Aspects of biology of *Atya gabonensis* (Giebel, 1875) (Crustacea: Decapoda: Natantia) at the confluence of river Niger and Benue, Ganaja, Kogi State, Nigeria

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Abstract

Aspects of biology of Gabon prawn, *Atya gabonensis* (Giebel, 1875) was investigated in the confluence of River Niger and Benue, North-Central Nigeria. A total of 2,175 specimens were collected from January to December, 2017 by fishermen using combination of gears (drag nets, set traps and traditional gear known as "Ahina") and transported in icebox containing water to the laboratory for further studies. No specimen was found during the peak of the rainy season (July to October). The highest number was collected in February and the lowest number was found in December. Higher mean values were recorded in males for all morphometric features. Negative allometry was observed in females, males and combined sexes with very strong correlation (r=0.95, 0.97 and 0.96, respectively). The mean Condition Factor was 2.29±0.04 in females and 2.42±0.04 in males. The highest percentage of moulting was in February (73.33%) and lowest (8.00%) in June. Males showed superiority in size than females in all the morphometric parameters. Sex ratio revealed higher number of males to female. Mean fecundity was 9,575±515. Mean egg size was 0.46±0.01mm and mean GSI was 0.33±0.01. Egg developmental studies revealed 25% of ovigerous females in stage 1; 12.5% in stage 2; 25% in stage 3; 29.17% in stage 4 and 8.33% in stage 5. Despite the abundance of *A. gabonensis* at Ganaja, it is yet to be fully exploited by the local fishermen. *A. gabonensis* is recommended as excellent candidate for aquaculture and Ganaja is recommended for collection of broodstock at the onset of rainy season. All male production of this species is also recommended to be more advantageous than female

Keywords: Gabon prawn, Morphometric features, Allometry, Moulting statistics, Fecundity, Gonadosomatic index

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Introduction

Prawns are highly esteemed food organisms and have been rated high among the most important internationally traded fishery products, which generate substantial economic benefits, especially for many developing countries (FAO, 2008). Nigeria is one of the tropical countries blessed with rich prawn resources, with a production capacity of 12,000 tonnes annually (Zabby *et al*., 2010). There are many species of prawns found across the various water bodies in Nigeria. One of the species found in abundance is *A. gabonensis* (Powel, 1982). Obande and Kusemiju (2006) reported the occurrence of large numbers of this species in River Niger.

Atya gabonensis (Fig. 1) is an arthropod belonging to the family of the Atyidae; Suborder, Natantia; Order, Decapoda; Subclass, Malacostraca and Class, Crustacea (Powell, 1980; 1982; Meye and Arimoro, 2005). It is the most diverse families of caridean prawns, found almost exclusively in freshwater habitats worldwide (De Grave *et al.*, 2015). It is the most beautiful and largest species belonging to the genus *Atya*. It has been given several common names such as African Fan Shrimp, African Filter Shrimp, African Giant Shrimp, Vampire Shrimp, Blue Rhino Shrimp, Gabon Shrimp, and Cameroon Fan Shrimp (Nwosu, 2009). Powell (1980) reported the morphology of *A. gabonensis:* it is recognizable by short rostrum, lacking dorsal teeth and flanked by a pair of lateral teeth; First and 2nd legs (chelipeds), reduced and specialised, appearing as mouthparts; their modified chelae bearing brushes of setae as long as the chelae; 3rd to 5th legs, stout, ambulatory, the third much larger than the 4th or 5th; the color uniformly dark greyish, no mid-dorsal stripe; and total length of about 12cm.

Figure 1: *Atya gabonensis*. Source: De Grave and Mantellato (2013).

Nigeria's prawn production capacity of about 12,000 tonnes annually is insignificant and mostly from the wild. In order to meet the high market demand for these products, without depleting the natural resources, it is essential to consider prawn culture in earnest. The country has not succeeded in this area of culture due to lack of knowledge on prawn biology, which is *sine qua non* for its successful culture.

The biology of *A. gabonensis* has been been documented in Nigeria (Powell, 1982; Anetekhai, 1986; Solomon *et al*., 1999; Abowei *et al*., 2006; Obande, 2006; Obande and Kusemiju, 2006; Nwosu, 2009; Okayi *et al*., 2010). However, not enough information is available on the reproductive capacity and adaptability of

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the species to Nigerian freshwater system.

Hence, this study aims to investigate the morphometrics and reproductive biology of *A. gabonensis* in Ganaja. This would provide vital information for successful assessment and fishery management and suitability of *A. gabonensis* for commercial production through aquaculture.

