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Morphological Characterization of Populations of *Macrobrachium vollenhovenii* and *Macrobrachium macrobrachion* from Badagry Creek, Southwest Nigeria

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ABSTRACT

Studies on the morphological characterization of the African river prawn, *Macrobrachium vollenhovenii* and the brackish water prawn, *Macrobrachium macrobrachion* from Badagry Creek in Southwest Nigeria were carried out. Samples of *M. vollenhovenii* (n = 275) and *M. macrobrachion* (n = 790) were collected from Badagry Creek. Morphometric analysis showed that *M. vollenhovenii* and *M. macrobrachion* exhibited positive allometric growth with "b" values of 3.11 and 2.58, respectively. *M. vollenhovenii* (6.29±3.48 g) was larger than *M. macrobrachion* (4.75±2.43 g). The males of both species were larger than the females. The correlation between Total Length (TL) and Body Weight (BW) was high and positive (*M. vollenhovenii*, r = 0.95; *M. macrobrachion,* r = 0.87). A significant ($p<0.05$) positive correlation occurred between TL and Carapace Length, (CL) (*M. vollenhovenii*, r = 0.83; *M. macrobrachion,* r = 0.66) and between TL and rostral length, RL (*M. vollenhovenii*, r = 0.73; *M. macrobrachion,* r = 0.79). Dorsally, *M. vollenhovenii* and *M. macrobrachion* had 6-14 (mean = 9.84±1.35) and 7-15 (mean = 9.38±0.84) rostral spines, respectively while on the ventral side of the rostrum, *M. vollenhovenii* had 3-8 spines (mean = 5.15±0.76) and *M. macrobrachion* had 3-10 spines (mean = 5.34±0.61). Female *M. macrobrachion* and *M. vollenhovenii* predominated with sex ratios of 1:3.73 ($p<0.05$) and 1:1.05 ($p>0.05$), respectively. There appears to be exploitation pressure on these prawns in Badagry Creek. Therefore, there is need for some management measures to be taken.

Key words: *Macrobrachium vollenhovenii*, *Macrobrachium macrobrachion*, length-weight relationship, carapace length, rostral length, rostral spine

INTRODUCTION

Freshwater prawns of the genus, *Macrobrachium,* are decapod crustaceans of the suborder Natantia and family Palaemonidae and are important for commercial fisheries and aquaculture, as they provide not only food but also revenue to many countries of the world (Bello-Olusoji *et al.*, 2006). Over the past decade, the farming of freshwater prawns has been gaining prominence, such that during the decade ending, 2001, the annual increase in freshwater prawn production, in the world, was estimated as 29 and 48% during 1999-2001, with the production of all *Macrobrachium* species in 2001 being about 300,000 mt (Chowdhury *et al.*, 2008). In Nigeria, there is a significant wild capture shrimp industry generating US $57 million per annum in foreign exchange (USAID, 2002). All of the freshwater prawns that have been cultured, so far, belong to the

Macrobrachium, the largest genus of the family Palaemonidae (Soundarapandian, 2008). About 200 *Macrobrachium* species have been identified (Jayachandran, 2001). All of which live in freshwater, at least, for part of their life (Davassi, 2011). These prawns are distributed throughout the tropical and subtropical countries of the world (Bello-Olusoji *et al*., 2006). They are found in most inland freshwater areas including lakes, rivers, irrigation ditches and ponds, as well as in estuarine areas (New, 2002; Davassi, 2011). Most species require brackish water in the initial stages of their life-cycle and therefore, they are found in water that is directly or indirectly connected with the sea (New, 2003), although some species such as *M. nipponense* (Kutty, 2005) and *M. australiense* (Cook *et al*., 2002) complete their life-cycle in freshwater. In Nigeria, Marioghae (1990) reported that *M. vollenhovenii* lives and breeds successfully in totally freshwater bodies such as Lokoja (River Niger) and Asejire (Upper Osun).

