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REPRODUCTIVE ECOLOGY OF THE COMMON ROCK CHITON *ACANTHOPLEURA GEMMATA* (MOLLUSCA: POLYPLACOPHORA) IN THE NORTHWESTERN COAST OF THE RED SEA

By

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ايكولوجية التكاثر للحمك الصخري «أكانثوبليورا جيماتا» (شعبة الرخويات : طائفة عديدة الدروع) في الجزء الشمالي الغربي للبحر الأحمر

فتحي السيد سليمان و محمد أحمد حسين
وعبد الراضي المراغي و تيتو نعيم يوسف

تناول البحث دراسة الدورة التكاثرية للحمك الصخري «أكانثوبليورا جيماتا» عن طريق تتبع معامل التكاثر لعشيرتين متباعدتين في الجزء الشمالي الغربي للبحر الأحمر . كما تناول البحث أيضا العلاقات البينية للأحشاء العامة وجدار الجسم . وقد ناقش البحث التغيرات الموسمية والمكانية للدورة التكاثرية والعوامل البيئية التي تؤثر عليها ، وأفادت الدراسة أن هذا النوع يتكاثر مرة واحدة في العام في الفترة من نهاية سبتمبر وحتى بداية أكتوبر . كما أوضحت الدراسة أن هناك علاقة عكسية بين نمو المناسل والأحشاء العامة وكذلك بين نمو المناسل وجدار الجسم .

Key Words: Reproductive ecology, Mollusca, Polyplacophora, Gonads, General viscera, Spawning.

ABSRACT

The reproductive cycle of the chiton, *Acanthopleura gemmata* was studied by observing the gonad indices at two localities in the North-western coast of the Red Sea, from January 1988 to December, 1989. The interrelationships between gonad, general viscera and body wall indices were evaluated. The gonad indices showed an inverse relationship with both the general viscera and the body wall indices. Spawning occurred once a year during the autumn. The annual and local changes in the reproductive cycle and the main factors affecting them are discussed.

INTRODUCTION

Knowledge on reproductive ecology of chitons seems to have increased in recent years. The relationship between reproduction and environmental factors has been reported for several Californian species [1, 2, 3], for *Acanthopleura granulata* and *Chiton tuberculatus* in the Coasts of Panama [4], for three Canadian species [5, 6], for *Chiton iatricus* [7], for the Australian chitons [8] and for *Acanthopleura japonica* [9].

Information on the chiton species in the Red Sea is still scarce and intermittent. Stephenson [10] and Pearse [11 and 12] examined the pattern of reproductive cycle and breeding habits of *Acanthopleura haddoni* in the Gulf of Seuz and other regions of the Red Sea. Soliman *et al.* [13] described the morphology and internal anatomy of *A. spiniger.* Soliman and Iskander [14] studied the reproduction and development of *A. spiniger* near Hurghada city. Soliman and Naeim [15] made intensive taxonomical studies on *A. spiniger* and *A. haddoni* and confirmed that the two are synonyms for *A. gemmata* that had two forms; one with banded girdle while the other was non-banded. Emam *et al.* [16] discussed the age and growth of *A. spiniger* collected from the northwestern region of the Red Sea.

The present paper deals with the seasonal and annual changes in the reproductive, general viscera and body wall cycles and spawning time of the chiton *Acanthopleura gemmata* and their relationship with the prevailing ecological factors in the field.

MATERIAL AND METHODS

A prelimnary survey was carried out, along the coast of the northwestern part of the Red Sea; from Marsa Alam city to north of Hurghada city, Egypt; about 300 km long (Fig. 1). Sampling of *A. gemmata* was done using 50 X 50 cm quadrats at 10 to 20 km intervals and where the coast was accessible for sampling. . From this preliminary survey, two locations, Sharm El nagha; 40 km south of Hurghada (26° 56' N) and (34° 00' E) and Alqusier Elqadeim; 10 km north of Alquseir city (26° 15' N and 34° 16' E) (Fig. 1 A and B), exhibiting high densities of this species were selected as sampling sites.