Materials and methods

Study area

The prawns were collected at the confluence of River Benue and River Niger at Ganaja in Lokoja, Kogi State (Fig. 2). Ganaja is located between latitude 7º 45 N and 8º 12 N and longitude 6º 39 E and longitude7º 00 E. The area has two major seasons, the dry season and wet season. The wet season begins from March to November while the dry season begins from November to February.

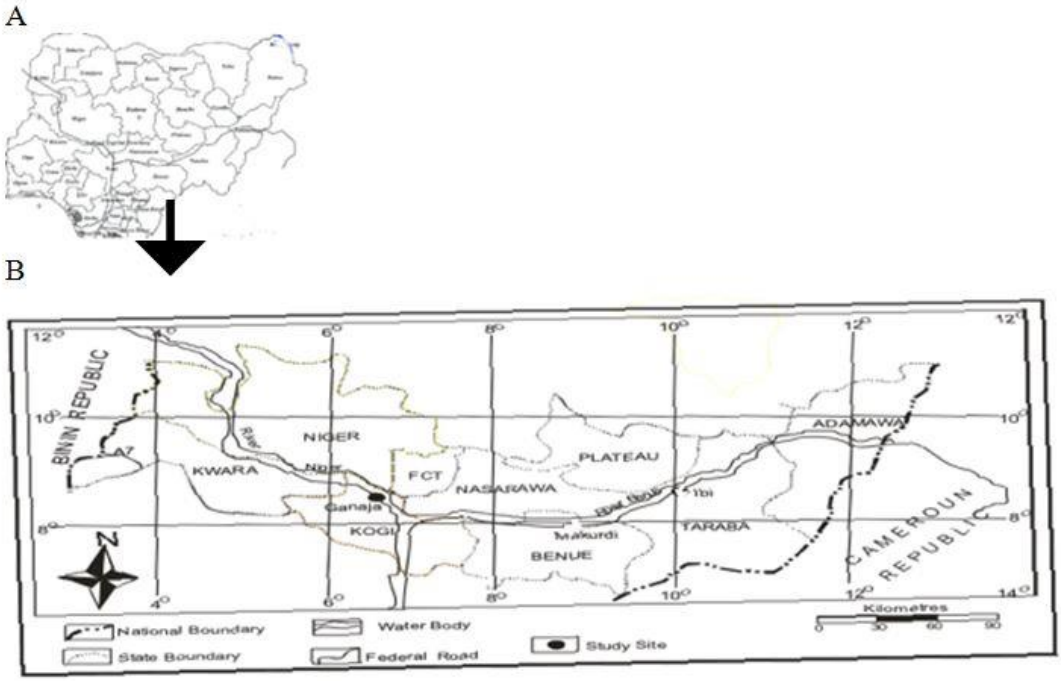

Figure 2: Map of Nigeria (A) and Sample Collection Site at Ganaja (B). Modified from Obaje (2009).

Prawn collection, identification and sex determination

Prawns were collected with the aid of fishermen and transported in iced box to the laboratory for further studies. Identification to species level was done by the keys provided by Powell (1982). The sexes were determined with the aid of specific morphological features that were peculiar to male and females of the prawns. The features used were appendix masculina, reproductive chamber and numbs on the first abdominal segment, as adopted and demonstrated by Grooves (1985) and Anetekhai (1990).

Morphological measurements

Morphological measurements were done according to a model of Adite *et al.*

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(2013). Fourteen morphometric characteristics of *A. gabonensis* were measured. The parameters measured were, Total Length (TL), Weight (W), Carapace Length (CL), Carapace Diameter (CD), Rostral Length (RL), Abdominal Length (AL), Telson Length (TSL), Uropod Length (UL), second Pleural Hight (PH), second Pleural Width (PW), Length of Merus of 3rd walking leg (LM), Length of Carpus of 3rd walking leg (LC), Length of Palm of 3rd walking leg (LP) and Length of Finger of 3rd walking leg (LF).

Length – weight relationship of A. gabonensis

The length-weight relationship was calculated by conducting a regression analysis between W and TL and the scattergrams plotted as described by Stooldley *et al.* (1980). This plot is best described by the formula:

$$\text{Log}y = a + b \log x \quad (1)$$

Where, y=weight of prawn (W); a=regression constant (intercept on the Y-axis); b=regression coefficient; and x=total length of prawn (TL)

Condition factor (K)

The condition factor was calculated monthly for males and females using the equation by (Ricker, 1975),

$$K = \frac{100w}{L^3} \quad (2)$$

Where K=Condition factor, L=Standard length (cm), W=Weight (g).

