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POPULATION STRUCTURE AND GROWTH CURVE OF *ACANTHOPLEURA GEMMATA* (MOLLUSCA: POLYPLACOPHORA) IN THE NORTHWESTERN RED SEA

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التركيب العمري ومنحنى النمو لجامعة الحمك أ كانثو بلورا جيماتا (الرخويات : عديدات الدروع) في الجزء الشمالي الغربي للبحر الاحمر

مقدم من

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يتناول البحث دراسة عشيرة الحمك اكانثو بلورا جيماتا (الرخويات : عديدات الدروع) في منطقة شرم الناقة على الشاطئ الشمالي الغربي للبحر الأحمر والتي تبعد حوالي ٤٠ كم جنوب مدينة الغردقة المصرية (٢٦ ٥٦ شمالا و ٣٤ شرقا). وقد اهتمت هذه الدراسة باستخدام قياس عرض الدرع الرابع للحمك بتحليل التركيب العمري والعمر والحجم عند بداية النضوج الجنسي وعند أول تكاثر وعدد مرات التكاثر خلال دورة الحياة. كما أهتم البحث أيضا بتقدير معدلات النمو ومنحنى النمو. وقد أوضحت الدراسات أن عشيره هذا النوع تشتمل على ٥ أو ٦ طوائف عمرية. وقد بدأت المناسل في الظهور عند عمر عام ونصف وحجم ١٥ و١٧مم. كما بينت الدراسات أن معدل النمو كان أعلى مايمكن في أحدث الطوائف العمرية وأقلها في أقدمها. كما اتضح من الدراسة أن منحنى النمو هو منحنى متغير فصلياً.

Key words: Population ecology, polyplacophora, age structure, growth curve, growth rate.

ABSTRACT

Studies on *Acanthopleura gemmata* population were carried out in a site located on northwestern coast of the Red Sea called Sharm Elnagha, 40 km south of Hurghada city, Egypt (26° 56' N and 43° 00' E). In these studies, the population age structure, age and size at maturity, age and size at first reproduction, number of spawning times per year and per life span, rate of growth and type of growth curve were evaluated using the width of the 4th shell valve as a measuring character. The species population has 5-6 year classes, starts maturity at 1.5 years old when it is 13.5 mm 4th shell valve wide. Reproduction first occurred when the chiton was two years old and 17.15 mm 4th shell valve wide. The growth rate was higher in the O^+ year class, steady in the middle classes and low in the oldest year class. The growth curve was a typical seasonally varying one and the growth rate was higher in winter and summer than in spring and autumn.

INTRODUCTION

Although the general ecology of polyplacophorans has been treated by many authors in different parts of the world, the population ecology or population parameters of only very few species have been formerly investigated, (1-15).

As for *Acanthopleura gemmata* (= *A. spiniger, A. haddoni*), it is the commonest polyplacophoran species in the rocky intertidal area in the Indo-Pacific area (16) including the northwestern coasts of the Red Sea. Several studies have been made on this species in the Red Sea, regarding its biology (17), pattern of its reproductive cycle (4, 5), reproduction and development (18), histology (19) and taxonomy (20). A number of studies have dealt with some aspects of its ecology but the evaluation of the different population parameters of the species has not yet been worked out. The aim of the present investigation is to study the population age structure, population growth curve, age and size at maturity, age and size at first reproduction, seasonal variations in growth rate and number of spawning times per year and per life span.

MATERIAL AND METHODS

Description of the population habitat

The habitat of the studied *A. gemmata* population is a site known as Sharm Elnagha located 40 km south of Hurghada, Egypt (26° 56' N and 43° 00' E) (Fig. 1). This site is rectangular in shape (307 x 180 m) and contains a small rocky island (about 197 x 37 m^2) (Fig. 2), 10 m or more high above the mean water tide level (MWTL) in some of its parts (Fig. 3). The island is nearly triangular in outline, mushroom-shaped and runs parallel to the shore with an extended angle pointed northward (Figs. 2 and 3). This structure provides considerable protection against wave action as well as a humid habitat suitable for algal growth and the flourishing grazing marine fauna including *A. gemmata.*

The area beyond the rocky island is a tidal flat, covered with sparse boulders and stones that are populated by various invertebrates. It extends for 6-8 meters from the island base towards the deeper water of the open sea becoming abruptly a reef crest.

