Journal of Coastal Life Medicine

journal homepage: www.jclmm.com

Document heading doi: 10.12980/JCLM.3.2015J5-8

Some aspects of the biology of the female blue crab *Callinectes amnicola* (De Rocheburne) from the Cross River estuary, Nigeria

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ARTICLE INFO

Article history:
Received 4 Feb 2015
Accepted 26 Feb 2015
Available online 3 Mar 2015

Keywords:
Callinectes amnicola
Cross River estuary
Fecundity
Carapace length-weight parameters
Condition factor
Carapace length-frequency distribution

ABSTRACT

Objective: To investigate some important aspects of the biology of *Callinectes amnicola* (*C. amnicola*) such as fecundity, carapace length-weight relationship, condition factor and carapace length frequency distribution from the Cross River estuary, Nigeria.

Methods: A total of one hundred and twenty ovigerous females of *C. amnicola*, freshly caught with basket traps, lift net trap, and gill net were collected from the catches of the artisanal fisheries in the study area between June 2012 and May 2013. Fecundity, carapace length-weight relationship, condition factor and carapace length frequency distribution were determined and analyzed following standard methods.

Results: Fecundity (F) ranged between 73090 eggs for crab of carapace length 8.1 cm and total weight 34 g and 809450 eggs for crab of carapace length 16.1 cm and total weight 395 g with a mean of 311808.93±17693.94 eggs. There was a positive significant relationship between fecundity and carapace length, total weight and condition factor as follows: F=6839.7CL$^{1.4403}$ (r^2=0.2145, P<0.05), F=15302TW$^{0.5798}$ (r^2=0.4079, P<0.05), F=147255K$^{0.2788}$ (r=0.2717, r^2=0.0738, P<0.05). A significant linear relationship between carapace length and weight of *C. amnicola* is given by the equation: Log W=2.0447LogL – 0.1389 (r^2=0.3357, P<0.05). The crab exhibited a negative allometric growth pattern (b=2.0447). Condition factor ranged between 21.48 to 104.95 with a mean value of 47.21±2.17. The carapace length frequency distribution showed a unimodal class size distribution.

Conclusions: Findings of this study is crucial in assessing the population dynamics and development of management strategies of the the Blue crab, *C. amnicola* from the estuary such as mesh size regulation, fishing season and fishing ground regulation in the Cross River estuary. Also, findings of this study will be useful in evaluation of the aquaculture potential of the Blue crab *C. amnicola*, which is a valuable shell fish for the inhabitants estuary.

1. Introduction

The blue crab, *Callinectes amnicola* (*C. amnicola)* belonging to the family Portunidae is an important shell fisheries resource in the inhabitants of the Cross River estuary, Nigeria. According to Lawson and Oloko[1], it is one of the most economically important swimming crabs inhabiting coastal waters of the tropical, subtropical and temperate regions, where it is a key resource in local fisheries. Udo and Arazu[2] assessed the nutritional qualities of the flesh and shell of *C. amnicola* of the Cross River, Nigeria, and reported that the flesh and shell of the crab is rich in nutrients such as protein, carbohydrate, fat, ash, moisture and fibre. Crab

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meat is a good source of vitamins and essential minerals substances such as phosphorus, zinc, calcium, and iron[3]. The blue crab, *C. amnicola* occupies a variety of aquatic habitats from the lower reaches of freshwater rivers, estuaries to coastal marine waters and are highly mobile, making it feasible for them to move between areas and to select habitats[4]. *C. amnicola* are freshwater crab species inhabiting cracks and holes when fully matured and small individuals are found under rocks in the littoral zone[2], and also it inhabits muddy bottoms in mangrove areas and river mouths[5]. In aquaculture and fisheries science, some important aspects of the biology of aquatic organisms considered by scientists include fecundity, which is defined as the number of eggs in the ovary of gravid female crabs[6], condition factor (CF), length-weight relationship, length-frequency distribution *etc*. These biological indices are regarded as more suitable for assessing not only fish, but also crustacean[7]. Uses of these indices in fisheries science include calculation of the standing stock biomass, condition indices, analysis of ontogenetic changes[8], stock assessment, egg and larval survival studies, exploited stock prediction, recruitment studies and formulation of management strategies[9,10]. According to Lagler[11], the relationship between carapace length and weight of the crabs can be used to estimate the recovery of edible meat from crabs of various sizes. Several scientists have conducted research on various aspects of the biology of the blue crab (*C. amnicola*) from similar water body. Powell[12], Jonathan and Powell studied its taxonomy and distribution[13]; Idoniboye-Obu and Ayinla[14], Alfred-Ockiya[15], Oduro *et al.*[16], Udo and Arazu[2], studied its nutritional qualities. Okafor[17] studied its ecology, Akin-Oriola *et al.*[18] and Lawal-Are[19] reported on its morphometric indices. Chindah *et al.*[20], Lawal-Are and Kusemiju[21], Arimoro and Idoro[22] studied its food and feeding habits while Ekanem *et al.*[3] reported on its parasites. In the Cross River estuary, reports on the biology of the blue crab *C. amnicola* are limited, which forms the basis of this study. Therefore, this study aims to investigate some aspects of the biology of *C. amnicola* such as fecundity, carapace length-weight relationship, condition factor and carapace length distribution frequency, from the Cross River estuary, Nigeria.

