Growth Characteristics of Edible Land Crab
*Cardisoma armatum* (Brachyura: Gecarcinidae) from Kribi Mangroves, Cameroon

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Abstract: The land crab *Cardisoma armatum* is traditionally overexploited for consumption issue in Cameroonian mangroves. However, the exploitation of this natural resource ignores sustainable management. Hence, the study aims to assess the availability and growth patterns of *C. armatum* in Kribi mangroves throughout some of their morphological parameters. Several individuals were captured inside traps baited once each two months from March 2019 to March 2020. Then, wellbeing, growth patterns and size at the first sexual maturity were assessed based on sex, seasons or maturity stages. Despite the fact that the condition factor (K) value overall remained below 1, females and matures individuals were in a better wellbeing compared to males and immature. In the CW-BW relationships, the allometry coefficients (b) were below 3 for both sexes, suggesting a negative allometry growth patterns which means that crabs are lighter than their body weights. In the CW-CL and CW-BH relationships, males showed a positive allometry (b>1) while females a negative allometry (b<1). Fifty percent maturity of females (CW⁵₀=58.87±0.14 mm) was significantly lower than that of males (CW⁵₀=62.67±0.08 mm). Immature and mature crabs were recorded throughout the sampling period indicating that this species breeds throughout the year with a peak between September and November.

Keywords: Allometry, Sex Ratio, Sexual Maturity, Size-frequency, Wellbeing

1. Introduction

Ecological roles of crabs in terms of structure and function in most aquatic ecosystems are multiples [1, 2]. They constitute one of the most important members of estuarine food chain [3]. Some crabs may be useful as biological indicators to assess the impacts of human activities on mangroves in the current degradation of these ecosystems [4] while the land crabs in particular are the major drivers of tree recruitment in tropical coastal forest ecosystems, and their conservation should be included in management plans of these forests [5]. Gecarcinid crabs are often large in size and commonly referred to as land crabs, based on the terrestrial habits shown by adults of most its species [6]. They comprise 24 species distributed among six genera, including *Cardisoma* among *C. armatum* Herklots, 1851 is a tropical species known [7, 8].

Human consumption of crabs has increased tremendously worldwide [9]. Usually, crabs are prominent sources of protein and of essential macro and micro element for local populations [10, 11]. In Cameroon in particular, edible crabs of mangroves are one that remain very little known unlike freshwater and marine crabs. However, in some West Africa countries mangrove crab *C. armatum* is known forms an important part of the diets for several coastal communities which ignores sustainable management of crab resources [12, 13]. Besides, this species also strongly suffers from impacts caused by depletion of their habitat for urbanization [4],
which affects its abundance and might even lead to local extirpation [14]. Currently, *C. armatum* primarily vegetarians but may show an opportunistic omnivorous diet. The aforementioned urbanization transformed vast mature stands of *Rhizophora* spp. trees into highly degraded areas with a dramatic change in botanical assemblages [15] thus causing the lack of food.

Facing the significant demographic growth of populations, the food and nutritional needs are increasing. Therefore, Cameroon chose some development programs to boost growth and jobs to maintain long-term food security and balance [16]. Among these programs, the promotion of aquaculture, including crab farming is prioritizing. However, this new income-generating activity is nevertheless confronted with the precariousness of techniques and an absolute ignorance of the biology of species. Faced with these shortcomings, preliminary works on the reproduction, growth, morphological and structural characterization of the new mangrove fisheries resources with high aquaculture potential such as *C. armatum* are data necessary as a prerequisite for aquaculture activities.

To assess the ecological condition of the species in the mangrove habitat, the size-frequency is one of the most widely used method for growth pattern [17]. For that, several measurements frequently made on crabs concern the weight, width and length of carapace, the abdomen and the chelipeds for estimating the population size and the growth pattern [18]. Additionally, the relative condition factor (K) that was derived from the size was determined for evaluating general health, habitat conditions [19, 20]. Considering their nutritional, ecological and economic importance, the current study aims to assess the availability and growth patterns of *C. armatum* crabs in the wild based on their morphological parameters in order to improve and promote knowledge and conservation of this species in Cameroon mangroves.

2. Materials and Methods

2.1. Site Description

The survey was carried out in the Kribicity around the back mangroves of Nziou (2°58'35"-2°58'44"N and 9°54'59"-9°55'07"E) (Figure 1). Wood harvesting for urban settlement and infrastructures and sand extraction are the most important factors of mangrove degeneration. The climate is of a typical equatorial regime with four seasons well individualized, marked by high and stable temperatures of about 28.7 °C. Heavy annual rainfalls reach 3,000 mm and the tidal regime reaches 1.5 m in the spring tide [21]. *Rhizophora* spp. are largely the dominant species of the flora.

