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Growth Pattern and Specificity of Attachment of Lagoon Crab (*Callinectes amnicola*) Fouled with Barnacles (*Chelonibia patula*) from Lagos Lagoon, South West, Nigeria

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ABSTRACT
The growth pattern and condition factor (K) of 810 lagoon crabs (*Callinectes amnicola*) fouled with barnacles (*Chelonibia patula*), collected from Lagos Lagoon between April-September, 2011 were studied. The carapace length of *C. amnicola* examined ranged from 3.8-8.6 cm while the carapace width ranged from 9.5-15.4 cm. The total weight ranged from 53.1-165.0 g. The fouled crabs exhibited a negative allometric growth. The correlated coefficient 'r' for the crabs was 0.72, showing a correlation between carapace length and total weight in the lagoon crabs fouled with barnacles. The condition factor (K) values of *C. amnicola* fouled with barnacles ranged from 3.2-9.7 with a mean value of 5.4. The highest K-value was recorded for the size group 3.5-4.4. The value decreased with increase in carapace length of *C. amnicola*. The sex ratio (1:80) indicated that there were more females (98.8%) than males (1.2%). Out of the 810 lagoon crabs examined, 12 (1.5%) were heavily fouled with barnacles distributed all over the points of attachment with the carapace having the most attachment (91.6%). Average diameter of the barnacles attached to the crabs ranged from 0.23-1.85 cm. The distribution shows that large-sized crabs had more barnacles attached to them than small-sized crabs, with greater barnacles found only in the females than in the males.

Key words: *Callinectes amnicola*, *Chelonibia patula*, specificity, lagoon, condition factor, sex ratio

INTRODUCTION
Crabs are economically important shell-fish that share the same phylum Arthropoda with other successful animals with exoskeletons such as insects and spiders with over 42,000 extant species. These crustaceans with broad, compact body and abdomen, which is greatly reduced and tucked away underneath the cephalothorax (Hickman *et al*., 1996), are related to lobsters, shrimps and crayfish and belong to the same subphylum Malacostraca with barnacles. Barnacles unlike crabs belong to the order Cirripedidia while crabs belong to order Decapoda. The crabs are so numerous with many families.

The lagoon crabs, *Callinectes amnicola* which favour brackish bays, are the most edible crab along the coastal habitats in the temperate, subtropical and tropical regions (Carmona-Suarez and Conde, 1996). The blue crabs due to their euryhaline nature are more widely distributed in our water. According to Lawal-Are and Kusemiju (2000), the Lagos Lagoon supports a major crab fishery based on the abundance of the blue crab. The blue crabs, *C. amnicola*, are mostly omnivores

(Warner, 1977) and eat any vegetable or animal matter preferably freshly dead or freshly caught. They also crush and eat young oysters or clams. According to Zimmer (2000), the most frequently noticed parasite of crabs is the rhizocephalan barnacle of the genus *Sacculina*. Crabs could also have a symbiotic association or commensalisms. Example of such relationship is the one between crabs and barnacle, *Chelonibia patula* (Williams, 1984).

Barnacles and their larvae are distributed throughout the world because of their attachment to the bottoms of ships. They also use their calcareous plates to attach solidly to floating timbers, large fish and shellfish. The unwanted colonization of a substrate in aquatic environments by a diverse array of organisms is known as "Biofouling" (Voskerician *et al*., 2003). According to Panchal *et al*. (1984), biofouling is simply the attachment of an organism or organisms to a surface in contact with water for a period of time. The problem of biofouling is more serious in tropical waters. Cold waters have a low prevalence of biofouling, perhaps, because of the physiology of the organisms responsible (Panchal *et al*., 1984). The most visible and prominent forms of fouling organisms as reported by Voskerician *et al*. (2003) are barnacles, mussels tubeworms, acsidians bryozoans and seaweed. The focus of this study is to describe some aspects of biology of the lagoon crab, *Callinectes amnicola* and describe the distribution of the ectosymbiotic barnacle, *Chelonibia patula* on the host crab.

MATERIALS AND METHODS

The crabs used for the project were collected from Lagos Lagoon which is the largest brackish water body of the southern lagoon system in Nigeria (Webb, 1958) located between longitude 3°23" and 3°53" and latitude 6°26" and 6°37"N (Fig. 1). The largest lagoon along the West African coast (tropical estuary), according to FAO (1969), has a surface area of 208 km^2. The lagoon is an environment with an average depth of 1.5 m (Brown and Oyenekan, 1998) and opens all the year round (Onyema *et al*., 2003).