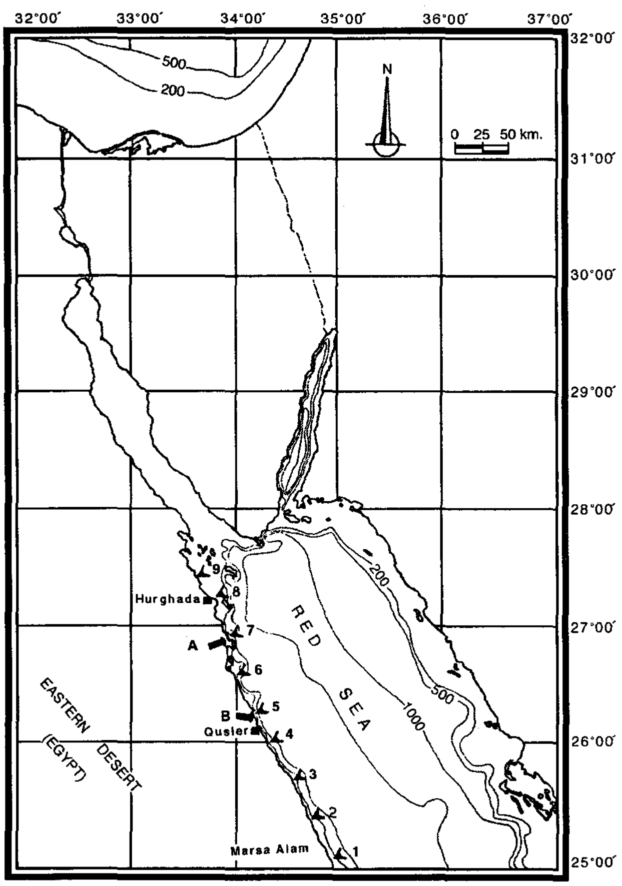

Fig. 1 . Map showing the sampling sites on northwestern coast of the Red Sea. A and B refer to the two main studied sites (A = Sharm Elnagha and B = Alquseir Elqadeim).

To evaluate the reproductive periodicities of the species population at the two studied sites, more than thirty individuals representing the different size groups were monthly collected at random from the two sites. The collected specimens were kept in plastic containers filled with oxygenated sea water and transferred to the laboratory for subsequent treatment.

The specimens were dissected after disarticulating the shell valves for obtaining data on sex ratio and gonadal shape. The shell plates, general viscera, body wall and gonads were separated and dried in preweighed aluminium foil at 70 °C in an incubator for 72 hours. Then, the different body components were weighed using an electrical balance with accuracy to 10^{-4} g.

General viscera and body wall indices were calculated as the ratio of the body wall component dry weight to the total body dry weight including the shell valves X 100, while, the gonad indices as the ratio of the gonad dry weight to the total body dry weight X 1000.

Monthly water and air temperature were recorded during the low tide. Topography and photography of the studied sites were carried out using Alidade Instrument and Nikkon camera.

RESULTS

Monthly changes in the maximum and minimum air and water temperature at the two studied sites, Sharm Elnagha and Alquseir Elqadeim were recorded from January, 1988 to December, 1989 Figs. 2A and B. The highest recorded levels of air temperature at Sharm Elnagha and Alquseir Elqadeim occurred during August and September, 1988 and July and October, 1989, respectively, while, the minimum ones were in February, 1988 in both locations and February and January, 1989 at Sharm Elnagha and Alquseir Elqadeim, respectively. The air temperarure did not exceed 40 °C in summer months at the two locations and did not fall below 12 °C and 15 °C in winter at Sharm Elnagha and Alquseir Elqadeim, respectively, *i. e.* the former was slightly colder in winter than the later. The most distinct phenomenon was that, the peaks and bottoms of higher and lower air temperatures were sharp at Alquseir Elqadeim site than that at Sharm Elnagha site.

The recorded water temperature at Sharm Elnagha and Alquseir Elqadeim ranged from 22 - 34 °C and 22.5 - 36 °C, respectively. The highest recorded levels were in July, 1988 and 1989 at Sharm Elnagha and in October at Alquseir Elqadeim during the same years. Generally, the increase and decrease of water temperature at Sharm Elnagha location were smooth and not abruptly changed as those recorded at Alquseir Elqadeim.

