



Morphological, structural characteristics and growth relationship of crabs *Callinectes amnicola* and *Cardisoma armatum* in the complex Nokoué lake Porto-Novo lagoon in South Benin.

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ABSTRACT

Objective: *Callinectes amnicola* (big fisted swim crab) and *Cardisoma armatum* (lagoon land crab) are two main species of decapod crustaceans exploited for consumption in South Benin. This study aims to assess the morphological, structural characteristics and the growth of the population of these two species in the complex Nokoué lake Porto-Novo lagoon in South Benin in order to assess the level exploitation.

Methodology and Results: For this, 1287 crabs *Callinectes amnicola* and 322 crabs *Cardisoma armatum* were collected between May 2016 and April 2017 through fishermen. Data on morphological variables, size structure, sex ratio, growth parameters were collected. The study revealed that in *Callinectes amnicola*, the carapace small width of immature females was higher than that of immature males ($p < 0.05$), while in mature individuals, the weight of males was higher than that of females ($p < 0.01$). In *Cardisoma armatum* on the contrary, the weight, the carapace large width and the carapace length of immature males were higher ($p < 0.05$) than those of immature females while in the mature, males had a higher carapace length than females ($p < 0.05$). The morphological variables comparison in the two species shows out that in immature, all the morphological variables were higher ($p < 0.001$) in the crab *Cardisoma armatum* while in mature individuals, only the carapace large width was higher ($p < 0.001$) in the crab *Callinectes amnicola*. The classes' size distribution in crabs is unimodal and the calculated sex ratios were not different from the theoretical sex ratio ($p > 0.05$). The allometric coefficients b were all lower than 3, reflecting a growth weight lower than the size growth. The condition factor varied significantly between the maturity's stages of the two species and was higher in mature subjects of *C. amnicola* and immature of *C. armatum*. However, the condition factor was higher in the crab *Cardisoma armatum* than in the crab *Callinectes amnicola* ($p < 0.001$). *Cardisoma armatum* presents the best growth parameters.

Conclusion and application of finding: *Callinectes amnicola* and *Cardisoma armatum* have better growth parameters and adapt very well to their environment. However, these species are affected by the effects of

fishing. The current study results are essential for the good policy of management and of sustainable use of this resource.

Keywords: crabs, morphology, growth, sex ratio, condition factor

INTRODUCTION

Crabs are invertebrates belonging to the decapod crustacean order and are widely spread throughout the world's regions. They are fairly diversified and represented by more than 6,800 valid species and subspecies (Ng *et al.*, 2008). They colonize different habitats ranging from the marine environment to the firm ground. Crabs play an important economic and bio-ecological role in most aquatic ecosystems and occupy a wide variety of trophic niches (Cartes *et al.*, 2010). They act at different trophic levels as herbivores, detritivores, predators and are prey for birds (Cumberlidge, 2006). Crabs play an important economic role. In West Africa, crabs are an important source of protein and several species are caught and traded by local populations (Lawal-Are *et Barakat* 2009, Fondo *et al.*, 2010, d'Almeida *et al.*, 2014, Sankaré *et al.*, 2014a *et* 2014b; Olalekan and Lawal-Are, 2015). In Benin, crabs are present in the southern waters of the country in particular, complex Nokoué lake Porto-Novo lagoon and Ahéme lake, where they are actively fished (Tohozin, 2012; Hinvi *et al.*, 2013). In total, six species were inventoried, of which three are mainly marketed and consumed by the local residents (Tohozin, 2012, Hinvi *et al.*, 2013). These are the crabs *Callinectes amnicola*, *Cardisoma armatum* permanently exploited, and *Portunus validus* (smooth swim crab seasonally exploited (Hountogan, 2011, Tohozin, 2012, Hinvi *et al.*, 2013). Crab fishing in Benin aquatic environments was considered as an accessory fishery compared to the fish that made up almost all the landings. Following the fishes decrease reflected by the decrease in captures, fishermen turned to crab fishing of which exploitation intensifies from day to day in Benin aquatic environments. Various fishing techniques such as crab balances, bow-net, traditional crab traps are used to exploit these

species, resulting in daily landings of large quantities (Hinvi *et al.*, 2013). These different practices show an overexploitation of these species, which is not without consequence for their survival and durability. Often wrongly considered by fishermen as species of which exploitation is "endless", they have long been neglected by researchers and public authorities. Very few studies have been initiated on these species in Benin. Works on the diversity of these species were first carried out at Nokoué lake (Hountogan, 2011) and then the fisheries and the different marketing channels for crabs have been described at the same lake (Tohozin, 2012). On the ecological plan, a description of the growth parameters, fishing zones and capture techniques was carried out on the crab *Callinectes amnicola* at the Ahéme Lake (Dessouassi, 2014). In order to diversify the candidate species for Beninese aquaculture, domestication trials of the crab *Callinectes amnicola* and *Portunus validus* were also performed (Hinvi *et al.*, 2013). Nowadays, no studies have been carried out on the morphological, structural characterization and growth of these species in their natural environments. It has also been reported that the complex Nokoué lake Porto-Novo lagoon represents the largest fishing area of these species and that *Callinectes amnicola* and *Cardisoma armatum* are the most abundant, fished and consumed species in the area (Hountogan, 2011; Tohozin, 2012). Studies are then needed to better characterize and valorize these resources in the area. The present study aims to determine the morphological, structural characteristics, and the growth of the two main species of crab *Callinectes amnicola* and *Cardisoma armatum* in the complex Nokoué lake Porto-Novo lagoon.

