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# Seasonality Effect on Habitat Status of Macrobrachium prawns on a Section of Ogun-Osun River Basin Channel, Nigeria

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**Abstract**
The effect of seasonal changes on habitat conditions and biological well-being of *Macrobrachium prawns* on a section of Ogun-Osun River Basin Channel, Southwestern Nigeria was investigated between June, 2015 and April, 2017. Morphological characterization of specimens collected revealed two populations of prawns in the *genus Macrobrachium* (*M. macrobrachion* and *M. vollenhovenii)* foraging together on this location. The study revealed that there is no significant variation (P>0.05) in the water quality parameters between seasons while sediment textural compositions vary significantly (P>0.05) between seasons. *M. macrobrachion* were more abundant in rainy seasons while *M. vollenhovenii* were more in dry seasons. However, condition factor (k) of the two prawns was better in rainy seasons than dry seasons. Results from this study revealed that seasonality affects habitat compositions and biological well-being of *Macrobrachium prawns*. Consequently, scientific observations recorded in this study will serve as important references in cultivation, assessment and management of prawn fisheries.
**Key words:** Habitat, Seasons, *Macrobrachium* prawns, Ogun-Osun River Basin Channel, Nigeria.

## 1.Introduction

The genus *Macrobrachium* is the largest in the family Palaemonidae (New 2002), with about 200 species so far identified (Jayachandran 2001). In the West African region, members of this genus have been reported across countries in the Eastern Atlantic region (Holthuis 1980). Most species in this genus require brackish water during the initial stages of their life-cycle, and so are found in water that is directly or indirectly connected to the sea (New 2003). However, landlocked populations of *M. vollenhovenii* in upland areas exist and are observed to complete their entire life cycle in freshwater (Anetekhai 1986; Marioghae 1990).

*M. vollenhovenii* and *M. macrobrachion* are believed to be the two largest members of this genus found foraging around estuaries and other inland water systems in Nigeria. Scientific observations have revealed that habitat compositions peculiar to an organism in their various environment usually influence development of adaptive traits (Magalhães 2000). Consequently, habitat peculiarities are influenced by environmental factors. Environmental factors, such as: temperature, pH and salinity may impose great influence on habitat well-being of ectotherm organisms (Schmidt- Nielsen 1997). In the tropics, these factors may be subject to seasonal fluctuations.

One of the most striking characteristics of prawn populations in the tropics which differ most from those of temperate stocks is their seasonality (Garcia 1985). Because of their short lifespan; the abundance, mean size and other parameters of prawn stocks vary greatly from season to season (Garcia 1985). Marioghae & Ayinla, (1995), observed that *M. vollenhovenii* and *M. macrobrachion* breed throughout the year but have their peak in rainy seasons. Nwosu and & Wolfi (2006), also studied the seasonality effect on the growth and population pattern of *M. vollenhovenii* in the Cross River Estuary, Nigeria and discovered that breeding cycle of the prawns falls within peak of the rainy seasons ranging from the month of May and progressively increases in amplitude to its first and second peak in the months of July and October. Garcia (1985) emphasized that although, lunar cycles are observed in molting, reproduction and migration, however, it can be disregarded, but seasonality is a key phenomenon in activities such as; spawning, recruitment, population age structure, catch ability, and so cannot be neglected.

Several authors have worked on aspects of biology of *Macrobrachium* prawns in Nigeria but much emphasis has not been placed on understanding the biology of these prawns in relation to the seasonal changes in their habitats. This is why this study is designed to examine seasonality effect on the habitat status of *Macrobrachium prawns* around the inter-phase of Ogun-Osun River Basin Channel tributary (Osun River) and Lekki lagoon, Nigeria.

## 2. Methodology

### 2.1Description of Study Location

This study location is a section of Ogun-Osun River Basin Channel around Itokin community, Lagos State,

Nigeria. It is a major tributary of River Osun which opens into Epe lagoon through Oruba riverine community on its left axis and Lekki Lagoon through Orugbo riverine community on its right axis. Three sampling sites were established along this river course and were designated into Upstream-**Itokin Section of Osun River** –bordered geographically by latitude N06$^0$37.972' and longitude E003$^0$47.994'**,** Midstream-**Oruba Section of Epe and Lekki Lagoon Confluence** with proximity to Epe Lagoon – bordered geographically by latitude N06$^0$37. 292' and longitude E 003$^0$ 48.505' and Downstream-**Orugbo Section of Lekki Lagoon** with proximity to Lekki Lagoon **–** bordered geographically by latitude N06$^0$37.2161'and longitude E003$^0$47.692'. This section of Ogun-Osun River Basin channel starting from Itokin through Oruba and Orugbo communities are exclusively fresh water ecosystem covered with high density of riparian vegetation consisting of white mangrove forest, nympha palms, palm trees, bamboo trees, and a robust diversities of aquatic weeds and emergent trees forming protective canopies on both sides of the river course and houses vast biodiversities of aves, reptiles and other aquatic wildlife. The elevation of this study location is 3 meters above sea level.

