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POPULATION ECOLOGY OF THE INTERTIDAL SEA STAR *ASTERINA BURTONI* GRAY (ASREROIDEA: ECHINODERMATA) IN THE WAKRAH BAY, SOUTH EAST OF QATAR

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بيئة عشائر نجم البحر «*استرينا بورتوني*» جراي (النجميات : جلد شوكيات) في منطقة المد والجزر بخليج الوكرة جنوب شرق دولة قطر

فتحي السيد سليمان محفوظ

تم في هذا البحث دراسة التواجد والتوزيع والتركيب العمري لعشيرة نجم البحر «*استرينا بورتوني* جراي» بمنطقة المد والجزر بخليج الوكرة جنوب شرق دولة قطر ، وقد أوضحت الدراسة أن هذا النوع يوجد بكثافة عددية ٢,٢ في كل متر مربع كما أن انتشاره يدل على هذا النوع موزع عشوائياً في البيئة الطبيعية مع تفضيل أحدث الطوائف العمرية لمنطقة معينة داخل بيئة العشيرة . كما أوضحت النتائج باستخدام ثلاث قياسات مختلفة هي طول الذراع والوزن الجاف لجدار الجسم (وزن الجسم بدون الاحشاء) والوزن الجاف لكل الجسم على أن العشيرة يوجد بها على الأقل أربع طوائف عمرية هي ١+ و٢+ و٣+ و٤+ بالاضافة إلى أحدث الطوائف العمرية التي انضمت إلى العشيرة في شهر نوفمبر ١٩٩٣ . كما قدرت متوسطات الأعمار للطوائف العمرية المختلفة بالقياسات السابقة خلال الفترة من أكتوبر ١٩٩٣ وحتى يناير ١٩٩٤م .

Key Words: *Asterina burtoni,* Population ecology, Age class, Evacuated body, Gonads, Pyloric caeca

ABSTRACT

The abundance, distribution and population age structure of the sea star *Asterina burtoni* Gray were investigated in the intertidal area of the Wakrah Bay, South East Qatar Peninsula from October, 1993 to January, 1994. The estimated density of the sea star was about 2.2 per m^2 and a clear habitat preference was recorded for the juveniles and adult sea stars. Analysis of the population age structure was carried out using three different parameters; arm length, body wall (evacurated body) dry weight and total body dry weight. This analysis indicated the presence of at least 4 year classes 1^+, 2^+, 3^+ and 4^+ in addition to a new recurit representing the 0^+ year class entered the population during November, 1993. The mean arm lenghth, mean body wall dry weight and mean total body dry weights for each year class were also estimated.

INTRODUCTION

Since characteristics and life histories of animal populations were first discussed [1,2] and comparison of various taxonomic groups was made (3) understanding of the characteristics of the species populations have been one of the main problems in nowadays ecology [4 - 11]. Most of these studies were developed by picking each species out of its community and determining its characteristics and life history tactics, taking into consideration that each species population does not exist alone but lives in a trophically definite system with other species [12-14]. Thus, characteristics and movement of a species population can be influenced by the traits of other populations or the community in which the species coexist [15 - 17].

Studies on the population ecology of the different echinoderm taxonomic groups are exstensive, while those on asterinids which are interesting from the ecological viewpoint are relatively few [10 and 18-24].

The present study deals with one of the commonest sea stars, *Asterina burtoni* Gray: Asterindae, Asteroidea, Echinodermata, in the intertidal area at Qatar of the Arabian Gulf to assess its population age structure, using three different parameters; arm length, body wall dry weight and total body dry weight and to see which one of them is the best to evaluate the population traits and life history tactics of the species.

MATERIALS AND METHODS

The Study Area And Study Site

The study area lies on the eastern coast of the Qatar Peninsula (Fig. 1). The area is situated at 51° 37' E and 25' 10' N(see Fig. 1 and 2) on a closed bay called the Wakrah Bay. The bay is about 5 km in length and one km in width. It has a wide exposed shore during low water that extends from the littoral to the lower intertidal zones (Plate 1).

Plate 1 : Study site during the mean water tide level showing the upper exposed part and the intertidal pool.