Sampling procedure

Monthly samples of *A. gemmata* were collected out from January, 1988 to December, 1989. The circumference of the rocky island was marked at 5 m intervals using a coloured paint spray. One square meter around each mark was fixed as a sampling point. By this method 110 points were inspected monthly (Fig. 2). For investigating the abundance

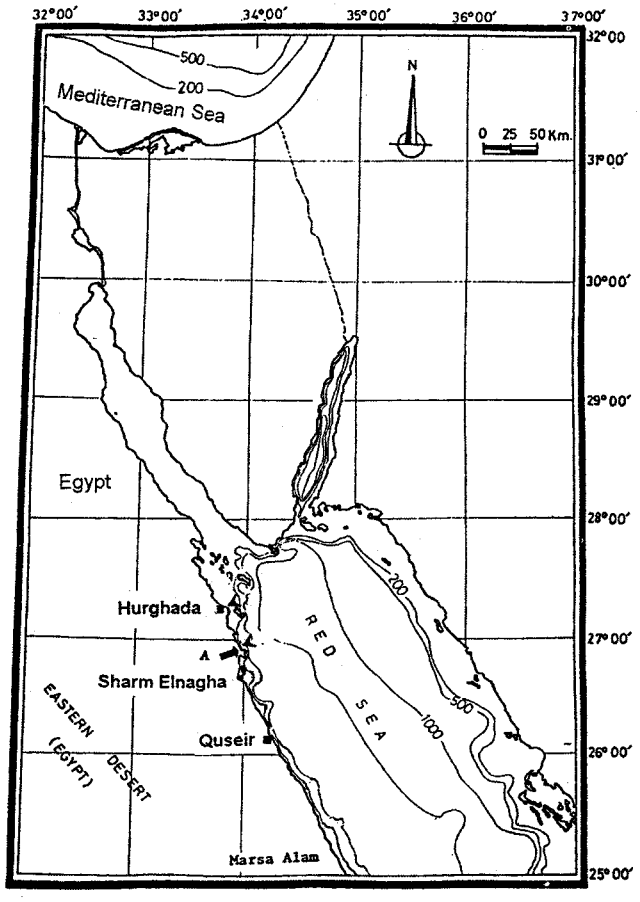


Fig. 1. Sampling site (A) on the northwestern coast of the Red Sea.

and distribution of chitons in the tidal flat between the rocky island and the shore, the area was divided by 13 lines perpendicular to the shore and 50 lines parallel to the shore at 10 and 5 metres intervals, respectively. The cross points of these lines (about 200 points) were chosen as sampling points (Fig. 2).

The density of the species population was determined using 50 x 50 cm^2 quadrats. Individuals in each quadrat were counted and measured using a vernier calliper with a minimum scale 0.01 mm. The whole length and width of each specimen, the total length of the shell valves and the width of the 4th shell valve were measured, the last feature being the most reliable character.

Statistical analysis and the chiton population parameters were estimated using STATSGRAPHICS and MIX computer programs. Topography of the studied site were drawn using Alidade Instrument.