MATERIALS AND METHODS

Study area: The present study was carried out in the complex Nokoué lake Porto-Novo lagoon. It is a complex located in the South East of Benin between the parallels

6° 25' and 6° 38' North latitude and 2° 27' and 2° 30' East longitude. The complex Nokoué lake Porto-Novo lagoon is connected to the Atlantic Ocean by the Cotonou

channel, which has a length of 4.5 km. This complex covers an area of 180 km² and is the largest continental watercourse in Benin in terms of area, exploitation and productivity. The hydrological regime of the complex Nokoué lake Porto-Novo lagoon corresponds to a low water period (December to April), a high water period (May to June) and a flood period (September to November). On this complex, 6 fishing habitats (including 3 for the crab *Callinectes amnicola* and 3 for the crab

Cardisoma armatum) were selected for the study. Fishing habitats were selected based on the practice of crab fishing activity, the stations accessibility throughout the study period, and the collaboration of fishers from these habitats. These fishing habitats are: Ganvié, Zogbo, Hwlacomey for the water crab *Callinectes amnicola* and Kétonou, Agonsagbo, Denou for the land crab *Cardisoma armatum* (Figure 1).

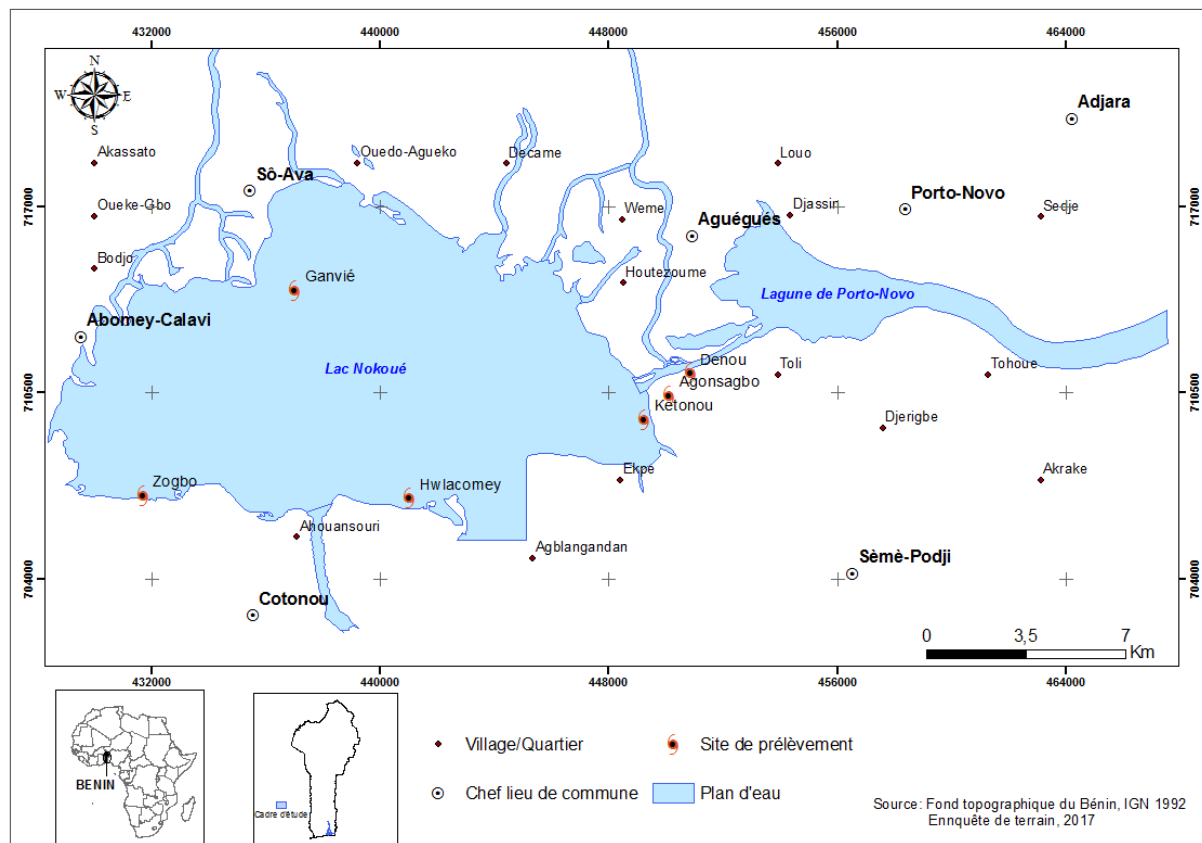


Figure 1: Location map of sampling sites

Methodology

Sampling: Samples of crabs *Callinectes amnicola* and *Cardisoma armatum* were collected very early in the morning in the identified fishing habitats in the complex Nokoué lake Porto-Novo lagoon through fishermen. The fishing gears or techniques used to catch crabs are crab balances and traps for water crab *Callinectes amnicola* and traditional crab traps and manual catch for land crab *Cardisoma armatum*. The number of crabs collected varies according to the landings. On average, 70 to 100 crabs *Callinectes amnicola* and 40 to 50 crabs *Cardisoma armatum* of all sizes were collected per trip. The collected samples were immediately preserved in a 10% formalin

solution and transported to the Laboratory of Animal Biotechnology and Meat Technology of the Abomey-Calavi Polytechnic School of the University of Abomey-Calavi for the different measurements. Sampling was carried out monthly between May 2016 and April 2017. **Identification of specimens:** In the laboratory, identification of specimens of the crabs *Callinectes amnicola* and *Cardisoma armatum* was performed using the identification keys West African Brachyuran Crabs Crustacean: Decapoda (Manning and Holthuis, 1981), the real crabs data sheet (Holthuis, 1974) and the Gulf of Guinea Commercial Marine Resources Guide (Schneider, 1992).

Determination of sex: Sex determination was mainly based on the method used by Sankaré (2007) and d'Almeida *et al.* (2014). These methods of sex determination are mainly based on the aspect of the abdomen of the male and female. In the crab *Callinectes*

amnicola, males have an upside down "T" shaped abdomen whereas in females the abdomen is triangular or semi-circular in shape (Photo 1). As for the crab *Cardisoma armatum*, males have a reversed "V" shaped abdomen, while the one of females is oval (Photo 2).

