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Population structure and reproductive biology of the bristle crab *Halimede tyche* (Herbst, 1801) (Brachyura: Pilumnidae) in Great Bitter Lakes, Suez Canal, Egypt

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ABSTRACT

The population structure and reproductive biology of crab *Halimede tyche* (Herbst, 1801) in Bitter lakes were studied. Crabs were monthly sampled during the period from January to December 2009. A total of 443 crabs were sampled, of them 249 were males (53.5 %), 138 non-ovigerous females (29.7 %), and 78 ovigerous females (16.8 %). Males were found to be larger than females. The overall males: females sex ratio estimated 1:1.2. The male of *Halimede tyche* attained 30.7 mm at first maturity, while female was 24.5 mm in size. The gonado-somatic indices of males were higher than that of females. Spawning season in both sexes extended from May to August. An increase in oocyte diameter was recorded in April (280 µm) and continued to reach the maximum value in June with an average of 397 µm. The absolute fecundity ranged from 10641 to 57810 eggs for crab size ranging from 22.2 to 36.5 mm.
Keywords: Pilumnidae, *Halimede tyche,* population structure, reproductive biology, Great Bitter Lakes, Suez Canal.

INTRODUCTION

Recently, more attention has been paid to study focusing on density, size frequency distributions, spatial dispersion, sex ratio, juvenile recruitment, and reproductive season (Thurman, 1985; Diaz & Conde, 1989; Leme & Negreiros-Fransozo, 1998 and Yamaguchi, 2001). Moreover, comparisons between populations may constitute an important strategy to verify differences among them, as well as to understand their environmental and biological characters (Mantelatto *et al.*, 1995; Oshiro, 1999; Fransozo *et al.,* 1999).

Studies of the brachyuran crabs are important among the Suez Canal marine organisms. Commercial brachyuran crabs have always been part of the human diet. On the other hand, non commercial brachyuran crabs play an important role in the establishment of the marine ecosystem. The present study deals with this group of true crabs, to throw light on their species composition, community structure different aspects of biology.

Reproduction is the main mechanism to guarantee species continuity; its study is of major importance. The reproductive strategy of brachyuran crabs is important to maximize egg production, thus increasing the preservation of the species (Hartnoll & Gould, 1988 and lopez Greco *et al.,* 2000). The determination of breeding periods is governed by a complex interaction of endogenous and exogenous factors, allowing both intra and interspecific variations regarding to the duration of the reproductive season (Sastry, 1983). Generally, peaks of higher breeding activity may be associated with variations of temperature, salinity, oxygen, food availability, photoperiod, rainfall (Pinheiro & Fransozo, 2002; Costa & Negreiros-Fransozo, 2003; Mantelatto *et al.,* 2003; Litulo, 2004 b). There are no studies on the reproductive biology of *Halimede tyche* in Bitter Lakes, Suez Canal. Thus, this research will through a shadow on the strategy of reproduction of the target species.

MATERIALS AND METHODS

Study area:

The Bitter Lakes are the central and most important water body of the Suez Canal (Figure 1). According to Thorson's (1971), it contains 85% of the waters of the canal system. The study area is bounded by latitudes 30°:10´ - 30°:26´ N, and longitudes 32°:10´ - 32°:40´ E. The Bitter Lakes consist of Great Bitter Lake and Little Bitter Lake which are connected to each other as shown in Figure 1. The total length of the lake is 36 km, which separates the basin into a northern part (the Great Bitter Lake with a maximum width of 13 km) and a much narrower southern part (the Little Bitter Lake). The western shore is steeper and a few rock outcrops are formed. The maximum water temperatures recorded were in July and August (30^{o}C), while the water temperature started to decline from September reaching the minimum value in January (15^{o}C). On the other hand, the salinity showed a great fluctuation from a month to another. It attained the maximum value in October (38‰) where as the minimum value has been recorded in January (10‰) (Ahmed *et al*., 2004).

