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Reproductive biology of the land crab *Cardisoma guanhumi* (Decapoda: Gecarcinidae) in north-eastern Brazil

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The reproductive cycle of Cardisoma guanhumi *was described from the analysis of seasonal variation of the gonadal maturation stages. The first maturity for both sexes was determined based on three different tests: inflexion point on the curve; relevant character (morphometry); and histological analysis (physiology). In addition, some aspects of sexual dimorphism for the population were studied. A total of 353 individuals caught in north-eastern Brazil between December 2006 and November 2007 were analysed. The sex-ratio was statistically equal* ($P \geq 0.05$) *and the carapace width (CW) of the females ranged from 4.34 to 8.56 cm and of the males from 2.84 to 9.22 cm. Mature females with fully developed gonads begin to appear in the dry season (August) and ovigerous females occurred from November to February, suggesting that spawning occurs mainly during the rainy season. The CW of first sexual maturity for females ranged from 5.87 cm to 6.70 cm and males from 6.22 cm to 7.20 cm. The highest percentage of individuals caught were juveniles, indicating the need for a targeted effort to preserve the species.*

Keywords: Brachyura, histology, allometry, maturity, reproductive biology

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INTRODUCTION

The land crab *Cardisoma guanhumi* Latreille, 1828 (Decapoda: Gecarcinidae) has nocturnal habits (Melo, 1996), with a circumequatorial distribution in the western Atlantic occurring in all the estuaries from Caribbean, Central America and South America (Burggren & McMahon, 1988), while in the United States, its distribution is limited only to the Gulf of Mexico and Florida (Hill, 2001). The extent of its distribution is limited by temperature, the larvae survival is compromised in areas where the temperature falls below 20°C (Hill, 2001).

Cardisoma guanhumi is an important fishery resource from Florida to Brazil (Bozada & Chávez, 1986; Shinozaki-Mendes, 2011a), including the Caribbean and Bahamas (Lloyd, 2001), Puerto Rico (Feliciano, 1962) and Venezuela (Taissoun, 1974). In Brazil it has a high commercial value, costing up to U$10 (an adult male specimen) in some restaurants (personal observation), thus, it is a fishery resource of great socio-economic importance. One of the important parameters to ensure the sustainability of any exploited fish stocks is the size of first sexual maturity in which 50% of the population is able to reproduce. Based on that, it is common to establish, the minimum catch size, in order to ensure the proper reproduction and subsequent recruitment.

The proportion of germ cells found in each ovary or testis, in addition to the somatic components, determines the stages of body development, providing understanding of the reproductive cycle of the species (Shinozaki-Mendes *et al.*, 2011b). Thus, the study of gonadal maturation, based on histological analysis of gonads is an important method for determining stages of gonadal development and maturity.

The studies on the maturity of this species, which is suffering greatly from anthropogenic impacts, both by the excessive capture of crabs, as well as the destruction of their ecosystems, become extremely relevant since the results can be used to protect the population, which ultimately aims to ensure the sustainability of its exploitation. This species has been listed in the 'National list of species of aquatic invertebrates and fish over exploited or threatened with overexploitation', published by the Brazilian Ministry of Environment (MMA–IBAMA, on Normative No. 5, 21 May 2004).

Despite its great ecological and socio-economic relevance, few studies have been carried out on the reproduction of *C. guanhumi*. In south-eastern Brazil, Silva & Oshiro (2002) evaluated the reproductive aspects of *C. guanhumi* based on macroscopic analysis of female gonads, while in north-eastern Brazil, Botelho *et al.* (2001) analysed population aspects and Abrunhosa *et al.* (2000) developed the cultivation from the egg to juvenile. Gifford (1962) studied the general biology of *C. guanhumi*, in Florida, United States, and Taissoun (1974)

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highlighted general aspects of the species in Venezuela. Giménez & Acevedo (1991), in turn, studied the morphometric relationships and size at first maturity in Cuba, while Rivera (2005) conducted tests in terms of the species as a fishing resource in Mexico.

In this study, the reproductive cycle of *C. guanhumi*, is described from the analysis carried out based on seasonal variation of gonadal maturation stages, determining the size of the first morphological and physiological maturity for both sexes; as well studies on some aspects of sexual dimorphism in the population were also carried out.

MATERIALS AND METHODS

The individuals were sampled in the mangrove estuary of the Jaguaribe River (04°26′S to 04°32′S and 037°46′W to 037°48′W), on the Cumbe community, east coast of Ceara State, north-eastern Brazil (Figure 1).