Fecundity

Fecundity was determined by calculating the total number of ripened eggs in the Ovary. The berried females were weighed and the eggs stripped into Petri dishes. The stripped eggs were weighed using a top loading electronic weighting balance (Model 59174). The eggs were preserved in Gilson's fluid which comprised of 60% alcohol (100mL), Water (850ml), 80% Nitric acid (18mL), Glacial acetic acid (15 ml) and Mercuric chloride (20mL). This fixative helped to remove ovarian tissues from the eggs and to harden them for easy counting. The eggs were then washed in distilled water and cleaned by pouring into a filter paper in the funnel to drain and dry leaving the eggs separated. The total number of eggs in the ovary (fecundity) was estimated by the gravimetric method of Fernandez *et al.* (1998) calculated as:

$$F = nG/g \quad (3)$$

Where, F=Fecundity; n=number of eggs; G=ovary weight in (g) and g=weight of subsamples in (g)

Egg diameter

Egg diameter was measured to the nearest millimeter using a calibrated eye piece of a binocular microscope. The mean of the diameter of 10 eggs from a female was used as the diameter of individual egg per female.

Egg developmental stages

To monitor the developmental stages, Eggs were categorized by color into Five (5) stages, in line with the external description of Marcelo and Michel (2009).

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Gonadosomatic Index (GSI)

The GSI was calculated from the formula:

GSI=100(GW)/BW (4)

Where: GW=Gonad weight and BW=Body weight after (Fernandez *et al*., 1998).

Results

Abundance and sex distribution of A. gabonensis

A total of 2,175 (1,525 males, 645 females) *A. gabonensis* were collected. Males were more abundant than females; the highest number of specimens was encountered in February and the lowest in December (Fig. 3).

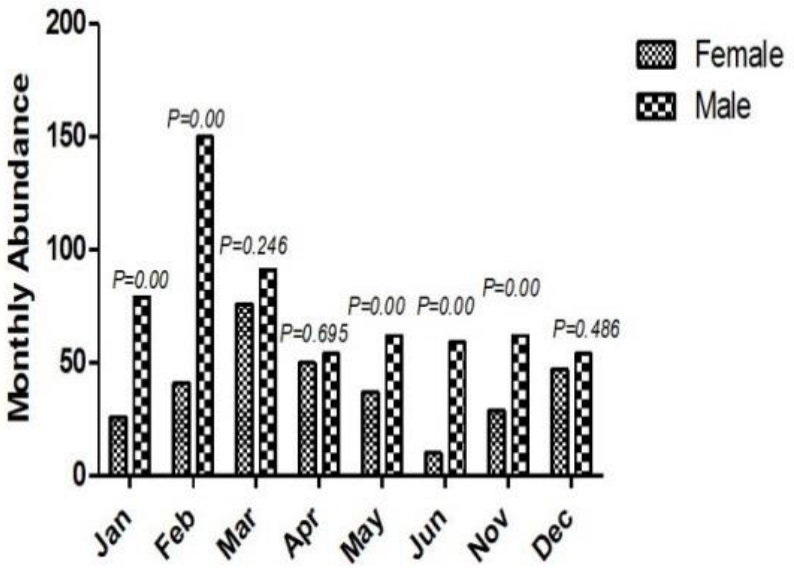

Figure 3: Abundance and sex distribution of *A. gabonensis* at Ganaja, January to December, 2017.

Morphometric parameters

All measured morphometric characters were strongly positively related to each other (Fig. 4A). From the PCA biplot, component 1 attributes showed a higher percentage variance (64.55%), with the morphometrical parameters clustering in quadrant 2 and 3 (Fig. 4A), while coefficient of correlation (r) from PCA loadings indicates strong positive relationships among morphometric characters (Fig. 4B).

The male and female morphometric characters are presented in Figure 5. Body weight and other morphometric characters differed between male and female. The male morphometric characters were significantly (p<0.05) higher compared to the female.

Length-weight relationship

The length-weight relationships of female, male and combined sexes of *A. gabonensis* from Ganaja are presented in Figures 6, 7 and 8. The regression analyses for both female and male showed negative intercept (a=-1.15, -1.49 and 1.40 respectively for female, male and combined sexes). Negative allometry revealed b=2.45, 2.85 and

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2.74 for female, male and combined sexes respectively. The different and combined sexes showed very high correlation (r=0.95, 0.97 and 0.96 respectively for female, male and combined sexes).