Field sampling and measurements

A total of 443 specimens of *Halimede tyche* (Herbst, 1801) were collected on monthly basis, during the period from January to December 2009, from the western side of the Great Bitter Lakes. Specimens were collected manually from the surface of the buoys and jetties and occasionally by fishermen at Deversoir and Fayed (Figure 1). All crabs were sexually differentiated by morphological examination, then bagged, labelled, and preserved in 4% formaldehyde sea water solution for further analysis. In the laboratory, crabs were checked for the presence of eggs on female pleopods. The carapace width (CW) was measured using a vernier caliper (±0.05 mm accuracy) (Macia *et al*., 2001 and Litulo, 2004). Females were dissected under a stereomicroscope and their ovaries removed, identified,

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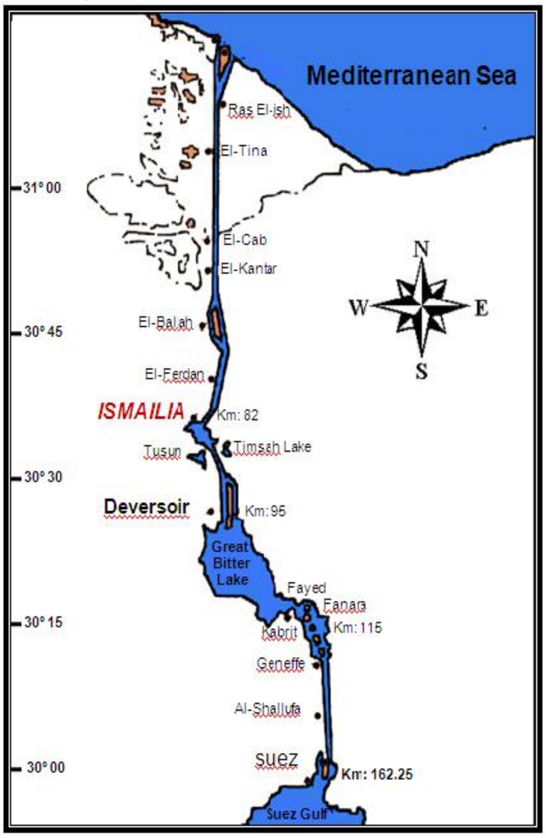
and stored with their respective females. After drying at 70 °C for 12 h (Yamaguchi, 2001), both females and gonads were weighed using an analytical balance (0.0001 g).



Figure(1): Sampling sites in Great Bitter Lakes, Suez canal, Egypt.

The gonado somatic index (G.S.I) was calculated for each specimens as follows:

$$G.S.I = \frac{\text{Ovary weight x 100}}{\text{Total body weight}}$$

A small piece of the ovary was examined under a dissecting microscope equipped with an ocular micrometer and the diameter of 20 oocytes was measured. To estimate fecundity, 20 ovigerous females with eggs were selected for egg counting. Pleopods were removed from females, placed in petri dishes filled with seawater, and eggs detached by the gradually addition of sodium hypochlorite solution. Three sub-samples of 1.5 ml each were taken using a pipette and eggs were counted under a dissecting microscope. The average value obtained was then extrapolated for the whole suspension to estimate the number of eggs (Flores & Paula, 2002 and Litulo, 2004 b). The fecundity was then calculated as follow:

Fecundity=

$$\frac{\text{Number of egg in the sample X Total egg weight (g)}}{\text{Weight of the sample (g)}}$$

Relationships between fecundity and body variables were established according to the following formula:

$$F = a \pm b\,x$$

Where; F = absolute fecundity

X = independent variable

(total length, total weight and ovary weight).

a = constant, equal to the intercept of straight line with y- axis.

b = an exponent.

RESULTS

Population structure

A total of 443 individuals were sampled during the study period, of which 249 were males (53.5 %), 138 non-ovigerous females (29.7 %), and 78 ovigerous females (16.8 %) (Table 1). Males ranged from 28.5 to 37.0mm carapace width (mean ± SD: 29.5 ± 0.215 mm); non-ovigerous females from 20.0 to 34.0mm carapace width (mean ± SD: 2.8 ± 0.153 mm); and ovigerous females from 22.2 to 36.5mm carapace width (mean ± SD: 32.5 ± 0.132 mm). Males were significantly larger than ovigerous females ($t = 12.28$, $p < 0.05$), which in turn were larger than non-ovigerous females ($t = 10.85$ $p < 0.05$) Figure (2) shows the mean size for all sampled crabs.