In the period between December 2006 and November 2007, 353 individuals were sampled, totalling to an average monthly sampling size of 30 specimens. All the animals were caught with artisanal traps, made by the local collectors. The specimens of *Cardisoma guanhumi* build individual burrows to inhabit, called holes. The choice of holes in which the traps were left was randomized, with no preference for burrows entrance with greater or smaller diameter.

Prior to dissection, the specimens were refrigerated to −10°C (but not frozen) until immobilization (~15 minutes). The individuals were measured in carapace width (CW), length (ML) of the major chela (the first right or left pereiopod) and width of the 5th (W_5) abdominal segment using a caliper (precision: 0.01 cm) (Figure 2). The individuals which had the smaller size chela, indicating the regeneration process, were excluded from the analysis.

Although not mentioned in the literature, after several visual observations, the following classification for males and females was applied: juvenile female—the abdomen not covering all thoracic esternites; adult female—abdomen covering all thoracic esternites (at the basis of coxa); juvenile male—the chela length is inferior to the carapace width; and adult male—the chela length exceeds the carapace width (Figure 2).

The animals were dissected, slicing up the shell laterally, to allow the removal of reproductive tract. The material collected was fixed in Davidson's solution for 24 hours before transferring and being kept in a 70% alcohol solution. Fragments of the reproductive tract were then dehydrated in increasing alcohol series, diaphanized in xylene and impregnated and included in paraffin at 60°C. Each block containing biological material was serial sectioned at 5 μm, with the slides being stained by the methods of Alcian Blue/Periodic Acid Schiff (adapted from Junqueira & Junqueira, 1983) and Gomori's trichrome (adapted from Tolosa *et al.* 2003).

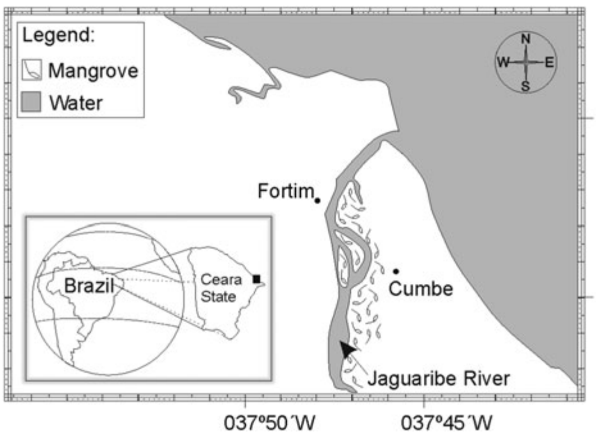

Fig. 1. Geographical location (east coast of Ceara State, north-eastern Brazil) of the sampling area of *Cardisoma guanhumi*.

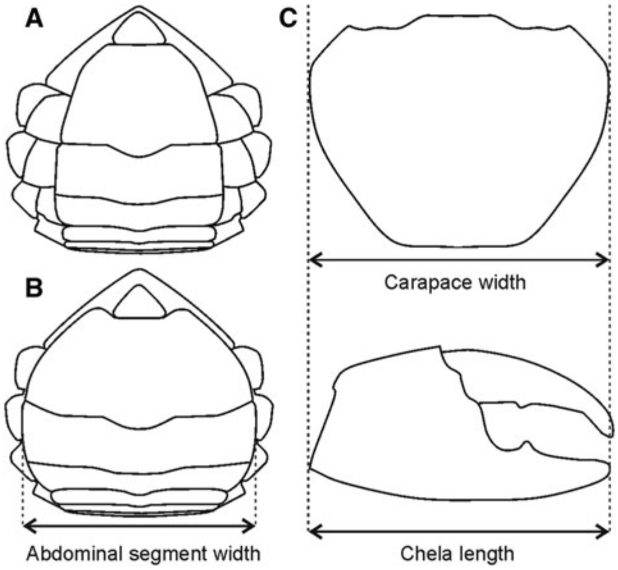

Fig. 2. Schematic drawing of the abdomen of immature (A) and mature (B) females indicating the width of 5th abdominal segment and the measures of the carapace width and chela length for the classifications of males of *Cardisoma guanhumi.*

The microscopic analyses of the gonads stages were classified following the scale of gonadal maturation of *C. guanhumi* as proposed by Shinozaki-Mendes *et al.* (2011a, 2011b) for males and females (see Table 1).

The absolute frequency of males and females was analysed for the CW classes and monthly. To examine whether the proportion between males and females showed statistical differences, the Chi-square test ($P < 0.05$) (Zar, 1984) was used for the period of 12 consecutive months.