As for the position of the two sites relative to the tidal levels, Sharm Elnagha site was slightly below the mean water tide level, while , Alquseir Elqadeim site was slightly at a depth above the mean water tide level.

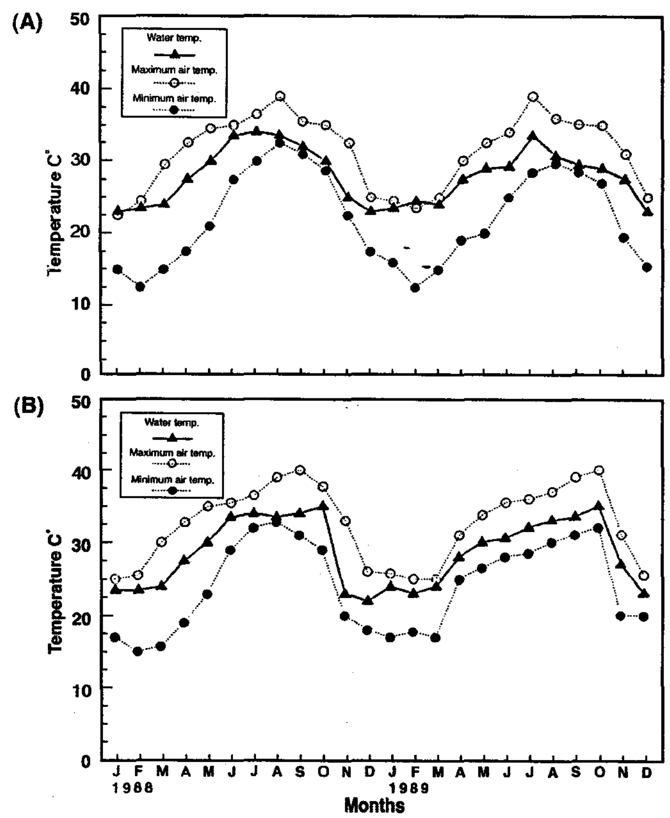

Fig. 2. Monthly changes in Air and water temperatures at Sharm Elnagha (A) and Alquseir Elqadeim (B). sites.

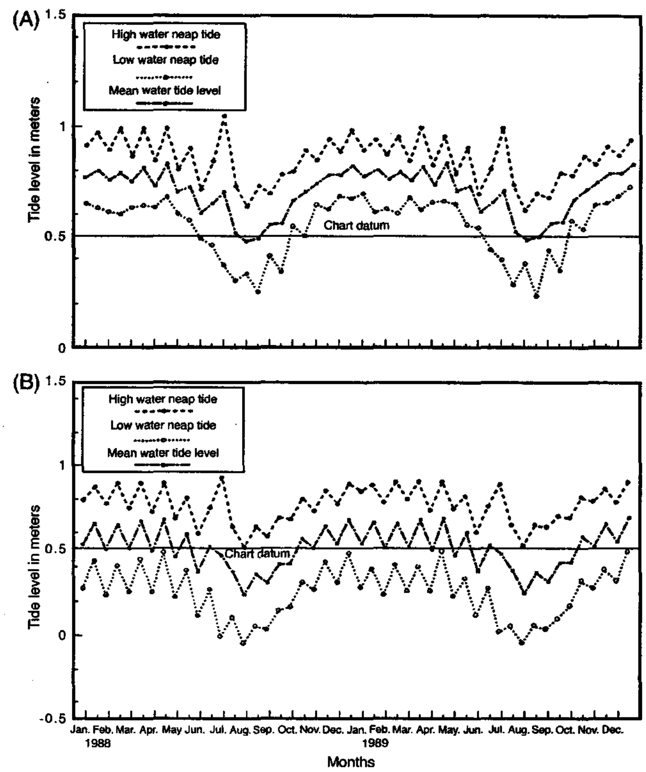

Fig. 3. Monthly fluctuation in tidal levels at Sharm Elnagha (A) and Alquseir Elqadeim (B) sites.