**2.2.1 Water Quality Parameters and Chemistry**

Analysis of some water quality parameters at sampling sites were carried out in-situ using Hydro lab water quality meter (Electronic Probe Type Hanna H198106 model). These measurements were done in triplicates at each sampling station. Records of these measurements were taken on seasonal basis over 24 months of study. The parameters measured are: Temperature ($^0$c), pH, Conductivity (mΩ/cm), Dissolved Oxygen (ppm), Salinity (%) and Total Dissolved Solid (ppm). Colorimetric Test kit methods (Pond Lab NT200) were also in-situ engaged to determine water chemistry values for Total water Hardness (ppm), Alkalinity (ppm), Ammonia level (ppm), Nitrate and nitrite levels (ppm). Titrimetric method was used to analyze for Sulphates (ppm), Carbonates (ppm) and Phosphates (ppm).

**2.2.2 River Sediment Texture and Chemistry**

Textural and chemical analyses of river sediments across the designated sampling stations were also analyzed on seasonal basis. Samples were collected and analyzed according to the methods described in International Institute of Tropical Agriculture Laboratory Manual on Soil and Plant Analysis (IITA 1979). Sediment samples were collected in triplicates at each sampling stations in labeled polyethylene bags and kept in lidded plastic containers based with ice. After routing laboratory sample treatments, Sediments Bulk Density were evaluated by the formula:

A. **Bulk density ($D_b$)** = $\dfrac{\text{Weight of oven-dry soil}}{\text{Volume of oven-dry soil}} = \dfrac{w3 - w1}{V}$ (1)

B. **Particle–size analysis** was used to determine the textural classifications of the river sediments. The Hydrometer method was employed to flocculate the river sediment while the United States Department of Agriculture Classification Technique (USDA) was used to fractionalize the sediment into their respective textural classes.

C. **The sediment pH** was determined by the use of Hanna 211 microprocessor electronic pH meter with model number T106018. The microprocessor unit was first inserted into a calibration buffer to set the scale reading to neutral pH (7.0) after which the microprocessor was inserted into the sediment to determine the actual reading through the electronic meter attachment.

D. **Sediments organic matter compositions** were determined using the Walkley-Black Wet Oxidation Method which utilizes the redox potentials of potassium dichromate (vi) ions ($K_2$ $cr_2$ $0_7$) to determine the percentage (%) organic carbon in the sediment. Thus the percentage organic matter in the sediment was calculated with the following formula:
**% Organic Matter = % organic carbon x 1.724 (Correction co-efficient)**
(IITA, 1979 & Ibitoye, 2006). (2)

**2.2.3Prawn Sampling Techniques**

Prawn specimens were collected with the assistance of fishermen fishing on this study location. Prawn basket traps were used across the three sampling stations established for specimen collection. Traps were set on river substrate and left for minimum of 72 hours or more before being hulled up to collect the catches. Catches were transported life to the shore where they were identified morphologically using the descriptions of Powell, (1982). They were then preserved in labeled sample bottles containing 10% formaldehyde solution for further laboratory based studies.

**2.2.4Seasonal Relative Abundance Estimation (SRAE)**

Seasonal relative abundance based on catch statistics of species and sex delineation of specimens already identified to species level is mathematically expressed with the formula:

$$\%\ R.A = \frac{AU+AM+AD}{Y} \times 100 : \frac{BU+BM+BD}{Y} \times 100$$

Where:

$$Y = A' + B' \quad (3)$$

Y is the gross seasonal catch of the identified specimens
A' is the total seasonal catches of specimen belonging to a species group for the three sampling stations and is expressed as: A' = AU + AM +AD
B' is the total seasonal catches of specimen belonging to another species group for the three sampling stations and is also expressed as: B' = BU + BM + BD

**2.2.5Seasonal Population Size Structure Determination**

Metric measurements of total lengths were recorded for specimens of the identified species group collected for the two seasons. The total lengths (mm) were measured using vernier caliper to nearest 1mm from the tip of the rostrum to the base of the tip of telson. Data obtained from measurements of lengths were used for the establishment of size structure of the stock in sampling locations following the method employed by Edokpayi, (1989) on length - frequency classification of prawn into different age groups. Where;

a. Prawn of size range of 10-30mm are classified as juveniles
b. prawn of size range of 31-80mm are classified as young adults
c. prawn of size range of 81-120mm are classified as old adults

Data obtained for each species were then compared to understand their seasonal relativity and provide clues on their stock structure and recruitment pattern based on seasons.