To determine the size of the first gonadal and morphometric maturations, the size in which 50% of individuals are able to reproduce, the percentage of individuals which has already begun the reproductive cycle (M) for each class of the CW, was estimated through the logistic model: $M = 1/(1 + \exp(\beta_0 + \beta_1 CW))$ (see Mendes, 1999). Also the size in which the pubertal moult occurs was determined by the inflexion point on the curve in the CW × W_5 and CW × ML relation to females and males, respectively. These measures were chosen because they showed greater variation in growth for each sex. The 'w' statistical test ($P < 0.05$) was used to compare the models. This test uses the maximum likelihood and the Chi-square distribution (Mendes, 1999), and is based on comparison between linear and angular coefficients of the models.

To correlate the possible influences of abiotic factors during the reproductive period, pluviometry data were obtained from the Cearense Foundation of Meteorology and Water Management (FUNCEME, 2008) for the period

Table 1. Main characteristics of the classification scale of maturation used in this study, suggested by Shinozaki-Mendes *et al.* (2011a, b), based on the description of macro and microscopic characteristics of the gonads.

Stage	Description of gonads characteristics
Females	
Immature	Quite small and translucent gonads. The spermatheca shows a reduced size. The germ zone shows the presence of oogonia, while the peripheral maturation zone holds only pre-vitellogenic oocytes in lower numbers. Follicular cells (FCs) in the germ zone form nests, while in the maturation zone, around the pre-vitellogenic oocytes (PVOs)
Maturing	The gonads have a colour ranging from yellow to dark brown. The spermatheca exhibits a little increase in size. The maturation zone shows PVOs, more internally, and vitellogenic oocytes, more peripheral. A large number of FCs are present in the maturation zone
Mature	The gonads reaching maximum ovary diameter and length. The spermatheca has a larger volume and whitish colour. Ovaries have a smooth texture and dark brown colour, with a predominance of mature oocytes (MOs). FCs are found surrounding the MOs
Spawning	(Females carrying eggs or release larvae recently). Macroscopically, similar to the maturing or mature stages. Atretic oocytes, FCs, empty spaces and eventually mature oocytes are observed
Resting	Macroscopically similar to the immature stage, only the gonad wall is thicker and colour can also be yellow. There is a greater space between the germinative cells, which is filled in by FCs and residual atretic oocytes
Males	
Immature	Rudimentary reproductive tract. Anterior and median vas deferentia are equal to the maturing stage and smaller than the mature one. The posterior vas deferens showed no spermatophores, and is filled with a homogeneous matrix
Maturing	Quite similar to immature stage, except the posterior vas deferens which is longer and wider. The contents of the posterior vas deferens start to become granular and the presence of spermatophores is observed
Mature	Every part of the vas deferens is developed. The posterior vas deferens is filled with glycoprotein matrix and contains more spermatophores than the maturing stage

between December 2006 and November 2007 at the meteorological station near the collection site.

RESULTS

From the 353 *Cardisoma guanhumi* specimens examined, 179 were females, and 174 were males. The monthly sex-ratio varied from 1:0.55 to 1:1.75 (male:female) (Table 2), with average proportion of 1:1.02. There were no statistically significant differences between the number of males and females ($P \geq 0.05$) along the different months, indicating there is no seasonality in the proportion of individuals of different sexes. The CW of the females ranged from 4.34 to 8.56 cm with a modal class between 5.0 and 7.0 cm. Males showed greater width, ranging from 2.84 to 9.22 cm with a mode between 5.0 and 6.5 cm (Figure 3). Note that the smallest and largest classes showed the predominance of males.

Table 2. Number of individuals of *Cardisoma guanhumi* monthly sampled in the period between December 2006 and November 2007 in north-eastern Brazil.

Month/year	Number of individuals		Proportion
	Male	Female	
Dec./06	12	14	1:1.17
Jan./07	14	16	1:1.14
Feb./07	10	9	1:0.90
Mar./07	20	11	1:0.55
Apr./07	19	12	1:0.63
May/07	11	19	1:1.73
Jun./07	8	14	1:1.75
July/07	17	15	1:0.88
Aug./07	16	13	1:0.81
Sept./07	11	11	1:1.00
Oct./07	13	22	1:1.69
Nov./07	23	23	1:1.00
Total	174	179	1:1.02

The females were observed into five stages of maturation: immature, maturing, mature, spawning and resting (Figure 4). The distribution of maturational stages during the year (Figure 5) indicates that the period in which female gonad maturation starts is from August to February, with higher frequency of mature females in the months of November and December. Spawning females were frequent from December to March, and in May and July three specimens in this stage were also observed. Ovigerous females were found from November to February ($N = 6$). The males were classified as immature, maturing or mature (Figure 4). Meanwhile there was no seasonal variation observed in this proportion, all stages being randomly distributed among months.

