Aspects of the bionomics of Brackish Water Prawn (*Macrobrachium macrobrachion*: Herklots 1851) in the interconnecting lagoons of South-Western Nigeria

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**ABSTRACT**

*Macrobrachium macrobrachion* is a caridean shrimp native to brackish and fresh waters of West Africa and is also considered to have potential for aquaculture and other research purposes. The bionomics of *M. macrobrachion* from Badagry, Lagos and Epe Lagoons were investigated monthly for 24 months between June 2013 and May 2015. The sex ratio revealed that there were more females from Badagry and Lagos Lagoons with males dominating Epe Lagoon. The fecundity estimates from the three lagoons ranged between 760 and 84,850 eggs with a weak correlation (R < 0.5). The mean GSI values ranged between 1.76 and 35.29% and showed that there were no significant differences (P > 0.05) in *M. macrobrachion* from Badagry and Lagos Lagoons while the GSI values from Epe Lagoon was significantly different (P < 0.05) from other lagoons. The egg diameter from the three lagoons ranged from 258 to 450 μm with no significant differences (P > 0.05) in the values. The dominance of females in Badagry and Lagos Lagoons could be attributed to the fact that both lagoons are salty and the females require such conditions to spawn while males dominated Epe Lagoon. The scientific observations documented in this study, will therefore serve as important references in the species assessment, cultivation, management and conservation of the prawn fisheries.

**Introduction**

The prawns of the genus *Macrobrachium* (Crustacea, Decapoda, and Palaemonidea) constitute one of the most diverse, abundant, and widespread crustacean genera [1]. The species of this genus are distributed throughout the tropical and subtropical zones of the world [2– 4]. Although the majority of *Macrobrachium* species inhabit freshwaters, some are entirely restricted to estuaries and many require brackish water during their larval development [5]. In West Africa, *Macrobrachium* species can be found throughout the region and play an important role in domestic fishery resources [6,7]. They are commercially important and sustain viable artisanal fisheries in some waterbodies within the region, while also providing direct and indirect employment [8,9].

Various studies have identified approximately 240 species of *Macrobrachium* [10–13], out of which 4 species have been reported in Nigeria [14]. These are *M. vollenhovenii* (African river prawn), *M. macrobrachion* (Brackish water prawn), *M. felicium* (Niger River prawn) and *M. dux* (Congo River prawn). Both *M. macrobrachion* and
M. vollenhovenii were recognizable by their large second cheliped which usually end in strong pincers. The chelipeds are stout and singular in M. vollenhovenii while they are slender and the pincer is furry in M. macrobrachion [15].

The studies on the sex ratio (male-female relationship in terms of number) are particularly important in cases where a fishery is being exploited with multiple gears. In this regard, any sex selection could lead to a drastic reduction in the ability of the stock to sustain itself over time. Sex ratio is important in estimating stock size and reproductive potential of an organism which helps in determining the adaptation and the rate of genetic processes in animal populations [16,17]. The fecundity of any species is an important ecological parameter in the studies of population dynamics and allows for reproductive studies as well as the establishment of criteria for the exploitation and management of commercially important fish species.

Previous reproductive studies on Macrobrachium species had been done by [15,18,19] from different habitats but there are dearth of information on Macrobrachium macrobrachion in this interconnecting lagoons.

This study therefore sought to determine the sex ratio, fecundity, gonadosomatic index (GSI) and egg diameter of Macrobrachium macrobrachion in the interconnecting lagoons of southwest Nigeria. This will serve to validate the current reproductive studies of West Africa Macrobrachium species and contribute to the overall biological studies which will be sufficient to develop management policies for the fisheries sector and for the species in Africa.

Materials and methods

Description of study sites

The Badagry Lagoon (Figure 1), with source in River Queme in the Republic of Benin to the west of Nigeria, is located in Lagos State and opens into the Atlantic Ocean via the Lagos harbor. It lies between longitudes 3°54” and 4°13”E and latitudes 6°25” and 6°35”N. The major ecological factors operating in the Badagry Lagoon have been documented by [20,21]. The temperature of Badagry Lagoon ranged from 26°C to 30°C [20]. The authors also observed an increase in salinity from June to September (rainy season) in the Badagry Lagoon due to the intrusion of salt water from the Cotonou Lagoon in the Republic of Benin.

