Nauplius
The Journal of The Brazilian Crustacean Society
e-ISSN 2358-2936
www.scielo.br/nau
www.crustacea.org.br

Carapace width/length-weight relationships for portunid crabs (genus *Callinectes* Stimpson, 1860) in northern Brazilian mangrove estuaries

Rory Romero de Sena Oliveira[1] orcid.org/0000-0002-1411-9059
Danielly Brito de Oliveira[2] orcid.org/0000-0002-7722-5844
Ana Patrícia Barros Cordeiro[3] orcid.org/0000-0003-4955-5405
Israel Hidenburgo Aniceto Cintra[4] orcid.org/0000-0001-5822-454X
Alex Garcia Cavalleiro de Macedo Klautau[5] orcid.org/0000-0002-0029-7639

1 Núcleo de Ecologia Aquática e Pesca da Amazônia, Universidade Federal do Pará. Cidade Universitária Prof. José Silveira Netto, Avenida Perimetral, 2651, Terra Firme, CEP 66077-830, Belém, PA, Brazil.
RRSO E-mail: rorysena@ymail.com

2 Instituto de Estudos do Xingu, Universidade Federal do Sul e Sudeste do Pará. Campus São Félix do Xingu, CEP 68380000, Pará, Brazil.
DBO E-mail: danielly.oliveira@unifesspa.edu.br

3 Universidade da Amazônia – UNAMA. Rodovia BR 316, km 03, Coqueiro, CEP 67113-000, Ananindeua, PA, Brazil.
APBC E-mail: anapaty2301@gmail.com

4 Universidade Federal Rural da Amazônia – UFRA. Av. Tancredo Neves, 2501, Terra Firme, CEP 66077-530, Belém, PA, Brazil.
IHAC E-mail: israelcintra@hotmail.com

5 Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Norte – CEPNOR, Instituto Chico Mendes de Conservação da Biodiversidade. Av. Tancredo Neves, 2501, Terra Firme, CEP 66077-530, Belém, PA, Brazil.
AGCMK E-mail: alex.klautau@icmbio.gov.br

ZOOBANK: http://zoobank.org/urn:lsid:zoobank.org:pub:25C72205-19E4-4F4D-9007-A15B463C2526

Corresponding Author
Rory Romero de Sena Oliveira
rorysena@ymail.com

SUBMITTED 16 September 2020
ACCEPTED 05 December 2021
PUBLISHED 16 May 2022

DOI 10.1590/2358-2936e2022011

Abstract

Carapace width–carapace length (CW/CLRs), carapace width–weight (CW/WRs), and carapace length–weight (CL/WR) relationships are presented for the portunid species *Callinectes bocourti* A. Milne Edwards, 1879, *Callinectes danae* Smith, 1869, and *Callinectes ornatus* Ordway, 1863 from the northern coast of Brazil. A total of 85 crabs were collected between May and October 2015 in intertidal zones of the Caeté, Pirabas and Salinas estuaries. All species had strong relationships between measurements with a coefficient of determination (r^2) ranging between 0.97 and 0.99. The variable most strongly related to CW was CL with 99 % of the variability provided by *C. ornatus*. These relationships are a useful tool for field ecologists to estimate length and/or mass of portunid species, and it is not necessary to euthanize the organism to collect body measurements. Additionally, this study describes the first reference of CW/CLRs and CL/WRs for these portunid species in the region. The *Callinectes* species in Amazon estuaries are still poorly studied, and there is a need for monitoring their stocks due to its importance for artisanal fishery. The present data are important for supplying biological information required for an adequate management of this fishery.

Keywords

Amazon region, Amazonian estuaries, intertidal zone, morphology, swimming crab

The Brazilian Amazon coastal zone represents a single ecosystem due to the high dynamics of the freshwater discharge, favoring a highly diverse invertebrate fauna, which is still poorly known. Recently, Lima and Martinelli-Lemos (2021) recorded a total of 194 crab species occurring within this coastal zone. Portunid crabs are found in high abundance along the Brazilian coast, presenting more than 20 species, 11 only on the northern coast of the country, with *Callinectes bocourti* A. Milne Edwards, 1879, *Callinectes danae* Smith, 1869, and *Callinectes ornatus* Ordway, 1863 being the most common representatives of the genus in the estuarine Amazon region (Melo, 1999; Nevis *et al.*, 2009; Andrade *et al.*, 2013). However, ecological information about these species is still sparse, especially in the Amazon region.