Monthly fluctuations in the tidal levels at the two studied sites during , 1988 and 1989 are shown in Figs. 3 A and B. Generally, there was a gradual fluctuation in the tidal levels from August to March and from March to August every year at both localities. Distinct high and low neap water levels at both localities were recorded every year in July and August. Also, the level of the habitat at which Sharm Elnagha populations lives was below the mean water tide level, while that, at Alquseir Elqadeim was at /or slightly above the mean water tide level.

Monthly changes in the indices of the body components of the species population

1 - At Sharm Elnagha site

Figure 4 A and B shows the body wall, gonads and general viscera indices of both sexes of the species population at Sharm Elnagha site. The indices of the body components of the females were generally higher than those of males. The females body wall indices (Fig. 4A) ranged between 15.8 - 19.1 in November and April, 1988 and 1989. The index of the body wall increased gradually fron November to reach its maximum level in April (nearly six months), then decreased to reach its minimum level in November of the next year.

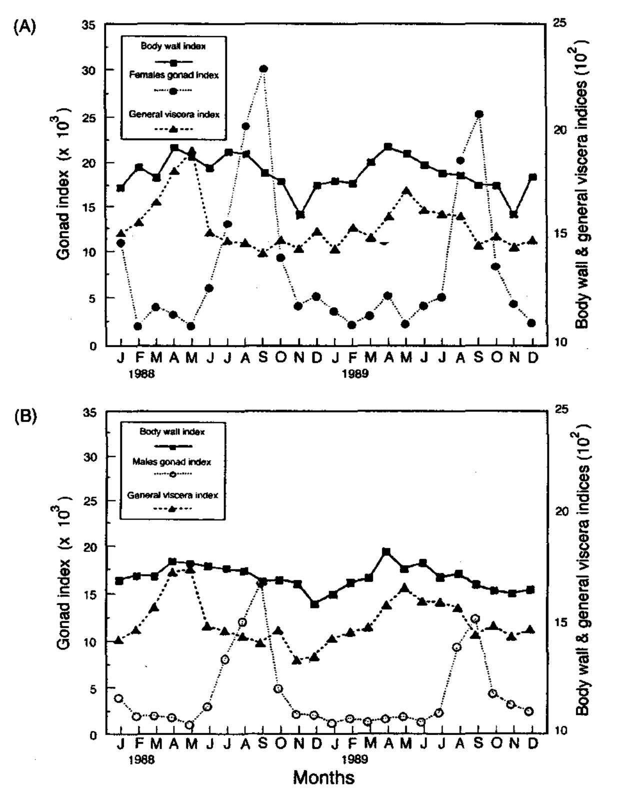

Fig. 4. Monthly changes in the body wall, gonads and general viscera indices of *A. gemmata* during 1988 and 1989 for the females (A) and Males (B), at Sharm Elnagha site.

The males body wall indices (Fig. 4B) ranged between 15.8 - 18.3 in December and April every year, i. e. the minimum body wall indices are similar in males and females but the maximum index was higher in the females. While timing of the highest index value coincided in April in both sexes, the minimum value of males was exhibited one month later. No clear annual differences were noticed in the females and males body wall indices.

Females general viscera indices (Fig. 4A) showed an annual peak during May, one month later than the peak of the body wall indices, while the minimum indices were in January two months later than that of the latter. The general viscera indices of the females ranged between 13.9 - 18.8 and 14.1 - 17.0 in September and May, 1988 and 1989, respectively. So, the peak of the indices in 1988 was higer than that in 1989, though the minimum indices were nearly similar.

The males general viscera indices (Fig. 4B) showed the same pattern as that of the females, its annual peak occurred in May but its lowest value was in November, one month later than that of the females. The males general viscera indices ranged between between 12.8 - 17.4 and 14.2 - 16.5 in November and May, 1988 and 1989, respectively. This indicates that the minimum and maximum values of the male general viscera indices differ in the two years but lesser that that of the females.

