GROWTH PATTERN, FECUNDITY, FOOD AND FEEDING HABITS OF *PANULIRUS REGIUS* (DE BRITO CAPELLO) OFF THE COAST OF NIGERIA

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ABSTRACT
The spiny lobster (Panulirus regius) off the coast of Nigeria is highly under-studied probably due to lack of stock assessment, accessibility and cost of fishery. In this study, the growth pattern, size composition, fecundity, food and feeding habits of P. regius were carried out off the Lagos Harbour. A total of 120 specimens of P. regius ranging from 13.2 - 28.5 cm in total length were collected. The highest frequency was in the class interval of 15.5 - 16.4 cm. The length - weight relationship showed an allometric growth with weight increasing proportionately with increase in length. The b values were 2.8732, 3.1394 and 2.9635 for male, female and combined sexes respectively. The correlation coefficient (r) for male, female and combined sexes were 0.7373, 0.9231 and 0.8523 respectively, an indication of strong correlation. The stomach contents include fish parts, worm, sea urchin parts, crabs parts and lobster parts while 35 (29.2%) P. regius having empty stomachs. There were 53 males and 67 females giving a sex ratio of 1:1.26 with a chi square (χ^2) of 1.64. Out of the 67 females recorded in this study, only17 (25.4%) were fecund. The fecundity estimate in relation to the total length showed a very low negative correlation. P. regius was highly fecund with a range of 109,375 - 494,645 eggs in female of 7.9 – 9.9 cm total length. Barnacle attachments were found on the abdomen and antenna of P. regius studied with preference of attachment to the antenna. There is need for continued research on its management and conservation to improve the paucity of information and stock assessment of the population in order to prevent over-exploitation and under-utilisation to boost its export trade.

Keywords: Growth pattern, Fecundity, Feeding habits, Spiny lobster, Barnacles, Lagos Harbour.

INTRODUCTION
The spiny lobsters are a clearly defined group of decapod crustaceans in the family Palinuridae. Although they superficially resemble true lobsters in terms of overall shape and having a hard carapace and exoskeleton, the two groups are not closely related (Hayward and Ryland, 1996). Spiny lobsters can be easily distinguished from true lobsters by their very long, thick, spiny antennae, lack of chelae (claws) on the first four pairs of walking legs, although the females of

most species have a small claw on the fifth pair, and the presence of a specialized larval phase called phyllosom (Holthius, 1991; Pollock, 1995). True lobsters have smaller antennae and claws on the first three pairs of legs, with the first being particularly enlarged. Spiny lobsters have typically a slightly compressed carapace and lacking any lateral ridges. Their antennae lack a scaphocerite, the flattened exopod of the antenna which is fused to the epistome (a plate between the labrum and the basis of the antenna). The flagellum, at the top of the antenna, is stout, tapering and very long. The ambulatory legs (pereiopods) end in claws (chelae) (Holthuis, 1991). The body plan of royal spiny lobster follows that of all decapods and is made up of twenty-one (21) body segments. These segments can be grouped together into the cephalothorax (head and chest area) and abdomen (Pollock, 1995).

Panulirus regius is readily distinguishable from *P. guttatus* (spotted spiny lobster), *P. laevicauda (*smooth tail spiny lobster) and *P. argus* (Caribbean spiny lobster) which are the only species with which it might be confused with (Freitas *et al*., 2007). Palinurid lobsters are relatively fecund, with usually up to 700,000 eggs per spawning. These values are achieved through large broods of small eggs produced over a relatively short adult lifespan (Pollock and Melville-Smith, 1993) and the smaller the egg size, the greater the fecundity (Pollock, 1995; Seudeal, 2013).

According to Clotilde-Ba *et al*. (1997), *P. regius* are considered to be an Atlantic–Mediterranean species of spiny lobster with one of the greatest geographical ranges among the Palinurids of commercial importance. Spawning occurs year round, peaking from June to September in the Northern Hemisphere and January to March in the Southern Hemisphere, although in both areas the organism requires temperature of 23–25°C for eggs maturation and 26°C for spawning. (Pollocks 1997). *P. guttatus*, occurs between May-October (Evans and Lockwood, 1994) and April- October in *P. argus* (Holthuis, 1991).

