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Research Article

Aspects of the Biology and Heavy Metal Concentration in the Giant Tiger Shrimp, *Penaeus Monodon* (Fabricius, 1798) from Lagos Lagoon

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ABSTRACT

The present study investigated aspects of the biology and heavy metals concentrations in the flesh of *Penaeus monodon* from the Lagos Lagoon. 183 samples were collected between July – September 2018 and they were used to study the ageing and growth pattern using length-frequency distribution and length-weight relationship. Food and feeding habits were determined by numerical and occurrence methods while heavy metals concentration was assayed by atomic absorption spectrophotometry. The samples consisted of 61 females and 122 males and their total length, carapace length and total weight ranged from 11.5 to 33.0 cm, 4.1 to 14.0 cm and 8.0 to 271.7 g, respectively. Three age groups were obtained from length-frequency distribution. The b values of 3.09 and 3.27 for the carapace length/weight relationship and the total length/weight relationship obtained respectively showed a positive allometric growth pattern of the species. *P. monodon* fed on green algae, diatoms, crustaceans and fish fragments and their condition factor ranged between 0.6 and 0.9. The sex ratio (1:0.5) showed that males were significantly ($p < 0.05$) more males than females in the study area. Heavy metals accumulated in the flesh in decreasing order of Fe > Zn > Pb > Mn > Cd > Cu > Cr. The concentrations of Pb, Mn and Cr were higher than the FAO/WHO maximum acceptable values for consumption. This study suggested a potential health risk which could arise from consumption of *P. monodon* from the lagoon, if relevant mitigating strategies are not enforced.

Keywords: Condition factor, Length-weight relationship, Stomach contents, Heavy metal, *Penaeus monodon*
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INTRODUCTION

The giant tiger prawn, *Penaeus monodon*, is a species of shrimp that is widely distributed in lagoons and coastal waters of tropical and subtropical regions (FAO, 2007). Although, it is non-native to West Africa, it has established itself in the offshore waters of Nigeria (Ayinla *et al*., 2009) and it can also thrive in fresh and brackish water environments with salinity levels ranging from 0.2-15 ppt (Saha *et al*., 1999; Mohanta, 2000). As a commercially important seafood with global relevance, *P. monodon* has high nutritional value and contributes significantly to the economy of many countries (Bondad-Reantaso *et al*., 2012). However, there is significant pressure on marine ecosystems due to increasing demand for seafood and other anthropogenic activities which are threatening the sustainability of shrimp fisheries; necessitating the need for updated knowledge in different aspects of their biology. Studying the feeding habits, reproductive biology and heavy metal accumulation in shrimps is crucial to understanding their ecology and potential risks to human health (Wootton, 1992; Karuppasamy & Menon, 2004). Understanding shrimps food sources and feeding behavior can provide valuable information about their habitat preferences and trophic interactions with other species in the ecosystem (Kulkarni *et al*., 1999). Gut content analysis has been the most commonly used technique in the study of the feeding behaviour of shrimps and it has provided valuable information on the prey items and feeding habits of the species. Many authors (Kulkarni *et al*., 1999; Karuppasamy & Menon, 2004; Bello-Olusoji *et al*., 2005; Akinwunmi *et al*., 2019) established that shrimps utilize a diverse range of food throughout their life cycle, including phytoplankton and zooplankton; while Marte (1980) observed that crustaceans and molluscs were their major sources of essential amino acids utilized for rapid growth and development. Adetayo and Kusemiju (1994) reported that penaeid shrimps are generally opportunistic omnivores, bottom feeders, and detrital feeders; with most feeding occurring at night and limited feeding during the day in turbid water. The specific food sources and feeding behaviour of *P. monodon* can vary across different habitats and life stages and this information is essential for managing the species sustainably.

Reproductive biology is another critical aspect of the ecology of shrimps essential for managing their populations sustainably. Water temperature, salinity, and food availability are some of the factors known to influence the reproductive success of *P. monodon* (Teikwa & Mgaya, 2003; Naser-Uddin *et al.* 2015). For example, low water temperature can delay the onset of spawning, leading to lower breeding success. Similarly, low food availability during the larval phase can result in high mortality rates and reduced recruitment to the adult population (Naser-Uddin *et al.* 2015). The knowledge of these factors affecting reproduction is important for managing shrimp populations and ensuring their sustainable use.

Although, *P. monodon* can be a rich source of indispensable micronutrients like zinc and copper needed for the biosynthesis and breakdown of carbohydrates, lipids, proteins and nucleic acids; yet they might pose health risks due to the accumulation of toxic heavy metals in their tissues. Heavy metals, such as mercury, lead and cadmium, can accumulate in the tissues of shrimp and other seafood, leading to adverse health effects when consumed by humans (Soyinka, *et al.,* 2021). Lead, for instance, have been reported to adversely affect infant developmental intelligence and cause heart and blood vessel diseases in adults, while continuous exposure to high levels of cadmium have been observed to cause liver and kidney damage (Garcia-Rico *et al.,* 2007; Barrento *et al.,* 2008; WHO, 2013). The concentrations of heavy metals in freshwater, estuarine, and marine environments have increased as a result of different anthropogenic activities such as domestic, agricultural, mining and industrial activities. *P. monodon* is particularly susceptible to heavy metal accumulation since they are bottom-dwelling species and heavy metals tend to accumulate in the sediments. .

Studies on food and feeding habits of *P. monodon* as well as probable accumulation of heavy metals in this commercially significant species from Lagos Lagoon are scarce. Thus, this study examined aspects of the biology and heavy metal concentration in *Penaeus monodon* from the Lagos Lagoon.