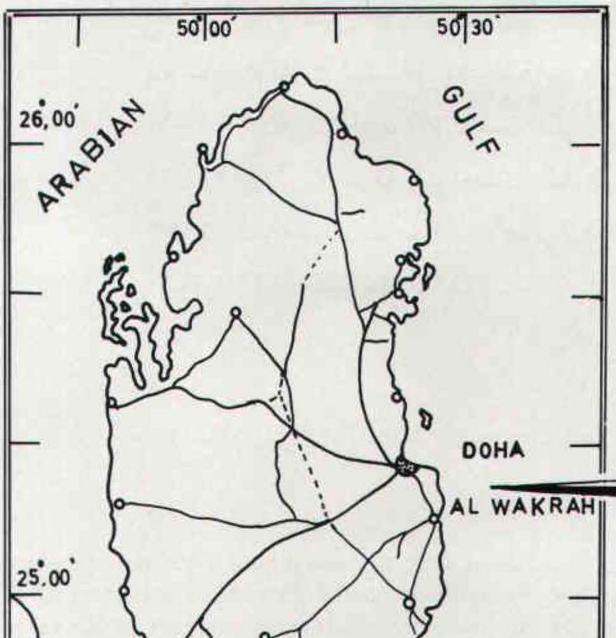

Fig. 1: Map State of Qatar.

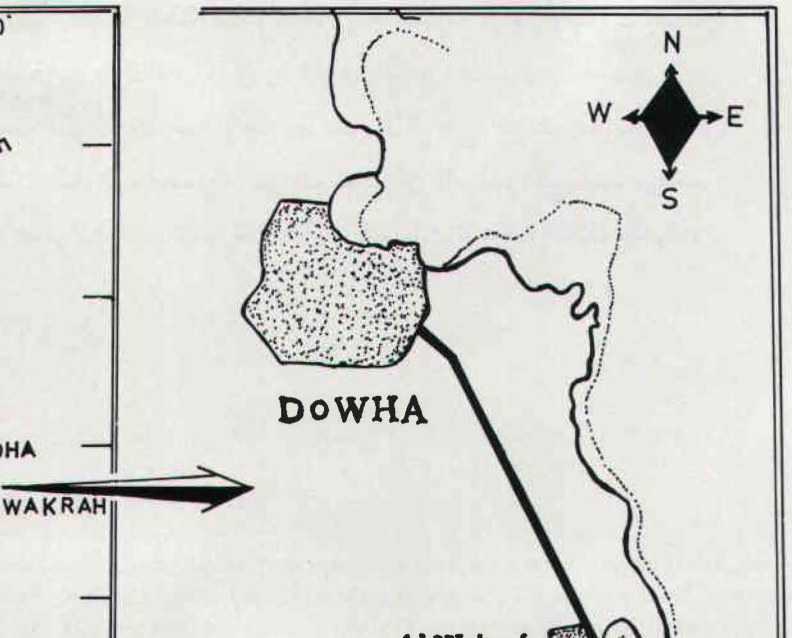

Fig. 2: Map showing the study area. WB and STS denote to Al Wakrah Bay and the study site respectively.

The study site is a location on the western side of the Wakrah Bay and about 3 km from Wakrah city (Fig. 2). The site extends from the upper intertidal to mid-intertidal zones to about 66 m in length and 42 m in width (Fig. 4). The site is protected from direct wave action by a semi-girdle of boulders and large stones on its lateral and se ward sides. The boulders and stones fall vertically from the mean water tide level to the level of the low water neap (Fig. 3). They are pierced by narrow gallies at the mean water level through which daily water exchange occurs. Also, during low water, the site can be distinguish into an upper and lower parts. The upper part is situated nearly at the mean water level (about one meter deep) and is exposed completely during low water (Fig. 3 & 4 and Plate 1). The lower part is an intertidal pool that lies below the mean water level by abut 25 - 30 cm (Fig. 4).