Lagos Lagoon (Figure 1) is located between longitudes 3°23” and 3°53”E and latitudes 6°26” and 6°37”N. It is an open tidal estuary situated within the low-lying coastal zone of Nigeria. Lagos Lagoon has a seasonal fluctuation in salinity with high brackish conditions during the dry season (December to May), while freshwater condition exists in the rainy season (June – November) [21–23].

Epe Lagoon (Figure 1) lies between latitudes 6°29”N and 6°38”N; and longitudes 3°30”E and 4°05”E and is fed by River Oshun [24]. With a surface area of about 225 km² and a maximum depth of 6 m. A large area of the lagoon is relatively shallow with a minimum depth of 1 m, and the vegetation surrounding the lagoon is of the mangrove swampy type [25]. The lagoon opens into the Atlantic Ocean via the Lagos harbor [26].

Collection of specimens

Samples of M. macrobrachion were collected monthly from Badagry, Lagos, and Epe Lagoons between June 2013 and May 2015. The prawns were collected from the lagoons using a basket trap, locally called Igun. The prawns were collected randomly from the traps which were set near the shore of the lagoons. They were immediately preserved in an ice-chest and later transported into a deep freezer at temperature of −20 °C in the Marine Research Laboratory of the Department of Marine Sciences for further studies. A total of three thousand two hundred and ninety four (3,294) M. macrobrachion were studied.
The prawns were removed from the freezer and allowed to thaw. Excess water was removed from the specimens using filter papers. The total length (TL) and the carapace length (CL) of the prawns were measured to the nearest 0.1 cm from the tip of the rostrum to the end of the telson and from the eye socket to posterior end of the carapace, respectively, with a measuring board, while the total weight was measured on an electronic weighing balance (Model: DT 1001A) to the nearest 0.01 gram [15].

**Sex ratio in Macrobrachium macrobrachion**

Macrobrachium species identification was done using [8] as a guide. The separation of the species into male and female was done by visual examination of the abdomen for the presence of eggs in the case of the female. Also, the ventral side of the first abdominal segment was examined for the presence of a lump in the males as described by [18]. Confirmation was by the presence of the appendix masculina in the second pleopods of the males [18]. The sex ratio of the specimens was determined monthly.

**Fecundity**

A total of 271 fecund *M. macrobrachion* from Badagry, Lagos, and Epe Lagoons were examined. The eggs were removed from the female prawns and excess fluid was dried with the aid of filter papers. They were then weighed on an electronic weighing balance (Model: DT 1001A) to the nearest 0.01 g and the weight recorded. The total number of ripe eggs was estimated using the gravimetric method [27].

The relationship between the fecundity, length, and weight of the prawns was expressed as:

\[ Y = a + bX \]  \[27\]

where
- \( Y \) = fecundity estimate
- \( X \) = total length (cm)/total weight (g)
- \( a \) = regression constant
- \( b \) = regression coefficient
**Gonadosomatic Index (GSI)**

GSI indicates the gonadal development and maturity of the prawns. The weight of the prawns and that of the gonads were used to determine the Gonadosomatic index (GSI). The GSI was estimated using the formula:

\[ GSI = \frac{\text{Gonad weight}}{\text{Weight of prawn}} \times 100 \]