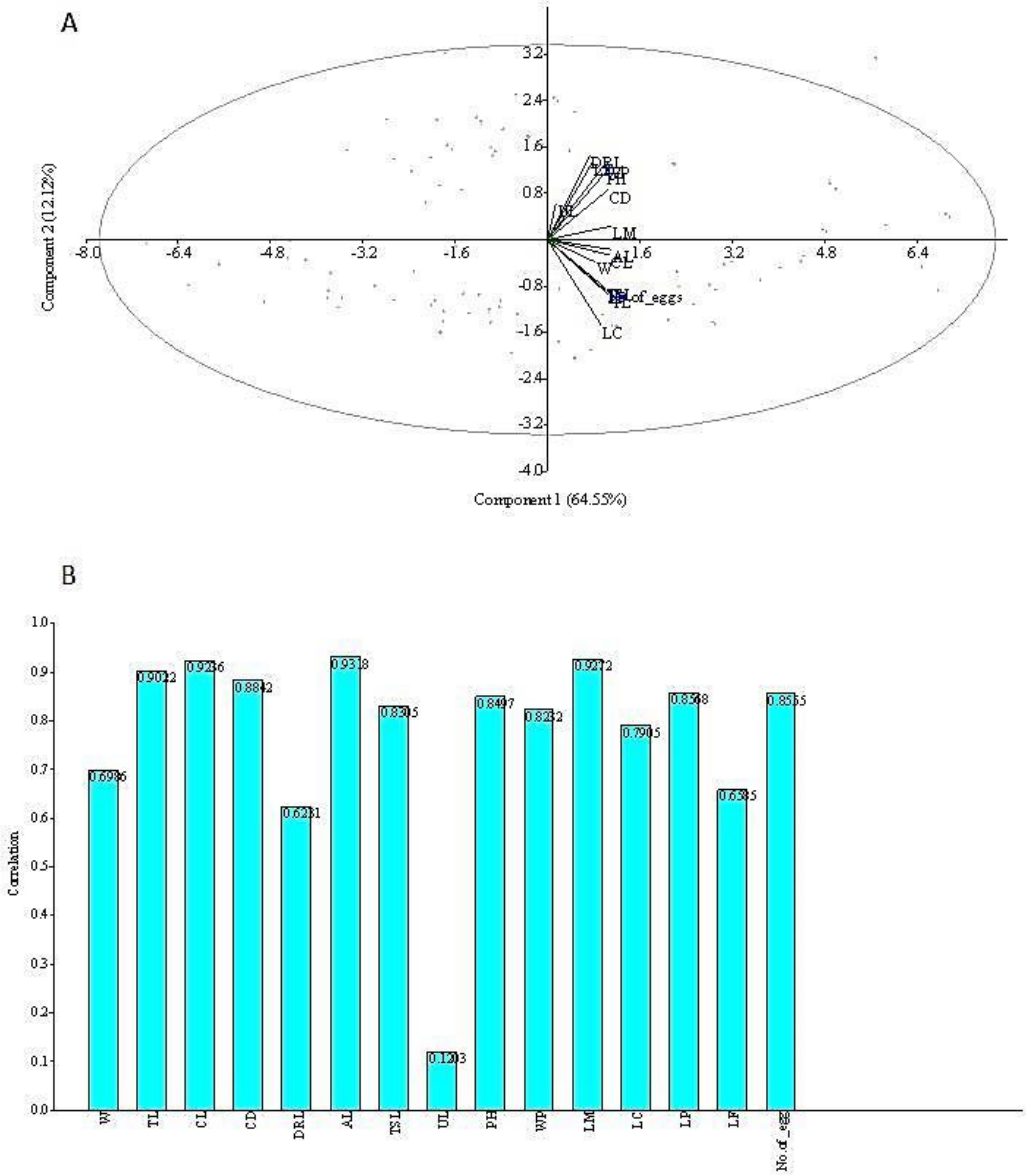

Figure 4: Principal component Analysis (A) biplot and (B) loadings of morphometric parameters from *A. gabonensis* collected from Ganaja.

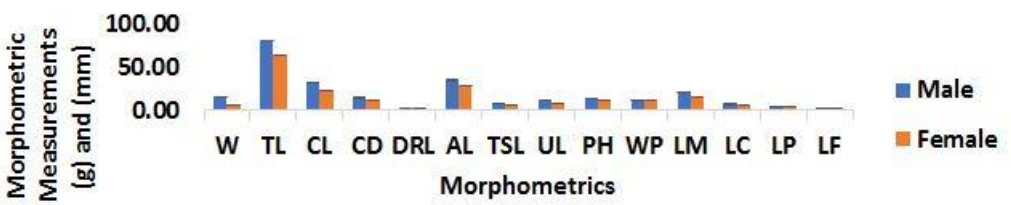

Figure 5: Morphometric parameters of male and female *A.gabonensis* collected from Ganaja, (all morphometrics differed significantly (p<0.05)).

