Global Science Research Journals

Available online at
www.globalscienceresearchjournals.org

Full Length Research Paper Open Access

Global Journal of Fisheries and Aquaculture

ISSN : 2408-5464, Vol. 8 (1). Pp. 533-540
February, 2020

Morphological studies of *Macrobrachium macrobrachion* and *Macrobrachium vollenhovenii* from Badagry Creek, Lagos, Nigeria: Need for conservation

Abayomi Abdul-Azeez Jimoh* and Magret Abosede Lawal

Department of Fisheries, Lagos State University, Ojo, Lagos, Nigeria
*Corresponding Author: Abayomi A. Jimoh, Department of Fisheries, Lagos State University, PMB 0001, LASU Post Office, Ojo, Lagos, Nigeria
princeaajimoh@yahoo.com; +2348080337152

Accepted 9 February, 2020

ABSTRACT

Prawns are of nutritional and economic importance, while morphological studies aid in the proper identification of organisms. Thus, considering the importance of prawns and need to provide morphological information, 150 samples of *Macrobrachium macrobrachion* and 100 samples of *M. vollenhovenii* were collected from fishmongers along Badagry Creek and examined for meristic and morphometric features. *M. macrobrachion* and *M. vollenhovenii* exhibited negative allometry with "b" values of 2.51 and 1.48 respectively. Males of both prawns were larger than the females. There was a high and positive correlation between total length and carapace length (*M. macrobrachion*, r = 0.84; *M. vollenhovenii*, r = 0.85) and between total length and rostral length (*M. macrobrachion*, r = 0.82; *M. vollenhovenii*, r = 0.80). Both prawns had more spines on the dorsal than the ventral side of the rostrum. Males predominated over females with a sex ratio of 1:1.83 (*M. macrobrachion*) and 1:1.08 (*M. vollenhovenii*). At 5% level of significance, there was a significant difference in the sex ratio recorded for *M. macrobrachion*, but there was no significant difference for *M. vollenhovenii*. The negative allometry recorded for both *M. macrobrachion* and *M. vollenhovenii* from Badagry Creek might suggest an over-exploitation of these prawns and reduction in natural productivity of the Creek as a result of anthropogenic activities; therefore, it is important that measures be put in place to address these possible causes with a view to ensure the survival and availability of these prawns.

Keywords: Morphological, *Macrobrachium macrobrachion*, *Macrobrachium vollenhovenii, Badagry* Creek, Conservation

INTRODUCTION

Macrobrachium species are decapod crustaceans belonging to the family Palaemonidae. These prawns are of high economic importance globally and have been subjected to intense aquacultural practices across the world. *Macrobrachium* species are found across the West African coast (Jimoh et al., 2005), and, in Nigeria, have been reported to have an extensive distribution across the southern region of Nigeria (Akintola and Bakare, 2011). Bello-Olusoji et al. (2004) reported four species of *Macrobrachium* in Nigeria, which are *M. vollenhovenii, M. macrobrachion, M. felicinum* and *M. dux*, with *M. vollenhovenii* and *M. macrobrachion* being the largest.

Both *M. vollenhovenii* and *M. macrobrachion* have aquaculture potentials; consequent upon which several researchers have reported on their biology. Molecular studies have also been used to characterize these prawns (Jimoh et al., 2013; Makombu et al., 2019); however, due to the huge expenses involved in molecular characterization, several authors have resorted to morphological studies. Such studies include those of

Jimoh et al. (2012), Konan et al. (2017), Adite et al. (2013) and Eniade et al. (2019). Morphological characters are generally divided into two major categories *viz* morphometric and meristic. Measurable characters are referred to as morphometric characters while countable characters are known as meristic characters. Morphometric analysis and relative growth studies are widely used in decapod crustaceans (Loveth and Felder, 1989) because of the possibility of changes related to sex, environmental conditions, food consumption, reproduction and genetics (Konan et al*.,* 2017). Jayachandran and Joseph (1988) also reported that variations in the growth of individual prawn or group of prawns can be measured using morphometric relationships. Furthermore, morphological studies are useful in the study of seasonal variations in growth (Rickter et al*.,* 2000) and estimation of weight from length (Beyer, 1991). Santos et al. (2002) and Rahman et al. (2004) also reported that allometry is an important factor for biological, physiological and ecological processes, and fisheries assessments.

