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POPULATION STRUCTURE, LENGTH WEIGHT RELATIONSHIPS AND RELATIVE GROWTH OF THE CALTROP SNAIL MUREX TRIBULUS IN BARDAWIL LAGOON, NORTH SINAI, EGYPT

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ABSTRACT

Population structure of the caltrop snail *Murex tribulus* at Bardawil lagoon, North Sinai, Egypt had been studied to evaluate their community structure in their habita. A total of 2400 individuals of *Murex tribulus* were randomly collected from landing site during the fishing season in Bardawil lagoon from June 2019 to February 2020 and from June 2020 to February 2021. The relationships between total length (TL) and total width (TW) of males (with total width range from 15 to 29.6 mm) and females (with total width range from 15.8 to 35.6 mm) and combined sexes (with total width range from 15 to 35.6mm) were determined to quantify shell size. Relative growth showed negative allometric growth (where b>1) was observed in males and females of *M. tribulus* in terms of the following body parts: top length (PL), bottom length (BL), aperture length (AL) and aperture width (AP) for males, females and combined sexes. The relationships between total length (TL) and (total weight TWt and flesh weight FWt) of *M. tribulus* illustrated a positive growth where b>1 for both sexes and combined sexes. However, the sex ratio was more or less constant throughout the season, except in August, January and February where females exceeds males. Generally, the total ratio for males and females was 1: 0.8.

INTRODUCTION

Bardawil lagoon plays an important role in lakes' fisheries since it is the least polluted wetland in Egypt and most of its catch is exported. It comprised around 22% of the total northern lakes' area and connected to the Mediterranean Sea *via* two inlets **(Noor El Deen *et al.*, 2016).** It is a shallow hyper-saline lagoon. The expansion of both human activities and tourism in North Sinai make it faces the pollution challenge in near future. Sea water was enter the lake in the past through three deltas: two artificial tidal inlets (270 and 300 m wide and 4-7 m deep), and a natural eastern inlet of Zaranik which is now occasionally closed by silting. It is characterized by the presence of high valued fish species like sea bass, sea bream, flatfish and grey mullet. In recent years a serious decline in the fish production of the lagoon was noticed especially for European sea bass **(Noor El Deen *et al.*, 2016).**

Gastropods are asymmetrical molluscs that underwent torsion. The body is generally divided into 2 main regions: (1) head-foot and (2) mantle (including shell), mantle cavity, and visceral mass. In most gastropods the muscular foot is the locomotion organ; gastropods principally crawl, attach, or burrow using the foot. The

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head includes sense organs (*e.g*., tentacles and eyes) and in many groups is the site of concentration of nerve ganglia and connectives.

The Gastropoda exhibit extremely expanded food habits. There are predators, scavengers, filter- and deposit-feeders, macro- and micro-herbivores. In addition, in order to reach the food source, some gastropods are able to drill through hard structures (*e.g*., shells) using the radula **(Jose, 2002).**

From the position of reproduction, gastropods may be dioecious or hermaphroditic (simultaneous or protandric), and may perform internal or external fertilization. Most gastropods go through pelagic larval development of varied duration (from a couple of hours to a few months), but some groups are known to have bypassed pelagic development, undergoing intracapsular (direct) development instead **(Jose, 2002).**

There is no important and accurate data for the annual catch of *Murex tribulus* in fisheries, although this species might be the active and more distribute in Bardawil lagoon in the few future years. It would be hard to use nets ships, where most of *Murex tribulus*, are caught as a by nets and various fishing methods because these are very opportunist snails.

MATERIALS AND METHODS

Description of the Study Area

The Bardawil lagoon (Fig. 1) is one of the largest salt water lagoons in the northern coast of Sinai province of Egypt. The Bardawil lagoon is located between 32º 40` and 33º 30`E and between 31º 3` and 31º 14` N **(Yitzhak, 1971; Siliem, 1989; El-Bawaab, 1995)**. The lagoon covers an assessed area of 136,318 Feddan with a maximum length of 95 Km and a maximum width of 22 Km, the water depth ranges from 0.5 m to 3 m **(GAFRD, 2015).** It is separated from the sea by a sandbar that varies in width between 100 m and 1 km. Three openings connect the lagoon with the sea; two artificial beginnings at the West side (Boughaz I and Boughaz II) and one natural opening at the East (El-Zaranik) **(Mehanna, 2006).** The salinity is 45 to 55 ppt and the water temperature ranges from 12.7°C in January to 30.5°C in June **(Pissanty, 1981).** The gastropods (family: Murcidae) in the lagoon is seasonally beginning in April and extends to the end of December **(Mehanna *et al.*, 2011).**

Sampling Station (El-Tulul)

The station is located of about 5Km at the point (31 09 90.211N//33 12 50.515"E) (which landing site of fisherman and it is the largest stations in Bardawil lagoon).

Biological sampling

A total of 2400 individuals of *Murex tribulus* were randomly collected from the commercial catch of trammel net from Bardawil lagoon from June 2019 to February 2020 and from June 2020 to February 2021. Collection of samples was carried out by nets in which overlap of different net diameter was used. A net with small diameter inside the large one and immersed in water over night. When the animals move, it clinging up in the net and trapped. Samples were taken to the laboratory and the different lengths were measured on it by a Digital caliper the length of the snail was measured to the nearest mm corrected to 0.01 mm (Total length TL).

The other measurements, such as Total width (TW), Aperture length (AL), Aperture width (AW), Top length (PL) and Bottom length (BL) were also taken (Fig. 4). Total weight of live animal with shell were also taken to the nearest g using the sensitive scale, then snails were broken using the hummer and the flesh was taken out to measure flesh weight (FWt) and the defferernce between males and females were recorded visualy (Fig. 4).