Reproductive biology

Sex ratio

The overall sex ratio (1:1.2 for males to females) did not differ significantly from the expected 1:1 proportion ($\chi 2$ test, $P < 0.05$). Generally, sex ratio monthly differed. Males outnumbered females in February, June and July, whereas the vice versa was recorded other months. However, significant differences were recorded in January, March and December (Table 1).

Size at first sex maturation

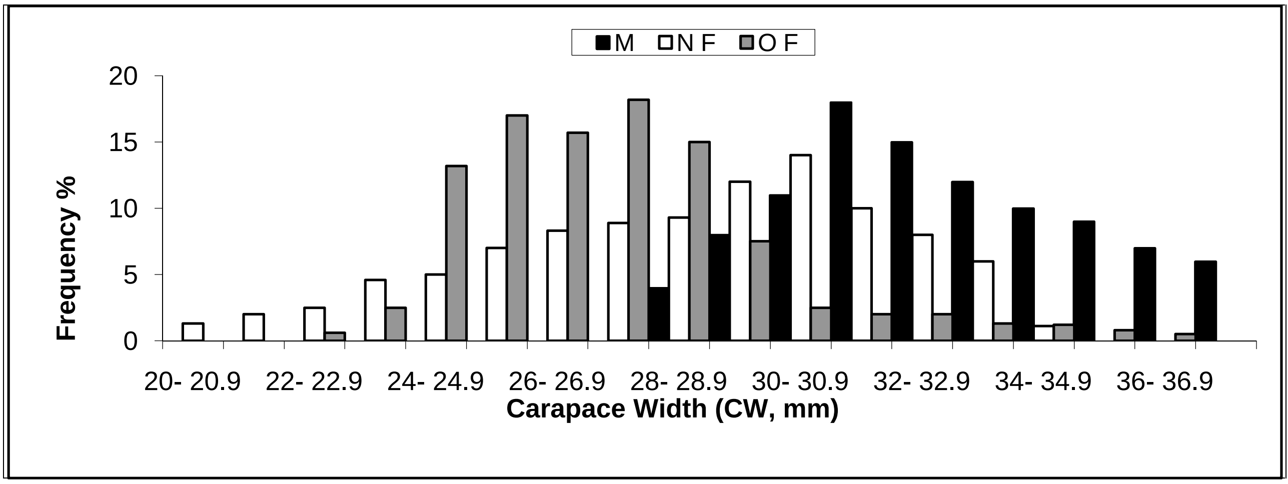
The occurrence percentage of mature individuals at each size group, for both males and females, are graphically represented in figures 3 and 4. The smallest mature males were recorded at carapace width group of 28- 28.9 mm while approximately 50% of mature males were recorded within carapace width group of 30- 30.9 mm. Therefore, the minimum size at maturity in males estimated 28 mm, while the size at first sex maturity was 30.7 mm carapace width.

The first sign of mature females was recorded at carapace width group of 22- 22.9 mm represented 18 % of examined females. This percentage of occurence increased gradually to reach a value of 93.5 % within carapace width group of 29- 29.9 mm. Therefore, the minimum female size at maturity was recorded at 22 mm, while the size at first sex maturity was recorded at 24.5 mm carapace width.

Table (1): *Hamilide tyche* total number of individuals collected monthly at Deversoir from January to December 2009. (n=sample size).

