REVISTA BIOCIÊNCIAS

ed. 26 | 3 | 2020

Structure of the population of the red mangrove crab *Goniopsis cruentata* (Latreille, 1803) (Crustacea, Decapoda, Brachyura), on a Brazilian sub-tropical estuarine mangrove

Estrutura da população do caranguejo de manguezal Goniopsis cruentata (Latreille, 1803) (Crustacea, Decapoda, Brachyura), em um manguezal estuarino subtropical

Valter José Cobo[1], Adilson Fransozo[2]

[1]Laboratório de Biologia Marinha – Instituto Básico de Biociências da Universidade de Taubaté; [2] Núcleo de Estudos em Biologia, Ecologia e Cultivo de Crustáceos – NEBECC-UNESP "Campus" de Botucatu

ABSTRACT

Goniopsis cruentata is one of the most abundant crabs in South Western Atlantic mangroves, and fill most of the niches provided by these ecosystems. The trophic role of this crab in the ecosystem is wider than reported to sesarmid and ocypodid crabs and plays important role on propagule predation, affecting the mangrove recruitment and community composition. This paper reports some population parameters as size classes frequency distribution, breeding period, sex-ratio, moult cycle and recruitment of the *G. cruentata* in southeastern Brazilian coast. A total of 1,150 crabs was obtained, without mean size meaning difference between sexes. Frequency distribution were bell-shaped and adult crabs were dominant. Ovigerous females were recorded in almost all months. The sex-ratio shows no meaning difference from 1:1 ratio. Moult activity was recorded over all sampled period. The frequency of moult on the size classes reveals a larger activity regarded to smallest body sizes. The population of *G. cruentata* seems to follow the expected standards of the tropical marine crabs. Moreover, some population attributes, as recruitment and breeding period did not match exactly within these standards, suggesting that population regulation is constrained for the local conditions.

Keywords: Conservation, frequency distribution, sex-ratio, recruitment, moult cycle

RESUMO

Gonipsis cruentata é um dos caranguejos mais abundantes nos manguezais do Atlântico Ocidental, explorando a maioria dos nichos oferecidos pelos manguezais. Seu papel nas relações tróficas é tão importante quantos o dos sesarmídeos e ocipodídeos, desempenhando importante função na predação de propágulos, afetando o recrutamento e a composição das comunidades dos manguezais. Este artigo

providencia informações sobre alguns parâmetros populacionais de *G. cruentata*, como distribuição de frequência em classes de tamanho, período reprodutivo, razão sexual, ciclo de muda e recrutamento. Um total de 1.150 indivíduos foram capturados e não foi verificada diferença significativa para tamanho médio entre sexos. A distribuição normal de frequência foi verificada e os machos foram dominantes. Fêmeas ovígeras foram capturadas em quase todo o período e a razão sexual não diferiu do esperado 1:1. A atividade de muda foi registrada para todo o período amostral e revelou maior atividade em indivíduos menores. A população de *G. cruentata* parece seguir padrões esperados para caranguejos marinhos tropicais. Entretanto, alguns parâmetros como recrutamento e período reprodutivo não reproduziram exatamente esses padrões, sugerindo que a regulação populacional é influenciada por condições locais.
Palavras-chave Conservação, distribuição de frequência, razão sexual, recrutamento, ciclo de muda

INTRODUCTION

Crabs are one of the most important substrate macrofauna group in tropical and sub tropical mangroves forests and bushes, concerning both number (Jones et al. 1994) and biomass (Golley et al. 1962). According Lee (1998) because of the large variety of habitats, especially the many microhabitats that they use and even their diet, a growing interest in the ecology of these mangrove crabs been arising.

According Twilley et al. (1995, 1996), mangroves play a key role in maintaining coastal stability and water quality, as well as in promoting soil development. In tropical regions, the mangroves are remarkable for sheltering a protracted catalogue of invertebrate species, thus being the main vegetation in supporting biodiversity.

Grapsoid crabs explore tropical, sub-tropical and even warm temperate habitats, present a broad ecologic valence. The red mangrove crab, *G. cruentata* is one of the most abundant grapsid crabs of mangrove ecosystems in the South Western Atlantic coast, distributed from North Carolina (USA) to Santa Catarina (Brazil) (Melo, 1996). Inhabit virtually all microhabitats on the mangrove forests and bushes and fill most of the niches provided by these ecosystems, walking on the ground in whole substratum types in the mangroves, climbing trees or occupying burrows made by another crab species, these abilities allow it a large range of displacement on the mangrove swamps for food and shelter. The trophic role of this crab in the ecosystem is so large as reported to sesarmid and ocypodid crabs (Lima-Gomes et al. 2011). In addition, Ferreira et al. (2013) suggesting that *G. cruentata* plays an important role concerning propagule predation, affecting the mangrove recruitment and community composition.