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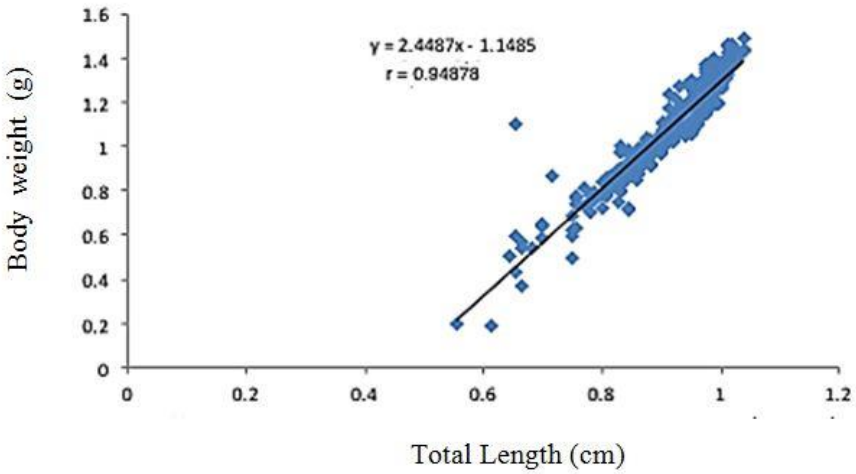

Figure 6: Length-Weight Relationship of Female *A. gabonensis* from Ganaja

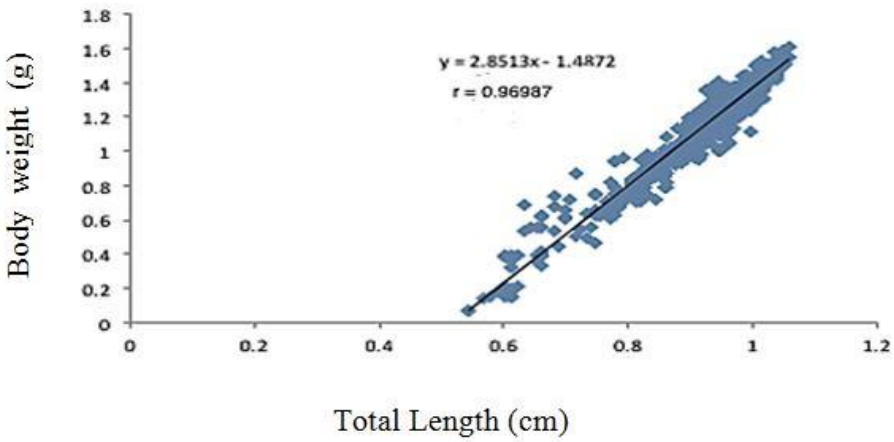

Figure 7: Length-Weight Relationship of Males *A. gabonensis* from Ganaja.

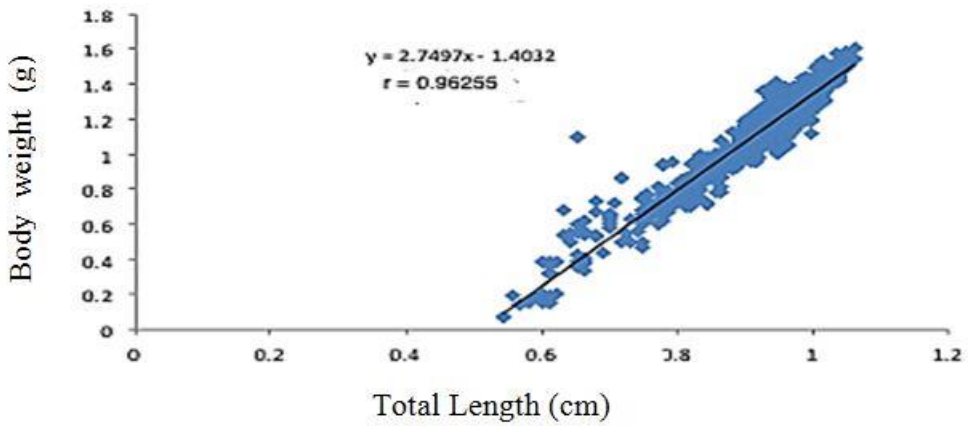

Figure 8: Length-Weight Relationship of Combined Sexes of *A. gabonensis* from Ganaja.