Using morphological studies, Jimoh et al. (2012) reported low mean prawn size for the *Macrobrachium* stock in Badagry Creek as a result of possible over-exploitation; this study therefore was a follow-up study on the morphology of these palaemonid prawns and the implications for conservation of the *Macrobrachium* stock in the Badagry creek.

MATERIALS AND METHODS

Sampling Station

Badagry Creek (Figure 1) is a part of the network of creeks, rivers and lagoons in Lagos, southwest Nigeria. The creek lies between latitudes 6º 22' and 6º 42'N and longitude 2º 42' and 3º 42'E (Agboola et al., 2008). It is a long stretch of water body covering about a distance of 106.5 kilometers. The major sources of waters into the creek are River Queme and Nakoue lagoon. It is the combination of these two water bodies that form the Badagry creek which joins part of the continuous lagoon known as Osa lagoon that stretches from Porto Novo to Lagos (Aderinola et al., 2013). The creek opens into the Atlantic Ocean via the Lagos harbour. The creek is shallow with irregular topography and the average water depth of Badagry creek is about 3.5m (Ajani and Balogun, 2015). The Creek is approximately equidistant from the entrances of Lagos and Cotonou harbours. The climate around Badagry creek is characterized by two seasons – rainy season which lasts from May - October and dry season from November – April (Jimoh et al., 2019).

Collection of Samples

One hundred and fifty (150) samples of *Macrobrachium macrobrachion* and one hundred (100) samples of *M. vollenhovenii* were collected from Badagry Creek for the morphological studies. The prawns which were caught with baited non-return valve traps were purchased from fish mongers along the Badagry Creek and transported on ice to the Fisheries laboratory of the Lagos State University for analysis. Identification of the specimens was done using Marioghae (1990) as a guide.

Morphometric and Meristic Measurements

The samples of *M. macrobrachion* and *M. vollenhovenii* were examined for morphometric and meristic features. The morphometric features examined were total length (from tip of rostrum to the tip of telson) with a transparent 30cm ruler, carapace length (from eye socket to mid-dorsal margin of carapace) and rostral length (from the tip to the posterior margin of the orbit) were measured with dividers. The carapace length and rostral length were then determined by putting the dividers to a 30cm ruler and the measurements recorded. The total length, carapace length and rostral length were measured to the nearest 0.1cm while the body weight was measured to the nearest 0.01g with a top-loading Mettler balance (Model PE 1600). The meristic features counted were the number of spines on the dorsal and ventral sides of the rostrum.

Total Length-Body Weight Relationship

The relationship between total length and body weight of *M. vollenhovenii* and *M. macrobrachion* were studied and represented by the equation:

$W = a + L^b$ (Le Cren, 1951)

where W = body weight (g), L = total length (cm), a = regression constant and b = regression coefficient.

The equation was further transformed into a linear regression equation as:

$\log W = \log a + b \log L$

Total Length-Carapace Length and Total Length-Rostral Length Relationships

The total length-carapace length and total length-rostral length relationships were studied using the equation:

$Y = a + bx$

where Y = dependent variable (carapace length/rostral length), X = independent variable (total length), a = regression constant and b = regression coefficient. This was transformed into a linear regression equation as: $\log Y = \log a + b \log X$

Determination of Sex Ratio

Samples of *M. macrobrachion* and *M. vollenhovenii* were separated into male and female by visual examination of the abdomen for the presence of eggs. Further separation was done using Anetekhai (1990) as a guide. The differences in the sex ratio were determined using chi square at 5% level of significance (p<.05).