Goniopsis cruentata is a continuous breeder over the Brazilian coast (Silva & Oshiro, 2002; Cobo & Fransozo, 2003; Lira et al. 2013; Santos et al., 2013). Along the Brazilian littoral the mean size of the red mangrove crab range significantly, enlarging to the lower latitudes, besides mangrove forest structure and size, and fisheries also constrain the crab' size (see Hirose et al. 2015). The recruitment shows peaks in some periods of the annual cycle, likely regarded to the more favorable environmental conditions, such as food and shelter to the recruits (Cobo & Fransozo 2005, Santos et al. 2013). Davanso et al. (2013) suggested that this species seems proper for biomonitoring in tropical estuarine areas. In addition, this species is consumed and exploited by artisanal fisherman', mainly in Northeastern Brazil (Moura, & Coelho 2004, Maciel & Alves 2009). This is a matter for concern once no management plan has yet been developed to ensure the conservation of natural stocks of this species in Brazil (Hirose et al. 2015).

Crab populations have several features or properties, such as density, biotic potential, recruitment and growth, which are not attributes of an isolated organism or individual, but when grouped they coordinate the dynamics of a natural population (Hutchinson 1981, Jones & Simons 1983). The individuals that are part of these populations interact, competing for food, shelter and reproductive access, among some other resources and the intra- and interspecific relationships that maintain the balance of the community (Fonteles-Filho 1989, Benetti et al. 2007).

This paper reports some population parameters, as frequency distribution on size classes, breeding period, sex-ratio, moult cycle and estimative about recruitment, of the red mangrove crab *Goniopsis cruentata* in a subtropical estuarine mangrove, on the southeastern Brazilian coast.

MATERIAL & METHODS

Monthly collections were made from January,1995 to December, 1996, in an estuarine mangrove area formed by de Comprido and Escuro Rivers at Fortaleza Bay, Ubatuba, northeastern coast of the São Paulo State, southeastern Brazil (23°29'45"S-45°09'00"W) (Fig. 1). A catch effort of 2 hours/month (two people for one hour) was used. Crabs were catch by hand, during low tides at daylight. Once in laboratory, sex and presence of eggs were assessed, and each crab was recognized as young or adult, based on the internal and external abdomen features. The carapace width (CW) was measured to nearest of 0.1mm using Vernier calliper, and crabs were grouped into five demographic categories: young males; adult males; young females; adult and ovigerous females. The mean size of males and females were compared by the "Z" test. The number, sex, and size of crabs in moult activity mole crab/postmoult and

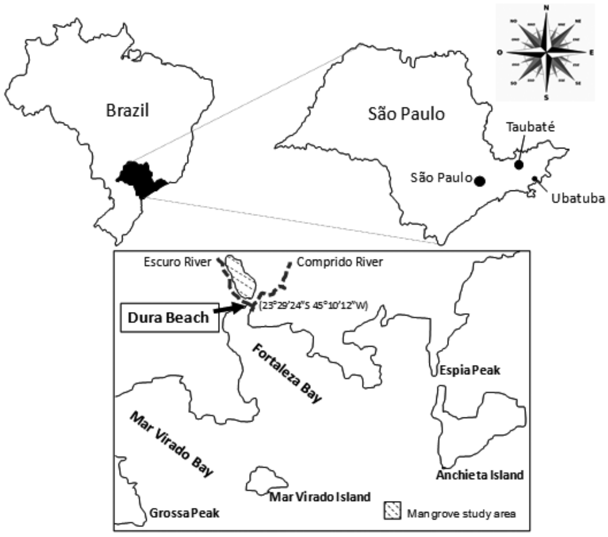

Figure 1. Map of the studied area.

premoult conditions) was also monthly recorded. Sex-ratio was estimated as the percentage male frequency. Chi-square test was performed to evaluated significant deviation from the 1:1 ratio between sexes in the population, for each month and in the size classes. (α= 5%) (Sokal & Rohlf 1995). The sex-ratio results were classified into Werner´s patterns. Crabs were distributed in size classes following the 4mmCW interval, ranging from 4—]8 to 52—]56 mmCW, as suggested by Cobo & Fransozo (1998). Monthly frequency histograms were constructed to follow the modal size class displacement and access the recruitment. In this investigation, the recruitment was measured as the crab frequency on the two first size classes. Frequency distribution normality was evaluated by Kolmorov-Smirnof test (α= 5%) (Sokal & Rohlf 1995). Moult condition was estimated based on the carapace consistency, as flexible and soft cuticle, and the presence of a new cuticle under the exoskeleton. Moult activity was evaluated monthly and for the size classes. The proportion of crabs with moult activity in relation to those intermoult ones was compared by Goodman test (α= 5%), to evaluate the differences between binomial proportions (Curi & Moraes 1981).