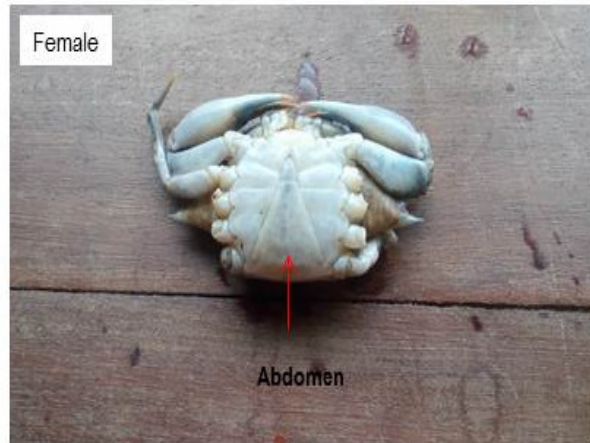
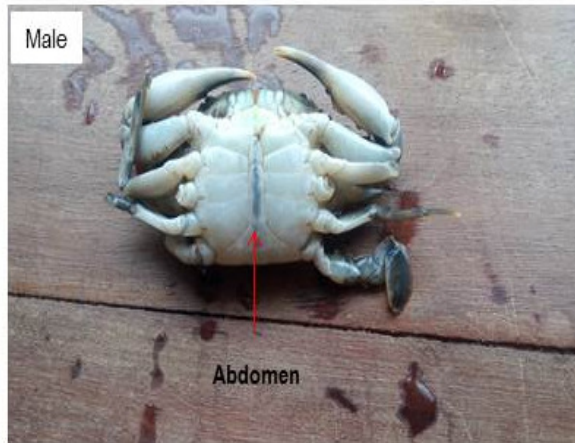


Photo 1: Crab *Callinectes amnicola* male and female



Photo 2: Crab *Cardisoma armatum* male and female

Determination of the stage of maturity: The stage of sexual maturity was determined using the scales of crabs proposed by Sankaré (2007) and Lawal-Are (2010). Five stages of maturity have been proposed:

- Stage I: immature (no development of the gonads);
- Stage II: developing (partial development of the gonads);
- Stage III: beginning maturation (extension of the gonads in the carapace);
- Stage IV: advanced maturation (mature carapace filled of mature gonad materials);
- Stage V: Empty gonads.

Measurements: After the stage of sexing and grading of specimens according to the stage of maturity, each individual was weighed and measured. The measurements performed concern the carapace large width (cm), the carapace small width (cm), the carapace length (cm) and the weight (g). The linear dimensions were taken using a calliper and the weight was taken using an electronic balance of precision 0.1 g.

Expressions of results

Relationship between the carapace large width and the weight : The relationship between the size (carapace

large width) and the total weight of each species was determined by the regression equation:

$$W = a(Lc)^b \text{ (le Cren, 1951).}$$

This equation is linearized in the form of $\text{Log } W = \text{Log } a + b \text{ Log } Lc$,

W: the weight of individuals in g,

Lc: the carapace large width in cm,

a: the intercept and

b: the slope or the allometry coefficient.

The coefficient b value is used to estimate growth. When the coefficient b is statistically equal to 3, the growth is isometric. When it is statistically different from 3 ($b < 3$ or $b > 3$), the growth is allometric (Olugbenga and Oloko, 2013).

Condition factor: The factor or condition coefficient K is an index that is used to evaluate the stoutness of the different species in their life environments. It is the ratio between the weight of individuals and the carapace large width. It is given by the formula:

$$K = \frac{100w}{Lc^3} \text{ (Arimoro et Idoro, 2007) where}$$

K is the condition factor,

W: the weight of individuals,

Lc: the carapace large width and

b: the allometry coefficient.

Statistical analysis: The Statistical Analysis System (SAS, 2006) software was used for the statistical analysis. The average of the morphological variables was calculated by the Proc Means procedure. A variance analysis was performed using the Generalized Linear Models (GLM) procedure. The considered variation sources were sex, stage of maturity and species. Interaction between species and stage of maturity was tested. The F test was used to determine the significance of each variation factor and the student t test was used to compare the paired averages and the allometric coefficient value b to 3. The Chi square test (χ^2) was used to compare sex ratios.

RESULTS

Morphological characteristics of water crab *Callinectes amnicola* and land crab *Cardisoma armatum*: The Tables 1 and 2 presents the distribution of morphological variables in the swimmer crab *Callinectes amnicola* and the ground crab *Cardisoma armatum*, respectively, according to the stage of maturity. In the crab *Callinectes amnicola*, morphological variables such as weight, carapace large width and carapace length in immature individuals did not significantly vary between male and female ($p > 0.05$). On the other hand, the carapace small width in immature females (1.29 cm) was significantly higher ($p < 0.05$) than in immature males (1.23 cm) (Table 1). In mature individuals, no significant difference was observed between male and female in the carapace large width, the carapace small width and the carapace length. On the other hand, only the weight varied between the two sexes. The weight of the male (38.74 g) was significantly higher ($p < 0.01$) than that of the female (33.66 g) in mature individuals (Table 1). As for the crab *Cardisoma armatum*, the weight, the carapace large width and the carapace length of immature males subjects were significantly higher ($p < 0.01$) than those observed in immature females (Table 2). Only the carapace small width showed no significant

variation between the sexes ($p > 0.05$). In mature subjects of the crab *Cardisoma armatum*, the tendency of variation between sexes is quite the opposite. Of all the morphological variables, only the carapace length varied significantly ($p < 0.05$) between the male and the female and the highest value of the carapace length was noted in the male. The other morphological parameters did not significantly varied between the two sexes (Table 2). The Table 3 presents the morphological variables comparison between the crabs *Callinectes amnicola* and *Cardisoma armatum* according to the stage of maturity. In immature individuals of all sex, significant differences were noted between the two species. In the immature subjects, the weight, the carapace large width, the carapace small width and the carapace length were significantly higher ($p < 0.001$) in the crab *Cardisoma armatum* than in the crab *Callinectes amnicola* (Table 3). In mature subjects, the same variation tendency was also observed. The weight, the carapace small width and the carapace length were significantly higher in the crab *Cardisoma armatum* than in the crab *Callinectes amnicola*. On the other hand, the carapace large width of the crab *Callinectes amnicola* (7.23 cm) was higher than that of the crab *Cardisoma armatum* (6.09 cm) (Table 3).