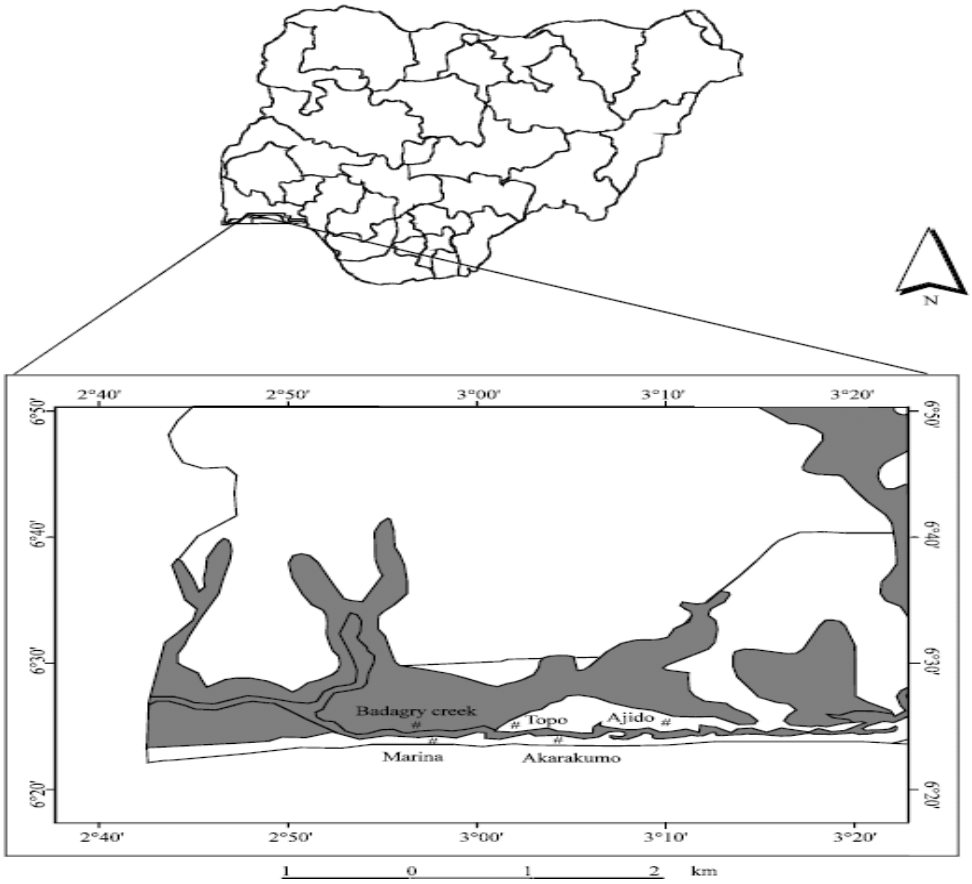

Figure 1: Map of Badagry Creek, Lagos, Nigeria

RESULTS

Morphometric and Meristic Features

Presented in Table 1 are the morphometric and meristic features of *M. macrobrachion.* The total length for male and female *M. macrobrachion* ranged from 5.2-11.8cm (mean= 8.44±1.51cm) and 5.7-10.3cm (mean= 7.54±1.28cm) respectively. The total length range for the combined sexes of *M. macrobrachion* was 5.2-11.8cm (mean=8.13±1.48cm). The corresponding body weight range for males, females and combined sexes of *M. macrobrachion* were 1.52-19.80g (mean=8.21±4.06g), 2.18-15.90g (mean =5.99±3.65g) and 1.52-19.80g (mean=7.47±4.03g) respectively. The respective mean carapace length and rostral length for males were 2.44±0.69cm and 2.71±0.50cm, while the mean carapace and rostral lengths respectively for females were 2.06±0.48cm and 2.28±0.34cm. The mean value recorded for carapace length and rostral length in the combined sexes were 2.31±0.59cm and 2.56±0.49cm. The dorsal rostral spines count for male and female *M. macrobrachion* respectively ranged from 5-14 (mean=9.98±1.51) and 7-15 (mean=10.30±2.24) while the value for the combined sexes was 5-15 (mean=10.09±1.80). The ventral rostral spines count ranged from 2-8 (mean=5.29±0.95, males), 1-6 (mean=4.58±1.08, females) and 1-8 (mean=5.04±1.05, combined sexes).

The total length for male and female *M. vollenhovenii* ranged from 5.4-10.8cm (mean=7.88±1.27cm) and 5.3-10.0cm (mean=7.39±1.14cm) respectively (Table 2),

while the total length for the combined sexes ranged from 5.3-10.8cm (mean= 7.68±1.26cm). The mean body weight for combined sexes was 5.77±3.02g (range=2.04-21.20g), while the body weight for male and females were 6.17±2.93g (range= 2.30-14.20g) and 5.19±2.88g (range = 2.04-21.20g) respectively. The mean carapace and rostral lengths for males were 2.22±0.46cm (range= 1.4-3.9cm) and 2.63±0.48cm (range=1.8-3.6cm) respectively, and the corresponding values for females were 1.96±0.37cm (range=1.4-2.9cm) and 2.32±0.37cm (range =1.2-3.2cm). The mean values recorded for carapace length and rostral length in the combined sexes were 2.11±0.45cm (range =1.4-3.9cm) and 2.49±0.46cm (range =1.2-3.6cm). The mean dorsal rostral spines count for male and female *M. vollenhovenii* respectively were 9.31±1.23 (range =7-13) and 9.33±1.06 (range =7-12), while the value for the combined sex was 9.33±1.15 (range = 7-13). Ventral rostral spines count ranged from 1-6 (mean=5.08±0.953, males), 3-7 (mean=5.33±0.81, females) and 1-7 (mean=5.21±0.88, combined sexes).

