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Morphometric measurements of *Penaeus monodon* shrimp, Sudanese Red Sea Coast

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Abstract
This study investigated sex-related morphometric variation in Penaeus monodon collected from the Sudanese Red Sea coast between October 2025 and February 2026. A total of 119 specimens were examined, and total length, body weight, abdomen length, dorsal–ventral length, cephalothorax length, and cephalothorax width were recorded. Linear measurements were taken in centimeters, while body weight was measured in grams using a digital balance. Total length ranged from 13.3 to 16.0 cm in males and from 14.2 to 19.0 cm in females, whereas body weight ranged from 17 to 38 g and 26 to 70.5 g in males and females, respectively. Abdomen length ranged from 4.0 to 6.0 cm, dorsal–ventral length from 1.2 to 2.6 cm, cephalothorax length from 3.0 to 6.6 cm, and cephalothorax width from 1.0 to 2.6 cm. The length–weight relationship showed strong positive correlations, with correlation coefficients of 0.945 for males and 0.970 for females. The corresponding regression equations were Log W = −2.046 + 2.663 Log L for males and Log W = −1.626 + 2.602 Log L for females. Females represented 56% of the sampled population and generally exhibited greater total length, body weight, and abdomen length than males. The findings demonstrate pronounced sexual dimorphism in *P. monodon* from the Sudanese Red Sea coast and provide baseline morphometric information for further biological and fisheries-related studies of this species.

Keywords: Shrimp, morphometric characteristics, length-weight relationship, sexual dimorphism

Introduction

Morphometric measurements are fundamental in fisheries biology and aquaculture research, as they provide essential insights into species growth patterns, population dynamics, and environmental adaptability. Crustaceans are a group of invertebrate animals belonging to the phylum Arthropods. They are characterized by a hard outer shell (exoskeleton), segmented body, jointed appendages (legs and claws), and bilateral symmetry. Common examples include crabs, lobsters, shrimps and crayfish. Crustaceans play a vital role in the ecosystem and human diet, providing essential nutrients to both wildlife and people (Alam, 2022) [2]. Shrimps, which are crustaceans under the order Decapods, are distinguished by their elongated bodies, segmented shells, and clawed legs. Several shrimp species are found in Sudanese waters, it play an important role in Sudan's economy. They are a major export commodity and contribute significantly to food security and national income. Shrimp provide a rich source of protein and create employment opportunities, supporting the livelihoods of coastal communities and generating foreign exchange.

This makes the shrimp industry a key contributor to Sudan's GDP (Ahmed, 2022) [1]. Shrimp are primarily distributed along Sudan's Red Sea coast. Key fishing grounds include Port Sudan, the country's largest shrimp landing site, and Suakin, a historic fishing port. In addition to marine environments the coastal waters including shallow zones, coral reefs, and estuaries, also support a diverse shrimp population. (Elhag, 2022) [4, 5]. The black shrimp Penaeus monodon, also known as the black tiger shrimp or black jumbo shrimp, is a species of marine crustacean recognized for its dark or black and gray striped coloration and its large size compared to other shrimp. This species commonly found in the Red Sea, particularly in coastal waters and coral reefs. It can reach up to 36 cm (14 inches) in length and weigh up to 450 gram (Kheir, 2022) [9]. This species feeds on phytoplankton, zooplankton, benthos, and detritus. (Elhag, 2022) [4, 5]. P. monodon (giant tiger prawn) has been farmed along the Red Sea coast since 2001, marking the beginning of shrimp aquaculture in Sudan.