RESULTS

Over two years of collections 1,150 individuals were obtained, distributed as 281 males and 261 females in 1995, and 280 males and 328 females in 1996. Male mean size of 30.08mmCW, ranging from 6.8 to 52.9 mmCW (N= 563), and for females (N= 587) 29.38mmCW, ranging from 6,8 to 43,8 mmCW. No significant difference was detected concerning the mean size between sexes (Z= -0.462910, *p*= 0.64342). The 28—]32 mmCW class was the modal size class for both 1995 and 1996. Frequency distributions of both years were bell-shaped (year 1995: K-S= 0.5374, *p*=0.00001; year 1996: K-S 0.03447; *p*= 0.01784) (Figs. 2 and 3). The smallest ovigerous female measured 25.1mmCW and 25.7mmCW in 1995 and 1996, respectively. Adult crabs were dominant on the population, with young crabs absent in some months in 1995 and present in low rates at the overall sampled period for 1996. In addition, ovigerous females were recorded in almost all months in both years, except June and July 1995

REVISTA BIOCIÊNCIAS

ed. 26 | 3 | 2020

and from July to September, and November 1996 (Figs 4 and 5). The monthly size classes' frequency histograms, for both years, not provided a clear understanding regarded to the pattern of the cohort's displacement, and bring no precise data concerning recruitment (Figs. 6 and 7).

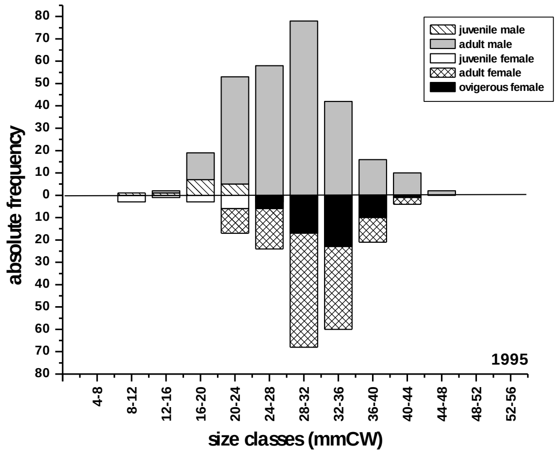

Figure 2. Size classes frequency histogram for demographic categories for 1995.

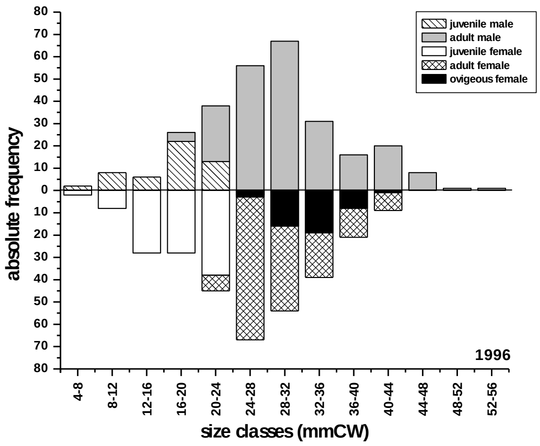

Figure 3. Size classes frequency histogram for demographic categories for 1996.

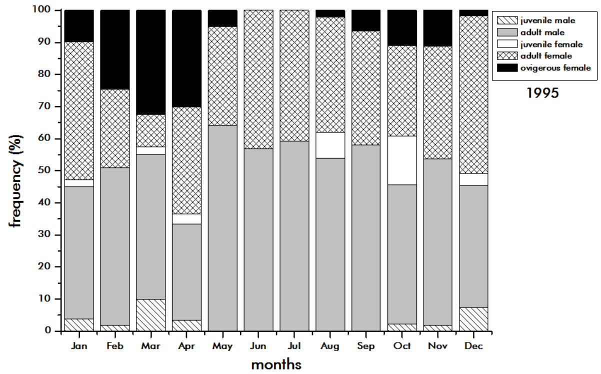

Figure 4. Monthly distribution frequency for demographic categories for 1995.