Macrobrachium species occur throughout the West African region (Etim and Sankare, 1998; Jimoh *et al*., 2005). However, of the about 200 species that make up the genus, 4 species have been reported in Nigeria (Bello-Olusoji *et al*., 2004). These are *M. vollenhovenii* (African river prawn), *M. macrobrachion* (brackish water prawn), *M. felicinum* (Niger River prawn) and *M. dux*. These prawns have an extensive distribution across the southern region of Nigeria (Akintola and Bakare, 2011). *M. vollenhovenii* has been reported to attain a maximum total length of 182 mm while *M. macrobrachion* and *M. felicinum* rarely exceed 120 and 80 mm, respectively (Saifullah *et al*., 2005; Jimoh *et al*., 2005). *M. dux* attained a maximum total length of 75 mm (Meye and Arimoro, 2005). In Nigeria, the two largest species of the genus, *Macrobrachium*, are *M. vollenhovenii* and *M. macrobrachion* (Marioghae and Ayinla, 1995). The African river prawn, *M. vollenhovenii* may be found in all kinds of freshwater and in the brackish water up to and sometimes above 20‰ while *M. macrobrachion* thrives only in tidal freshwaters and in low salinity waters of up to and a little above 10‰ (Jimoh *et al*., 2005). The brackish water prawn, *M. macrobrachion* are usually absent from waters with a heavy silt load while *M. vollenhovenii* is usually absent from clear-water rivers (Anetekhai, 1997).

The widespread distribution of the freshwater prawn, *Macrobrachium vollenhovenii* and the brackish water prawn, *M. macrobrachion*, across the West African coast, attainment of large size, disease resistance, high market value and good taste make them potential candidates for aquaculture in Nigeria (Jimoh *et al*., 2005). Consequently, several studies have been carried out on the biology as well as systematic studies on the morphological features of these prawns (Rahman *et al*., 2000; Soundarapandian *et al*., 2008; Sriputhorn and Sanoamuang, 2011). These parametric features are considered important in age determination and the identification of the different prawn species. However, there is very little information available on these prawns in the Badagry Creek. The Badagry Creek, with source in River Queme in the Republic of Benin to the west of Nigeria, is located in Lagos State (southwest Nigeria). It lies between latitudes 6°25′ and 6°30′ N and longitude 3°0′ and 3°45′ E (Lawal-Are and Kusemiju, 2000) and opens into the Atlantic Ocean via the Lagos harbour. It is part of a continuous system of lagoons and creeks lying along the coast of Nigeria from the border with the Republic of Benin to Niger Delta, with the depth of water ranging from 1-3 m (Ndimele and Jimoh, 2011). Hence, *M. vollenhovenii* and *M. macrobrachion* from the Badagry Creek will be characterized with respect to some morphological features. The kind of relationship that exists between these features, as well as the sex ratio will also be determined.

MATERIALS AND METHODS

Sample collection: Between July 2003 and October 2004, two hundred and seventy five samples of *M. vollenhovenii* and seven hundred and ninety samples of *M. macrobrachion* 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 at these sites. In assessing the meristic and morphometric features, the specimens were examined either fresh or kept in a freezer for subsequent examination. The total length (from tip of rostrum to the tip of telson) was measured, to the nearest 0.1 cm while the 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 using Vernier Calipers, to the nearest 0.01 cm. The body weight was measured, to the nearest 0.01 g, with a top-loading Mettler balance (Model PE 1600). The dorsal and ventral rostral spines were also counted.

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

$$W = a+bL$$

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

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

$$\text{Log } W = \text{Log } a+b \text{ Log } L$$

Total length-carapace length and total length-rostral length relationships: The relationship between total length and carapace length and between total length and rostral length, were studied using the equation:

$$Y = a+bX$$

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

$$\text{Log } Y = \text{Log } a+b \text{ Log } X$$

Sex ratio: Species identification was done using Marioghae (1990) as a guide. The separation of *M. vollenhovenii* and *M. macrobrachion* into male and female was done by visual examination of the abdomen for the presence of eggs. Also, the ventral side of the first abdominal segment was examined for the presence of a lump in the males as described by Anetekhai (1990). Confirmation was by the presence of the appendix masculina in the second pleopods of the males (Anetekhai, 1990).

Statistical analysis: Statistical analysis was done using SPSS (version 13.0) and in microsoft excel package. The correlation coefficients obtained from the various linear regression analyses were tested for significance using the Student's t-test. The analyses were tested for significance at 5% level of significance.

RESULTS

Meristic and morphometric features: Morphological features of *M. vollenhovenii* (males, females and combined sexes) are presented in Table 1; while Table 2 shows these features for males, females and combined sexes of *M. macrobrachion*, respectively.