Portunid crabs are the most abundant estuarine macro-invertebrate species that support valuable commercial and recreational fisheries along the Atlantic coast. However, ecological parameters that can be useful for their fishery management are still poorly understood (Moruf and Lawal-Are, 2017). These species compose a significant by-catch fraction and are frequently discarded during shrimp trawling along the Brazilian coast (Keunecke *et al.*, 2008). On the Amazon continental shelf, the crustaceans were also dominant in the invertebrate assemblage impacted by shrimp trawl fisheries, including *Callinectes* species (Nóbrega *et al.*, 2021).

Many studies have been carried out with swimming crabs in Brazil (Nevis *et al.*, 2009; Araújo *et al.*, 2011; Andrade *et al.*, 2013; Shinozaki-Mendes and Lessa, 2017a; 2017b). However, only a few of them verified morphological relationships of the portunid crabs (Newcombe, 1948; Haefner Jr., 1990; Mantelatto and Martinelli, 1999; Araújo and Lira, 2012; Udoh, 2017; Kevrekidis, 2019). These relationships between morphological measurements are important when converting length or width data into weight. Also, they are an important tool for evaluating ontogenetic standards and other aspects of population dynamics of the crabs, suggesting measures for the sustainable management of fisheries (Atar and Seçer, 2003; Araújo and Lira, 2012; Kakou *et al.*, 2017; Moruf and Lawal-Are, 2017).

Although portunid crabs are widely captured by the artisanal fishers along the northern Brazilian coast and in general in the Neotropics, they are also targeted by industrial fisheries, *e.g.*, *C. ornatus* is one of the most abundant brachyurans discarded in the bycatch of the *Xiphopenaeus kroyeri* (Heller, 1862) shrimp fishery. The state of knowledge on the ecology, however, is considered incipient (Nevis *et al.*, 2009; Carvalho *et al.*, 2011; Araújo and Lira, 2012; Shinozaki-Mendes and Lessa, 2017b; Nóbrega *et al.*, 2021). Therefore, this study reports on the CW-W and CL-W relationships for the swimming crabs *C. bocourti*, *C. danae* and *C. ornatus*, and represents the first reference of these relationships for these crab species from northern Brazil.

Samples were collected in the intertidal zones of three estuarine systems along the northern coast of Brazil (Fig. 1) between May and October 2015: Urindeua and Maramuipy Rivers - Salinópolis, Pirabas River - Pirabas and Caeté River - Bragança. These coastal areas are macrotidal estuaries (tidal range 4 to 7.5 m) (Souza-Filho, 2005), and the mangrove forest is dominated by *Rhizophora mangle* and *Avicennia germinans* (Souza-Filho, 2005; Menezes *et al.*, 2008).