**2.2.6Determination of Relative Co-Efficient of Condition Factor**

Measurement of condition factor (relative robustness that is; the degree of well-being of the prawn samples) in this study location was carried out with respect to seasons. The condition factor (k) was calculated by using the formula;

$$K = \frac{100{,}000W}{L^3} \quad (4)$$

Where: $W$ = the weight of the prawn in grams;
$L$ = the standard length of the prawn in millimeters.

A condition factor plot was obtained using Microsoft Office Excel package, (2010) to compare rainy and dry seasons' data.

**2.2.7 Fecundity Determination**

Fecundity rate was evaluated by gravimetric method. The eggs were carefully removed from the ovarian tissues and put inside labeled EDTA free specimen bottles. The specimen bottles containing the eggs were corked and then chilled in a refrigerator for an hour. These were transferred into a freeze-dryer machine (Labfreez with model number FD-12-MR) operated at a temperature of $-45^0$C for 2 hours. The samples were then exposed to dry air in the specimen bottle for 24 hours. The total weight of eggs in each specimen bottles was obtained using a Mettler weighing balance (Sartorius Model Number E12000). Random sampling of about 500 eggs were done for samples in each specimen bottle and weighed. The total numbers of eggs in the ovaries were then evaluated with the equation;

$$F = nG/g \quad (5)$$

Where F = fecundity, n = number of eggs in the subsample, G = total weight of the ovaries, g = weight of the subsample in the same units.

Average fecundity was then obtained based on seasonality and age classes of the identified species.

## 3. Results

Results on seasonal averages for water quality parameters on the section of Ogun-Osun River Basin Channel designated for this study revealed that there is no significant variation ($P>0.05$) in both physical and chemical properties of the river following mild seasonal fluctuations (Table 1). Analysis of parameters on river sediments also revealed no significant variations ($P>0.05$) between seasons. However, the river sediments' pH was observed to range between $5.94\pm0.16^a$ to $5.29\pm0.27^a$ and $4.48\pm0.58^a$ to $5.65\pm0.81^a$ at both seasons for the two years of study, and texturally ranged from sandy loam to sandy clay loam from dry to rainy season (Tables 2 & 3). Seasonal relative abundance for catch statistics of species observed in this study showed that higher percentages of *M. vollenhovenii* were caught during dry seasons than rainy seasons. Subsequently, higher percentages of *M. macrobrachion* were recorded in catch statistics during the rainy seasons (Table 4.0). Results on seasonal population structure (relative to age classes of prawns that appeared in catches) revealed that juvenile sizes (0-30mm) were totally absent (0%) in catches for both species at respective seasons. The young adults' population (31-80mm) for *M. macrobrachion* was consistently more abundant in catches at both seasons (Figure 1a). Consequently, percentage population of young adults was also observed higher in abundance than that of old adults during the rainy seasons for *M. vollenhovenii* while old adults of this prawn had higher abundance percentages during dry seasons (Figure 1b). Average length and weight statistics for both species revealed higher length and weight values for specimen collected during rainy seasons than dry seasons (Tables

5a & 5b). Condition factor (k) values for both specimens were higher during rainy seasons (Figures 2a & 2b). Fecundity estimation for *M. macrobrachion* revealed that average egg carrying ability for young adults ranged from 1,059 to 1,496 oocytes, while that of old adults ranged from 2,475 to 4,398 oocytes and that berried females are only collected during rainy seasons. Also, fecundity estimates for young adults of *M. vollenhovenii* ranged from 1,166 to 1,347 oocytes while old adults revealed an estimate range of 4,128 to 12,155 oocytes. Berried females for *M. vollenhovenii* are observed at both rainy and early dry season months (Table 6).

