Morphological heterogeneity in the giant African River Prawn, *Macrobrachium vollenhovenii* from three rivers systems in the Niger Delta Region, Nigeria

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Abstract— *The study investigated morphological variations among samples of Macrobrachium vollenhovenii captured from Taylor Creek, Calabar Estuary and New Calabar River in the Niger Delta Region. A total of 76 individuals were caught using cone-shaped bamboo basket traps. The prawns were identified and 18 morphological characters were measured on each individual. All the data generated were analyzed using the PAST3 and JASP statistical software. The results of the study indicated that the morphometric measurements among the populations of M. vollenhovenii total length, rostrum length, third segment length, fifth segment length and abdominal length were significant different ($p < .05$) while telson length, telson width, caudal length, merus length and palm length were not different ($p > 0.05$). The coefficient of regression in the length-weight relationship were positively allometric ($p < 0.05$) for all populations with values of 3.5402, 4.6686 and 4.420. The condition factor varied from 0.668 to 2.729 averaging 1.498, 1.628 and 1.630 for New Calabar River, Calabar Estuary and Taylor Creek, respectively.*

Keywords— African River prawn, Macrobrachium vollenhovenii, morphological heterogeneity, length-weight relationship, condition factor.

I. INTRODUCTION

The genus *Macrobrachium* (Bate, 1868) belongs to a group of freshwater prawns (Crustacea, Decapoda, and Palaemonidae). They constitute one of the most diverse, abundant, and widespread crustacean genera (Murphy and Austin, 2005), occurring throughout the tropical and subtropical zones of the world with the exception of Europe (Holthuis, 1980; Fossati et al., 2002; March et al., 2002). Several studies have reported the existence of about 74 species (Chen et al., 2009; Holthuis and Ng, 2010; de Grave and Fransen, 2011). However, the number of species in the Niger Delta Region (NDR) of Nigeria are not well-understood and poorly known. The species that have been documented so far in the NDR include *M. macrobrachion*, *M. vollenhovenii*, *M. dux*, *M. felicinum* and the invasive species of *M. equidens*.

The most economically important species for NDR are *M. macrobrachion* and *M. vollenhovenii*. The African river prawn, *M. vollenhovenii* is endemic to the west coast of Africa stretching from the Senegal River in the north to Angola in the south (Holthuis, 1980; Willfuhr-Nast *et al*., 1993; Paterson, 2007). In Nigeria, It does not, however, occur as plentiful in nature as *M. macrobrachion* even though it has a higher fecundity (Lawal-Are and Owolabi, 2012; George *et al*., 2013; Nwosu and Holzlöhner, 2016). In the Niger Delta, *M. vollenhovenii* is an important economic resource in the rural areas, supporting and sustaining viable artisanal fisheries in some rivers and estuaries within the region. Because it is the biggest of all the *Macrobrachium* species in West Africa (Konan *et al*., 2008) and grows at relatively fast rates in addition to a number of other favourable culture characteristics, it is considered a good candidate for aquaculture (Marioghae, 1987; Willfuhr-Nast *et al*., 1993; Niass and Fall, 2015). The African river prawn is also hardy in many parameters, it thrives in murky waters with dissolved oxygen as low as one part per million (Jimoh *et al*., 2011)

To develop the culture of the species, knowledge of the degree of genetic variation is crucial and must be understood because it will provide information on the condition or status of a population with respect to long-term survival of a species and the fitness of the population to adapt to environmental dynamics (Dunham, 2002). Also, natural population are perhaps the best gene bank, a critical resource for genetic variation for current and future application in genetic improvement for farmed species and specialized sports fish application (Dunham, 2011).

One of the major requirements for shrimp aquaculture is the initial selection of breeders which involves analyses of external morphology. Morphological variability is not only used to explore differences among geographically distinct populations but also to ascribe distinct genetic structures or environmental conditions to each geographic location (Kinsey *et al*., 1994). In order to effectively manage fishery resources and exploit the aquaculture potentials, identification of the population structure of an explored species is necessary (Grimes *et al*., 1987).

At the present, scant information is available on the morphological variations of *M. vollenhoveniii* from the Niger Delta Region of Nigeria thereby creating a knowledge gap. Most importantly, no study has compared morphological traits of populations of the animal in the Niger Delta. Hence, the purpose of this study was to determine the morphological variations of *M. vollenhovenii* caught in three locations from the Niger Delta Region.

