Sex ratio, fecundity and egg development of *Macrobrachium felicinum* (Holthuis, 1949) (Crustacea: Decapoda: Natantia) in the Lower River Benue, Makurdi, Nigeria

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Abstract

Sex ratio, fecundity and egg development of *Macrobrachium felicinum* were investigated in the Lower River Benue from January 2018 to December 2018. Four hundred and eighty (480) specimens of *M. felicinum* were collected from fishermen using combination of gears (drag nets, set traps and traditional gear known as "Ahina)". The specimens were transported in icebox containing water to the laboratory for further studies. The prawns were identified to species level by the keys of Schneider. Morphological measurements were done according to Adite et al. Body weight was taken with a top loading electronic Metler balance. The sexes were determined using morphological features according to Anetekhai. Fecundity was determined by gravimetric method. Embryonic development was characterized into five stages based on colour of egg mass. Sex ratio ranged from 5:1 to 26:1. Fecundity varied from 230 to 69,782, and strongly correlated with weight (r= 0.860) than with length (r=0.760). Most of the eggs (29.17%) were in stage 4. Stage 3 and 1 each had 25%. Stage 2 had 12.5% and the least number (8.33%) was observed in stage 5. The presence of mostly females and all stages of egg development in the specimens projects River Benue as a likely place for both breeding and spawning of *M. felicinum*. *Macrobrachium felicinum* is recommended as a good candidates for aquaculture in Nigeria as its seeds are readily found in the wild and in freshwater.

Keywords: Niger River prawn, Lower River Benue, Embryonic development, Fecundity, Sex ratio, *Macrobrachium felicinum*

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Introduction

Prawn cultivation is an important industry that generates billions of US dollars in export annually (Flegel, 2012). It contributes significantly to poverty alleviation. The average income per capita of a prawn farm household member was seven times higher than the national average it generates employment in rural areas both from the hiring of farm workers and by the self-employment of household members (Pongthanapanich *et al*., 2019). However, Countries in East and Southeast Asia (83.4% of production) and Latin America (16.3%) account for the major share of shrimp production (Emerenciano *et al*., 2022).

Aquaculture production from Africa is overwhelmingly dominated by finfishes (99.3%), with only a small fraction from shellfish such as prawn and shrimp (0.5%) and marine molluscs (0.2%) (FAO, 2012). Although the aquaculture sector in Nigeria has been growing, the shrimp sub-sector has shown a worrying slowdown. Aquaculture production in Nigeria increased from 25 718 tones in 2000 to 261 711 tones in 2020 with finfish having a share of 92.6% while shellfish production was 7.4% (FAO, 2022).

Nigeria is still struggling with production capacity of 12, 000 tones of shellfish annually (The Nation Newspaper, 2021; Obetta *et al*., 2022). This is due to inadequate information on biology and farming technology of prawn. In freshwater prawns, *Macrobrachium rosenbergii* has been successful in commercial farming because its biology and farming technology are well known compared to other species (Valenti, 1990). In order to take advantage of the ecological and economic benefits of prawn farming in Nigeria, there is need to intensify research on the reproductive biology and farming techniques of the indigenous prawn species.

The freshwater prawns of genus Macrobrachium (Crustacea, Decapoda, and Palaemonidea) constitute one of the most diverse, abundant, and widespread crustacean genera (Murphy and Austin, 2005). The species of this genus are distributed throughout the tropical and subtropical zones of the world (Holthuis, 1980; Fossati *et al*., 2002; March *et al*., 2002). Various studies have identified approximately 240 species of Macrobrachium (Chen *et al*., 2009; De Grave and Fransen, 2011; Holthuis and Ng, 2010; Wowor *et al*., 2009). Although the majority of them inhabit freshwaters, some are entirely restricted to estuaries and many require brackish water during larval development (New, 2002).

