract

The sesarmid crab *Armases rubripes* presents a wide geographical distribution in the Western Atlantic and is very abundant in the Brazilian estuaries, in both mangroves and salt marshes. This paper describes the reproductive aspects of *A. rubripes* from seven mangroves on the São Paulo coast, Brazil, including size at morphological sexual maturity, reproductive period (frequency of ovigerous females throughout the year) and its fecundity. Crabs were obtained monthly from July 1999 to June 2000. The latitudinal difference among the studied areas is not large, but there are significant differences in some biological aspects of this species between localities. These differences can be related to the mangrove density as well as type of substrate, interaction among species and even the degree of conservation of each mangrove forest.

Key words: fecundity, recruitment period, reproduction period, sexual maturity

Introduction

According to Hartnoll and Gould (1988), the great variety of life history patterns observed in Crustacea maximizes offspring survival under different circumstances. This consideration can explain the great flexibility seen in the life cycles and reproductive strategies of crabs, mainly when different geographical distributions are considered.

Studies on reproductive biology in Brachyura have included aspects such as sexual maturity (Haefner, 1977; Abelló, 1989; González-Gurriarán and Freire, 1994), the spawning period (Pillay and Nair, 1971; Pillay and Ono, 1978; Emmerson, 1994; Flores and Negreiros-Fransozo, 1998), interactions between growth and the reproductive process (Hartnoll, 1969; 1988), fecundity (Hines, 1988; Luppi *et al.*, 1997), and other important aspects that constitute the basic information about the life cycles of this group.

The Grapsoidea (*sensu* Kitaura *et al.,* 2002) comprises a highly diversified group, since it includes salt water, fresh water and some semi terrestrial species. Successful colonization of these different environments reflects the adaptive diversity of grapsoid reproductive strategies (Sastry, 1983).

Armases rubripes (Rathbun, 1897) belongs to the family Sesarmidae. It can be found in estuaries, living on the sediment among mangrove roots and branches, and also in rock crevices. This crab has a wide geographical distribution in the Western Atlantic, from Central America, north of South America, Guyana, Brazil (from Ceará to Rio Grande do Sul) to Uruguay and Argentina (Melo, 1996).

This study describes some reproductive aspects of *A. rubripes* from different mangroves of São Paulo coast, Brazil, such as the size at sexual morphological maturity, the spawning period (ovigerous-ratio all year-round) and its fecundity.

Material and Methods

Study Area

The study region is located on the São Paulo State coast, Brazil: Itapanhaú (23° 49' 9" S; 46° 9' 74" W), Itaguaré (23° 46' 37" S; 45° 58' 11" W) and Guaratuba (23° 45' 9" S; 45° 53' 42"W) rivers, in Bertioga municipality, and Comprido (23° 29' 21" S; 45° 9'54" W), Indaiá (23° 24' 51" S; 45° 3' 14" W), Itamambuca (23° 24' 43" S; 45° 01' 03" W) and Ubatumirim (23° 20' 18" S; 44° 53' 2" W) rivers, in Ubatuba municipality.

The mangroves from the São Paulo coast are important primary producers, recycling nutrients in organic material and providing food for organisms from adjacent areas. The mangrove vegetation is composed by 3 typical species: *Laguncularia racemosa* (Linnaeus), *Avicennia shaueriana* (Staf & Leechman) and *Rhizophora mangle* Linnaeus, as mentioned by Lacerda *et al.* (2002).

Crab Samplings, Laboratory Procedures and Statistical Analyses

Crabs were collected monthly throughout one year (from July 1999 to June 2000). At each site, samples were obtained using a catch per unit effort of two collectors over a 30-min during ebb tide period. Specimens were identified based on Melo (1996). The sex discrimination was based on the morphology of the abdomen and the number of pleopods (two pairs in males and four pairs in females).

The presence of eggs was also recorded. The ovigerous females were isolated in plastic bags and preserved in 70% ethanol. In the laboratory, the size of the following dimensions from each crab was measured with a digital caliper (0.01mm): carapace width (CW) and length (CL), abdomen width (AW), cheliped propodus length (CPL) and height (CPH). For males, the gonopod length (GL) was also measured.

A comparison of the size (CW) of males and females was performed using the Kruskal-Wallis test (a = 0.05) (Zar, 1996).