II. MATERIALS AND METHODS

2.1 Study location

The study was conducted with specimen of *M. vollenhovenii* caught during 2019 in three river or drainage systems in the Niger Delta Region (NDR), namely; Taylor creek in Bayelsa State, New Calabar River in Rivers State and the Calabar estuary in Cross River State (Fig. 1). Taylor Creek (BAY), Calabar Estuary (CAL) and New Calabar River (NCR) are tributaries of the Niger Delta Basin. The Niger Delta is characterized by extensive coastline (approximately 450 km) and 21 estuaries that drain the inland waters into the Atlantic Ocean in the Gulf of Guinea.

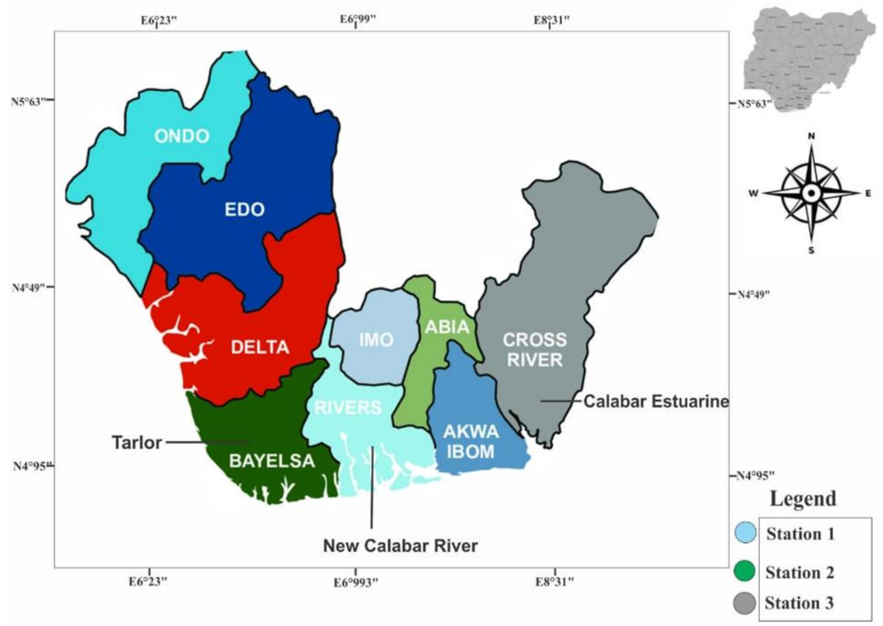

FIGURE 1: Sampling Stations in Niger Delta, Nigeria

2.2 Collection of Samples

The fishing was done with cone-shaped bamboo basket traps described by Solarin *et al*. (2003) and Jimoh *et al.* (2011). The basket trap had a two non-return valve mechanism at the center of the trap. It had a total length and opening aperture of about 1.0 m and 0.3 m, respectively. Fresh oil palm fruits were used as baits for the prawns. The prawns were preserved in ice-chest with ice-blocks and later fixed in 75% ethanol. *Macrobrachium vollenhovenii* was identified using morphological characters reported by Holthius (1980) and Powell (1982).

2.3 Morphometric measurements and analyses

Each specimen was weighed using an electronic balance, coded, and preserved in 75% ethanol. Morphometric measurements were taken on the following traits including total length (TL), carapace length (CL), rostral length (RL), abdominal length

(AL), first segment (FSL), second segment (2SL), third segment (3SL), fourth segment (4SL), fifth segment (5SL) and sixth segment (6SL), telson length (TEL), eye diameter (ED), and carapace height (CH) using dial calipers to the nearest 0.01 cm.

2.4 Statistical Analyses

The relationships between total length and wet weight (W) was established by calculating Log W=Log a+b Log L, Where, W=weight of prawn in g, L=total length in cm, a=regression constant and b=regression coefficient. The association degree between TL and W was calculated by the determination coefficient (r^2). Fulton's condition factor (K) was estimated from the individual length and individual weight in the sample estimated from this equation:

$$K=100\ W/SL^b,$$

Where K=condition factor, W=mean weight (g), SL=body length (cm), and *b* value was derived from the $W=a\times SL^b$. Morphometric variables were evaluated by one-way analysis of variance (ANOVA). Variables presented in this study were expressed as mean ± SD, and one-way ANOVA was used to compare the differences in morphometric traits and Fulton's condition factor between the three populations of the shrimp (PAST 3.26). When a significant family effect was found, Tukey's test was performed for multiple range comparisons ($P<0.05$). The correlation coefficients obtained from the various linear regression analyses were tested for significance using the Student t-test. The analysis were tested for significance at 5% level of significance.

