integrity Research Journals

Global Journal of Fisheries Science
Volume 4(1), pages 1-6, July 2022
Article Number: CF94D0001
ISSN: 2782-750X
https://doi.org/10.31248/GJFS2022.033
https://integrityresjournals.org/journal/GJFS

Full Length Research

Egg development stages and fecundity of *Atya gabonensis* (Giebel, 1875) (Crustacea: Atyidae) from three different locations in Nigeria

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Received 26th March 2022; Accepted 8th June 2022

ABSTRACT: Comparative studies of fecundity and stages of egg development of *Atya gabonensis* in River Benue at Makurdi, River Niger, Jebba and the confluence of the two rivers at Ganaja was done from January 2016 to December 2017. A total of 300 berried females were collected with the aid of fishermen and transported in ice box to the laboratory for further studies. Species identification was done using keys of Powell (1982). The sexes were determined using morphological features such as appendix masculina, reproductive chamber and numb. Morphological measurements were done according to Adite et al. (2013). Body weight was taken with a top loading electronic Metler balance. Fecundity was estimated by gravimetric method. Egg development stages were determined using external features of the eggs. The number of eggs varied from 550-36,673 in Jebba, 300-24,532 in Ganja and 4,300-8,600 in Makudi. Positive correlation was observed between fecundity and morphometric parameters in all the locations. All the ovigerous females in Makurdi, 14% in Ganaja and 17% in Jebba were in stage 1. Ganaja and Jebba had 39 and 35% respectively in stage 2. Stage 3 was 26 and 12% from Ganaja and Jebba respectively. Stage 4 had 10% from Ganaja and 17% from Jebba while stage 5 had 11% from Ganaja and 19% from Jebba. It was concluded that *A. gabonensis* is fecund and could make an excellent candidate for culture.

Keywords: Comparative studies, freshwater prawn, Ganaja, Jebba, Makurdi, number of eggs, spawning ground.

INTRODUCTION

Prawns constitute a large group of crustaceans varying in size from a few millimetres bout 35cm long (FAO, 1981). Apart from their ecological significance in controlling the structuring of the aquatic community, they are of considerable socioeconomic importance (Mrugała *et al*., 2019). They are valued food organisms and have been considered one of the most important internationally traded fishery products, which generate substantial economic benefits, especially for many developing countries (FAO, 2008). Prawns from the Atyidae and Palaemonidae families are an important resource for the artisanal fishery (Gooré Bi, 1998; Vanga, 2007; Almeida, 2010; Boguhé, 2011). *Atya* comprises of large number of the family Atyidea occurring in the tropic of West Africa and Americas (ITIS, 2022).

The genus Atya ranges through the Antilles and along the Atlantic and Pacific slopes of Central and South America and in western Africa (Mrugała *et al*., 2019). Among the species of this genus, *Atya gabonensis,* taxonomically classified by (ITIS, 2017), was reported to occur in abundance in Nigeria's main rivers and tributaries (Okayi *et al.,* 2015). Aquatic Arts (2017) reported that it is certainly among the most fascinating and unique aquarium shrimp available, and it is commonly called African Filter Shrimp, Viper Shrimp, Gabon Shrimp, and Cameroon Shrimp. It is reputed to have a superior flavor and was

sought after by some Europeans in Ibadan, Oyo State of Nigeria years ago (Reed, 1967). It was reported to be harvested by Ijaw fishermen, along the River Osse, in lengths of bamboo set on the river bottom to catch Chrvsichthys, but customarily released as the traditional "king" or protector of other shrimp species (Powell, 1982). Wild populations might be managed and harvested by the provision of suitable artificial shelters. Related species, *A. Africana* (Bouvier, 1904), occurs in hilly areas of Cross River State, and juveniles of it have been found in the River Nun; it is distinguished from *A. gabonensis* by the lack of lateral teeth on the rostrum and the presence of a light-coloured mid-dorsal line (Powell, 1982).

FAO (2002) recounted that during reproduction in most prawns, eggs are laid within a few hours after mating and are fertilized by the sperm contained in the gelatinous mass, attached to the outside of the female's body. The female then transfers the fertilized eggs to the underside of the abdominal (tail) region, in a "brood chamber," where they are kept aerated and cleaned by movement of the abdominal swimming appendages. Eggs remain attached to the abdomen until they hatch. The number of eggs produced at each spawn is directly proportional to the size of the female. As long as water temperature exceeds 70°F, multiple spawns per female can occur annually. The bright-orange color of newly spawned eggs gradually changes to orange, then brown, and finally gray before hatching.