The evaluation of the morphological sexual maturity was carried out using the allometric technique, which allows the detection of differences in the allometric growth patterns between the mature and immature phases. The relations between AW vs. CW, CPL vs. CW and CPH vs. CW for both sexes and GL vs. CW for males were analyzed. Among the studied relations, only the regressions AW vs. CW for females and CPH vs. CW for males proved to be useful for the sexual maturity analysis. The computer software Mature II (Somerton, 1980) was used to determine the size in the first maturation, based on the morphology of males and females.

The ovigerous-ratio, i.e., the proportion of ovigerous females in relation to the number of the sexually mature females, was analyzed each month throughout one year, to determine the spawning period. The absolute frequencies were compared using multinomial proportions analysis (MANAP) (Curi and Moraes, 1981). The median size of ovigerous females was calculated for each site and compared using Kruskal-Wallis test (a = 0.05) (Zar, 1996).

A total of 549 ovigerous females were sampled, of which 247 were carrying eggs in initial stage of embryonic development (absence of embryonic eyes) and only these were used for the fecundity analysis.

The egg counting was accomplished by sub-sampling using a Motoda split sampler. The mean number of eggs was calculated for each site and compared using a one-way ANOVA, complemented by the Tukey test (a = 0.05) (Zar, 1996).

The number of eggs produced per ovigerous female, in each mangrove, was correlated with the carapace width cubed. According to Hines (1982), this dimension reflects the body volume available for egg production.

The fecundity obtained at each site was adjusted to a power function to convert for body size, and after that the regressions were compared by a covariance analysis (ANCOVA) (Zar, 1996).

Results

A total of 5 117 specimens of *A. rubripes* was collected. The descriptive measures for *A. rubripes* males and females are presented in Table I. The size comparison analyses indicated that the median size of males was greater than females (p<0.05) in Itapanhaú, Itaguaré and Indaiá mangroves, but no differences were detected in the other localities. The mean size of male crabs from Ubatumirim was smaller than that from Guaratuba, Comprido and Itamambuca. The females from Itamambuca and Guaratuba mangroves reached greater size than the females from the other mangroves (p<0.05).

The sizes in which males and females reached their morphological sexual maturity are presented in Table I. Males reached maturity at sizes slightly greater than females in all populations.

Table I: Descriptive measures of *A. rubripes* at each site, including the size at morphological sexual maturity for males (M) and females (F) of *A. rubripes* based on the allometric technique.

Sites	CW (mm)									
	N		Min		Max		Median*		Maturity	
	M	F	M	F	M	F	M	F	M	F
Itapanháu	653	692	4.9	2.7	16.5	14.1	9.5 AB a	7.6 B b	9.0	8.5
Itaguaré	418	500	4.5	3.6	15.8	15.3	9.3 AB a	7.1 B b	11.6	9.8
Guaratuba	252	285	4.0	4.1	14.8	14.4	8.9 BC a	8.4 B a	9.9	7.6
Comprido	274	281	4.3	4.7	14.5	14.1	9.2 BC a	9.3 B a	9.1	7.7
Indaiá	211	199	4.6	4.6	15.7	13.7	9.4 AB a	8.0 B b	9.5	9.0
Itamambuca	342	422	4.5	3.5	15.6	14.4	10.1 A a	9.8 A a	9.5	8.8
Ubatumirim	301	287	4.6	5.0	12.9	11.7	8.2 C a	8.0 B a	10.0	9.2

*Small letters compare the median size between sexes and capital letters compare the median size among sites within each sex (p<0.05).

Considering the ovigerous females' frequency at all the studied mangroves, a seasonal model characterizes the spawning period of *A. rubripes*, with major percentages registered mainly at summer (figure 1).

The mean carapace width for ovigerous females, used in the fecundity analyses, is presented in figure 2. The greatest and smallest mean fecundity were registered in Indaiá mangroves (3 526.7 ± 1 494.7 eggs) and Comprido River (1 709.1 ± 826.5 eggs), respectively. The maximum number of eggs produced by an ovigerous female (6 387) was registered in Indaiá mangrove (12.89 mm CW) and the minimum number of eggs (448) was registered in Comprido River (6.03 mm CW) (Table II).