Pluviometry data in the sampling area (Table 3) indicated that the rainy season starts in December (rainfall of 42 mm) and ends in June (rainfall of 80 mm). The period between July and November shows very much reduced rainfall activity. February to May, when the rains are most intense, also coincides with the decrease of the reproductive period. After

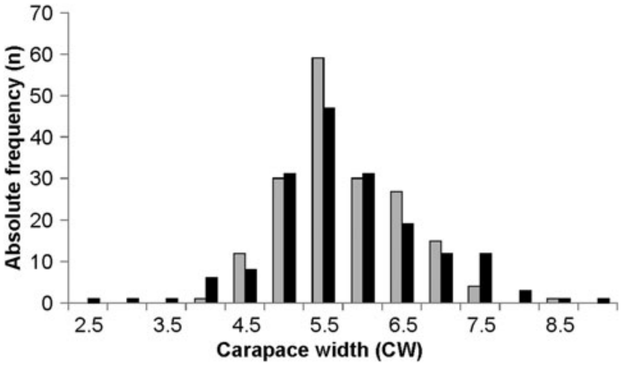

Fig. 3. Distribution of absolute frequency of carapace width (CW) for males (in black) and females (in grey) of *Cardisoma guanhumi* caught between December 2006 and November 2007 in north-eastern Brazil. The values of CW indicate the initial size of the class.