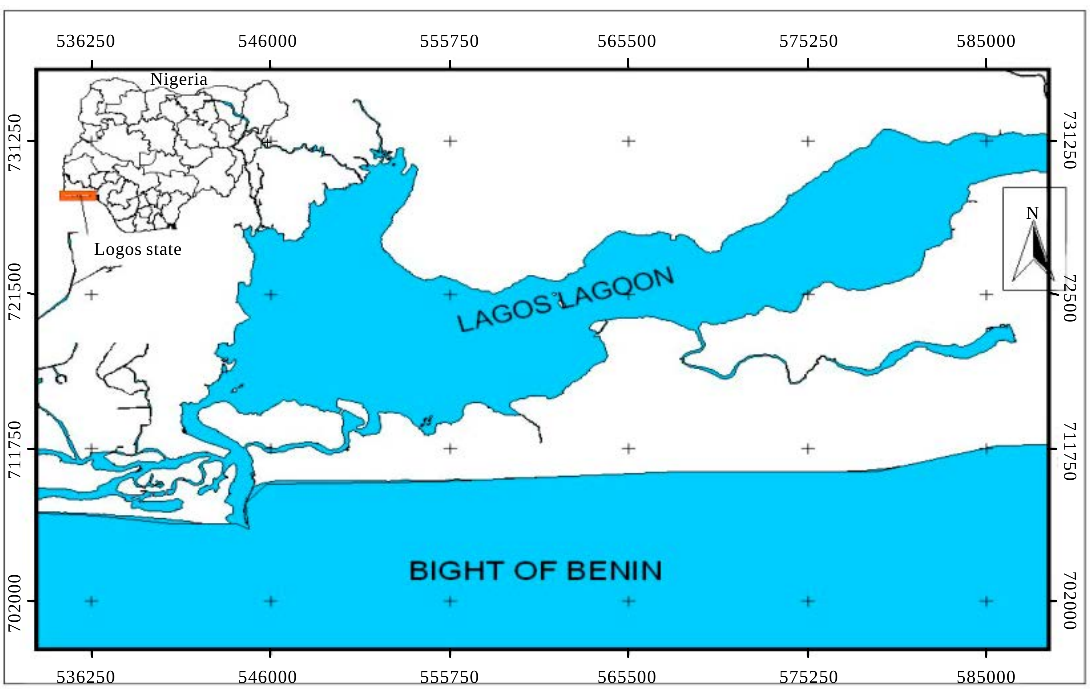

Fig. 1: Lagos Lagoon showing sampling site

Collection of sample: The crabs used in this study were collected from western part of Lagos Lagoon where the crabbers operate between April and September, 2011. Collection of crabs was done randomly as they were being brought from the crab pots, which were set in the lagoon. The sampling was based on the presence of barnacles on any part of the crab and they were immediately preserved in iced-cooler and later transferred into a deep-freezer in the laboratory prior to examination.

The crabs were removed from the freezer and allowed to thaw. Excess water was removed from the specimens using filter paper. The carapace length of the crab was measured to the nearest centimeters from the edge of the frontal region to the tip of the carapace backward using a simple measuring board, the carapace width was also measured using a vernier calliper. The total weight of the crabs was taken on a Sartorious Top Loading Balance (Model 1106) to the nearest tenth of 1 g. The weight and length of the left and the right cheliped were measured to the nearest centimeters using a vernier caliper. Barnacles on the crab specimens were detached using a scalpel. Also, the location (specificity) and abundance of individual barnacle on crab was recorded. The relationship between the carapace length-frequency distributions was established and the cumulative worked out. For the study of the growth pattern, data for the carapace length-weight relationship and carapace width-weight relationship were compiled. The relationship between the carapace length and weight of the crab was expressed by the linear relationship equation (Parsons, 1978):

$$\text{Log W} = \text{Log a} + \text{b Log L} \ldots\ldots.$$

Where:
W = Weight of crabs (g)
L = Length of carapace (cm)
a = Regression constant
b = Regression coefficient

Condition factor (K): The condition factor (K) indicates the state of general wellbeing of the crab fouled with barnacles and was determined using the following equation (Gayanilo and Pauly, 1997):

$$K = \frac{100\ W}{L^b}$$

Where:
W = Weight of the crab (g)
L = Carapace length (cm)
K = Condition factor

Sex ratio: The ratio of male to female was determined based on the total number of male and female crabs that was studied. The Chi-square (χ^2) test was used to determine any significant difference in the sex ratio of the crabs from the expected 1:1 ratio.