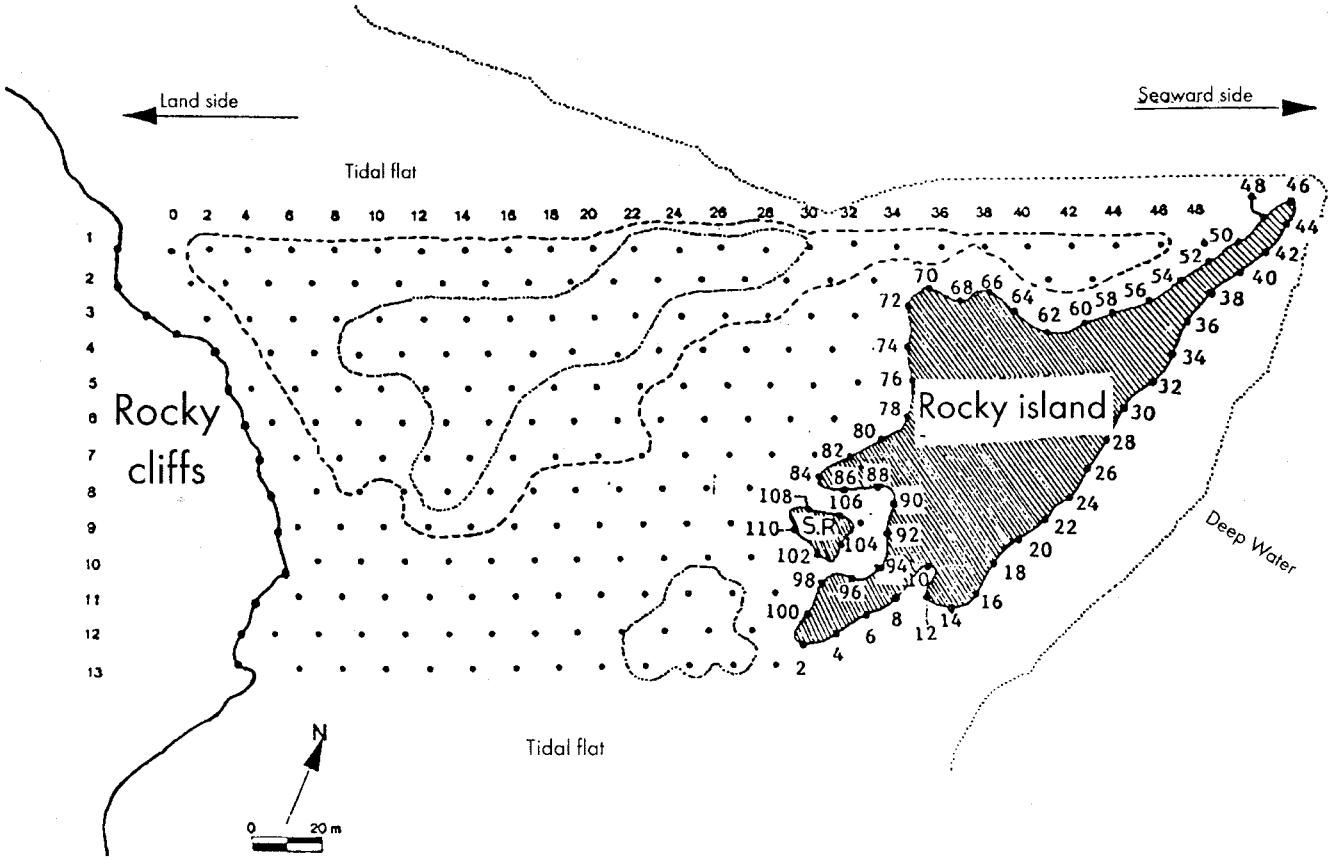


Fig. 2. Map showing the sampling plan at Sharm Elnagha. Dots show the monthly sampling points.

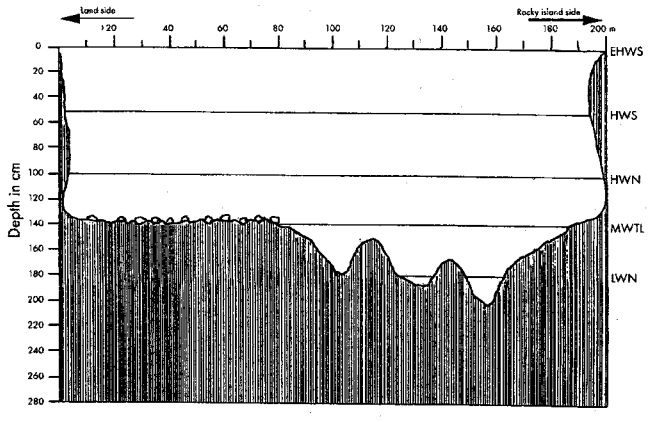


Fig. 3. Profile of the rocky shore at Sharm Elnagha site. EHWS = extreme high water spring; HWS = high water spring; HWN = high water neap; MWTL = mean water tide level; LWN = low water neap.