Total length-body weight relationship: The total length (Table 1) of *M. vollenhovenii* (combined sexes) from Badagry Creek ranged from 4.2-13.8 cm (mean = 8.06±1.17) while for the males and females, the total length range were 6.2-13.8 cm (mean = 8.25±1.18) and 4.2-12.1 cm (mean = 7.88±1.14), respectively. The corresponding body weight range were 2.46-30.81 g (mean = 6.97±3.58, males), 0.81-29.48 g (mean = 5.65±3.25, females) and 0.81-30.81 g (mean = 6.29±3.48, combined sexes). The equation for the total length-body weight relationship in *M. vollenhovenii* is given as:

- **Males:** $\log W = -1.96 + 3.02 \log L$ ($n = 134$, $r = 0.94$, $R^2 = 0.89$)
- **Females:** $\log W = -2.07 + 3.10 \log L$ ($n = 141$, $r = 0.95$, $R^2 = 0.91$)
- **Combined sexes:** $\log W = -2.06 + 3.11 \log L$ ($n = 275$, $r = 0.95$, $R^2 = 0.90$)

The males, females and combined sexes of *M. macrobrachion* (Table 2) recorded total length range of 3.5-14.0 cm (mean = 8.31±1.42), 1.6-10.7 cm (mean = 7.45±0.84) and 1.6-14.0 cm (mean = 7.63±1.05), respectively while the corresponding body weight range were 1.50-20.08 g (mean = 6.72±3.75), 1.17-16.15 g (mean = 4.22±1.55) and 1.17-20.08 g (mean = 4.75±2.43). The equation for the length-weight relationship in *M. macrobrachion* is given as:

- **Males:** $\log W = -1.71 + 2.72 \log L$ ($n = 167$, $r = 0.88$, $R^2 = 0.77$)
- **Females:** $\log W = -1.43 + 2.34 \log L$ ($n = 623$, $r = 0.85$, $R^2 = 0.73$)
- **Combined sexes:** $\log W = -1.63 + 2.58 \log L$ ($n = 790$, $r = 0.87$, $R^2 = 0.76$)

The values of the exponent "b" (Table 3), in *M. vollenhovenii*, were 3.02, 3.10 and 3.11 for the males, females and combined sexes , respectively. From Table 4, *M. macrobrachion* recorded "b" values of 2.72 (males), 2.34 (females) and 2.58 (combined sexes). This indicates that both *M. vollenhovenii* and *M. macrobrachion* exhibited positive allometric growth in the Badagry Creek.

Table 1: Morphological features of *Macrobrachium vollenhovenii* (males, females and combined sexes) from Badagry Creek, South- West, Nigeria

	Males				Females				Combined sexes			
Parameter	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
BW	2.46	30.81	6.97	3.58	0.81	29.48	5.65	3.25	0.81	30.81	6.29	3.48
TL	6.20	13.80	8.25	1.18	4.20	12.10	7.88	1.14	4.20	13.80	8.06	1.17
CL	1.10	6.00	1.96	0.51	0.70	3.40	1.74	0.37	0.70	6.00	1.85	0.46
RL	1.10	2.80	1.90	0.32	0.75	2.75	1.75	0.36	0.75	2.80	1.83	0.35
VRS	4.00	7.00	5.19	0.59	3.00	8.00	5.12	0.89	3.00	8.00	5.15	0.76
DRS	6.00	14.00	9.48	1.03	7.00	14.00	10.18	1.53	6.00	14.00	9.84	1.35

BW: Body weight (g), TL: Total length (cm), CL: Carapace length (cm), RL: Rostral length (cm), VRS: Ventral rostral spines, DRS: Dorsal rostral spines, SD: Standard deviation

Table 2: Morphological features of *Macrobrachium macrobrachion* (males, females and combined sexes) from Badagry Creek, South-West, Nigeria

	Males				Females				Combined sexes			
Parameter	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
BW	1.50	20.08	6.72	3.75	1.17	16.15	4.22	1.55	1.17	20.08	4.75	2.43
TL	3.50	14.00	8.31	1.42	1.60	10.70	7.45	0.84	1.60	14.00	7.63	1.05
CL	1.10	6.00	2.10	0.87	0.90	4.60	1.64	0.39	0.90	6.00	1.74	0.56
RL	1.25	3.00	2.06	0.38	1.00	2.70	1.73	0.23	1.00	3.00	1.80	0.30
VRS	4.00	10.00	5.42	0.76	3.00	7.00	5.32	0.56	3.00	10.00	5.34	0.61
DRS	8.00	15.00	9.31	0.91	7.00	13.00	9.40	0.82	7.00	15.00	9.38	0.84