Table 1: Distribution of morphological variables in crab *Callinectes amnicola* by maturity stage

Variables	Immature				Mature				ANOVA	
	Males		Females		Male		Females		Immature	Mature
	Mean	SE	Mean	SE	Mean	SE	Mean	SE		
Weight (g)	11.80a	0.32	11.76a	0.25	38.74a	1.15	33.66b	1.07	NS	**
Carapace large width (cm)	4.66a	0.04	4.70a	0.04	7.32a	0.08	7.15a	0.09	NS	NS
Carapace small width (cm)	1.23b	0.02	1.29a	0.01	2.01a	0.02	2.00a	0.03	*	NS
Carapace length (cm)	2.29a	0.02	2.31a	0.02	3.54a	0.03	3.46a	0.04	NS	NS

ANOVA: Variance Analysis; SE: Standard Error; NS: Not Significant; *: $p < 0.05$; **: $p < 0.01$. Means of male and female of the same stage of maturity followed by identical letters do not differ significantly at the threshold of 5%.

Table 2: Distribution of morphological variables in crab *Cardisoma armatum* by maturity stage

Variables	Immature				Mature				ANOVA	
	Males		Females		Males		Females		Immature	Mature
	Mean	SE	Mean	SE	Mean	SE	Mean	SE		
Weight (g)	70.89a	2.26	58.08b	2.90	100.48a	2.74	95.02a	1.85	***	NS
Carapace large width (cm)	5.39a	0.05	5.06b	0.09	6.14a	0.05	6.04a	0.04	**	NS
Carapace small width (cm)	2.00a	0.04	1.95a	0.05	2.22a	0.03	2.22a	0.02	NS	NS
Carapace length (cm)	4.38a	0.06	4.10b	0.06	5.01a	0.05	4.88b	0.04	**	*

ANOVA: Variance Analysis; SE: Standard Error; NS: Not Significant; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$. Means of male and female of the same stage of maturity followed by identical letters do not differ significantly at the threshold of 5%.

Table 3: Distribution of morphological variables between crabs *Callinectes amnicola* and *Cardisoma armatum* according to the stage of maturity

Variables	Immature				Mature				ANOVA	
	<i>C. amnicola</i>		<i>C. armatum</i>		<i>C. amnicola</i>		<i>C. armatum</i>		Immature	Mature
	Mean	SE	Mean	SE	Mean	SE	Mean	SE		
Weight (g)	11.78b	0.20	65.50a	1.97	36.25b	0.80	97.70a	1.65	***	***
Carapace large width (cm)	4.68b	0.03	5.25a	0.05	7.23a	0.06	6.09b	0.03	***	***
Carapace small width (cm)	1.26b	0.01	1.98a	0.03	2.00b	0.02	2.22a	0.30	***	***
Carapace length (cm)	2.3b	0.02	4.27a	0.05	3.5b	0.03	4.94a	0.03	***	***

ANOVA: Variance Analysis; SE: Standard Error; NS: Not Significant; ***: $p < 0.001$. Means of *Callinectes amnicola* and *Cardisoma armatum* of the same biological stage followed by different letters differ significantly at the threshold of 5%.

Correlations between morphological variables in crabs *Callinectes amnicola* and *Cardisoma armatum*:

The Table 4 presents the correlation matrix between the morphological variables in the crab *Callinectes amnicola* (above the diagonal) and the crab *Cardisoma armatum* (below the diagonal). In the crab *Callinectes amnicola*, the weight, the carapace large width, the carapace small width and the carapace length were strongly and positively correlated ($0.865 < r < 0.935$, $p < 0.001$). The lowest correlation coefficient (0.865) was observed between the carapace large width and the carapace small width, while the highest (0.935) was observed between

the carapace large width and the carapace length. In the crab *Cardisoma armatum*, the same correlation trend was also observed. All the variables were strongly and significantly correlated with each other. The lowest correlation ($r = 0.513$) was observed between the carapace length and the carapace small width, while the highest correlation ($r = 0.865$) was observed between the weight and the carapace large width. In sum, the evolution of morphological variables in the crabs *Callinectes amnicola* and *Cardisoma armatum* is significantly proportional.

Table 4: Correlation matrix between morphological variables in crabs *Callinectes amnicola* (above the diagonal) and *Cardisoma armatum* (below the diagonal)

Variables	Weight	Carapace large width	Carapace small width	Carapace length
Weight	1	0.926***	0.870***	0.921***
Carapace large width	0.865***	1	0.865***	0.935***
Carapace small width	0.561***	0.555***	1	0.921***
Carapace length	0.780***	0.819***	0.513***	1

*** : $p < 0.001$.

Size general structure (carapace large width) in crabs *Callinectes amnicola* and *Cardisoma armatum*: The Figures 2 and 3 shows the distribution of the carapace large width respectively in the crabs *Callinectes amnicola* and *Cardisoma armatum*. In the crab *Callinectes amnicola*, the distribution of the carapace large width in immature individuals is unimodal and the corresponding mode is 4.5 cm. The average carapace large width in these subjects was 4.68 cm and the corresponding median was 4.6 cm. The distribution of the carapace large width in the immature crab *Callinectes amnicola* is normal (symmetric). As for the mature subjects, the distribution

was also unimodal. The average carapace large width was 7.23 cm, the median was 7 cm and the mode was 6.5 cm. The distribution of the carapace large width in the mature subjects is not normal and the asymmetry is right. For the whole population (immature + mature) of the crab *Callinectes amnicola*, the distribution of size classes is unimodal and the corresponding mode is 4.5 cm. The mean is 5.50 cm and the median is 5.2 cm. In the swimmer crab *Callinectes amnicola*, the population is mainly dominated by immature individuals and the distribution of the carapace large width is not normal and the asymmetry is right (Figure 2).