![Figure 1. Location of study area.](image)

2.2. Data Sampling

Specimens were collected once each two months from April 2019 to March 2020 during the low tide at day time into the traps baited distributed around their holes. Additional crabs were captured randomly inside sampling area. Captured crabs were immediately transported in individual plastic bags and stored for one hour in a deep freeze in the laboratory. Then, they were thawed, washed and separated by sex (Figure 2). Crab carapace width (CW) and length (CL), body height (BH) and abdomen size (AW and AL) were measured using caliper (0.01 mm accuracy). Body weight was...
determined using digital scales to the nearest 0.01g. The size at first maturity (CW$_{50}$) which is the one reached by 50% of mature individuals of both sexes for the first time was assessed according to Giresse et al. [22]. Then, all individuals were dissected in order to identify macroscopically the gonadal development stages according to Lawal-Are [23].

**Figure 2. Ventral views and sexual dimorphism of C. armatum. A, male triangular abdomen and heterogeneous chelipeds; B, female semi-circular abdomen and homogeneous chelipeds.**

### 2.3. Data Analysis

A Chi-squared test ($\chi^2$) was performed to detect significant deviations from a 1:1 sex ratio [24] as follows:

$$\chi^2 = \sum \frac{(f_{obs} - f_{th})^2}{f_{th}}$$

- $f_{obs}$=frequency of crab observed;
- $f_{th}$=frequency of crab expected

The condition factor (K) was calculated as follows:

$$K = \frac{100 \cdot BW}{CW^3}$$

- K=condition factor (g.mm$^{-3}$);
- BW=body weight (g);
- CW=carapace width (mm)

The population structure was analyzed for both sexes according to the CW size classes. The one-way ANOVA test was used to compare morphometric variables and condition factor (K) of individuals among the sex, months, seasons or stages of maturity. Morphometric variables were described by the proportionality index (I):

$$I = \frac{100 \cdot L}{CW}$$

- I=proportionality index;
- L=morphometric variable (mm);
- CW=carapace width (mm)

Determination model of the relationship between the widths of the carapace and other morphological parameters using the equation according to [25]:

$$Y = aCW^b$$

- $a$=Constant;
- CW=carapace width (mm);
- $b$=allometry coefficient

The above equation may be a linear regression equation algorithm:

$$\ln BW = \ln a + b \ln CW \text{ or } Y = a + bX$$

Growth pattern related to value of allometry coefficient (b) was defined. Then, b value was comparing with the theoretical value 1 or 3 according to linking of the two parameters. If $b=0$, isometry growth; $b>1$ (3), positive allometric growth; $b<1$ (3), negative allometry [26]. The significance of b was tested using Student’s test at 5%.

CW$_{50}$ will be determined from the equation of the sigmoid curve of evolution of mature individuals’ percentages (stages two to five) according to the carapace width (in mm). This curve is obtained by logistic transformation according to [27] and is given by the formula: $P = \frac{x}{(1+x)}$ with $x=e^{(a+bCW)}$, $a$ and $b$ being the model’s parameters.

The logarithmic transformation of the equation has permitted to put it in the form: $\ln \frac{P}{(1-P)} = a + bCW$ and by replacing $P=50\%$ in the equation, the CW$_{50}$ is obtained by

$$CW\;50 = -\frac{a}{b}$$

This function tracks sexual maturity by size and accurately estimates the widths CW$_{50}$, CW$_{25}$, and CW$_{75}$ which are often required by most stock analysis software. The degree of adjustment of the equation is tested using the Chi-squared test ($\chi^2$) given by the formula:

$$\chi^2 = \sum \frac{(M_i - nPi)^2}{nPi}$$

- $M_i$=mature individuals observed;
- $nPi$=mature individuals expected.

This logistic model of the first maturity size is determined using the StatView software (version 5.0.1).