The mean fecundity of females in the seven mangroves is shown in figure 3. Comparing the data it can be verified that in all size classes the greater rates were found in Indaiá mangrove, excepting the fifth class, in which Ubatumirim presented the greatest average (ANOVA: p< 0.05).
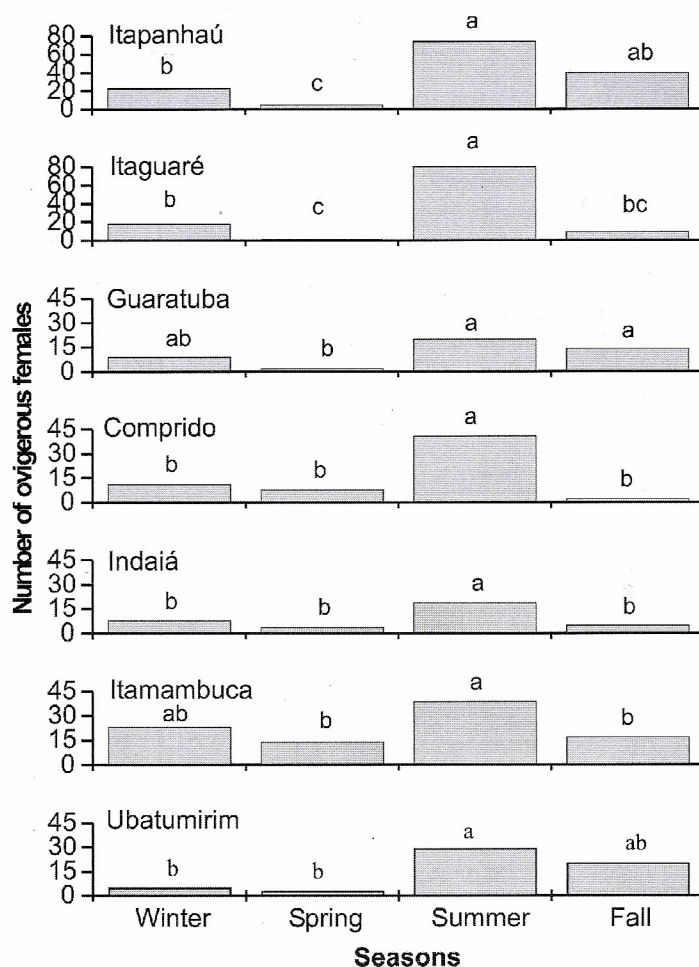
Figure 1: Reproductive period of *A. rubripes* based on the absolute frequency of ovigerous females throughout seasons of year.

Table II: Mean fecundity of *A. rubripes* in each mangrove.

	Number		
Mangrove	Ovigerous females	Eggs min. - max.	Eggs mean*
Itapanhaú	48	520 - 5 456	2,583.0 c
Itaguaré	38	816 - 4 000	2,030.8 bc
Guaratuba	38	640 - 5 789	2,453.6 bc
Comprido	36	448 - 3 456	1,709.1 b
Indaiá	26	1 242 - 6 387	3,526.7 a
Itamambuca	35	584 - 4 875	2,424.1 bc
Ubatumirim	26	512 - 4 544	2,089.4 bc

*Median values followed by at least one same letter in the column did not differ statistically among sites ($p > 0.05$).