MATERIALS AND METHODS

Description of the Study Area

The research was conducted on specimens from the Lagos Lagoon. It is a brackish coastal lagoon, which lies within latitude 6°26'–6°37' N and longitude 3°23' - 4°20' E. The Lagos Lagoon is characterized by seasonal fluctuation in salinity, high brackish water during the dry season (December – May), while freshwater condition exists in the rainy season (June- November) (Kusemiju, 1975; Solarin, 1998; Akinwunmi & Lawal-Are, 2019; Akinwunmi, 2020). It receives freshwater from Lekki Lagoon via Epe Lagoon in the North-East and discharges from Majidun, Agboyi and Ogudu creeks as well as Ogun River in the North-West (Soyinka, 2008; Lawal-Are *et al.,* 2010).Lagos Lagoon is more than 50 km long and 3-13 km wide and is separated from the Atlantic Ocean by long sand bars 2-5 km wide**.** Fishing is one of the human activities carried out in the lagoon. The fauna is composed of fresh, marine and brackish water species, depending on the season. Among the fauna exploited for commercial purposes are finfish and shellfish (Isebor*et al.,* 2006).

Collection of Specimens

A total of 183 samples of *Penaeus monodon* were collected from the artisanal fishermen in the Lagos Lagoon between July and Sep*t*ember 2018. The samples were preserved in ice at the point of collection and immediately transferred to the deep freezer (-20 ºC) at the Marine Research Laboratory, Department of Marine Sciences, University of Lagos, where they were kept prior to laboratory analyses.

Laboratory Procedures

Length and Weight Measurements: The samples were brought out of the freezer and thawed at room temperature at the Marine Research laboratory, Department of Marine Sciences, University of Lagos, Nigeria. Excess water was removed from the samples using tissue paper. The total length (TL) was measured from the tip of the rostrum to the end of the telson, to the nearest centimetreusing a meter rule. Similarly, the carapace length (CL) measured to the nearest 0.1 cmwas taken as the length from the post-orbital margin to the rear margin of the carapace. The total weight was measured to the nearest 0.1 g was taken on an electronic weighing balance (Model: DT 1001A). All measurements obtained were recorded on proforma data sheets for the sexes separately.

Growth Pattern: The length and weight of the shrimps recorded were collated into data to obtain the growth rate of the shrimps. The length-weight relationship is represented using the expression in Eq. 1 (Pauly, 1983).

$$W = aL^{b} \dots\dots Eq. 1$$

Where: W= weight of the prawns in grams.
L = total length of the prawns in cm.
a = regression constant
b = regression coefficient

The values of constants a and b were estimated from log transformation values of length andweightusing the expression in Eq. 2 (Parsons, 1988).

$$LogW = Loga + bLogL \dots\dots. Eq. 2$$

Condition Factor (K)

The Condition factor (K) was calculated according to Gayanilo & Pauly (1997) using the expression in Eq. 3.
Mathematically, Condition factor can be represented by the equation;

$$K = \frac{100W}{L^3} \dots\dots\dots\dots. Eq. 3$$

Where: K = condition factor
W = weight of the fish in grams (g).
L = Length of fish in centimeters (cm)

Stomach Analysis

The stomach of each specimen was dissected, examined and scored with regards to the degree of fullness– 0/4 (empty), ¼ (quarter full), 2/4 (half full), ¾ (three-quarter full) and 4/4 (full). The contents were washed into a Petri dish and investigated using a light microscope. The enumeration of the stomach contents was carried out by both the numerical and frequency of occurrence methods as described by Akinwunmi *et al*. (2019). The food items were identified with the aid of the keys using several identification texts (Edmunds, 1978; Schneider, 1990; Anderson, 1999).

Reproductive Biology

Sex Determination

The sexes of the shrimps were observed and determined by the physical presence of the thelycum and the petasma for the female and male sexes respectively. The external organ lies between the 4^{th} and5^{th} pairs of the pereiopods (walking legs) for the female while the male external organ lies between the 1^{st} pairs of pleopods (Oluboba, 2015). The male-female ratio statistical hypothesis of H_0 = 1:1 for male and female was tested using the Chi- square as expressed in Eq. 4.

$$\chi 2 = \frac{\Sigma\,(\text{Observed} - \text{Expected})^2}{\text{Expected}} \dots\dots. Eq. 4$$

where: χ^2 = Chi-square to be calculated and compared with χ^2 (1 d.f., 5%) tabulated value.

Heavy Metal Analysis of Samples

Monthly analyses of the heavy metals - cadmium(Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), lead (Pb) and zinc (Zn) – were done with three samples of the specimen per month, using standard procedure of the Association of Official Analytical Chemists (2005). The samples were allowed to defrost at room temperature; the consumable tissue of the samples was excised using stainless steel scalpels and dried in the oven at 105°C. 2 grams of the dried sample were soaked overnight in 10 ml Nitric acid (HNO_3) at ambient temperature. The samples were then digested in boiling (100°C) water bath for 2 hours. The digests were left to cool, sieved and transferred into 25 ml volumetric flasks and made up to mark, with 1% nitric acid (AOAC, 2005). The digests were kept in plastic bottles and the heavy metal concentrations were determined using an Atomic Absorption Spectrophotometer (Bulk Scientific VGB 211 Model).