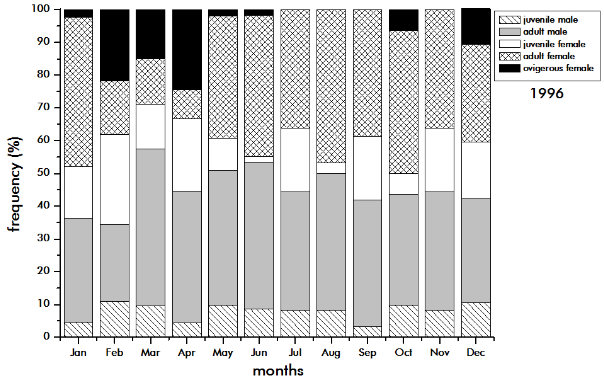

Figure 5. Monthly distribution frequency for demographic categories for 1996.

A sex-ratio of 1:1.04 (male : females) was recorded for the total of sampled crabs during the combined years, providing no statistical difference from the expected 1:1 ratio (50% of males and females) ($p > 0,05$). For the crabs sampled during 1995, a sex-ratio of 1:0.93 was recorded, also without meaning differences from de 1:1 expected ratio ($p > 0.05$). However, for 1996, the sex-ratio of 1:1.17 pointing a statistical difference from the expected 1:1 ratio ($p < 0.05$) female biased. The male frequency distribution in size classes, showed some deviations from the expected 1:1 sex-ratio in both 1995 and 1996, and may be classified as anomalous distribution, according Wenner´s pattern (Figs. 8 and 9). In 1995 were verified deviations from the 1:1 sex-ratio only in April and May, biased for females and males respectively ($p< 0.05$) (fig. 10), while in 1996 this deviations were recorded at January and February, both female biased ($p< 0.05$) (Fig. 11).

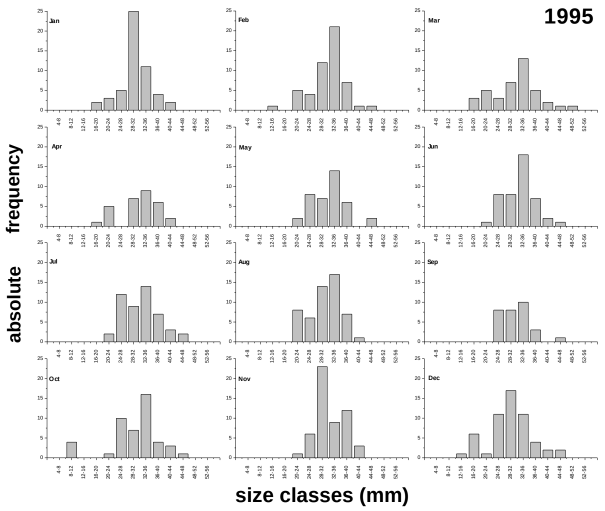

Figure 6. Monthly distribution frequency for 1995.

Moult activity was recorded over the all sampled period, with peaks of moult activity in February and November 1995 (multinomial proportion analysis $\chi^2= 32.0824$) (Fig. 12), and October 1996 (multinomial proportion analysis $\chi^2= 19.8817$) (Fig 13), However, was recorded a larger proportion of intermoult individuals over the whole studied period. The frequency of moult on the size classes reveals a larger activity regarded to smallest body sizes and the absence of moult activity on the 48—]52 and 52—]56 size classes, in both years. The monthly frequency of moult activity for females was always less than 40%, and absent in April 1995 and August 1996. For males, the moult activity was recorded over the whole period studied, with monthly frequencies always smaller than 50%.

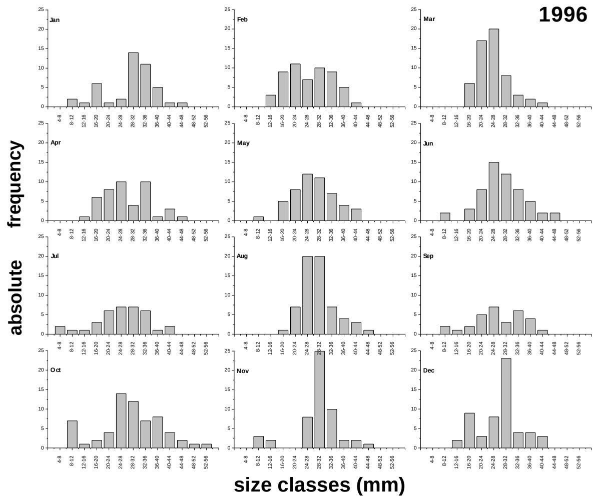

Figure 7. Monthly distribution frequency for 1996.