2. Materials and methods

2.1. Study area

The study area for this research is the Cross River estuary, Nigeria, which lies approximately between latitude 4° and 8° N and longitude 7°30' and 10° E in the southern part of Nigeria. It takes its rise from the Cameroon Mountain and meanders westwards into Nigeria and then southward through high rainforest formation before discharging into the Atlantic Ocean at the Gulf of Guinea. The study area has a mangrove forest vegetation (Ama-Abasi *et al.* estimated that the climate was characterized by long wet season from April to October and a dry season from November to March[23]. Mean annual rainfall is about 2 000 mm[24]. A short dry period known as August break occurs in August. There is usually a cold, dry and dusty period between December and January, referred to as the harmattan season. Temperatures generally range from 22 ℃ in the wet to 35 ℃ in the dry seasons. Relative humidity is generally above 60% at all seasons, with close to 90% during the wet season[23,24].

2.2. Collection and identification of the female blue crab

One hundred and twenty freshly caught ovigerous females of *C. amnicola* were collected between June 2012 and May 2013 from the catches of the artisanal fisheries at Nsidung beach, Obufa Esuk, Esuk Atu and Esuk Anantigha, Calabar, which are the major landing point of the artisanal fisheries of the Cross River estuary. The crabs were caught with fishing gear such as basket traps, lift net trap, and gill net made of 0.20 mm twine thickness, with mesh size range of 50 mm to 55 mm. Samples were transported in ice-packed containers to the Fisheries and Aquaculture Laboratory, Institute of Oceanography, University of Calabar for further analysis. Identification of *C. amnicola* was based on photo cards and identification key given by Fischer and Schneider[25,26]. Differentiation of sexes was based on external features such as triangular or rounded aprons in the abdomen of the females and a T-shaped abdomen in the males[25-28].

2.3. Measurements of biometric indices

The following biometric parameters were measured for each specimen: carapace length (cm) and total weight (TW). Carapace length was measured using from the tip of one lateral spine to the tip of the other lateral spine. Carapace length was taken to 0.1 cm using sliding jaw vernier caliper while TW was taken to the nearest 0.01 g Metlar-2000D electronic weighing balance.

2.4. Fecundity and egg diameter

Eggs from each specimen were removed and weighed using Metlar-2000D electronic weighing balance to the nearest 0.01 g[29]. The eggs removed from each sample were fixed in Gilson fluid in order to loosen the tissues surrounding the eggs[29]. Fecundity (F) was determined as the product of TW of eggs in the ovary and count in 1 g of egg mass as shown below:

F=TW of eggs in the ovary × count in 1 g of egg mass

The different developmental stages for the ovary were classified according to[6].

2.5. Condition factor

The Fulton's condition factor was calculated as follows: $K=100W/L^{2.0447}$

where K is the CF, W is the total body weight, L is the carapace length and 2.0447 is the b-value (growth exponent) obtained from the length-weight relationship curve.

2.6. Carapace length-weight relationship

The carapace length-weight relationship was estimated using the equation given by Pauly[30]:

$W=aL^b$

Where W is the weight, a is the intercept, L is carapace length and b is the slope. The parameters a and b were estimated by linear regression based on logarithms using the linear regression routine of Microsoft Office Excel in PC windows (2007) as follows:

Log (W)=Log (a) + b Log (L)

Where W=weight of the crabs in grams, L=carapace length in centimeters.