## 4. Discussion

The study on the effect of seasonality on habitat status of *Macrobrachium* prawns around the Osun River tributary (inter-phase between Lekki and Epe lagoons) on the Ogun-Osun River Basin Channel, Nigeria, was conducted between the months of June, 2015 and April, 2017. Two species of prawns in the *genus Macrobrachium* (*M. macrobrachion* and *M. vollenhovenii*) were identified in catches throughout the entire period of study. In-situ and laboratory assessments of water quality on this study location revealed that there is no significant variation ($P>0.05$) in physical and chemical properties between seasons, although mild fluctuations were observed in average monthly and seasonal statistics of parameter values. Consequently, seasonal amplitudes of fluctuations in water quality parameter values were within the tolerance thresholds reported for fresh water prawns by Marioghae (1987). These were also observed to range within recommended thresholds for fresh water aquaculture as reported by Boyd (1990) and Swan (1993). Observations on the river sediments' chemical and physical compositions revealed that there are no significant seasonal variations ($P>0.05$) in parameters and that the sediments' pH is weakly acidic at both seasons. On the contrary, the soil textural compositions vary with seasons as the textural classifications vary from sandy loam at dry season to sandy clay loam at rainy season. Uwadiae (2010) observed that the nature of aquatic sediments is usually influenced by the geology of the environment. Nwilo & Onouha (1993) also emphasized that sediments found around Nigeria coastal lagoons is hydromorphic, clayed and sandy and impose great influence on the distribution and diversities of benthic fauna. Relative abundance of species was influenced by season. Catch statistics of *M. macrobrachion* showed higher percentage abundance at rainy seasons while *M. vollenhovenii* showed higher percentage abundance during the dry seasons. This result is synonymous with the discovery of Edokpayi & Victor (2005) on the ecological study of *M. macrobrachion* at Benin River, Koko, South western, Nigeria. He observed that the recruitment of young prawns and its overall catch statistics was significantly higher during rainy season. The results for *Macrobrachium* prawns in this study based on seasonal catch statistics also aligned with the above findings as higher percentages of young adults of *M. macrobrachion* and *M. vollenhovenii* are collected at rainy seasons than dry seasons (Figures 1a & 1b). This result emphasizes that seasonality influences population size structure of *Macrobrachion* prawns. Average seasonal lengths and weights measurements-cum-condition factor (k) records indicated that lengths and weights of the two prawns increased in values from dry seasons to rainy seasons (Tables 5a & 5b). However, estimated (k) values for both species were higher at rainy seasons than dry seasons (Figures 2a & 2b). These results showed that lengths and weights for the two prawn species increased progressively from dry season to rainy season as water level, foraging interspace and food availability increases bringing about increase in condition factor at rainy seasons. Lawal-Are and Owolabi (2012) observed that (k) values of *Macrobrachium* prawns collected from both Lekki and Lagos lagoons decreases with increasing sizes. This phenomenon is not unlikely especially when the population under study is within the age bracket that requires length to increase more rapidly than the weight. However, seasonal changes from dry to rainy season support increase in (k) values. Furthermore, observations on fecundity estimation in this study revealed that seasonality, species ability, body sizes and age of females affect prawn fecundity. This supports the observation of Eni *et. al.,*(2013). Also, most berried female specimens for the two species were caught during rainy seasons. However, female specimens of *M. vollenhovenii* were observed ovigerous at early dry season months between November and January. Marioghae & Ayinla, (1995) had also been reported to pick ovigerous females during the months of December and January which is supposed to be off-breeding season.

## 5. Conclusion

Seasonality has been observed as a key phenomenon in understanding the habitat and biological status of *Macrobrachium* prawns in tropical regions as reported in this study. Scientific observations documented in this study may serve as references for prawn fishery management and conservation purposes. The results also project important ecological and biological information useful in simulation of culture environment for domestication of *Macrobrachium* species.

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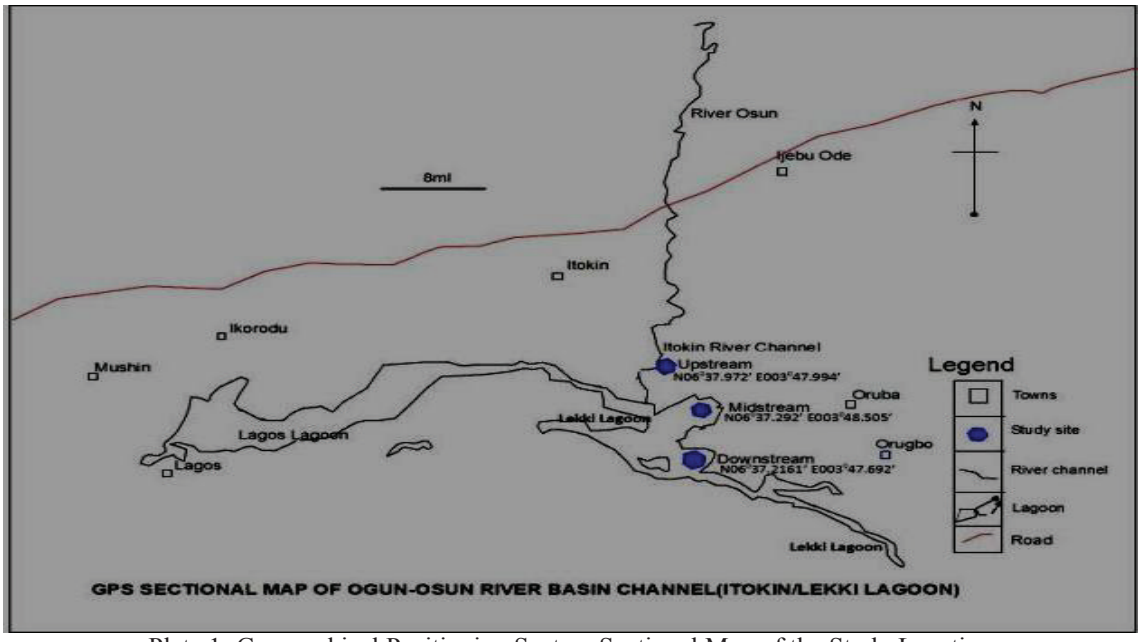