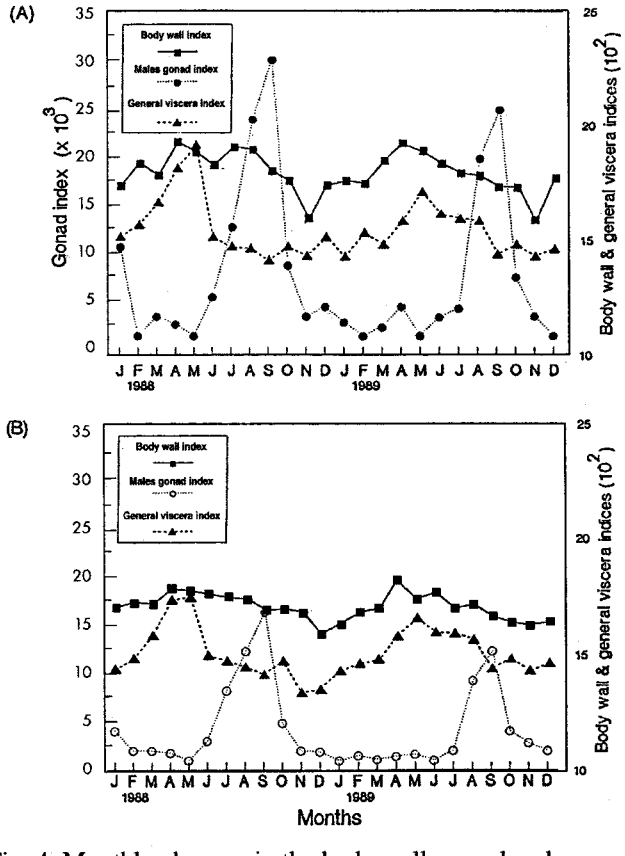


Fig. 4. Monthly changes in the body wall, gonad and general viscera indices of *A. gemmata* during 1988 and 1989 for the females (A) and males (B).

RESULTS

Monthly changes in water and air temperature at the studied site

Monthly changes in the maximum and minimum air and water temperature were measured from January, 1988 till December, 1989. The highest recorded air temperature (40°C occurred during August, 1988 and July, 1989, while the minimum (12°C) was in February, 1988 and 1989.

Water temperature ranged between 22-34°C in January and July respectively.

Growth of the different body components and spawning season

Figure 4 shows the changes of the body components of both sexes represented as the dry weight of each body component to the total dry body weight. In this figure, the values of the body wall index are the true values while that of the general viscera and gonads are the true values multiplied by 10^2 and 10^3, respectively. The growth of the body wall and general viscera have shown to be consistent but inversely proportional to the growth and depression of the gonads. Spawning occurred one time annually during September and October.

Gonadal conditions of *A. gemmata* and size at first reproduction

To investigate mature individuals and size at first reproduction, a large sample was collected in the prespawning season (during September, 1988) from the main studied site and another site called Alquseir Elqadeim (to preclude decimation of the main population at the main site). The data are represented in Table 1. Discrimination of mature individuals was based on the colour of the gonads and smear preparation. The 4th shell valve width of smallest mature individuals collected from the above two sites was 13 and 14 mm, respectively. On the other hand the corresponding figures of the largest immature individuals were 18 and 20 mm.

Analysis of the size distribution of the species at the studied site

The width of the 4th shell valve of *A. gemmata* population collected by monthly sampling from September, 1988 to August, 1989, is shown as size frequency distribution histogram (Fig. 5). Since the year classes tended to merge with

Table 1

Gonadal conditions of *A. gemmata* population during September, 1988 at the two studied sites.

W (±0.5) mm	Frequency of individuals			
	With mature gonads		With immature gonads	
	A	B	A	B
40 mm	1	1	–	–
39	2	4	–	–
38	5	1	–	–
37	4	1	–	–
36	2	2	–	–
35	1	1	–	–
34	1	3	–	–
33	2	3	–	–
32	6	9	–	–
31	4	14	–	–
30	5	8	–	–
29	2	5	–	–
28	1	3	–	–
27	2	4	–	–
26	1	1	–	–
25	1	2	–	–
24	3	1	–	–
23	4	2	–	–
22	17	15	–	–
21	6	2	–	–
20	10	8	–	2
19	7	14	–	2
18	9	6	2	6
17	7	4	4	4
16	3	6	5	4
15	3	8	2	2
14	4	4	4	1
13	3	–	–	3
12	–	–	7	4
11	–	–	2	4
10	–	–	6	1
9	–	–	8	6

