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# Observations on some morphometric characters of the webfoot octopus, *Amphioctopus membranaceus* (Quoy and Gaimard, 1832) from the Suez Gulf, Red Sea, Egypt

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## ABSTRACT

Some morphometric characters of the webfoot octopus, *Amphioctopus membranaceus* were subjected to study in the Suez Gulf in the Northern Red Sea. The present results showed that the length-weight relationship of mantle length (ML) and total weight (TW) of *A. membranaceus* is negative allometric. Findings were obtained using the equation of $y= 0.7391x^{2.4222}$ with the correlation coefficient of $r^2= 0.843$ for males, and $y= 0.85x^{2.3348}$ with the correlation coefficient of $r^2= 0.9031$ for females. The length-length relationships of ML and the different body measurements of *A. membranaceus* reported a negative allometric ($b<1$) relation. While, the relations of ML and total length (TL), long arm length (LAL) and short arm length (SAL) recorded positive allometric growth ($b>1$) for both males and females. Remarkedly, the correlation coefficient ($r^2$) showed a good fitted data for all relationships.

## INTRODUCTION

The exploitation of fisheries resources in the Suez Gulf (Fig. 1) has greatly contributed to the development of fisheries and national economy in Egypt; however, the status of fisheries resources and the ecosystem structure in the Gulf have substantially changed. The fisheries resources in the Suez Gulf are depicted and the ecosystem has largely changed; switching from large-size and high value demersal fisheries dominated ecosystem to an ecosystem dominated by small-size and low value pelagic fisheries **(GAFRD, 2018)**. Recent studies showed that coastal and shelf cephalopod populations have increased globally over the last six decades. Although cephalopod landings are dominated by the squids, which represent about 80% of the world cephalopod catches, octopuses and cuttlefishes represent ∼10% each. Over the past three decades, the total reported global production of octopuses indicates a relatively steady increase in catch;

almost doubling from 179,042 t in 1980 to 355,239 t in 2014 **(Sauer *et al.*, 2019)**. Octopuses are relatively abundant in the trawl landings of the Suez Gulf; they were discarded species till 1990's **(El-Ganainy *et al.*, 2005)**, but currently they have a relatively high occurrence and commercial importance in the trawl landings, representing about 0.07% of the total trawl catch **(GAFRD, 2018)**.

This species was identified based on FAO species catalogue for fishery purposes **(Jereb *et al.*, 2014)**. In the recent revision on octopods **(Norman & Hochberg, 2005)**, the genus *Octopus* was synonymized by genus *Amphioctopus*. Few studies have been conducted on the morphometric variations of octopoda in the Egyptian waters **(Riad & Gabr, 2007; El-Ganainy & Riad, 2008; Riad, 2008; Osman *et al.*, 2014)**. The study of the length-length and length-weight relationships of octopus is one of a radical required information to manage octopus fisheries resources. **Richter (2007)** stated that the measurement of fish weight is used to determine the specific weight and length variations of individual fish or groups of individuals as an indication of obesity, health, productivity and physiological conditions including gonad development. Therefore, this study aims to determine the pattern of growth through morphometric relationships of *A. membranaceus* in the Suez Gulf to help in the proper management and sustainability of this species.

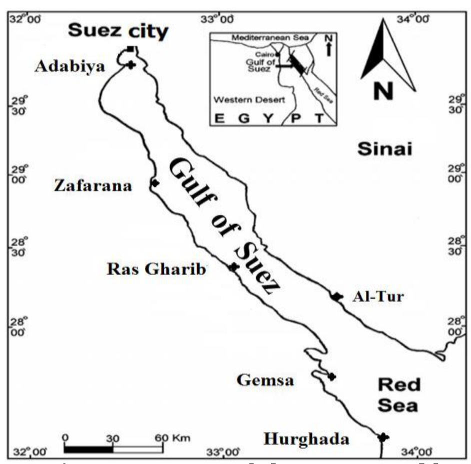


**Fig. 1.** A map of the Suez Gulf.

## MATERIALS AND METHODS

The total number of 383 *A. membranaceus* individuals were collected monthly from commercial trawlers at Attaka fishing harbor during the period from September 2017 to April 2018 fishing season. Samples were transported to the Fisheries Biology Laboratory of the National Institute of Oceanography and Fisheries (NIOF), Suez Branch. Individuals were dissected and sorted by sex. A single set of a divider, ruler and an electronic balance were used for all samples. All measurements were achieved by one author to avoid unnecessary variations (All lengths were measured to the nearest 0.1 cm and weight to the nearest 0.1 gm).