RESULTS

A total of 810 specimens of *C. amnicola* fouled with *Chelonibia patula* were studied for length and width frequency distributions. Carapace length of *C. amnicola* examined ranged from

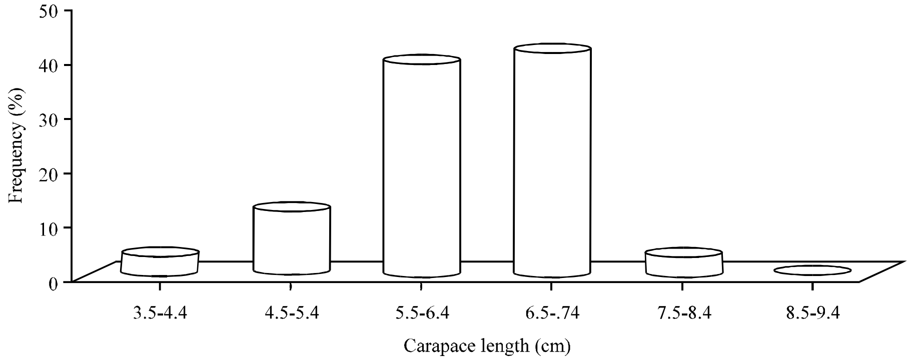

Fig. 2: Carapace length frequency distribution of *Callinectes amnicola* with barnacles (April-September, 2011)

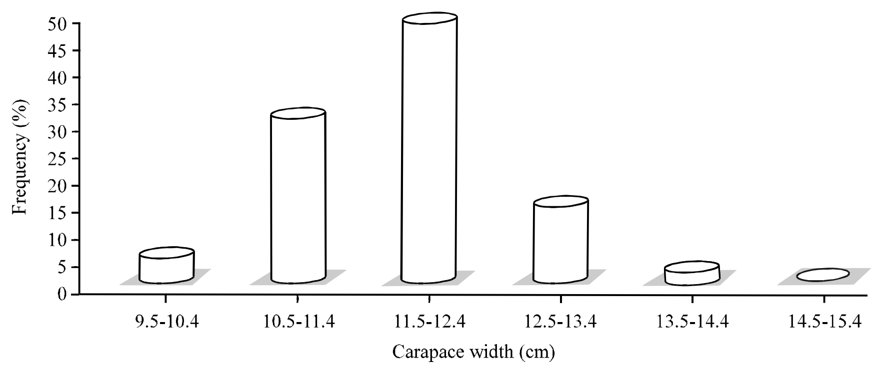

Fig. 3: Carapace width frequency distribution of *Callinectes amnicola* with barnacles (April-September, 2011)

Table 1: Summary of carapace width frequency distribution (by size group) of *Callinectes amnicola* from Lagos Lagoon (April-September, 2011)

Carapace width			
Size group	Range (cm)	Number	Frequency (%)
Small	3.5-8.4	6	0.7
Medium	8.5-12.4	612	75.6
Large	12.5-16.4	192	23.7
Total		810	100.0

3.8-8.6 cm while carapace width ranged from 9.5-15.4 cm. The largest specimen of *C. amnicola* collected weighed 165.0 g while the smallest weighed 53.1 g. The carapace length frequency polygon of *C. amnicola* showed distinct size groups. The size group 6.5-7.4 cm (41.2%) was most abundant as shown in Fig. 2.

The carapace width frequency of *C. amnicola* is shown in Fig. 3. The carapace width frequency polygon showed that the size group 11.5-12.4 cm (47.9%) was most abundant.

The specimens was further divided into three size groups (Table 1) as small crabs (CW: 3.5-8.4 cm), medium (CW: 8.5-12.4) and large (CW: 12.5-16.4). The medium size groups (75.6%) of *C. amnicola* were predominant.