Gonad indices of the females (Fig. 4A) showed an annual peak during September (prespawning period) and a minimum value in February and May. The gonad indices increased gradually from May to September then dropped suddenly during October (spawning time). The minimum value of the gonad indices were similar (*ca.* 2) in 1988 and 1989, while, the maximum values were 30 and 25.5 in 1988 and 1989, respectively.

As for males, the annual peak of gonad indices occurred in September ; about 16 in 1988 and about 12 in 1989. The minimum values were similar in the two years (*ca.* 1). Generally, the males gonad indices were much less than that of the females (about its half).

2 - At Alquseir Elqadeim site

The indices of the body wall, gonads and general viscera of the species population at Alquseir Elqadeim are shown in Fig. 5A and B. The indices of the body components of the females were generally higher than those of the males. The females body wall indices (Fig. 5 A) ranged between 16.1 - 19.1 and 16.5 - 19.1 in September and May, 1988 and 1989, respectively. The indices of the body wall increased gradually from September to reach its maximum level in May, then decreased to its minimum level in next September.

The males body wall indices (Fig. 5B) ranged between 16.3 - 18.2 in September and May, 1988 and 1989. Thus, the minimum and maximum body wall indices coincided in females and males in the two years, 1988 and 1989 except the females value in 1989 that was higher than in 1988.

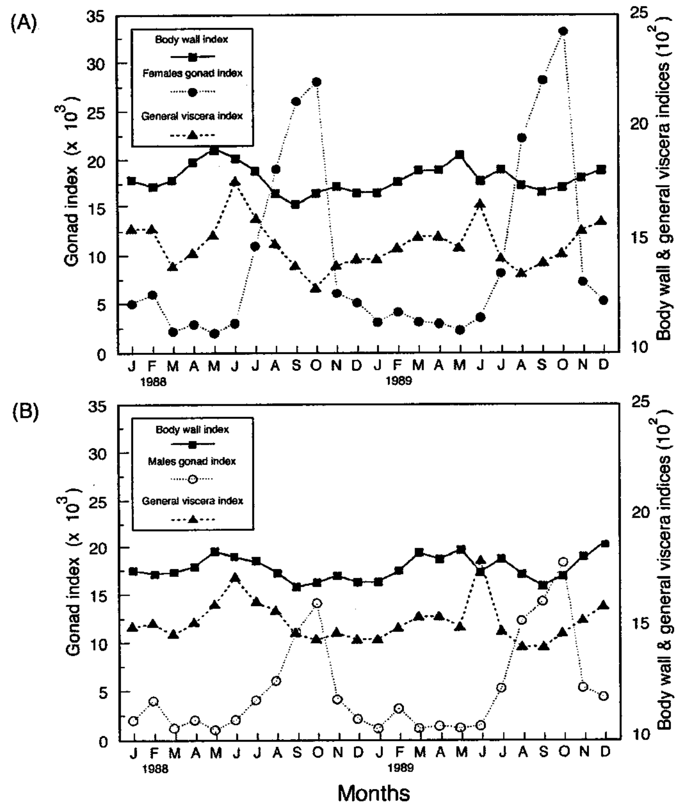

Fig. 5. Monthly changes in the body wall, gonads and general viscera indices of A. gemmata during 1988 and 1989 for the females (A) and Males (B), at Alquseir Elqadeim site.

The females general viscera indices (Fig. 5A) showed an annual peak during June, one month later than that of the body wall indices. They ranged between 12.9 - 17.2 and 13.1 - 16.1 in October and June, 1988 and August and June , 1989, respectively. Their peak in 1988 was higher than that in 1989., though, their minimum values were nearly similar.

Changes in males general viscera indices were similar to those described in the females in 1988 and 1989. However, they ranged between 14.2 - 16.8 and 13.7 - 17.4 in 1988 and 1989, respectively and their minimum values were in October, 1988 and August, 1989.