There are bright prospects and great potentials for prawn culture development in Nigeria (Anyanwu *et al*., 2012), due to the nation's favourable conditions: the tropical climate which will ensure all-year round production, the rainfall, solar radiation, wind, air and water temperatures that are very suitable for culture of prawn especially in the coastal areas. In addition, the country is endowed with enormous water resources which include a long coastline of 853 km, a continental shelf of 37,934 km^2, an Exclusive Economic Zone (EEZ) of 210,900 km^2, inland water surface area of 14 million hectares, and a land mass of 923,768 km^2 with many suitable coastal sites for the establishment of shrimp and prawn farms. Even with this natural endowment, prawn culture has not excelled in the country, it is still underdeveloped. This is due to paucity of information on the reproductive biology of culturable prawn species in Nigeria. Nigeria, being among the tropical countries endowed with rich shrimp and prawn resources, dwells in the production capacity of 12,000 MT annually, which is even mostly caught from the wild (Zabbey *et al.,* 2010). The quantity produced is insignificant, compared to the soaring demand for the product at the international market (Zabby *et al.,* 2010).

In order to take advantage of its great economic potentials, there is need for prawn culture to be developed in the country. Nevertheless, efforts are being made to introduce prawn farming into the country but unsuccessful. Studies on the ecology, biology, behaviour and distribution of indigenous Nigerian shrimp and prawn species have been carried out by various researchers, to provide the scientific lead way for prawn culture in Nigeria (Abowei *et al.,* 2006; Deekae and Abowei, 2010; Kingdom and Erondu, 2012; Lawal-Are and Owolabi, 2012; Opeh and Udo, 2014; Kingdom 2015). However, there is need for more information on the reproductive biology of such indigenous prawn species, as *A. gobonensis* which has been reported to occur in abundance in Nigerian inland waters. This study was designed to provide information on the comparative fecundity and stages of egg development of *A. gabonensis* in River Benue (Makurdi); River Niger, (Jebba); and the Confluence of the two rivers (Ganaja).

MATERIALS AND METHODS

Study areas

The prawn collection sites were Makurdi, Jebba and Ganaja (Figure 1). Makurdi is located on latitude 7˚ 55' and 7 56' North of equator and longitude 8˚20' and 8˚ 40' East of the Greenwich meridian. Jebba is located on latitude 9° 35` and 9° 50` N and longitude 9° 30` and 5° 00` E. Ganaja is located between latitude 7º 45 N and 8º 12 N and longitude 6º 39 E and longitude7º 00 E.

Prawn collection and studies

Prawns were collected with the help of fishermen and transported in iced box to the laboratory for further studies. Identification to species level was by keys of Powell (1982). The sexes were determined with the aid of specific morphological features that were peculiar to male and females of the prawns, such as appendix masculina, reproductive chamber and nubs on the first abdominal segment as demonstrated by Anetekhai (1990). Morphological measurements were done according to a model of Adite *et al*. (2013). Total body weights (g) were taken using a top loading electronic Metler balance (Model 59174). Fecundity was estimated by the gravimetric method of Fernandez *et al*. (1998). Stages of egg development were characterized based on the colour of egg mass according to Anetekhai (1990).

Statistical analyses

Data collected were analyzed using mini tab 14 computer software. Data were tested for normality and homogeneity of variance before Analysis of Variance (ANOVA) was computed. Where significant differences occurred, means were separated using Fisher's least significant difference at a significance level of $p \leq 0.05$.

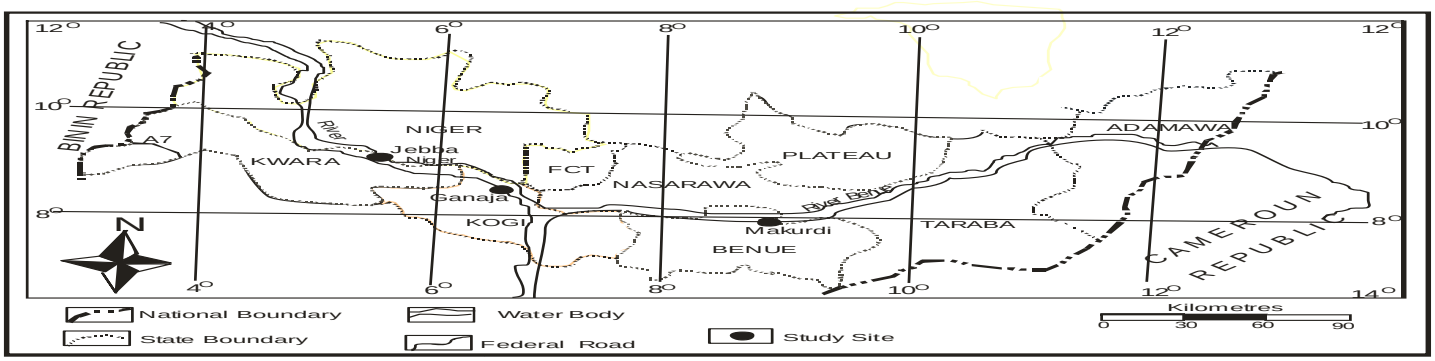

Figure 1. Map Showing Sample Collection Site at Makurdi, Jebba and Ganaja (Modified from Obaje, 2009).