Despite the limited scale of production, shrimp along with cuttlefish constitute about 5% of the total marine fisheries production (Elnaiem and Elawad, 2008). with the majority destined for export markets and only a small portion consumed locally. A comprehensive breakdown of fisheries production along the Sudanese Red Sea coast provided by (Elawad, 2009), recording approximately 3,000 tons from artisanal fisheries, 2,000 tons from trawling, and 2,300 tons from purse seine fishing. Shrimp production was estimated at around 60 tons from trawling besides, an additional 6 tons from aquaculture. Overall, the shrimp fishery in Sudan remains less compared to other marine fisheries. Artisanal fisheries continue to dominate the industry, with most marine fishing conducted by small boats employing traditional techniques. However, foreign fishing fleets had been also operated in Sudanese waters periodically. The marine fisheries sector facing many environmental and management challenges. The Objectives of this study are to identifying the size differences between male and female, Assess the growth patterns, determining sex ratio of populations and providing a reference database for *Penaeus monodon* in the Sudanese Red sea coast.

Materials and Methods

This study was conducted between October 2025 and February 2026 in Sudan, on Sudanese Red Sea coast.

Latitude: approximately 19.0833°N, Longitude: approximately 37.3833°E, and other places Sawakin Archipelago19.150° N 37.400° E**.**
Shubuk Latitude: approximately 18.950° N Longitude: approximately 37.450° E
KhorRawaya Latitude: approximately 18.800° N Longitude: approximately 37.450° E Tokar Delta Latitude: approximately 18.300° N Longitude: approximately37.500° E. Mangroves Area (Latitude: approximately 18.250° N Longitude: approximately 37.470° E, Depth of shrimp fishing: Mostly between 10 meters – 50 meters depth

1. Sample Collection
119 samples for male and female were randomly collected of *Penaeus monodon*populations (Giant Tiger Prawn) are caught using cast net. A cast net is a circular fishing net with weights on its edges. It is manually thrown into the water, spreading out to capture small fish like shrimp, sardines, anchovies, and other aquatic organisms.



Plate 1: *Penaeus monodon*

2. Morphometric measurements of *P. monodon*:
Shrimp were identified in accordance with (FAO, 1984). Following this, the approach outlined by Primavera,1998) was used to measure the body morphometric parameters of *P.monodon*. The morphometric characters studied were:
TL = Total Length, BW = Body Weight, AL = Abdomen Length, DVL = Dorsal-Ventral Length, CL = Cephalothorax Length, and CD = Cephalothorax Depth (Kumar,2020) [10].

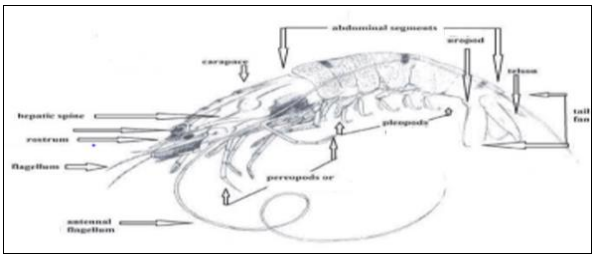


Plate 2: Morphometric measurements of *P. monodon*

The total length (L) of each shrimp was measured from the tip of the rostrum to the end of the telson, to the nearest 1 mm, using a measuring board or ruler. The weight (W) was measured to the nearest 0.01 g with an electronic balance after wiping off any moisture from the body of the shrimp.

3. Regression analysis
The length – weight relationship between total length and body weight was calculated by the Equation 1 proposed by (Parenrengi, 2022) [12, 14].

$W = aL^b$ (1)
Where W - Total body weight (mg) ,L - Total length of the body form (cm) ,b - Exponent,a – constant. The length-weight relationships were estimated for males and females separately by using logarithmic transformation of the above equation (Equation 2).
Log10 W = log10 a + b log10L (2)
Parameters "a" and "b" were estimated by linear regression on the logarithmic transformed equation. The degree of relation between the variables was computed by the coefficient of determination (R^2).

4. Statistical analysis
Based on the estimated length-weight relationship equation: W = 0.132 × L^2.954
Since the exponent (b) is approximately 2.954, which is close to 3, we can describe the growth pattern as isometric. (Nguyen, 2022) [11].