The females gonads indices (Fig. 5A) showed their annual peaks during October, 1988 and ,1989 (prespawning period), and the minimum value in May. The gonad indices increased gradually from May to October, then drop suddenly in November every year indicating that the spawning occurs during November. Annual variations in gonads indices of the chiton population were very distinct in this study site. The gonads in 1989 were higher than those in 1988, though, the minimum values were nearly similar in the two years (*ca.* 2.5). The females gonads indices ranged between 2.5 - 29 in 1988 and 2.5 - 33 in 1989.

Table 1

Spawning times of the chiton species in locations with different latitude

	Species name	Location	Spawning time	No. spawning per year	References
1	*Acanthopleura gemmata*	Great Barrier Reef, Australia	(Warmest part of the year) during spring and summer	Eight times	Stephenson (1934)
2	*A. granulata*	Puerto Rico, Australia Panama (Atlantic), USA	in fall (warmest season) throughtout the year	one time continuous	Glynn (1970)
3	*A. haddoni*	Wadi El-Dom, Red Sea Near Qusier, Red Sea	In summer (August-November) in fall (September - October)	one time one time	Pearse (1978)
4	*A. spiniger*	Near Hurghada, Red Sea Egypt	early fall (late September)	one time	Soliman & Iskandar (1982)
5	*A. tuberculatus*	Puerto Rico, Australia	in fall (warmest season)	one time	Glynn (1970)
6	*Acanthochiton hemphilli*	Panama (Atlantic) USA	throughout the year	continuous Glynn (1970)	
7	*Chiton apiculata*	Laboratory, cape Cod, Massachustts, USA	during summer season	four times	Grave (25) (1922)
8	*C. marmoratus*	Puerto Rico, Australia	fall to winter (November-February)	one time	Glynn (1970)
9	*C. pelliserpentis*	New Zealand, Holland Sydney, Australia Sydney, Australia	late summer to autumn in spring in spring and Autumn	one time one time two times	Johns (26) 1960 Selwood (27) 1968 Sakker (1968)
10	*C. porosus*	New Zealand, Holland	in Summer (July-October)	five times	Brewin (1942)
11	*C. Squamosus*	Puerto Rico, Australia	in fall (September-October)	one time	Gynn (1970)
12	*Katharina tunicata*	Central California British Columbia	May-July March-August	one time one time	Gynn (1969) Himmelman (1976)
13	*Lepidochitona cinereus*	Easthaven, Scotland	July-August	one time	Baxter & Jones (1978)
14	*L. dentines*	Alaska-so., California	in spring (February-May)	one time	Eernisse (1988)
15	*L. hartwegii*	Baja, California	February, March and October	three times	Eernisse (1988)
16	*L. berryana*	Santa Cruz, California	(twice in May and one in June)	three times	Eernisse (1988)
17	*Mopalia hindsii*	Central California	throughout the year September-May	continuous	Giese et al., (1959)
18	*Mopalia muscosa*	Central California	throughout the year	continuous	Barnawell (1951)
19	*Onithochiton quercinus*	Puerto Rico, Australia	in spring and summer	two times	Sakker (1986)
20	*O. lyelli*	Gulf of Suez, Red Sea	throughout the year	continuous	Pearse (1978)
21	*Plaxipyhora paeteliana*	Sydney, Australia	in spring and autumn	two times	Sakker (1986)

The males gonads indices (Fig. 5B) coincided with those of the females i. e. during October and May every year. They ranged between 1 - 14 in 1988 and 1 - 17.4 in 1989. Also, from Figures 5A and B, the females and males gonad indices were completely inactivated during late spring and early summer. In addition, the minimum values of the males and females gonads indices were about one and two, respectively.

DISCUSSION

Reproduction, reproductive periodicity, spawning time and number per year of polyplacophorans have been studied by many authors (Table 1). It is clear from this table that, the spawning time and number differ among various genera and sometimes within the same genus or even at the species level, depending on the area in which the species lives and the seasonal variations together with other ecological factors. Spawning in most recorded polyplacophoran species varies from 1 - 5 times per year or runs cotinuously through out the year.