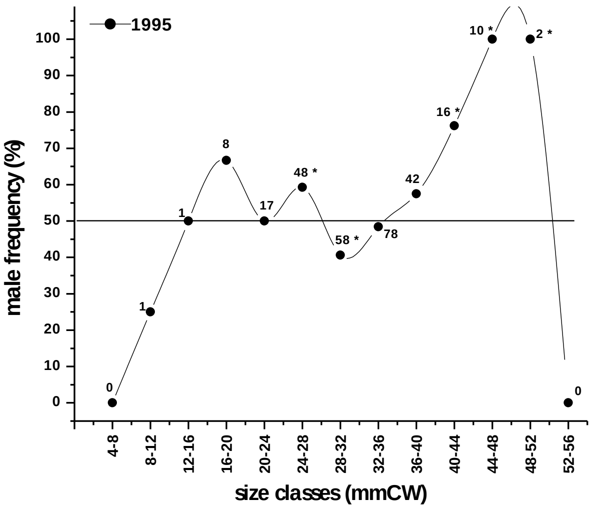

Figure 8. Male frequency distribution in size classes for 1995 (Numbers in the line represents

the number of individuals and the asterisks pointing meaning differences to 50%).

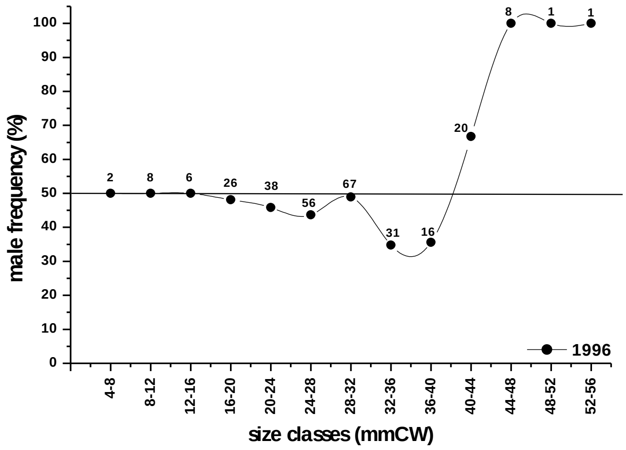

Figure 9. Male frequency distribution in size classes for 1996 (Numbers in the line represents the number of individuals and the asterisks pointing meaning differences to 50%).

DISCUSSION

The no significant differences verified for the mean size between the sexes, for *G. cruentata*, may reveal the same roles for both male and female on the environment. However, a distinct pattern was recorded for another *G. cruentata* population on the northeastern Brazilian coast, as reported by Moura et al. (2000), Hirose et al. (2015), and in the southeastern Brazilian coast by Silva & Oshiro (2002), which found the mean size of males larger than females.

The mean size recorded for *G. cruentata*, in this investigation, was smaller those recorded by Moura et al. (2000) (males 43.0±5.9; females 41.4.7mmCW) and Hirose et al. (2015) (males 48.3; females 43.5mmCW) in northeastern mangroves, and Silva & Oshiro (2002) (35.6±7.84mmCW), for Rio de Janeiro population. All these sites are located at higher latitudes than the area of the present study. According Lopez-Greco et al. (2000) size differences, for populations of same brachyuran species, have been attributed to the latitudinal distribution variation, due by the forest maturity and conservation. This relationship was report to *Sesarma messa* Campbel 1967, by Micheli (1993), whose data, based on laboratory experiments, hint that there is a direct link between mangrove forest primary production and secondary production of crabs.

In this sense, availability and quality of food could led to important differences concerning to population characteristics, especially on the growth and reproductive parameters (Conde et al. 2000). The pattern of variation, of these parameters, would indicate that small-scale factors are also important for regulating population structure (Hines 1989).

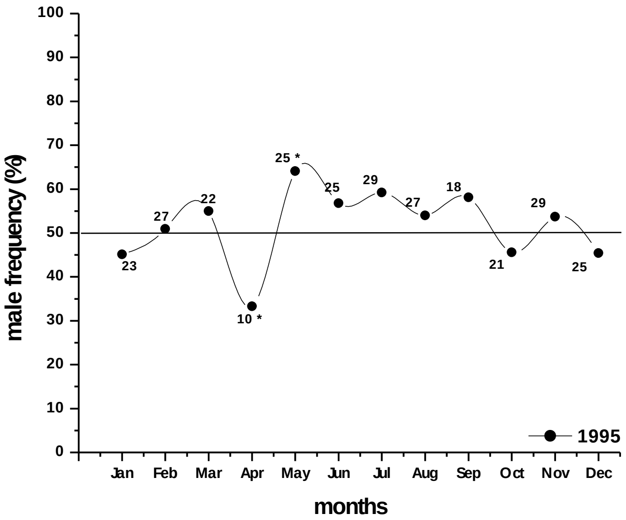

Figure 10. Monthly male frequency distribution for 1995 (Numbers in the line represents the number of individuals and the asterisks pointing meaning differences to 50%).