From an economic perspective, *P. regius* is the most important crustacean species found in West Africa. The aim of this study is to determine the growth pattern, the morphometric characteristics, food and feeding habits and fecundity of *P. regius* off the Nigerian coast as a baseline study for sustainability of its fisheries.

MATERIALS AND METHODS

Collection of specimens and sample site

One hundred and twenty (120) specimens of *P. regius* were collected from fishermen off the Lagos Harbour from May to October 2014 between the hours of 8am and 10am. Specimens were immediately placed in an ice-chest and transported to the Department of Marine Sciences Laboratory of the University of Lagos where they were labelled and stored in a freezer (-20ºC).

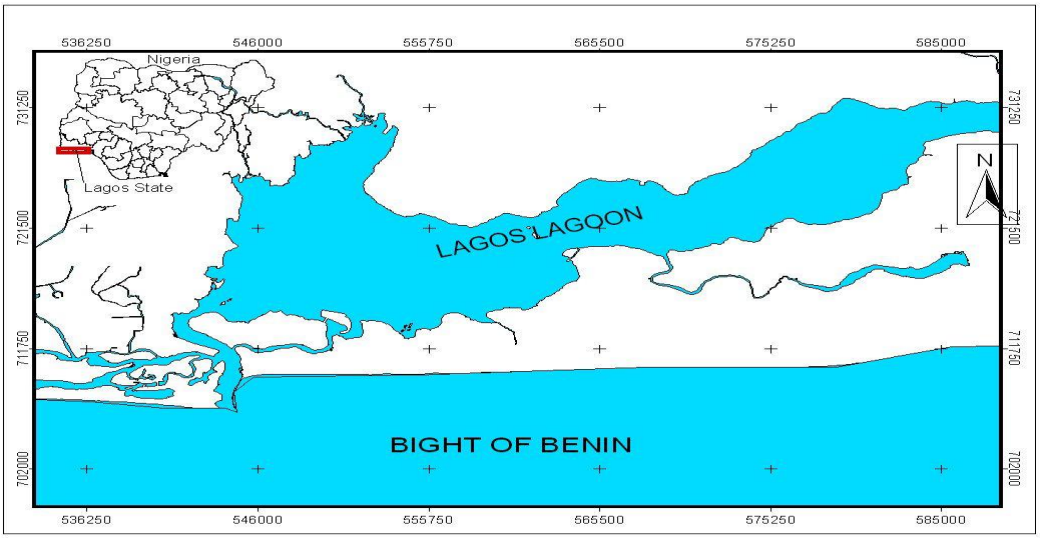

Fig. 1: Map of Lagos Lagoon showing harbour, South-Western Nigeria.

Laboratory Analysis

The lobsters were removed from the freezer, allowed to thaw and a towel was used to remove excess moisture from their body. The total length and weight were measured using a Vernier caliper and Sartorius weighing balance (Model: DT1001A) to the nearest tenth of a centimetre and nearest tenth of a gram respectively. All measured data were recorded in a pro-forma sheet.

Growth pattern

The growth pattern of the specimens was estimated using the length-frequency distribution (Peterson's method). This method is based on the fact that the length of one age tends to form a normal distribution. The lengths of the lobsters sampled were plotted against their respective frequencies.

Length-weight relationship

The length-weight relationship of the samples was studied and represented by the equation:

$$W = aL^b \quad \text{……. (Pauly, 1983)}$$

where W = weight in grams (g)
L = total length in centimetre (cm)
a = regression constant (intercept)
b = regression coefficient (slope)

The relationship was transformed into a straight line using logarithm,

$$\text{Log } W = \text{Log } a + b \text{ Log } L \quad \text{…… (Parsons, 1988)}$$

Fo**od and feeding habits**

The stomach was cut open and the content was extracted into a Petri dish. A drop of water was added to the stomach content and mixed. The content was viewed under a microscope to identify the various food types using the numerical and occurrence methods according to Hyslop, (1980).