Statistical Analysis

Data from the morphometric and meristic features were analyzed using descriptive statistics. Standard deviation and standard errors were calculated and scatter diagrams were plotted for the specimens to illustrate the relationship between the total or carapace lengths and weight of the shrimps. The log of total or carapace lengths and weight were obtained and plotted in order to establish the relationship between them. Chi- square test was used to determine the population dynamics. Results from the heavy metals analysis were presented using descriptive statistics.

RESULTS

Age and Growth Pattern of *Penaeus monodon*

Total length frequency distribution of *Penaeus monodon*: One hundred and eighty-three (183) *P. monodon* examined in this study consisted of 61 females and 122 males. The size grouping of the species ranged from 12.2 – 26.8 cm and 11.5 – 33.0 cm (total length), 4.1 – 9.8 cm and 4.1 – 14.0 cm (carapace length), while the total weight ranged from 9.0 – 135.8 g and 8.0 – 271.7 g for the male and female species respectively (Table 1).

Figures 1 – 3 which showed the total length frequency polygon of *P. monodon* revealed that the most prevalent size group in the males was 5.5 – 6.4 cm; 4.5 – 5.4 cm was most common in the females whereas 5.5 – 6.4 cm was most frequent in the combined sexes. From the frequency polygons, there are three age groups represented in the combined sexes: two age groups in the males while we have three age groups in the females.

Log Carapace-length/Log weight distribution in *Penaeus monodon*: Carapace length and weight logarithmic relationships for male, female and combined sexes of *Penaeus monodon*, presented in Figures 4-6, showed positive allometric growth pattern with high correlations in the males, females and combined sexes (Eqns. 5-7)

Male: $Log\,Y = -0.9053 + 3.099\ \mathrm{Log\,X}$……
………Eqn. 5
(n = 122, r = 0.9349, R^2 = 0.874)

Female: $Log\,Y = -0.911 + 3.0758\ \mathrm{Log\,X}$
………….Eqn. 6
(n = 61, r = 0.9615, R^2 = 0.9244)

Combined: $Log\,Y = -0.9065 + 3.0904\ \mathrm{Log\,X}$
……….Eqn. 7
(n = 183, r = 0.9478, R^2 = 0.8983)

The Total Length – Total Weight Relationship: The logarithmic association between total length and weight of *P. monodon* (Figs. 7 – 9) for the males, females and combined sexes in the study area also revealed positive allometric growth pattern with high correlations in the males, females and combined sexes (Eqns. 8-10).

Males: $Log\,Y = -2.3751 + 3.1818\ \mathrm{Log\,X}$
…………………... Eqn. 8
(n = 122, r = 0.9655, R^2 = 0.9321)

Females: $Log\,Y = -2.5904 + 3.3531\ \mathrm{Log\,X}$
………..… Eqn. 9
(n = 61, r = 0.9728, R^2 = 0.9464)

Combined: $Log\,Y = -2.4794 + 3.2653\ \mathrm{Log\,X}$
………..… Eqn. 10
(n = 183, r = 0.9689, R^2 = 0.9387)

Condition Factor (K)

Table 2, which showed the condition factor of *P. monodon* collected from Lagos Lagoon, revealed K values ranging between 0.6 and 0.9 for the males, females and the combined sexes.

Food and Feeding Habits

The 183 stomach contents examined showed that 20.8 % of the specimens had empty stomachs, 25.7% of the samples was one-quarter full, 22.4 % was two-quarters full, 11.5 % is three-quarters full and 19.7 % had full stomach (Table 3).

The food items were made up of green algae, diatoms, crustaceans, fish fragments and some unidentified matters (Table 4). Green algae were the dominant food item in terms of numbers (59.4%) and occurrence (74.48%).

Reproductive Biology

Sex Ratio: The male:female ratio of the sampled *P. monodon* ranged between 1:0.45 in July 2018 and 1:0.55 in August 2018. There was significantly ($p < 0.05$) more males than females during the period of investigation (Table 5).

Heavy Metal Concentration

The result of concentration of heavy metals in the flesh of *P. monodon* from Lagos Lagoon (Table 6) revealed that Fe was highest among the assessed heavy metals with value range of 28.13 mg/kg in

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August to 77.38 mg/kg in July (mean value: 54.43±24.79 mg/kg), while Cr was least with the mean concentration of 0.11±0.02mg/kg. Heavy metals accumulated in the flesh of *P. monodon* in decreasing order of Fe > Zn > Pb > Mn > Cd > Cu > Cr

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Table 1: Size groupings of *Penaeus monodon* from Lagos Lagoon (July – September, 2018)

		Minimum	Maximum
Male	Total length (cm)	12.2	26.8
	Carapace length (cm)	4.1	9.8
	Total weight (g)	9.0	135.8
Female	Total length (cm)	11.5	33.0
	Carapace length (cm)	4.1	14.0
	Total weight (g)	8.0	271.7