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Condition factor (K)

There was no significant difference (p>0.05) in the condition factor across the months the highest K (mean=2.44±0.08) was observed in specimens collected in March while those collected in December showed the lowest K (mean=2.27±0.05) (Fig. 9).

Condition factor was lower in females (2.29 ± 0.04) with a range of 1.50-7.85 and higher in males (mean=2.42±0.04 and range=1.34-6.06) at a significant difference (p=0.001. In combined sexes, K ranged from 1.34-13.85 (mean=2.38±0.02) (Table 1).

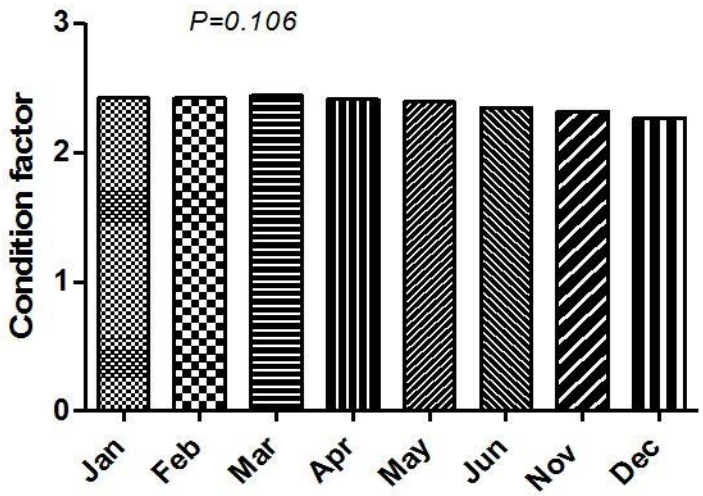

Figure 9: Conditon Factor of *A. gabonensis* at Ganaja, January to December, 2017.

Table 1: Mean Condition Factor of *A. gabonensis* from Ganaja, January to December, 2017.

Male		Female		Combined		*p*-value
Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	
2.29 ± 0.04	1.50-7.85	2.42 ± 0.02	1.34-6.06	2.38 ± 0.02[b]	1.34-13.85	0.001

Moulting statistics

A total number of 2,175 specimens were collected, out of which 494 specimens moulted. The highest percentage (73.33%) of moulted specimens was observed in February while the lowest (8.00%) was in June (Table 2).

Table 2: Moulting Statistics of *A. gabonensis* at Ganaja, January to December, 2017.

Month	Total number of specimens	Number of moulted specimens	Percentage of moulted specimens
January	115	8	6.96
February	210	154	73.33
March	179	117	65.36
April	115	6	5.22
May	108	13	12.04
June	75	6	8.00
November	91	8	8.79
December	109	13	11.93
TOTAL	2,175	494	

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Frequency distribution of egg developmental stages

The frequency distribution of egg developmental stages is presented in Figure 10. All the developmental stages of the eggs were observed in this location during the period of the studies. The highest percentage (29.17%) of the ovigerous females were found in stage 4, followed by those in stages 3 and 1 (25% each). Stage 2 had 12.5% while the lowest percentage (8.33%) was in stage 5. Stage 1 contained light orange eggs which were newly spawned and immature with uniform yolk; Stage 2 had dark orange eggs; Stage 3 exhibited light brown eggs; Stage 4 showed dark brown eggs; Eggs in Stage V were gray in color, fully developed and ready for hatching (Fig. 11).