Month	Males		Non-ovigerous females		Ovigerous females		Total	sex ratio
	(n)	**%**	**(n)**	**%**	**(n)**	**%**		
January*	13	5.2	5	4.2	3	3.9	21	1: 1.6
February	8	3.2	8	6.8	2	2.6	18	1: 0.8
March*	14	5.6	7	5.9	4	5.3	25	1:1.3
April	13	5.2	3	2.5	9	11.8	25	1:1
May	31	12.5	12	1.8	17	9.2	60	1:1
June	29	11.7	19	16.2	12	15.8	60	1:0.9
July	38	15.3	13	11	8	10.5	59	1:0.8
August	34	13.7	22	18.6	9	11.8	65	1:1
September	25	10	18	15.3	5	6.6	48	1:1
October	20	8	15	4.2	4	2.6	39	1:1
November	15	6	11	9.3	3	3.9	29	1:1
December*	9	3.6	5	4.2	2	2.6	16	1:1.3
Total	**249**	**53.5**	**138**	**29.7**	**78**	**16.8**	**465**	**1:1.2**

***** Significant differences from the 1:1 ratio ($\chi2$ test, $P < 0.05$).



Figure(2): Overall size frequancy distribution of *Halimede tyche*

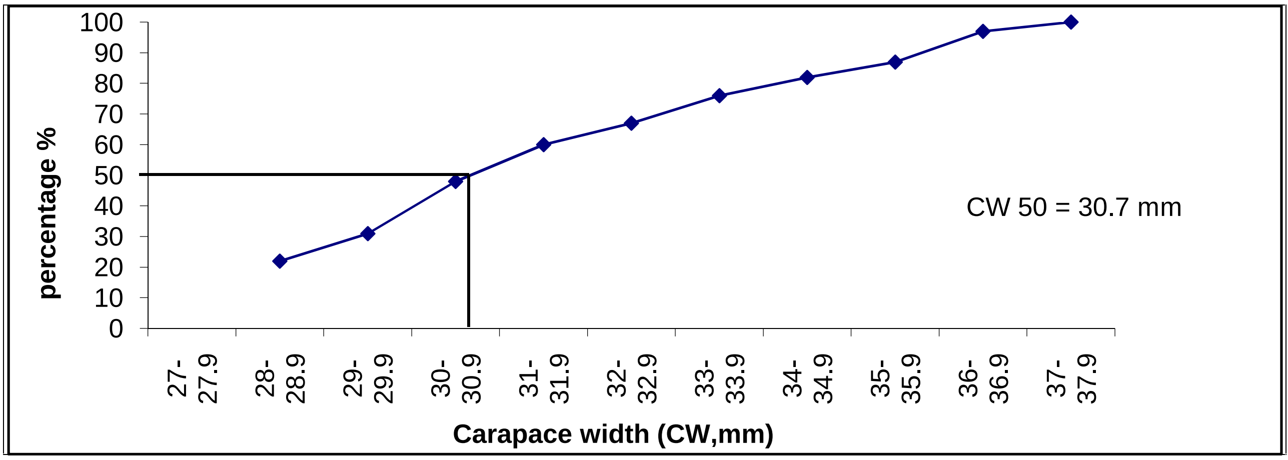
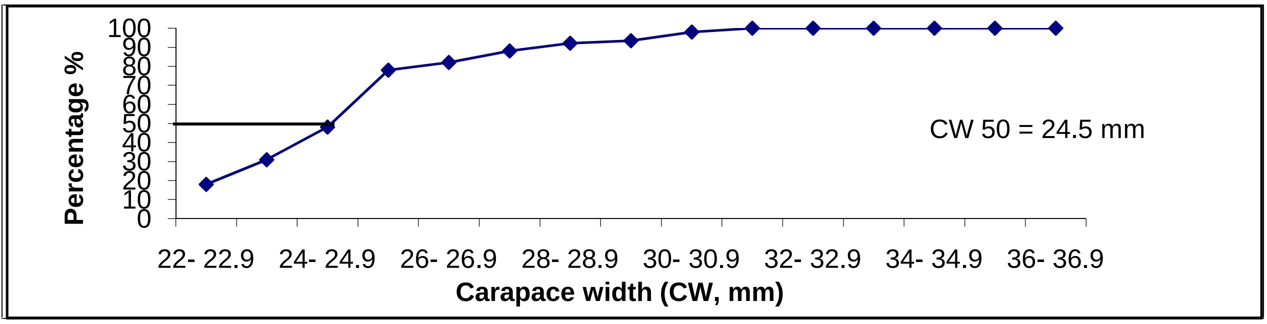