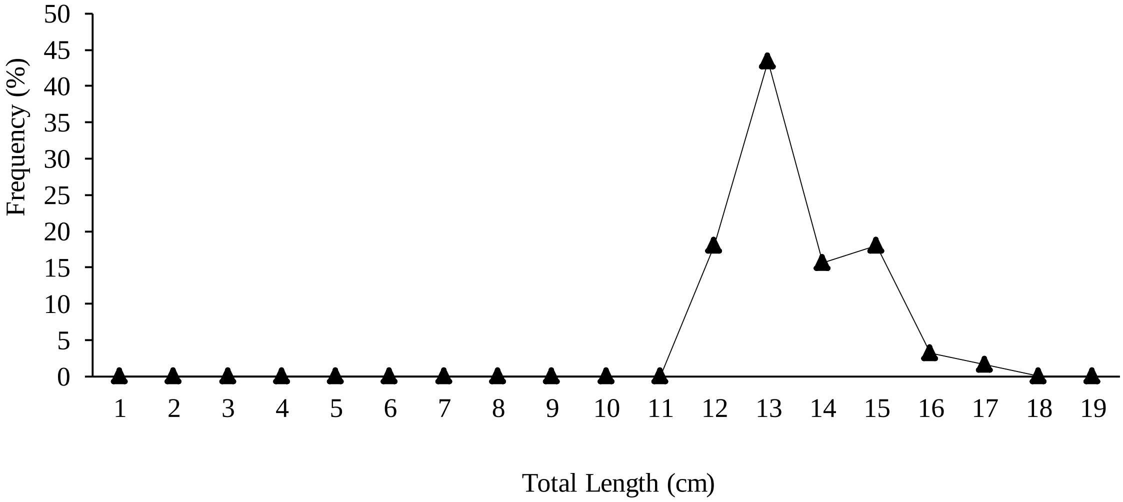

Figure 1: Total Length – frequency distribution of *Penaeus monodon* (males) in Lagos Lagoon (July – September, 2018).

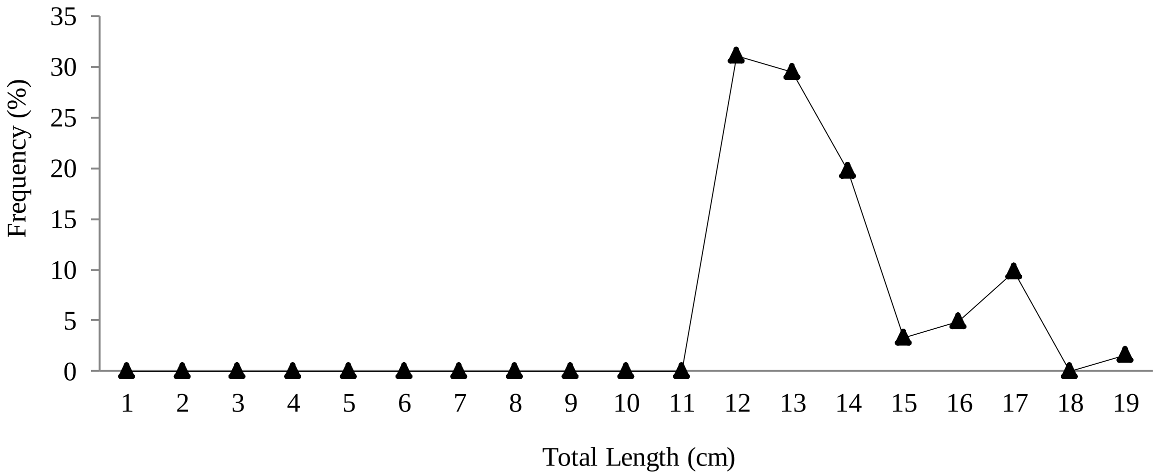

Figure 2: Total Length – frequency distribution of *Penaeus monodon* (females) in Lagos Lagoon (July – September, 2018).

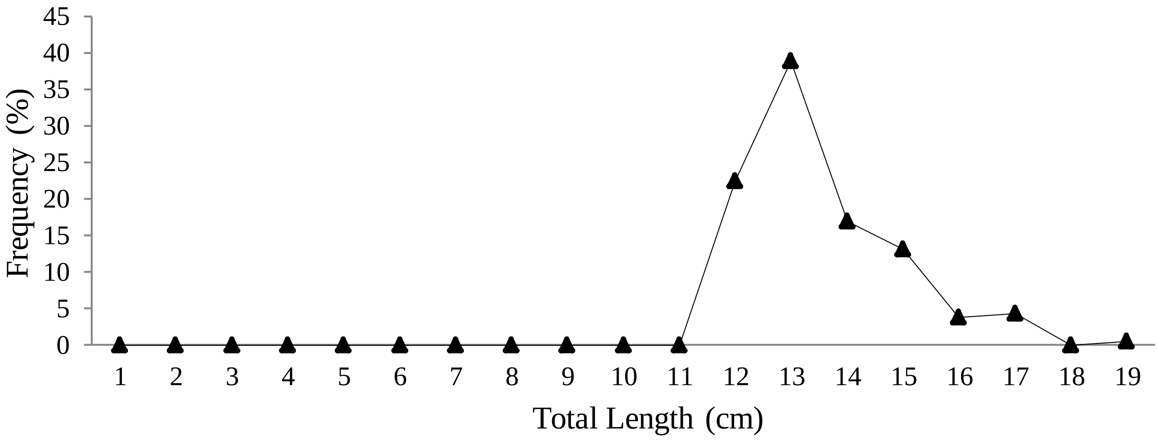

Figure 3: Total Length – frequency distribution of *Penaeus monodon* (combined sexes) in Lagos Lagoon (July – September, 2018).