The relation between ovigerous female body size and the number of eggs per female is shown in figure 4. The covariance analysis (ANCOVA) reveals that almost all populations show different regressions of fecundity ($p < 0.05$), with exception the Itapanhaú and Itamambuca and Itapanhaú and Comprido.
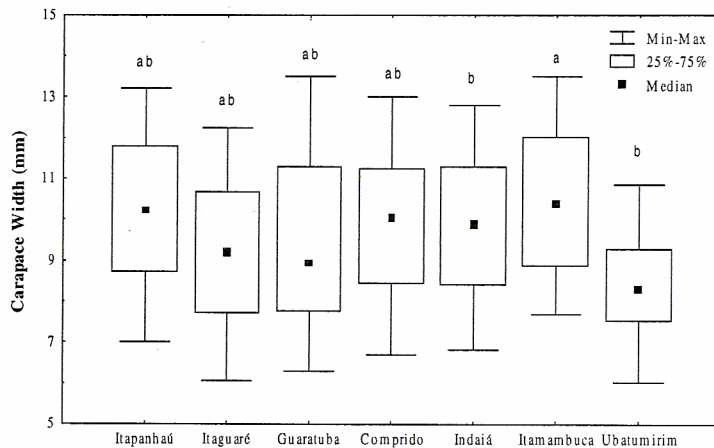
Figure 2: Descriptive measures of carapace width (mm) for ovigerous females *A. rubripes*.
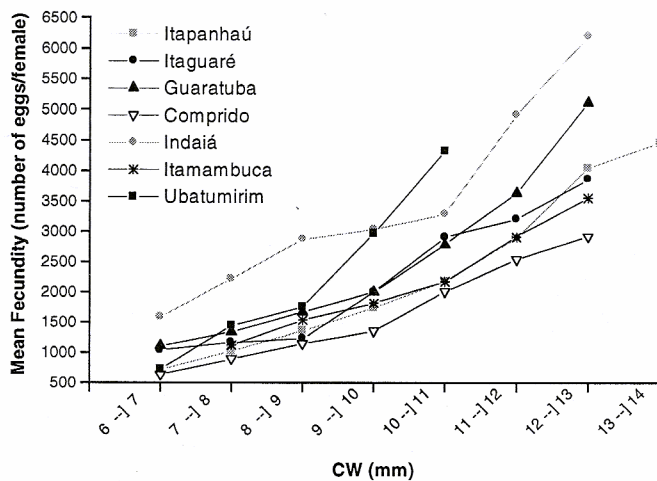

Figure 3: Mean fecundity of *A. rubripes* by size classes of carapace width (mm).

Discussion

In this study, male *A. rubripes* reached the morphological sexual maturity at greater sizes than females. Among the analyzed population, males and females from the mangrove in Comprido River reached the morphological sexual maturity at the smallest sizes and females from this area produced less eggs than females from the other studied areas. Possibly this occurs because that locality has a smaller density (trees/ha) than other mangroves from the same region (Negreiros-Fransozo, 2002).

The smallest median size for females (7.1 mm CW) was found in the Itaguaré mangrove; however, these females presented the greatest size at morphological maturation (9.8 mm CW). This difference can indicate that young animals are predominating in the population. This explanation is also applicable for males from Ubatumirim and Indaiá. At Itamambuca, the median size values for females and the size at the first maturation are close, what could mean that the number of young and adult females is similar.
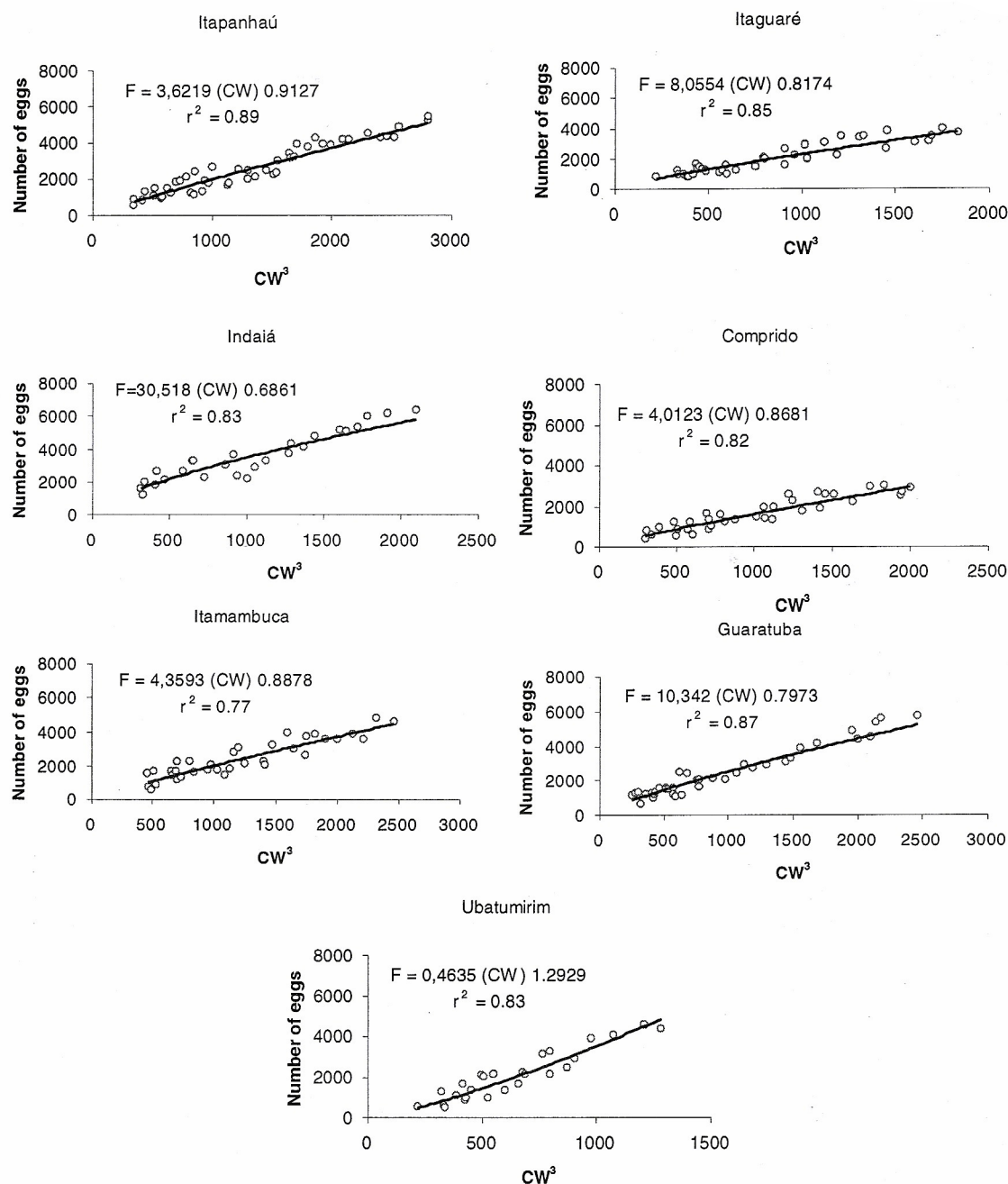
Itapanhaú