Figure (3): Size at first sex maturity of male *Halimede tyche*



Figure(4): Size at first sex maturity of female *Halimede tyche*

Gonado-somatic indices (G.S.I)

Monthly gonado-somatic indices of both sexes of *Halimede tyche* are represented in figures 5 and 6. The gonado-somatic indices of males averaged the minimum value of 1.3 in January. Significant increase was estimated starting from March (2.0) to reach the maximum values between June and August.

Females showed the lowest G.S.I value in February (1.1). Starting from March G.S.I increased from 1.8 to reach the peak of 2.7 in June then decrease to 2.1 in August. It was obvious that the spawning season was extended from May to August.

Oocyte diameters

The monthly variations in oocyte diameters of *Halimede tyche*, during the period of study are represented in figure 7. The minimum oocyte diameters averaged 265.5 µm in February. The mean diameter started to increase in March to reach 280 µm in April. The largest mean diameter of 397 µm was estimated in June.

This may indicate that the peak of maturation and spawning was occurred in June- July.

Fecundity

The total fecundity varied with the female size (CW). In other words, the larger females the larger number of oocytes (Table 2). The total fecundity ranged from 10641 oocytes for female size of 22.45 mm CW to 57810 for female size of 36.5 mm CW. The relation between total fecundity and female carapace width CW (mm) is represented by the following equation:

$$F = 12707\ CW^{0.541} \quad (r^2 = 0.9563,\ p < 0.0001)$$

DISCUSSION

The size frequency distribution of a population is a dynamic character that can change throughout the year as a result of reproduction and rapid recruitment from larvae (Thurman, 1985; Spivak *et al.*, 1991 and Costa & Negreiros-Fransozo, 2003). In the present study, *Halimede tyche* (family Pilumnidae); the size frequency distributions for both sexes were bimodal which show seasonal reproductive events and this is in agreement with Fransozo *et al.*, (1999); Yamaguchi, (2001); Costa and Negreiros-Fransozo, (2003) and Gonzalez-Gordillo *et al.*, (2003) who stated that the global size frequency distributions for both sexes are bimodal and show seasonal reproductive season. Sexual dimorphism is evident in the present study, with males reaching larger sizes than females. This agrees with Lopez *et al*., (2000) and Mantelato *et al*., (2003) who concluded that females may have reduced somatic growth compared to males because they concentrated on their energetic budget for gonad development. Moreover, males may reach larger sizes for successful competition for copulation with more than one female (Henmi, 2000).

The overall sex ratio between males and females of *Halimede tyche* was 1:1.2 and did not differ significantly from the expected 1:1 ratio, but significant deviations were observed in some months. In Crustaceans, sexual differences in distribution caused by mortality, differential life span, growth rates and sampling artifact may be responsible for unbalanced sex ratios (Wenner, 1972 and Johnson, 2003).

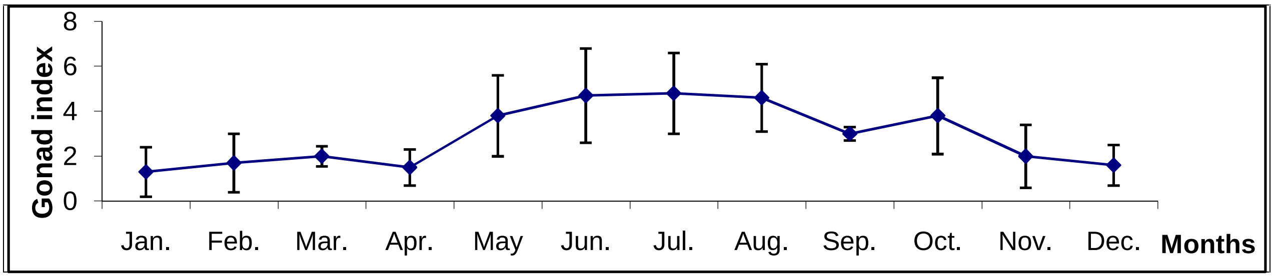
The length at first sexual maturity varies greatly from one species to another and within the same species that might be due to different environmental conditions such as water salinity and temperature (Campbell & Fielder, 1986 and Sukumaran & Neelakatan, 1996). In the present work, the length of first maturation of female *H. tyche* attained 24.5 mm while in males was at 30.7 mm.