Fecundity estimation

The total length and number of eggs (fecundity) was recorded and analyzed. A scattered graph showing the relationship between the Log total length and Log fecundity was plotted. The eggs from the berried females were removed and analyzed using the gravimetric analysis (FAO, 1974).

$$F = \frac{nG}{g}$$

where F = fecundity
n = number of eggs in the subsample
G = total weight of the eggs
g = weight of the sub-sample in the same units

Regression analysis was carried out relating fecundity to size of lobster. The relationship between the fecundity and size of lobster was determined by using the formula

$$F = aX^b$$

where F = Fecundity
X = Standard length of lobster (cm) or weight of lobster (g)
a = Regression constant
b = Regression coefficient.

Sex ratio
The sex ratio was tested for any deviation from the expected 1:1 ratio by using chi-square analysis. Level of significance was tested at 5% level of significance ($p < 0.05$).

The chi square value (χ^2) was calculated using the formula:

$$\chi^2 = \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

where Observed = number of females in the sample
Expected = the total number of males in the sample.

Barnacle attachment on *P. regius*
The specimens with barnacle attachment were sorted. The area of attachment on the lobster and number of barnacles found at these locations were noted and recorded.

Statistical analysis
Data were analyzed using Microsoft Excel 2010 and Statistical Package for Social Sciences (SPSS) software.

RESULTS

GROWTH PATTERN

Length frequency distribution
A total of 120 samples of *P. regius* were collected off the Nigerian coast. The total length of the samples in May ranged from 16.0 - 21.0 cm with the highest frequency in the class interval of 18.5 - 19.4 cm. In the month of June, the total length of the samples ranged from 13.2 - 17.5 cm with the highest frequency from the class interval of 14.5 - 15.4 cm. The total length of the samples for the month of July ranged from 13.6 - 17.7 cm and the highest frequency was from the class interval of 14.5 - 15.4 cm and 15.5 - 16.4 cm (both having the same frequency). In August, the total length ranged from 13.8 - 28.5 cm with the highest frequency from the class interval of 15.5 - 16.4 cm. In September, the total length ranged from 13.7 - 27.0 cm with the class interval ranging between 15.5 - 16.4 cm and had the highest frequency. While in October, the total length ranged from 14.6 - 27.0 cm with the highest frequency in the class interval of 15.5 - 16.4 cm.

A cumulative of all the months (May - October) was also determined with the total length ranging from 13.2 - 28.5 cm and the highest frequency in the class interval of 15.5 - 16.4 cm. Figure 2 showed the cumulative frequency distribution against length of *P. regius* for the months of May – October, 2014.

Length-weight relationship

The relationship between the Length-Weight was determined and the Log transformed data for the male, female and combined sexes is shown in Table 1. The graph for the Log transformed values is presented in Figure 3.

The regression equations were:

Male:	Log Y = 0.1903 + 2.8732 Log X
Female:	Log Y = 0.3378 + 3.1394 Log X
Combined sexes:	Log Y = -1.5454+ 2.9635 Log X