**Egg diameter**

The diameters of 20 eggs per berried female which were randomly selected were measured with an ocular micrometer inserted into the eyepiece of the microscope in order to determine the egg size (oocyte diameter). The stage micrometer was initially standardized (calibrated) with the ocular micrometer using X10 objective lens. The process involved placing the stage micrometer on the microscope stage, focused with a particular objective (X10). The eyepiece of the microscope was then replaced with another in which the ocular micrometer was placed. The eyepiece was viewed by rotating it so that the scale of the ocular became parallel to that of the stage. Thus, the zero on the ocular was super-imposed to that of the stage micrometer. The eggs were placed on a slide and viewed under the microscope. Counts were then made on the number of divisions where a division or sub-division of both scales coincided (Akinwunmi, 2020). Value in \( \mu m \) for one division on the ocular scale for that particular microscope objective = \( \frac{X}{Y} \)

where \( X = \) No of divisions on the Stage micrometer \times 10

\( Y = \) No of divisions on the ocular scale

**Statistical analysis**

Test for goodness of fits of the sex-ratio was determined statistically using chi-square \( (\chi^2) \) test. The data from the egg diameter and the GSI were analyzed using one-way analysis of variance (ANOVA). Mean differences were tested for significance \( (P < 0.05) \) using Duncan’s Multiple Range Test. Further analysis was carried out using Descriptive statistics and Microsoft Excel for windows (2007).

**Results**

**Sex ratio in Macrobrachium macrobrachion**

The total of 1606 specimens (Table 1) of *M. macrobrachion* collected from the Badagry Lagoon were made up of 791 males (Plate 1) and 815 females (Plate 2) giving a sex ratio of 1:1.03 (male:female). In Lagos Lagoon, 778 specimens of *M. macrobrachion* collected were made up of 216 males and 562 females giving a sex ratio of 1:2.60 (male:female).

Out of the 910 specimens of *M. macrobrachion* collected from the Epe Lagoon, 544 were males and 366 were females giving a sex ratio of 1:0.67 (male:female). The result showed that there were more females of *M. macrobrachion* from Badagry and Lagos Lagoons while in Epe Lagoon, there were more males of *M. macrobrachion* than the females. The monthly sex ratio for *M. macrobrachion* in Badagry Lagoon (Figure 2) showed that females were more than the males in the rainy season of July – December 2013 and August – September 2014.

The monthly sex ratio for *M. macrobrachion* in Lagos Lagoon (Figure 3) shows that females were more than the males in the rainy season of August – November 2013 and July – October 2014. The monthly sex ratio for *M. macrobrachion* in Epe Lagoon (Figure 4) shows that males were more than the females in the rainy season of August – November 2013; March 2014, August – October 2014 and March – April 2015.

| **Table 1. Size composition of *Macrobrachium macrobrachion* from Badagry, Lagos, and Epe Lagoons (June 2013 – May 2015).** |
|-----------------|-------------|-------------|--------------|
| **SAMPLING SITES** | **Male** | **Female** | **Combined** |
| Badagry Lagoon  | 791        | 815         | 1606         |
| Lagos Lagoon    | 216        | 562         | 778          |
| Epe Lagoon      | 544        | 366         | 910          |
| **Total**       | 1551       | 1743        | 3294         |
Figure 2. Monthly variation in sex ratio in *Macrobrachium macrobrachion* from Badagry Lagoon (June 2013 – May 2015).

Figure 3. Monthly variation in sex ratio in *Macrobrachium macrobrachion* from Lagos Lagoon (June 2013 – May 2015).

**Fecundity**

From the total 271 fecund *M. macrobrachion* that was examined from the three lagoons, 82 was recorded from Badagry Lagoon. These fecund species ranged from 6.1 to 9.8 cm (total length), 1.6–2.7 cm (carapace length) and weighed between 3.2 and 12.8 g. The fecundity varied from 2,900 to 21,400 eggs with an average fecundity of 7,399 eggs. In Lagos Lagoon, 152 fecund *M. macrobrachion* was examined for fecundity. They ranged from 4.3 to 9.0 cm (total

Figure 4. Monthly variation in sex ratio in *Macrobrachium macrobrachion* from Epe Lagoon (June 2013 – May 2015).
length), 1.3–2.5 cm (carapace length) and weighed between 1.7 and 9.3 g. The fecundity varied from 760 to 84,850 eggs with an average fecundity of 8,179 eggs. In Epe Lagoon, 37 fecund M. *macrobrachion* were examined for fecundity. They ranged from 7.5 to 9.7 cm (total length), 1.9–2.6 cm (carapace length) and weighed between 5.3 and 11.3 g. The fecundity varied from 960 to 14,300 eggs with an average fecundity of 7,144 eggs.