In West Africa, Macrobrachium species can be found throughout the region and play an important role in domestic fishery resources (Etim and Sankare, 1998; Nwosu and Wolfi, 2006). They are commercially important and sustain viable artisanal fisheries in some rivers and estuaries within the region, while also providing direct and secondary employment (Marioghae, 1990; Okogwu *et al*., 2010). However, the species are poorly known in the region. Monod (Monod,

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1980) developed a Macrobrachium characterization key, which when applied to West Africa resulted in the identification of 10 species of Macrobrachium: *M. vollenhovenii*, *M. Macrobrachion* (Herklots, 1851), *M. chevalieri*, *M. Dux* (Lenz, 1910), *M. Felicinum* (Holthuis, 1949), *M. Raridens* (Hilgendorf, 1893a), *M. thysi* (Powell, 1980), *M. equidens* (Dana, 1852), *M. zariquieyi* (Holthuis, 1949), and *M. sollaudii*, of which, at least, three have been identified in Nigeria: *M. felicinum*, *M. vollenhovenii* and *M. macrobrachion* (Monod, 1966; Monod, 1980; Powell, 1980).

Macrobrachium felicinum (Fig. 1) has been reported to occupy the Northern part of Nigeria including River Benue (Obande and Kusemiju, 2006; Ayoola, *et al*., 2009; Bello-Olusoji *et al*.,1997) have studied its distribution in Nigeria. A lot of work has been done on the sex population structure and other aspects of Macrobrachium species (Marioghae, 1982; Powell, 1980; Nwosu and Wolfi, 2006; Ukagwu *et al*., 2020). This study is in continuation with some other studies and it is reporting on the sex ratio, fecundity and egg development of *M. felicinum.* The knowledge of reproductive biology of this species is important for evaluation of their potentials for commercial farming, as well as an estimation of the stock size of natural population.

Figure 1: *Macrobrchium felicinum*. Photograph by Obetta, C.

Materials and methods

Study Areas

The prawns were collected from River Benue, located in Makurdi (Fig. 2). 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. River Benue originates from Adamawa hills and flows from the Southern part of Cameroon through Makurdi and Southwards to Lokoja where it forms a confluence with River Niger. At bank full, the area of Lower River Benue is about 129,000 hectares with as much as 25m difference between high and low water levels.

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Prawn collection

Prawn specimens were collected from catch statistics from fishermen using various gears such as drag net (Fig. 2a), unbaited local non-return set trap (Fig. 2b)) which has two non-return valve mechanisms, an opening, which permits entrance of prawns but prevents them from getting out, at the center of the trap. The length of the trap is between 0.95 and 1 m while the opening aperture is between 25 and 30 cm. This trap was dropped in a marked position for ease of retrieval. Another trap used was leaves called "Ahina" in local (Tiv) language.

The leaves were tied to sticks in the shallow part of the river (Fig. 3c) and left for two or more days after which the leaves were collected in baskets to check for prawns. The collected prawns were transported in iced box containing water to the laboratory for further studies.

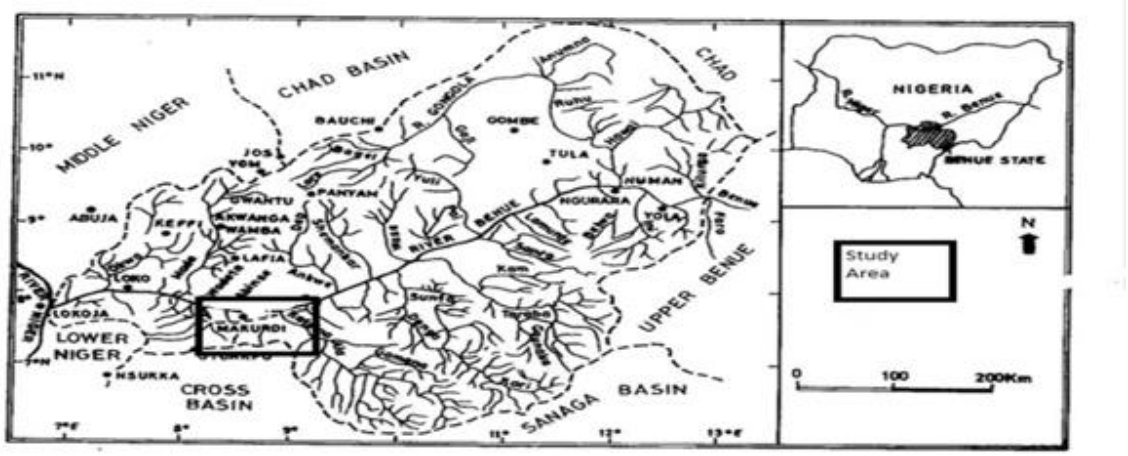

Figure 2: Map of Lower River Benue showing Makurdi, the sampling site. Source: Wikipidia.com