Plate 1: Geographical Positioning System Sectional Map of the Study Location

**Table 1: Seasonal Average of Water Quality Parameters for Habitat Study of *Macrobrachium Prawns* on Designated Sections of Ogun-Osun River Basin Channel, Nigeria for the Two Years of Study**

| R QUALITY PARAMETERS | OGUN-OSUN RIVER BASIN CHANNEL, NIGERIA | | | |
|---|---|---|---|---|
| | SAMPLING YEAR 1 MEAN±S.D | | AMPLING YEAR 2 MEAN±S.D | |
| | EASON 1 | SEASON 1 | EASON 2 | SEASON 2 |
| Temp ( $^0$C ) | 2.24$^a$ | 0.94$^a$ | .08$^a$ | .88$^a$ |
| pH | 25$^a$ | 31$^a$ | 54$^a$ | 35$^a$ |
| Conductivity (Mμ-Cm) | ±0.00$^{ab}$ | ±0.00$^a$ | ±0.00$^b$ | ±0.00$^{ab}$ |
| D.O$_2$ (ppm) | 51$^a$ | 03$^a$ | 08$^a$ | 01$^a$ |
| Salinity (ppm) | 41$^a$ | 03$^a$ | 01$^a$ | 03$^a$ |
| Tds (ppm) | ±412.04$^a$ | ±43.81$^a$ | 0.99$^a$ | ±63.99$^a$ |
| Hardness (ppm) | 61.66$^a$ | 10.27$^a$ | 0.00$^a$ | 18.42$^a$ |
| Alkalinity (ppm) | 6.85$^b$ | 27.18$^a$ | 10.27$^a$ | 3.42$^b$ |
| Ammonia (ppm) | 00$^a$ | 00$^a$ | 17$^a$ | 15$^a$ |
| Nitrates (ppm) | 40$^a$ | 92$^a$ | 01$^a$ | 47$^a$ |
| Nitrites (ppm) | 14$^a$ | 47$^a$ | 00$^a$ | 47$^a$ |
| Sulphates (ppm) | 0.19$^a$ | ±0.70$^d$ | ±0.70$^c$ | 0.65$^b$ |
| Carbonates (ppm) | 6.45$^a$ | 1.50$^a$ | 11.52$^a$ | 18.28$^a$ |
| Phosphates (ppm) | 00$^a$ | 00$^a$ | 00$^a$ | 05$^a$ |

- S.D. = Standard Deviation of the Mean
- Duncan Multiple Range Test (P = 0.05)
- Means with different superscripts are significantly different across rows at P≤0.05.
- Mean value equal to 0.00 connotes undetected parameter

**Table 2: Comparative Analysis of River Sediments Chemistry and its Physical Properties for Habitat Study of *Macrobrachium Prawns* at Selected Locations on Ogun-Osun River Basin Channel, Nigeria, based on Sampling Seasons**

| R QUALITY PARAMETERS | OGUN-OSUN RIVER BASIN CHANNEL, NIGERIA | | | |
|---|---|---|---|---|
| | SAMPLING YEAR 1 MEAN±S.D | | AMPLING YEAR 2 MEAN±S.D | |
| | EASON 1 | SEASON 1 | EASON 2 | SEASON 2 |
| Moisture ( % ) | .54[a] | .16[a] | .04[a] | .29[a] |
| pH | 16[a] | 27[a] | 56[a] | 81[a] |
| Organic Matter (%) | 35[b] | 70[a] | 34[b] | 63[b] |
| Bulk Density (g/cm$^3$) | 26[a] | 08[a] | 10[a] | 01[a] |

- Duncan Multiple Range Test (P = 0.05)
- Means with different superscripts are significantly different across rows at P≤0.05.
- Mean value equal to 0.00 connotes undetected parameter
- S.E. = Standard Error of the Mean

**Table 3: Seasonal Variations in River Sediments Textural Properties on Ogun-Osun River Basin Channel, Nigeria**

| SAMPLING LOCATIONS | | DRY SEASON | | | TEXTURAL CLASS | RAINY SEASON | | | TEXTURAL CLASS |
|---|---|---|---|---|---|---|---|---|---|
| | | TEXTURAL PROPERTIES (MEAN±S.E) | | | | TEXTURAL PROPERTIES (MEAN±S.E) | | | |
| | SAMPLING YEAR | SAND (%) | SILT (%) | CLAY (%) | | SAND (%) | SILT (%) | CLAY (%) | |
| Ogun-Osun River Basin Channel, South Western Nigeria | 1 | 45.45±5.85 | 46.14±6.51 | 8.39±0.55 | Loam | 50.70±17.49 | 27.17±5.58 | 22.12±4.97 | Sandy clay loam |
| | 2 | 55.00±4.16 | 33.33±5.08 | 11.66±0.92 | Sandy loam | 47.88±5.33 | 26.66±3.58 | 14.44±1.34 | Sandy clay loam |