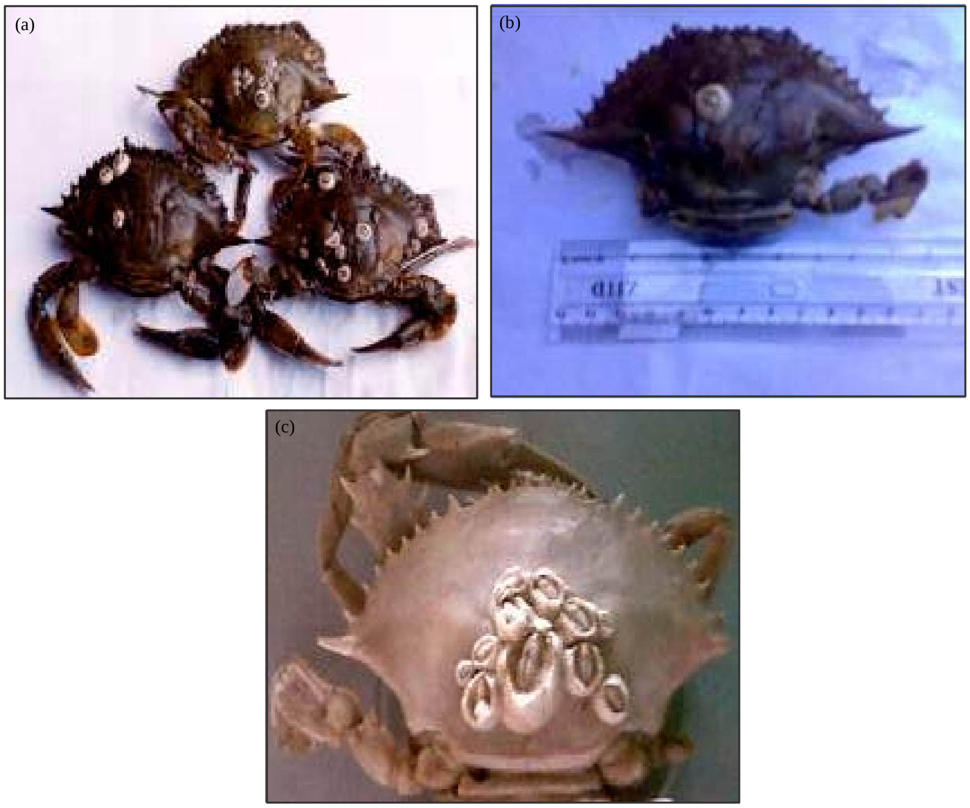

Fig. 4(a-c): Dorsal view of *Callinectes amnicola* with barnacles attachment on the carapace

Table 2: Barnacle distribution and frequency on *C. amnicola* from Lagos Lagoon (April-September, 2011)

	Crabs attached		Barnacles attached	
Location on crabs	No.	%	No.	%
CP	810	100	4746	91.6
CH	112	14	194	3.7
ABM	142	18	226	4.4
LG	22	3	18	0.3
Total			5184	100.0

CP: Carapace, CH: Cheliped, ABM: Abdomen, LG: Swimming leg

All the lagoon crabs examined had attachments with 2 of the crabs being heavily fouled with barnacle. The crabs with minimum number of attached barnacles were 22 while, the maximum number were 810 (Table 2). Four different locations on the *C. amnicola* were fouled by *C. patula*; carapace (91.6%), cheliped (3.7%), abdomen (4.4%) and fifth leg (0.3%). Barnacle ectosymbionts were most abundant on carapace than any other target examined (Fig. 4-6). Figure 7 shows the summary of barnacle distribution and frequency on *C. amnicola*.

Average diameter of the barnacle, *C. patula* attached to the lagoon crabs, *C. amnicola* ranged from 0.23-1.85 cm. The size distribution and abundance of barnacles showed that the frequency was independent of crab width (Fig. 7 and 8). On the average, large-sized crabs had much barnacles attached to them than the small-sized crabs as shown in Table 3.

Fig. 5: Ventral view of *Callinects amnicola* with barnacles attached on the abdomen

Fig. 6: Dorsal view of *Callinects amnicola* with abundant barnacles attached on the carapace and chelipeds

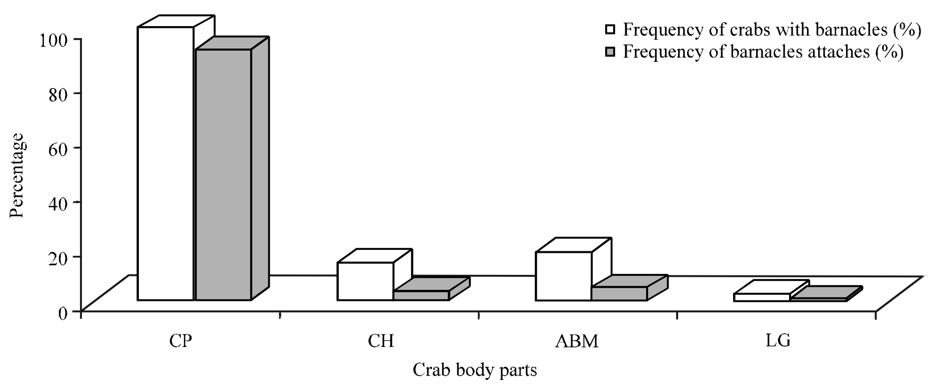

Fig. 7: Barnacle distribution and frequency on *Callinects amnicola* from Lagos Lagoon (April-September, 2011)