Figure 3: Drag Net (a) Set Trap (b) and Leaves and Basket (c) Used for Catching *M. Felicinum*

Prawn identification

The prawns were identified to species level, using keys by Powell (1982).

Morphological measurements

The total length (cm) was measured by using a meter rule, as the distance from the tip of the telson to the tip of the

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dorsal teeth; carapace length (cm) was measured with the aid of a meter rule as the distance from the tip of the rostrum to the end of the carapace; carapace diameter was the distance between lateral margin of cephalothorax; abdominal length (cm) was measured as the distance between distal extremity of rostrum and the medium point of posterior part of carapace. The total body weight (g) was taken using a top loading electronic Metler balance (Model 59174) to the nearest gram.

Sex determination

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).

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 (15mL) 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 the eggs 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:

$F = nG/g$ (1)

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

Results

Sex distribution

Out of a total of 413, males were 38 and females were 375 (giving an overall sex ratio of 9.87:1(F:M). In March, highest sex ratio of 26.00:1(F:M) was observed and the least sex ratio of 5.00:1(F:M) was in September. In January, February and September, the sex ratios did not differ significantly (p>0.001). No prawn was encountered from October to December (Table 1).

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Table 1: Sex Distribution of *M. felicinum* from Makurdi (January 2018 to December 2018).

Year 2018	Female	Male	*Sex ratio* (F:M)	X^2	*p-value*
January	19	2	9.50: 1	2.00	0.157
February	16	1	16.00: 1	0.33	0.564
March	26	1	26.00: 1	3.57	0.050
April	41	3	13.67: 1	8.00	0.008
May	69	8	8.63: 1	14.4	0.001
June	59	6	9.83: 1	13.4	0.001
July	96	10	9.60: 1	22.3	0.001
August	29	3	9.67: 1	8.00	0.005
September	20	4	5.00: 1	3.26	0.071
October	0	0			
November	0	0			
December	0	0			
TOTAL	375	38			

Mean fecundity of M. felicinum from Makurdi

Table 2 shows the mean fecundity of *M. felicinum* collected from Makurdi. The fecundity ranged from 230 to 69,782 eggs (15,133 ± 1,222).

Table 2: Mean Fecundity of *M. felicinum* from Makurdi (January 2018 to December 2018).

Station	Mean	Minimum	Maximum	N
Makurdi	15.133 ± 1222	230	69,782	158

Table 3 shows correlation matrix of morphometric parameters and fecundity of berried female *M. felicinum* from Makurdi. Positive correlation was observed between fecundity and other features measured except with CD. Stronger correlation was observed between Fecundity and weight (r= 0.86) than with total length (r=0.76).

Table 3: Correlation Matrix of Morphometric Parameters and Fecundity of *M. felicinum* from Makurdi (January 2016 to December 2017) (n=318).

	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

(p>0.05). Keys: W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length.

Stages of egg development

Based on colour of egg mass, the eggs of *M. felicinum* was categorized into five (5) as shown in Figure 4. All the five stages of egg development where uncounted in the samples. Stage I is shown in A. it represents newly spawned eggs with orange colouration. Stage II which is in B, shows changes in coloration from orange to light green. Eggs in stage III as in C are Dark green in colour. Brown colour was observed for eggs in stage IV as in D. And gray was observed for eggs in stage V, represented in E, about to hatch. Most of the eggs (29.17%) were in stage 4. Stage 3 and 1 each had 25%. Stage 2 had 12.5% and the least number (8.33%) was observed in stage 5 (Table 4).