Table 1: Morphometric Characters of *Macrobrachium macrobrachion* from Badagry Creek

Character	Male					Female					Combined Sexes				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
TL	97	5.2	11.8	8.44	1.51	53	5.7	10.3	7.54	1.28	150	5.2	11.8	8.13	1.48
BW	97	1.52	19.80	8.21	4.06	53	2.18	15.90	5.99	3.65	150	1.52	19.80	7.47	4.03
CL	97	1.2	5.6	2.44	0.69	53	1.3	3.1	2.06	0.48	150	1.2	5.6	2.31	0.59
RL	97	1.5	4	2.71	0.50	53	1.8	3.1	2.28	0.34	150	1.5	4.0	2.56	0.49
DRS	97	5	14	9.98	1.51	53	7	15	10.30	2.24	150	5	15	10.09	1.80
VRS	97	2	8	5.29	0.95	53	1	6	4.58	1.08	150	1	8	5.04	1.05

N = Number, TL = Total Length (cm), BW=Body Weight (g), CL=Carapace Length (cm), RL=Rostral Length (cm), DRS= Dorsal Rostral Spines, VRS=Ventral Rostral Spines, SD=Standard Deviation

Table 2: Morphometric Characters of *Macrobrachium vollenhovenii* from Badagry Creek

Character	Male					Female					Combined Sexes				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
TL	52	5.4	10.8	7.88	1.27	48	5.3	10.0	7.39	1.14	100	5.3	10.8	7.68	1.26
BW	52	2.30	14.20	6.17	2.93	48	2.04	21.20	5.19	2.88	100	2.04	21.20	5.77	3.02
CL	52	1.4	3.9	2.22	0.46	48	1.4	2.9	1.96	0.37	100	1.4	3.9	2.11	0.45
RL	52	1.8	3.6	2.63	0.48	48	1.2	3.2	2.32	0.37	100	1.2	3.6	2.49	0.46
DRS	52	7	13	9.31	1.23	48	7	12	9.33	1.06	100	7	13	9.33	1.15
VRS	52	1	6	5.08	0.93	48	3	7	5.33	0.81	100	1	7	5.21	0.88

N = Number, TL = Total Length (cm), BW=Body Weight (g), CL=Carapace Length (cm), RL=Rostral Length (cm), DRS= Dorsal Rostral Spines, VRS=Ventral Rostral Spines, SD=Standard Deviation

Morphometric Relationships

The relationships between total length and body weight, total length and carapace length, and total length-rostral length relationship for males, females and combined sexes of *M. macrobrachion* are presented in Table 3. The values of the exponent 'b' in *M. macrobrachion* were 2.47, 2.62 and 2.51 for the males, females and combined sexes respectively. Negative allometric growth pattern was recorded for both sexes. The correlation coefficient values "r" recorded total length-carapace length relationship for males, females and combined sexes of *M. macrobrachion* were 0.80, 0.91 and 0.84 respectively. Thus, there was high and positive correlation between total length and carapace length. Also, the "r" values for total length-rostral length relationship were 0.82 (males), 0.79 (females) and 0.82 (combined sexes) which indicated high and positive correlation between total length and rostral length.

Similarly, the values of the exponent 'b' in *M. vollenhovenii* for the total length-body weight relationship were 1.51, 1.27 and 1.48 for males, females and combined sexes respectively (Table 4). This indicated negative allometry. Total length-carapace length relationships recorded "r" values of 0.80 (males), 0.91 (females) and 0.85 (combined sexes), and the corresponding values for total length-rostral length relationships were 0.77, 0.82 and 0.80 for males, females and combined sexes of *M. vollenhovenii* respectively. The correlation coefficient values recorded for total length-carapace length and total length-rostral length relationships indicate that there was high and positive correlation between total length and carapace length, on one hand, and total length and rostral length, on the other.