F = 3,6219 (CW) 0.9127
$r^2 = 0.89$

Itaguaré

F = 8,0554 (CW) 0.8174
$r^2 = 0.85$

Indaiá

F=30,518 (CW) 0.6861
$r^2 = 0.83$

Comprido

F = 4,0123 (CW) 0.8681
$r^2 = 0.82$

Itamambuca

F = 4,3593 (CW) 0.8878
$r^2 = 0.77$

Guaratuba

F = 10,342 (CW) 0.7973
$r^2 = 0.87$

Ubatumirim

F = 0,4635 (CW) 1.2929
$r^2 = 0.83$

Figure 4: Linear regressions between the number of eggs and the third power of carapace width (mm^3) of *A. rubripes* (F= fecundity; CW^3= third power of carapace width — mm^3; r^2= determination coefficient).

Some species can present variation in maturity size in a small local scale. This pattern can be caused by factors such as food availability, population density or subtle changes in the substrate, which can be more related with a variation in the maturity size than latitudinal factors in some species, as for *Hemigrapsus oregonensis* (Dana, 1851) and *Scyra acutifrons* Dana, 1851 (Hines, 1989). This fact was also observed in the present study for *A. rubripes*, which presented small variations in sexual maturity size and fecundity, from one locality to another.

Some Grapsoidea species concentrate their spawning period in certain months in which the environmental conditions are suitable for the reproductive process. According to Sastry (1983), the specific variations in length of the ovigerous period can be explained as genotypic answers to the environment for obtaining reproductive success over favorable conditions. One population can present continuous reproduction if females produce eggs at the same intensity

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throughout the year (Sastry, 1983), or seasonal reproduction, if the spawning is more intense in a certain period of the year, when the environmental conditions are suitable for the offspring development.

As ovigerous females were more frequent during summer, *A. rubripes* shows a seasonal spawning at all sites and the female probably synchronizes it in periods that offer better conditions for offspring development. This seasonality can be attributed to the fact that this species habits intertidal regions, where they are more susceptible to influences of seasonal alterations. It seems that there is not a rule for spawning pattern in grapsid crabs studied at Ubatuba region (São Paulo state - Brazil). Some species spawns at all seasons, like *Aratus pisonii* (H. Milne Edwards, 1837) studied by Leme and Negreiros-Fransozo (1998) and *Goniopsis cruentata* (Latreille, 1803) by Cobo and Fransozo (1999), while ovigerous females of *Pachygrapsus transversus* (Gibbes, 1850) by Flores and Negreiros-Fransozo, (1999) occur in higher percentages only in summer, characterizing a seasonal reproduction.