- Results are presented as a measure of percentage mean composition
- S.E = standard error of mean

**Table 4: Relative Abundance Statistics of *Macrobrachium* Species on Ogun-Osun River Basin Channel, Nigeria based on Seasonality of Sampling**

| ES RELATIVE ABUNDANCE (%) | OGUN-OSUN RIVER BASIN CHANNEL, NIGERIA | | | |
|---|---|---|---|---|
| | SAMPLING YEAR 1 | | AMPLING YEAR 2 | |
| | EASON 1 | SEASON 1 | EASON 2 | SEASON 2 |
| *M. macrobrachion* | | | 5 | .13 |
| *M. vollenhovenii* | | | 5 | .55 |

 

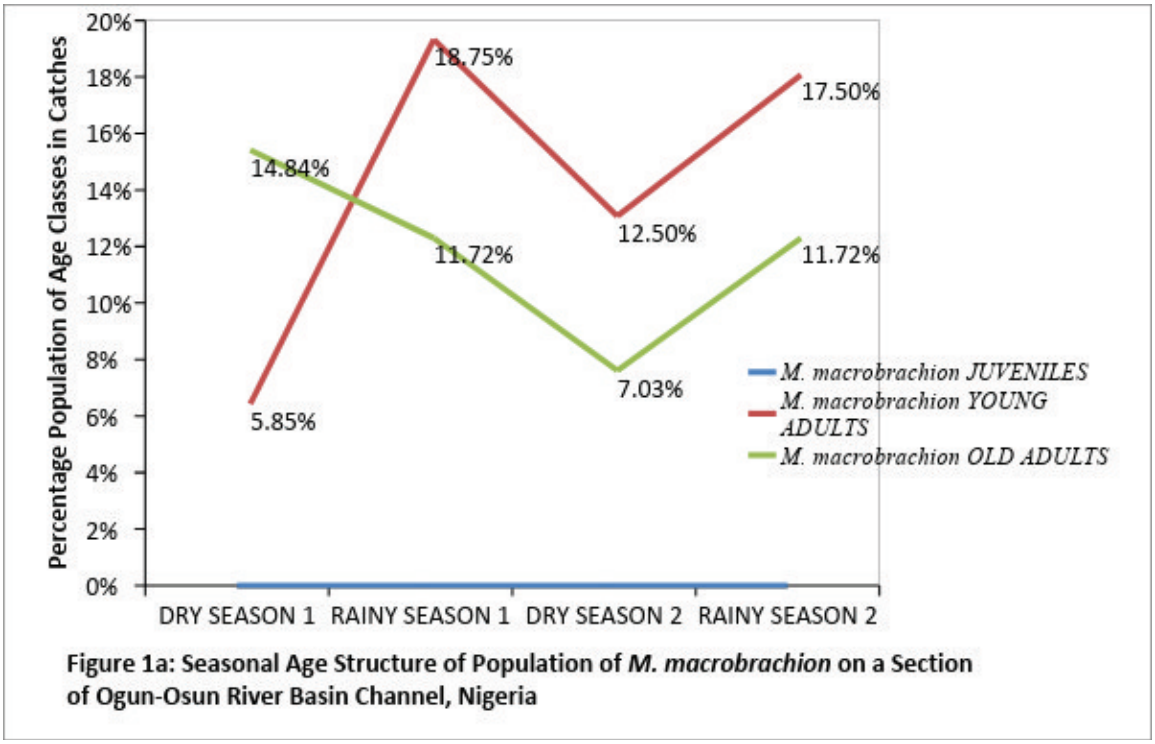


**Figure 1a: Seasonal Age Structure of Population of *M. macrobrachion* on a Section of Ogun-Osun River Basin Channel, Nigeria**