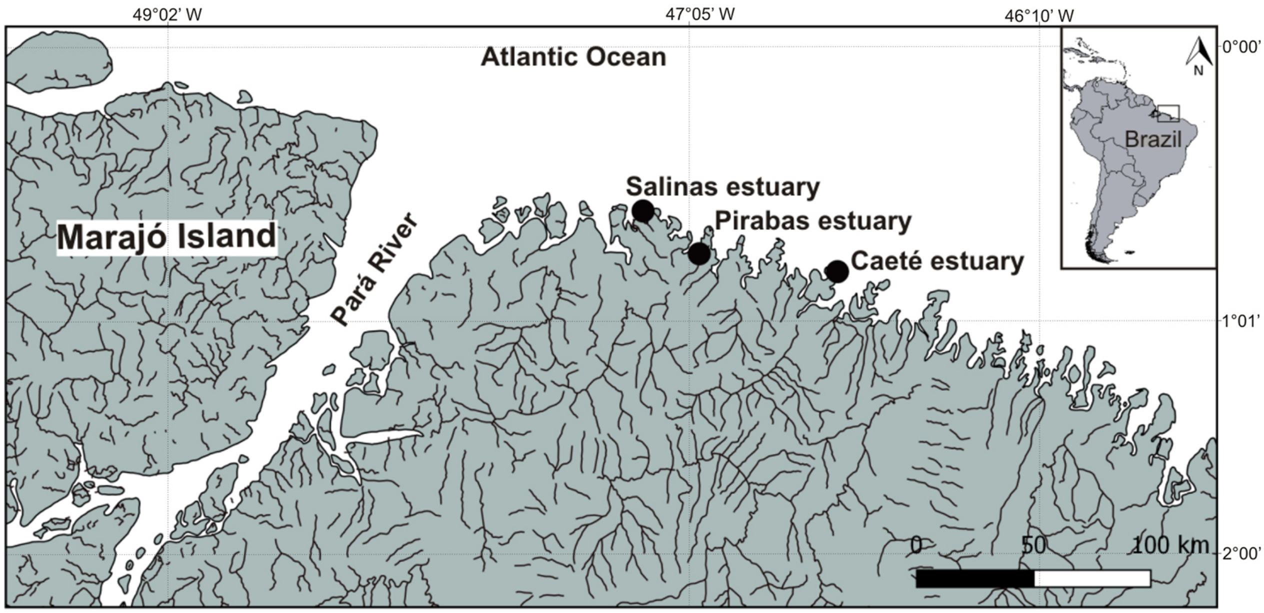

Figure 1. Estuaries sampled along the Pará coast, northern Brazil.

Callinectes crab specimens were captured using manual beach seines during ebb tide; the collected individuals were immediately stored in ice and transported to the laboratory for analysis. All crabs were identified to the species level using identification keys provided by Melo (1996). Also, phenotypic sex was judged by observing the morphology of the crab's abdomen (Melo, 1996; Shinozaki-Mendes and Lessa, 2017a); carapace widths (CW) were measured using digital calipers with an accuracy of 0.01 mm; body weight was obtained by using a digital balance with an accuracy of 0.01 g.

The relationship between CL-CW was estimated by linear regression model for each sex, where CL is the carapace length (mm) and CW carapace width (mm). Furthermore, CL-W; CW-W was calculated using the expression: $W = a.C^b$ (C = CW and CL), and logarithmically transformed into $\log W = \log a + b \log C$ (C = CW and CL; adapted from Froese, 2006) where W is the wet weight of the crab (g), a is a constant, and b is the allometric coefficient (Sokal and Rohlf, 1995). The coefficient of determination (Pearson r-squared, r^2) was used as an indicator of quality of the linear regression. Outliers for each species were removed by graphical inspection of log-log plot (Froese, 2006). Additionally, Analysis of Covariance (ANCOVA) was used to compare the slopes and intercepts of the lines between sexes, to detect different growth stanzas and, if necessary, males and females were grouped by the same relationship (Araújo and Lira, 2012). In order to check if crab growth (b) was statistically different from isometric growth, a Student t-test (H0: $b = 3$; Hartnoll, 1982), with $\alpha = 0.05$, was performed (Sokal and Rohlf, 1995).

During the sampling period, a total of 68 crab specimens belonging to three species was collected and measured: 23 individuals of *C. bocourti* (11 males and 12 females), 35 of *C. danae* (23 and 12), and 10 of *C. ornatus* (6 and 4) (Tab. 1). Statistical results of the regression parameters a and b, based in 95 % confidence limits and coefficients of determination (r^2) of the CW/CL, CW/W and, CL/W relationships for *C. bocourti*, *C. danae* and *C. ornatus* species are given in Table 2. The parameter b of the CL/WR ranged from 2.845 to 3.515 for *C.ornatus* and *C. bocourti*, respectively, characterized as isometric growth (Tab. 2).

Measures of CL, CW and total weight were lowest in male *C. ornatus* and highest in male *C. bocourti* (Tab. 1). The CW/CLRs of the *Callinectes* species were significant ($p < 0.01$) and with most of the coefficient of determination (r^2) values being above 0.98 for each sex. Since ANCOVA did not detect differences regarding CW/CL and CW/W relationships between sex for *C. bocourti* and *C. ornatus*, both sexes were grouped for these species (Tab. 2). The parameter b of the CW/WRs ranged from 2.4927 to 3.1693 for female *C. bocourti* and male *C. bocourti*, respectively.

Table 1. Sample size (N) and ranges of carapace length (CL), carapace width (CW), and weight (W) for male, female and combined sexes of *Callinectes bocourti* A. Milne-Edwards, 1879, *Callinectes danae* Smith, 1869 and *Callinectes ornatus* Ordway, 1863 from northern Brazil.