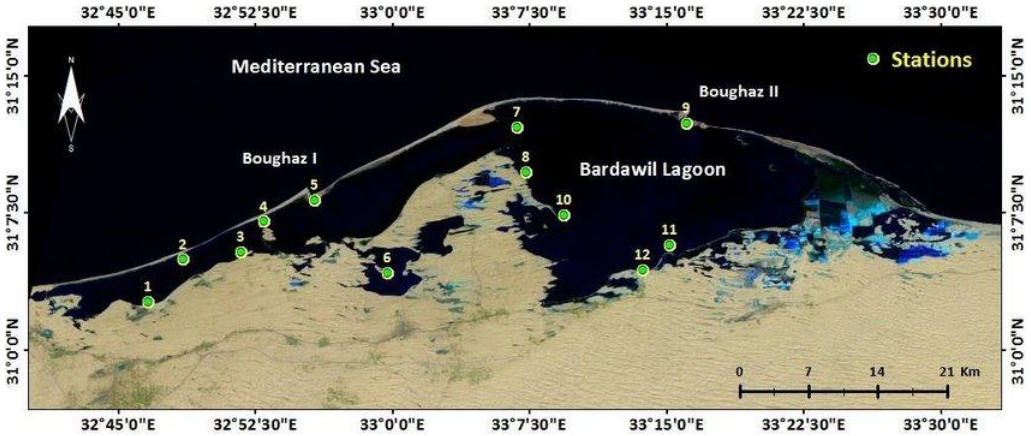

Fig. 1. Map of Bardawil Lagoon showing the investigated site

Fig. 2. Map of Bardawil lagoon showing the sampling station

Fig. 3. Photos of *Murex tribulus*

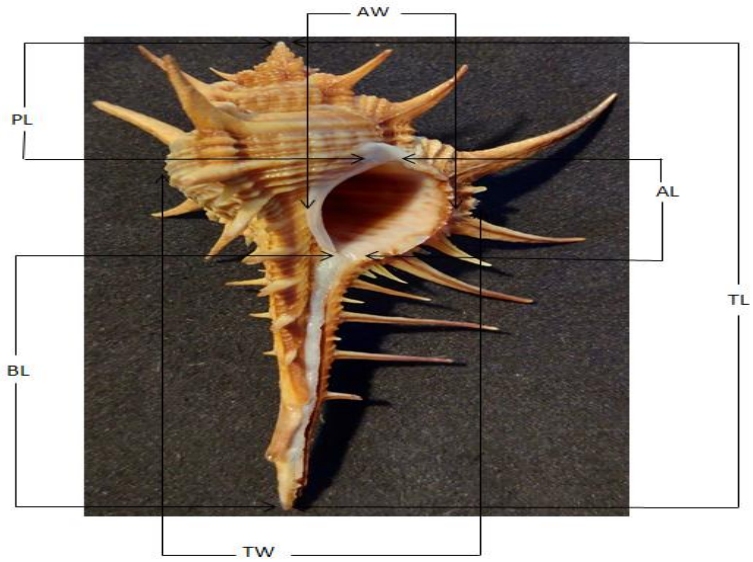

Fig. 4. Calibration size of *Murex tribulus*

The relationship between each two characters can be expressed by the general equation

$$Y = a + bx$$

Where a is the intercept and b the slope of the line.

Logarithmic calculation was as following way:

$$\text{Log } Y = \text{Log } a + b \text{ Log } x$$

(Wilbur and Owen, 1964)

b = 1 Means isometric growth.

b > 1 Means positive allometric growth.

b < 1 Means negative allometric growth.

Total length- weight relationships:

The relationships between the weight and the width for each sex were presented by the formula:

$$Y = a\, x^b$$ **(Zar, 1984)**.

Anywhere "Y" was the total weight expressed in g, "X" was the total width in mm,"a" was a constant and "b" was the slope and represented the coefficient of correlation.

When growth is isometric, the slope "b" equals to 1 and weight proceeds in the same dimension as the cube of length. When "b" is unequal to 1 weight growth is allometric meaning that it proceeds in a different dimention (differing from width). If weight is increasing relatively faster than total length, at that time the relationships is said to be positive allometric growth (b>1) indicates that weight increases relatively slower than length.

RESULTS

Population Structure

A total of 2400 individuals of *Murex tribulus* (including 1355 males and 1045 females) were sampled from Bardawil lagoon. The size - frequency distributions of males and females of *M. tribulus* within 5mm total length class intervales are shown in Fig. 5.

The total size of *M. tribulus* population ranged from 24.3 to 75.2 mm for males, it ranged from 37 to 83 mm for females (Fig. 5) and ranged from 24.3 to 83 mm for combined sexes (Fig. 6). The average size of

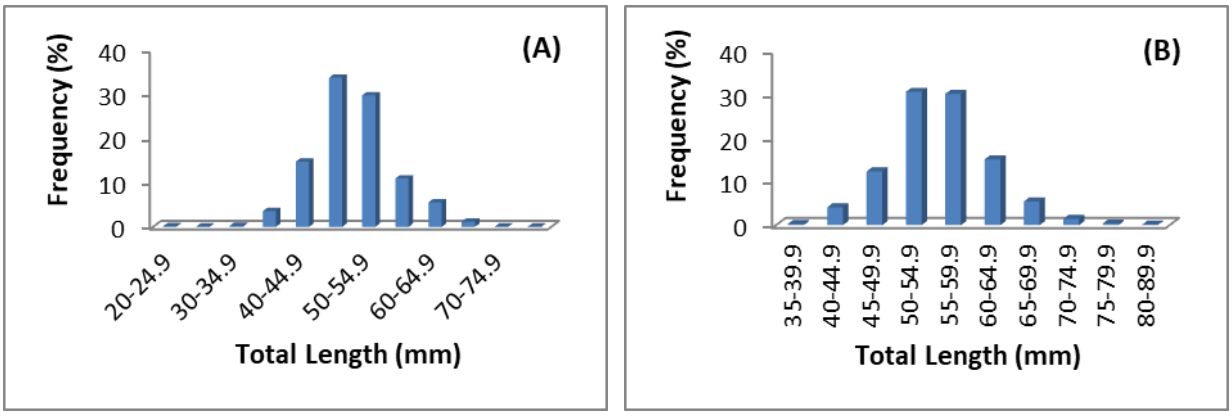

Fig. 5. Size frequency distribution of (A) Male and (B) Female of *M. Tribulus*

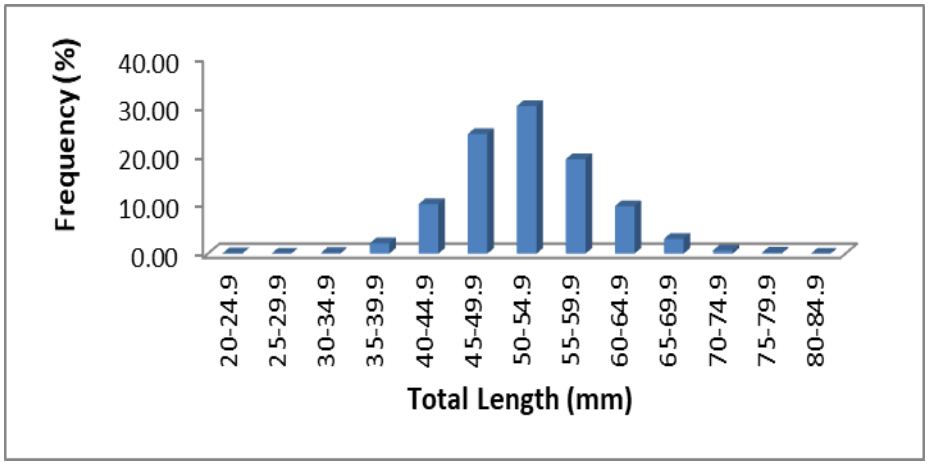

Fig. 6. Size frequency distribution of combined sexes of *M. Tribulus*

males *M. tribulus* (49.8 mm TL),it was smaller than that of females (55.6 mm TL). Small number of females had small size less than 35 mm, while males smaller than this size were completely absent from the population. The largest individual sampled was a female of 83 mmTL.

Relative Growth

Total length-width relationships

The relationships between total length (TL) and total width (TW) of *murex* male (with total width range from 15 to 29.6 mm, SD=2.5) and females (with total width range from 15.8 to 35.6mm, SD= 2.56) are shown in Fig. 7 and combined sexes (with total width range from 15 to 35.6mm, SD= 5.96). That of combined sexes is shown in Fig. 8 representing their regression equations in Table 1. Linear models were observed in all relationships.

Linear relationships and correlation coefficient between total length and total width were found to be negative allometric growth (b<1); slope values were b= 0.33, 0.326, 0.331 for males, females and combined sexes, respectively. The two variables (total length and total width) did not exhibit high correlations where the coefficients of determination (R^2) had values less than 0.69.