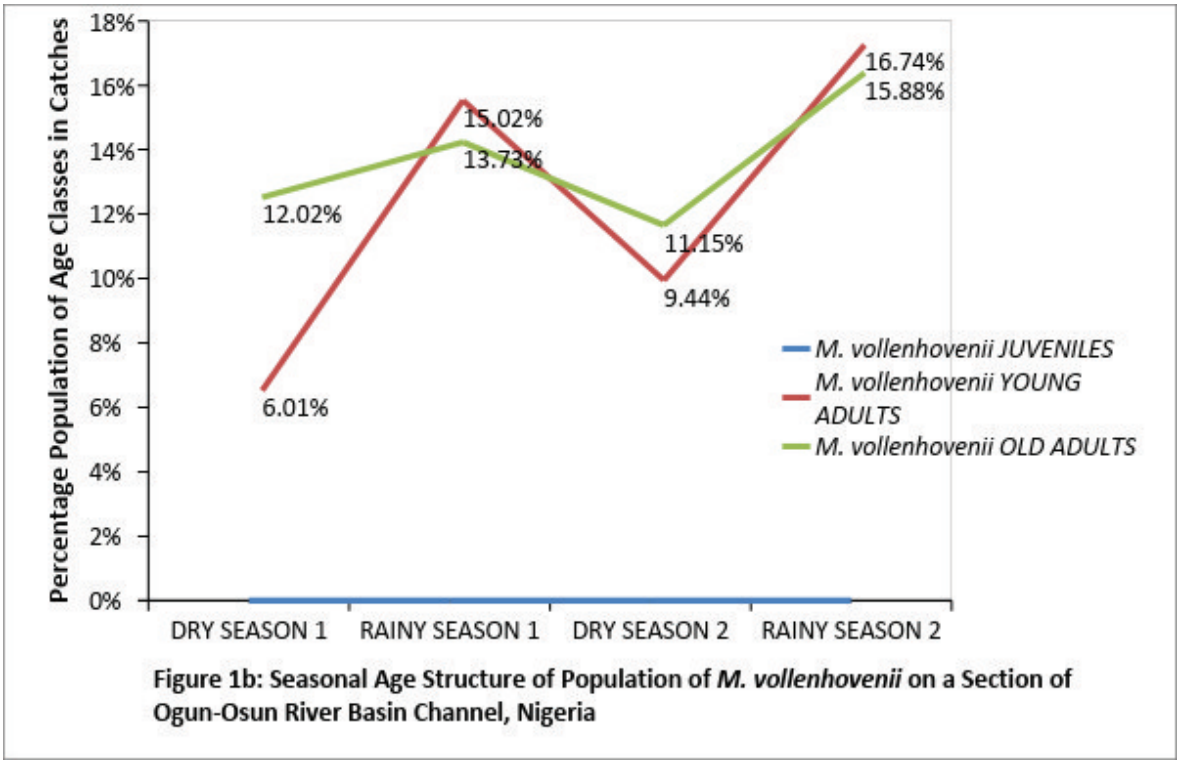


**Figure 1b: Seasonal Age Structure of Population of *M. vollenhovenii* on a Section of Ogun-Osun River Basin Channel, Nigeria**

**Table 5a: Average Seasonal Length-Weight Statistics of Species of *Macrobrachium Prawns* collected on Ogun-Osun River Basin Channel, Nigeria**

| CIES | OGUN-OSUN RIVER BASIN CHANNEL, NIGERIA | | | | |
|---|---|---|---|---|---|
| | METRICFEATURES | SAMPLING YEAR 1 MEAN±S.D | | AMPLING YEAR 2 MEAN±S.D | |
| | | EASON 1 | SEASON 1 | EASON 2 | SEASON 2 |
| *M. macrobrachion* | (mm) | .77 | 8±10.54 | ±8.43 | ±13.20 |
| | (g) | .51 | 3±4.56 | -1.32 | -5.52 |