Table 3: Morphometric Relationship and Correlation values of *Macrobrachium macrobrachion* from Badagry Creek

Sex	Number	Variables	Regression Equation	Allometry	r^2	r
Male	97	TL-BW	Log W = -12.58 + 2.47 Log L	Negative	0.84	0.92
		TL-CL	Log CL = -0.29 + 0.32 Log L	Negative	0.64	0.80
		TL-RL	Log RL = 0.41 + 0.27 Log L	Negative	0.68	0.82
Female	53	TL-BW	Log W = -13.80 + 2.62 Log L	Negative	0.85	0.92
		TL-CL	Log CL = -0.53 + 0.34 Log L	Negative	0.82	0.91
		TL-RL	Log RL = 0.71 + 0.21 Log L	Negative	0.62	0.79
Combined	150	TL-BW	Log W = -12.92 + 2.51 Log L	Negative	0.85	0.92
Sexes		TL-CL	Log CL = -0.42 + 0.34 Log L	Negative	0.71	0.84
		TL-RL	Log RL = 0.34 + 0.27 Log L	Negative	0.68	0.82

TL= Total Length, BW= Body Weight, CL=Carapace Length, RL=Rostral Length, R^2 = Correlation Coefficient.

Table 4: Morphometric Relationship and Correlation values of *Macrobrachium vollenhovenii* from Badagry Creek

Sex	Number	Variables	Regression Equation	Allometry	r^2	r
Male	52	TL-BW	Log W = -5.52 + 1.51 Log L	Negative	0.43	0.66
		TL-CL	Log CL = -0.07 + 0.29 Log L	Negative	0.64	0.80
		TL-RL	Log RL = 0.32 + 0.29 Log L	Negative	0.59	0.77
Female	48	TL-BW	Log W = -4.17 + 1.27 Log L	Negative	0.25	0.50
		TL-CL	Log CL = -0.19 + 0.29 Log L	Negative	0.82	0.91
		TL-RL	Log RL = 0.36 + 1.48 Log L	Negative	0.68	0.82
Combined	100	TL-BW	Log W = -5.61 + 1.48 Log L	Negative	0.38	0.62
Sexes		TL-CL	Log CL = -0.20 + 0.30 Log L	Negative	0.73	0.85
		TL-RL	Log RL = 0.24 + 0.29 Log L	Negative	0.64	0.80

TL= Total Length, BW= Body Weight, CL=Carapace Length, RL=Rostral Length, R^2 = Correlation Coefficient

Sex Ratio

35.33% and 64.67% of the 150 specimens of *M. macrobrachion* examined were females and males respectively, and this represented a sex ratio of 1 female: 1.83 male. Of the 100 specimens of *M. vollenhovenii* examined, 48 (48%) and 52 (52%) were females and males respectively. Thus, a sex ratio of 1 female: 1.08 male was recorded for *M. vollenhovenii*. Consequently, males of both *M. macrobrachion* and *M. vollenhovenii* predominated over the females. Although, the chi-square analysis showed that there was no significant difference (X^2_{Cal} = 0.16, X^2_{tab} = 3.84, p>.05) between the expected 1:1 and the observed 1:1.08 at 5% significance level in *M. vollenhovenii*; however, there was significant difference (X^2_{Cal} = 12.91, X^2_{tab} = 3.84, p<.05) between the expected 1:1 and the observed 1:1.83 at 5% significance level in *M. macrobrachion*.

DISCUSSION

Tesch (1971) reported that when the value of b = 3, fish is said to grow isometrically, and that values other than 3 show that the fish exhibit allometric growth, while Ricker (1975) reported that allometric relationship between total length and body weight imply that the body forms do not grow at the same rate. The values of the exponent 'b' in *M*. *vollenhovenii* and *M. macrobrachion* which were less than 3 in this study indicated negative growth pattern for the two species and this imply that both species becomes thinner with increase in length. The allometry growth pattern recorded in this study was different from the reports of Jimoh et al. (2005), and Anetekhai and Fagade (1989) who reported positive allometry for *M*. *vollenhovenii* in Ologe Lagoon and Asejire Lake respectively. Jimoh et al. (2012) also reported that *M. macrobrachion* and *M. vollenhovenii* from Badagry Creek exhibited positive allometry while Adite et al. (2013) reported that *M. macrobrachion* from two locations of the Mono-River Coastal Lagoon system exhibited allometric growth. However, Konan et al. (2017) reported that all the allometry types (negative allometry, isometry and positive allometry) were recorded for *M. macrobrachion* from the rivers of Cote d'Ivoire. The negative allometry recorded for both *M. macrobrachion* and *M. vollenhovenii* from Badagry Creek might suggest reduction in natural productivity of the Creek as a result of anthropogenic activities and continued over-exploitation of these prawns in the Creek, since Jimoh et al. (2012) reported a possible over-exploitation of these prawns in Badagry creek. This is more so since Konan et al. (2017) had reported that allometric coefficient varied depending on the groups, environments and characters.