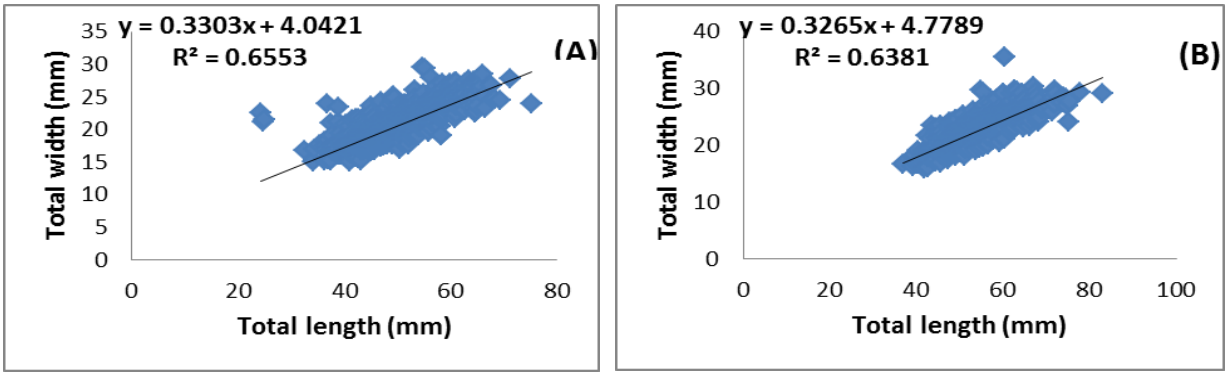

Fig. 7. Relationship between total length and total width (A) Male, (B) Female

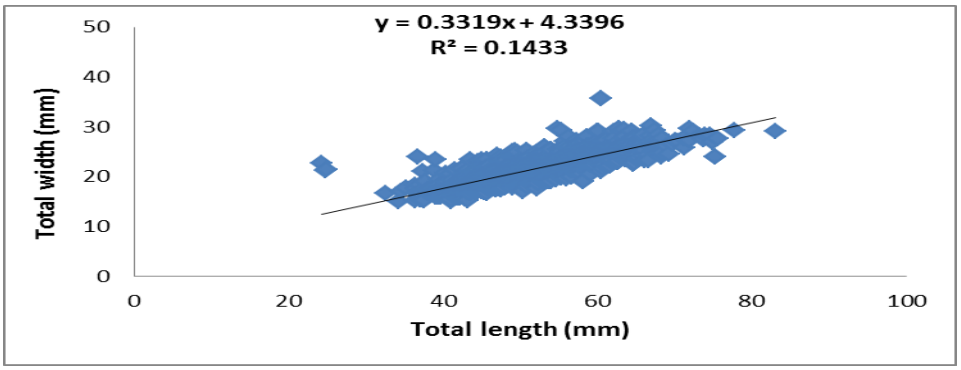

Fig. 8. Relationship between total length and total width of combined sexes

Table 1. Regression equations describing the relative growth of the dimensions of different body parts in male, female and combined sexes of *Murex tribulus*. Independent variable is Total length (TL).

Sex	Dependent variable	Range (mm)	SD	Regression equations	B	R^2	n
Male	Total width (TW)	15-29.6	2.50	TW= 0.3303TL + 4.0421	0.3303	0.6553	1355
	Top length (PL)	11-25.7	2.23	PL= 0.3015TL + 1.6496	0.3015	0.6857	1355
	Bottom length (BL)	9.2-33	3.32	BL= 0.4463TL - 0.1603	0.4463	0.6765	1355
	Aperture length (AL)	8.5-22	1.70	AL= 0.2119TL + 3.034	0.2119	0.5842	1355
	Aperture width (AW)	6.8-19	1.46	AW= 0.1787TL + 1.8689	0.1787	0.5599	1355
Female	Total width (TW)	15.8-35.6	2.56	TW= 0.3265TL + 4.7789	0.3265	0.6381	1045
	Top length (PL)	11.3-27.2	2.43	PL= 0.3193TL + 1.0814	0.3193	0.6752	1045
	Bottom length (BL)	12.3-39.2	3.56	BL= 0.4742TL - 2.0194	0.4742	0.6952	1045
	Aperture length (AL)	10.2-22	1.80	AL= 0.2186TL + 2.8281	0.2186	0.5772	1045
	Aperture width (AW)	8-27.9	1.61	AW= 0.1753TL + 2.3464	0.1753	0.4611	1045
Combined sexes	Total width (TW)	15-35.6	5.96	TW= 0.3319TL + 4.3396	0.3319	0.1433	2400
	Top length (PL)	11-27.2	4.48	PL= 0.3308TL + 0.3758	0.3308	0.2519	2400
	Bottom length (BL)	9.2-39.2	3.60	BL= 0.4543TL - 0.7794	0.4543	0.5409	2400
	Aperture length (AL)	8.5-22	1.87	AL= 0.2195TL + 2.7126	0.2195	0.6354	2400
	Aperture width (AW)	6.8-27.9	1.66	AW= 0.1859x + 1.6479	0.1859	0.3783	2400

Level of significance $P < 0.05$.

Biometric relationships

The relationships between total length (TL) and each measurement of the body parts of males, females and combined sexes are represented by the regression equations in Table 1.

Negative allometric growth (where b<1) was observed in males and females of *M.tribulus* in terms of the following body parts: top length (PL) and bottom length (BL);(b=0.3015, 0.4463), (b=0.319, 0.4742) and (b=0.3308, 0.4543) for male, female and combined sexes, respectively are shown in Figs. 9, 10, 11 and 12. Other body parts also showed negative allometric growth (b<1) where aperture length (AL) and aperture width (AP); (b= 0.211, 0.178) and (b=0.218, 0.175) and (b= 0.219, 0,185) for males, females and combined sexes respectively are shown in Figs. 13, 14, 15 and 16.

For both sexes, the different morphometrics were consistently correlated with total length. The coefficient of determination (R^2) was from 0.2 to 0.6 for most of the body parts measurements when regressed on total length.

Total Length-Weight Relationships

The relationships between total length (TL) and total weight (TWt) of male and female and combined sexes of *M.tribulus* are shown in Fig. 17. Table 2 show the regression equations obtained for these relationships. The regressions of the relationships illustrated a positive allometric growth where b>1 for each sex and combined sexes. The coefficients of correlation showed high values, (R^2= 0.5562, 0.6094, 0.1632) in males, females and combined sexes, respectively.

Total Length and Flesh Weight Relationships

The relationships between total length (TL) and flesh weight (FWt) of male, female and combined sexes of *M. tribulus* are shown in Fig. 18. Table 2 show the regression equations obtained for these relationships. The regressions of the relationships illustrated a positive allometric growth where b>1 for both sexes and combined sexes. The coefficients of correlation showed high values (R^2) ranged from (0.30 to 0.37) im males, females and combined sexes.

Seasonal Variation of Size Frequency

Seasonal change in the total length distribution of both sexes is graphically represented in Fig. 19. During summer, juveniles with size class 35 mm were observed by 2.08% in males (Fig. 19A). This class size is totally disappeared in females (Fig. 19B). On the other hand, during autumn the majority of population was recorded in size classes more than 50 mm in adult females, while there were few adult males at this class size. However, this size bagan to disappear in adult males during winter in contrast to adult female.