The carapace volume in some Brachyura is a good predictor of the numbers of eggs produced as a function of female size, since it is related to the inner space available in the female to produce eggs (Hines, 1982). In general, the fecundity increases as the cephalothoracic width increases (Hines, 1982). In the majority of the studied mangroves a positive correlation was found between the number of eggs produced and the carapace width of the crab, since as the crustacean increases in size the number of eggs increases too. This was also observed by Castiglioni and Santos (2001) for another Grapsoidea species, *Cyrtograpsus angulatus* Dana, 1851, sampled in an estuarine lagoon in Rio Grande do Sul, Brazil.

The tree crab, *A. pisonii*, had an average fecundity of 16 379 eggs in Venezuela mangroves (Conde and Díaz, 1989). Another population of the same species, sampled in a mangrove area with marine characteristics (elevated salinity) had an average fecundity of 11 577 eggs (Conde and Díaz, 1989). Such significant difference in the average number of eggs between the two populations can be related to the mean size of the crabs in each population and differential availability of energetic resources in diverse environments. The species *A. pisonii* reaches greater sizes in estuarine conditions, probably because this environment is more productive than marine ones.

The greatest fecundity rate shown by *A. rubripes* in the Indaiá mangrove can be related to the high productivity in this mangrove and to the high food supply available, as cited by Negreiros-Fransozo (2002), who studied *A. pisonii* at the same places and found the largest specimens and fecundity rate at this site. Crabs from this locality can reach greater sizes than other populations and consequently, females are able to produce more eggs.

Probably, the environment in Ubatumirim does not present conditions as good to *A. rubripes* development as Indaiá mangrove (7.2 and 10.8 trees/ha, respectively, according to Negreiros-Fransozo, 2002), since the smallest crabs and one of the smallest fecundity rates were registered in such locality.

Among the studied populations there are differences in the mean size, size at the first maturation, reproductive period and fecundity rate. These results can be related to the differential characteristics of the mangroves, previously mentioned by Negreiros-Fransozo (2002), like height, density and diameter of trees. It is known that in Indaiá, where the sizes and the fecundity of *A. rubripes* were greater than other localities, the vegetation density is higher too, presumably providing a greater amount of litter. Since leaves and other vegetal items are the principal food source of many crabs at mangrove areas, it can be presumed that the nutritional requirements for growth and reproduction should be largely obtained from mangrove trees. However, more factors can also be contributing, as the type of substrate, the interaction among species and even the degree of conservation of each mangrove.

Acknowledgements

References

Abelló, P. 1989. Reproductive biology of *Macropipus tuberculatus* (Roux, 1830) (Brachyura, Portunidae) in the Northwestean Mediterranean. Ophelia, 30(1): 47-53.

Castiglioni, D. S. and Santos, S. 2001. Reproductive aspects of *Cyrtograpsus angulatus* (Grapsidae) in the Lagoa do Peixe, RS, Brazil. Nauplius, 9(1): 11-20.

Cobo, V. J. and Fransozo, A. 1999. Fecundity and reproduction period of the red mangrove crab *Goniopsis cruentata* (Brachyura, Grapsidae), São Paulo state, Brazil. *In* Klein, J. C. V & Schram, F. R. (eds.), Proceedings of the Fourth International Crustacean Congress. pp 527-533. Leiden University, Amsterdam, The Netherlands.

Conde, J. E. and Díaz, H. 1989. The mangrove tree crab *Aratus pisonii* in a tropical estuarine coastal lagoon. Estuarine, Coastal and Shelf Science, 28: 639-650.

Curi, P. R. and Moraes, R. V. 1981. Associação, homogeneidade e contrastes entre proporções em tabelas contendo distribuições multinomiais. Ciência e Cultura, 33(5): 712-722.

Emmerson, W. D. 1994. Seasonal breeding cycles and sex ratios of eight species of crabs from Mgazana, a mangrove estuary in Transkei, southern Africa. Journal of Crustacean Biology, 14(3): 568-578.

Flores, A. A. V. and Negreiros-Fransozo, M. L. 1998. External factors determining seasonal breeding in a subtropical population of the shore crab *Pachygrapsus transversus* (Gibbes, 1850) (Brachyura, Grapsidae). Invertebrate Reproduction and Development, 34(2-3): 149-155.