From this study, higher values of body weight and total length were recorded for males of *M. macrobrachion* and *M. vollenhovenii* than for the females; however, the differences were not statistically significant. These findings agreed with the reports of Anetekhai (1997) and Jimoh et al. (2005) who reported that males of *M. vollenhovenii* and *M. macrobrachion* were larger than females. According to Mariappan and Balasundaram (2004) the growth of total length and weight of a male *M. nobili* and that of the female differs significantly. The low body weight of *M. macrobrachion* and *M. vollenhovenii* recorded in this study could be as a result of exploitation pressure on the species in Badagry creek. Similar observation has been reported for *Callinectes amnicola* in Badagry creek (Lawal-Are and Kusemiju, 2000).

Anetekhai (1997) reported that features such as carapace length and rostral length when expressed as proportion of total length are very useful in the identification of prawns since such features when expressed as percentage of total length give similar proportion in same species. The correlation coefficient values (r) for the males, females and combined sexes of *M. macrobrachion* and *M. vollenhovenii* in this study indicated that there was positive correlation between the total length and carapace length, on one hand, and total length and rostral length on the other. These findings are in agreement with Meye and Arimoro (2005) who reported high correlation for TL-BW in *M. dux* and Konan *et al*. (2017) who reported high values of coefficient of determination (0.66 – 0.97) in all length-length and weight-length relationships in *M. macrobrachion* from the rivers of Cote d'Ivoire. These high correlations suggest that an increase in total length also resulted into an increase in both carapace length and rostral length.

The number of spines on the dorsal side of the rostrum in *M. macrobrachion* and *M. vollenhovenii* ranged from 5 – 15 and 7 – 13 respectively, while the corresponding ventral rostral spines ranged from 1 – 8 and 1 – 7. Thus, in both species, there were more spines on the dorsal than the ventral side of the rostrum, and this agrees with Adite et al. (2013) who reported that *M. macrobrachion* had more spines (12 - 15) on the dorsal side of the rostrum than on the ventral side (3 - 5). Eniade et al. (2019) also reported that meristic count of dorsal spines on the rostrum ranged from 8 – 15 and 8 – 16 while that of ventral spines ranged from 3 – 7 and 3 – 8 for *M. macrobrachion* and *M. vollenhovenii* respectively from the Osun River. Murphy and Austin (2005) reported that among meristic characters, rostrum, and particularly rostral spines, is one of the main useful taxonomic characters that diagnose prawns species.

From this study, sex ratio of 1:1.83 and 1:1.08 were recorded in favour of the males of *M. macrobrachion* and *M. vollenhovenii* respectively. There was a significant difference in the sex ratio recorded for *M. macrobrachion*, but there was no significant difference for *M. vollenhovenii*. Although this does not agree with Jimoh et al. (2012) and Meye and Arimoro (2005) which reported higher sex ratio in favour of the females for the *Macrobrachium* species studied, it was, however, in agreement with Konan et al. (2017) who reported that the number of male *M. macrobrachion* (153) was considerably higher than the number of females (22) in the rivers of Cote d'Ivoire. In Nigeria, the breeding season for *Macrobrachium* species falls within April – October, and male *Macrobrachium* species have been reported to be territorial during the breeding season preferring the females to come into its nest (Anetekhai, 1995). Since the prawns used for this study were collected in September and October, the higher sex ratio in favour of the males could imply an invasion of the breeding grounds of the prawn stock in Badagry creek, which might further imply over-exploitation of prawns in the creek.