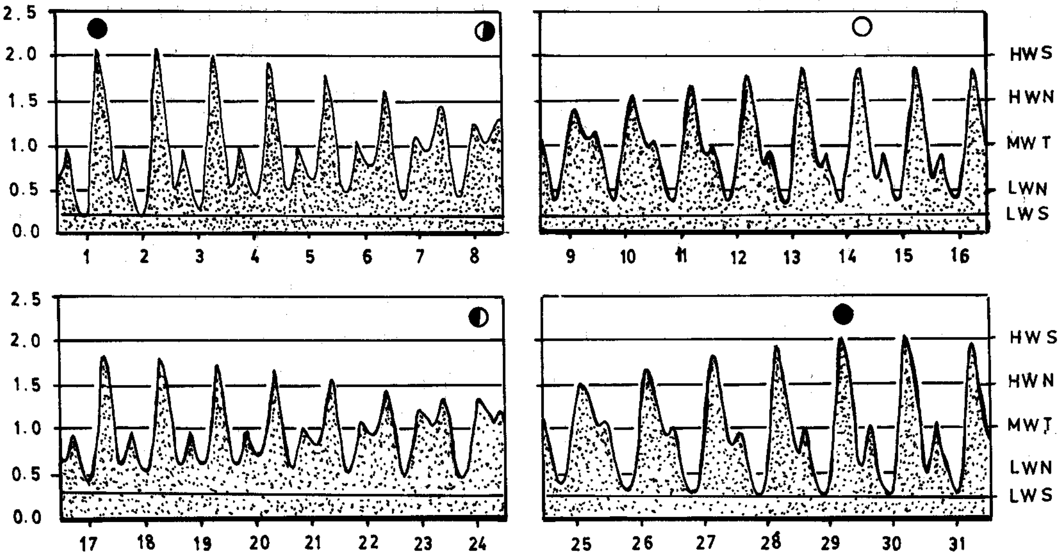

Fig. 3: Changes in water level at the Wakrah Bay. HWS and LWS, HWN and LWN and MWN are the water level during high and low water spring high and low water neap and mean water tide levels respectively.

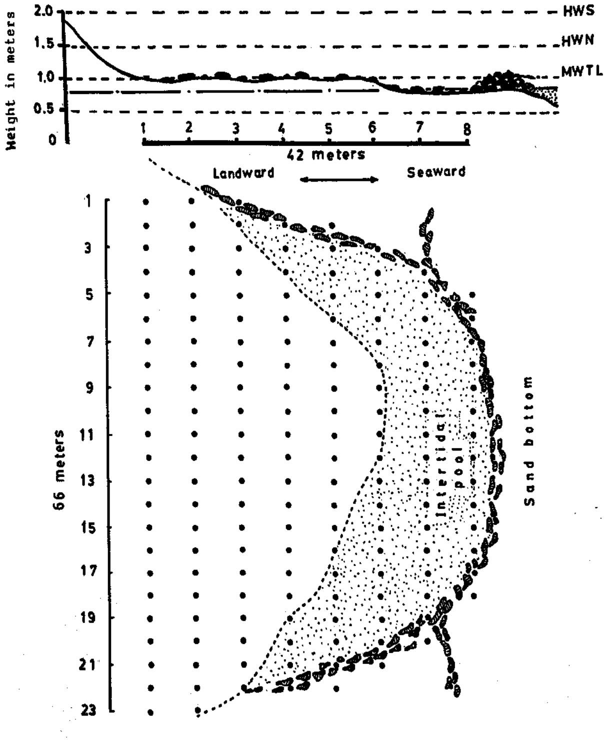

Fig. 4: Shore profile and a contour map for the study site. Solid circles show the sampling points.

The upper part and the pool contain many randomly dispersed stones that are inhabited by *Asterina burtoni* Gray as well as other invertebrates, such as, *Balanus* sp. and *Scopimera scabricauda* (Crustacea); *Planaxis salcatus* and *Cerithidia cingulata* (Gastropoda); *Saccostra cuculata* (Bivalvia); *Onchidium verruculatum* (Opithobranchia) and *Membranipora sp.* (Bryozoa). In addition, some unidentified species of sponges, soft corals, annelids and tunicates were present.