III. RESULTS

TABLE 1
MORPHOMETRIC CHARACTERS OF *M. VOLLENHOVENII*

Trait	CAL (N=28)				NDR ARAC (N=22)				BAY (N=26)				P-Value
	Min	Max	$\bar{X}$ ±SE	CV%	Min	Max	$\bar{X}$ ±SE	CV%	Min	Max	$\bar{X}$ ±SE	CV%	
Wt (g)	4.6	41.5	15.16±1.42	49.69	02.0	33.50	12.47±1.73	65.10	2.1	45.0	18.18±2.26	59.99	*
TL cm	6.8	12.0	9.55±0.21	11.89	6.60	12.20	9.04±0.28	14.47	6.8	12.2	10.16±0.27	13.56	*
RL cm	3.0	4.8	4.05±0.08	10.33	2.6	4.8	3.85±0;11	13.57	3.2	6.2	4.60±0.15	16.43	**
CL cm	1	3.7	1.49±0.11	40.67	0.9	3.2	1.25±0.11	41.43	1	3.8	1.84±0.16	45.29	**
CH cm	1	3.5	1.92±0.10	26.48	1	3.7	1.54±0.14	41.80	1	3.7	1.93±0.13	34.41	*
AL cm	3	5.8	4.21±0.12	14.58	2.3	6	3.73±0.19	24.08	2.5	6	4.41±0.17	20.19	**
FSL cm	0.3	1	0.55±0.04	35.04	0.3	0.7	0.47±0.02	22.34	0.4	1	0.67±0.03	26.43	**
2SL cm	0.3	0.9	0.61±0.03	24.93	0.4	0.7	0.56±0.02	15.73	0.5	1.6	0.73±0.05	38.03	**
3SL cm	0.3	0.8	0.55±0.03	24.99	0.4	0.8	0.57±0.02	18.33	0.4	0.9	0.64±0.02	19.78	*
4SL cm	1	1.6	1.34±0.03	11.92	0.5	1.4	0.9±0.08	40.57	0.5	1.8	1.29±0.08	32.21	**
5SL cm	1	1.4	1.23±0.02	10.09	0.5	1.4	0.90±0.07	37.91	0.5	1.4	1.10±0.06	26.32	**
6SL cm	0.4	0.8	0.59±0.02	16.57	0.4	0.8	0.65±0.02	17.71	0.4	0.8	0.64±0.03	21.65	NS
TELcm	1	2	1.29±0.04	15.51	0.8	1.8	1.28±0.05	17.91	0.9	2	1.38±0.05	19.67	NS
TEWcm	2	3.7	2.60±0.08	16.65	1.2	3.6	2.25±0.13	26.25	1.2	3.6	2.33±0.11	24.80	*
CaL cm	1	3	1.41±0.07	25.14	1.2	3.4	1.58±0.13	39.44	1	3.4	1.72±0.13	39.52	NS
ML	1	2.6	1.39±0.06	21.75	1	2.5	1.50±0.08	24.31	1	2.5	1.52±0.08	25.64	NS
PL	1.1	6	1.9±0.17	46.22	1.4	2.5	1.75±0.07	20.03	1	7.1	2.38±0.30	63.26	NS
ED	1.2	1.7	1.42±0.03	11.04	0.5	1.7	1.30±0.06	23.36	0.5	1.7	1.39±0.05	17.23	NS

3.1 Morphometric variation

Morphometric characters of *M. vollenhovenii* from three locations of the NDR are shown in Table 1. Weight varied from 4.5-41.5g, 2.0-33.5g and 2.1-45 g with corresponding means of 15.16±1.42g, 12.47±1.73g and 18.18±2.26 g for CAL, NCR and BAY, respectively. One-way ANOVA showed significant differences in mean weight of the prawn ($P\leq0.05$). The range of TL were 6.8-12 cm in CAL (X = 9.55±0.21cm), 6.8 cm – 12.2 cm in BAY (X=10.16±0.27cm) and 6.8 cm – 12.2 cm (X= 9.04±0.28cm) in NCR. The TL showed statistically significant difference between NCR and BAY/CAL ($P<0.05$). However, there was no difference in TL between BAY and CAL ($P>0.05$). The mean RL of 3.85±0.11cm, 4.60±0.15cm and 4.05±0.08cm for NCR, BAY and CAL, respectively were significantly different (*P*<0.05). The ANOVA further showed that populations displayed marked difference differences in ED, Table 1: Spatial variation in weight and length of Macrobrachium volenhovenii from the Niger Delta 6SL, CaL, TEL, TEW, ML, PL and CH (*P*>0.05).