A = Sharm Elnagha site
B = Quseir Elqadeim site

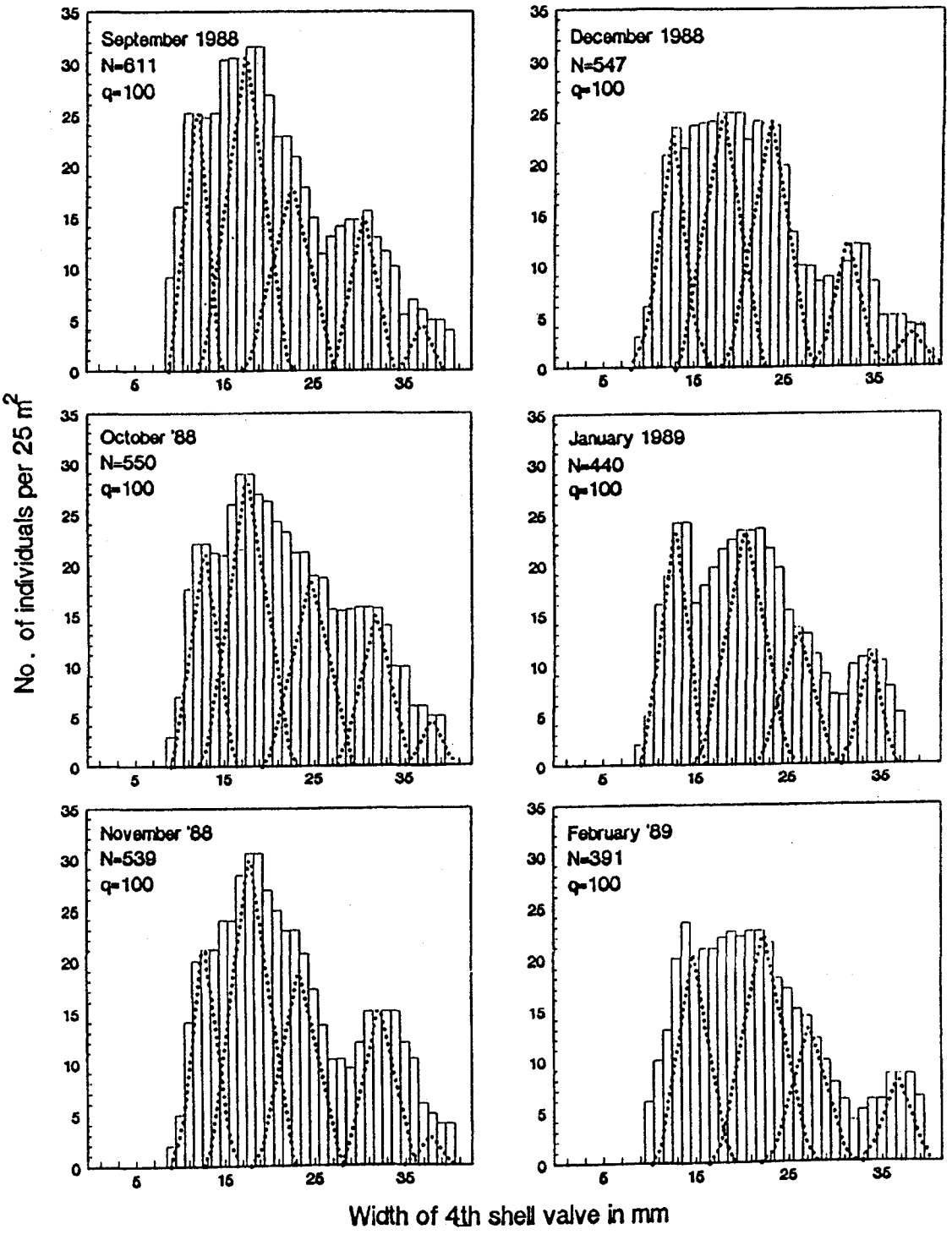


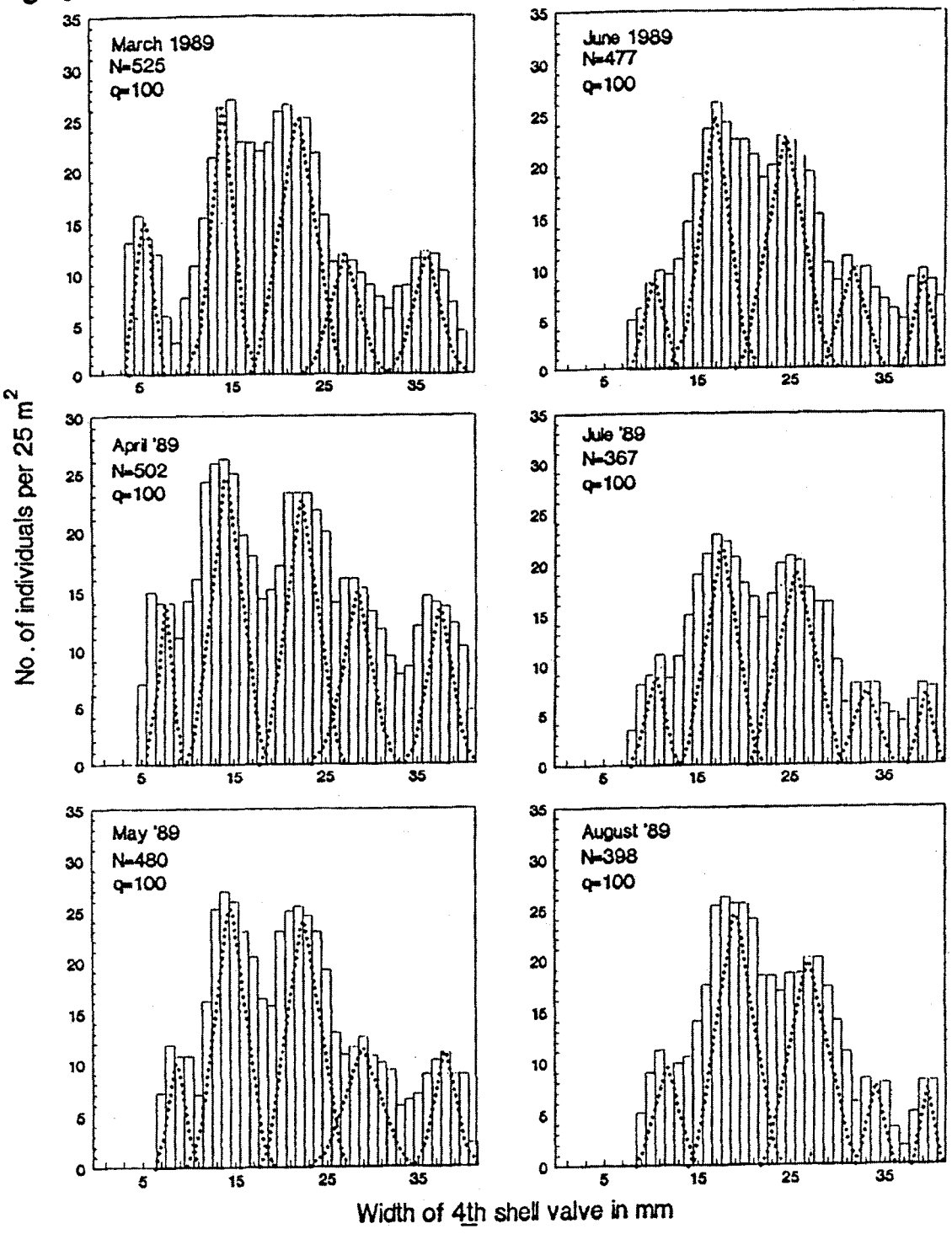
Fig. 5. Size frequency distribution of *A. gemmata* during the period from September, 1988 to August, 1989. N = total number of chitons and q = number of quadrats.

each other in all histograms, the data were subject to a modifying method of probability paper devised by Cassie (21) and estimated using STATGRAPHICS and MIX computer programs. Application of the method to the size frequency histogram of the different months of the year revealed that *A. gemmata* population contained 5 year classes along one year from September, 1988 to August, 1989 (except during January and February, 1989, where, there were only 4 year classes). In the latter months, the oldest year class with the 4th shell valve width above 35 mm did not exist. On the other hand, a new year class with 4th shell valve width less than 10 mm entered the population in March, 1989. Although spawning occurred in October, 1988 (Fig. 4), the new recruit appeared on March, 1989. At that time, the mean size of the 4th shell valve width of the new year class (O^+ year class) which reached 6 months of age, was 5.28 mm. The mean widths of the 4th shell valve of the other year classes were 14.02, 22.76, 27.27 and 36.15 mm for the 1^+, 2^+, 3^+ and 4^+ year classes, respectively.