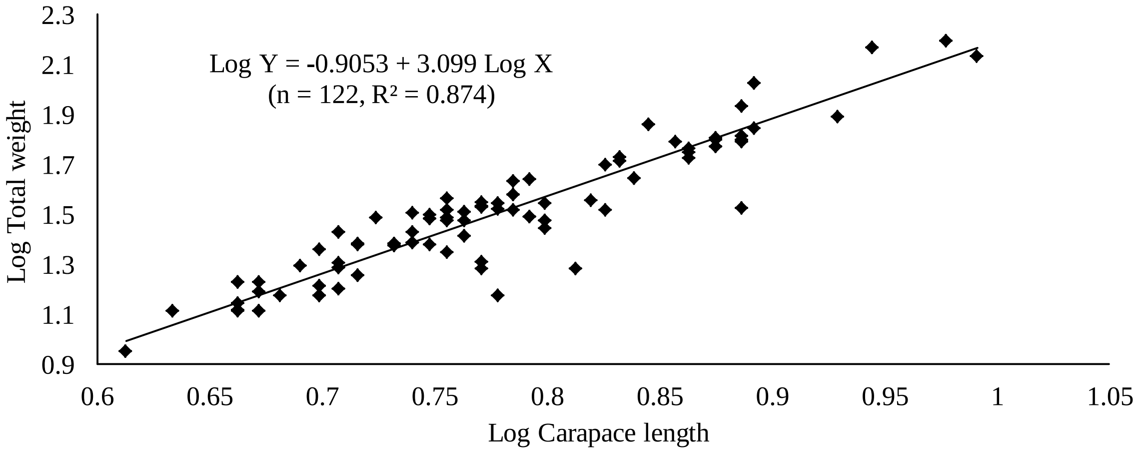

Figure 4: Log carapace length – Log weight relationship of male *Penaeus monodon* from Lagos Lagoon (July – September, 2018)

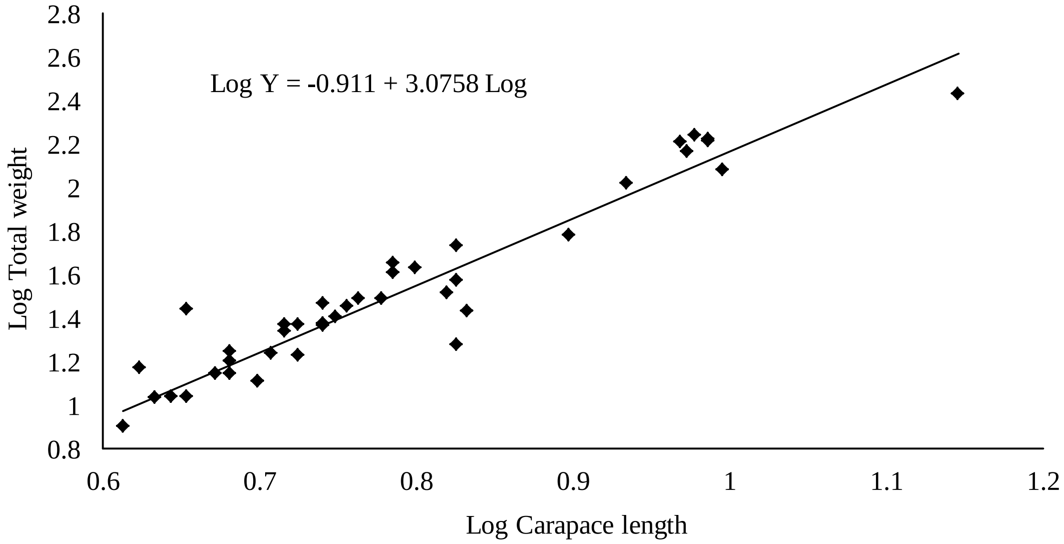

Figure 5: Log carapace length – Log weight relationship of female *Penaeus monodon* from Lagos Lagoon (July – September, 2018)

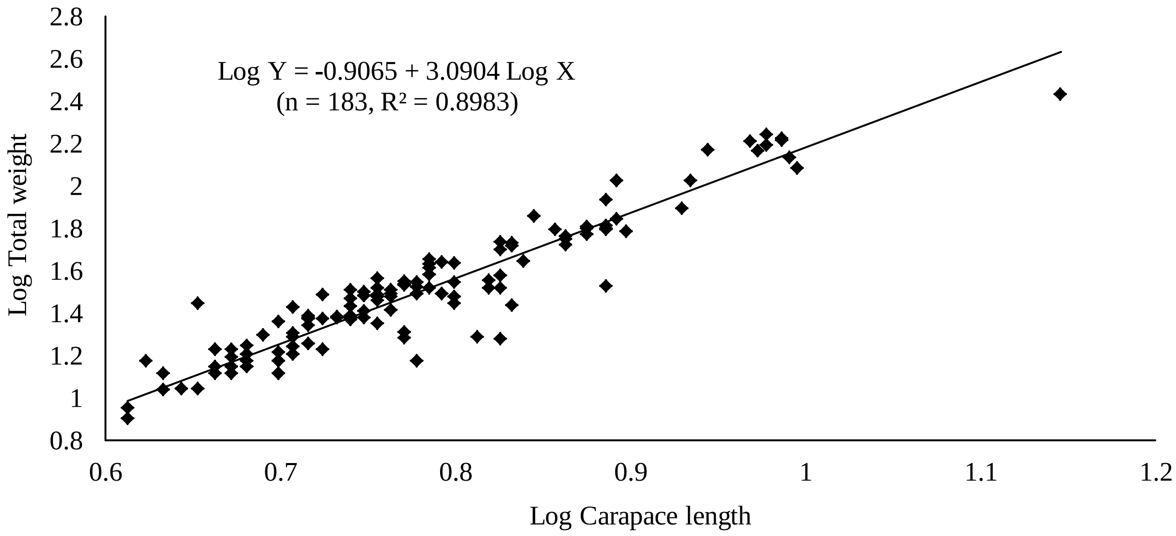

Figure 6: Log carapace length – Log weight relationship of combined sexes *Penaeus monodon* from Lagos Lagoon (July – September, 2018)