### 3. Results and Discussion

#### 3.1. Sex Ratio

Sex ratio was identified as illustrated in Table 1. In all, 111 crabs were collected 51 females (45.95%) and 60 males (54.05%). Sex was globally unbalanced (1:0.85) in favor to males but the global Chi-squared test confirms that the difference was not significant ($p>0.05$). Females were abundant than males only in September (male/female ratio 1:1.5) and November 2019 (M/F 1:1.4). In conformity with [28] survey which reported the cumulative sex ratio of C. armatum showed that males are higher than female and found no significant difference between the number of males and females. Also, [29] reported the calculated sex-ratio in C. armatum is not different from the theoretical sex-ratio but that the males are in high proportion (M/F 1:0.97).
Table 1. Sex ratios according to gender and sampling periods. M, males; F, females.

|                  | Number of individuals | M  | F  | Sex ratio (M/F) | Chi-squared test | Significance of test |
|------------------|-----------------------|----|----|-----------------|------------------|---------------------|
| March_2019       | 13                    | 8  | 5  | 1.63            | 0.11             | NS                  |
| May              | 16                    | 10 | 6  | 1.60            | 0.125            | NS                  |
| July             | 18                    | 12 | 6  | 1.50            | 0.222            | NS                  |
| September        | 19                    | 10 | 9  | 1.90            | 0.006            | NS                  |
| November         | 20                    | 8  | 12 | 1.50            | 0.08             | NS                  |
| January_2020     | 12                    | 5  | 7  | 1.40            | 0.056            | NS                  |
| March_2020       | 13                    | 7  | 6  | 1.86            | 0.012            | NS                  |
| Global           | 111                   | 60 | 51 | 1.85            | 0.013            | NS                  |

Figure 3. Variation of condition factors by sex (a) and by sampling periods.

3.2. Condition Factor K

Globally, Condition factor (K) ranged from 0.22 to 0.95 g.mm⁻³ (mean 0.55±0.18 g.mm⁻³) (Figure 3a, b). K of immature ranged from 0.22 to 0.64 and from 0.32 to 0.95 (mean 0.57±0.20) for matures individuals. Throughout the entire sampling period, (K) was below 1 means that crab is not wellbeing according to [30]. Therefore, K values obtained were very low compared to those of [28] which recorded the highest values of K for C. armatum (30.7) indicating favorable environmental conditions such as habitat and food availability. Like in fish, variations of K may be indicative of food abundance, adaptation to environment and gonadal development [31]. The mean K of females (0.60±0.24) was significantly (p<0.001) higher compared to males (0.52±0.09) suggests that females showed a better condition (welfare) than males. K higher for females was previous reported with a significant growth rate [32]. In contrast, in some brachyuran crabs, males show their K higher than females because K is strongly influenced by ecological factors, gonad development, rate of feeding (or growth), degree of parasitism and may vary among seasons, species and populations [33, 34]. The one-way ANOVA test showed the strongly different and significantly K condition factor among the sampling periods (p<0.001). K was not significantly higher (p>0.05) during dry season (mean 0.56±0.26) compared to rainy season (mean 0.54±0.11). K of matures was significantly higher (p<0.001) compared to immature.

3.3. Relationships Between Carapace Width and Other Parameters

The mean values of morphological parameters were illustrated in Table 2. Globally, Carapace width (CW) ranged from 46 to 93 mm. Carapace length (CL) varied from 26 to 80 mm. Body weight (BW) varied from 71.9 to 400 g. Body height (BH) varied from 26 to 55 mm. Abdomen length (AL) varied from 25 to 57 mm. Abdomen width (AW) varied from 10 to 42 mm. The maximum carapace length in this study was 80 mm which is low compared to 95 mm recorded in some previous studies in Table 3. This is probably due to the poor abundance of trees and the low richness in the mangrove ecosystem in the study area, in contrary to the findings of [35].

Table 2. Proportionality index (I) according to the carapace width (CW) in C. armatum.

| Metric variables | Males | Females | Combined |
|------------------|-------|---------|----------|
|                  | Mean±SD | ±SD | Mean±SD | ±SD | Mean±SD | ±SD |
| CW               | 70.63±9.51 | 100 | 69.50±9.40 | 100 | 70.13±9.46 | 100 |
| CL               | 60.00±9.91 | 84.93±8.40 | 59.24±10.07 | 85.64±11.72 | 59.66±9.96 | 85.24±9.99 |
| BH               | 37.39±6.12 | 52.87±4.10 | 37.52±6.11 | 54.11±5.99 | 37.45±6.10 | 53.42±5.05* |
| BW               | 191.06±82.16 | 261.42±83.30 | 191.34±78.27 | 269.68±89.33 | 191.19±80.27 | 265.09±85.93 |
| AW               | 25.37±7.70 | 36.50±11.67 | 24.38±6.57 | 34.90±7.32 | 24.80±6.87 | 35.30±8.60 |
| AL               | 42.28±6.66 | 60.16±7.76 | 40.23±7.42 | 58.60±11.59 | 36.18±14.46 | 52.60±21.01* |