Departure from isometry (*i.e.* b=3) for the exponents (b) of the two length-weight relationships above were tested using a *t*-statistic function given in according to Pauly as follows[31]:

$$t = \frac{\text{s.d. (x)}}{\text{s.d. (y)}} \cdot \frac{/ b - 3 /}{\sqrt[2]{1-r^2}} \sqrt[2]{n-2}$$

Where s.d. (x) is the standard deviation of the Log L values, and s.d. (y) is the standard deviation of Log W values, *n* is the number of crabs used in the computation, b is the estimated exponent of the LWR and r^2 is the correlation coefficient of the relationship. If t calculated is greater than the tabled value of t for the degree of freedom, n–2, it implies that the value of b is different from 3[31].

2.7. Carapace length frequency distribution

The data from the carapace length measurement of 120 *C. amnicola* specimens were grouped into six length classes of 2 cm interval for subsequent analysis. A bar chart was plotted using Microsoft Excel to show the variation of carapace length frequency distribution of *C. amnicola* from the Cross River estuary throughout the study period.

3. Results

3.1. Fecundity

Fecundity of *C. amnicola* ranged between 73 090 eggs for crab of carapace length (8.1 cm) and TW (34 g) to 809 450 eggs for crab of carapace length (16.1 cm) and TW (395 g). Mean fecundity of 120 *C. amnicola* was 311 808.93±193 827.70 eggs.

3.2. Condition factor (K)

Fulton's condition factor (K) determined for one hundred and twenty (120) specimens of *C. amnicola* collected from the Cross River estuary ranged between 21.48 to 104.95 with a mean value of 47.21±2.17.

3.3. Relationship between biometric indices and fecundity

Fecundity of *C. amnicola* from the Cross River estuary showed a linear relationship with the carapace length (cm). Power regression equation for fecundity and carapace length as shown in Figure 1 was as follows:

Fecundity (F)=$6839.7L^{1.4403}$ (r^2=0.2145, *n*=120, *P*<0.05)

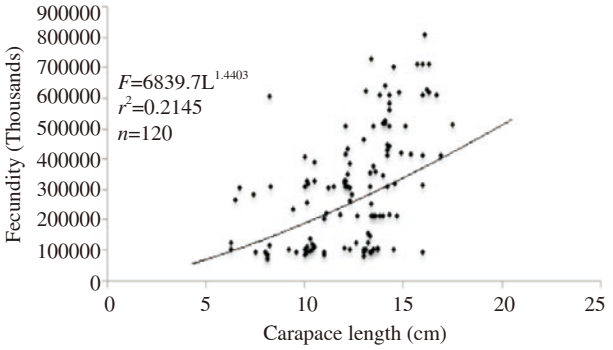

Figure 1. Power regression between fecundity and carapace length of *C. amnicola* from the Cross River estuary.

Fecundity of *C. amnicola* from the Cross River estuary showed a linear relationship with the TW (g). Power regression equation for fecundity and TW (g) as shown in Figure 2 was as follows:

Fecundity (F)=$15302TW^{0.5798}$ (r^2=0.4079, *n*=120, *P*<0.05)

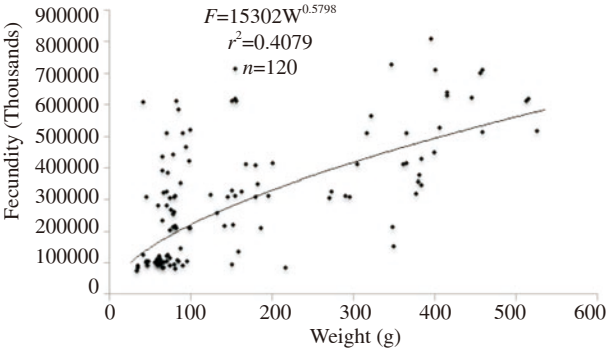

Figure 2. Power regression between fecundity and weight of *C. amnicola* from the Cross River estuary.

Fecundity of *C. amnicola* from the Cross River estuary showed a linear relationship with the CF (K). Power regression equation for fecundity and CF (K) as shown in Figure 3 was as follows:

Fecundity (F)=$147255K^{0.2788}$ (r^2=0.0738, *n*=120, *P*<0.05)

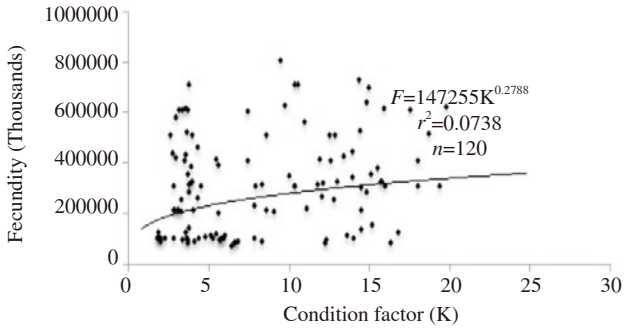

Figure 3. Power regression between fecundity and condition factor (K) of *C. amnicola* from the Cross River estuary.