Sex ratio

The sex ratio of *M.tribulus* population refers to the frequency or the perecentages of males and females in the population or the catch. The variation of sex ratio were studied monthly. Table 3 show the monthly variation in the ratio of males to females in the fishing season 2019 and 2020 in Bardawil lagoon. The sex ratio values were significantly different between males and females at significant level 0.05%. In *M.tribulus*, there was a predominance of males in all months. However, the sex ratio was more or less constant throughout the season, except in August, January and February where females exceeds males. Finally, the total ratio for sex ratio between males and females was 1: 0.8.

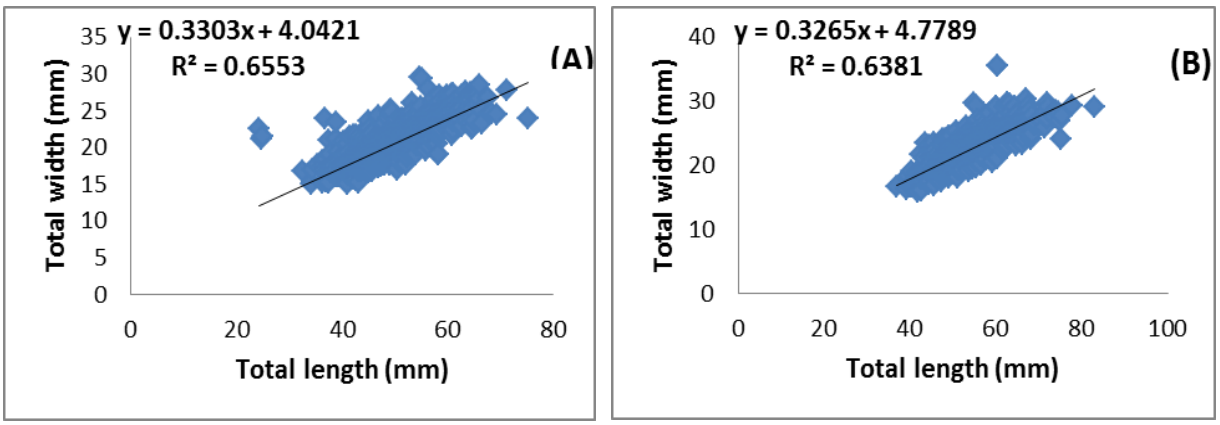