Length-weight relationship was carried out between mantle length (ML) and total weight (TW) for males and females of *A. membranaceus* by the growth equation (power regression) according to **Bowker (1995)**:

$$Y= aX^b$$

Where, Y is a weight variable (gm); X is the length variable (cm); a and b are constants.

The linear regression equation (Y= a+bX) was used to describe the relation between different body measurements (length-length) as:

1- Mantle width (MW) and mantle length (ML).
2- Head length (HL) and mantle length (ML).
3- Head width (HW) and mantle length (ML).
4- Long arm length (LAL) and mantle length (ML).
5- Total length (TL) and mantle length (ML).
6- Short arm length (SAL) and mantle length (ML).
7- Ventral mantle length (VML) and mantle length (ML).
8- Funnel length (FL) and mantle length (ML).

Where, Y is the dependent variable; X is the independent variable of the length (cm); a is a constant (the intercept of the regression line) and b is the slope regression coefficient that gives the rate at which the variable Y alter with the variable X.

When the two variables have the same units of measurement (i.e. length-length relationship), value of the exponent b that is greater than unity (1) indicates a positive allometric manner. While, when value of the exponent b is lesser than unity (1), a negative allometric growth is indicated. But the value of unity for the exponent b describes an isometric relationship when it equals (1). In case of different units of measurement for the two variables (i.e. length-weight relationship), different criteria for allometric and isometric applied were value of the exponent b= 3, then that corresponds to isometric **(Gould, 1966)**. The growth is allometric if $b\neq 3$ (negative allometric if $b<3$ and positive allometric if $b>3$) **(Ricker, 1975)**.

## RESULTS

### Morphometric analysis

Some morphometric relationships as: length-weight and length-length relationships were determined for males and females of *A. membranaceus*. A length-weight and length-length measurements are used to determine the pattern of growth by using length and weight parameters. Moreover, such measurements can describe the growth pattern and environmental impact on animal growth. A numberof 383 individuals of *A. membranaceus* were measured during the study were (156 males and 227 females). The results showed power models for length-weight relationship and linear models for length-length relationships.

## 1. Length-weight relationship

### Mantle length - total weight relationship:

A power regression between mantle length (ML) and total weight (TW) showed a positive significant relationship ($P<0.001$) as shown in Fig. (2), where the correlation coefficient ($r^2$) showed a good fitted data, and the exponent b values indicated a negative allometric growth, and were represented by the following equations:

$$TW = 0.7391\ ML^{2.4222}\ \&\ r^2 = 0.843\ \text{(males).}$$

$$TW = 0.85\ ML^{2.3348}\ \&\ r^2 = 0.9031\ \text{(females).}$$

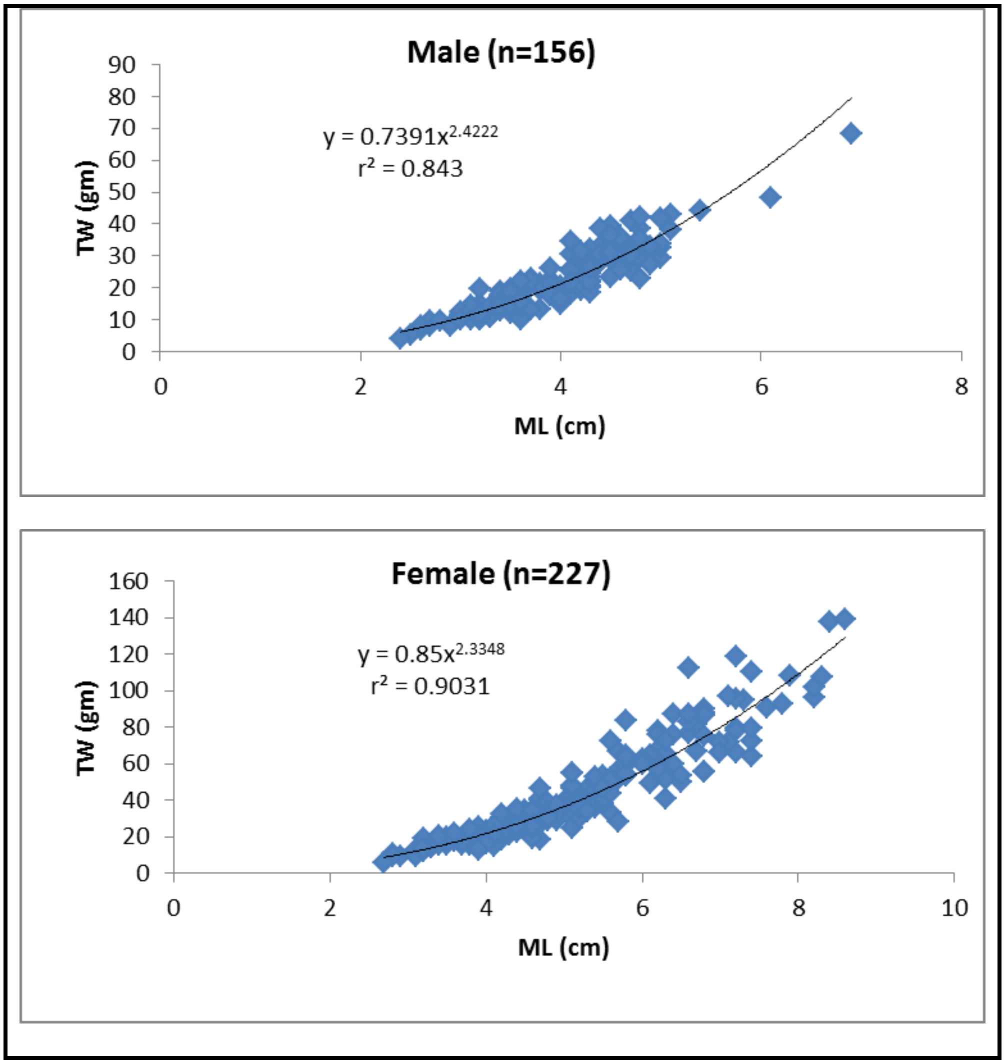


**Fig. 2.** Mantle length and total weight relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

## 2. Length-length relationships

### 2.1. Mantle length - mantle width relationship:

A linear relation between mantle length (ML) and mantle width (MW) showed a positive significant relationship (P<0.001)and were represented by the following equations:

$$MW = 0.7054\ ML + 0.4585\ \&\ r^2 = 0.8605\ \text{(males).}$$

$$MW = 0.6967\ ML + 0.5745\ \&\ r^2 = 0.9209\ \text{(females).}$$

The correlation coefficient ($r^2$) showed a good fitted data, and the exponent b values indicated a negative allometric (Fig. 3).

### 2.2. Mantle length - head length relationship:

A linear regression between mantle length (ML) and head length (HL) showed a positive significant relationship (P<0.001) and were represented by the following equations:

$$HL = 0.3318\ ML - 0.0193\ \&\ r^2 = 0.8041\ \text{(males).}$$

$$HL = 0.1865\ ML + 0.3932\ \&\ r^2 = 0.8434\ \text{(females).}$$

The exponent b values indicated a negative allometric manner, and the correlation coefficient showed a good fitted data as shown in Fig. (4).