The determination of spawning season is a result of the complex interaction of endogenous and exogenous factors, allowing both inter and intra-specific variations regarding to the duration of the reproductive cycle (Sastry, 1983). Peaks of higher breeding intensity may be associated with variations in temperature, salinity, food availability, rainfall, and photoperiod (Emmerson, 1994 and Pinheiro & Fransozo, 2002).

The examination of gonads is one of the most accurate techniques, but precise estimates rely on some previous knowledge about specific patterns of growth and reproduction to aid the interpretation of the results, as well as knowledge of short-term breeding cycles to avoid confusion between spent and immature specimens (Flores and Paula, 2002). Gonado-somatic indices (GSI) reflect the physiological activity of the gonads, where the increase is an indication of the beginning of the breeding season. In the current work, the monthly changes in GSI of males and females of *H. tyche* showed a definite breeding season which extends from May till August. Fe-cundity is a species-specific character, not only regarding to the number of eggs extruded in a single batch but also the frequency of brood production during the life cycle of crustaceans (Sastry, 1983 and Ramirez Llodra, 2002). Fecundity may vary in relation to latitudinal range, habitat structure and food availability (Litulo, 2004b). Food availability is the most important factor, as feeding factor is of paramount importance for yolk formation (Ramirez Llodra, 2002; Litulo, 2004b). In the present study, total fecundity ranged from 10641 for 22.2 mm CW to 57810 for 36.5 mm CW. The fecundity of *H. tyche* increased in accordance with length (CW) as found in other brachyurans (Litulo, 2004b). The determination coefficients for the relationship between egg number and female size (CW) was high (r^2= 0.9563), suggesting that this is a good estimation for fecundity and that egg losses are minimal.

Table (2): The mean total fecundity and realtive fecundity of *Halimede tyche* at Deversoir.(n = sample size).

C.W (mm)	Mean total length (mm)	n	Total Fecundity
22- 22.9	22.45	1	10641
23- 23.9	23.45	1	22502
24- 24.9	24.45	2	26308
25- 25.9	25.45	2	27424
26- 26.9	26.45	3	27559
27- 27.9	27.45	5	32971
28- 28.9	28.45	6	37810
29- 29.9	29.45	8	39514
30- 30.9	30.45	11	42000
31- 31.9	31.45	9	42177
32- 32.9	32.45	12	45129
33- 33.9	33.45	10	48505
34- 34.9	34.45	5	49475
35- 35.9	35.45	2	50968
36- 36.9	36.45	1	57810



Figure(5): Monthly gonadosomatic index of male *Halimede tyche*
(Vertical lines indicate standard deviation)

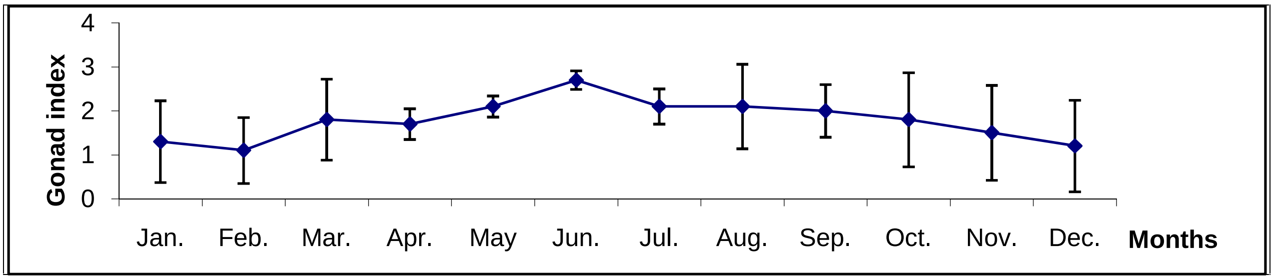


Figure (6): Monthly gonadosomatic index of female *Halimede tyche*
(Vertical lines indicate standard deviation)