Fig. 7. Relationship between total length and total width (A) Male, (B) Female

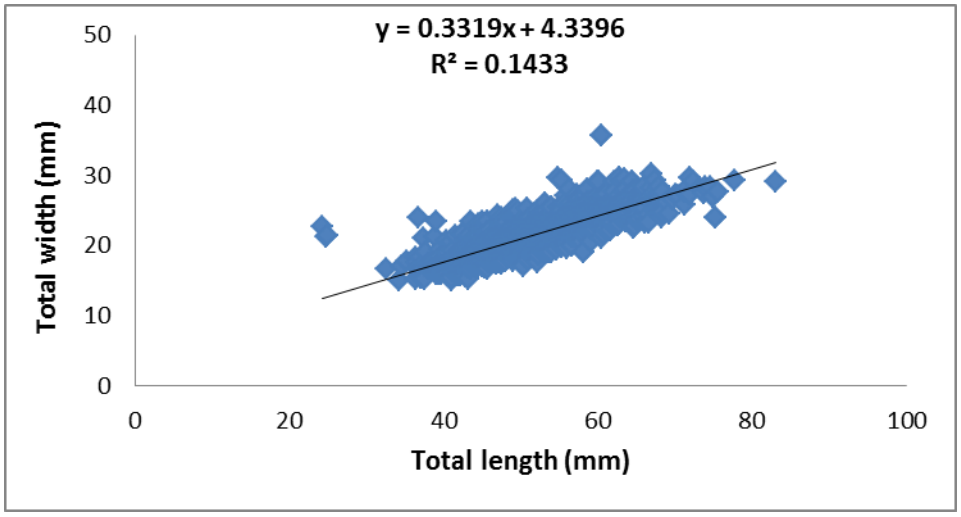

Fig. 8. Relationship between total length and total width of combined sexes

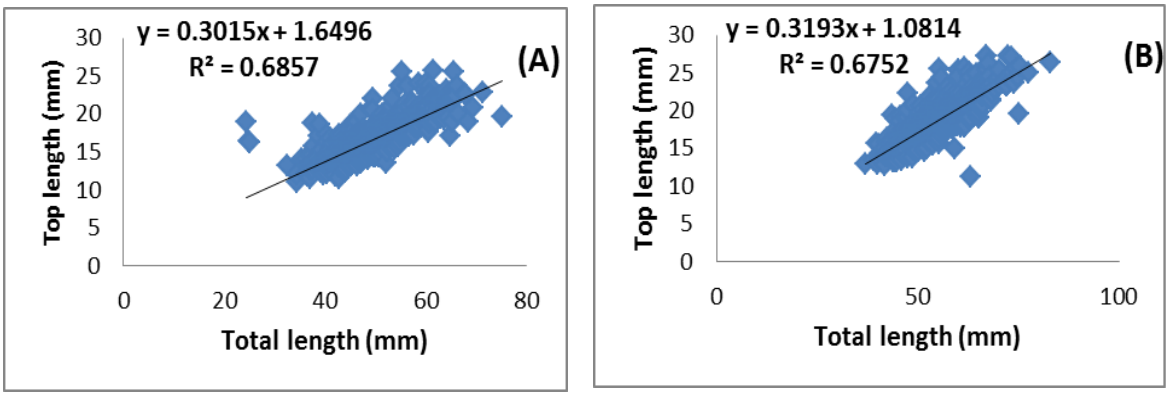

Fig. 9. Relationship between total length and top length (A) Male, (B) Female

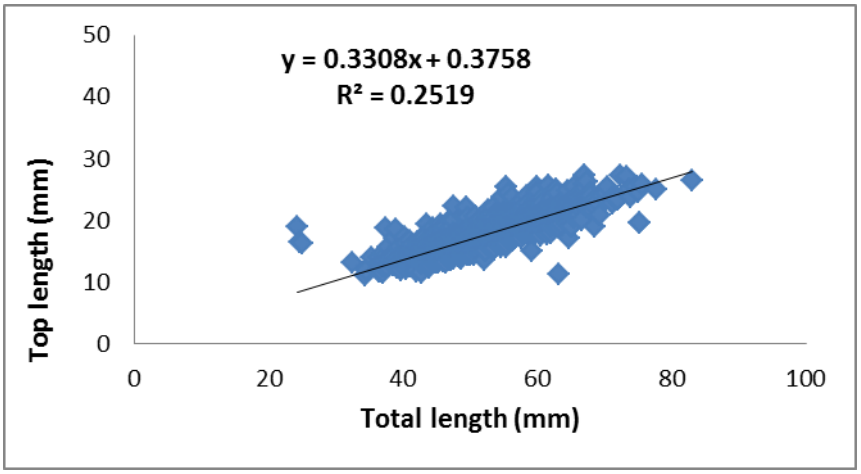

Fig. 10. Relationship between total length and top length of combined sexes

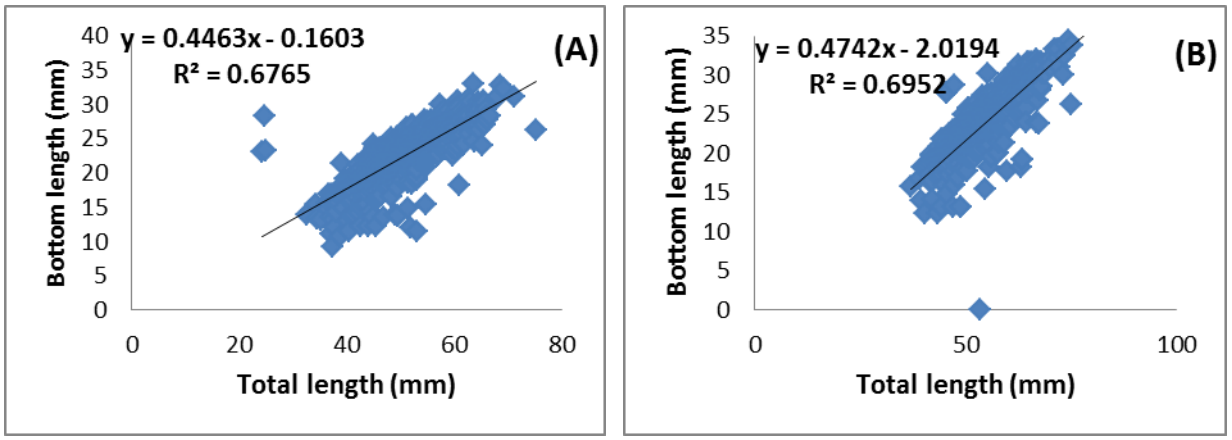

Fig. 11. Relationship between total length and bottom length (A) Male, (B) Female

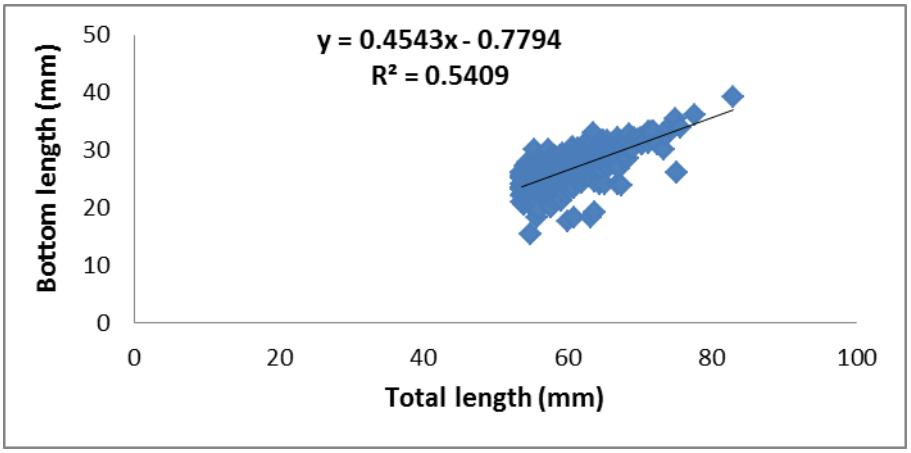

Fig. 12. Relationship between total length and bottom length of combined sexes.

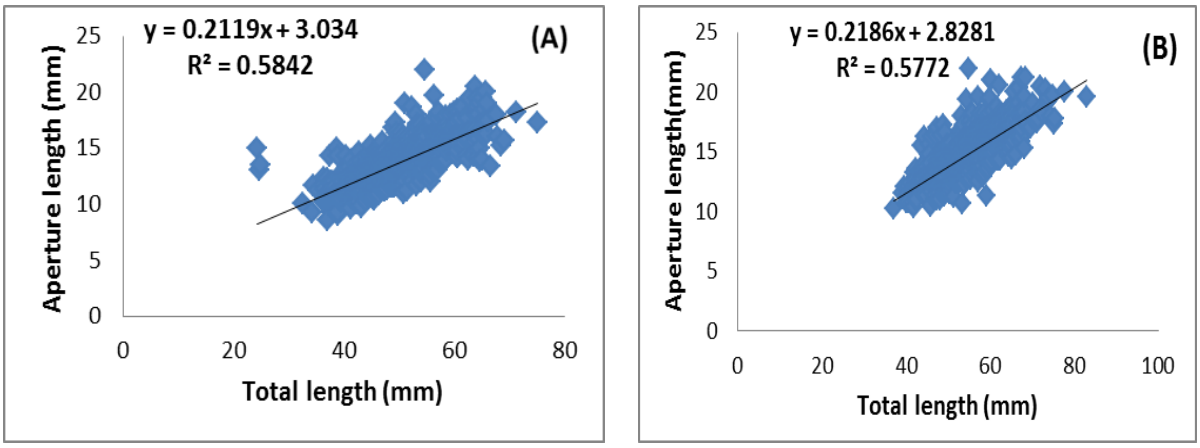

Fig. 13. Relationship between total length and aperture length. (A) Male, (B) Female