Species	S	N	CL (mm)		CW (mm)		W (g)	
			Min	Max	Min	Max	Min	Max
Portunidae								
Callinectes bocourti	M	11	13.69	62.75	29.02	130.4	1.38	176.44
	F	12	23.48	56.12	42.68	118.95	7.26	110.52
	CS	23						
Callinectes danae	M	23	19.13	53.26	43.02	130.07	4.84	109.73
	F	12	29.64	45.25	55.89	102.73	10.27	62.09
	CS	35						
Callinectes ornatus	M	6	5.88	25.88	10.66	57.25	0.1	8.28
	F	4	14.46	26.32	33.44	59.59	1.98	8.31
	CS	10						

S: sex; M: male; F: female; CS: combined sexes; CL: carapace length; CW: carapace width; W: weight.

Studies on swimming crabs in the Amazonian region of Brazil are relatively scarce, which hinders crustacean conservation on a local and regional scale (Nevis *et al.*, 2009). However, studies on the relationship of body proportions of swimming crabs have been increasing in other regions of Brazil (*e.g.*, Araújo and Lira, 2012 and Shinozaki-Mendes and Lessa, 2017b - northeast Brazil; Mantelatto and Martinelli, 1999 - southeast Brazil). The present study is the first record of body size and mass relationships for three *Callinectes* species from the northern coast of Brazil. Carapace width–weight relationships for *C. ornatus* indicate negative allometry (CW-WRs) and isometry (CL-WRs), contradicting results of other studies with the same species in Ubatuba Bay (Mantelatto and Martinelli, 1999; Chacur and Negreiros-Fransozo, 2001; Gonçalves *et al.*, 2017), in which the species was considered to have a positive allometric growth pattern. Nonetheless, the results of this study suggest caution when assessing sex and other reproductive characters in juvenile stages of the life cycle within the same species. According to Araújo and Lira (2012), the differences in the life history for the same species may be the result of spatial patterns between populations, abiotic factors, or fisheries exploitation, for example.

Depending on the morphological measure used, the level of allometry may change (see females and males of *C. bocourti* and *C. danae* in CW-W and CL/WRs, respectively in Tab. 2). Additionally, sex should also be a factor to be considered during species identification and data analysis (*e.g.*, CW-W for *C. bocourti*). These characteristics are directly related to the life stage and differential reproductive effort between sexes: males expend a lot of energy and time in mate-guarding behavior during and after copulation, and females direct a large portion of their energy budget to the production of eggs; being heavier than non-ovigerous females (Melo, 1996; Araújo and Lira, 2012; Shinozaki-Mendes and Lessa, 2017b).

Relationships between body size and biomass are important tools in studies of fisheries biology, physiology and ecology, since it improves our understanding of the use of the ecosystem by the species and supports fisheries management strategies (Sokal and Rohlf, 1995; Froese, 2006; Araújo and Lira, 2012). Additionally, these regressions can also be used as an effective tool for ecologists in the field because growth parameters could be estimated without sacrificing the organisms. The results of the present study is a contribution to the knowledge about the relationships between body size and mass of *C. bocourti*, *C. danae* and *C. ornatus* from the northern Brazilian coast and may serve as a baseline for future studies on morphological patterns and ecological surveys for swimming crab species.

Table 2. Relationship values of the carapace width/length–weight for male, female and combined sexes of *Callinectes bocourti* A. Milne-Edwards, 1879, *Callinectes danae* Smith, 1869 and *Callinectes ornatus* Ordway, 1863 from northern Brazil.