* Significant difference between males and females by the one-way ANOVA test
The correlation coefficients (r) obtained for the CW and BW of males, females and combined were positive and nearly to 1 (0.70 < r < 0.90; p<0.001) indicating that a high degree of correlation was evident between CW-BW. Relative growth between carapace width and body weight (BW) were below 3 which imply a negative degree of correlation was evident between CW-BW. Relative growth between carapace width and carapace length (CL) relationships, males showed a positive allometry (b >1) while females a negative allometry (b<1). For CW-AL relationships, males and females showed a negative allometry (b<1) while for CW-AW relationships, both of them showed a positive allometry (b >1). Globally, the negative allometric growth suggests that crabs have a relatively slow growth rate and tend to be thinner [36] and for female crabs in particular means slow rate of growth which is scientifically attributed to the great amount of energy invested in the reproductive process at the expenses of growth [37]. The relationships between carapace width and body weight were illustrated in Figure 4 below.

Table 3. Distribution of morphometric parameters in C. armatum in some Africa countries.

| Authors/year | CW (mm) | CL (mm) | BW (g) | Allometric growth | Country |
|--------------|---------|---------|--------|-------------------|---------|
| Present study | 46-93   | 26-80   | 71.9-400 | Negative         | Cameroon |
| Oriola et al. 2005 | 32-58 | 38.07-214.60 | Positive | Nigeria |
| Ngo-Massou et al. 2014 | 136-157 | 91-130 | 152.2-158.9 | Negative | Cameroon |
| Elegbede et al. 2015 | - | 25-95 | 96-290 | Negative | Nigeria |
| Ethian et al. 2016 | 49.4-51.8 | 61-64.6 | 99.71-121 | Negative | Cote d’Ivoire |
| Kakou et al. 2017 | 64.61-68.64 | - | 133.4-161.53 | Negative | Cote d’Ivoire |
| Gassanou et al. 2017; 2018 | 8.2 | - | 65.50-97.70 | Negative | Benin |
| Elegbede et al. 2018 | 27-94 | 25-93 | 96-290 | Negative | Nigeria |

*mean value of females; * mean value of males; * maximum value

C. armatum is a well-known species in Nigeria by [35]. In the CW-CL and CW-BH relationships, males showed a positive allometry (b >1) while females a negative allometry (b<1). For CW-AL relationships, males and females showed a negative allometry (b<1) while for CW-AW relationships, both of them showed a positive allometry (b >1). Globally, the negative allometric growth suggests that crabs have a relatively slow growth rate and tend to be thinner [36] and for female crabs in particular means slow rate of growth which is scientifically attributed to the great amount of energy invested in the reproductive process at the expenses of growth [37]. The relationships between carapace width and body weight were illustrated in Figure 4 below.

Table 4. Relative growth between carapace width (CW) and body weight (BW). a and b, estimated parameters; R², coefficient of determination; R, correlation coefficient; ***, higher significant correlation; N, number of individuals; Y=aCW, growth equation; tcal, student test calculated; tth, student test standard value.

| Sex          | a     | b     | R²    | r     | n     | Y=aCW  | tcal | tth | Allometry |
|--------------|-------|-------|-------|-------|-------|--------|------|-----|-----------|
| Males        | 0.0001 | 2.965 | 0.796 | 0.892*** | 60    | BW=0.0001CW² | 26.98 | 1.671 | Negative |
| Females      | 0.014  | 2.219 | 0.539 | 0.734  | 51    | BW=0.014CW² | 7.81  | 1.676 | Negative |
| Combined     | 0.006  | 2.412 | 0.634 | 0.796*** | 111   | BW=0.006CW² | 8.25  | 1.66  | Negative |

Table 5. Relative growth between carapace width (CW) and carapace length (CL).

| Sex          | a     | b     | R²    | r     | n     | Y=aCW  | tcal | tth | Allometry |
|--------------|-------|-------|-------|-------|-------|--------|------|-----|-----------|
| Males        | 0.76   | 1.025 | 0.569 | 0.754*** | 60    | CL=0.76CW² | 31.13 | 1.671 | Positive |
| Females      | 0.55   | 0.663 | 0.253 | 0.504*** | 51    | CL=0.55CW² | 32.74 | 1.676 | Negative |
| Combined     | 1.62   | 0.847 | 0.403 | 0.634*** | 111   | CL=1.62CW² | 31.82 | 1.66  | Negative |