*mean across rows with p<0.05, ** across means with p<0.01 were significantly different; NS means across row not significant (p>0.05)

3.2 Fulton condition factor and growth pattern distribution of *M. vollenhovenii*

The Fulton's condition Factor varied from 1.08 – 2.729 (X=1.628 ±0.310), 0.668 -2.318 (X=1.498±0.465) and 0.668 – 2.670 (X=1.630 ±0.481) for CAL, NCR and BAY, respectively. One-way ANOVA showed that the condition factor was the same for all three populations (p>0.05) and the Welch test for unequal variances failed also to detect any significant difference (p>0.05).

The Log length/Log weight relationships are shown in Figures 2 to 4. The calculated log of the length/weight relationship of the *M. vollenhovenii* showed a linear relationship between the length and weight of the species with R^2 of 0.877, 0.894 and 0.881 and corresponding R of 0.936, 0.945 and 0.939, respectively for CAL, NCR and BAY.

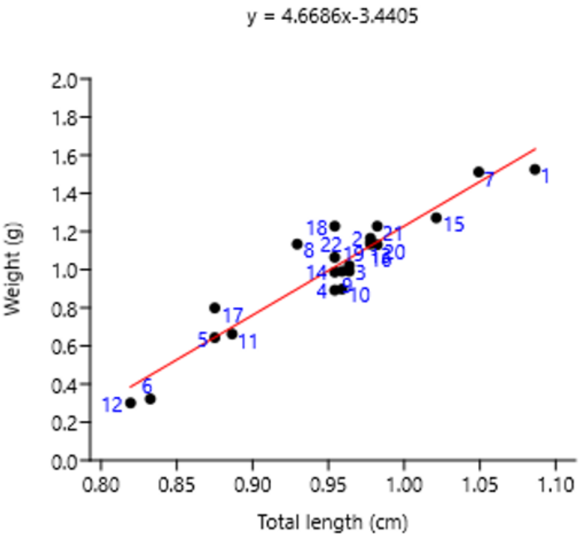

FIGURE 2: Length Weight relation of M. vollenhovenii from New Calabar River

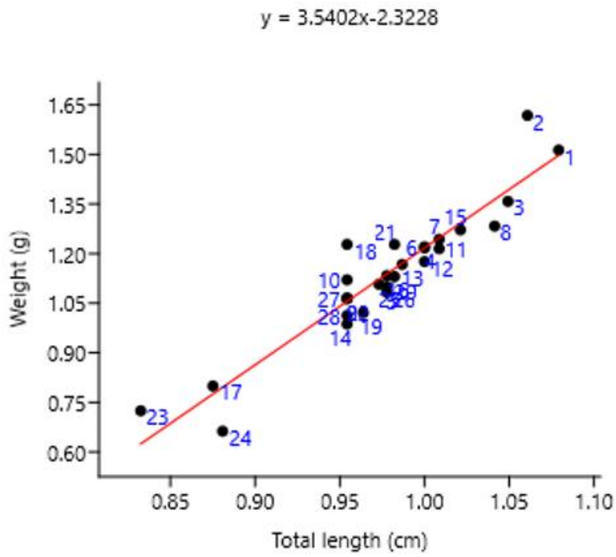

FIGURE 3: Length-weight relationship of *M. vollehovenii* from Calabar Estuary

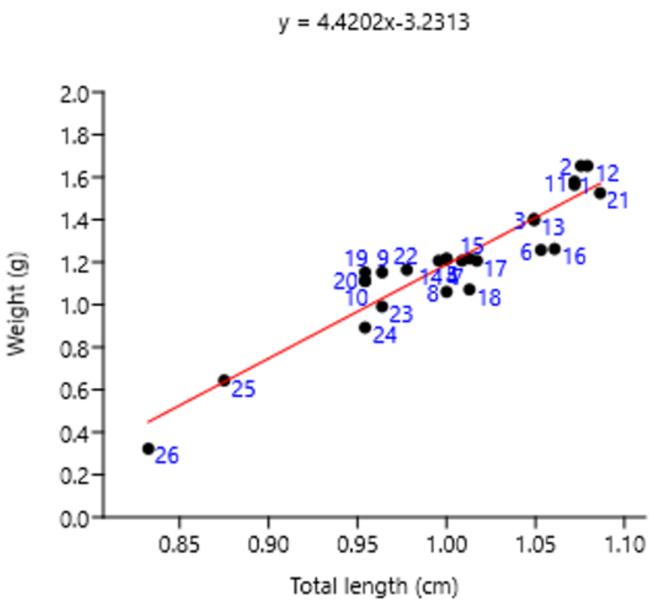

FIGURE 4: Length-weight relationship of *M. vollenhovenii* from Taylor Creek

IV. DISCUSSION

The Niger Delta Region supports major artisanal fishery that have been sustained for hundreds of years. The region is the richest in shrimp shellfish resources in Nigeria. The decapod crustaceans *Macrobrachium* species have sustained local fishery across the region, serving as source of income and rich animal protein for the communities and commercial traders. The rich organic sediment characteristic of the NDR makes it the ideal environment for shrimps to thrive and grow. In fish ecological studies, the condition index is the common denominator used in monitoring how populations respond to changes in the environmental over a period and in the assessment of the overall health and productivity (Richter, 2007). Fulton's condition index is generally used to estimate populations health and growth rate (Rochet, 2000), assess adaptation to culture systems (Araneda et al., 2008) and the overall biotic and abiotic conditions for growth (Gopalakrishnan et al., 2014). The high condition factor ranging from 1.478 to 1.630 of the species from the three rivers indicates, perhaps, similar prevailing environmental conditions that supports growth and provide adequate nutrition. The rich organic debris input arising from runoff due to frequent rains that characterize the delta basin support rich shrimp resources in and off the coast of the Niger Delta (Zabbey et al., 2010).

The Length–weight relationship (LWR) has important implications for fisheries management. LWR is used in determining growth rates, age structure and other aspects of shrimp population dynamics (Anastasiadou and Leonardos, 2008; Nahavandi et al., 2010). In selective breeding, LWR is a useful measure for body condition and comparison of morphological differences between populations in different regions (Nie et al., 2013). The condition of *M. vollenhovenii* assessed from the value of the slope in the length-weight relationship in the present study show that for all populations the slope was above 3, indicating increasing growth rate in relation to length. The relationship between length and weight *M. vollenhovenii* from the New Calabar River, Taylor Creek and Calabar Estuary were linear relationship. Lawal-Are