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Discussion

In this study, *M. felicinum* has more females than males, with a female to male ratio ranging from 5.67:1 to 26.00:1. Ukagwu and Deekae (2016) reported similar observation of more females *M. felicinum* than males with the sex ratio of 1:2 (M: F) in Akor River, Ibere Ikwuano, Abia State. Similarly, a sex ratio of 1:2 (M: F) was established in *M. vollenhovenii* by Ukagwu and Deekae (2016) and also by George and Rao (1967) in respect to *Penaeus indicus, Metapenaeus dobsoni, Machrobrancium affinis* and *Parapenaeopsis stylifera.* These observations contradict the reports of Menon (1957) and Marioghae (1982) where the sex ratio was the same. In this study area, it is likely that more females of *M. felicinum* are prone or vulnerable to catch in nature than the males which migrate into deeper waters soon after spawning. Tawari-Fufeyin *et. al*. (2005) reported that sex ratios may not always be static, as they vary from season to season or from year to year within the same population.

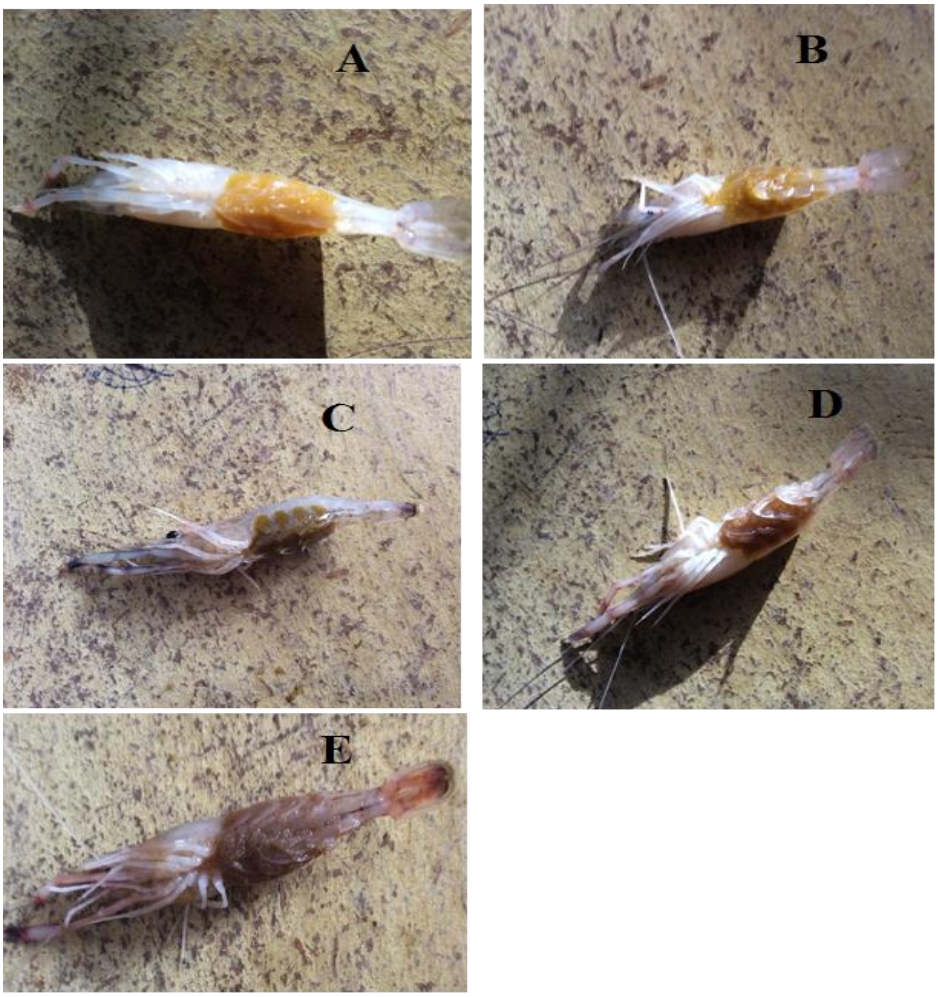

Figure 4: Stages of Embryonic Development, Based on Egg Colour of *M. felicinum*. A= Stage I (Orange coloured eggs), B= Stage II (Light green-coloured eggs), C= Stage III (Dark green-coloured eggs), D= Satge IV (Brown coloured eggs) and E=Stage V (Gray coloured eggs).