Species	S	CW x CL Regression parameters					CW x W Regression parameters					Allometric	CL x W Regression parameters					Allometric
		a	95 % CL of *a*	*b*	95 % CL of *b*	r^2	*a*	95 % CL of *a*	*b*	95 % CL of *b*	r^2		*a*	95 % CL of *a*	*b*	95 % CL of *b*	r^2	
Portunidae																		
Callinectes bocourti	M						0.00003	0.00001 to 0.0001	3.1693	2.91 to 3.43	0.99	isometry	0.0003	0.0001 to 0.0008	3.146	2.92 to 3.37	0.99	isometry
	F						0.0007	0.0003 to 0.0015	2.4927	2.31 to 2.67	0.99	negative	0.0007	0.0003 to 0.0015	2.955	2.74 to 3.17	0.99	isometry
	CS	3.0412	0.40 to 5.68	0.4589	0.43 to 0.48	0.98	0.0001	0.00004 to 0.0003	2.9188	2.71 to 3.13	0.98	isometry	0.0004	0.0002 to 0.0007	3.084	2.93 to 3.23	0.99	isometry
Callinectes danae	M	2.708	1.09 to 4.32	0.3859	0.37 to 0.40	0.99							0.0006	0.0003 to 0.0013	3.039	2.83 to 3.24	0.98	isometry
	F	0.8105	-1.10 to 2.72	0.4244	0.40 to 0.45	0.99							0.0011	0.0006 to 0.0019	2.858	2.70 to 3.01	0.99	negative
	CS	3.3358	1.94 to 4.73	0.3832	0.37 to 0.40	0.99	0.0001	0.0001 to 0.0002	2.7933	2.67 to 2.91	0.99	negative	0.0006	0.0004 to 0.001	3.03	2.88 to 3.18	0.98	isometry
Callinectes ornatus	CS	0.7807	-0.34 to 1.91	0.4337	0.41 to 0.46	0.99	0.0003	0.0001 to 0.0005	2.5535	2.35 to 2.75	0.99	negative	0.0008	0.0003 to 0.0023	2.845	2.48 to 3.21	0.98	isometry

S. sex; M: male; F: female; CS: combined sexes; CW: carapace width; CL: carapace length; W: weight; CL: confidence limits.

Acknowledgments

The authors are thankful to local fishermen for their assistance in the field collections and also to Mr. Otoniel and Patrícia, from ICMBIO. We also acknowledge the anonymous referees and the Associate Editor that helped to improve the manuscript. RRSO and DBO were funded by the National Council for Scientific and Technological Development (CNPq) during the study.

References

Andrade, L.S.; Fransozo, V.; Cobo, V.J.; Castilho, A.L.; Bertini, G. and Fransozo, A. 2013. Ontogenetic distribution of *Callinectes ornatus* (Decapoda, Portunoidea) in southeastern Brazil. *Ciencias Marinas*, 39: 371–385.

Araújo, M.S.L.C.; Negromonte, A.O. and Barreto, A.V. 2011. Reproductive period of the swimming crab *Callinectes danae* at the Santa Cruz Channel, a highly productive tropical estuary in Brazil. *Nauplius*, 19: 155–162.

Araújo, M.S.L.C. and Lira, J.J.P.R. 2012. Condition factor and carapace width versus wet weight relationship in the swimming crab *Callinectes danae* Smith 1869 (Decapoda: Portunidae) at the Santa Cruz Channel, Pernambuco. *Nauplius*, 20: 41–50.

Atar, H.H. and Seçer, S. 2003. Width/length-weight relationships of the Blue Crab (*Callinectes sapidus* Rathbun 1896) population living in Beymelek Lagoon Lake. *Turkish Journal of Veterinary and Animal Sciences*, 27: 443–447.

Carvalho, E.A.S.; Carvalho, F.L. and Couto, E.C.G. 2011. Maturidade sexual em *Callinectes ornatus* Ordway, 1893 (Crustacea: Decapoda: Portunidae) no litoral de Ilhéus, BA, Brasil. *Papéis Avulsos de Zoologia*, 51: 367–372.

Chacur, M.M. and Negreiros-Fransozo, M. L. 2001. Spatial and seasonal distributions of *Callinectes danae* (Decapoda, Portunidae) in Ubatuba Bay, São Paulo, Brazil. *Journal of Crustacean Biology*, 21: 414–425.

Froese, R. 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22: 241–253.

Gonçalves, G.R.L.; Bolla, E.A. Jr.; Negreiros-Fransozo, M.L. and Castilho, A.L. 2017. Morphometric and gonad maturity of the spider crab *Libinia ferreirae* Brito Capello, 1871 (Decapoda: Majoidea: Epialtidae) on the south-eastern Brazilian coast. *Journal of the Marine Biological Association of the United Kingdom*, 97: 289–295.

Haefner Jr, P.A. 1990. Morphometry and size at maturity of *Callinectes ornatus* (Brachyura, Portunidae) in Bermuda. *Bulletin of Marine Science*, 46: 274–286.

Hartnoll, R. 1982. Growth. p. 111–196. In: L. Abele (ed), The Biology of Crustacea: 2. Embryology, Morphology and Genetics. Academic Press, New York.