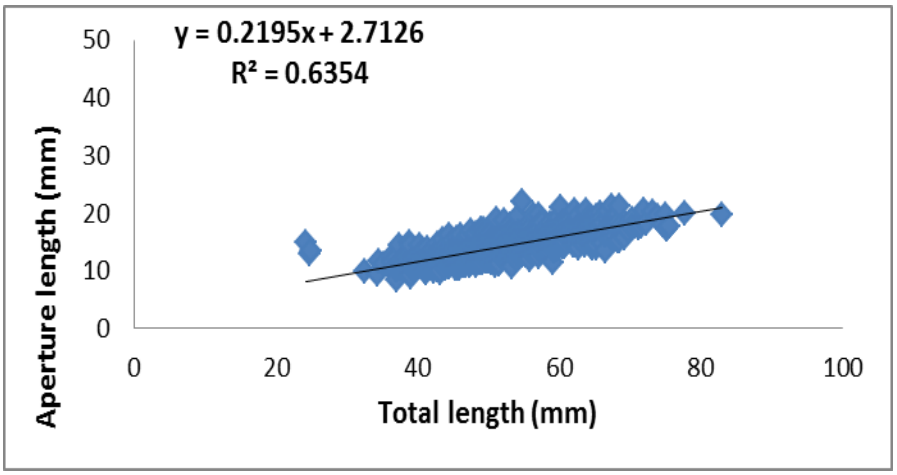

Fig. 14. Relationship between total length and aperture length of combined sexes

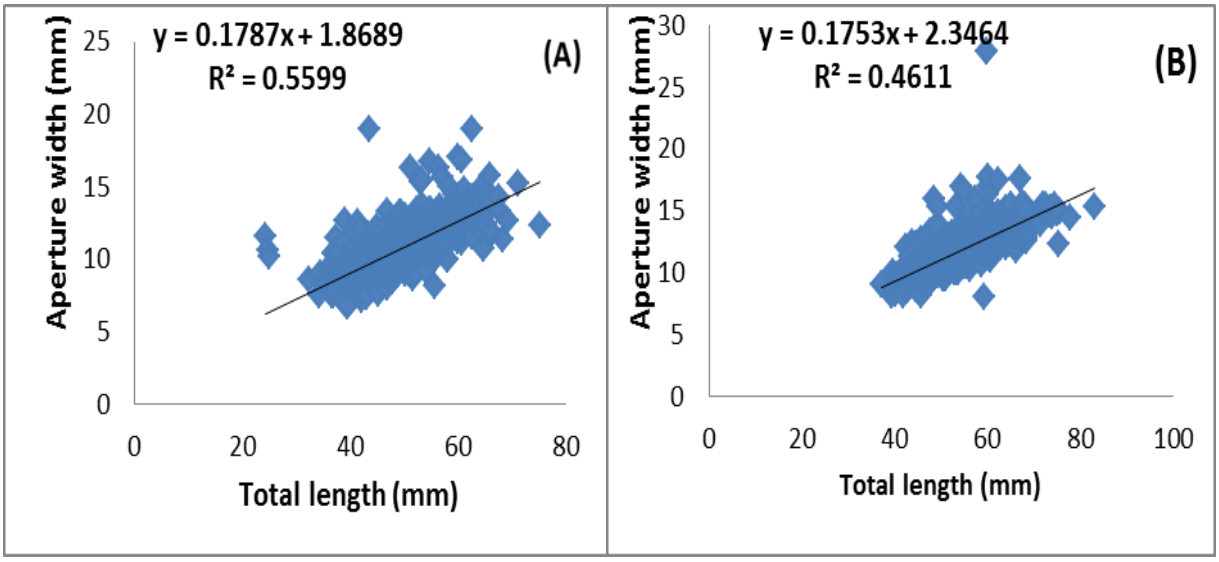

Fig. 15. Relationship between total length and aperture width. (A) Male, (B) Female

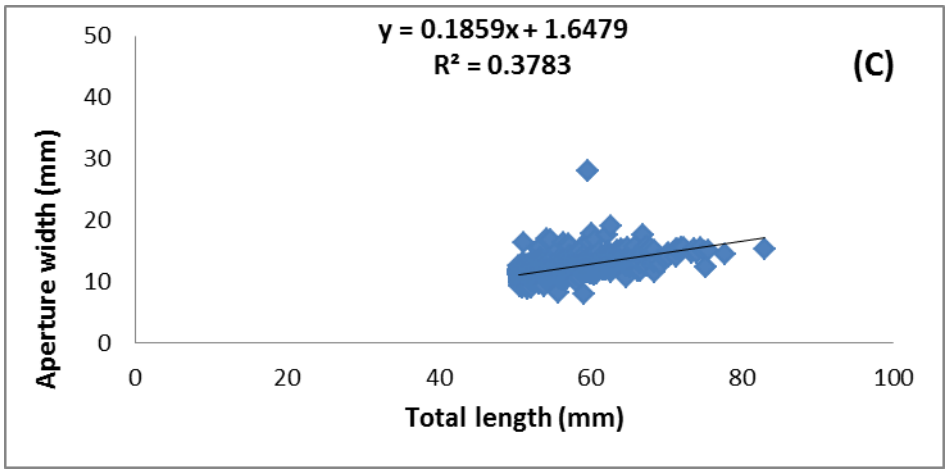

Fig. 16. Relationship between total length and aperture width of combined sexes

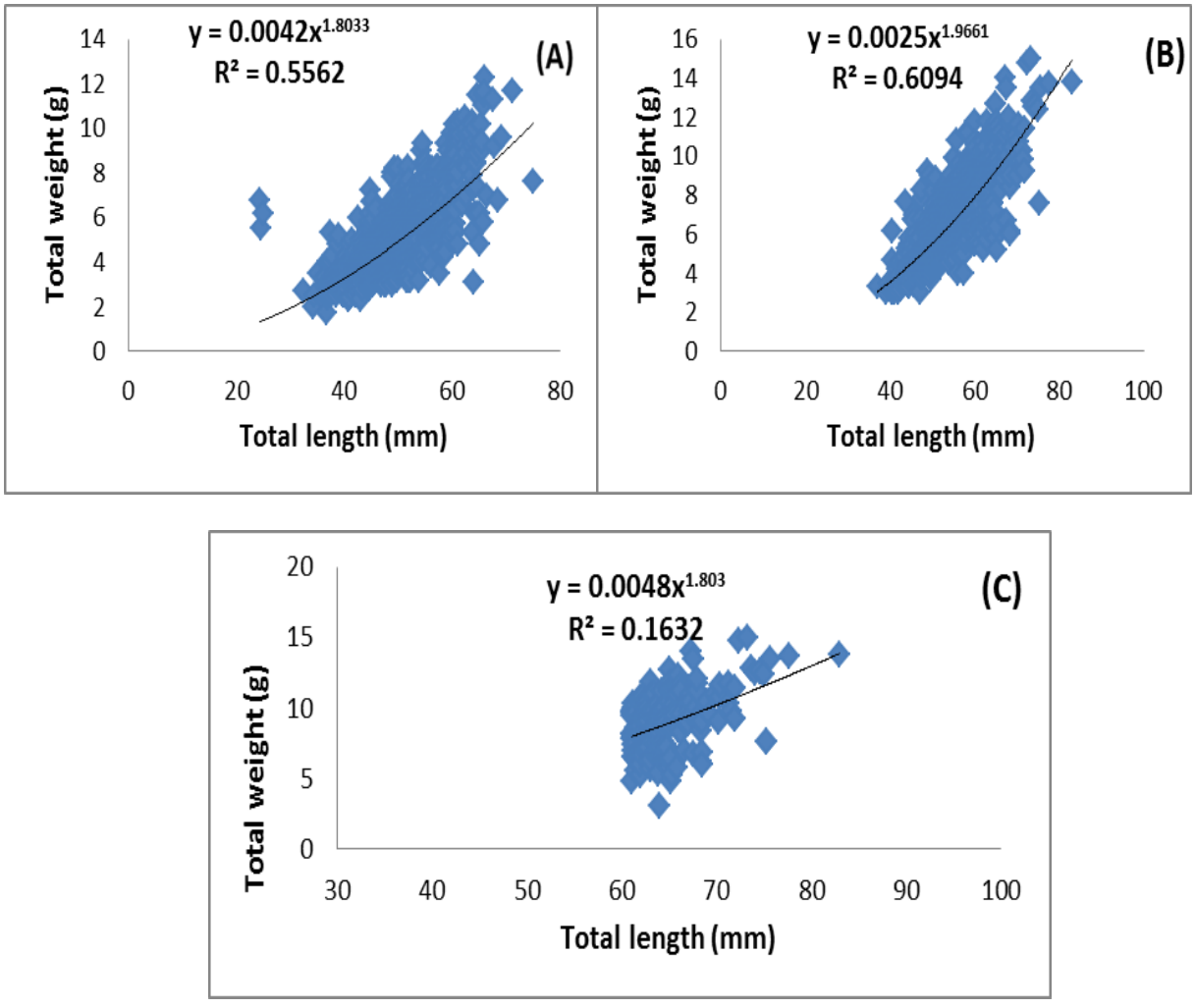

Fig. 17. Relationship between total length and total weight (A) Male, (B) Female and (C) Combined sexes

Table 2. Regression equations describing the relationships between the different weight in male, female and combined sexes of *Murex tribulus*. Independent variable is total length (TL)

Sex	Dependent variable	Range (gram)	SD	Regression equations	b	R^2	n
Male	Total weight (TWt)	1.7-12.3	1.61	$TWt= 0.0042TL^{1.8033}$	1.8033	0.5562	1355
	Flesh weight (FWt)	0.2-3.8	0.46	$FWt = 0.0027TL^{1.5848}$	1.5848	0.3044	1355
Female	Total weight (TWt)	3-15	1.96	$TWt= 0.6094TL^{1.9661}$	1.9661	0.6094	1045
	Flesh weight (FWt)	0.6-4.6	0.58	$FWt = 0.0046TL^{1.512}$	1.512	0.3746	1045
Combined sexes	Total weight (TWt)	1.7-15	2.01	$TWt= 0.0048TL^{1.803}$	1.803	0.1632	2400
	Flesh weight (FWt)	0.2-4.6	0.62	$FWt = 0.0004TL^{2.1159}$	2.1159	0.3727	2400

Level of significance $P < 0.05$.