BW: Body weight (g), TL: Total length (cm), CL: Carapace length (cm), RL: Rostral length (cm), VRS: Ventral rostral spines, DRS: Dorsal rostral spines, SD: Standard deviation

Table 3: Morphological relationships and correlation values observed in *Macrobrachium vollenhovenii* from Badagry Creek, South-West, Nigeria

Sex	No.	Variable	a	b	r	R^2
M	134	TL-BW	-1.96	3.02	0.94	0.89
		TL-CL	-0.87	1.26	0.84	0.71
		TL-RL	-0.58	0.93	0.73	0.53
F	141	TL-BW	-2.07	3.10	0.95	0.91
		TL-CL	-0.79	1.14	0.82	0.67
		TL-RL	-0.72	1.07	0.72	0.52
CS	275	TL-BW	-2.06	3.11	0.95	0.90
		TL-CL	-0.85	1.23	0.83	0.69
		TL-RL	-0.67	1.03	0.73	0.53

M: Male, F: Female, CS: Combined sexes, TL: Total length (cm), BW: Body weight (g), CL: Carapace length (cm), RL: Rostral length (cm)

Total length-carapace length relationship: Males, females and combined sexes of *M. vollenhovenii*, from Badagry Creek, had total length values that ranged from 6.2-13.8 cm, 4.2-12.1 cm and 4.2-13.8 cm, respectively while the mean total lengths were 8.25±1.18 (males), 7.88±1.14 (females) and 8.06±1.17 (combined sexes). The corresponding carapace length range were 1.10-6.00 cm (males), 0.70-3.40 cm (females) and 0.70-6.00 (combined sexes), with the mean carapace lengths being 1.96±0.51 (males), 1.74±0.37 (females) and 1.85±0.46 (combined sexes). Total length values that ranged from 3.5-14.0 cm (males), 1.6-10.7 cm (females) and 1.6-14.0 cm (combined sexes) were recorded for *M. macrobrachion*, with corresponding mean values of 8.31±1.42, 7.45±0.84 and 7.63±1.05. For the carapace length, in *M. macrobrachion*, the range were 1.10-6.00 cm (males), 0.90-4.60 cm (females) and 0.90-6.00 cm (combined sexes) while the mean values were 2.10±0.87, 1.64±0.39 and 1.74±0.56 for the males, females and combined sexes, respectively. The equation for the total length- carapace length relationship (Table 3) showed that the correlation values "r" for males, females and combined sexes of *M. vollenhovenii* were 0.84, 0.82 and 0.83, respectively while "r" values of 0.75 (males), 0.55 (females) and 0.66 (combined sexes) were recorded for *M. macrobrachion* (Table 4). This showed that there was a high degree of positive correlation between the total length and carapace length in both *M. vollenhovenii* and *M. macrobrachion* from Badagry Creek.

Total length-rostral length relationship: *M. vollenhovenii* from Badagry Creek had total length values that ranged from 6.2-13.8 cm (males), 4.2-12.1 cm (females) and 4.2-13.8 cm

Table 4: Morphological relationships and correlation values observed in *Macrobrachium macrobrachion* from Badagry Creek, South-West, Nigeria

Sex	No.	Variable	a	b	r	R^2
M	167	TL-BW	-1.71	2.72	0.88	0.77
		TL-CL	-0.95	1.37	0.75	0.55
		TL-RL	-0.49	0.88	0.81	0.66
F	623	TL-BW	-1.43	2.34	0.85	0.73
		TL-CL	-0.59	0.91	0.55	0.31
		TL-RL	-0.47	0.81	0.74	0.55
CS	790	TL-BW	-1.63	2.58	0.87	0.76
		TL-CL	-0.79	1.15	0.66	0.44
		TL-RL	-0.54	0.90	0.79	0.62

M: Male, F: Female, CS : Combined sexes, TL: Total length (cm), BW: Body weight (g), CL: Carapace length (cm), RL: Rostral length (cm)