Table 6. Relative growth between carapace width (CW) and body height (BH).

| Sex          | a     | b     | R²    | r     | n     | Y=aCW  | tcal | tth | Allometry |
|--------------|-------|-------|-------|-------|-------|--------|------|-----|-----------|
| Males        | 0.391  | 1.070 | 0.7904 | 0.8891*** | 60    | BH=0.391CW⁻¹ | 43.36 | 1.671 | Positive |
| Females      | 0.226  | 0.733 | 0.4234 | 0.6507*** | 51    | BH=0.226CW⁻¹ | 37.61 | 1.676 | Negative |
| Combined     | 0.825  | 0.897 | 0.594 | 0.7712*** | 111   | BH=0.825CW⁻¹ | 37.79 | 1.66  | Negative |

Table 7. Relative growth between carapace width (CW) and abdomen length (AL).

| Sex          | a     | b     | R²    | r     | n     | Y=aCW  | tcal | tth | Allometry |
|--------------|-------|-------|-------|-------|-------|--------|------|-----|-----------|
| Males        | 3.594  | 0.570 | 0.2153 | 0.464*** | 60    | AL=3.594CW⁻³ | 36   | 1.671 | Negative |
| Females      | 1.185  | 0.226 | 0.0295 | 0.171 | 51    | AL=1.185CW⁻² | 35.69 | 1.676 | Negative |
| Combined     | 7.200  | 0.406 | 0.102 | 0.3196*** | 111   | AL=7.200CW⁻³ | 35.63 | 1.66  | Negative |

Table 8. Relative growth between carapace width (CW) and abdomen width (AI).

| Sex          | a     | b     | R²    | r     | n     | Y=aCW  | tcal | tth | Allometry |
|--------------|-------|-------|-------|-------|-------|--------|------|-----|-----------|
| Males        | 0.327  | 1.011 | 0.233 | 0.4833*** | 60    | AI=0.327CW⁻³ | 11.30 | 1.671 | Positive |
| Females      | -0.455 | 1.001 | 0.230 | 0.4803 | 51    | AI=-0.455CW⁻³ | 10.75 | 1.676 | Positive |
| Combined     | 0.347  | 1     | 0.230 | 0.4804*** | 111   | AI=0.347CW⁻³ | 11.16 | 1.660 | Isometry |

Table 5 presents the correlation matrix between the morphological variables in C. armatum. Various others factors may be responsible of the b value variations in the CW-BW relationships such as temperature, salinity, food (quantity, quality and size), sex, and time of year and stage of maturity [38, 39]. Ovigerous females are usually heavier than non-ovigerous in...
many species of crabs [40, 41]. The overall low symmetrical or isometric growth of \( b \) values was less than 3 and it’s due to the recruitment stock in biomass which is invariably due to the peculiarity of coastal dwelling land crabs to show irregular recruitment pattern with uncertainty of returning to a small land mass after the planktonic larval phase [42]. Observations of higher \( b \) value of \( C. armatum \) were linked to the higher population and standing stock biomass and condition indices [43].

![Figure 4. Carapace width-Body weight relationships in C. armatum.](image)

Table 9. Correlation matrix between some morphological parameters. Male values above and female values below the diagonal; **p <0.01; ***p <0.001.

| Variables          | CW   | CL   | BH   | BW   | AL   | AW   |
|--------------------|------|------|------|------|------|------|
| Carapace width (CW)| 1    | 0.75***| 0.89***| 0.91***| 0.46***| 0.48***|
| Carapace length (CL)| 0.50***| 1    | 0.83***| 0.50***| 0.50***| 0.48***|
| Body height (BH)   | 0.65***| 0.81***| 1    | 0.48***| 0.49***| 0.42***|
| Body weight (BW)   | 0.68***| 1.00  | 0.81***| 0.48***| 0.49***| 0.42***|
| Abdomen length (AL)| 0.17  | 0.43***| 0.43** | 0.43** | 1    | 0.65***|
| Abdomen width (AW) | 0.48***| 0.48***| 0.62** | 0.48***| 0.58  | 1    |