Sampling of *Asterina burtoni* Gray population was carried out as follows: eight transects were set parallel to the shore line at six meters intervals and another 23 transects perpendicular to the shore line were set at 3 meters intervals. The cross points of these transects (160 points) were selected as the sampling points (Fig. 4). A 50 x 50 cm quadrat was used for monthly sampling. All the stones in each quadrat were turned over carefully and the juvenile and adult sea stars were counted. The arm length of each sea star (i.e. the length from the center of the aboral disc to the tip of the normally extended arm) was measured using a slide calliper graduated to 0.05 mm. The arm length of sea stars less than 2 mm in body diameter was difficult to measure, so, the body diameter was measured and divided by two to get the arm length. Repeated measurements of an individual sea star showed difference of less than 0.05 mm. Contraction or expansion by feeding sea stars during sampling was avoided by detaching the sea stars from the feeding item and measuring their arm length on another flat stone. After taking measurements, the sea stars were replaced carefully on the stones in their original positions to minimize disturbance to the population. The data on arm lengths were collected from October, 1993 to January, 1994.

For estimating the age structure of the sea star population using the body wall (evacurated body) dry weight and total body dry weight, a number of sea stars equals to that investigated in the main study site were collected randomly from adjacent pools of the same area. The collected specimens were dissected under a binucular microscope and the gonad and pyloric caeca were separated from the body wall and placed in a preweighed aluminium foil. These three components, i.e., the gonad, pyloric caeca and evacurated body were dried in an incubator at 60^{0} C for three days until a constant weight was obtained using a direct reading balance with minimal scale of 0.1 mg.

The data on the gonads, pyloric caeca and body wall were collected from October to December, 1993.

To separate the different age classess of the sea star population, the data were subjects to a modifying method of probability paper analysis devised by Cassie [25] and using a computer program called PCAP prepared by Tsutsumi (unpublished).

Changes in water level at the study site (Fig. 3) was obtained from Department of Meteorology, Ministry of Communication and Transport, Doha, State of Qatar.

RESULTS

Local Abundance and distribution of the sea star

The distribution of the sea star at the study site before and after the appearance of the new recruit in the population are shown in (Fig. 5 and 6). The spatial distribution of the sea star during October, 1993 (Fig. 5) showed that, all the sea stars had a deep brown colour (i.e. adults) and no white or white brown specimens (i.e. juveniles) were detected. From this figure, adult sea stars were randomly distributed with some bias towards the lowest part; the intertidal pool. The highest density recorded was 3 individuals per 0.25 m^2 and a total of 86 individuals per 40 m^2 (2.15/m^2). Appearance of the juvenile sea stars was started in November, 1993 (Fig. 6). Spatial distribution of the sea star during this month indicated that, the juvenile sea stars were appeared in the intertidal pool specially on the sides of the stone girdle and where water is maintained during low water. Although the new recruit was added to the population, the highest number was still 3 per 0.25 m^2 similar to that described before in October and a total of 93 individuals per 40 m^2 were counted showing a density of 2.3/m^2. The estimated densities of the sea star during December, 1993 and January, 1994 were 2.13 and 2.1/m^2, respectively.