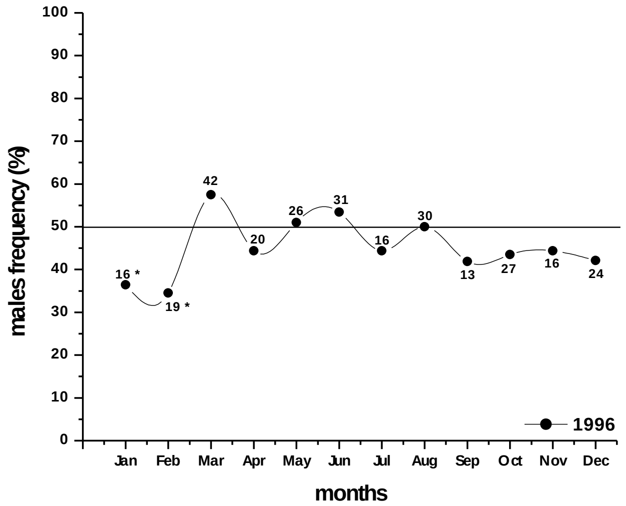

Figure 11. Monthly male frequency distribution for 1996 (Numbers in the line represents the number of individuals and the asterisks pointing meaning differences to 50%).

The population frequency distribution showed a normal curve for both studied years, and throughout of the most of the months was, in general, represented by a single mode, which, according Hartnoll & Briant (1990), can indicate the stability of the population. The appearance of a second mode, as recorded for some months in this study, may indicate a higher juvenile recruitment, however, juveniles coming up to the population throughout the almost whole sampled period, corroborate the hypothesis of stability of this population. According to Mouton & Felder (1995), differences in monthly size frequency are typically found in species that produce several clutches per individual, as previously reported to *G. cruentata* by Cobo & Fransozo (2005).

In spite to latitudinal variation, the size of the smallest ovigerous females, recorded during the sampled period, was compared to those founded by Silva & Oshiro (2002) (26.0mmCW), in the coast of the Rio de Janeiro State. However, in a more pronounced latitudinal distance, Moura et al. (2000), found ovigerous female from 31.9mmCW, remarkably larger than those recorded during the present study (25.1mmCW). This difference may corroborate to the hypothesis of the latitudinal variation influence, which seems no large enough between São Paulo and Rio de Janeiro coasts, but significantly in relation to coast of Pernambuco State to provide effects in ovigerous size.

According to Hines (1989) temperature and temperature-photoperiod, interactions are variables that produce latitudinal clines in metabolic rates, growth, and size at higher latitudes, as than as small-scale factors such as food availability, population density or subtle changes in substrate, which can vary among compared mangrove areas, rather than latitudinal factors are important in regulating the size range.

The presence of adult crabs characterizes the studied population. In addition, our results and the limitations provided by the collections avoid assess to the recruitment pulses. In most situations is extremely hard assess the recruitment as the entrance of individuals on the population. Some features as size, cryptic behavior, and failure of the catch method, may provide a remarkable absence of recruits on the records.

Therefore, the *G. cruentata* recruitment was measured as the frequency of juveniles on the population. In this sense, considering the presence of juveniles over almost whole sampled period, especially for 1996, we suggest the continuous recruitment for the studied population. Moura et al. (2000) and Silva & Oshiro (2002) reporting a comparable pattern to populations of the Rio de Janeiro and Pernambuco coasts. In all of these reports, as than as for the present study, is remarkable the absence of juveniles during the coldest months in the southern hemisphere, when the environmental conditions, as food availability and low temperatures, may represent a threaten season for the establishment of these juveniles on the population, probably providing a recruitment delay.

A similar pattern was recorded for the ovigerous female's distribution for both years, when they are absent during for some months, especially June and July, characteristically cold in the southern hemisphere. However, the egg incubation must represent an important time during the life cycle, hence, is appropriated suggest that cryptic behavior, already described for *G. cruentata* (Hartnoll 1969, Warner 1970), may be maximized during this season. Cobo & Fransozo (1999) previously reported the absence of *G. cruentata* ovigerous females, during coldest months, for the northeastern of the coast of São Paulo State, Moura et al. (2000), on the coast of Pernambuco and Silva & Oshiro (2002) in an estuary on the coast of the Rio de Janeiro State.

Therefore, the population of *G. cruentata* seems to follow the expected standards of the tropical marine crabs, as the latitudinal constrains already reported for some marine species (*see* Lenihan & Micheli 2001, for revision). Moreover, some population attributes, as recruitment and breeding period no match exactly within these standards (*see* Araújo et al. 2016), suggesting that population regulation is strongly related to the mangrove development.