3.4. Sizes at First Sexual Maturity

The 111 individuals collected were grouped into 17 class sizes with class number interval (3 mm). The minimum carapace widths at sexual maturity were 58.2 mm for males and 55.7 mm for females. Fifty percent maturity (CW_{50}) was attained at 62.67±0.08 mm in males and 58.87±0.14 mm in females and according to a Chi-squared test, CW_{50} in females is significant low compared to in males (p<0.05). The CW_{50} and CW_{75} were 59.01 mm and 66.33 mm respectively for males and CW_{50}=56.19 mm and CW_{75}=61.55 mm for females. The CW_{50} in C. armatum in both males and females were close to that reported for the same species by [44]. C. armatum was few documented, but reported for some other crab species like Carcinus aestuarii (male=43 mm and female=34 mm) and Scylla serrata (male=75 mm and female=70 mm) [45, 46]. Many factors may affect the size at sexual maturity in a crab population such as the availability of food, predation, density and as well as differences in the duration and the proportion of molting crab [47-49].

![Combined](image)

4. Conclusion

This study contributes to improve the baseline data about growth pattern of C. armatum crab in Cameroon. Overall, the condition factor value remained below 1; indicate that C. armatum does not show the good wellbeing in this natural area. Almost all CW-BW relationships showed a negative allometric growth which suggests that crabs have a relatively slow growth rate and tend to be thinner; might be attributed to the degradation of their environmental conditions. Here, the size at first sexual maturity of C. armatum is very close to those reported for the same species in other country. According to the low abundance of C. armatum recorded in the study area, the current exploitation of this crab represents a threat to the survival of this species.

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References

[1] Lee SY. 1998. Ecological role of Grapsid crabs in mangrove ecosystems: a review. Marine and Freshwater Research 49: 335-343.
[2] Cartes JE, Fanelli E, Papiol V, Maynou F. 2010. Trophic relationships at intranannual spatial and temporal scales of macro and megafauna around a submarine canyon of the Catalonian coast (western Mediterranean). Journal of Sea Research 63: 180-190.

[3] Hall D, Lee SY, Meziane T. 2006. Fatty acids as trophic tracers in an experimental estuarine food chain: Tracer transfer. Journal of Experimental Marine Biology and Ecology 336: 42-53.

[4] Din N, Ngo-Massou VM, Essomé-Koum GL, Ndem-Sombo E, Kotte-Mapoko ME, Nyamsi-Moussian L. 2017. Impact of urbanization on the evolution of Mangrove ecosystems in the Wouri River Estuary (Douala-Cameroon). In: Finkl CW, Makonsky C. (eds), Coastal Wetlands: Alteration and Remediation. Springer, Coastal Research Library 21. pp 867.

[5] Lindquist ES, Kraus KW, Green PT, O'Dowd DJ, Sherman PM, Smith III TJ. 2009. Land crabs as key drivers in tropical coastal forest recruitment. Biological reviews 84: 203–223.

[6] Cuesta JA, Liu HC, Schubart CD. 2002. First zoal stages of Epigrapus politus Heller and Gecarcideae islandii H. Milne-Edwards, with remarks on zoal morphology of the Gecarcideae Macleay (Crustacea: Brachyura). Journal of Natural History 36 (14): 1671-1685.

[7] Manning, R. B., Holthuis, L. B., 1981. West African Brachyuran Crabs (Crustacea: Decapoda). Smithsonian contributions to Zoology, number 306, p 379.

[8] Davie PJF, Guinot D, Ng PKL. 2015. Anatomy and functional morphology of Brachyura. In: Castro P, Davie PJF, Guinot D, Schram F, Von Vaupel Klein C. (eds), Treatise on Zoology:Anatomy, Taxonomy, Biology-The Crustacea, complementary to the volumes translated from the French of the Traité de Zoologie, 9 (C) (1), Decapoda: Brachyura (Part 1). pp 11-163.

[9] Fagbuar O, Oso JA, Majolagbe FA, Oladapo AO. 2013. Quality Analysis of Freshwater crab Cardisoma armatum and Marine blue crab Callinectes antennuloe Collected from Yaba Lagos, Nigeria. Natural Sciences 11 (8): 22-29.

[10] Sankaré Y, Konan KJ, Amalatchy NJ, Soro MB. 2014. Swimming crab Callinectes antennuloe (Decapoda:Portunidae): capture analysis of a Lagoon with high continental influence (Aby Lagoon, Côte d’Ivoire, West Africa). Wyno Academic Journal of Biological Sciences 2 (2): 9-19.

[11] Elegbede IO, Lawal-Are AO, Titilade PR. 2015. Size and growth of Cardisoma armatum and Cardisoma guanhumi as ecological parameters for mangrove ecosystem. Journal of Marine Science Research and Development 5 (2): 1-7.