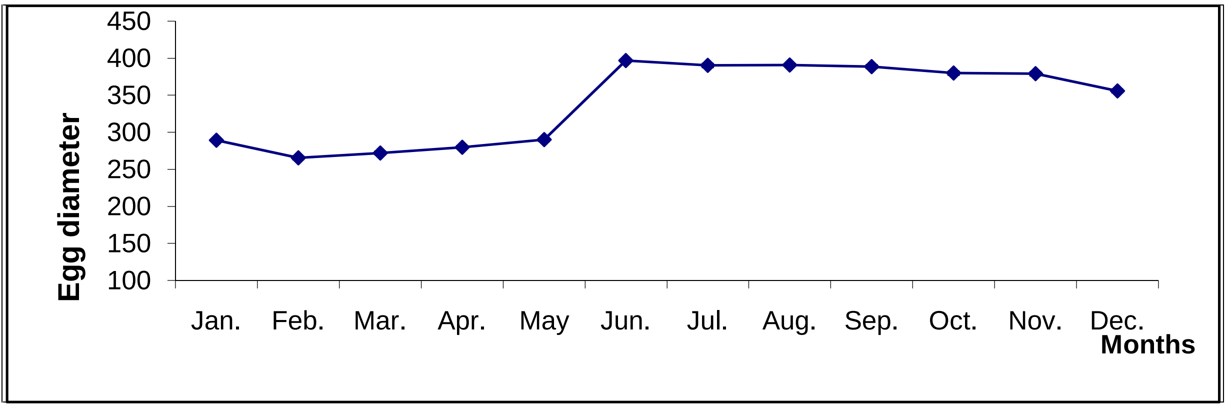


Figure (7): Monthly Variation in egg diameter of ova of *Halimede tyche*

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التركيب العشيري و بيولوجية التكاثر للسرطان الخشن هاليميدي تايكي بالبحيرات المرة- قناة السويس - (باليومنيدي: السرطانات الحقيقية) مصر.

نسرين قدري مرسي

قسم علوم البحار – كلية العلوم- جامعة قناة السويس بالإسماعيلية– مصر.

الملخص العربى

تم دراسة التركيب العشيري و بيولوجية تكاثر السرطان هاليميدي تايكي بالبحيرات المرة الكبرى و لمدة عام و تم تجميع العينات شهريا في الفترة من يناير و حتى ديسمبر 2009. تم تجميع 443 عينة من هاليميدي تايكي كان من بينهم 249 ذكر بنسبة 53.5 % و 138 اناث لا تحمل البيض بنسبة 29.7 % و 78 عينة اناث تحمل البيض بنسبة 16.8 % و كان حجم الذكور أكبر من الأناث و كانت نسبة الذكور الى الأناث 1:1.2

و لقد سجلت الدراسة أن طول أصغر ذكر بالغ 30.7 مم في حين كانت أصغر أنثى 24.5 مم طولا. سجل معامل علاقة وزن المنسلس الى وزن الجسم أن معامل العلاقة في الذكور أكبر منه في الأناث و كانت مواسم تكاثر كلا النوعين الأناث و الذكور لنوع هاليميدي تايكي محدودة و تتروا ح ما بين مايو حتى أغسطس.

لوحظ زيادة في قطر البويضة ابتداءا من شهر ابريل و استمرت تلك الزيادة حتى وصلت البويضة الي اقصى قطر و هو 397 مم في شهر يونيو. تراوحت الخصوبة العددية لسرطان هاليميدي تايكي ما بين 10641 بويضة الي 57810 لأطوال تتراوح ما بين 22.2 مم و حتى 36.5 مم .