### 2.3. Mantle length - head width relationship:

The correlation coefficient showed a good fitted data, and the exponent b values indicated a negative allometric growth on establishing a relationship between mantle length (ML) and head width (HW). A positive and significant relationship (P<0.001) was performed as shown in Fig. (5), and were represented by the following equations:

$$HW = 0.3458\ ML + 0.2417\ \&\ r^2 = 0.9\ \text{(males).}$$

$$HW = 0.2438\ ML + 0.6423\ \&\ r^2 = 0.8671\ \text{(females).}$$

### 2.4. Mantle length - long arm length relationship:

The relation between mantle length (ML) and long arm length (LAL) gave a positive significant relationship (P<0.001) and were represented by the following equations:

$$LAL = 3.7075\ ML - 0.5767\ \&\ r^2 = 0.8524\ \text{(males).}$$

$$LAL = 3.2054\ ML + 1.2127\ \&\ r^2 = 0.8891\ \text{(females).}$$

The correlation coefficient showed a good fitted data, and the exponent b values indicated a positive allometric manner (Fig. 6).

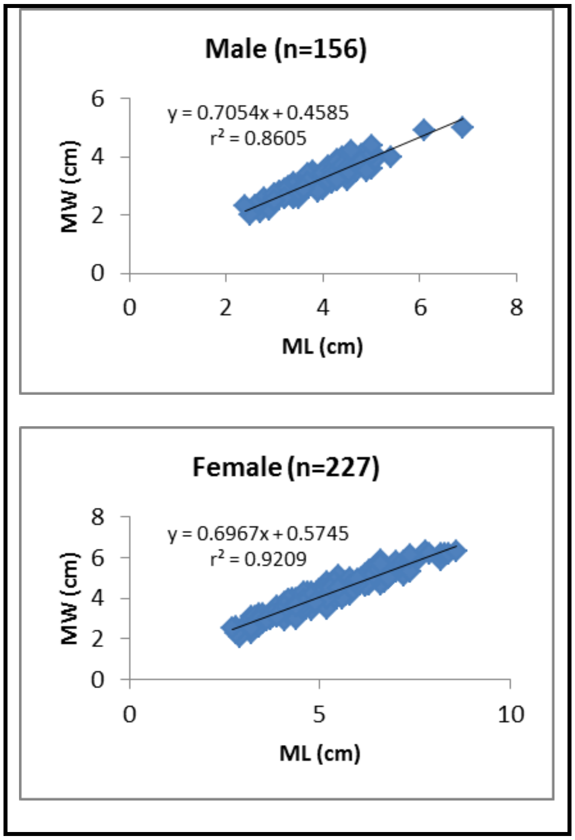


**Fig. 3.** Mantle length and mantle width relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

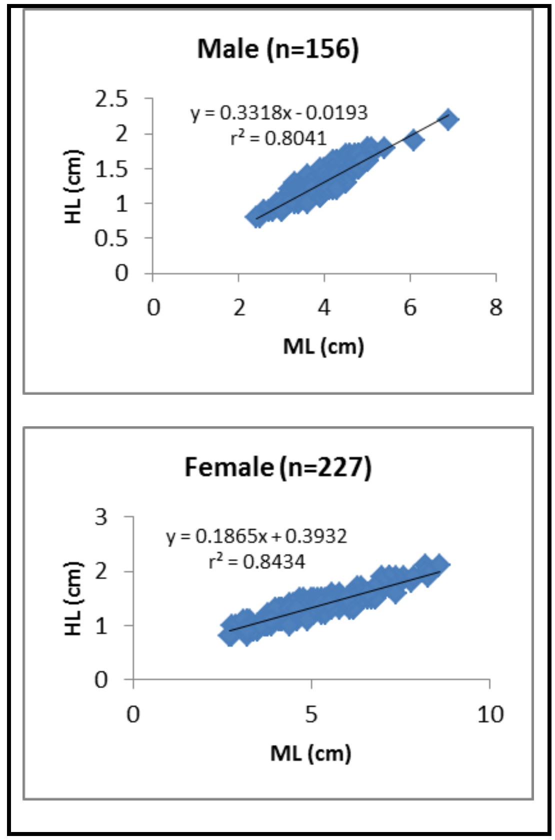


**Fig. 4.** Mantle length and head length relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

**2.5. Mantle length - total length relationship:**

The relation between mantle length (ML) and total length (TL) gave a positive significant relationship (P<0.001). The correlation coefficient showed a good fitted data and the exponent b values indicated a positive allometric one (Fig. 7), and were represented by the following equations:

$$TL = 4.8705\ ML + 1.0308\ \&\ r^2 = 0.85\ \text{(males).}$$

$$TL = 4.2004\ ML + 3.6092\ \&\ r^2 = 0.8998\ \text{(females).}$$

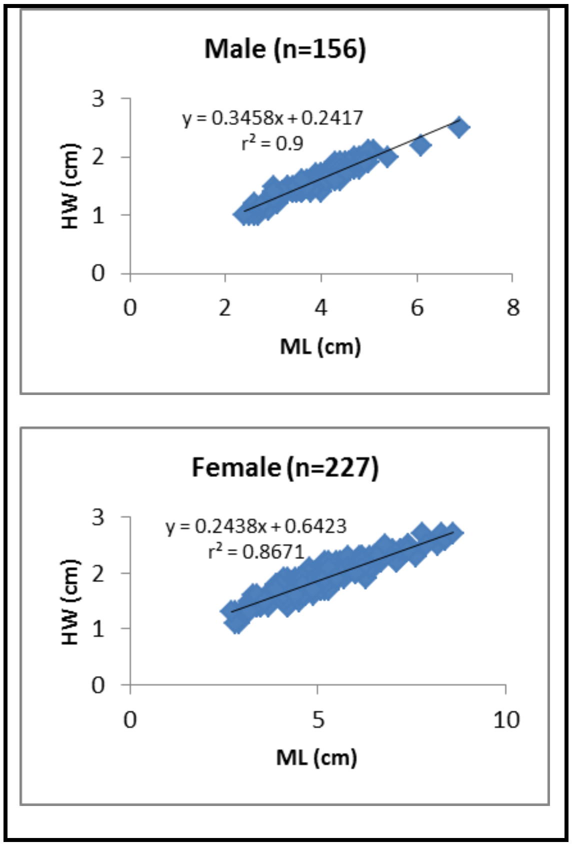


**Fig. 5.** Mantle length and head width relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

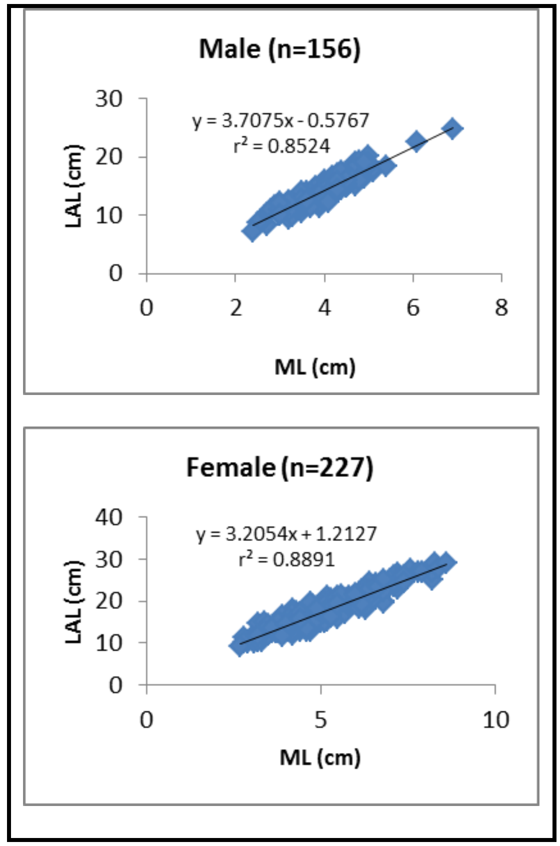


**Fig. 6.** Mantle length and long arm length relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

**2.6. Mantle length - short arm length relationship:**

The mantle length (ML) was plotted against short arm length (SAL) and gave a positive significant relationship ($P<0.001$) as shown in Fig. (8), and were represented by the following equations:

$$SAL = 2.2759\ ML + 0.8883\ \&\ r^2 = 0.8001\ \text{(males)}.$$

$$SAL = 1.7879\ ML + 3.9128\ \&\ r^2 = 0.8582\ \text{(females)}.$$

The correlation coefficient showed a good fitted data and the exponent b values indicated a positive allometric.