Flores, A. A. V. and Negreiros-Fransozo, M.L. 1999. On the population biology of the mottled shore crab *Pachygrapsus transversus* (Gibbes, 1850) (Brachyura, Grapsidae) in a subtropical area. Bulletin of Marine Science, 65(1): 59-73.

Gonzalez-Gurriarán, E. and Freire, J. 1994. Sexual maturity in the velvet swimming crab *Necora puber* (Brachyura: Portunidae): morphometric and reproductive analyses. Journal of Marine Science, 51: 133-145.

Haefner, Jr. P.A. 1977. Reproductive biology of the female deep-sea red crab, *Geryon quinquedens,* from the Chesapeake Bight. Fishery Bulletin, 75(1): 91-102.

Hartnoll, R. G. 1969. Mating in the Brachyura. Crustaceana, 16: 161-181.

Hartnoll, R. G. 1988. Notes on the marine grapsid crabs of Jamaica. Proceedings of the Linnean Society of London, 176 (2): 113-147.

Hartnoll, R. G. and Gould, P. 1988. Brachyuran life history strategies and the optimization of egg production. Symposium of the Zoology Society of London, 59: 1-9.

Hines, A. H. 1982. Allometric constraints and variables of reproductive effort in brachyuran crabs. Marine Biology, 69: 309-320.

Hines, A. H. 1988. Fecundity and reproductive output in two species of deep-sea crabs, *Geryon fenneri* and *G. quinquedes* (Decapoda, Brachyura). Journal of Crustacean Biology, 8(4): 557-562.

Hines, A. H. 1989. Geographic variation in size at maturity in brachyuran crabs. Bulletin of Marine Science, 45(2): 356-368.

Kitaura, J.; Wada, K. and Nishida, M. 2002. Molecular phylogeny of grapsoid and ocypodoid crabs with special reference to the genera *Metaplax* and *Macrophthalmus.* Journal of Crustacean Biology, 22(3): 682-693.

Lacerda, L. D.; Conde, J. E; Kjerfve, B.; Alvarez-Léon, R.; Alarcon, C. and Polnanía, J. 2002. American Mangroves. pp. 1-62 In Lacerda, L. D., Mangrove Ecosystems Function and Management. Environment Science Series. Springer –Verlag, Berlin.

Nauplius

Leme, M. H. A. and Negreiros-Fransozo, M. L. 1998. Reproductive patterns of *Aratus pisonii* (Decapoda: Grapsidae) from an estuarine area of São Paulo northen coast, Brazil. Revista de Biologia Tropical 46(3): 673-678.

Luppi, T. A.; Bas, C. C.; Spivak, E. D. and Anger, K. 1997. Fecundity of two grapsid crab species in Laguna Mar Chiquita, Argentina. Archives of Fishery and Marine Research, 45 (2): 149-166.

Melo, G. A. S. 1996. Manual de identificação dos Brachyura (caranguejos, siris) do litoral brasileiro. Plêiade/ FAPESP, São Paulo. 603p.

Negreiros-Fransozo, M. L. 2002. Size variation in the grapsid crab *Aratus pisonii* (H. Milne-Edwards, 1837) among population of different subtropical mangroves. p. 183-188 In Escobar-Briones, E. and Alvarez, F. Modern Approaches to the Study of Crustacea. Vol I. Kluwer Academic / Plenum Publishers, New York.

Pillay, K. K. and Nair, N. B. 1971. The annual reproductive cycles of *Uca annulipes, Portunus pelagicus* and *Metapenaeus affinis* (Decapoda: Crustacea) from the south-west coast of India. Marine Biology, 11: 152-166.

Pillay, K. K. and Ono, Y. 1978. The breeding cycles of two species of grapsid crabs (Crustacea: Decapoda) from the north coast of Kyushu, Japan. Marine Biology, 45: 273-248.

Sastry, A. N. 1983. Ecological aspects of reproduction. p. 179-270 In: Vernberg, F. J. and Vernberg, W. B. The Biology of Crustacea: Behavior and Ecology. Vol. 7. Academic Press, Inc., New York.

Somerton, D. 1980. A computer technique for estimating the size of sexual maturity in crabs. Canadian Journal of Fishery and Aquatic Science, 37: 1488-1494.

Zar, J. H. 1996. Biostatistical analysis. Prentice-Hall, Upper Saddle River, New Jersey, 662p.