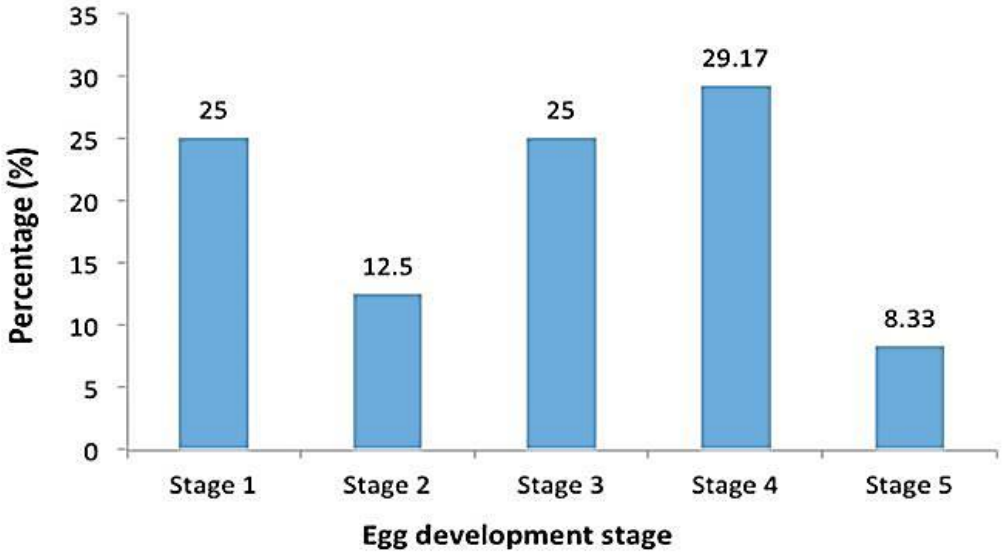

Figure 10: Frequency Distribution of Egg Development Stages of *A. gabonensis from Ganaja*.

Fecundity, gonadosomatic index and egg diameter

One hundred (100) specimens were collected for fecundity study. Fecundity varied from 300 to 24,532 egg (mean=9,575±515) (Table 3).

Gonadosomatic index ranged from 0.10 to 0.09 (mean=0.33±0.01), while egg diameter ranged from 0.2 to 0.6 mm (mean=0.46±0.01).

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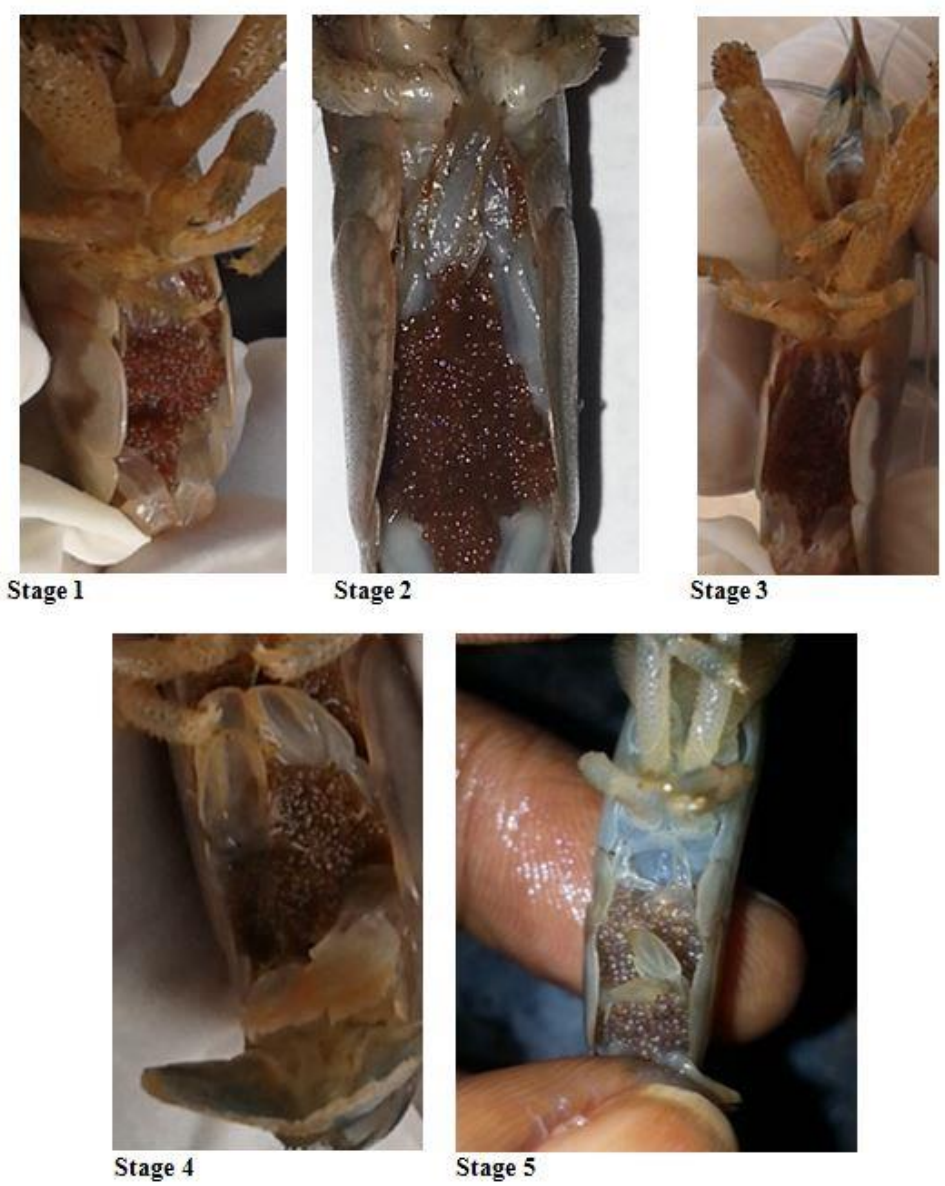

Figure 11: Different Stages of Embryonic Development Based on Egg Color
At stage 1, eggs were newly spawned, immature with uniform yolk and light orange in color. In stages 2 (dark orange), 3 (light brown) and 4 (dark brown), the color change indicates that development is in progress. Eggs in Stage V are gray in color, fully developed ready for hatching.