3.4. Length-weight relationship

Length-weight relationship of *C. amnicola* from the Cross River estuary as shown in Figure 4 was given by the equation: $TW=0.7262L^{2.0447}$ (r=0.5794, r^2=0.3357, n=120, P<0.05). There was a significant linear relationship between carapace length and weight of *C. amnicola*. The t-statistic indicated that the value of b (2.0447) is significantly different from 3.

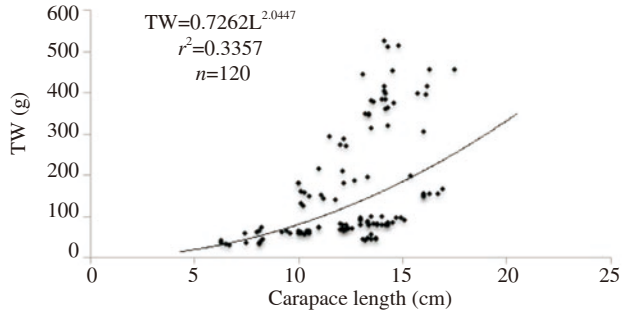

Figure 4. Length-weight relationship of *C. amnicola* from the Cross River estuary.

3.5. Carapace length frequency distribution

The carapace length frequency distribution of *C. amnicola* from the Cross River estuary (Figure 5) showed that the highest length frequency was in length class 12.1-14.0 cm (42), followed by 14.1-16.0 cm (27), followed by 10.1-12.0 cm (24), followed by 8.1-10.0 cm (13), and lowest (7) in 6.1-8.0 cm and 16.1-18.0 cm respectively.

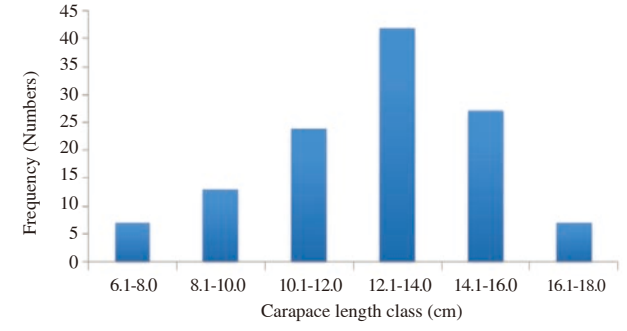

Figure 5. Carapace length frequency distribution of *C. amnicola* from the Cross River estuary.

3.6. Ovary developmental stages of C. amnicola

The ovary of *C. amnicola* obtained in this study was classified into six stages (Table 1) based on the presence of the most advanced oocytes as follows:

Stage 1: This stage is known as the immature or inactive stage where the nucleus is visible and surrounded by the cytoplasm. It is also known as the virgin stage.

Stage 2: This is the early active stage and is also known as the maturing virgin where the oocytes increase in size.

Stage 3: This is the developing stage where increase in size of the ripening oocytes is visible.

Stage 4: This is the ripped stage where ovary reaches its maximum weight.

Stage 5: This is where oocyte development is complete and spawning occurs.

Stage 6: This is where the eggs are spent with ovary appearing like empty sac with very few eggs.

Table 1
Percentage occurrence of ovary developmental stages in *C. amnicola*.