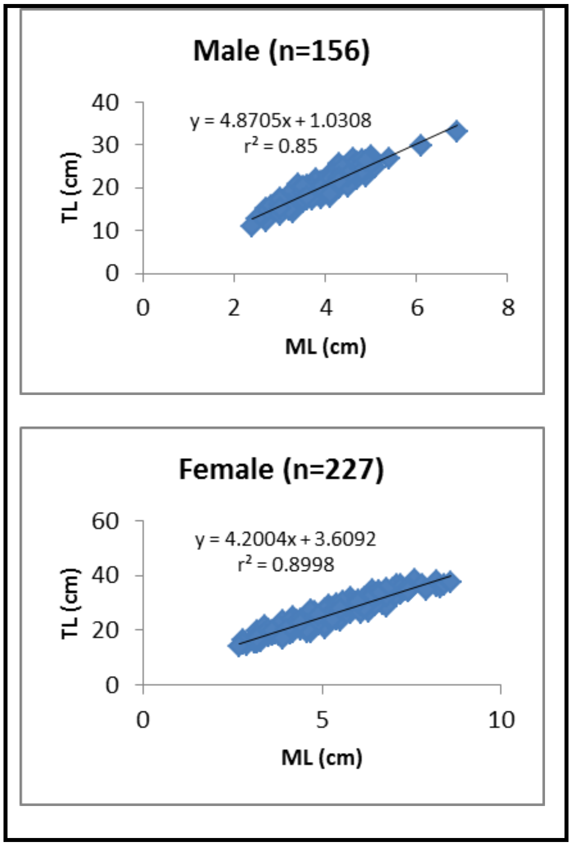


**Fig. 7.** Mantle length and total length relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

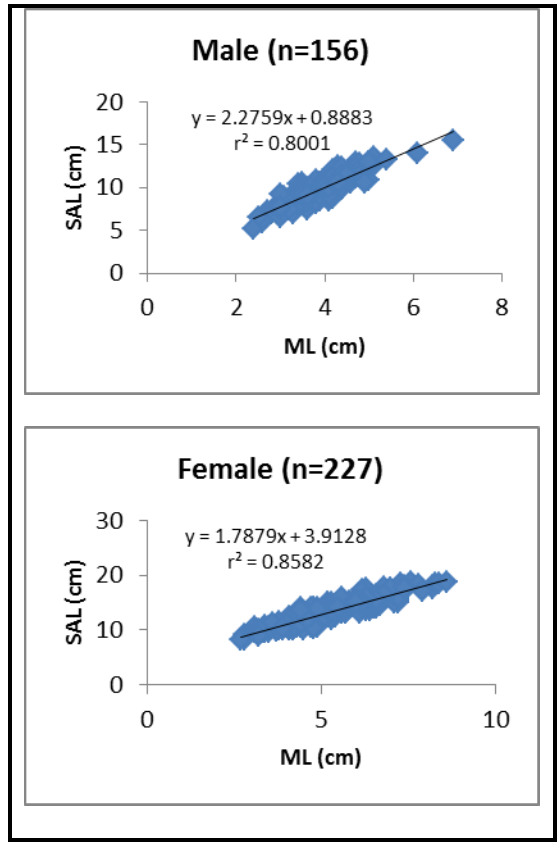


**Fig. 8.** Mantle length and short arm length relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

**2.7. Mantle length - ventral mantle length relationship:**

The relation between mantle length (ML) and ventral mantle length (VML) was highly correlated and a positive significant relationship was obtained ($P<0.001$) and were represented by the following equations:

$$VML = 0.8807\ ML - 0.1273\ \&\ r^2 = 0.8743\ (males).$$

$$VML = 0.8259\ ML + 0.0076\ \&\ r^2 = 0.9315\ (females).$$

The correlation coefficient showed a good fitted data, and the exponent b values indicated a negative allometric (Fig. 9)