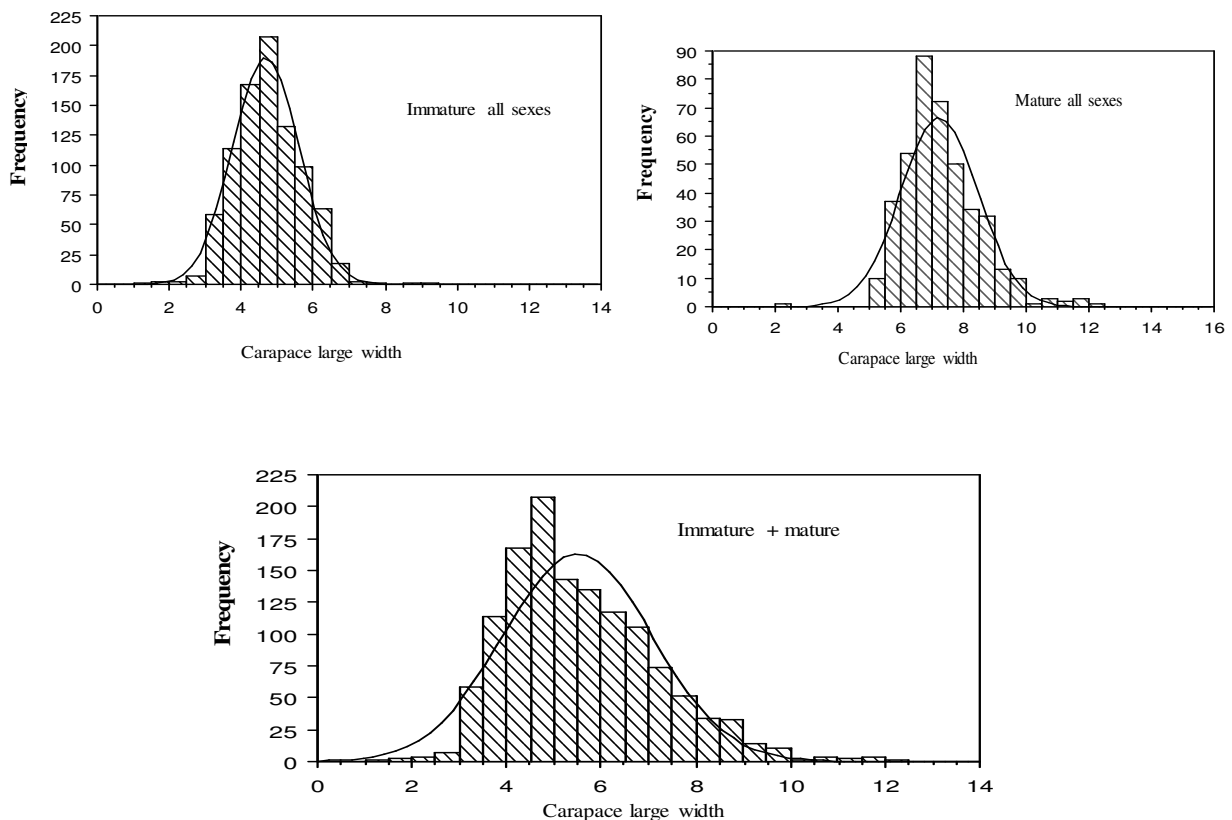


Figure 2: Carapace large width frequency distribution of *Callinectes amnicola*

In the crab, *Cardisoma armatum*, the carapace large width distribution is unimodal at all biological stages (**Figure 3**). In immature individuals, the average carapace large width is 5.25 cm and the mode is 5.2 cm. The median value is 5.30 cm, the distribution is not normal, and the asymmetry is left. In mature subjects, the

distribution is normal or symmetric because the mean (6.09), the median (6.00) and the mode (6.00) coincide. For the whole population of the *Cardisoma armatum* (immature + mature), the same trend was observed. The mean (5.94), median (6.00) and mode (6.00) have approximately the same values (**Figure 3**).