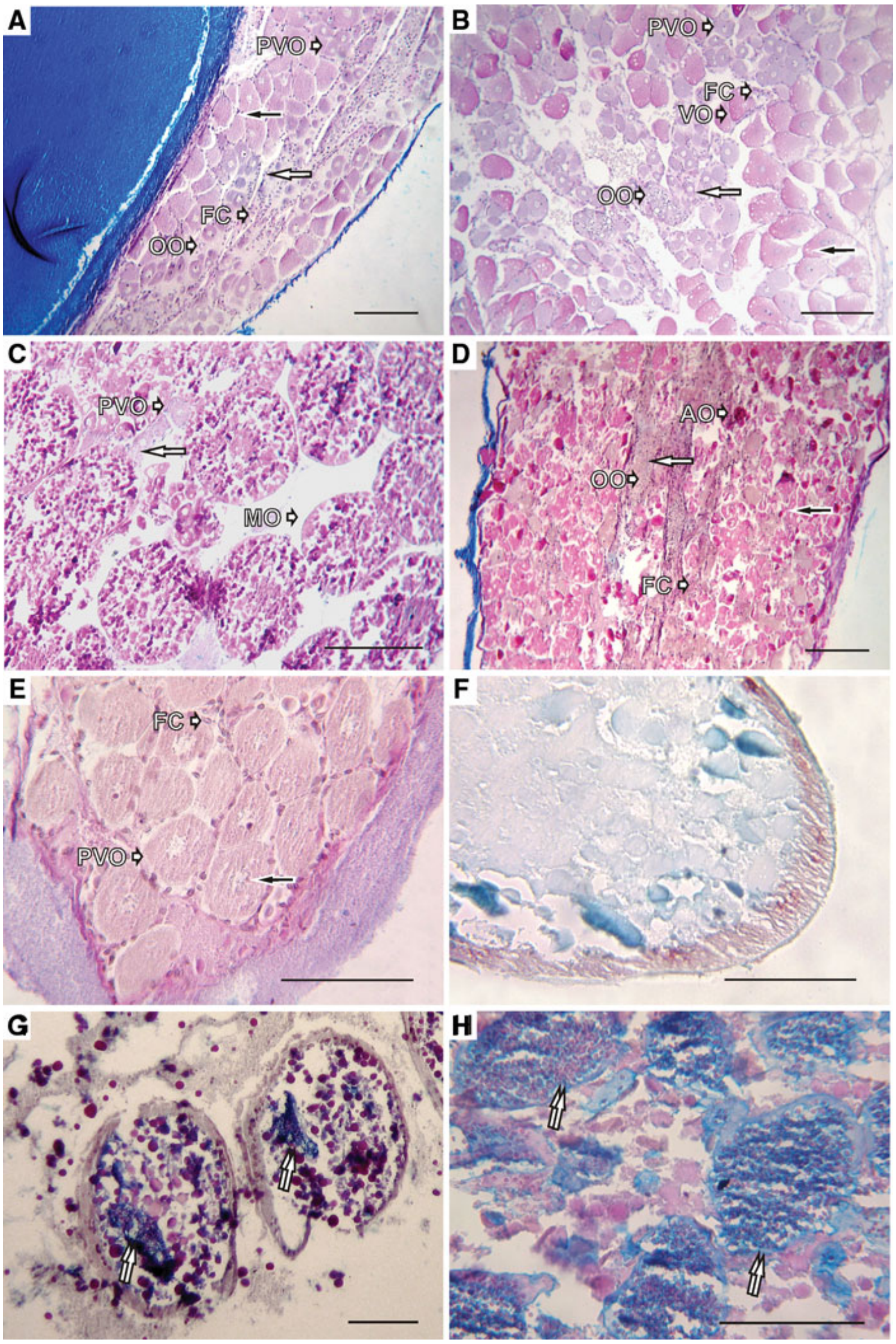

Fig. 4. Photomicrographs of ovaries (from A to E) and posterior vas deferens (from F to H) of *Cardisoma guanhumi* in different stages of maturation: (A, F) immature; (B, G) maturing; (C, H) mature; (D) spawning; (E) resting. The white arrows indicate the germinative zone and the black arrows indicate the maturation zone. The short arrows indicate: oogonia (OO); pre-vitellogenic oocytes (PVO); vitellogenic oocytes (VO); mature oocytes (MO); atretic oocytes (AO); follicular cells (FC). The double arrows indicate the spermatophores. Staining: Alcian Blue/Periodic Acid Schiff (A, B, C, D, E, G, H) and Gomori's trichrome (F). Scale bars: 200 µm (A,B, C, D) and 100 µm (E, F, G, H).

June, when the rainy season ends, the female's gonads start to mature.

Estimates on the first maturation size (CW_{50}) based on gonadal maturity (physiology) for females and males, respectively, using a logistic model (Table 4) were equal to: $CW_{50} = 5.87$ cm and $CW_{50} = 6.22$ cm (Figure 6). The size of the first morphometric maturity is based on the abdomen width and chela length. Secondary characters, were also determined based on the logistic model (Figure 6; Table 4), with values of $CW_{50} = 6.12$ cm (female) and $CW_{50} = 6.91$ cm (male).

Once the sigmoid functions for the determination of maturity are estimated, it is possible to estimate the maximum maturation size (CW_{99}) based on the CW, with size of $CW_{99} = 6.91$ cm and $CW_{99} = 8.39$ cm for females and males, and based on physiology, the CW_{99} is 7.18 cm and 7.56 cm for females and males, respectively.

Based on the inflexion point on the curve in the CW × W_5 and CW × ML relation (Figure 7; Table 4), females presented 6.40 cm as the first maturation size and males presented 7.10 cm indicating the carapace average width in which the pubertal moult would occur.

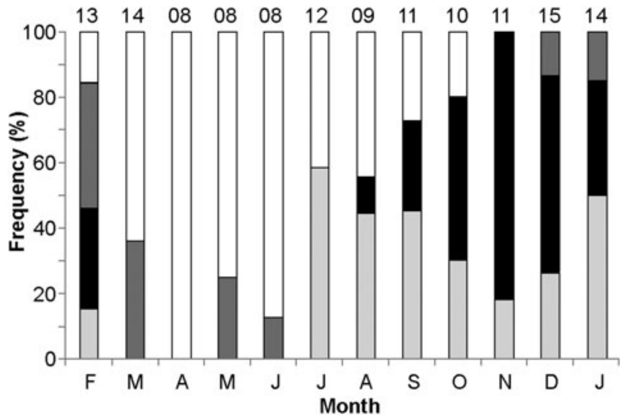

Fig. 5. Reproductive cycle of females of *Cardisoma guanhumi* based on microscopic analysis of gonadal stages: maturing (light grey bars), mature (black bars), spawning (dark grey bars), and resting (white bars), caught between December 2006 and November 2007 in north-eastern Brazil. The upper numbers indicate the sample size.

By analysing the percentage and size-range of individuals in each stage (Table 5), it is noted that the highest percentage of juveniles occurred, during the analysis of the inflection point, achieving 70.4% of females and 84.5% of males. However, the measure individual-to-individual (not the mean value measured in the analysis of the inflection point), indicated that the maturation of the gonads and pubertal moult already occurred in 60.9% of females and 23.0% of males (Table 5).