Results and Discussion
In the present study, *Penaeus monodon* (giant tiger prawn) individuals collected from the Sudanese Red Sea coast exhibited a total length range of 6 cm to 16 cm, with the maximum length reaching approximately 19 cm. These findings align with those of (Parenrengi, 2021) [13]. who documented similar length ranges for wild-caught juvenile and sub-adult *P. monodon* in Southeast Asian coastal waters. In contrast. (Ibrahim, *et al*,2020) [7]. Reported significantly larger sizes, with total lengths ranging from 20 cm to 36 cm. This discrepancy may be attributed to differences in habitat characteristics, sampling periods, shrimp maturity stages, or gear selectivity. The larger sizes observed by (Ibrahim *et al* 2020) [7]. likely represent mature individuals collected from deeper or more productive marine environments, where greater food availability and environmental stability enhance growth potential. Sudan's Red Sea coast stretches across northeastern Sudan, bordered by Egypt to the north, Eritrea to the southeast, and Saudi Arabia across the Red Sea to the northeast. The coastline extends approximately 714 kilometers (444 miles) and reaches up to 350 kilometers (217 miles) at its widest point. (Elhag, 2020) [3].

Morphometric Differences Between Male and Female *Penaeus monodon:*
The morphometric differences between male and female *Penaeus monodon*, focusing on total length, body weight, abdomen length, dorsal-ventral length, cephalothorax length, and cephalothorax width. The results confirming the accuracy of the comparison.

Table 1: morphometric comparison between male and Female *Penaeus monodon*

Morphometric Parameter	Male	Female	Comparison
Total Length (TL)	13.3cm-16cm	14.2cm-19cm	Female > Male
Body Weight (BW)	17g-38g	26g-70.5g	Female > Male
Abdomen Length (AL)	1.7cm-9cm	6.9cm-10cm	Female > Male
Dorsal-ventral length (DVL)	1.7cm-2cm	1.7cm-2.4cm	Female > Male
Cephalothorax Length (CL)	5.8cm-6cm	5.8cm-6.9cm	Female > Male
Cephalothorax Width (CW)	2cm-2cm	1.5cm-2.3cm	Female > Male

The length - weight Relationship

In *Penaeus monodon*, the relationship between length and weight was found to be highly significant ($p < 0.001$), with females weighing more than males at each corresponding length group.

Table 2: Length-weight relationships for of *Penaeus monodon*

Sex	Equations	Correlation
Male	Log(w) = -2.046+2.663Log(L)	0.945
Female	Log(w) = -1.626 +2.602Log(L)	0.970

The length–weight relationship for both male and female *Penaeus monodon* was showed a significant correlation ($p < 0.05$) between the two parameters. For males, the relationship was expressed as: Log(W) = –2.046 + 2.963 Log(L) (r = 0.945) For females, the relationship was: Log(W) = –1.929 + 2.902 Log(L) (r = 0.970). (Parenrengi, 2022) [12, 14] reported that a strong correlation was observed between total length and body weight, as reported by in their study on the length–weight relationship and sexual dimorphism in *Penaeus monodon*. The study discovered that the *Penaeus monodon* total lengths ranged from 6 cm to 19 cm. This finding agrees with the range reported by (Parenrengi, 2021) [13]. but differs from that of (Ibrahim, 2020) [7]. who found a total length range of 20 cm to 36 cm. In the present study, the maximum total length recorded for *Penaeus monodon* was about 19 cm. However, (Nguyen, 2022) [11]. reported maximum total lengths of 33–36 cm for females and 25–30 cm for males. The total weight of *Penaeus monodon* in this study ranged between 10.5 g and 70.5 g, which differs from the values reported by (Khan, 2022) [8]. The cephalothorax length ranged from 3 cm to 6.9 cm, which is similar to the range proposed by (Hossain, 2022) [6]. who reported values between 6 cm and 9 cm.

Length–Weight Relationship of *Penaeus monodon*

The length–weight relationship for both male and female *Penaeus monodon* was studied and showed a significant correlation ($p < 0.05$) between the two parameters.