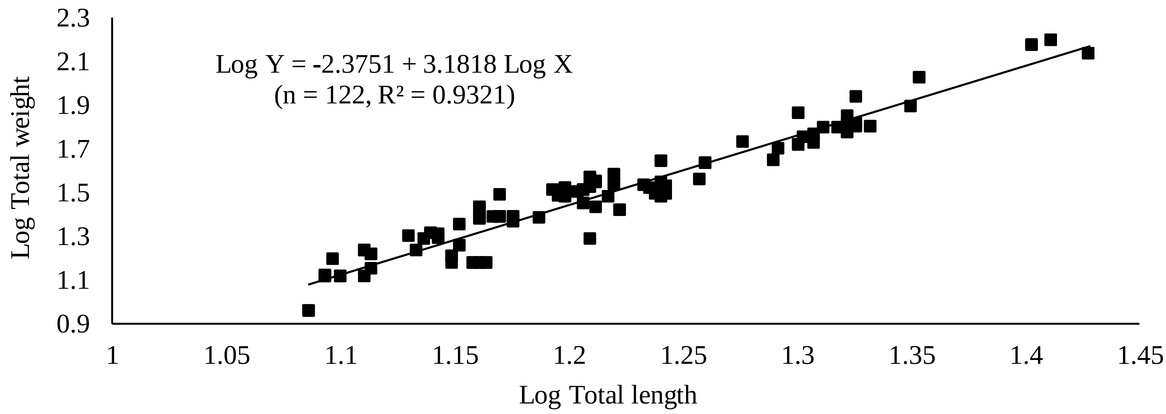

Figure 7: Log total length – Log weight relationship in *Penaeus monodon* (males) in Lagos Lagoon (July – September, 2018)

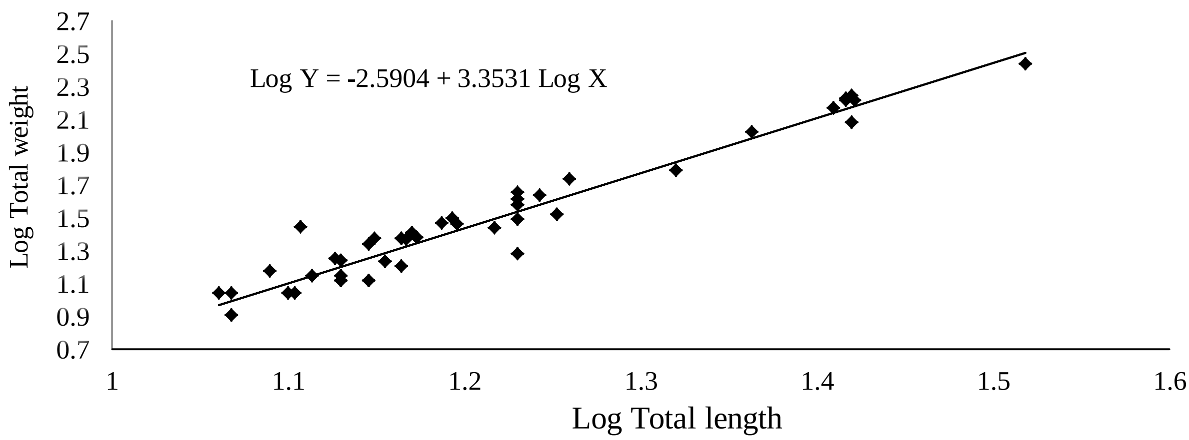

Figure 8: Log total length – Log weight relationship in *Penaeus monodon* (females) in Lagos Lagoon (July – September, 2018)

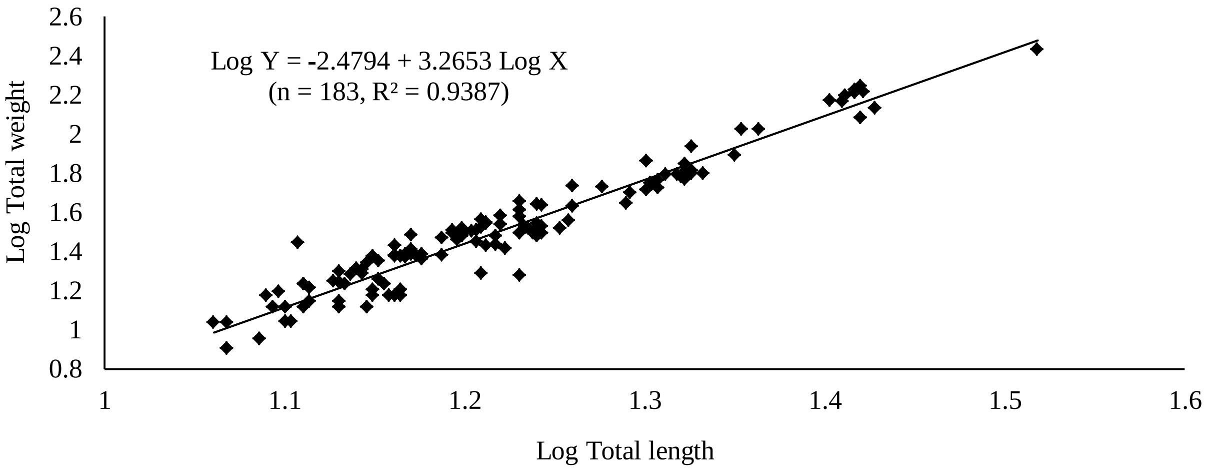

Figure 9: Log total length – Log weight relationship in *Penaeus monodon* (combined sexes) in Lagos Lagoon (July – September, 2018)