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Table 4: Stages of Egg Development of *M. felicinum* in River Benue, January, 2018 to December, 2018.

Stage of Egg Development	Percentage (%)
Stage I	25
Stage II	12.5
Stage III	25
Stage IV	29.17
Stage V	8.33

Fecundity

The number of eggs (230 - 69,782) recorded in this study is far lower than 100,000 - 700, 000 eggs observed by New and Singholka (New and Singholka, 1982) in *M. rosenbergii,* and within the range (20,000 and 70,000) reported by Rao (Rao, 1998) in the same *M. rosenbergii.* However, the result of this study is much higher than what was reported for *M. macrobrachion*: 805 - 6,600 eggs (Ovie, 1986); 3,000 - 12,060 eggs (Marioghae, 1987); and 7,200 eggs per clutch (Ribeiro *et al*., 2012). Much lower values have been reported (Coelho *et al*.,1982; Gamba, 1984; Lobão *et al*., 1986; Scaico, 1992; Da Silva *et al*., 2004). Some authors also observed varieties of fecundity in different species of prawns: *M. acanthurus* (Valenti *et al*., 1986; Valenti *et al*., 1989), *M. carcinus* and *M. rosenbergii* (Da Silva *et al*., 2004; Lara and Wehrtmann, 2009). This variations in fecundity could be attributed to species variation, size, environmental factors (Ishmael and New, 2000; Karplus *et al*., 2000).

The Fecundity/total length relationships show an increase in number of eggs with increasing female size. A similar phenomenon was observed by Albertoni *et al.* (2002) in *M. acanthurus* and Hart *et al*. (2003) in *M. felicinum*. 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). Ovie (1986) showed that there was high correlation between female weight and the number of eggs. Significant correlations between carapace length, wet weight and fecundity have been found for some *Macrobrachium* species (Bond and Buckup, 1982; Lobão *et al*., 1986; Mashiko, 1990; Mossolin and Bueno, 2002; Tamburus *et al*., 2012). The lack of significant correlations, between female size and fecundity has also been found for other palaemonid species with abbreviated larval development (Mantel and Dudgeon, 2005).

Stages of egg development

All the stages of egg development of *M. felicinum* were represented in the samples, and most specimens were females. This indicates that River Benue is likely a breeding and spawning ground for *M. felicinum*. Egg colour ranges from orange colour to gray and oval in shape before hatching. This corresponds with the findings of Habashy *et al*. (2012) on the morphological studies of the embryonic development of *M. 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. In the fertilized eggs of

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M. idella Idella and *M. gangeticum*, eggs were opaque, greenish round and oval shape and, as development progresses, its greenish colour changes into light green, brownish-yellow and finally to dull whitish in colour when it is about to hatch (Kanaujia, 2003). Using egg colour, classification was also made as: immature, developing and ripe (Anetekhai, 1990). The immature eggs were orange in colour, the developing eggs were greenish in colour and the ripe eggs were dark gray in colour with two eye spots referred to as 'eye' larval eggs (Xavier, 1997). These egg colour changes were attributed to the absorption of the yellow yolk and development of dark pigment in the eyes (Vijayakumar, 1992; Veera, 1994).

Conclusion and recommendation

All the stages of embryonic development were observed in the samples. This leads to a conclusion that Makurdi is likely a breeding and spawning ground for this species.

Makurdi is recommended for collection of broodstock of *M. felicinum* for commercial production, when water level is high (from July to August)

M. felicinum is a freshwater prawn and it is recommended as an excellent candidate for aquaculture since its seeds are readily available in the wild. Future studies are needed to reveal details of larval development so as to establish techniques for production of post-larvae in captivity for the progress of prawn culture in Nigeria.

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