Table 3: Mean Fecundity, gonadosomatic index and egg diameter of *A. gabonensis* from Ganaja (January to December 2017).

	Fecundity	GSI	Egg Diameter (mm)
Mean	9,575 ± 515	0.33 ± 0.01	0.46 ± 0.01
Minimum	300	0.10	0.2
Maximum	24,532	0.09	0.6
N	100	100	10

Discussion

Atya gabonensis prefers shallow water with less turbidity and low current

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velocity. This may be responsible for abundance of this species during the dry season (November to March) Adetayo and Kusemiju (1994) reported peak of highest catch of prawns in the dry season.The months with no catch of *A. gabonensis* (July to October) coincided with periods of heavy rains when the water turbidity becomes high. Fishing activities generally were reduced because fishermen encountered difficulties in setting their nets and traps due to flooding and ferocity of the river. Powell (1982) attributed lack of prawn catches in fishermen loadings, during the peak rainy season, to inaccessibility of them to the fishermen due to high water depth, lack of water transparency and high current or velocity.

Males were found to be more in number than females. Obande (2006) and Solomon *et al*. (1999) reported similar phenominon and attributed it to their genetic characteristics. However, higher ratio of female to male has been reported in *Macrobrachium felicinum* and *M. vollenhovenii* (Ukagwu and Deekae, 2016). Menon (1957) and Marioghae (1982) have reported equal sex ratio in Macrobrachium species.

Variation in the morphometric relationships obtained between the male and female may have resulted from variation in food, population density, environmental conditions and genetic makeup of the species (Mariappan and Balasundaram, 2004). In general, it was found that the morphometrics and weight parameter used, allowed discrimination between male and female prawn species and this gives advantage to males as observed that male grow faster from sampled population, this corroborates the findings of Tizkar *et al*. (2017) and Torres *et al.* (2014). Furthermore, it can be suggested that all male prawn production is more advantageous than female production.

Correlations between length and weight were strong and positive. This shows that the River is a favourable place for this organism. This is in agreement with the observations of Obande and Kusemiju (2006), Solomon *et al.* (1999), Nwosu (2009), Jimoh *et al*. (2012), and Kingdom and Erondu (2013). The difference in the condition factor between male and female could be due to the presence of gravid females or due to higher weight of the female's gonads, which are lacking in their male (Udiongyang *et al*. 2016).

The higher percentage of moulted specimens in February and March (the onset of rainy) may be due to increase in temperature which coincides with the onset of the rains and possible availability of food. FAO (2000) reported that under natural conditions, mating occurs throughout the year, although there are, sometimes, peaks of activity related to environmental conditions; in tropical areas moulting and mating coincides with the onset of the rainy season.

Fecundity differed from that of Obande *et al*. (2009) on the same species. This may be related to environmental aspects, genetic variations of populations and predation on eggs. Almeida *et al*. (2010) reported same phenomenon on *Atya Scrabra*.

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Although this prawn was reported to be moderately fecund (Anetekhai, 1990), its fecundity is lower than what was reported in some genus of Macrobrachium (New and Singholka, 1982). This is an indication that prawns of macrobrachium genus are more fecund than *A. gabonensis.* The Fecundity/body size relationships show an increase in number of eggs with increasing female size; a similar situation was also observed by Albertoni *et al*. (2002) in *M. acanthurus*, Hart *et al*. (2003) in *M. felicinum* and Deekae and Abowei (2010) in *M. macrobrachion*. It could be perceived that the increase of fecundity with body size seems to be a rule that is applicable to many crustaceans.

Ganaja is likely a breeding and spawning ground for this species. This is evident in the representation of all the stages of egg development. This species has exhibited good reproductive performance and its seeds are readily available in the wild. Tt is likely to make a good candidate for aquaculture. All male production of this species is recommended to be more advantageous than female. Genetic analyses are required to better understand the processes of dispersal involved in the variation in body shape among freshwater prawns

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