REFERENCES

ARAÚJO, M. S. L. C.; AZEVEDO, D. S.; SILVA, J. V. C. L.;

PEREIRA, C. L. F.; CASTIGLIONI, D. S. Population biology of two sympatric crabs: *Pachygrapsus transversus* (Gibbes, 1850) (Brachyura, Grapsidae) and *Eriphia gonagra* (Fabricius, 1781) (Brachyura, Eriphidae) in reefs of Boa Viagem beach, Recife, Brazil. **Pan-American Journal of Aquatic Sciences**, 11(3): 197-210. 2016.

BENETTI, A. S.; NEGREIROS-FRANSOZO, M. L; COSTA, T. M. Population and reproductive biology of *Uca burgersi* Holthuis, 1967 (Crustacea, Brachyura, Ocypodidae) in three subtropical mangroves forests. **Revista de Biologia Tropical**, 57: 61-69. 2007.

COBO, V. J.; FRANSOZO, A. Relative Growth of *Goniopsis cruentata* (Crustacea, Brachyura, Grapsidae), on the Ubatuba region, SP/Brazil. **Iheringia. Série Zoologia**, 84: 21-28. 1998.

COBO, V. J.; FRANSOZO, A. External factors determining breeding season in the red mangrove crab *Goniopsis cruentata* (Latreille) (Crustacea, Brachyura, Grapsidae) on the São Paulo State northern coast, Brasil. **Revista Brasileira de Zoologia**, 20(2): 213-217. 2003.

COBO, V. J.; FRANSOZO, A. Physiological maturity and relationship of growth and reproduction in the red mangrove crab *Goniopsis cruentata* (Latreille) (Brachyura, Grapsidae) on the coast of São Paulo, Brazil. **Revista Brasileira de Zoologia**, 22(1), 219-223. 2005.

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

CURI, P. R.; MORAES, R. V. Associação, homogeneidade e contrastes entre proporções em tabelas contendo distribuições multinomiais. **Ciência & Cultura**, 33 (5): 712-722. 1981.

DAVANSO, M. B.; MOREIRA, L. B.; PIMENTEL, M. F.; COSTA-LOTUFO, L. V.; ABESSA, D. M. S. Biomarkers in mangrove root crab *Goniopsis cruentata* for evaluating quality of tropical estuaries. **Marine Environmental Research**, 91: 80-88. 2013.

FERREIRA, A. C., GANADE, G., FREIRE, F. A. M.; ATTAYDE, J. L. Propagule predation in a Neotropical mangrove: the role of the Grapsid crab *Goniopsis cruentata*. **Hydrobiologia**, 707(1), 135-146. 2013.

FONTELLES-FILHO, A. A. **Recursos pesqueiros, biologia e dinâmica populacional.** Fortaleza, Imprensa Oficial do Ceará. 296 p. 1989.

GOLLEY, F. B.; ODUM, H. T.; WILSON, R. F. The structure and metabolism of a Puerto Rico red mangrove forest in May. **Ecology**, 43:9-19. 1962.

HARTNOLL, R. G. Mating in the Brachyura. **Crustaceana**, 16: 11 - 181. 1969.

HARTNOLL, R. G.; BRYANT, A.D. Size-frequency distributions in Decapod Crustacea - The quick the dead, and the cast-offs. **Journal of the Crustacean Biology**, 10 (1): 14 - 19. 1990.

HINES, A. H. Geographic variation in size at maturity in Brachyuran crabs. **Bulletin of Marine Science**, 45(2), 356-368. 1989.

HIROSE, G. L.; SOUZA, L. S.; SILVA, S. L. R.; ALVES, D. F. R.; NEGREIROS-FRANSOZO, M. L. Population structure of the red mangrove crab, *Goniopsis cruentata*

(Decapoda: Grapsidae) under different fishery impacts: Implications for resource management. **Revísta de Biologia Tropical**, 63(2): 443-457. 2015.

HUTCHINSON, G. E. **Introducción a la ecologia de poblaciones.** Editorial Blume, Barcelona, Espanha, 492 p. 1981.

JONES, M. B.; SIMONS, M. J. Latitudinal variation in reproductive characteristics of a mud crab *Helice crassa* (Grapsidae). **Bulletin of Marine Science**, 33 (3): 656-670. 1983.

JONES, C. G.; LAWTON J. H.; HACHAK, M. S. Organisms as ecosystem engineers. **Oikos**, 69: 373-386. 1994.

LEE, S. Y. Ecological role of grapsid crabs in mangrove ecosystems: a review. **Marine and Freshwater Research**, 49: 335-343. 1998.