[12] Elegbede IO, Fashina HA. 2013. Proximate and mineral compositions of common crab species (Callinectespaludioides and Cardisomaarmatum) of Badagry Creek, Nigeria. Poultry, Fisheries and Wildlife Sciences 2: p. 110.

[13] Ngo-Massou VM, Kenne M, Dongmo AB. 2016. Effect of anthropogenic activities on mangrove crab diversity in Cameroon Atlantic coast. International Journal of Research Studies in Biosciences 4: 1-12.

[14] Maia RC, Coutinho R. 2013. The influence of mangrove structure on the spatial distribution of Melampus coffeus (Gastropoda: Eliginiidae) in Brazilian estuaries. Pan-American Journal of Aquatic Sciences 8 (1): 21-29.

[15] Nfotabong-Atheull A, Din N, Koum LGE, Satyanarayana B, Koedam N, Dahdouh-Guebas F. 2011. Assessing forest products usage and local residents' perception of environmental changes in peri-urban and rural mangroves of Cameroon, Central Africa. Journal of Ethnobiology and Ethnomedicine 7 (1): 41.

[16] DSCE 2009. Strategy Document for Growth and Jobs. Reference framework for government action for the period 2010-2020. p 170.

[17] Vogt G. 2012. Ageing and longevity in the Decapoda (Crustacea): A review. ZoologischerAnzeiger - A J. Comparative Zoology 251 (1): 1-25.

[18] Gaddes SW, Sumpton WD. 2004. Distribution of barnacle epizoites of the crab Portunus pelagicus in the Moreton Bay region, Eastern Australia. Marine and Freshwater Research 55: 241-248.

[19] Le Cren ED. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the Perch (Percafluviatilis). Journal of Animal Ecology 20: 201–219.

[20] Schneider JC, Laarman PW, Gowing H. 2000. Length-weight relationships. Chapter 17. In: Schneider JC. (Ed.), Manual of Fisheries Survey Methods II: With Periodic Updates. Michigan Department of Natural Resources, Fisheries Special Report 25, pp 1-18.

[21] Giresse P, Megope-Boompe JD, Ngueutchoua G, Aloisi JC, Kuete M, Monteillet J. 1996. Carte sédimentologique du plateau continental du Cameroun à 1: 200000. ORSTOM, Paris, France.

[22] Delathiere S. 1990. Biologie et exploitation du crabe de palétuviers Scylla serrata. Thèse présentée à l’Université de Bretagne Occidentale pour l’obtention du grade de Docteur en Océanographiebiologique. pp 194.

[23] Lawal-Are, A. O., 2010. Reproductive biology of the blue crab, Callinectes antennuloe (De Rochebrune) in the Lagos Lagoon, Nigeria. Turkish Journal of Fish and Aquatic Sciences 10: 1-7.

[24] Aydin M, Karadurmus U, Erbay M. 2012. Length-weight Relationships and Reproduction Characteristics of Liocarcinus navigator (Herbst, 1794), Ege Journal of Fisheries Aquatic Science 29 (4): 193-197.

[25] Rickert W. 1957. Computation and interpretation of biological statistics of fish populations. Journal of the Fisheries Research Board of Canada 191: 203-233.

[26] Yilmaz, S., Yazicioglu, A., Erbas aran, M., Esen, S., Zengin, M., Polat, N. 2012. Lengthweight relationship and relative condition factor of white bream, Bliccabjoerkna (L., 1758), from Lake Ladik, Turkey. J. Black Sea/Medit. Environment 18: 380-387.

[27] Dagnelie P. 1973. Théorie et Méthodes Statistiques: Applications Agronomiques Presses Agronomiques de Gembloux: Belgique, 1.

[28] Elegbede IO, Lawal-Are AO. 2013. Comparative study of condition factor, stomach analysis and some aspects of reproductive biology of two land crabs: Cardisoma armatum (Herklots, 1851) and Cardisoma guanhumi (Latreille, 1825) from a mangrove swamp ecosystem, Lagos, Nigeria. Journal of Marine Science Research and Development 4 (1): 1-4.
[29] Goussanou A, Bonou AG, Chikou A, Gandonou P, Mensah GA, Youssao AKI. 2017. Morphological, structural characteristics and growth relationship of crabs Callinectes annicola and Cardisoma armatum in the Nokoué lake Porto-Novo lagoon in South Benin. Journal of Applied Biosciences 118: 11803-11816.