Table 1. Mean Fecundity of *A. gabonensis* from Ganaja, Makurdi and Jebba (January 2016 to December 2017).

Station	Mean	Minimum	Maximum	N
Lokoja	9,575 ± 515[b]	300	24,532	100
Makurdi	6,450 ± 2150[c]	4,300	8,600	100
Jebba	11,937 ± 902[a]	550	36,673	100

Numbers in each cell are means ± standard error. Mean in the same column with different superscript differ significantly (P<0.05).

RESULTS AND DISCUSSION

The mean fecundity of *Atya gabonensis* from Ganaja, Makurdi and Jebba is presented (Table 1). One hundred (100) prawns were sampled from each location. There was significant difference (p<0.05) in the fecundity of *A. gabonensis* from the 3 locations. Specimens from Jebba had the highest mean fecundity (11,937 ± 902) followed by prawns from Ganaja (mean fecundity = 9,575 ± 515); the lowest fecundity (6,450 ± 2,150) was recorded for Makurdi. The number of eggs varied from 550 – 3,6673 in Jebba; from 300 – 24,532 in Ganja; and 4,300 – 8,600 in Makurdi. The result of fecundity in this study is higher than that of Obande *et al*. (2009) on the same species in the Lower River Benue. The differences may be related to environmental aspects, genetic variations of populations and predation on eggs. However, fecundity in this study is lower than what was observed on prawns of the genus *Macrobrachium*. For example, New and Singholka (1982) reported 100,000 - 700, 000 eggs in *M. rosenbergii*. This is an indication that prawns of *Macrobrachium* genus are more fecund than *A. gabonensis*. The same phenomenon was reported by Anetekhai (1990).

In Ganaja and Jebba, all the features correlated positively with fecundity (Tables 2 and 3). The most correlated feature with fecundity was total length (r= 0.87) in Ganaja, while in Jebba, the most correlated feature with fecundity was body weight (r= 0.86). The least correlated features were carapace diameter and carapace length (r= 0.59 for each) (Table 3). In Makurdi, Table 4 shows positive correlation of morphometric parameters and fecundity, except with CD. Strongest correlation was observed between Fecundity and total length (r= 0.64). The Fecundity/total length relationships shows 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. macrobrachium*. The increase of fecundity with body size seems to be a rule that is applicable to many crustaceans (Udo and Ekpe, 1991; Llodra *et al*. 2000).

All the ovigerous females found in Makurdi, including 14% of those in Ganaja and 17% of those in Jebba were in stage 1. Most ovigerous females in both Ganaja and Jebba (39% and 35% respectively) were in stage 2. Ganaja had 26% and Jebba had 12% of the ovigerous females in stage 3. Stage 4 had 10% from Ganaja and 17% from Jebba while stage 5 had 11% from Ganaja and 19% from Jebba. All the stages of egg development were represented in the samples collected (Figure 2). However, only the first stage was observed at Makurdi. All the five stages were observed on Ganaja and Jebba specimens. It is plausible that River Benue may not be a spawning ground for this species. They probably migrate to River Niger in Jebba and the Confluence of the two Rivers in Ganaja to spawn.

The Embryonic development (Plate 1) started with a fertilized egg containing yolk mass with a light orange

Table 2. Correlation matrix of morphometric parameters and fecundity of *A. gabonensis* from Ganaja (January 2016 to December 2017) (n=100).

	W	TL	CL	CD	AL
TL	0.63				
CL	0.58	0.88			
CD	0.56	0.71	0.80		
AL	0.56	0.87	0.99	0.82	
Fecundity	0.65	0.87	0.78	0.64	0.78

W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length.

Table 3. Correlation matrix of morphometric parameters and fecundity of *A. gabonensis* from Jebba (January 2016 to December 2017) (n=100).

	W	TL	CL	CD	AL
TL	0.80				
CL	0.68	0.82			
CD	0.67	0.75	0.83		
AL	0.72	0.89	0.92	0.86	
Fecundity	0.86	0.76	0.59	0.59	0.68

W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length.

Table 4. Correlation matrix of morphometric parameters and fecundity of *A. gabonensis* From Makurdi (January 2016 to December 2017) (n=318).