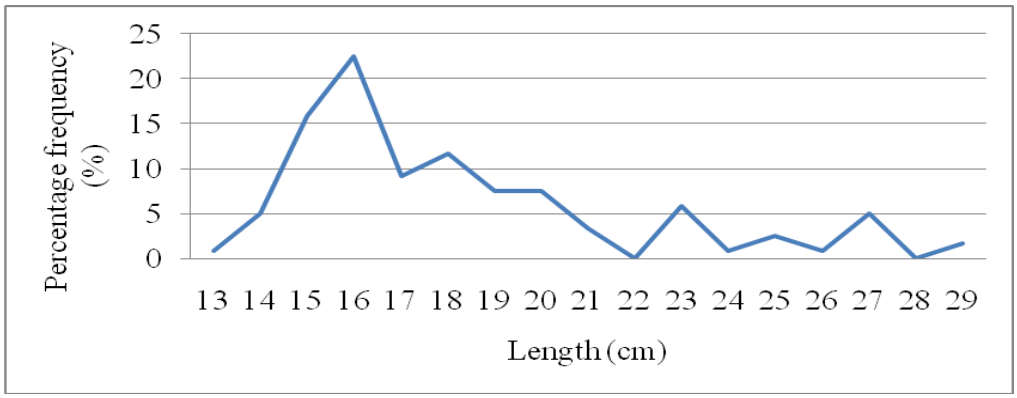

Figure 2: Percentage Length frequency of *P. regius* off Nigerian Coast

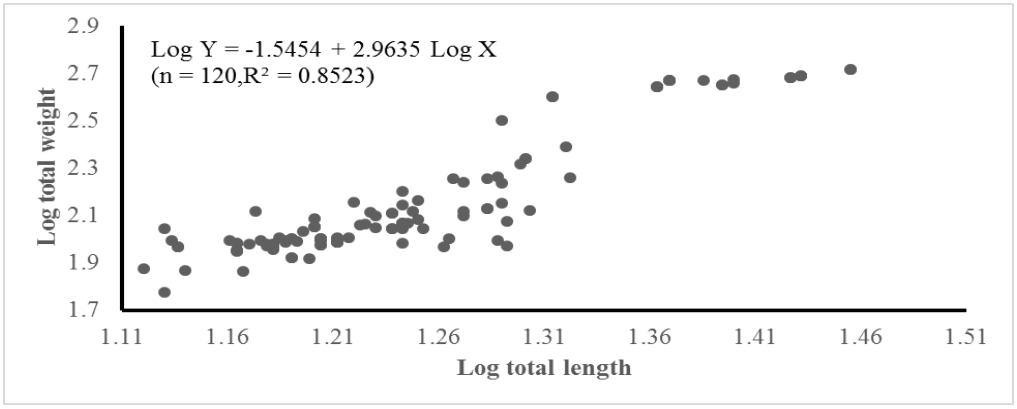

Figure 3: Log Total Length - Log Total Weight of *P. regius* off Nigerian Coast

Table 1: Total length-total weight relationship of *P. regius* off Nigerian Coast

Sex	N	A	B	r	R^2	$W=aL^b$
Male	53	0.1903	2.8732	0.8586	0.7373	$0.1903L^{2.8732}$
Female	67	0.3778	3.1394	0.9607	0.9231	$0.3778L^{3.1394}$
Combined sexes	120	-1.5454	2.9635	0.9232	0.8523	$-1.5454L^{2.9635}$

n = total number of samples, A= Regression constant, B= Regression coefficient, R = Ranges

FOOD AND FEEDING HABITS

Stomach content analysis

A total of 120 samples examined, 35 (29.2%) had empty stomachs while the remaining 65 (70.8%) stomachs had food contents in them. The stomach content consists of fish, worms, sea urchins, crabs and lobster's parts. The stomach content was determined using the numerical and the occurrence method as shown in Figure 4.