## 2.8. Mantle length - funnel length relationship:

The mantle length (ML) was plotted against funnel length (FL) and gave a positive significant relationship (P<0.001) as shown in Fig. (10), where the correlation coefficient showed a good fitted data, and the exponent b values indicated a negative allometric manner and were represented by the following equations:

$$FL = 0.4142\ ML + 0.081\ \&\ r^2 = 0.8105\ \text{(males)}.$$

$$FL = 0.3134\ ML + 0.4742\ \&\ r^2 = 0.8488\ \text{(females)}.$$

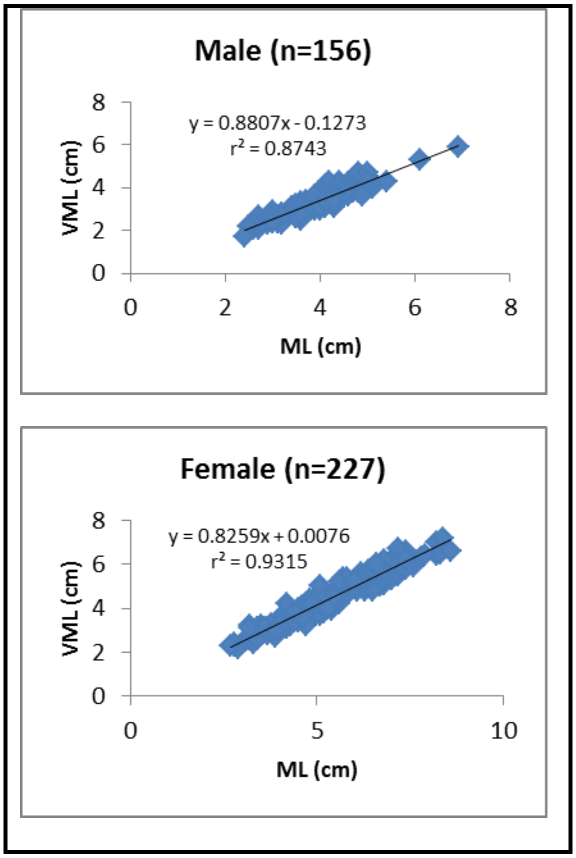


**Fig. 9.** Mantle length and ventral mantle length relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

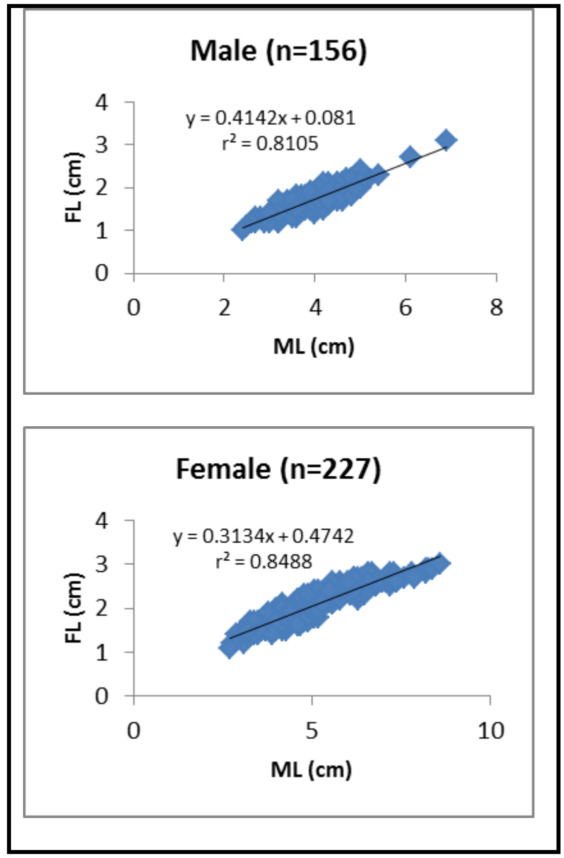


**Fig. 10.** Mantle length and funnel length relationship for males and females of *A. membranaceus* from the Suez Gulf during 2017/2018.

