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LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF INVASIVE *Penaeus monodon* ALONG THE SOUTH COASTLINE OF NIGERIA

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ABSTRACT
The study of Length-weight relationship (LWR) of aquatic species is significant in fisheries biology because of their usefulness in estimating weight parallel to a given length. In this study, ten locations covering five coastal states vis-à-vis Lagos Makoko (LM), Lagos Apapa (LA), Lagos Takwabay (LT), Lagos Tincan (LC), Lagos Folu (LF), Ondo Aiyetoro (AO), Bayelsa Brass (BB), Rivers Bonny (RB), Rivers Kaa (RK) Akwa Ibom Ibeno (AB) were used for the analysis of LWR and condition factor of the invasive tiger shrimps. A total of 400 samples were used. Sex dimorphism by size variation showed Females (South West: 24.4±2.7 cm; 143.2±29.3g , South-South: 24.0±2.5 cm;139.3±28.2g) being significantly larger than males (South West: 19.0±4.02 cm; 96.8±35.1g , South-South: 19.7±3.26 cm;100.4±25.8g) (P<0.01). Condition factor k was reported significantly higher in males (South west: 1.548± 0.6, South-South: 1.393±0.53) than females (South west: 0.974±0.17, South-south: 0.971±0.14) (P < 0.01). All Length-Weight relationships were positively correlated.
Keywords: *Penaeus monodon*, Morphometric, Regression

INTRODUCTION

The study of Length-weight relationship (LWR) of aquatic species is significant in fisheries biology because of their usefulness in estimating weight parallel to a given length. Furthermore, LWR may be used to examine possible variation between separate unit stocks of species (Ighwela, 2011). In addition LWR helps establish a mathematical connection between the two variables-Length and weight (Lalrinsanga , 2012), allows the conversion of one variable form into other can possibly differentiate among different stocks of same species and can explain to some extent growth in wild environment (Abohweyere and Williams, 2008; Deekae and Abowei, 2010). In addition, information on the condition and patterns of growth can be provided by LWR. Fish farmers and industries frequently record body weight since their benefits depend largely on biomass, whereas research scientists may have a preference for length measurements that can easily be taken on field. Data from LWR can be incorporated into fisheries management database for any work on assessment (Yakubu and Ansa, 2007)

An index which reflects the interactions between biotic and abiotic factors in the physiological and environmental condition of the fishes is the condition factor, K. Although condition factor may not reflect qualitative characteristics such as protein, lipid or carbohydrates, it is an indicator of the general body condition (Lalrinsanga *et al.,* 2012). The most extensively used condition factor in fisheries biology studies is that of Fulton. Fulton's condition factor (K) is calculated from the relationship between the weight and the length of a fish. It presupposes isometric growth in which fish shape does not vary with growth (i.e. slope $b = 3$). Moreover, a relative condition factor (Kn) was proposed by Le Cren (1951) in preference to Fulton's condition factor (K). Kn considers all the variations associated with food, feeding, sexual maturity, etc., while the Kf does so just if the exponent value is only equal to 3. Therefore, K factor assesses variations from an ideal fish based on the cube law while, Kn measures individual deviations from the expected weight obtained from the LWR (Manorama and Ramanujam, 2014).

The tiger shrimp (*Penaeus monodon*) is an invasive species to the Nigerian coastal waters (Anyanwu *et al*., 2011; Ayinla *et al.,* 2009) and a number of reports have been documented on the morphometrics, LWR and condition factor of *P. monodon* in its native rage. Gopalakrishnan *et al.* (2013) reported negative allometric growth in tiger shrimp for both cultured population (Male b values= 2.805; Female b= 2.780) and wild population (male b values = 2.432; females = 2.568). Moreover female had a higher condition factor K in the cultured system while males had higher k vales in the wild samples. In Nigeria, Yakubu and Ansa (2007) have compared the weight of the indigenous penaeid shrimp *P. notialis* with the exotic *P. monodon* species stating that the observed significant difference with higher values obtained for *P. monodon* is due to its ability to grow larger and at a faster rate than other Penaeids shrimps. Ajani *et al.,* (2013) reported higher condition factor index in *P. monodon* compared with *P. notialis.* The aim of this research is to study the pattern of morphological variation across the south west and south south coastline of Nigeria.