DISCUSSION

A population with balanced annual sex-ratio (1:1) has also been found for *Cardisoma guanhumi* in Mexico (Bozada & Chávez, 1986) and in south-eastern Brazil (Silva & Oshiro, 2002). Thus, this feature seems to be common for this species. Masunari *et al.* (2005) mentioned that this proportion is also observed for species of the genus *Uca*.

The frequency distribution of the CW indicates that females are more numerous in the most abundant modal class (5.5 to 6.0 cm), not being present in the peripheral classes, while the males are present in all classes. Peripheral classes represented by only one sex may indicate different sizes or rates of recruitment and mortality.

Males of *C. guanhumi* with larger size in relation to females were also confirmed by Rivera (2005) for the same species in Cuba (6.5 to 10.5 cm for males, and from 7.0 to 9.0 cm for females), by Bozada & Chávez (1986) for the population in Mexico (2.7 to 10.5 cm for males, and from 4.2 to 7.9 cm for females) and by Silva & Oshiro (2002) in Brazil (2.7 to 8.5 cm for males, and 3.1 to 8.3 for females). Such results suggest that this is an intrinsic feature of populations of *C. guanhumi*, regardless of location. Although the males and females did not differ in the body size, the males have, statistically, more developed chelae than the females. An accelerated chela growth in mature individuals is associated with territory protection and competition among males for females, which occur for most decapods (Hartnoll, 1978).

Under normal circumstances, the males, after reaching maturation, will always have spermatozoa reserves present (Duffy & Thiel, 2007). This is the main reason why description of the reproductive cycle is always based on the female's gonadal development, also because the male's maturity is only related to their size, whatever the season. The reproductive period of *C. guanhumi* based on the female cycle suggested by several authors always occurs in summer and spring and sometimes in the autumn (Table 6).

The termination of reproductive activities in the month in which the rains are most intensified has the benefit of limiting desiccation stress (Hartnoll *et al.*, 2010). Based on our results, we suggest that gonadal development occurs mainly in the dry season; the start of rainfall is a trigger for the end of the maturation and probably the trigger for the beginning of the spawning period.

The first maturity size can vary depending on the geographical distribution of the population (Burggren & McMahon, 1988), and the character measured. This feature can vary within the same species as a function of different environmental factors such as salinity, temperature and luminosity (Hines, 1989), and can also vary among populations in the same geographical region in response to harvesting, vegetation, leaf-litter standing stock and leaf-litter consumption (Rodríguez-Fourquet & Sabat, 2009). Thus, it is subjective to compare the size at first maturity between localities due to its peculiarities.

Hartnoll (1982) reported that although the pubertal moults may not coincide with the gonads maturation, it invariably indicates that the individual entered to the maturity stage (size obtained after a certain number of moults) in which sexual activity begins; however, the individual is able to reproduce only after completing all the necessary changes. The gonads maturation seems to occur before the pubertal moult in *C. guanhumi*, which is reflected in the morphometric measurements. From total females sampled, only 25.7% had immature gonads, while 39.1% were found below the first morphometric maturity size. For this reason, the first maturity size to be considered must be that in which the animal is completely able to reproduce, i.e. when the morphological maturation occurs. The same trend was observed for males.

The small number of ovigerous females obtained in the samples (N = 6, less than 4% of the females collected) may underestimate the spawning period, since females were observed spawning in May and June, although in small

Table 3. Pluviometry measured in the meteorological station from Aracati region in the period between December 2006 and November 2007 and the average of the last five years. Source: Cearense Foundation of Meteorology and Water Management.

Month	Pluviometry (mm)	
	Sampling period	**Last 5 years**
December	42.00	30.00
January	42.60	119.60
February	284.60	157.23
March	113.00	173.83
April	422.20	212.73
May	145.20	106.50
June	80.00	59.23
July	0.00	22.23
August	0.00	1.20
September	0.00	0.00
October	0.00	0.00
November	0.00	0.00

Table 4. First maturity size for males and females of *Cardisoma guanhumi*, based on three different tests: inflexion point on the curve, relevant character and histological analysis. R^2, reliability coefficient; MS, first maturity size (carapace width) in cm; J, juvenile; A, adult; W_5, width of 5th abdominal segment; CW, carapace width; ML, length of the major chela; M, fraction of individuals able to reproduce.