(combined sexes), with a mean total length of 8.25±1.18 (males), 7.88±1.14 (females) and 8.06±1.17 (combined sexes). The rostral length ranged from 1.10-2.80 cm, 0.75-2.75 cm and 0.75-2.80 cm for the males, females and combined sexes, respectively while the mean rostral length values were 1.90±0.32 (males), 1.75±0.36 (females) and 1.83±0.35 (combined sexes). The mean total length values, for *M. macrobrachion*, were 8.31±1.42 (males), 7.45±0.84 (females) and 7.63±1.05 (combined sexes) while the total length values ranged from 3.5-14.0 cm (males), 1.6-10.7 cm (females) and 1.6-14.0 cm (combined sexes). The corresponding rostral length values were 1.25-3.00 cm (males), 1.00-2.70 cm (females) and 1.00-3.00 cm (combined sexes), with the mean rostral length values being 2.06±0.38, 1.73±0.23 and 1.80±0.30 for the males, females and combined sexes , respectively. From the equation for the total length-rostral length relationship, the "r" values, for *M. vollenhovenii,* were 0.73, 0.72 and 0.73 for males, females and combined sexes, respectively (Table 3) while the values for *M. macrobrachion* males, females and combined sexes were 0.81, 0.74 and 0.79 , respectively (Table 4). Thus, the correlation between the total length and rostral length in both species of prawns from the Badagry Creek was high and positive.

Rostral spines: The rostral spines on the ventral side of *M. vollenhovenii* ranged between 3 and 8 (mean = 5.15±0.76) while the dorsal spines were between 6 and 14 (mean = 9.84±1.35). On separation of the sexes, the males had 4-7 ventral spines (mean = 5.19±0.59) and 6-14 (mean = 9.48±1.03) dorsal spines. A high percentage (66.42%) of the male prawns had 5 ventral spines, with 23.88, 8.21 and 1.49% having 6, 4 and 7 spines, respectively. Dorsally, 47.76% of the male prawns had 9 spines while those with 6, 8, 10, 11, 12, 13 and 14 spines made up 0.75, 8.21, 35.82, 3.73, 1.49, 0.75 and 1.49%, respectively of the total number of male prawns examined. The female prawns had 3-8 ventral spines (mean = 5.12±0.89) and 7-14 (mean = 10.18±1.53) dorsal spines. Ventrally, 48.23% of the females had 5 spines while 2.13, 19.86, 24.82, 3.55 and 1.42% had 3, 4, 6, 7 and 8 spines, respectively. On the dorsal side, 34.75% of the females had 10 spines while 0.71, 5.67, 29.79, 9.22, 10.64, 4.26 and 4.96% had 7, 8, 9, 11, 12, 13 and 14 spines, respectively. On the whole, 57.09% of the prawns examined had 5 spines, 1.09% 3 spines, 14.18% 4 spines, 24.36% 6 spines, 2.55% 7 spines and 0.72% 8 spines on the ventral side of the rostrum. Dorsally, 38.55% of the prawns had 9 spines while 0.36, 6.91, 35.27, 0.36, 6.55, 6.18, 2.55 and 3.27% had 6, 8, 10, 7, 11, 13 and 14 spines, respectively.

Ventrally, *M. macrobrachion* had between 3 and 10 spines (mean = 5.34±0.61) while the dorsal spines ranged between 7 and 15 (mean = 9.38±0.84). Male *M. macrobrachion* had 4-10 ventral spines (mean = 5.42±0.76) and 8-15 dorsal spines (mean = 9.31±0.91). Ventrally, 54.49, 38.32 and 4.79% of the male prawns had 5, 6 and 4 spines, respectively while male prawns with 7, 8, 9 and 10 spines accounted for 0.60% each. Dorsally, 55.69% of the male prawns had 9 spines while those with 8, 10, 11, 13 and 15 spines made up 11.98, 25.15, 5.99, 0.60 and 0.60%, respectively. The female prawns had 3-7 ventral spines (mean = 5.32±0.56) and 7-13 dorsal spines (mean = 9.40±0.82). Dorsally, 50.24% of the female *M. macrobrachion* had 9 spines while 0.16, 9.31, 32.26, 6.74, 0.96 and 0.32% had 7, 8, 10, 11, 12 and 13 spines, respectively. On the ventral side, 61.96% of the females had 5 spines while 0.32, 2.89, 34.02 and 0.80% had 3, 4, 6 and 7 spines, respectively. On the whole, ventrally, 60.38% of *M. macrobrachion* examined had 5 spines, 34.94% had 6 spines and 3.29% had 4 spines. Dorsally, 51.39% had 9 spines while 30.76, 9.87 and 6.58% represented prawns with 10, 8 and 11 spines, respectively.