MATERIALS AND METHODS

Study sites

After a pilot survey on noticeable artisanal tiger shrimp fishing areas around the South-West and South-South coastal states of Nigeria, five states and 10 stations were selected for this study. All Sites for the study (Fig. 1, Table 1) were previously described by Oketoki (2015).

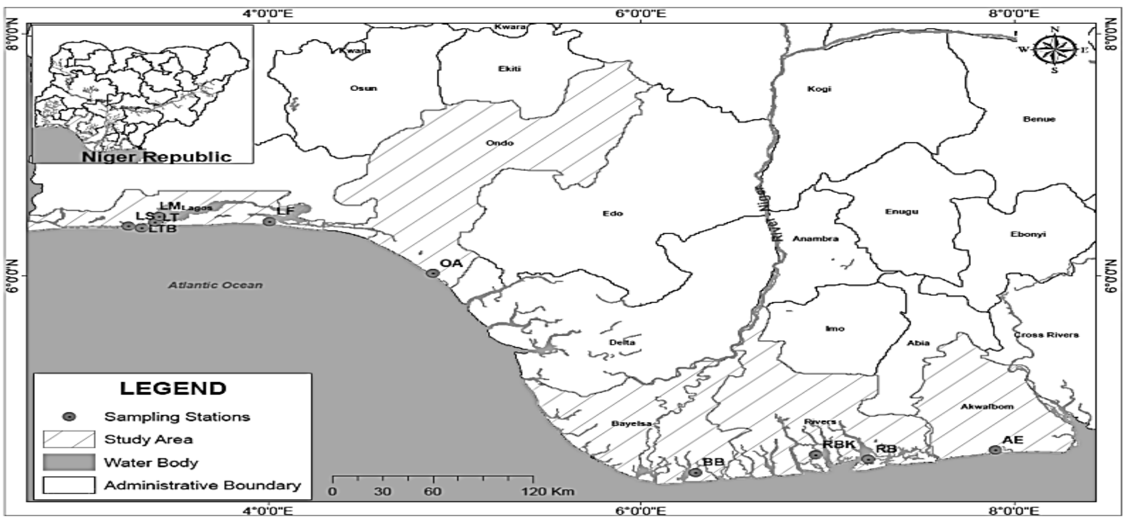

Fig.1: Nigeria's coastline showing South-West and South-South sampling sites

Table 1: Sampling stations with coordinates

STATE	REGION	SAMPLING STATIONS	COORDINATES	
			Longitude	Latitude
LAGOS	SouthWest	Folu (LF)	4° 0' 16.128"	6° 26' 50.438“
LAGOS	SouthWest	Makoko (LM)	3°23'8.405"	6°28'35.00"
LAGOS	SouthWest	Apapa (LA)	3°21'7.352"	6°27'0.520"
LAGOS	SouthWest	Tarkwa Bay (LT)	3°23'42.392"	6°24'10.075''
LAGOS	SouthWest	Tin can Island (LC)	3°20'30.562"	6°26'8.401"
ONDO	SouthWest	Aiyetoro (OA)	4°40'11.91"	6°11'37.53''
BAYELSA	SouthSouth	Brass (BB)	6° 15' 55.532"	4° 17' 33.431"
RIVERS	SouthSouth	Bori-Kaa Water side (RK)	7° 30' 53.352"	4° 44' 7.9553“
RIVERS	SouthSouth	Bonny (RB)	7° 9' 21.926"	4° 39' 47.274”
AKWA IBOM	SouthSouth	Eket-ibeno (AB)	8° 0' 30.974"	4° 32' 31.000”

Sampling

A total of 400 samples of tiger shrimp were obtained between July and November, 2013 from shrimpers at the landing sites of each station; South-West (males 121, females 113) and South-South (males 90, females 76). They were kept on ice, transported to the lab and stored in freezer until time of analysis.

Morphometric measurements

Sexes were determined by checking the external genital organs. The total length (TL), carapace length (CL) and rostral length (RL) of the shrimp samples were measured in centimetres (cm) using the graduated meter ruler, while the body weight (BW) and carapace weight (CW) were measured using a Sartorius balance (Model 1100). Total length measured was obtained by stretching out the curved body and taking measurements from the telson to the base of the eyestalk. Carapace length was obtained by cutting off the cephalothoraxes and measurements were taken from the posterior end of the carapace to the base of eyestalk.