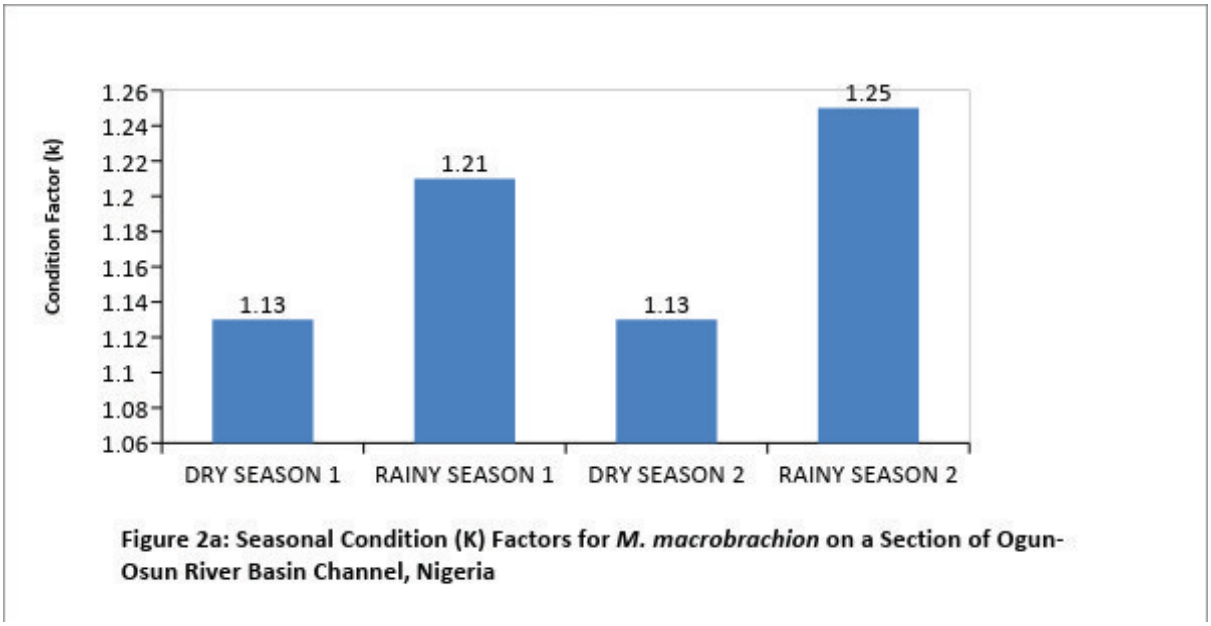


Figure 2a: Seasonal Condition (K) Factors for *M. macrobrachion* on a Section of Ogun-Osun River Basin Channel, Nigeria

**Table 5b: Average Seasonal Length-Weight Statistics of Species of *Macrobrachium Prawns* collected on Ogun-Osun River Basin Channel, Nigeria**

| ES NAME | OGUN-OSUN RIVER BASIN CHANNEL, NIGERIA | | | | |
|---|---|---|---|---|---|
| | METRIC FEATURES | SAMPLING YEAR 1 MEAN±S.D | | AMPLING YEAR 2 MEAN±S.D | |
| | | EASON 1 | SEASON 1 | EASON 2 | SEASON 2 |
| *M. vollenhovenii* | (mm) | .51 | 2±10.19 | ±13.86 | ±15.70 |
| | (g) | .31 | 7±5.57 | -4.53 | -5.46 |

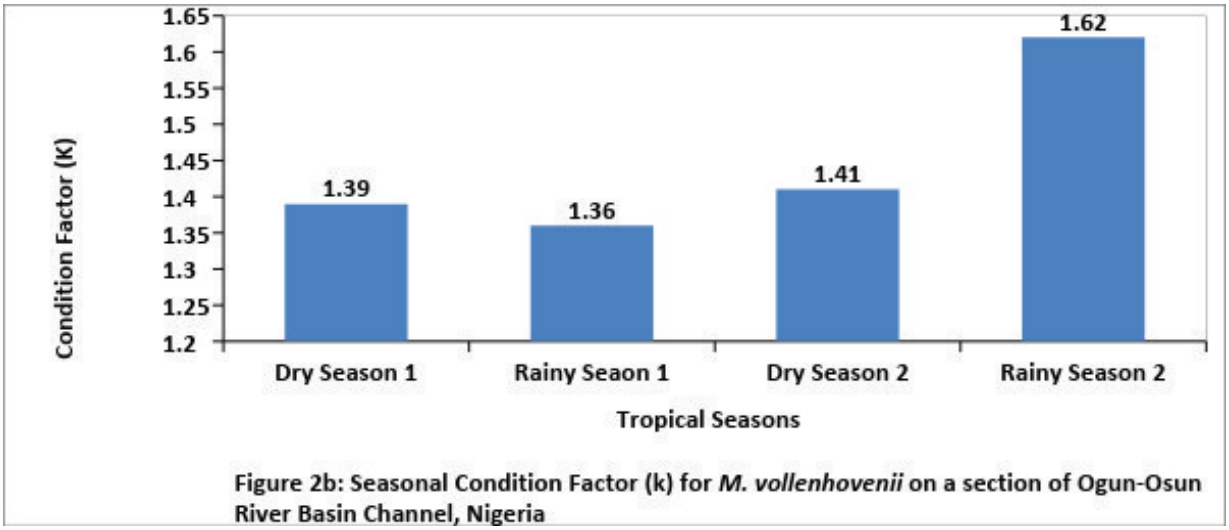


Figure 2b: Seasonal Condition Factor (k) for *M. vollenhovenii* on a section of Ogun-Osun River Basin Channel, Nigeria

**Table 6: Fecundity Estimation for Species of *Macrobrachium* prawns collected from a Section of Ogun-Osun River Basin Channel, Nigeria based on their Age Class distribution and Seasonality of Sampling**

| IFIED PRAWN SPECIMEN | NDITY ESTIMATION FOR *MACROBRACHIUM PRAWNS* SPECIMENS ON OGUN-OSUN RIVER BASIN CHANNEL, NIGERIA | | | |
|---|---|---|---|---|
| | DRY SEASONS | | RAINY SEASONS | |
| | NG ADULT | ADULT | G ADULT | D ADULT |
| *M. macrobrachion* | | ,266 | 8 | 3,437 |
| *M. vollenhovenii* | | ,112 | 8 | 12,155 |

**YOUNG ADULT = 31- 80MM**
**OLD ADULT = 81MM AND ABOVE**