Sex ratio: The sex ratio of the 790 specimens of *M. macrobrachion* examined showed that 167 (21.1%) were males while 623 (78.9%) were females, giving a sex ratio of 1 male: 3.73 females. The females, thus, predominated over the males, accounting for more than half of the prawns examined. The chi-square analysis showed that there was a statistically-significant difference (X^2_{cal} = 263.2, X^2_{tab} = 3.84) between the expected 1:1 and the observed 1:3.73 sex ratio in *M. macrobrachion* at 5% level of significance. For *M. vollenhovenii,* 134 (48.7%) of the 275 specimens examined were males while 141 (51.3%) were females, giving a sex ratio of 1 male: 1.05 female. The chi-square analysis showed that there was no significant difference (X^2_{cal} = 0.18, X^2_{tab} = 3.84) between the expected 1: 1 and the observed 1:1.05 at 5% level of significance.

DISCUSSION

Fish is said to grow isometrically when the value of b = 3; values other than 3 show that the fish exhibit allometric growth (Tesch, 1971). Ricker (1975) reported that allometric relationship between body length and body weight show that the body forms do not grow at the same proportion. The specimens of *Macrobrachium vollenhovenii* and *M. macrobrachion* from Badagry Creek exhibited positive allometric growth with a "b" value of 3.11 and 2.58, respectively. This is in agreement with the result of Anetekhai and Fagade (1989) who observed that *M. vollenhovenii* from Asejire Lake exhibited positive allometry with a "b" value of 5.8 and Jimoh *et al.* (2005) who reported a "b" value of 6.32 for *M. vollenhovenii* from Ologe Lagoon. Thus, according to Wootton (1992), *M. vollenhovenii* and *M. macrobrachion* became plumber as they grew larger.

The mean total length and body weight in *M. vollenhovenii* were 8.06 cm and 6.29 g, respectively while the corresponding values in *M. macrobrachion* were 7.63 cm and 4.75 g. The correlation between total length and body weight in both species of prawn (*M. vollenhovenii,* r = 0.95; *M. macrobrachion,* r = 0.87) was found to be positively high. On subjecting the "r" values to a test of significance, it was found that the correlation was significant ($p<0.05$). Meye and Arimoro (2005) also recorded a positive correlation between total length and body weight for males (r = 0.84) and females (r = 0.86) of *M. dux*. Generally, *M. vollenhovenii* was observed to be larger than *M. macrobrachion*. New (2002) also described *M. vollenhovenii* as one of the largest species of *Macrobrachium* known. In *M. vollenhovenii,* the mean total length and body weight values in the males were 8.25 cm and 6.97 g, respectively while the females averaged 7.88 cm and 5.65 g in

length and weight, respectively. In *M. macrobrachion,* the males recorded mean total length and body weight values of 8.31 cm and 6.72 g, respectively while the corresponding values in the females were 7.45 cm and 4.22 g, respectively. Thus, the males, in both prawn species, were observed to be larger than the females. Anetekhai (1990, 1997), Marioghae and Ayinla (1995) and Falaye *et al.* (1998) also reported that the males were much larger than the females.

It was also observed that the mean body weight and total length values recorded for both *M. vollenhovenii* and *M. macrobrachion* in this study were relatively low when compared with previous observations. Anetekhai (1997) reported mean body weight and total length values of 77.86 g and 14.94 cm for male *M. vollenhovenii* while the corresponding values in the females were 47.27 g and 13.25 cm. *M. vollenhovenii* attained a mean body weight of 18.7 g (Falaye *et al.*, 1998). The absence of larger prawns could be due to exploitation pressure on these prawns in the Badagry Creek. Similar observations were made by Lawal-Are and Kusemiju (2000) on the size composition and growth patterns in the blue crab, *Callinectes amnicola* in the Badagry Lagoon. Enin (1995) reported that the stock of *M. macrobrachion* in the Cross River estuary was excessively fished. Enin (1997) reported that the main fishing season of *M. macrobrachion* (July- November), in the Cross River estuary, coincides with the period of intensive spawning (July-September). According to USAID (2002), the main fishing season of *Macrobrachium* species in Nigeria is May-October while Marioghae (1990) reported a breeding season of April-October for *Macrobrachium* species in Nigerian waters. Thus, the fishing season coincide with the period of intensive spawning and according to Enin (1997), a likely consequence of this coincidence between the spawning and fishing seasons is the exposure of the spawning population to intense exploitation with severe consequences for the spawning adults, the eggs, larvae and the stock size.