All measurements were to the nearest 0.1 cm; while weight was measured to the nearest 0.1 g.

Then length–weight relationship was calculated using the conventional formula:

$$W = a.L^b$$

log transformed as Log W = Log a + b Log L,

where; **W** is the derived weight of shrimps (g), **L** is the length (cm) coefficient, **'a'** is the intercept in the y-axis, and the regression parameter **b** (slope) is an exponent indicating isometric growth when close to 3.

Fulton's condition factor (Kf) and relative condition factor (Kn) of the shrimps was estimated from mean length and mean weight in the sample using the relationship:

$$Kf = 100\ W/L^3$$

$$Kn = 100W/L^b$$

Where;

Kf = Fulton's Condition factor, Kn = Relative Condition factor W = mean weight of shrimp (g), and L = mean length of shrimp (cm), b =slope

The statistical significance level was estimated on the log transformed linear regression equation. PLOTLY, PAST and R-STUDIO statistical software were used to compute all statistical analyses including linear regression analysis, PCA and scattered plot for multivariate data.

RESULTS

The frequency distribution of male and female specimens of *P. monodon* is displayed in Fig. 2. While the mean differences in total length and body weight of sex by region are represented in Figs. 3 and 4. Significantly higher mean value ($P < 0.01$) was observed in female compared to male. Log transformed linear regression of sex-wise length-weight and length-length relationships of total length, body length, carapace length and body weight are shown in Figs. 5, 6 and 7. The values for intercept/elevation (a) and slope (b) together with their corresponding coefficients of determination (r^2) relationships in *P. monodon* are also shown. The relationships vary with sexes and location such that different equations had to be used for purposes of inter-conversions and scatter plots. Significant higher slope was observed in females compared to males ($P < 0.01$). Figure 8 depicts the mean values of Fulton's and Relative condition factors Kf and Kn respectively. Analysis of Variance for K values reveals significant difference ($P < 0.01$) between sexes for both Kf and Kn. However, there was no significant difference within females across region for both (Kf and Kn) but males recorded significant difference across regions.

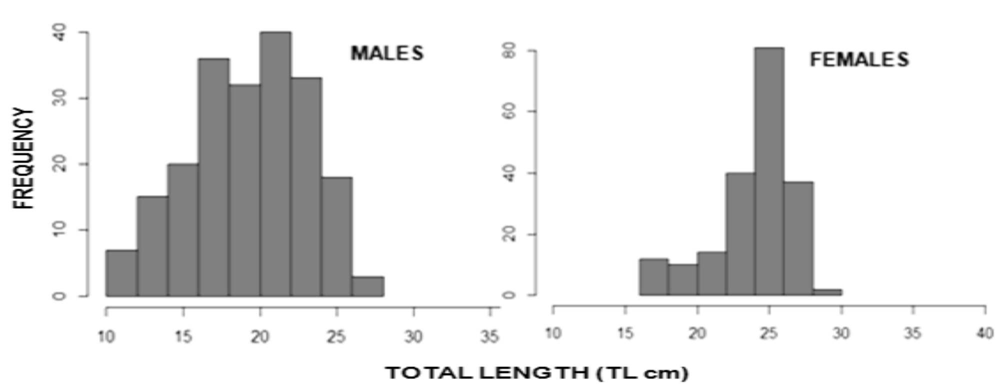

Fig. 2: Frequency distribution of *Penaeus monodon* by sex

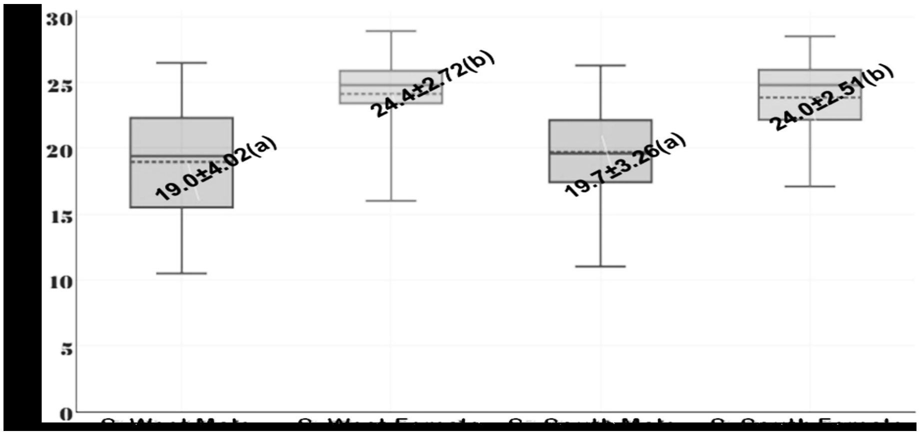

Fig. 3: Mean total length of male and female *Penaeus monodon* from South-West and South-South Nigeria