LENIHAN H. S.; MICHELI, F. Soft sediment communities. *In*: Bertness, M. D., Gaines, S. D. & Hay M. E. (eds) **Marine community ecology**. Sinauer Associates, Sunderland, MA. 253–287 p. 2001.

LIMA-GOMES, R. C.; COBO, V. J.; FRANSOZO, A. Feeding behaviour and ecosystem role of the red mangrove crab *Goniopsis cruentata* (Latreille, 1803) (Decapoda, Grapsoidea) in a subtropical estuary on the Brazilian coast. **Crustaceana**, 84, 735-747. 2011.

LIRA, J. J. P. R.; CALADO, T.C.S.; ARAÚJO, M.S.L.C. Breeding period in the mangrove crab *Goniopsis cruentata* (Decapoda: Grapsidae) in Northeast Brazil. **Revísta de Biologia Tropical**, 61, 29-38. 2013.

LÓPEZ-GRECO, L.; HERNANDEZ, J.; BOLAÑOS, J.; RODRIGUEZ, E.; HERNANDEZ, G. Population features of *Microphrys bicornutus* Latreille, 1825 (Brachyura, Majidae) from Isla Margarita, Venezuela. **Hydrobiologia**, 439 (1-3): 151-159. 2000.

MACIEL, D. C.; ALVES, A. G. C. Conhecimentos e práticas locais relacionadas ao aratu *Goniopsis cruentata* (Latreille, 1803) em Barra de Sirinhaém, litoral sul de Pernambuco, Brasil. **Biota Neotropica**, 9, 29-36. 2009.

MELO, G. A. S. **Manual de identificação dos Brachyura (caranguejos e siris) do litoral brasileiro.** São Paulo: Plêiade. 604 p. 1996.

MICHELI, F. Feeding ecology of mangrove crabs in north Eastern Australia: mangrove littler consumption by *Sesarma messa* and *Sesarma smithii*. **Journal of Experimental Marine Biology and Ecology**, 171: 165-186. 1993.

MOUTON, E. M.; FELDER, D. L. Reproduction of the fiddler crabs *Uca longisignalis* and *Uca spinicarpa* in a Gulf of Mexico salt marsh. **Estuaries**, 18, 469–481. 1995.

MOURA, N. F. O.; COELHO-FILHO, P. A.; COELHO, P. A. Population structure of *Goniopsis cruentata* (Latreille 1803) in the Paripe estuary, Brazil. **Nauplius**, 8: 73-78. 2000.

MOURA, N. F. O.; COELHO, P. A. C. Maturidade sexual fisiológica em *Goniopsis cruentata* (Latreille) (Crustacea, Brachyura, Grapsidae) no Estuário do Paripe, **Pernambuco, Brasil. Revista Brasileira de Zoologia**, 21(4): 1011-1015. 2004.

SANTOS, M. C. F.; BOTELHO, E. R. R. O.; IVO, C. T. C. Biologia populacional e manejo da pesca de aratu, *Goniopsis cruentata* (Latreille, 1803) (Crustacea: Decapoda: Grapsidae) no litoral sul de Pernambuco–Brasil. **Boletim Técnico e Científco do CEPENE**, 9: 87-123. 2001.

SILVA, Z. S.; OSHIRO, L. M. Y. Aspectos reprodutivos de *Goniopsis cruentata* (Latreille) (Crustacea, Brachyura, Grapsidae) na Baía de Sepetiba, Rio de Janeiro, Brasil. **Revista Brasileira de Zoologia**, 19(3), 907-914. 2002.

SOKAL, R. R.; ROHLF, F. J. **Biometry**. 3rd Edition. Freeman, New York, 887 pp. 1995.

TWILLEY, R. R.; SNEDAKER, S. C.; YÁNEZ-ARANCIBIA, A.; MEDINA, A. Mangroves systems. *In* Heywood, V. H. (Ed.). **Global biodiversity assessment, biodiversity and ecosystem function: ecosystem analysis.** Cambridge, Cambridge University Press, p. 387-393. 1995.

TWILLEY, R. R.; SNEDAKER, R. R.; YÁÑEZ-ARANCIBIA, S. C.; MEDINA, A. Biodiversity and ecosystem processes in tropical estuaries: perspectives of mangrove ecosystems. *In*: Mooney H. A., Cushman, J.H., Medina, E., Sala, O. E. and Schulze, E. D. (Eds), **Functional Roles of Biodiversity: a Global Perspective.** J Wiley & Sons Ltd., New York, p. 327-370. 1996.

WARNER, G. F. The behavior of two species of grapsid crabs during intraspecific encounters. **Behavior**, 36: 9-19. 1970.