Kakou, B.I.; Adepo-Gourene, A.B.; Konan, K.M. and Dagou, S. 2017. Length-weight relationship, condition factor and proportionality index of two crabs: *Cardisoma armatum* and *Callinectes amnicola* of Ebrié lagoon of Côte d'Ivoire. *International Journal of Agronomy and Agricultural Research*, 11: 1–7.

Keunecke, K.A.; D'Incao, F.; Moreira, F.N.; Silva Jr., D. and Verani, J.R. 2008. Idade e crescimento de *Callinectes danae* e *C. ornatus* (Crustacea, Decapoda) na Baía de Guanabara, Rio de Janeiro, Brasil. *Iheringia, Série Zoologia*, 98: 231–235.

Kevrekidis, K. 2019. Relative growth of the blue crab *Callinectes sapidus* in Thermaikos Gulf (Methoni Bay), northern Aegean Sea. *Cahiers de Biologie Marine*, 60: 395–397.

Lima, F.A. and Martinelli-Lemos, J.M. 2021. Checklist of the Brachyura of the Brazilian Amazon coastal zone and knowledge status of their larval development. *Zootaxa*, 4646: 301–321.

Mantelatto, F.L.M. and Martinelli, J.M. 1999. Carapace width-weight relationships of *Callinectes ornatus* (Brachyura, Portunidae) from Ubatuba, bay, Brazil. *Iheringia, Série Zoologia*, 87: 111–116.

Melo, G.A.S. 1996. Manual de Identificação dos Brachyura (caranguejos e siris) do Litoral Brasileiro. São Paulo, Editora Plêiade/FAPESP, 603p.

Melo, G.A.S. 1999. Manual de Identificação dos Crustáceos Decapoda do Litoral Brasileiro: Anomura, Thalassinidea, Palinuridea e Astacidea. São Paulo, Editora Plêiade/FAPESP, 551p.

Menezes, M.P.M.; Berger, U. and Mehlig, U. 2008. Mangrove vegetation in Amazonia: a review of studies from the coast of Pará and Maranhão States, north Brazil. *Acta Amazonica*, 38: 403–420.

Moruf, R. and Lawal-Are, A. 2017. Size composition, growth pattern and condition factor of two portunid crabs, *Callinectes amnicola* (De Rochebrune) and *Portunus validus* (Herklots) from Lagos coast, Nigeria. *Journal of Fisheries and Aquaculture*, 5: 15–21.

Nevis, A.B.; Martinelli, J.M.; Carvalho, A.S.S. and Nahum, V.J.I. 2009. Abundance and spatial-temporal distribution of the Family Portunidae (Crustacea, Decapoda) in the Curuçá estuary on the northern coast of Brazil. *Brazilian Journal Aquatic Science and Technology*, 13: 71–79.

Newcombe, C.L. 1948. An application of the allometry equation to the study of growth in *Callinectes sapidus* Rathbun. *The American Naturalist*, 82: 315–325.

Nóbrega, P.S.V.; Santos, C.R.M.; Cordeiro, A.P.B. and Martinelli-Lemos, J.M. 2021. Invertebrates assemblage captured by a pink shrimp's fishery on Amazon continental shelf. *Latin American Journal of Aquatic Research*, 49: 227–241.

Shinozaki-Mendes, R.A. and Lessa, R. 2017a. Ontogenetic trajectories in *Callinectes danae* (Crustacea: Brachyura): sex and age polymorphism. *Journal of the Marine Biological Association of the United Kingdom*, 99: 111–118.

Shinozaki-Mendes, R.A. and Lessa, R. 2017b. Population dynamics of *Callinectes danae* Smith, 1869 (Brachyura: Portunidae) in a tropical estuary. *Journal of Crustacean Biology*, 37: 683–692.

Sokal, R. and Rohlf, F. 1995. Biometry: Principles and Practice of Statistics in Biological Research. Third edition. WH Freeman and Company, New York, 880p.

Souza-Filho, P.W.M. 2005. Costa de Manguezais de macromaré da Amazônia: Cenários morfológicos, mapeamento e quantificação de áreas usando dados de sensores remotos. *Revista Brasileira de Geofísica*, 23: 427–435.

Udoh, J.P. 2017. Size composition and growth pattern of by-catch marine crabs *Callinectes amnicola* off the Atlantic coast, southeast Nigeria. *Journal of Forestry, Environment and Sustainable Development*, 3: 71–88.