Morphometric and meristic features such as post-orbital carapace length and rostral length when expressed as proportion of the total body length are very useful in the identification of prawns since such body structures when expressed as percentage of total length give similar proportion in same species (Anetekhai, 1997). The correlation between total length and carapace length in *M. vollenhovenii* and *M. macrobrachion* were 0.83 and 0.66, respectively. Thus, there was a high degree of positive correlation between the total length and carapace length in both species of prawns. Enin (1994) also reported a significant correlation between total length and carapace length ($r = 0.98$) in *M. macrobrachion* from the Cross River estuary. Hence, an increase in the total length of the prawns was associated with an increase in the carapace length. A high positive correlation (*M. vollenhovenii*, $r = 0.73$; *M. macrobrachion,* $r = 0.79$) was also observed between the total length and rostral length, indicating that an increase in the total length of the prawn brought an increase in the rostral length. The high and significant correlation between total length and carapace length, on one hand and total length and rostral length, on the other, implies that any of these three variables could be used in establishing length-weight relationship in both species of prawns.

It was observed that in both prawn species, there were more spines on the dorsal side of the rostrum than on the ventral side. On the ventral side of the rostrum, in both *M. vollenhovenii* and *M. macrobrachion,* 5 spines had the highest frequency of occurrence (*M. vollenhovenii,* 60.38%; *M. macrobrachion,* 57.09%). On the dorsal side, in *M. macrobrachion,* 9 spines occurred the most (51.39%) while in *M. vollenhovenii,* 9 and 10 spines accounted for 38.55 and 35.27%, respectively. Rostrum, teeth, morphology of the chelipeds, palm and fingers have been viewed as useful and diagnostic taxonomic characters in prawns (Naiyanetr, 2001; Murphy and Austin, 2005).

In *M. vollenhovenii,* the male to female sex ratio of 1:1.05 recorded in this study is not significantly different ($p>0.05$) from the expected 1:1 sex ratio. Similar sex ratio had been reported

by Inyang (1981) for *M. felicinum,* Meye and Arimoro (2005) for *M. dux, M. vollenhovenii* and *M. macrobrachion* by Marioghae (1990). In *M. macrobrachion,* on the other hand, a significant ($p<0.05$) male: female sex ratio of 1: 3.73 was recorded. The sex ratio shows that the proportion of females was higher than the males. This was in agreement with the findings of Anetekhai (1990) who reported a mean monthly sex ratio of 1:3 in favour of the females for *M. vollenhovenii* from Asejire Lake. Sagua (1980) reported a sex ratio of 1 male to five females in *Palaemon hastatus.* Marioghae (1990) reported a fishing season of April to October for *Macrobrachium* species and since samples of *M. vollenhovenii* and *M. macrobrachion* used for this study were collected between July and October which fell within the breeding season, the higher sex ratio recorded in favour of the females could be due to the search for mating partners, on the part of the females. This is in agreement with the findings of Anetekhai (1995) who reported that the males were territorial and that the females had to come into the male's nest for mating and protection and Penn (1980) who stated that the increase in catchability of the female prawns, during reproduction, was associated with high sex ratio in favour of the females.

In conclusion, to avoid over-exploitation of the *Macrobrachium* stock in the Badagry Creek which probably resulted in the relatively low mean prawn size, there is the need for some management measures to be taken. A likely effective management measure will be an occasional fishing ban within the Creek. Since the spawning and fishing seasons probably coincide, a fishing ban between July and October in the breeding areas of the prawns within the Creek will help to conserve the prawn stock. During this ban period, fishing activities in other areas of the Creek should be allowed. Also, although morphological features are important in the identification of the different prawn species however, the current trend is the use of molecular methods to characterize organisms. Thus, there is need for molecular characterization, using mitochondrial DNA, of these organisms as phylogeographic studies using mtDNA usually provide more resolution of intraspecific patterns of geographical variation than non-molecular methods.

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