Species of the genus *Acanthopleura* spawn once a year in the Caribbean Sea [4] and in the Red Sea [11 and 14] and throughout the year in the coasts of Panama [4]. In Massachusetts, *Chiton apiculata* spawns four times a year. Most species of the genus Chiton spawn one time a year in Australia except *C. pelliserpentis* that spawns two times [8] and *C. porous* that spawns five times per year [17] . In *Katharina tunicata* in Central California [1] spawning was not in in synchrony with that in British Colombia [5 and 6]. Moreover, its spawning time shows considerable variations from year to year in the same locality [18] . Spawning occurs one time in *Lepidochiton cinereus* and *L. dentines* in Scotland [19] and in Alaska and south California [20], while, *L. hartwegii* and *L. berryana* spawn three times a year in Baja and Santa Cruz, California, [20] . Species of the genus *Mopalia* spawn through out the year in central California [21 and 1]. *Onithochiton quercinus* and *Plaxiphora paetelinana* reproduce two times a year in Australia [8], while, *O. lyelli* spawns continuous in the Red Sea [11].

The recorded spawning times in most polyplacophorans were in the spring, summer and autumn or in the late spring and early summer or late summer and early autumn or throughout the year. No seasonally reproductive species was found to spawn in winter.

In the present study *A. gemmata* was reported to spawn once a year (during autumn) at two locations on the western coast of the Red Sea . The time of spawning was delayed by nearly one month in the southern studied location Alquseir Elqadeim than in the other location (about 100 km to the north) at Sharm Elnagha. These results agree with those of Soliman and Iskander [14] near Hurghada as well as those of Pearse [11] near Alquseir. These authors concluded that spawning varied for the same species in different localities. The present study indicated that there are two main factors affecting time of spawning of the species in different habitats. The first is the structure and level of the species habitat in ralation to tidal datum. The second is the period of exposure to the physical stresses during the low tide especially air and water temperature.

Studies on the interrelationships between seasonal variations of the digestive gland and gonadal maturity have been dealt with some investugators [3 and 22 , 23]. Nimits and Giese [22] as well as Lawrence and Giese [23] concluded that the size of the digestive gland in *Katharina tunicata* varied inversely with the size of the gonads and the relationship varied from year to year. Giese and Hart [3] attributed this phenomenon to the nutrients that are accumulated in the digestive gland to reach some critical level before the start of gametogenesis. Himmelman [3, 6 and 24] indicated that differences in the time of spring plankton bloom which stimulated spawning in *K. tunicata* could lead to different spawning times

In the present study, the relationships between the indices of the three body components, body wall, general viscera and gonads and their local and seasonal variations were examined in two populations of *A. gemmata* (at Sharm Elnagha and Alquseir Elqadeim). and between sexes of each population.

Generally, body wall indices of Sharm Elnagha population were higher in females than males during the same year. Annual growth of body wall was parallel with the growth of general viscera, but started one month later and falled one month earlier than the latter. Also, both the growth of body wall and general viscera were inversely related to the growth of the gonads at this location. It is worth mentioning that, though the higher values of body wall indices differed between sexes of the same population, the lowest values were similar. This means that, the body wall nutrients decrease gradually during the growth of gonads to the lowest limit to promote spawning.

Gonad indices of females and males at Sharm Elnagha location started to grow in parallel but the former declined slightly earlier. The higher values of females gonad indices were nearly double that of males, though the minimum values were similar in both sexes. This indicates that the reproductive effort of females is higher than that of males and may explain why general viscera indices are higher in the females of this population.

Indices of the body components of Alquseir Elqadeim population were nearly similar to that of Sharm Elnagha population except for some local variations. These vaiations can be related to the structure of the habitat and level at which the population lives , tidal datum and time of exposure to physical stresses. The chiton population at Sharm Elnagha site lives slightly below the mean water tide level that is more shaded with rocks, while that of Alquseir Elqadeim lives nearly at or above the mean tide level and less shaded .

The annual variations in gonadal indices of the two populations may be related to the effect of air temperature in autumn and winter as the latter differed among the two years, 1988 and 1989. , while the temperatures were nearly similar in spring and summer . So, the growth of body components and time of spawning of this species varies annually as well as betwen locations.

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