Growth curve of *A. gemmata* population

Monthly changes in the average of the 4th shell valve width of each year class are shown in Table 2 and repre-

Fig. 5 Continued



sented as growth curve in Fig. 6. The most noticeable fact in the growth curve is the absence of data on the O^+ year class during the first 6 months of the life cycle. Immature with an average 4th shell valve width 5.28 mm started to appear in the population in March and grew rapidly to reach 11.88 mm by August, with an average monthly growth rate of 1.1 mm. The average of the 4th shell valve width of the 1^+ year class was 12.02 mm in September, 1988 and 19.05 mm in August, 1989 with an average monthly growth rates of 0.8, 0.9, 0.7 and 0.3 mm, respectively. Because the data represented an annual cut section of the species population, the growth rate of the cohort born in 1988 (O^+ year class) cannot be absolutely compared with that of the other cohorts (year classes) which were born in the preceding years. So, generally, this indicates that the growth rate was highest in the O^+ year class (1.1 mm), decreased in the 1^+ year class to reach 0.6 mm, had nearly a constant value in the 2^+, 3^+ and 4^+ year classes and greatly dropped in the 5^+ year class. Also, Fig. 6 shows that the growth of the O^+ year class was continuous without seasonal variations, while, that of 1^+ to 5^+ year classes had very clear seasonal variations. Moreover, the growth rate was higher in winter and summer than in spring and autumn. Individuals with 17.15 mm 4th shell valve width have shown by dissection to be mature taking part in

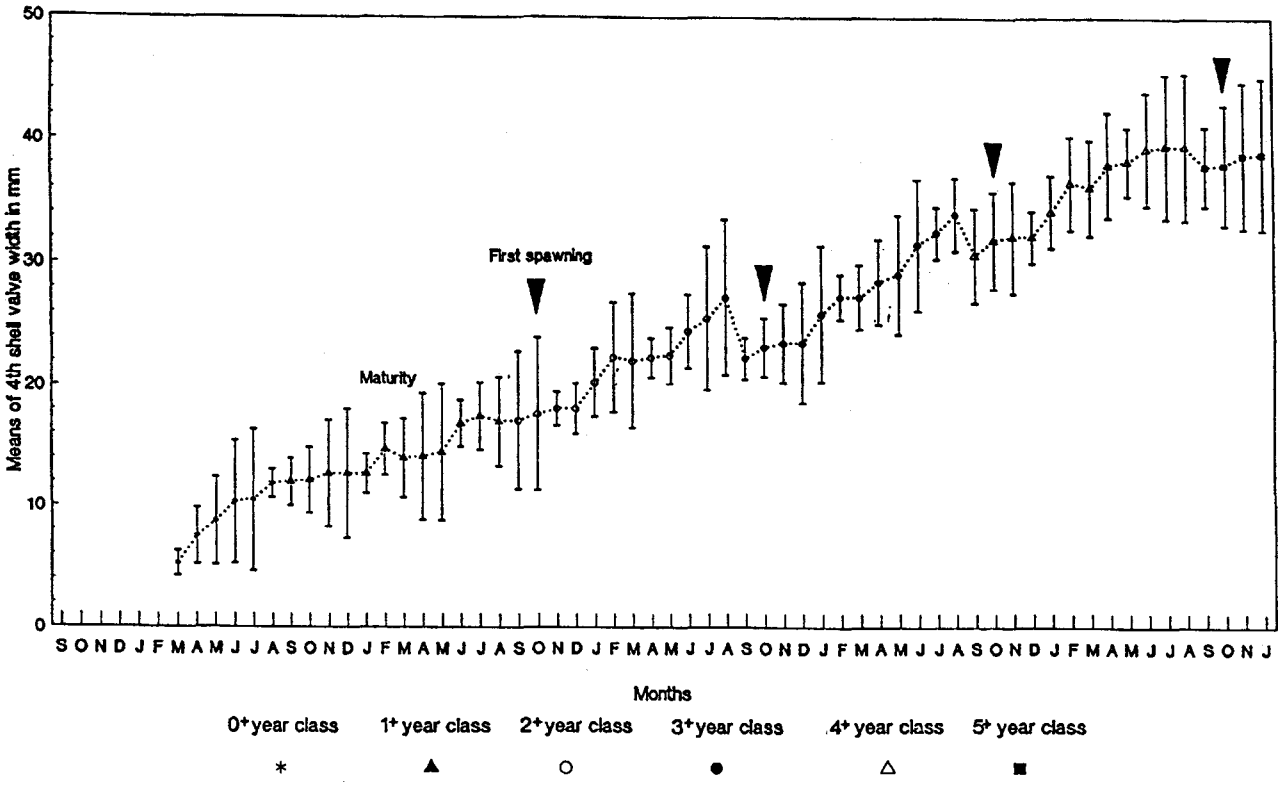


Fig. 6. Changes of 4th shell valve width in each year class and the estimated growth curve at Sharm Elnagha site. Vertical bars are standard deviations of the means.