The Log fecundity – Log total length, Log fecundity – Log carapace length, Log fecundity – Log weight relationships are shown in Figures 5–7 (Badagry Lagoon), Figures 8–10 (Lagos Lagoon) and Figures 11–13 (Epe Lagoon), respectively. The linear regression equations were:

\[
\log Y = 3.3018 + 1.6191 \log X \\
(n = 82, R^2 = 0.2819)
\]

Figure 5. Log total length/Log fecundity relationship of *Macrobrachium*.

\[
\log Y = 2.2561 + 1.6574 \log X \\
(n = 152, R^2 = 0.0565)
\]

Figure 8. Log total length/Log fecundity relationship of *Macrobrachium*.

\[
\log Y = 3.3991 + 0.5574 \log X \\
(n = 82, R^2 = 0.2549)
\]

Figure 7. Log weight/Log fecundity relationship of *Macrobrachium macrobrachion* from Badagry Lagoon.

\[
\log Y = 3.138 + 1.8814 \log X \\
(n = 152, R^2 = 0.0763)
\]

Figure 9. Log carapace length/Log fecundity.
**Figure 10.** Log weight/Log fecundity relationship of *Macrobrachium macrobrachion* from Lagos Lagoon.

\[
\log Y = 3.1346 + 0.8124 \log X \\
(n = 152, R^2 = 0.11)
\]

**Figure 11.** Log total length/Log fecundity relationship of *Macrobrachium*.

\[
\log Y = 0.7169 + 3.3006 \log X \\
(n = 37, R^2 = 0.2291)
\]

**Figure 12.** Log carapace length/Log fecundity relationship of *Macrobrachium*.

\[
\log Y = 3.0419 + 2.1596 \log X \\
(n = 37, R^2 = 0.1243)
\]

**Badagry lagoon**

\[
\log Y = 2.2639 + 1.7499 \log X \\
n = 82, R^2 = 0.2629
\]

\[
\log Y = 2.2561 + 1.6574 \log X \\
n = 152, R^2 = 0.0565
\]

\[
\log Y = 3.138 + 1.8814 \log X \\
n = 152, R^2 = 0.0763
\]

**Lagos lagoon**

\[
\log Y = 3.318 + 1.8814 \log X \\
n = 152, R^2 = 0.0763
\]

\[
\log Y = 3.1346 + 0.8124 \log X \\
n = 82, R^2 = 0.2291
\]

\[
\log Y = 2.9435 + 1.0003 \log X \\
n = 37, R^2 = 0.1845
\]

**Epe lagoon**

\[
\log Y = 0.7169 + 3.3006 \log X \\
n = 37, R^2 = 0.2291
\]

\[
\log Y = 2.9435 + 1.0003 \log X \\
n = 37, R^2 = 0.1845
\]
The Gonadosomatic Index (GSI) of *Macrobrachium macrobrachion* from the three lagoons was examined as presented in Table 2. The GSI for *Macrobrachium macrobrachion* from Badagry Lagoon ranged from 3.17% to 22.22% with mean values of 8.48 ± 1.04%. For Lagos Lagoon, it ranged from 3.45% to 35.29% with mean values of 10.34 ± 0.44% while in Epe Lagoon, it ranged from 1.67% to 12.35% with mean values of 7.01 ± 0.44%.

Means with the same superscripts along the row were not significantly different (P > 0.05).

**Egg diameter of *Macrobrachium macrobrachion***

The measurement of the egg diameter of mature females of *M. macrobrachion* from the three lagoons is presented in Table 3. The egg diameter from Badagry Lagoon ranged from 258 to 450 µm (0.258–0.45 mm) with mean values of 351.9 ± 22.99 µm. In Lagos Lagoon,
the egg diameter ranged from 258 to 450 µm (0.258–0.45 mm) with mean values of 348.88 ± 6.32 µm while in Epe Lagoon, it ranged from 258 to 410 µm (0.258–0.41 mm) with mean values of 348.14 ± 7.93 µm.