Characteristic	Equations	R^2	MS	Figure
Females				
Ovary histology ($CW_{50\text{-physiological}}$)	$M = \frac{1}{1 + e^{20.6329+(-3.5099CW)}}$	72.30%	5.87	6
Abdomen format ($CW_{50\text{-morphometric}}$)	$M = \frac{1}{1 + e^{35.9692+(-5.8688CW)}}$	97.62%	6.12	6
Inflexion point on the curve	$(J)W_5 = 0.6854CW - 1.0703$ $(A)W_5 = 0.5312CW - 0.0641$	85.30% 66.97%	6.40	7
Males				
Testis histology ($CW_{50\text{-physiological}}$)	$M = \frac{1}{1 + e^{22.0951+(-3.5295CW)}}$	89.43%	6.22	6
Chela length ($CW_{50\text{-morphometric}}$)	$M = \frac{1}{1 + e^{19.2055+(-2.8339CW)}}$	91.57%	6.91	6
Inflexion point on the curve	$(J)ML = 1.3352CW - 2.3701$ $(A)ML = 1.8958CW - 6.1869$	91.33% 76.07%	7.10	7

numbers. The scarcity of ovigerous females may be linked to the fact that they rarely leave theirs holes, with the purpose of saving energy and avoiding predators (Kennelly & Watkins, 1994), although any decrease in the proportion between males and females during reproduction has not been observed. In addition, Rivera (2005), while studying the same species in Quintana Roo, observed a segregation of the population, with ovigerous females found in a different mangrove region. Rivera (2005) also cited a lower density of ovigerous females, having found 5.6 ind./100 m^2 (ovigerous) in contrast to 45.8 ind./100 m^2 (non-ovigerous). In our study, however, spatial segregation does not seem to occur since males and females were observed in various maturation stages in all the locations sampled.

There are some discrepancies when the non-fishing season established by governmental law and reproductive periods cited by several authors are compared. In south-eastern Brazil, for example, the month that the closed season ends is also the start of the reproductive period (Silva & Oshiro, 2002). In north-eastern Brazil, the period suggested by Botelho *et al.* (2001) to be inserted into the period specified in the legislation, although the ban is unnecessary in March, is further supported based on this research.

In Mexico, the reproductive season coincides with the period suggested by the legislation, according to Rivera (2005). Meanwhile only half of the period is coincidental in the research of Chavez & Bozada (1986). In Florida, Hill (2001) and Gifford (1962) included the months of November and December during the breeding seasons, however, the legislation ends the closure in October. These results indicated a clear disconnection between the management measures taken and scientific information about the species.

This is the first time that the reproductive cycle of *C. guanhumi* is analysed using microscopic observation and size at first maturity is estimated based on different methods. The main importance of developing research on population dynamics, with emphasis on reproductive biology of a species is to provide relevant scientific information to the appropriate agencies to encourage laws and fishery

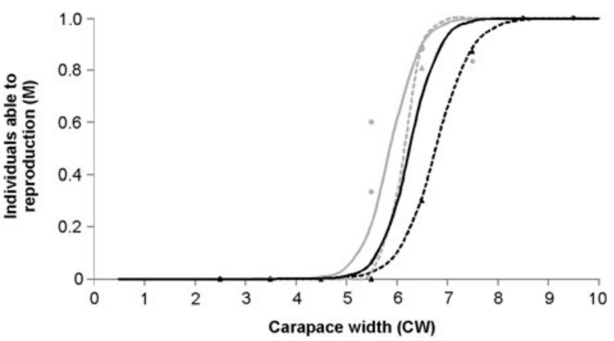

Fig. 6. Percentage of individuals of *Cardisoma guanhumi* able to reproduction per carapace width (CW) classes, caught in the period between December 2006 and November 2007 in north-eastern Brazil. Males in black and females in grey. Continuous line and circles (•) indicate physiological maturity and dotted line and triangles (▲) indicate morphometric maturity. The values of CW indicate the initial size of the class.

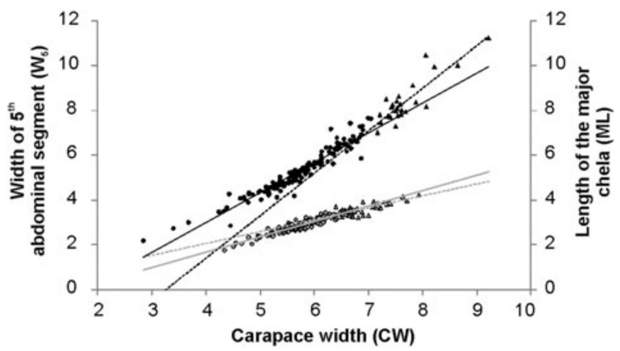

Fig. 7. Relationship between carapace width (CW) (cm) and the 5th abdominal segment width of females (in grey) and chela length of males (in black) of *Cardisoma guanhumi*, caught in the period between December 2006 and November 2007 in north-eastern Brazil. Continuous line and circles (•) indicate juvenile and dotted line and triangles (▲) indicate adult, based on the point of maximum inflexion of the curve. The values of CW indicate the initial size of the class.