[30] Fulton TW. 1902. The rate of growth of fishes. 20th Annual Report of the Fishery Board of Scotland 1902 (3): 326-446.

[31] King M. 1995. Fisheries biology, assessment and management. Cambridge, Massachusetts: Fishing News Books, Blackwell. ISBN: 0852382235.

[32] Arimoro FO, Idoro B. 2007. Ecological studies and biology of Callinectes annicola (Family: Portunidae) in the Lower Reaches of Warri River, Delta State, Nigeria. World Journal of Zoology 2 (2): 57-66.

[33] Pinheiro MAA, Fiscarelli AG. 2009. Length-weight relationship and condition factor of the mangrove crab Ucides cordatus (Linnaeus, 1763) (Crustacea, Brachyura, Ucidae). Brazilian Archives of Biology and Technology 52: 397-406.

[34] Franco-López J, Sánchez CB, Escocia HB, Abarca LGA, Ferreira TC, Vázquez-López H. 2010. Biological and ecological aspects regarding Cynoscionnothus Holbrook, 1855 (Perciforms: Sciaenidae). Research Journal of Fisheries and Hydrobiology 5: 66-75.

[35] Elegbede IO, Lawal-Are AO, Titilade PR. 2018. Size and growth of Cardisoma armatum and Cardisoma guanhumi as an ecological parameters for mangrove ecosystem. Journal of American Science 14 (7): 90-105.

[36] Nazek J, Younes G, Sukhn C, El-Dakdouki MH. 2018. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. Egyptian Journal of Aquatic Research 44: 299-305.

[37] Turner LM, Hallas JP, Morris S. 2011. Population Structure of the Christmas Island Blue Crab, Discoplax hirtipes (Decapoda: Brachyura: Gecarcinidae) on Christmas Island, Indian Ocean. Journal of Crustacean Biology 31 (3): 450-457.

[38] Sparre P. 1992. Introduction to tropical fish stock assessment. Part I Manual. FAO Fisheries Technical Paper 306/1. Rev 1. Rome, p 376.

[39] Moura NFO, Coelho PA. 2004. Maturidade de sexual fisiológica em Goniopsis cruentata (Latreille) (Crustacea, Brachyura, Grapsidae) no Estuário do Paripue, Pernambuco, Brazil. Revista Brasileira de Zoologia 21: 1011-1015.

[40] Ali RAS, Elawad AN, Khalifa MM, El-Mor M. 2016. Length-weight relationship and condition factor of Liza ramada from Eastern coast of Libya. International Journal of Fish and Aquatic Research 2: 1-9.

[41] Atar HH, Seher S. 2003. Width/length weight relationships of the blue crab (Callinectes sapidus, Rathbun, 1986) population living in Beymeleklagoon lake. Turkish Journal of Veterinary and Animal Sciences 27: 443-447.

[42] Goussanou A, Bonou AG, Chikou A, Mensah GA, Karim IYA. 2018. Sizes at first sexual maturity and capture and demographic parameters of crabs Callinectes annicola and Cardisoma armatum in the complex Nokoué Lake Porto-Novo lagoon in South Benin. International Journal of Fisheries and Aquatic Studies 6 (1): 195-201.

[43] Poulin E, Follana R, Bourget M, Yoshida M. 2010. Contribution à l’étude écobiologique et biochimique du crabe Carcinus aestuarii dans la région Nord de Sfax. Mémoire présenté pour l’obtention du diplôme de mastère en biodiversité et ressources aquatiques, Faculté des Sciences de Sfax, Université de Sfax, p 104.

[44] Fondo EN, Kimani EN, Odongo DO. 2010. The status of mangrove mud crab fishery in Kenya, East Africa. International Journal of Fisheries and Aquaculture 2 (3): 79-86.

[45] Johnson DD, Gray CA, Macbeth WG. 2010. Reproductive biology of Portunus pelagicus in a south-east Australian estuary. Journal of Crustacean Biology 30 (2): 200-205.

[46] Soudarapandian P, Varadharajan D, Anand T. 2013. Male reproductive system of blue swimming crab, Portunus pelagicus (Linnaeus, 1758). Journal of Cytology and Histology 5: 206.

[47] Kunsook C, Gajaseni N, Paphavasit N. 2014. A stock assessment of the blue swimming crab Portunus pelagicus (Linnaeus, 1758) for sustainable management in Kung Krabaen Bay, Gulf of Thailand. Tropical Life Sciences Research 25 (1): 41-59.