Table 2

Average 4th cell valve width in mm of each year class, separated by size frequency distribution analysis of the fitted normal curves from September, 1988 to August, 1989.

	Date	Sept. 1988	Oct.	Nov.	Dec.	Jan. 1989	Feb.	Mar.	Apr.	May	June	July	Aug.
year classes	O^+ year class	–	–	–	–	–	–	5.28	7.51	8.76	10.35	10.51	11.88
	1^+ year class	12.02	12.17	12.73	12.73	12.71	14.75	14.02	14.15	14.53	16.91	17.51	19.05
	2^+ year class	17.15	17.68	18.13	18.13	20.29	22.36	22.76	22.32	22.53	24.47	25.52	27.22
	3^+ year class	22.28	23.19	23.53	23.54	25.88	27.29	27.27	28.50	29.09	31.49	32.47	33.96
	4^+ year class	30.66	31.85	32.13	32.14	34.19	36.51	36.15	38.02	38.29	39.32	39.55	39.48
	5^+ year class	37.90	38.01	38.78	38.90	–	–	–	–	–	–	–	–

the new recruit, i.e., first reproduction occurred in individuals two years old. The mean width of the 4th shell valves at the second, third and fourth reproduction was 22.28, 30.66 and 37.9 mm, respectively. The highest average of the 4th shell valve width was 38.9 mm, while that of the largest individual collected was 40 mm.

DISCUSSION

Studies of the size and age at first maturity of most polyplacophoran species revealed that most of these species reach sexual maturity within one to two years, but the size at first reproduction varies greatly (6, 11, 22, 23, 24). As for species within the genus *Acanthopleura*, Glynn (6) recorded that, *A. granulata* reached maturity at one year of age and size at first maturity ranged between 34-38 mm (total body length). The same conclusion was arrived at by Guirguis (17), who reported that sexual maturity in *A. spiniger* could not be detected in specimens less than 40 mm long (total body length). Both authors (6, 17) built their conclusion on the appearance of mature eggs within the gonads; the attainment of the egg a full size of 150-175 μm (4); and total length of the body. Investigating the total body length during the present study has shown that it is not a reliable character in view of the changeable dimensions of the contractile mantle edge of living individuals. Therefore, the size and age at first maturity were traced monthly by applying gonadal smear preparation and width of the 4th shell valve as stable characters. Accordingly, the gonads of *A. gemmata* started to develop in individuals one and half year old, ranging between 13-18 mm 4th shell valve wide. Individuals two years old took part in reproduction (i.e. first reproduction) when they reached 17.15 mm 4th shell valve width. The species population reproduced 4 times through the life span when the width of the 4th shell valves was 17.15, 22.28, 30.66 and 37.99 mm, respectively.

As for longevity of chitons, Glynn (6) indicated that,

Acanthopleura granulata Gmelen and *Chiton tuberculatus* Linne from the Caribbean regions varied between 2-5 years. Baxter & Jones (11) mentioned that the North European *Lepidochitona cinereus* has a life span of 6 years or more. Emam & Ismail (15) estimated the age of *A. haddoni* (synchronous with the species studied) to be more than 5 years in the Arabian Gulf. In this study, the longevity of *A. gemmata* was estimated to be 5-6 years. The growth curve has shown seasonally varying pattern except in the O^+ year class that has a continuous and steady growth rate. The seasonality in the growth rate was clear in mature individuals (Fig. 6) with a growth rate higher in winter and summer than in autumn and spring. Such differences may be related to changes in the tidal rhythm and not in water temperature.

The percentage of the increment in body length was recorded for some chitons. Pearse (5) and Glynn (6) estimated this percentage in *Acanthopleura granulata* and *Acanthochitona fasciculata* in the first year of the life span to be 40% and 70%, respectively. Emam & Ismail (15) reported 22% and 50% increment in length of *A. haddouni* in the first and second years, respectively. In the present investigation, the growth in length based on the increment in width of the 4th shell valve of *A. gemmata* was estimated to be 30% and 49% of its maximum size in the first and second years, respectively.

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