Mean ± S.E (Standard Error)

Means with the same superscripts along the row were not significantly different (P > 0.05)

**Stages of egg development in Macrobrachium macrobrachion**

In the prawns, the gonadal development varied and the eggs when present, had various colors ranging from yellow to brown and greenish-black depending on the stages of maturity. Five stages: Stage I (Immature), Stage II (Developing), Stage III (Ripening), Stage IV (Ripe) and Stage V (Ripe and ready to be spawned) were observed throughout the study period. Stage III was most prominent while Stage II occurred least from the three lagoons. The percentage of occurrence in the different egg stages of *M. macrobrachion* are shown in Table 4, while the percentage frequency of occurrence of the egg stages are presented in Figure 14.

Epe Lagoon (June 2013 – May 2015)

**Discussion**

Sex ratio in the present study showed that there were more females of *M. macrobrachion* from Badagry and Lagos Lagoons with males dominating Epe Lagoon. The dominance of the females from these lagoons could be attributed to the vast movement of the females into their nests to spawn while the male exhibited territorial behavior [29]. Higher number of females could also be due to their movement in search of food to replenish weight loss in gonadal development and spawning. Wet season might prompt females searching for male partners for the purpose of reproduction [30]. This was in agreement with the findings of [19] for *M. macrobrachion* from Badagry Lagoon and [18] for *M. vollenhovenii* from Asejire Lake. The dominance of male over female for Epe Lagoon was similar to the work of [15] on *M. vollenhovenii* from Epe lagoon. The occurrence of more male in this lagoon could be due to the salinity of the environment being a fresh waterbody. Besides [31], opined that the differences in the salinity levels of these three lagoons could also be a major factor responsible for the sex distribution in the lagoons.

The number of fecund *M. macrobrachion* for the three lagoons could be said to be more closely related, though the species from Lagos Lagoon had the highest number of ripe eggs compared to the two other lagoons. This findings is in conformity with the work documented by [15] on *M. vollenhovenii* from Lagos Lagoon. Eni et al., 2013 reported that the number of eggs for *M. macrobrachion* from Calabar ranged from 63 to 14,531 with a mean of 4,420.58 [32];

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**Table 2.** Gonadosomatic Index (GSI) of *Macrobrachium macrobrachion* from Badagry, Lagos, and Epe Lagoons.

|                | Badagry Lagoon | Lagos Lagoon | Epe Lagoon |
|----------------|----------------|--------------|------------|
| Range (%)      | 3.17–22.22     | 3.45–35.29   | 1.67–12.35 |
| Mean (%)       | 8.48 ± 1.04^a | 10.34 ± 0.44^a | 7.01 ± 0.44^b |

**Table 3.** Diameter of eggs in mature female *Macrobrachium macrobrachion* from Badagry, Lagos, and Epe Lagoons.

|                | Badagry Lagoon | Lagos Lagoon | Epe Lagoon |
|----------------|----------------|--------------|------------|
| Range (µm)     | 258–450        | 258–450      | 258–410    |
| Mean (µm)      | 351.9 ± 22.99  | 348.88 ± 6.32 | 348.14 ± 7.93 |

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**Table 4.** Egg stages of *Macrobrachium macrobrachion* from Badagry, Lagos, and Epe Lagoons (June 2013 – May 2015).