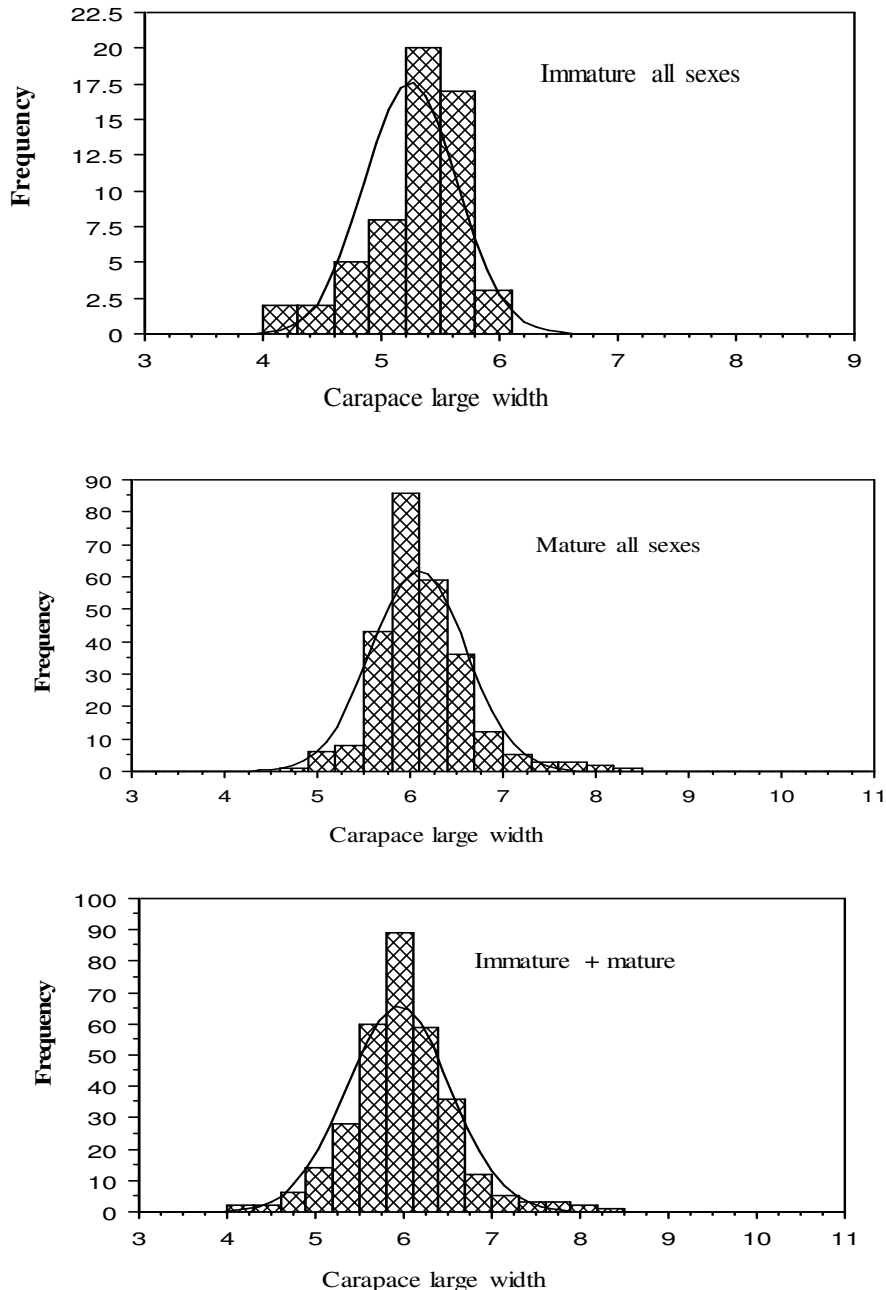


Figure 3: Carapace large width frequency distribution of *Cardisoma armatum*

Sex ratios: The Table 5 presents the sex ratios calculated for crabs *Callinectes amnicola* and *Cardisoma armatum* according to the stages of maturity. In the crab

Callinectes amnicola, 1287 individuals were collected including 635 males and 652 females. The calculated sex ratios were not significantly different from the theoretical

sex ratio (1: 1) at the different stages of maturity ($p > 0.05$). In the crab *Cardisoma armatum* over the 322 individuals collected, 163 are males and 159 are females.

The sex ratios calculated were not significantly different from the theoretical sex ratio (1: 1) at the different stages of maturity ($p > 0.05$).

Table 5: Calculated sex ratios according to maturity stages in the two species

Species	Stage of maturity	No examined		Sex ratio (M/F)	Chi-square	Significance test
		Males	Females			
<i>C. amnicola</i>	Immature	426	450	1/1.06	0.66	NS
	Mature	209	202	1/0.97	0.11	NS
	Immature + mature	635	652	1/1.03	0.22	NS
<i>C. armatum</i>	Immature	33	24	1/0.73	1.42	NS
	Mature	130	135	1/1.04	0.09	NS
	Immature + mature	163	159	1/0.97	0.048	NS

NS : Not Significant;

Morphometric relationships in crabs *Callinectes amnicola* and *Cardisoma armatum*: The estimation parameters of the relationship between carapace large width and weight in crabs *Callinectes amnicola* and *Cardisoma armatum* were presented in **table 6**. The carapace large width -weight relationships established at all stages of maturity of these two species were very significant ($p < 0.001$). In the crab *Callinectes amnicola*, the correlation coefficients of the carapace large width - weight relationship at the maturity stage were positive,

very high and ranged from 0.698 (mature) to 0.863 (immature + mature). Growth in crab *Callinectes amnicola* was isometric at all the biological stages. The allometric coefficients b determined were all less than 3, which show the weight growth of the crab *Callinectes amnicola* is less important than its size growth. In crab *Cardisoma armatum*, growth was also negative allometric in the maturity stages ($b < 3$) (**Table 6**). Correlation coefficients were positive and significant and ranged from 0.473 (immature) to 0.741 (immature + mature).

Table 6: Estimation parameters of the relationship between carapace large width - weight and growth patterns in crabs *Callinectes amnicola* and *Cardisoma armatum*

Species	Stage of maturity	Number	a	b	R ²	t	TC
<i>C. amnicola</i>	Immature	876	0.390	2.152	0.706	*	A-
	Mature	411	0.759	1.927	0.698	*	A-
	Immature + mature	1287	0.281	2.391	0.863	*	A-
<i>C. armatum</i>	Immature	57	1.775	2.162	0.473	*	A-
	Mature	265	0.609	2.795	0.698	*	A-
	Immature + mature	322	0.752	2.679	0.741	*	A-

*: b significantly different from 3 ($p < 0.05$)

a and b = estimated parameters of the carapace large width -weight relationships; r^2 = coefficient of determination; t = student test; TC = growth pattern; A-: Negative allometric growth.

Condition factors: The **Figures 4 and 5** show the condition factors respectively in the crabs *Callinectes amnicola* and *Cardisoma armatum*. In the crab *Callinectes amnicola*, the condition factor varied significantly at the maturity stage. The condition factors were 42.54 in immature subjects, 80.12 in mature subjects and 33.25 in the whole population. The condition factors were all greater than 1. The highest value of the

condition factor was recorded in mature subjects (**Figure 4**) In the crab *Cardisoma armatum*, the condition factor also varied between stages of maturity. Immature individuals presented the best condition factor (**Figure 5**). In the crab *Cardisoma armatum*, the condition factor was greater than 1, which indicates a good adaptation of the species to its environment.