Table 5. Percentage of individuals and size of the largest and smallest specimens in each stage of maturation, based on three different tests: inflexion point on the curve, relevant character and histological analysis, in females and males of *Cardisoma guanhumi* sampled in the period between December 2006 and November 2007 in north-eastern Brazil.

Characteristic		%	Size-range (CW)
Females			
Gonad histology	Immature	25.7%	4.34 to 5.94 cm
	Maturing	19.6%	5.14 to 7.34 cm
	Mature	20.7%	5.48 to 7.32 cm
	Spawning	9.5%	5.41 to 8.56 cm
	Resting	24.6%	5.50 to 6.64 cm
Abdomen format	Juvenile	39.1%	4.34 to 6.38 cm
	Adult	60.9%	5.33 to 8.56 cm
Inflexion point on the curve CW × W_5	Juvenile	70.4%	4.34 to 6.39 cm
	Adult	29.6%	6.40 to 8.56 cm
Males			
Gonad histology	Immature	52.9%	2.84 to 5.83 cm
	Maturing	18.4%	5.24 to 6.42 cm
	Mature	28.7%	5.88 to 9.22 cm
Chela length	Juvenile	77.0%	2.84 to 7.50 cm
	Adult	23.0%	6.14 to 9.22 cm
Inflexion point on the curve CW × ML	Juvenile	84.5%	2.84 to 7.05 cm
	Adult	15.5%	7.17 to 9.22 cm

CW, carapace width; W_5, width of 5th abdominal segment; ML, length of the major chela.

Table 6. Reproductive period and first maturity size (MS, in cm) of *Cardisoma guanhumi* found by various authors and in the existing laws (*) of several countries. ♀, females; ♂, males; Sp, spring; S, summer; F, autumn; W, winter.

Country/State	Reproductive period	Hemisphere Station	MS	Reference
*Brazil/Espírito Santo, Rio de Janeiro and São Paulo	October to March	South—Sp/S	8.00 (♂)	IBAMA (2003)
Brazil/Rio de Janeiro	March to May	South—S/F	5.3 (♀); 5.1 (♂)	Silva & Oshiro (2002)
*Brazil/Ceará, Rio grande do Norte, Paraíba, Pernambuco, Alagoas and Sergipe	December to March	South—Sp/S	6.00 (♂)	IBAMA (2006)
Brazil/Ceara	November to February	South—Sp/S	6.12 (♀); 6.91 (♂)	Present Study
*Brazil/BA	December to March	South—Sp/S	7.00 (♂)	IBAMA (2006)
Brazil/PE	December to February	South—Sp/S	3.55 (♀)	Botelho (2001)
Venezuela	September to January	South—W/Sp/S	7.00 (♀)	Taissoun (1974)
Venezuela	July to November	South—S/F		Hill (2001)
*Mexico	July to September	North—S		SAGARPA (2006)
Mexico/Quintana Roo	Start in August	North—S		Rivera (2005)
Mexico	June to July	North—Sp/S		Bozada & Chávez (1986)
Cuba			5.00 (♀)	Giménez & Acevedo (1982)
Bahamas	July to September	North—S		Hill (2001)
USA/Florida	July to December	North—S/F		Hill (2001)
USA/Florida	June to December	North—/S	(40 g) ♀	Gifford (1962)
*USA/Florida	June to October	North—Sp/S/F		FFWCC (2002)

management standards in order to ensure the sustainable use of natural resources. The current law in north-eastern Brazil (IBAMA Normative No. 90, 2 February 2006) stipulates that the minimum size of capture for males in the States of Ceara, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas and Sergipe is 6.00 cm (CW), although the size of the first sexual maturation found for males in the population analysed in this study was equal to 6.91 cm.

High catches of juveniles, smaller than the size at first maturity, can result in overfishing, which can bring serious damage to this important stock, compromising their sustainability. Finally, we highlighted the importance of environmental education to spread the knowledge that juvenile males can be identified by their chelae length being shorter than their carapace width and juvenile females by their abdomens not covering all their thoracic sternites.

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