CONCLUSION

This study provides follow-up information on the morphological characteristics of two palaemonid prawns, *Macrobrachium macrobrachion* and *M. vollenhovenii* from Badagry Creek. An earlier study of the *Macrobrachium* stock in Badagry Creek reported relatively low prawn size as a result of possible over-exploitation, and results from this present study also indicated negative allometry for both prawn species. This is a pointer to continued over-exploitation of these organisms and also possible reduction in the productivity of Badagry Creek itself as a result of anthropogenic activities. It therefore becomes imperative that management measures be put in place to ensure the sustenance and availability of these prawns. As part of the management measures, it is important to establish occasional fishing ban in the Badagry Creek and also encourage aquaculture of these prawns to reduce the exploitation pressure on wild populations of these prawns. Adequate enlightenment programmes should also be embarked upon to educate the people on the dangers of continued over-exploitation of these prawns.

REFERENCES

Aderinola OJ, Adu AA, Kusemiju V (2013). Baseline Study of Surface Water Chemistry of Badagry Creek, Lagos, Nigeria. International Journal of Science and Research 5(4): 843-851.

Adite A, Abou Y, Sossoukpe E, Gildas Gbaguidi MHA, Fiogbe ED (2013). Meristic and morphological characterization of the freshwater prawn, *Macrobrachium macrobrachion* (Herklots, 1851) from the Mono River-Coastal Lagoon System, Southern Benin (West Africa: Implications for species conservation. International Journal of Biodiversity and Conservation 5(11): 704-714.

Agboola JI, Anetekhai MA, Denloye AAB (2008). Aspects of the Ecology and Fishes of Badagry Creek (Nigeria). Journal of Fisheries and Aquatic Science 3: 184-194.

Ajani EK, Balogun KJ (2015). Variability in Levels of Heavy Metals in Water and Fish (*Chrysichthys nigrodigitatus*) tissues from Badagry Creek, Nigeria. Journal of Biology and Life Science 6(2): 193-207.

Akintola SL, Bakare BS (2011). Microbiological changes in freshwater prawn (*Macrobrachium vollenhovenii*, Herklots 1857) stored in ice. Am. J. Food Technol. 6: 500-506.

Anetekhai MA (1990). Sexual dimorphism and egg production in the African river prawn, *Macrobrachium vollenhovenii* (Herklots, 1857), from Asejire Lake, Oyo State, Nigeria. Niger. J. Sci. 24: 147-151.

Anetekhai MA (1995). Aspects of the behavior of African river prawn, *Macrobrachium vollenhovenii* (Herklots, 1857) from Asejire Lake, Oyo State, Nigeria. Niger. J. Sci. 29: 95-100.

Anetekhai MA (1997). Moulting, meristics and morphometric in the African river prawn, *Macrobrachium vollenhovenii* (Herklots, 1857) from Asejire Lake, Oyo State, Nigeria. J. Prospects Sci. 1: 110-114.

Anetekhai MA, Fagade SO (1989). Age, growth and moulting in *Macrobrachium vollenhovenii* (Herklots, 1857) from Asejire Lake, Ibadan, Oyo State, Nigeria. J. Expt. Appl. Biol. 1: 70-82.

Bello-Olusoji AO, Omolayo AT, Arinola A (2004). Taxonomical studies on rocky freshwater prawns at Erin-Ijesha waterfalls. J. Food Agric. Environ. 2: 280-28

Beyer JE (1991). On length-weight relationships. PART II: Computing mean weights from length statistics. Fishbyte 9: 50-54.

Eniade AA, Odedeyi DO, Bello-Olusoji O, Adebayo OT (2019). Morphological Traits Characterization of *Macrobrachium macrobrachion* (Herklots, 1851) and *Macrobrachium vollenhovenii* (Herklots, 1857) from Osun River, Southwestern, Nigeria. International Journal of Aquatic Science 10(1): 48-54.

Jayachandran KV, Joseph NI (1988). Length-weight relationship of two palaemonid prawns, *Macrobrachium idella* and *M. scabriculm.* A Comparative Study. Fishery Technology 25: 189-195.

Jimoh AA, Fakoya KA, Hammed AM, Amosu AO, Kumolu-Johnson CA (2005). Meristics and morphometrics in the African river prawn, *Macrobrachium vollenhovenii* (Herklots, 1857) from Ologe Lagoon, Southwest Nigeria. J. Agric. Environ. Res. Stud. 1: 12-18.