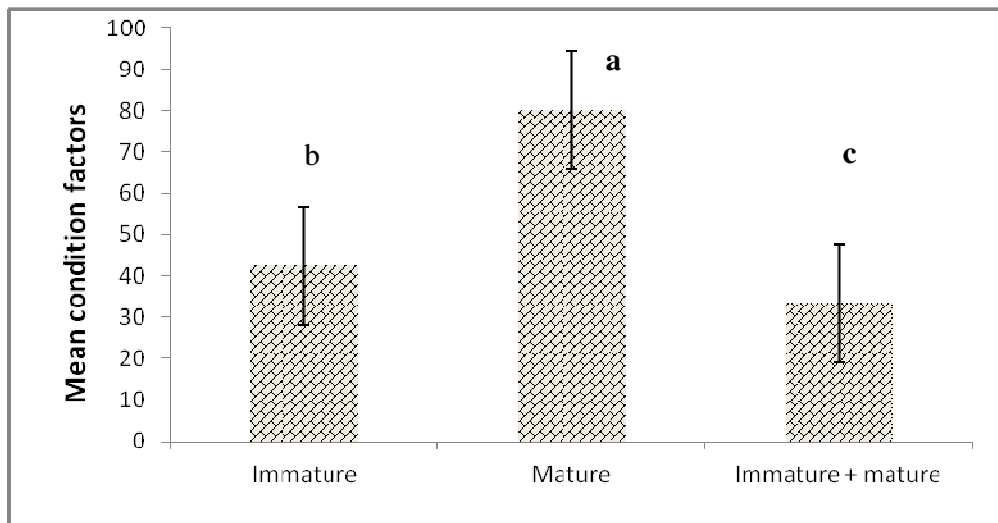


Figure 4: Variation of condition factors in crab *Callinectes amnicola* by maturity stage

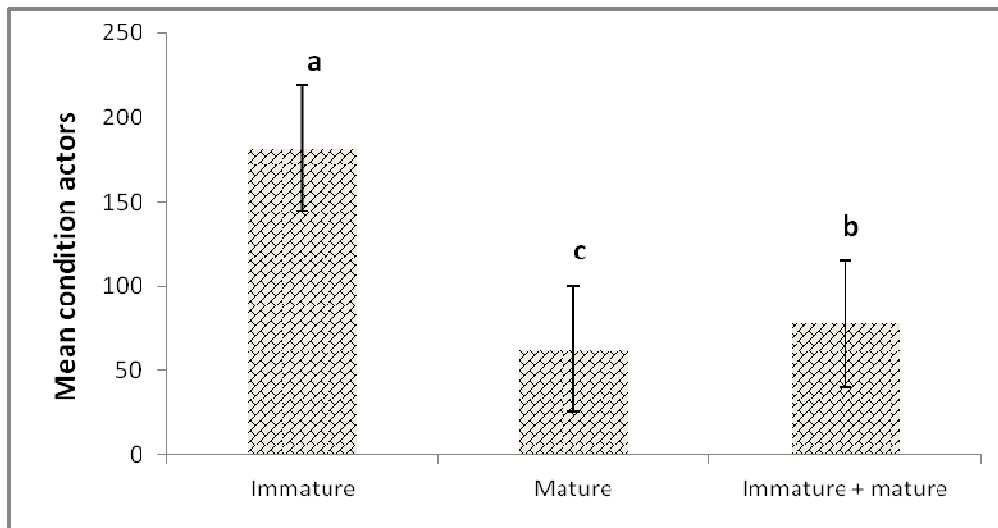


Figure 5: Variation of condition factors in crab *Cardisoma armatum* by maturity stage

DISCUSSION

Morphological characteristics in crabs *Callinectes amnicola* and *Cardisoma armatum*: The means of the morphological characteristics in the crab *Callinectes amnicola* globally did not vary according to the sex and the stage of maturity. The absence of a significant difference in the distribution of morphological variables in male and female is related to the moult frequency, which is identical in both sexes. Moulting is a biological phenomenon during which crustaceans evolve in size. The frequency of occurrence of this phenomenon, which is under nervous and hormonal control, varies according to species, age, sex and environmental conditions (Chartois *et al.*, 1994, Miserey, 2005, Zouari, 2010). Omuvwie and Atobatele (2013) report on the same

species in Nigeria that there is no significant difference between the carapace large width of the male and female. These observations confirm this study results. On the other hand, Nlewadim *et al.* (2009) reported opposite observations. The length of the carapace of the males is higher than that of the females according to these authors. The difference with this study results may be related to the presence in the samples of many mature individuals (88 -90%). In the crab *Callinectes pallidus*, a species of the same genus as *Callinectes amnicola*, similar results to those of the present study have been reported by Oluwatoyin *et al.* (2013) in the Ojo River in Nigeria. In the *Cardisoma armatum* crab, the weight, the carapace large width and the carapace length of

immature males were higher than those of immature females. The presence of significant differences in the distribution of variables in immature individuals is related to moult, whose frequency of occurrence is higher in immature males. In mature individuals, the mean of the variables did not globally show differences between sexes except the carapace length, which showed a difference in favour of the males. The results obtained in mature subjects are similar to those obtained by Akin-Oriola et al. (2005) on the same species in Nigeria except for the carapace length of the male and female that does not present a significant difference. A comparison of the morphological variables in the two species shows that the morphological variables of the *Cardisoma armatum* crab were higher than those of the crab *Callinectes amnicola*. This difference is of genetic origin. Crabs of the *Cardisoma* genus are generally walkers, large-format and frequent terrestrial habitats (Almeida et al., 2014).