	W	TL	CL	CD	AL
TL	0.29				
CL	0.26	0.81			
CD	0.03	-0.15	-0.15		
AL	0.23	0.48	0.54	-0.11	
Fecundity	0.42	0.64	0.57	-0.00	0.14

W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length.

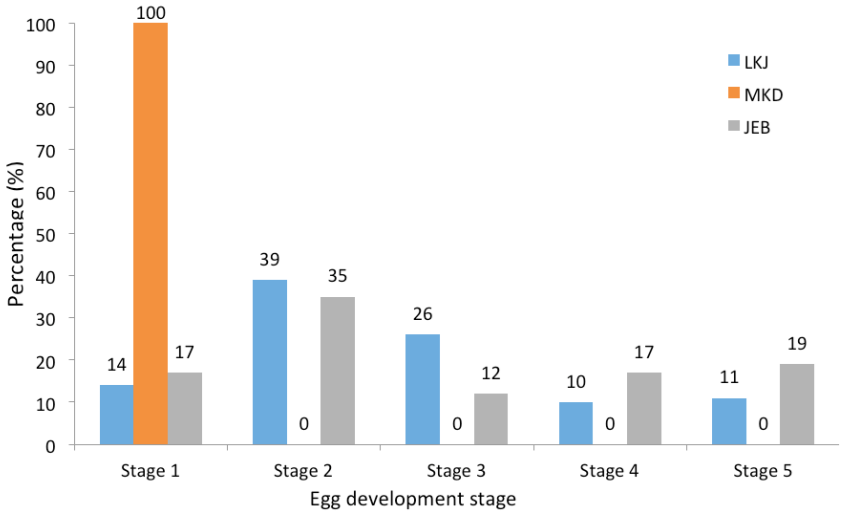

Figure 2. Frequency distribution of stages of egg development of *A. gabonensis* from Ganaja, Makurdi and Jebba (January 2016 to December 2017.

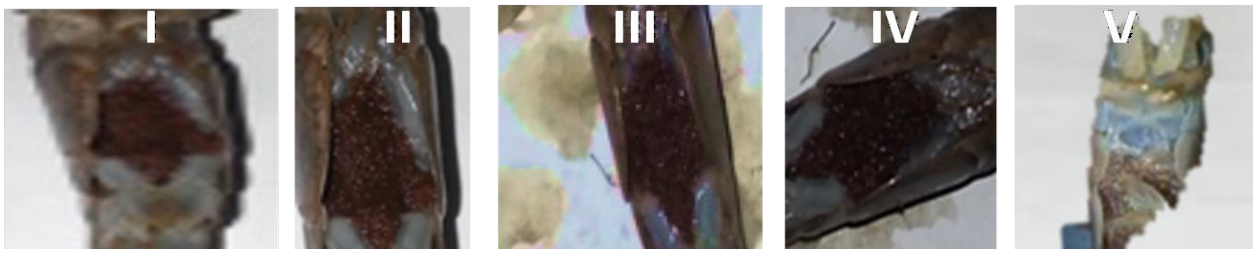

Plate 1. Different stages of embryonic development based on egg colour of *A. gabonensis.*

colouration (stage 1). Here, eggs were newly spawned, immature with uniform yolk and no eye pigments visible. At stage II, eggs were dark orange in colour; at stage III, the eggs had light brown appearance; and at stage IV, dark brown eggs were observed. Eggs in Stage V are gray in colour, fully developed and two eye spots are visible, ready for hatching. The egg colour ranged from orange colour to gray and oval in shape before hatching to zoea. This corresponds with the findings of Habashy *et al*. (2012) on the morphological studies of the embryonic development of *Macrobrachium rosenbergii* in which the eggs were slightly elliptical in shape, initially bright orange to yellow in colour which gradually changed to deep brown a few days before hatching. It was reported that the fertilized eggs of *Macrobrachium idella Idella,* had opaque, greenish round and oval shape, as development progresses, its greenish colour changed into light green, brownish-yellow and finally to dull whitish colour when it was about to hatch (Vijayakumar, 1992). This is quite different from the present study. These colour changes were attributed to the absorption of the yellow yolk and development of dark pigment in the eyes (Vijayakumar,1992; Veera, 1994). The colour change is likely to indicate progress development.

All the stages of egg development were represented in the samples. However, only the first stage of egg development was observed at Makurdi. All the five stages were observed at Ganaja and Jebba. It is suspected that River Benue at Makurdi may not be a spawning ground for this species and they probably migrate to the Confluence of the two Rivers and/or River Niger to spawn. It is recommended that further studies be done to understand the hatchability and larval development of this species in captivity, so as to have a stepping stone for the domestication of this prawn in Nigeria.

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