## DISCUSSION

Length-weight relationship plays a vital role in the fisheries biology and population dynamics. It helps estimating the standing stock or biomass and thereby establishing the yield by converting one variable into the other as is often done during field studies **(Petrakis & Stergiou, 1995)**. Knowledge on the length-weight and length-length relationship is very useful to study biology of octopus, as it helps to comprehend both the ideal conditions for appropriate growth and the effect of environmental changes on the growth of octopus. This relationship is one of the important aspects used to manage the mathematical relation between the length-weight and length-length of octopus, as it reflects the environmental condition of a habitat where octopus lives.

In the present study, the correlation value ($r^2$), which is close to 1, indicates a close and good relationship between growth of weight and octopus length. The b values were mostly less than 1 in length-length relationships and totally less than 3 in length-weight relationship (all morphometric relationships of *A. membranaceus* showed a negative allometric growth except that of ML with LAL, whereas TL and SAL showed a positive allometric growth for males and females). These results are more or less similar to those of **Osman *et al*, ( 2014)**, who studied the length weight relationship of *Octopus aegina* in the Mediterranean Sea, Suez Canal and Suez Gulf. In the Mediterranean Sea, octopuses grow in negative allometric manner as b values are significantly lower than 3 for males, females and pooled sexes. In the Suez Canal, octopuses grow isometrically as b values are equal to 3 for males, females and pooled sexes. In the Suez Gulf, octopuses seem to have positive allometric growth as b values is significantly higher than 3 for both sexes and pooled sexes. **El-Ganainy and Riad (2008)** investigated some morphometric relationships for each sex separately by fitting regressions to total length on total weight, mantle length on total weight and total length on mantle length of *Octopus defilippi* in the Suez Gulf. As a result, they found that the growth in weight was allometrically negative in all three cases for males and females.

Furthermore, these findings were in agreement with **Yedukondala and Mohana (2013),** who indicated that the length-weight relationship of *Octopus membranaceus* in Visakhapatnam, east coast of India was negative allometric growth and the growth coefficient (b) was 2.1331, 2.6836 and 2.3724 for males, females and combined sexes, respectively. **Marzuki *et al.* (2018)** reported the growth patterns of octopus (*Octopus spp*.) from North Lombok, Indonesia, with b value of 2.1279. According to **Effendie (1997)**, the length-term relationships suggest that relative growth means the potential to change according to time. If there is a variation in the environment and food availability, this value will also change. Further studies clarified that there are several factors that affect growth, including internal factors and external factors including: food available, gonads maturation, age, temperature, dissolved oxygen and water quality parameters.

**Suruwaky and Gunaisah (2013)** stated that, the low value of b (b< 3) can be caused by over-exploitation of fishing catches that affect the length-weight. In addition, the growth of both gonads is affected by biological factors, the environment, the provided food and water conditions **(Effendie, 1997; Rosli & Isa, 2012)**. The allometry coefficient (b) differs according to the different hydrological and sedimentological features in various geographical areas **(Gaspar *et al.*, 2002)**. Besides, seasonal variations can also influence the growth. According to **Welcomme (2001)**, growth generally increases during the rainy season (water rises) and slows down in the dry season. This usualy happens because seasonal differences would cause changes in food availability, temperature, food activity and spawning activities.

## CONCLUSION

The results of the current study concerning the relationships between mantle length and all octopus body measurements maybe an indication of specific environmental conditions in the Suez Gulf, where the environmental factors, such as: temperature, salinity, pH values, depth, waves, currents, sediments, fresh water inputs, pollutants, petroleum platforms and tourist activities differ considerably from anywhere else. All those factors affect the comparison between the species from different geographical areas.

## ACKNOWLEDGEMENT

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