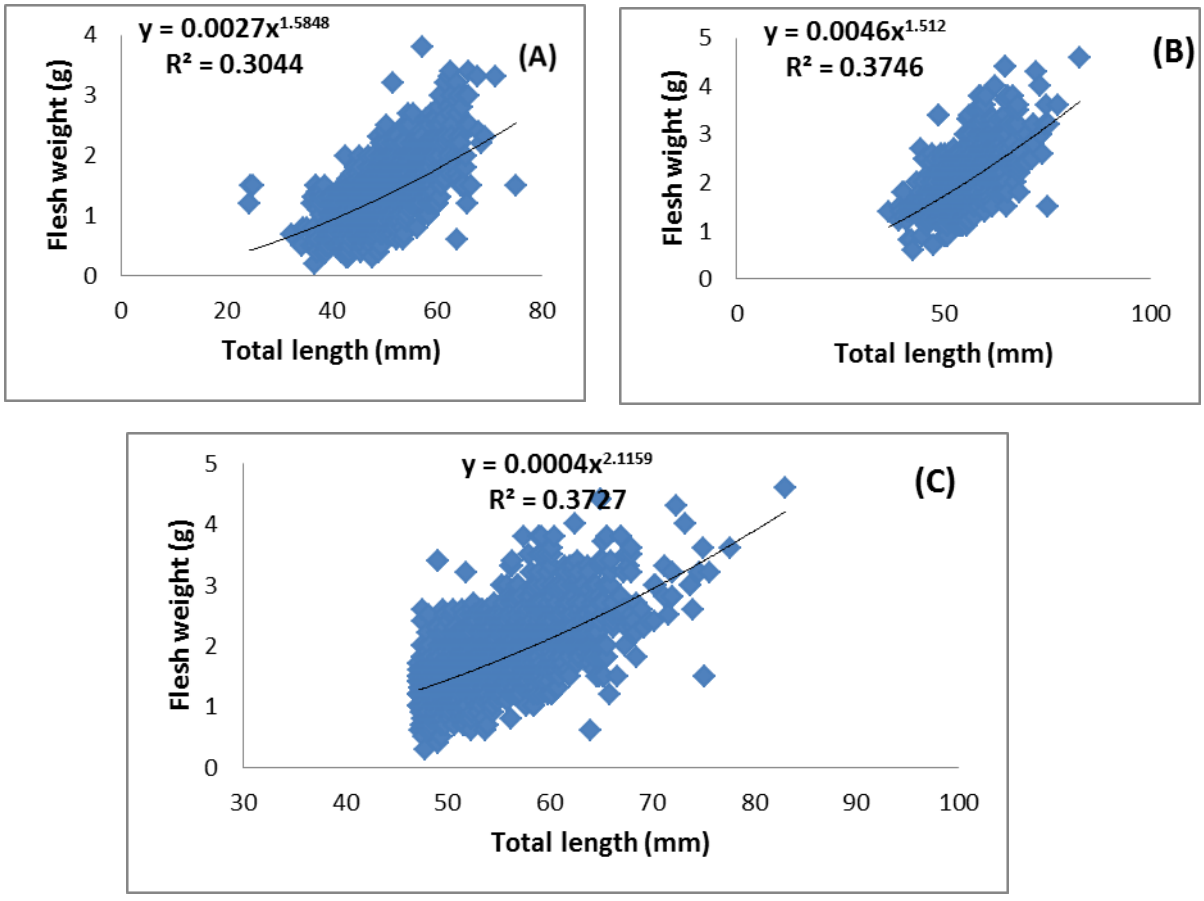

Fig.18. Relationship between total length and flesh weight (A) Male, (B) Female and (C) Combined sexes