For males, the relationship was expressed as:

Log(W) = –2.046 + 2.963 Log(L) (r = 0.945)

For females, the relationship was:

Log(W) = –1.929 + 2.902 Log(L) (r = 0.970)

(Parenrengi, 2022) [12, 14]. Reported additionally, a strong correlation was observed between total length and body weight, as reported by in their study on the length–weight relationship and sexual dimorphism in *Penaeus monodon*. Table 3 provides an overview of all descriptive data for the various body measurements and parameters of male *Penaeus monodon*. The total length, body weight, abdominal length, dorsal-ventral length, cephalothorax length, and cephalothorax depth of male *Penaeus monodon*.

Table 3: Growth Statistics for Male *Penaeus monodon*

Variable	Maximal Growth for male	Median Growth for male	Minimal Growth for male
TL(cm)	17cm	14cm	11 cm
BW(g)	44.9g	28.5g	12.1g
AL(cm)	8.8cm	6.9cm	5cm
DVL(cm)	2.8 cm	2.1cm	1.4cm
CL(cm)	7.6cm	5.3cm	3cm
CW(cm)	2.5cm	1.85cm	1.2cm

Growth Statistics for Female *Penaeus monodon*

Table 4 provides an overview of all descriptive data for the various body measurements and parameters of the female *Penaeus monodon*. The table shows the total length, body weight, abdomen length, dorsal-ventral length, cephalothorax length, and cephalothorax depth of the female *Penaeus monodon*.

Table 4: Growth differences for female *Penaeus monodon*

Variable	Maximal Growth of female	Median growth of female	Minimal Groth of femle
TL(cm)	20cm	13cm	6cm
BW(g)	70.5 g	45.5g	10.5g
AL(cm)	10cm	7cm	4cm
DVL(cm)	2.8cm	2cm	1.2cm
CL(cm)	7.1cm	5.5cm	3.9cm
CW(cm)	2.8cm	1.9cm	1cm

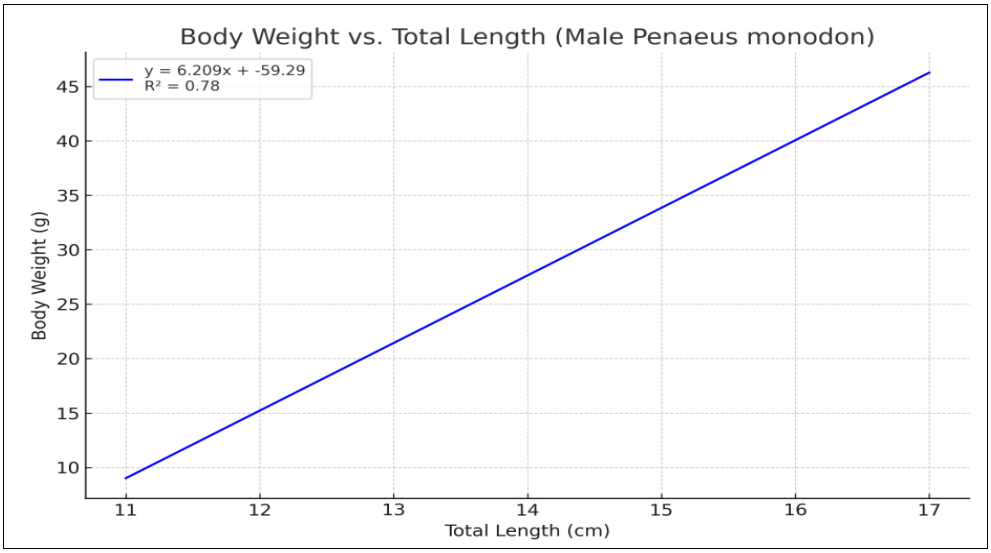


Fig 1: Relationship between Body-Weight and Total-Length for (Male *Penaeus monodon*)