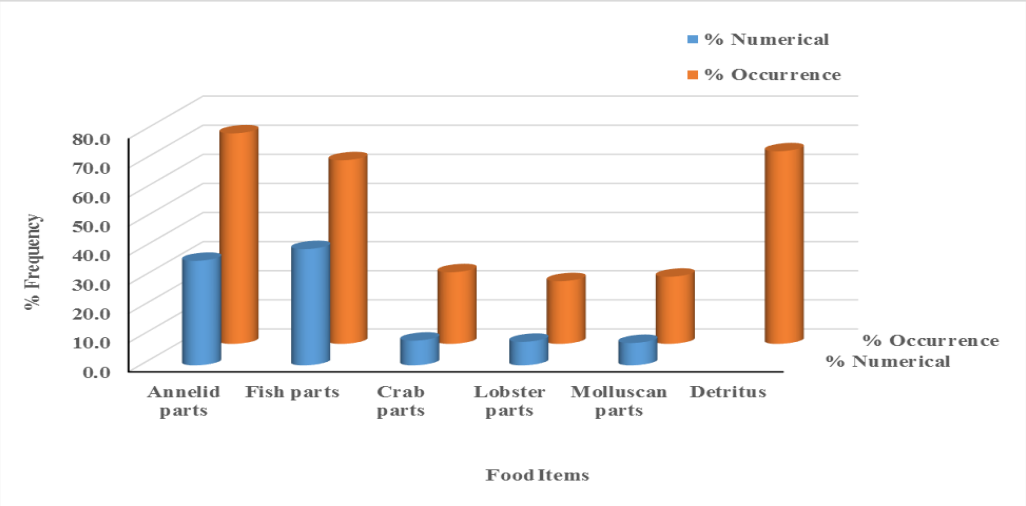

Figure 4: Stomach contents of *Panulirus regius* off Nigerian Coast

REPRODUCTIVE BIOLOGY

Sex ratio

Out of the total of 120 specimens of *P. regius*, 53 were males and 67 were females, a sex ratio of 1:1.26 with calculated chi-square (χ^2) of 1.64. Thus, there was no significant difference in the sex-ratio.

Fecundity

Sixty-seven (67) females of *P. regius* were studied, 17 (25.4%) had eggs. Plate 1 shows a typical berried of *P. regius* while the total length and fecundity of female *P. regius* off Nigerian Coast showed a positive allometric relationship (Figure 5).

Plate 1: Berried female *P. regius* off Nigerian Coast

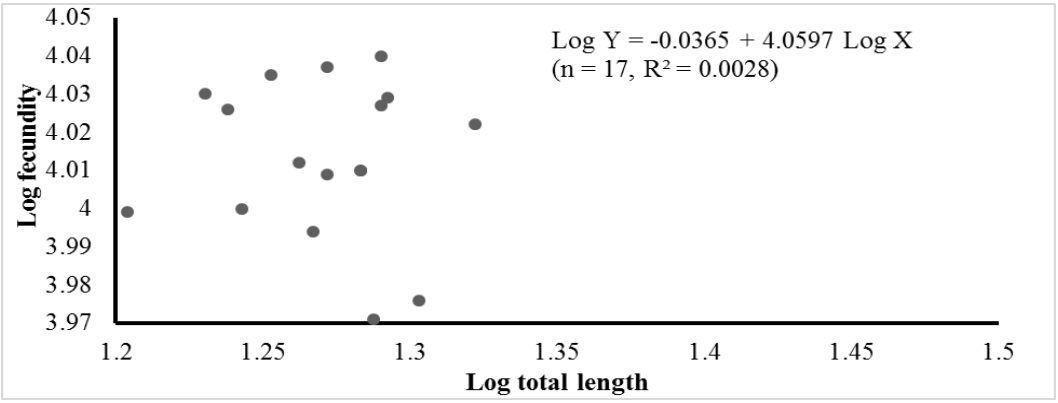

Figure 5: Relationship between total length and fecundity of female *P. regius* off Nigerian Coast

BARNACLE ATTACHMENT ON *P. REGIUS*

Barnacle attachment was obvious on the body of the lobster *P. regius*. Out of the 120 specimens of *P. regius* studied, 29 (24.2%) had barnacle attachments. The barnacles were located on the abdomen and the antenna only, with more attachment on the antenna of *P. regius*. A total of 95 (76.0%) barnacles were attached to the antenna while a total of 30 (24.0%) barnacles were found on the abdomen (Plates 2a and b).

Plate 2a: Barnacle attachment on the antenna abdomen of *Panulirus regius* off Nigerian Coast

Plate 2b: Barnacle attachment on the *Panulirus regius* off Nigerian Coast

DISCUSSION

The growth pattern, size composition, fecundity, food and feeding habits of Royal spiny lobsters (*P. regius*) were carried out off the Nigerian coast. A total of 120 specimens were examined, the largest male with a total length of 28.5 cm was recorded in the month of August, the largest female with the total length of 27.2 cm was recorded in the month of September. The smallest *P. regius*, a female with total length 13.2 cm was recorded in the month of June. The size group of 15.5 - 16.4 cm occurred most in the months of July, August, September and October. According to Pollock (1995), *P. regius* can reach a maximum length of 35.0 cm in total length. This suggests that the specimens collected for the purpose of this study were either in their juvenile stage or the stock composition is of smaller sizes. The results from this study was in agreement with Freitas *et al*., (2007) on Cape Verde with males attaining larger size than females.