Months	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Total
Jun 2012	10	20	20	20	10	10	100
Jul 2012	-	10	20	30	10	30	100
Aug 2012	10	20	30	20	10	10	100
Sep 2012	10	20	40	20	10	-	100
Oct 2012	-	20	30	30	20	-	100
Nov 2012	-	10	20	40	30	-	100
Dec 2012	-	20	20	40	20	-	100
Jan 2013	30	20	10	10	30	-	100
Feb 2013	30	50	10	-	-	-	100
Mar 2013	20	40	40	-	-	-	100
Apr 2013	30	30	20	10	10	-	100
May 2013	20	10	20	30	20	-	100

4. Discussion

The blue crab *C. amnicola* is an important fisheries resource that is highly valued by the inhabitants of the Cross River estuary. Fecundity is a key factor in the persistence of a fisheries stock and is used to evaluate the status of a population because it has direct effects on the recruitment of species such as the blue crab, *C. amnicola* in estuarine and marine environments[32]. The high fecundity obtained for *C. amnicola* in this study indicates that during spawning of this crab in the Cross River estuary, recruitment level will be high. The range for fecundity of *C. amnicola* obtained in this study (73 090-809 450 eggs) is lower than fecundity range (260 000-2 150 692 eggs) reported by Lawson and Oloko for *C. amnicola* from Yewa river[1], Southwest Nigeria but higher than (1 148-736 226 eggs) reported by Emmanuel for *C. amnicola* from Lagos Lagoon and (628-812 egg) reported by Arimoro and Idoro for *C. amnicola* from Warri river[22,33]. Findings obtained in this study are similar to findings of Emmanuel who reported that

fecundity of *C. amnicola* did not depend on the carapace length or weight as specimens of the same carapace length or weight had variable fecundity[33]. Methods of obtaining fecundity has been reported to vary with time[34], and this may possibly explain some of the differences in fecundity estimates obtained for *C. amnicola* in other studies by other authors. Fecundity of *C. amnicola* in this study showed a positive significant (P<0.05) relationship with biometric indices such as TWs and carapace lengths. The positive value of correlation coefficient (r) obtained for *C. amnicola* in this study indicates that fecundity increases with increase in these biometric indices and this finding is similar to findings of Lawson and Oloko[1]. Condition factor ranged between 21.48 to 104.95 with a mean value of 47.21±2.17. Mean Fulton's condition factor (47.21±2.17) of *C. amnicola* collected from the Cross River estuary obtained in this study is higher than 5.49±0.95 reported by Lawson and Oloko[1], 6.28 reported by Emmanuel[33], 7.30±0.97 reported by Arimoro and Idoro[22]. However, the range of CF obtained in this study is greater than the range of 17.15 to 23.52 reported by Meye *et al.* for the fresh water crab, *Sudanonautes aubryi* in Orogodo River, Nigeria[37]. The variation in the range reported for condition factor in this study may be attribted to the use of b=2.0447 for its calclation. Sizes of *C. amnicola* in the Cross River estuary observed in this study are bigger than size of *C. amnicola* reported by other authors in other water bodies. Presence of bigger size of *C. amnicola* in the Cross River estuary may be attributed to low fishing mortality. As reported by Lawson and Oloko[1], direct fishing mortalities from illegal harvest of blue crabs and indirect fishing mortality have important management implications because many juveniles' approaching matured sizes are impacted, and probably it will result in reduced catch of larger size crabs. The interpretation of b value (2.0447) obtained for *C. amnicola* in this study reveals that this crab exhibits a negative allometric growth pattern. This fact is strongly supported by Arimoro and Idoro who reported a negative allometric growth in *C. amnicola* from Warri River, Lawal-Are and Kusemiju who had similar observations in Badagry Lagoon, Nigeria[21], Abowei and George in Okpoka Creek, Niger Delta, Nigeria[27]. However, findings of this study disagree with findings of Akin-Oriola *et al.* on Ojo Creek who reported positive allometric growth (b >3) in their study[18]. According to Lawson and Oloko[1], the growth coefficient (b) values have some implications and significant impacts on the well-being of fishes (including shell fish) and fishery. The implication of the negative allometry (b<3) obtained in this study is that the crabs were heavier than their carapace length. Wootton explained that fish with high b (b>3) values are heavy for their lengths, while those with low b are lighter[41]. In this study, various stages of egg development found at the same time in fecund crab is similar to findings of Lawal –Are (2010)[42].

The blue crab (*C. amnicola*) from the Cross River Estuary exhibits a very high fecundity which is one of the desired characteristics of a potential aquaculture species. A positive significant relationship was obtained between fecundity with biometric indices of *C. amnicola* such as total weights and carapace lengths. Also, negative allometric growth pattern was obtained for the blue crab. In conclusion, these information will be useful in assessing the population dynamics, development of management strategies, stock assessment and evaluation of the aquaculture potential of the Blue crab, *C. amnicola* which is one of the most important shell fish for the inhabitants of the Cross River estuary.

Conflict of interest statement

We declare that we have no conflict of interest.

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