and Owolabi (2012) reported that the prawn obtained from Lekki and Lagos Lagoons showed a linear relationship between length and weight, however, growth was allometrically negative with values of regression coefficient (b) ranging between 2.2788 and 2.7117. However, in the present study the prawn exhibited positive allometric growth with values of regression coefficient ranging from 3.54 to 4.67 (Fig 2-4). Variability in the LWR is a feature that can reflect fluctuations in the uptake and allocation of energy. Biswas (1993) suggested that differences in b values could be a result of gear selective influence and other factors such as sex, gonadal development, nutritive conditions in the environment of fish, physiological conditions of the fish at the time of collection and seasonal fluctuations in environmental parameters.

The phenotype of individuals including morphological traits within a species may be underlined by genetic and environmental effects or the interaction between genetic and environment, and selection (Cadrin, 2000; Poulet, 2004). Thus, explaining morphological differences between populations present some difficulties. However, it has been known that the morphometric characters can describe level of plasticity in response to environmental (Wimberger 2008). This study identified significant differences ($p< 0.05$) in the weight, total length, rostrum length, carapace length, abdominal length, carapace height and TEW of *M. vollenhovenii* from the three selected drainage. We suggest that morphological differences displayed by populations may be due to adaptation to prevailing local environmental conditions and limited larval dispersal. Environmental conditions, food availability and state of maturity may be responsible for the variations in weight and total length of the species. Elsewhere, studies have showed that environmental variation could lead to morphological heterogeneity (Tzeng et al., 1998; Begg et al., 1999; Giri and Collins, 2004; Collins et al., 2007; Giri and Loy, 2008; Torres et al., 2014). Mashiko and Numachi (2000) reported that populations of the oriental river prawn from fresh-water were differentiated from estuarine populations in morphometric traits. The high level of variations observed in this study could have been facilitated by limited larval dispersal of species with life histories associated with alternating freshwater and brackish-water environment creates room for wide morphological divergence due to lack of gene flow which homogenizes populations. We align with Begg et al. (1999) who suggested that morphometric variation could be more applicable for understanding short-term environmentally induced variation. Morphological characters are phenotypically plastic being influenced by the physical environment during different stages of growth.

V. CONCLUSION

There is a high level of morphological traits heterogeneity in *M. vollenhovenii* in the three selected drainage systems in the Niger Delta. The data in this study is valuable for selecting broodstock and establishing a monitoring and management system of the species in view of the environmental degradation of the Niger Delta. The current study provided the first baseline data comparing populations of *M. vollenhovenii* from different drainage systems of the Niger Delta Region of Nigeria and should be expanded to capture other river systems with corresponding genetic studies.

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