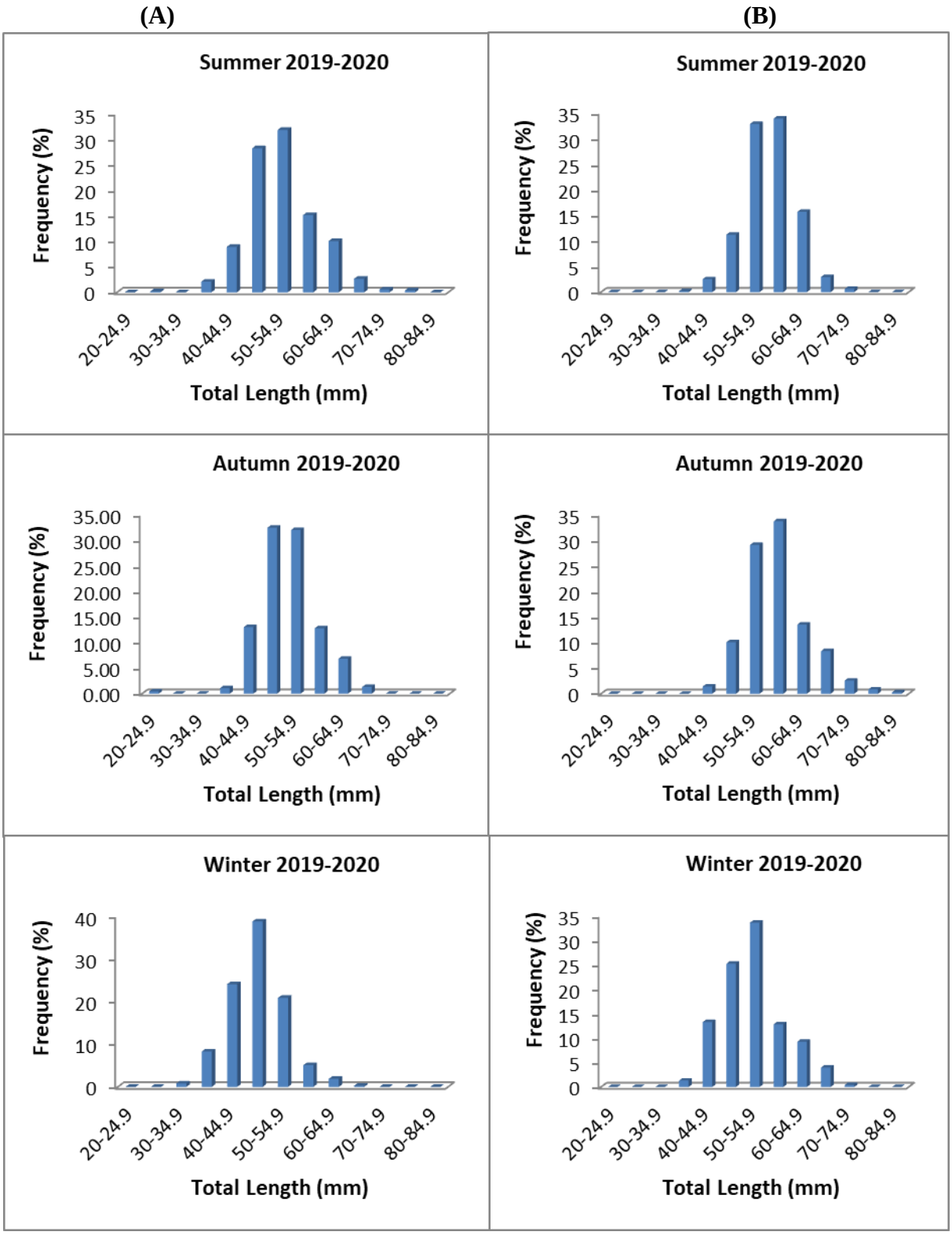

Fig. 19. Seasonal frequency histograms for total length of (A) Males and (B) Female *M. tribulus*

Table 3. Monthly variations in the sex ratio of *M. Tribulus* collected in Bardawil lagoon 2019 and 2020.

Month	Total	Males		Females		Males: Females
		No.	(%)	No.	(%)	
June	200	110	55.0	90	45.0	1 : 0.8
July	200	119	59.5	81	40.5	1 : 0.7
Aug.	400	194	48.5	206	51.5	1 : 1.1
Sep.	400	215	53.75	185	46.25	1 : 0.9
Oct.	400	207	51.75	193	48.25	1 : 0.9
Nov.	400	246	61.5	154	38.5	1 : 0.6
Dec.	400	279	69.75	121	30.25	1 : 0.4
Jan.	200	95	47.5	105	52.5	1 : 1.1
Feb.	200	98	49.0	102	51.0	1 : 1.04
Total	2800	1563	496.25	1237	403.75	1 : 0.8

DISCUSSION

During the present study, catches of snails per boat or per meter length of fishing net per day were found to be significantly correlated with the abundance of the snails at the fishing ground as well as with season. Hence, the higher the abundance the higher the catch. This is explainable according to the reproductive cycle of the snails, for they tend to migrate into shallow water during the spawning season (April-May) and increasing activity for searching food during warm months **(Hanafy, 1993)**. The present study indicated the presence of considerable variations in the body size of the sea snail *Murex tribulus* in Bardawil Lagoon. Population size of females was larger than that of males. Growth determination was based on size frequency distribution and its change with seasons.

The change in the shape of growing animals at a point of time is due to the simultaneous increase in size and weight **(Byers, 2000).** The present study measures *M. tribulus* length - weight relationship to evaluate the snail growth. Length – weight relationship of living organism is an exclusive and constant feature. It is stated that the relationship of length weight takes the formula $Y = a\ x^b$. Our study, using the length–weight data by month, found that there was a general negative allometric growth for the studied snail M. tribulus, as reflected by low b values (*i.e.*, <3). For C. moreletiana, although there were higher b values found in the dry season, due to nutrient accumulation that supports their growth **(Vanderploeg *et al.*, 1995; Vaughn and Hakenkamp, 2001)**, the b values were still lower than 3.

Similarly, various other relationships such as top length, bottom length, aperture length and aperture width can be resulting by using linear regression. On the other hand, there are several limitations to shell length as a measure of animal size. Most molluscs have a slope values (b) between 2.5 and 4.5 when logarithm of the body weight is plotted as a function of the logarithm of the shell length **(Wilbur and**

Owen, 1964). In the present study, it ranged between 1.5 and 2.0.

This result agree with **(Hanafy, 1993)** who stated that the regression relationship of *Murex tribulus* between animal shell length and total weight, tissue weight, is in strong correlation coefficients. Positive allometric growth appeared between shell length with total weight and flesh weight. Negative allometric growth appeared between shell length with total width, top length, bottom length, aperture length and aperture width**. Garcia *et al.* (2000)** the biological interpretation of the numerical values of the parameters "a" and "b" is not always straight forward, only when growth is isometric **(Gayathri, 2016)**. Generally, the "b" values of males and females mean that they had different growth rates from one and another. **Ngor *et al.* (2018)** stated that the length-weight relation varies seasonally so the length-weight data were studied throughout the annual cycle.

The LWR is commonly used as an indicator of biological fisheries, changes in individual and population status and growth patterns of organisms **(Gayon, 2000; Gaspar *et al.*, 2001; Albuquerque *et al.*, 2009)**. We found that the weight gain in the studied species is slower than the growth in length, as inferred from low b values.

The sex ratio of *M. tribulus* showed the presence of an excess of males for most of the year. However, there is no known sex-related burrowing behavior in the studied species which might affect the catchability of the sexes.

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الملخص العربي

التركيب العشائري، وعلاقات الطول بالوزن والنمو النسبي لمحاصرة قوقع كالتروب موريكس في بحيرة البردويل، شمال سيناء، مصر

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ركز هذا البحث على الدراسات البيولوجية لـ *Murex tribulus* في بحيرة البردويل، شمال سيناء، مصر. تم جمع 2400 عينة من *Murex tribulus* بشكل عشوائي من موقع الإنزال (ميناء التلول) خلال موسم الصيد في بحيرة البردويل من (يونيو 2019 إلى فبراير 2020) ومن (يونيو 2020 إلى فبراير 2021). العلاقات بين الطول الكلي (TL) والعرض الكلي (TW) لذكور murex (مع إجمالي العرض الكلي من 15 إلى 29.6 ملم) والإناث (مع إجمالي العرض الكلي من 15.8 إلى 35.6 ملم) والجنسين معاً (مع إجمالي العرض الكلي من 15 إلى 35.6mm). ولوحظ النمو السلبي للقياسات الطولية (حيث b<1) في الذكور والإناث من *M.tribulus* من حيث أجزاء الجسم التالية: الطول الجزء العلوي (PL) وطول الجزء السفلي (BL)؛ (b= 0.3015، 0.4463)، (b= 0.319، 0.4742) و (b= 0.3308، 0.4543) للجنسين الذكور والإناث والجمع، على التوالي. وأظهرت أجزاء أخرى من الجسم أيضا النمو السلبي (حيث b<1) حيث طول الفتحة (AL) وعرض الفتحة (AP)؛ (b= 0.211، 0.178) و (b= 0.218، 0.175) و(b= 0.219،0.185) للذكور والإناث والجنسين معا على التوالي. توضح العلاقات بين الطول الإجمالي (TL) و(الوزن الإجمالي TWt ووزن اللحم FWt) من *M.tribulus* نموا إيجابياً (حيث b>1) لكلا جنس والجنسين معاً. غير أن النسبة بين الجنسين كانت ثابتة إلى حد ما طوال الموسم، باستثناء أغسطس ويناير وفبراير حيث تتجاوز الإناث الذكور. وأخيرا، بلغ مجموع النسبة الإجمالية لنسبة الجنس بين الذكور والإناث 1:0.8.

الكلمات الإسترشادية: التركيب العشائري، النمو النسبي، علاقة الطول والوزن، *Murex tribulus*، بحيرة البردويل.

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