| STAGES | BADAGRY LAGOON | LAGOS LAGOON | EPE LAGOON |
|--------|----------------|--------------|------------|
| No     | %              | No           | %          | No           | %          |
| Stage I| 74             | 44.3         | 74         | 37.3         | 27         | 26.7       | 108.3     |
| Stage II| 4              | 2.4         | 12         | 6.1          | 0          | 0          | 8.5       |
| Stage III| 79           | 47.3        | 38         | 19.2         | 67         | 66.3       | 132.8     |
| Stage IV| 6             | 3.6         | 23         | 11.6         | 2          | 2.0        | 17.2      |
| Stage V| 4              | 2.4         | 51         | 25.8         | 5          | 5.0        | 33.2      |
| Total  | 167            | 100          | 198        | 100          | 101        | 100        | 300       |
gave a range of 180–5,800 with a mean of 1,403 for *M. macrobrachion* from Niger Delta. These results were found to be less in comparison to that of *M. macrobrachion* in this study. The findings from this work showed that this species had low fecundity when compared with *M. vollenhovenii* from other works as reported by [15,33,34]. This might be due to the fact that *M. vollenhovenii* is larger than *M. macrobrachion*. However, the differences observed in fecundity might be due to differences in species, its size, environment, and season of the year. The fecundity of these species in the lagoons can be increased by ensuring that the environment is favorable for their spawning, as spawning is a function of the seasons of the year, which has a lot to do with factors, such as food availability, temperature, and photoperiod [35]. According to [36], prawns require food to grow and reproduce; hence, food deprivation was reported to reduce their rate of growth, gonad development, and total fecundity.

There is a weak correlation between fecundity and total length, fecundity, and carapace length and/or body weight for *M. macrobrachion* from the three lagoons. This implied that fecundity was not a measure of size and the relationship was insignificant. Little wonder why small-sized prawn was observed from this research to possess eggs, a similar situation also observed by [37] on *M. lamarrei* and [15] on *M. vollenhovenii* [34], reported that there was no correlation between fecundity and total weight of *M. vollenhovenii* [38], reported a decline in the number of eggs with an increase in the size of *Penaeus plebejus* and found out that this could possibly be due to ovarian senescence in large (old) females.

The result of the GSI showed that there were no significant differences (P > 0.05) in *M. macrobrachion* from Badagry and Lagos Lagoons while the GSI values from Epe Lagoon is significantly different (P < 0.05) from other lagoons. The mean GSI values in Badagry, Lagos, and Epe Lagoons were 8.48%, 10.34%, and 7.01%, respectively. The implication of this is that, the species on the average used these values of their body weight for egg production. These values are higher than that reported by [34,39] for *M. vollenhovenii* and *Penaeus kerathurus*, respectively. However [15], reported an average GSI of 4.62%, 7.64%, and 7.59% for *M. vollenhovenii* from same lagoons,
respectively, which can be said to be lower than the values reported in this study.

There were no significant differences ($P > 0.05$) in the egg diameter of *M. macrobrachion* from the three lagoons. The values of the egg diameter from this study were lower when compared to the work done by [15] on *M. volffenhovenii* but higher than that reported by [40] which ranged between 0.25 and 0.38 mm. The work of [32] suggested that the size of eggs of *M. macrobrachion* for Luubara creek was from 0.40 to 0.78 mm.

The eggs are slightly elliptical in shape and it was initially yellow in color, then the color gradually changed to brown and finally to a greenish-black in a few days before hatching as was also observed by [41]. The color changes are caused by absorption of the yellow yolk and development of dark pigment in the eyes and on the body of the embryos [42]. In this study, the stages of egg development showed that the Stage III was most prominent while Stage II occurred least from the three lagoons.

**Conclusion**

The findings from this work gave a comparative studies on the aspects of the bionomics of *M. macrobrachion* from three interconnecting lagoons. In this research, apart from the occurrence of more females in Badagry and Lagos Lagoons, it was also observed that more fecund eggs were found in the species from Lagos Lagoon. It can be deduced that *M. macrobrachion* is not as fecund as *M. volffenhovenii* of the same genus *Macrobrachium*. All these variations might be attributed to differences in the species, size, and environment with which they occur and as well as the season of the year in which they were collected. Therefore, the scientific observations documented in this study, will serve as important references in the species assessment, cultivation, management, and conservation of the prawn fisheries.

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**Disclosure statement**

No potential conflict of interest was reported by the author(s).

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