Same alphabets represent no significant difference while different letters indicate significant difference

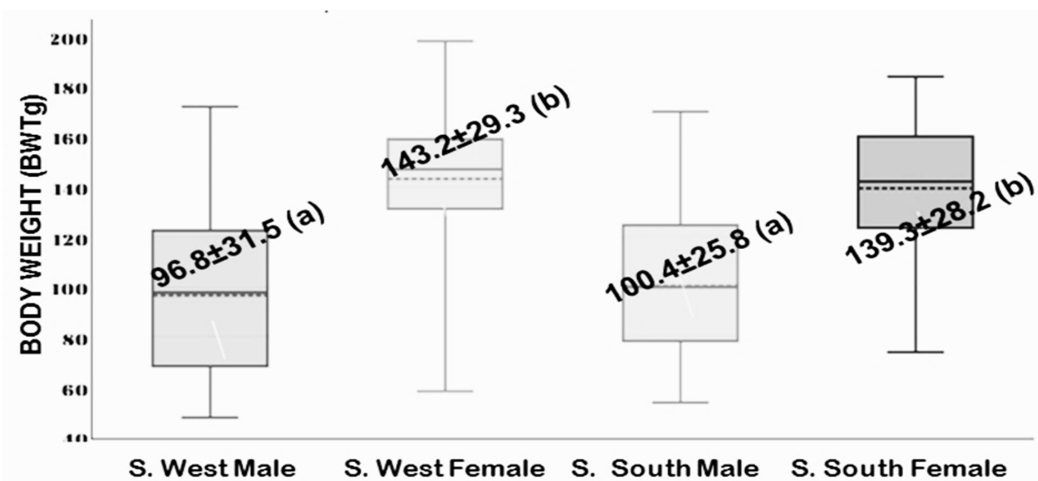

Fig. 4: Mean body weight of male and female *Penaeus monodon* from South-West and South-South coastline of Nigeria

Same alphabets represent no significant difference while different letters indicate significant difference

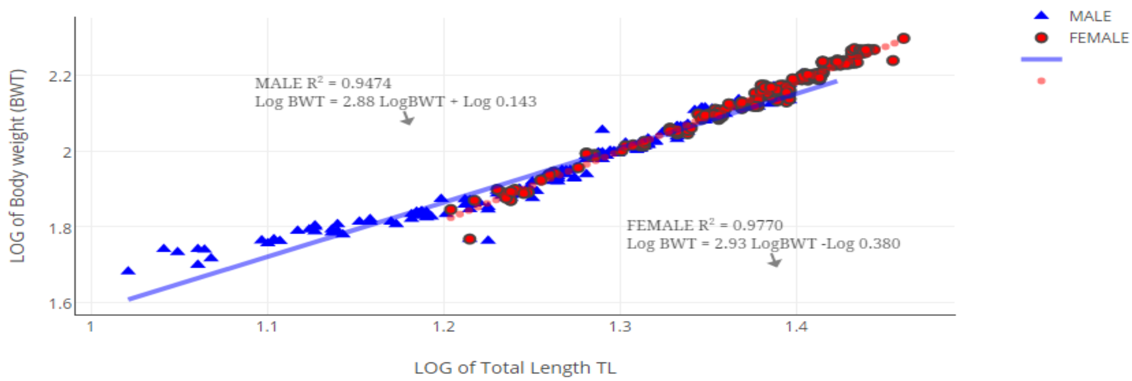

Fig. 5: Sex-wise linear regression of total length-body weight relationship of *Penaeus monodon*