Jimoh AA, Clarke EO, Whenu OO, Anetekhai MA, Ndimele PE (2012). Morphological characterization of populations of *Macrobrachium vollenhovenii* and *Macrobrachium macrobrachion* from Badagry Creek, Southwest Nigeria. Asian Journal of Biological Science 5(3): 126-137.

Jimoh AA, Anetekhai MA, Cummings S, Abanikannda OTF, Turner GF, Oosterhout CV, Hanfling B (2013). Mismatch between molecular (mtDNA) and morphological classification of *Macrobrachium* prawns from Southern Nigeria: Cryptic freshwater species and brackish water morphotypes. Aquaculture 410-411: 25-31.

Jimoh AA, Clarke EO, Godwin AO (2019). Seasonal and spatial variations in physico-chemical parameters of water and proximate composition of *Macrobrachium macrobrachion* from Ologe lagoon and Badagry creek, Lagos, Nigeria. Global Journal of Fisheries Science 1(3): 32-40.

Konan KM, Doumbia L, Adépo-Gourène AB, Ouattara A, Gourène G (2017). Relationships between morphometric characteristics of brackish water prawn, *Macrobrachium macrobrachion* (Herklots, 1851) of Cote d'Ivoire (West Africa). Iranian Journal of Fisheries Sciences 16(1): 275-295.

Lawal-Are AO, Owolabi AT (2012). Comparative biology of prawns, *Macrobrachium macrobrachion* (Herklots, 1851) and *Macrobrachium vollenhovenii* (Herklots, 1857), from two interconnecting fresh and brackish water lagoons in South West Nigeria. Journal of Marine Science Research Development 2: *108.*

Le Cren CD (1951). The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition in Perch, *Perca fluviatilis.* Journal of Animal Ecology 20: 201-219.

Loveth DL, Felder DI (1989). Application of regression techniques to studies of relative growth in crustaceans. Journal of Crustacean Biology 9: 529-539.

Makombu JG, Stomeo F, Oben PM, Tilly E, Stephen OO, Oben BO, Cheruiyot EK, Tarekegn GM, Zango P, Egbe AE, Ndagyong A, Mialhe E, Ngueguim JR, Mujibi FDN (2019). Morphological and molecular characterization of freshwater prawn of genus *Macrobrachium* in the coastal area of Cameroon. Ecology and Evolution 9: 14217-14233.

Mariappan P, Balasundaram C (2004). Studies on the morphometry of *Macrobrachium nobilii* (Decapoda, Palaemonidae). Braz. Arch. Biol. Technol. 47(3): 441-449.

Marioghae IE (1990). Studies on Fishing Methods, Gear and Marketing of *Macrobrachium* in the Lagos Area. Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos, Nigeria: 20 pp.

Meye JA, Arimoro FO (2005). Aspects of the ecology, reproductive and growth characteristics of *Macrobrachium dux* (Lenz, 1910) (Crustacea: Decapoda: Natantia) in Orogodo River, Niger Delta, Nigeria. Eur. J. Sci. Res. 2: 585-596.

Murphy NP, Austin CM (2005). Phylogenetic relationships of the globally distributed freshwater prawn genus *Macrobrachium* (Crustacea: Decapoda: Palaemonidae). Biogeography, taxonomy and the convergent evolution of abbreviated larval development. Zool. Scr. 34: 187-197.

Rahman MS, Rahman MA, Rahman MR, Kamal D (2004). Length-weight relationship, condition factor and harvesting records of silver pomfret (*Pampus argenteus*) in the south western region of Bangladesh. Pakistan Journal of Biological Sciences 7(4): 452-456.

Ricker WE (1975). Computation and Interpretation of Biological Statistics of Fish Populations. Bull. Fish. Res. Board Can. 191: 1-382.
Rickter H, Lückstädt C, Focken UL, Becker K (2000). An improved procedure to assess fish condition on the basis of length-weight relationships. Archive of Fishery and Marine Research 48: 255-264.
Santos MN, Gaspar MB, Vosconcelos P, Monteiro CC (2002). Weight-length relationships for 50 select fish species of the Algarve coast (southern Portugal). Fisheries Research 59: 289-295.
Tesch FW (1971). Age and Growth. In: Methods for Assessment of Fish Production in Freshwaters. Ricker, W.E. (Ed.), Blackwell Scientific Publications, Oxford, UK, pp. 98-103.