DISCUSSION

The range of total length, carapace length and total weight of the sampled *P. monodon* under current investigation are similar to those in previous reports. For instance, Lawal-Are & Apapa (2014) observed a range of 19.5 to 34.4 cm, 3.3 to 7.9 cm, and 51.5 to 303.4 g in total length, carapace length, and total weight, respectively for tiger shrimp in the Niger-Delta region of Nigeria. Similarly, Naser-Uddin et al. (2015) reported total length and weight ranges of 9.0 to 19.4 cm and 8.0 to 58.0 g, respectively. The discrepancy in these values between the current study and the earlier findings may be due to differences in habitat type or location, species maturity stage, and time of data collection.
From the length-frequency distribution, three age groups were obtained in the present study. Sriraman *et al.* (1989) recorded 4 broods of *P. monodon* in a year during the investigation in the Porto Novo coast.

The carapace and total length – weight relationship of the studied *P. monodon* showed a positive allometry (b>3) for the male, female and combined sexes. This was similar to the observation of Enin (1994) who reported a positive allometry (3.28) for *M. macrobrachion* from Cross River Estuary. Contrary to the result of the growth pattern in the present study, Solanki *et al*. (2020) and Akinwunmi *et al.* (2021) observed a negative allometry (b<3) for *P. monodon* and Mantis shrimp. The total and carapace length of *P. monodon* in the present study correlated strongly and positively with the body weight; indicating that an increase in carapace and total length of the shrimps generated a matching rise in body weight. This is in contrast to the report of Akinwunmi *et al*. (2021) for Mantis shrimp which found a weak and negative association (R^2 = 0.2771) between the species' total length and body weight. Our result however, corroborates the work of Lawal- Are & Apapa (2014), who similarly observed a strong and positive association between length and weight of *P. monodon* sampled from Niger Delta area of Nigeria.

A shrimp is said to be in good condition when its K value is equal to 1 or greater (Wade, 1992). The K values of *P. monodon* from this work ranged between 0.6 and 0.9 similar to the range (0.58 - 0.79) reported for *P. monodon* by Lawal-Are & Apapa (2014). Olawusi-Peters *et al.* (2014) also observed a range of 0.31 to 0.82 in four shrimps from the coastal waters of Ondo state. However, the condition factor observed in the present study is lower than the range (0.9 - 1.5) documented by Akinwunmi *et al.* (2021) for Mantis shrimp. It could be suggested that the species are in low condition in the study area. A number of factors such as unavailability of adequate food, presence of environmental stressors in the aquatic environment, season of collection, among other factors could interplay to impair the condition factor of the shrimps in the ecosystem.

This investigation revealed that *P. monodon* primarily consumed green algae, crustaceans, diatoms, and small pieces of fish. The most significant dietary item was green algae, which accounted for 74.48% by frequency of occurrence and 59.4% by numerical method. This is consistent with the findings of Oluboba (2015) which stated that *P. monodon* eats filamentous algae and diatoms.

The analysed stomach content of *P. monodon* under current investigation suggests that they are

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Table 2: Condition factor (K) by sex and size group of *Penaeus monodon* from Lagos Lagoon (July – September, 2018)

S/N	Total length (cm)	Male				Female				Combined Sex			
		N	TL (cm)	WT(g)	K	N	TL (cm)	WT(g)	K	N	TL (cm)	WT(g)	K
1	11.5-12.4	5	12.32	11.42	0.6	5	11.78	10.54	0.6	10	12.05	10.98	0.6
2	12.5-13.4	9	12.82	15.04	0.7	8	12.85	14.70	0.7	17	12.84	14.88	0.7
3	13.5-14.4	16	13.99	18.22	0.7	12	13.81	16.20	0.6	28	13.91	17.35	0.6
4	14.5-15.4	17	14.72	22.61	0.7	9	14.79	22.84	0.7	26	14.74	22.69	0.7
5	15.5-16.4	21	16.00	31.56	0.8	2	15.65	29.90	0.8	23	15.97	31.42	0.8
6	16.5-17.4	16	17.02	33.75	0.7	9	16.94	34.53	0.7	25	16.99	34.03	0.7
7	17.5-18.4	6	17.83	36.27	0.6	4	17.88	40.88	0.7	10	17.85	38.11	0.7
8	18.5-19.4	1	18.90	53.60	0.8					1	18.90	53.60	0.8
9	19.5-20.4	10	19.93	55.38	0.7					10	19.93	55.38	0.7
10	20.5-21.4	10	21.01	65.50	0.7	2	20.90	61.00	0.7	12	20.99	64.75	0.7
11	21.5-22.4	3	21.80	68.00	0.7					3	21.80	68.00	0.7
12	22.5-23.4	2	22.60	105.80	0.9	1	23.10	105.60	0.9	3	22.77	105.73	0.9
13	23.5-24.4												
14	24.5-25.4	2	25.30	148.00	0.9					2	25.30	148.00	0.9
15	25.5-26.4	2	25.80	156.30	0.9	8	26.11	150.78	0.8	10	26.05	151.88	0.9
16	26.5-27.4	2	26.80	135.80	0.7					2	26.80	135.80	0.7
17	27.5-28.4												
18	28.5-29.4												
19	29.5-30.4												
20	30.5-31.4												
21	31.5-32.4												
22	32.5-33.4					1	33.00	271.70	0.8	1	33.00	271.70	0.8
		122				61				183			

omnivorous feeders. This supported the works of Motoh (1984) and Edah and Erinle (2016) on the biology and ecology of Tiger Shrimp (*Penaeus monodon*) from Lagos Lagoon in which it was observed that the shrimps fed primarily on Plankton, Pisces, Crustaceans and some digested food materials. The relatively low percentage of empty stomachs among the sampled *P. monodon* suggests the relative availability of the food items of the species in the Lagos Lagoon.