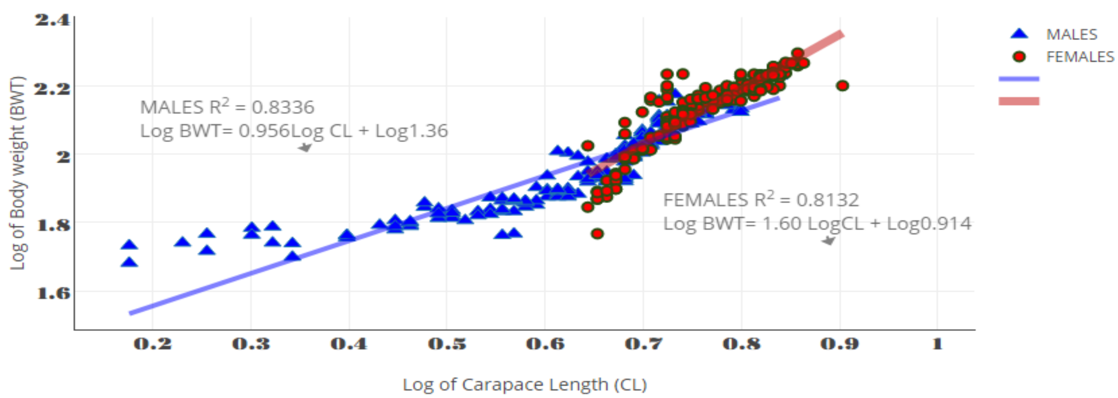

Fig. 6: Sex-wise linear regression of carapace length-body weight relationship of *Penaeus monodon*

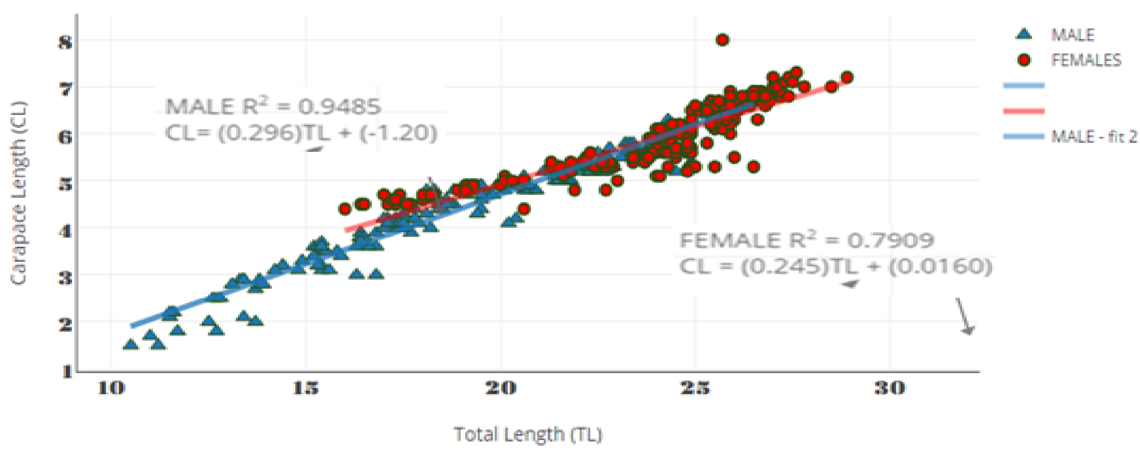

Fig. 7: Sex-wise linear regression of carapace length- total length relationship of *Penaeus monodon*