Table 3: Summary of barnacle distribution on *Callinects amnicola* from Lagos Lagoon (April-September, 2011) based on their carapace widths

Carapace width (cm)	No. of *C. amnicola*	No. of barnacles	Barnacles (%)
9.5-10.4	38	356	6.9
10.5-11.4	246	1576	30.4
11.5-12.4	388	2168	41.8
12.5-13.4	114	902	17.4
13.5-14.4	18	170	3.3
14.5-15.4	6	12	0.2
Total	810	5184	100.0

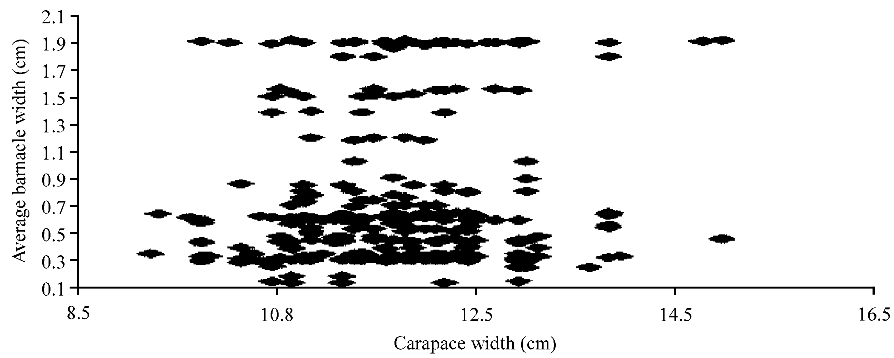

Fig. 8: Average width of barnacle and carapace width of *Callinectes amnicola* from Lagos Lagoon (April-September, 2011)

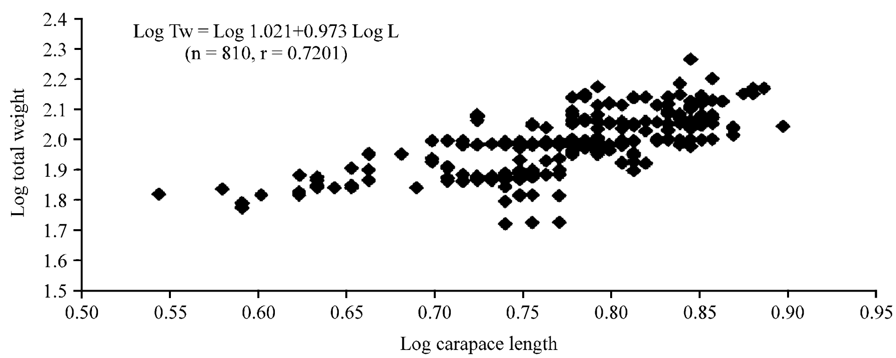

Fig. 9: Log length and log weight relationship of *Callinectes amnicola* with barnacles (April-September, 2011)

Growth pattern: The carapace length of *C. amnicola* ranged from 3.8-8.6 cm while the carapace width ranged from 9.5-15.4 cm, the total weight ranged from 53.1-165.0 g. The carapace length and total weight of *C. amnicola* was transformed into the logarithm form. The log length-log weight relationship showed a linear relationship between the length and weight of the crab. The log length and log weight relationship is illustrated in Fig. 9.

The values of length-weight relationship for *C. amnicola* are given as follows:

$$\text{Log } W = \text{Log } 1.021 + 0.973 \text{ Log } L$$
$$(n = 810, r = 0.7201)$$

Table 4: Condition factor (K) by size group of *Callinectes amnicola* with barnacles from Lagos Lagoon (April-September, 2011)

CL range (cm)	N	CL (cm)	Wt (g)	K
3.5-4.4	40	4.0	62.3	9.7
4.5-5.4	118	5.0	74.0	5.9
5.5-6.4	418	6.0	95.5	4.4
6.5-7.4	214	7.0	125.4	3.7
7.5-8.4	20	8.0	165.0	3.2
Total	810			5.4

CL: Carapace length (cm), Wt: Total weight (g), N: Number, K: Condition factor

The value of 'b' obtained for the crab was less than 3. This indicated that *C. amnicola* from the lagoon exhibited a negative allometric growth. The correlated coefficient 'r' was 0.7201 for the crabs showing a low correlation between carapace length and total weight in the blue crabs fouled with barnacles.