The sex ratio under current investigation deviated from the anticipated 1:1 ratio for male and female *P. monodon*. The result revealed that there was significantly ($p < 0.05$) more males of *P. monodon* in Lagos Lagoon relative to females and corroborates the sex ratio of 1:0.38 reported by Akinwunmi *et al.* (2021) for mantis shrimp from Lagos Lagoon. Unlike the result of the sex ratio in the present study, Naser-Uddin *et al.* (2015) reported a 1:1.6 (male: female) ratio for *P. monodon* from Digha coast, India. Akinwunmi (2020) also documented a sex ratio of 1:1.65 for *Macrobrachium vollenhovenii* from Lagos Lagoon while Akinwunmi & Moruf (2021) reported a sex ratio of 1: 2.60 for *Macrobrachium macrobrachion* from Lagos Lagoon. These reports do not support the findings from this study and the variation could be due to differences in species, study periods and location.

The results indicated that the highest concentrations of Iron (Fe) in the shrimp species were 77.38 mg/kg with the mean concentration of 54.43 ± 24.79 mg/kg across the whole months of study, which is still within the FAO/WHO permissible limit for human consumption. Although, the concentration of iron is usually high in most aquatic sediments due to discharges from point and non-point sources of petrochemical substances, the benthic feeding habit common in shrimps allow for higher intake of the iron. The distribution of heavy metals accumulated in the flesh of *P. monodon* followed the decreasing order of Fe > Zn > Pb > Mn > Cd > Cu > Cr with the concentrations of Copper (Cu), Cadmium (Cd) and Chromium (Cr) being very low. The concentrations of Copper (Cu), Zinc (Zn) and Cadmium (Cd) were normal and within the maximum acceptable limit for human consumption. Similar result was reported by Lawal-Are *et al.* (2017) on *Callinectes amnicola* and *Farfantepenaeus notialis* from three selected tropical water bodies in Lagos while Bello *et al.* (2017) reported that Cadmium (Cd), Lead (Pb) and Chromium (Cr) were not detected (ND) with higher concentration of Zinc in the flesh of *P. monodon*. Bragigand *et al.*(2004) reported that crustaceans are rich sources of trace metals like Cu and Zn which are good sources of dietary intake in addition to their rich protein content.

The concentrations of Lead (Pb) in this report are higher than WHO permissible limits. This supported the findings reported by Sarkar *et al.* (2016) on shrimps collected from different farms and rivers at Khulna-Satkhira region, Bangladesh but contrary to the findings of Biswas *et al.* (2021) on *Penaeus monodon* sampled from Khulna, Bangladesh. This study showed that some metals (Pb, Mn and Cr) in the flesh of *P. monodon* are higher than the maximum acceptable values for human consumption.

Table 3: Stomach condition of *Penaeus monodon* from Lagos Lagoon (July – September, 2018)

S/N	Stomach	Frequency	% Frequency
1.	0/4	38	20.8
2.	1/4	47	25.7
3.	2/4	41	22.4
4.	3/4	21	11.5
5.	4/4	36	19.7
	Total	183	

Table 4: Summary of stomach contents of *Penaeus monodon* from Lagos Lagoon (July – September, 2018).

Food items	Numerical method	% Frequency	Occurrence method	% Frequency
Green algae	1012	59.4	108	74.48
Diatoms	386	22.7	39	26.90
Crustaceans	43	2.5	40	27.59
Fish Fragments (bones and eggs)	38	2.2	20	13.79
Unidentified masses	225	13.2	18	12.41

Table 5: Monthly variations in sex ratio of *Penaeus monodon* from Lagos Lagoon (July - September, 2018)

Month	Number Examined	Male	Female	Sex ratio Male: Female	Chi – Square (χ^2)
July	61	42	19	1: 0.45	8.67*
August	62	40	22	1: 0.55	5.23*
September	60	40	20	1: 0.5	6.67*
Total	183	122	61	1: 0.5	20.33*

* = Significant

Table 6: Heavy metals concentration in the flesh of *Penaeus monodon* from Lagos Lagoon (July - September, 2018)

Month	Parameters (mg/kg)						
	Cu	Zn	Pb	Mn	Cr	Fe	Cd
July	0.21	4.89	1.75	2.65	0.13	77.38	0.24
August	0.17	6.12	2.23	2.17	0.09	28.13	0.23
September	0.01	3.51	5.26	0.87	0.11	57.77	0.32
Mean±SD	0.13±0.11	4.84±1.31	3.08±1.90	1.90±0.92	0.11±0.02	54.43±24.79	0.26±0.05

Hence, due to the potential health risks to consumers, serious attention should be given regarding continuous monitoring and enforcement of regulations on discharge of contaminants by industries and households into the lagoon. In this way, fisheries resources in this lagoon would still be safe for human consumption.

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