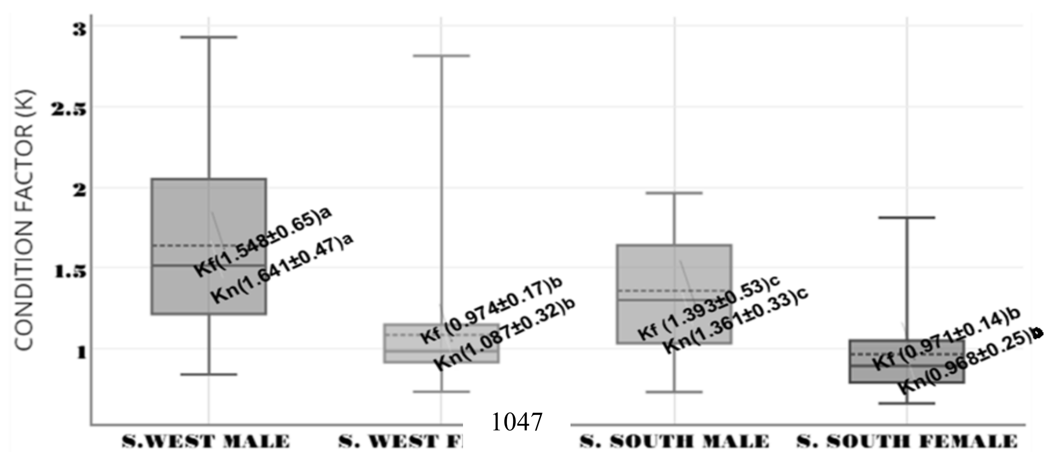

Fig. 8: Sex-wise mean relative condition factor (Kn) and Fulton's condition factor (Kf) from South-West and South-South coastline of Nigeria

Means with same alphabet indicates no significant difference while different alphabets indicates significant difference ($P < 0.01$)

DISCUSSION

The use of total length to determine length-weight morphometric relationships has been extensively applied in wild and captive *P. monodon* species (Chu *et al*., 1995) and hence in this study. All length-weight relationships estimated in the present study were within ranges previously reported for penaeids (Abohweyere and Williams, 2008; Deekae and Abowei, 2010). There was significant difference in the length and weight of females (range; 16 cm – 28.9 cm and 58.5 g – 198.0 g) being greater than males (10.5 cm – 26.5 cm and 48.0 g – 171.0 g) within and between the South-West and South-South geographic regions of Nigeria. Makinouchi and Hirata (1995) reported that differential weight gains in *P. monodon* (> 45 g BW) were observed as 5.5 g/month for males and 10 g/month for females. Greater weight increase per frequent moult cycle in females leading to a faster growth rate may be responsible for being larger than males (Hansford and Hewitt, 1994). More so, size variation may also be connected with higher proportion of sexually matured females as ripe ovaries represent about 8% of total body weight in *P. monodon (*Chu *et al.,* 1993).

In shellfishes dimensional equality is generally maintained such that weight increase is always proportional to the cube of length increment. Slope of 3 is assumed isometric growth (maintaining dimensional equality as the organism grow). Values less than 3 indicates slender bodies as they increases in length, whereas slope values higher than 3 represents stoutness (Lalrinsanga *et al.,* 2012; Yakub and Ansa, 2007). Thus positive allometric growth results when weight increases more than length (b>3) and negative allometric when length increases more than weight (b < 3) (Datta *et al.*, 2013). Regressing TL with BWT in the current study gave slope values less than 3 which was not significantly different from 3. In contrast with higher slopes for female than male in the current study, slope values were higher for male *Parapeneopsis stylifera, P. semisulcatus* and *M. affinis from wild* fisheries in Kuwait (Farmer, 1986.).

According to Manorama and Ramanujam (2014) condition factor k is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live. In the current studies, higher K values were reported for males in Sex wise comparison (1.548 vs 0.974 South-West and 1.393 vs 0.971 South-South). Gopalakrishnan *et al*., (2013) also observed that in wild *P. monodon*, the males have higher condition factor values than females, 0.975 vs 0.939 respectively. Abohweyere and Williams (2008) and Arimoro and Meye (2007) also reported higher condition factor in male of *M. macrobrachion* compared to female and suggested that males generally appear to have better mean condition factor than the females. The significant difference in condition values of male between South West and South-South regions may suggest better environmental condition for *P. monodon* in the South West compared to South-South. Yakub and Ansa (2007) observed condition values of 0.807 and 0.876 for *P. monodon* and *P. notialis* respectively from Buguma creek, River state and documented the ecological suitability of the environment for both indigenous and exotic species. However Ajani *et al*. (2013) reported condition factor range of 0.451 - 1.52.

CONCLUSION

Morphological studies on length weight relationship show significant difference between male and female *P. monodon*. A positive correlation exists between body weight and body length of the tiger shrimp and can therefore be useful to scientist during field work. High values of condition factor means that the biotic and abiotic factors in Nigerian coastal waters are suitable for the establishment of the exotic tiger shrimp. Genetic diversity studies enhanced by molecular tools may further be useful in elucidating paucity in morphological variation across Nigeria's South-West and South-South coastline as observed in the present study.

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