Size structure in crabs *Callinectes amnicola* and *cardisoma armatum*: In the crabs *Callinectes amnicola*, the average carapace large width in immature and mature individuals is 4.68 cm and 7.23 cm, respectively. The distribution of size frequencies (carapace large width) is unimodal in the different stages of maturity. In Nigeria, Arimoro and Idoro (2007) also report a unimodal distribution with size classes greater than those obtained in this study. This difference may be related to the presence in this study of many immature individuals. The abundance of immature specimens in the samples is related either to the fishing gears used that catch more juveniles or to the identified fishing areas, which possess favourable physicochemical characteristics constituting environments of recruitment and development of immature individuals. These two assumptions therefore imply the need to have on the one hand regular control of the catching gears and, on the other hand, to delimit these fishing zones (or even a fishing ban) in order to ensure a sustainable exploitation of the stock of this resource. As for the *Cardisoma armatum* crabs, the size distribution is unimodal and symmetric for the whole population. The distribution regroups mainly subjects of large sizes. Immature in this case account for only 17.70% of all the caught crabs. The fishing pressure on immature individuals of this species is lower than that of the crabs *Callinectes amnicola*. The catch gears used for this species are mainly selective and catch fewer immature individuals.

Sex ratio: In the crab *Callinectes amnicola*, the calculated sex ratios were not different from the theoretical sex ratio at the different stages of maturity. In this species, recruitment of juveniles is effected in an

equal proportion of males and females. The observations made by Dessouassi (2014) on the same species at Ahéme lake show that the sex ratio is no different from the theoretical sex ratio. These observations confirm the results of this study. Arimoro and Idoro (2007) report the same observations in the Warri River in Nigeria. Contrary to the results of this study, Guerrero and Arana (2009) report in the *Chaceon chilensis* crab in the Juan Fernandez Archipelago in Chile, a difference between the calculated sex ratio and the theoretical sex ratio with a high proportion of male subjects (97.9%). In the *Cardisoma armatum* crab, the same observations were also made on the sex ratio at the different stages of maturity. The male and female of this species are in equals proportions at the time of the recruitments of juvenile. In accordance with the results of the present study, Olalekan and Lawal-Are (2013) report in Nigeria that the calculated sex-ratio in the crab *Cardisoma armatum* is not different from the theoretical sex-ratio (1 male for 0.8 female) but that the males are in high proportion. These observations made by these authors confirm the results of the present study. Some contrary observations have been report by Vasquez and Ramirez (2015) in the crab *Cardisoma crassum*.

Growth Relationships: The growth relationships between size (carapace large width) and weight in the crab *Callinectes amnicola* were all very significant in the maturity stages. Growth coefficients b are less than 3 and reflect negative allometric growth. During growth, the weight evolution in the crab *Callinectes amnicola* is less important than that in size. In Benin, Dessouassi (2014) and Hountogan (2011) report the same observations on this species in Ahéme Lake and Nokoué Lake respectively. As in this study, Omuvwie and Atobatelé (2013), Abowei, and George (2010) conducted similar studies on the growth of crab *Callinectes amnicola* in Nigeria. These authors show that in this species growth is also negative allometric, which confirms the results of the present study. The correlation coefficients obtained in the growth relationships are all positive and very high, which implies that the increase in size induces an increase in weight. In the *Cardisoma armatum* crab, growth relationships were also significant and growth was negative allometric ($b < 3$). The correlation coefficients were also positive and significant. The type of growth obtained in the *Cardisoma armatum* crab confirms the results obtained by Olalekan et al. (2015) on the same species in the Lagos Lagoon in Nigeria. Olalekan et al. (2015) and Vasquez and Ramirez (2015) report the same observations respectively in the crabs *Cardisoma*

guanhum and *Cardisoma crassum* which are species of the same genus as *Cardisoma armatum*.

Condition factors: According to Abba et al. (2010), the condition factor determines the physiological state of a species, including its reproductive capacity as well as the influence of the living environment on the species. In the crab *Callinectes amnicola*, the condition factor varied between the biological stages. The condition factor varied between 33.25 and 80.12. Mature subjects presented the best condition factor. This may be related to the accumulation in mature individuals of the nutritious reserves necessary for the development of the genital organs and the different reproduction physiological processes. The condition factor observed in all the individuals of the crab *Callinectes amnicola* is much greater than that reported by Dessouassi (2014) on the same species in the Ahéme lake in Benin. In Nigeria, Arimoro and Idoro (2007), Olugbenga and Oloko (2013) also report condition factors far below the results of the

present study on the same species. On the other hand, the results of Omuvwie and Atobatelé (2007) on the same species in the Lagos lagoon are similar to those obtained in this study. In the *Cardisoma armatum* crab, the condition factor also showed significant variations between maturity stages. In this species, the best condition factor was observed in the immature one. This condition factor observed in the immature individuals of the *C. armatum* crab may be related to the moult phenomenon of which occurrence frequency is higher in juveniles. Zouari (2010) reports that in tropical and terrestrial crabs, before the moult process, the animal accumulates a large quantity of water and a deposit of gastroliths in the connective tissues of the stomach wall, which would promote a much greater weight. In accordance with the results of this study, Akin-Oriola et al. (2005) report similar observations on the *Cardisoma armatum* crab in Nigeria.

CONCLUSION

The study on morphological, structural and growth characteristics of crabs *Callinectes amnicola* and *Cardisoma armatum* shows that morphological variables vary little in both sexes of the same stage of maturity. In general, *Cardisoma armatum* crabs have the best growth parameters. The distribution of size classes in the two species is globally unimodal. The sex ratio in the crabs *Callinectes amnicola* and *Cardisoma armatum* is no different from the theoretical sex ratio. Growth in these two species is much more in favour of the carapace width. Both species have a good stoutness and are well adapted

to their respective living environment. However, *Cardisoma armatum*, adapts better to its environment and have better stoutness than *Callinectes amnicola*. Crabs *Callinectes amnicola* and *Cardisoma armatum* are affected by fishing in the complex Nokoué lake Porto-Novo lagoon. It is then necessary to determine the exploitation parameters of these species in order to assess the current exploitation level and propose management measures. For this purpose, the performed measurements will be used as the basis for the different analyzes.

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