Condition factor (K): The condition factor by size group of *C. amnicola* with barnacle attachment from lagos lagoon is presented in Table 4. The K-values ranged from 3.2-9.7 (combined sex). The highest K-value was recorded for the size group (3.5-4.4). The value decreased with increase in carapace length of *C. amnicola* with a mean value of 5.4.

Sex ratio: Out of the 810 specimens of the lagoon crabs with barnacle attachment studied, 10 were males while, 800 crabs were females. The result of Chi-square test showed that the number of female lagoon crabs with barnacle attachment is significant (χ^2 = 770.50, 1 df at 5% level) than the number of males. Thus, there is a significant difference between male and female crabs fouled with barnacles.

DISCUSSION

The data collected on 810 specimens of *C. amnicola* showed that there were several size groups in the crabs' community sampled. The crabs with carapace length 6.5-7.4 cm (41.2%) was most abundant. The carapace width frequency polygon of *C. amnicola* also showed that the carapace width 11.5-12.4 cm (47.9%) was predominant. The population showed three main size groups as small crabs 0.7% (CW: 3.5-8.4 cm), medium 75.6% (CW: 8.5-12.4 cm) and large 23.7% (CW: 12.5-16.4 cm). The medium size groups being the most abundant are mostly female (98.8%) compared to the males (1.2%). This supports the study of Key *et al.* (1997) that the prevalence and intensity of barnacles are dominantly controlled by the locomotory and migratory habits of the host since female crabs spend more time in deeper waters of higher salinity and stationary during molting and reproduction, thus they are more likely to be fouled by barnacle larvae. Of all the site of attachment, the specificity of attachment to the carapace of *C. amnicola* by *C. patula* was significantly higher than any other part of the organism. This is in conformity with the results reported by Key *et al.* (1997) and Lawal-Are and Daramola (2010). The spatial distribution of barnacles on the crab carapaces were controlled by the roughness of the surface of the carapace, availability and its conspicuousness on the lateral regions than medial. The settling barnacle larvae may prefer the dorsal surface because it is exposed to more light and probably more attractive biofilm (Crisp and Barnes, 1954).

Crabs were inhabited by barnacle populations having different densities and size frequencies. Average diameter of the barnacle, *C. patula* attached to the lagoon crabs, *C. amnicola* ranged from

0.23-1.85 cm. This was similar to the result reported by Afshin *et al.* (2012), that the average diameter of the barnacle *C. patula* attached to *Portunus pelagicus* crab ranged between 0.7 and 2.1 cm. The size distribution and abundance of barnacles showed that the frequency was independent on crab width. This observation conformed to the results of Jeffries and Voris (1983), that the barnacle, *Octolasmis miilleri* densities on *Callinectes sapidus* did not correlate with the crab size. They, however, opined that barnacles were significantly more abundant on the large gills of the crab.

The result of linear relationship between carapace length and total weight of the crab reflected an increase in weight with increasing length regardless sex and age. This was similar to the results obtained by Lawal-Are and Kusemiju (2000, 2011) for unfouled Lagoon crabs. The length-weight relationship exhibited a cluster pattern which indicated that the species were from the same age range within the lagoon. The carapace length-weight of the lagoon crabs with barnacles from Lagos lagoon showed negative allometric growth showing that the carapace width grows horizontally instead of vertically with increase in weight also as reported by Guillory and Perret (1998). The correlated coefficient 'r' was 0.72 for the crabs showing a correlation between carapace length and total weight in the blue crabs fouled by barnacles. Therefore, there was an indication that an increase in carapace width of the crabs fouled by barnacles gave a minimal increase in body weight.

The condition factor (K) determining the habitat condition and overall wellbeing of crab varied by size for the lagoon crabs. A crab is said to be in a good habitat condition when the value of K is high. The data on condition factor showed decrease in value with increase in carapace length with a mean value of 5.4. Prager *et al.* (1990) observed that ecdysis becomes difficult as crabs grow old. The result of the sex ratio revealed that there was significant difference between male and female crabs fouled with barnacles, indicating that there were more females fouled than males. Despite the attachment of barnacles to the external area of the crabs, there was a steady growth of the crab, hence no indication of the attachment of barnacle to the exposed parts affecting the growth of the crab.

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