The b value of the females (3.1394) showed positive allometric growth while the males (2.8732) showed negative allometric growth. The combined sexes value of 2.9635 showed a negative allometric growth. The correlation co-efficient (r)

indicated a positive correlation between weight and length. This implied an increase in length gave a corresponding weight increase. This is in agreement with the work of Vaitheeswaran *et al*. (2012) on *Panulirus versicolor* from Thoothukudi waters in India.

The stomach content analysis using numerical method showed that fish parts were the most abundant food item in the stomach, while the occurrence method showed worms were the most occurring food. The presence of lobsters in the stomach of some of the specimens showed that cannibalism also occurred within the group probably during the process of ecdysis. According to the work of Munro (1983) on *Panulirus* regius, he reported that they feed on mollusks, fish and plant materials. Nassrin *et al.* (2011) in their work on *P. homarus* found out that the frequencies of occurrence suggested bivalves as the main food; crabs, gastropods, barnacles and algae as secondary food and polychaetes, fish, echinoderms and Ascidiacea as incidental food for *P. homarus* in the South East Coast of Iran.

The females occurred more than the males during the sampling period with no significant difference ($P > 0.05$) in the sex ratio. This is likening to the work of Kanciruk (1980) who reported that the sex ratio in Palinurids can vary considerably. According to Bensahla-Talet *et al*. (2016), they reported that there was no significant difference ($P > 0.05$) in the sex ratio of Pink Spiny Lobster (*P. mauritanicus*) caught in the Beni-Saf bay.

The specimens with eggs occurred more between the months of August - October. This indicated that the spawning period of *P. regius* is between August – October (rainy season) off Nigerian coast, this coincides with the late wet season. This is in line with the work documented by Freitas *et al*. (2007) whose studies showed a peak in ovigerous females from June to September, which are also regarded as the wet months.

In this study, the number of eggs (fecundity) ranged between 109,375 and 494,645 with a carapace length of 7.9 - 9.9 cm. These values were lower than that of Freitas *et al*. (2007) whose studies showed a minimum of 134,000 eggs in a female with 6.9 cm carapace length and a maximum of 995,000 eggs in 11.9 cm total length. The result of the Log transformed values of total length and fecundity showed that there exists a very low negative correlation ($r = 0.0529$, $R^2 = 0.0028$) between length and fecundity. Thus, length of *P. regius* was not directly proportional to the number of eggs produced.

Most of the *P. regius* studied were not fully manifesting barnacle attachment. The months of August, September and October had higher number of barnacles' attachment on the body of *P. regius*. The attachments were more on the antenna. It can be deduced that the attachments were more in these months as a result of their slow movement due to process of ecdysis prior to reproduction like in other crustacean in peak dry months. October had the highest number of barnacles totaling 55 while the month of May had the lowest with only 7 barnacles. Thus, *P. regius* with barnacles attachment were more in the dry season when the salinity of the water body was high and lowest in wet season due to high flushing rates and low salinities that reduce barnacle larval concentrations. Hence, barnacle attachment is a function of high salinity of the aquatic environment.

CONCLUSION

The *P. regius* from the Nigerian coastal water system is highly under-studied. The quantity collected during this study period was limited due to inaccessibility and cost of fisheries as they are strictly benthic organism.

This study has shown the stock assessment, size composition, foods and fecundity variation of *P. regius* off Nigerian coast, the data will be a baseline study for further research. Therefore, there is need for continuous research on its management and conservation in order to boost its export trade and prevent its extinction which could occur due to improper management.

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