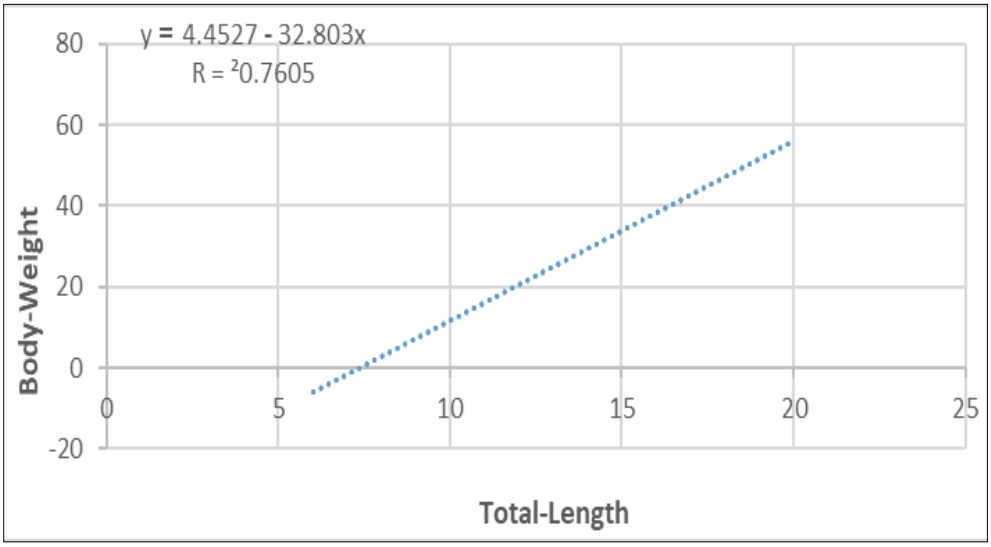


Fig 2: Relationship between Body-Weight and Total-Length for (Female *Penaeus monodon*)

Morphometric variability comparison between sexes in *Penaeus monodon*

Table 5: Descriptive Statistical Analysis of Sexes in *Penaeus monodon*

Variable	Male Mean ± SE	Significant	Female Mean ± SE	Significant
TL(cm)	14.2cm ±1.07cm	0.05	14.69 ± 0.689	0.05
BW(g)	21g ± 1.23g	0.01	29.4g ± 2.07g	0.01
AL(cm)	7.23cm ± 0.263cm	0,05	7.33cm ± 0.316cm	0.05
DVL (cm)	2.04cm ± 0.075cm	0.05	2.07cm ± 0.075cm	0.05
CL(cm)	5.76cm ± 0.26cm	0.05	5.93cm ± 0.19cm	0.05
CW(cm)	1.73cm ± 0.11cm	0.05	1.92cm ± 0.097cm	0.01

Descriptive Statistical Analysis of Sex Ratio Variations in *Penaeus monodon* Populations

In this study, *Penaeus monodon* (Giant Tiger Prawn) specimens were collected to examine sexual dimorphism. The differentiation between male and female individuals was determined based on differences in size, shape, and other morphological characteristics.

Sexual Dimorphism in *Penaeus monodon*

The findings showed that 50 (42%) of the collected *Penaeus monodon* were males, while 69 (58%) were females. According to (Parenrengi, 2022) [12, 14]. a separate analysis of 57 samples revealed that 18 (31.6%) were males and 39 (68.4%) were females. the observed differences in sex ratio and physical traits may be influenced by geographical and environmental factors.

Conclusion

The length–weight relationship for male and female *Penaeus monodon* in this study was determined using the parameters a = 0.132 and b = 2.954.

The equation used is:

$W = aL^b$

$W = 0.132 \times L\text{^}2.954$

This equation describes the relationship between total length (L) and body weight (W) for *P. monodon*. The coefficient b indicates that for every 1% increase in length, weight increases by approximately 2.95%.The intercept (log a) represents the theoretical weight at a length of 1 cm. The high R-squared value ($R^2 = 0.964$) indicates a strong fit of the model to the data. The study showed that the b-values for males and females not significantly indicating isometric growth. The mean weight values by sex revealed that females were significantly ($p < 0.05$) heavier than males. This information on the length–weight relationship can be used to select suitable strains with faster growth rates for aquaculture and to estimate the optimal culture duration for achieving marketable size in *P. monodon*.

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