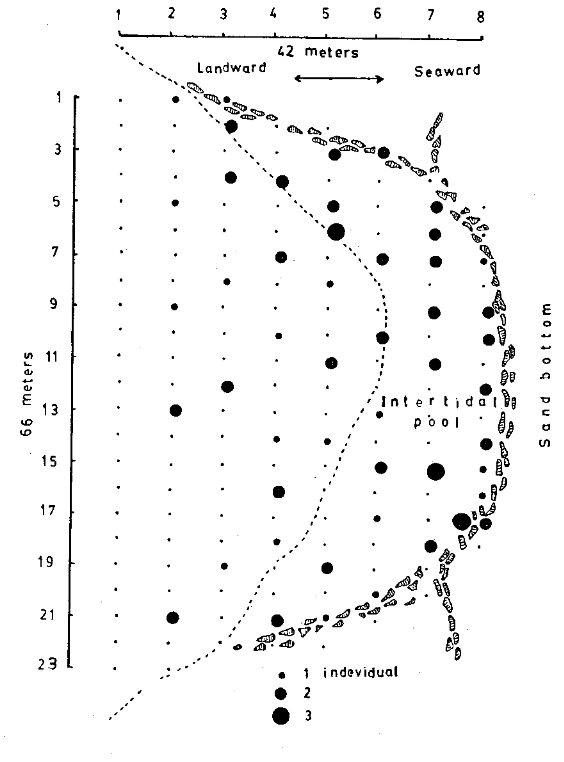

Fig. 5: Spatial distribution of *A. burtoni* population at the study site in October, 1993. Solid circles show number of adult sea stars per 0.25:m^2

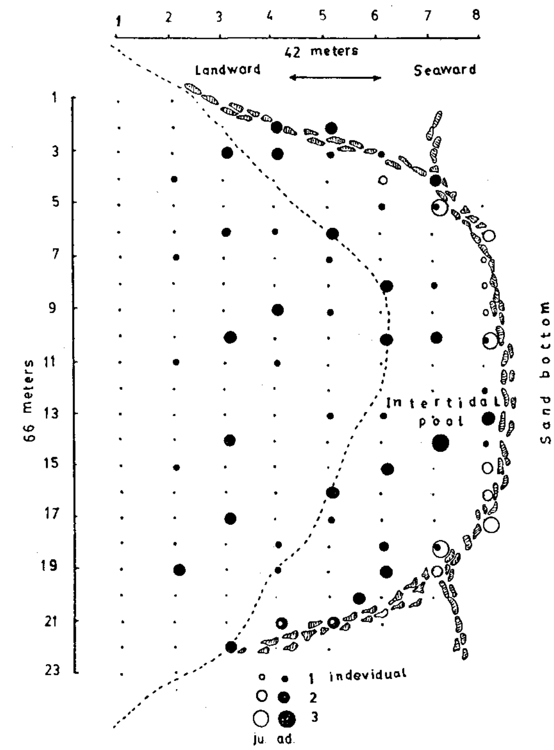

Fig. 6 : Spatial distribution of *A. burtoni* poplation at the study site during November, 1993. Solid and open circles show the number of adults and juveniles per 0.25 m^2 respectively.

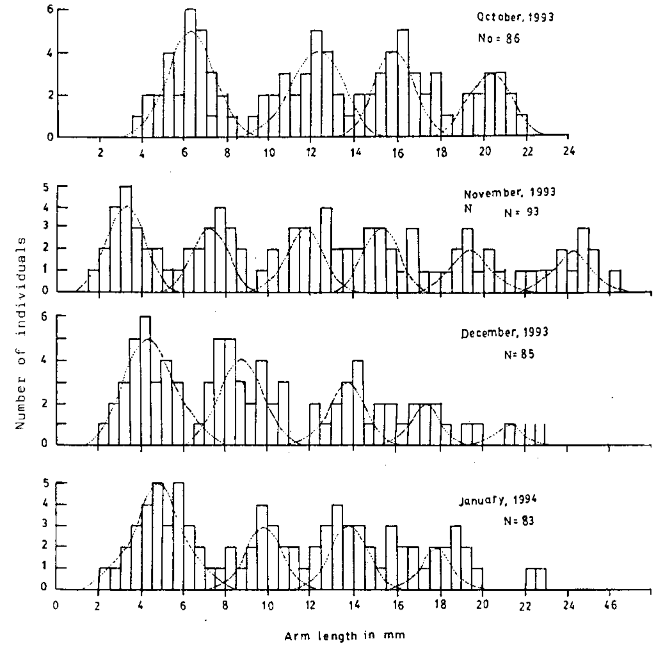

Fig. 7: Changes in the mean arm length of the different year classes of *A. burtoni* population during the period October, 1993 to January, 1994.

Age Structure Of The Sea Star Population

Age structure of the sea star population was estimated by analysis of the three parameters: arm length, body wall dry weight and total body dry weight. Size distribution of the collected sea stars in October, November, December, 1993 and January, 1994 is shown in Fig. 7 with fitted normal curves. Four to five normal curves were distinguished in each month except November, 1993 where six normal curves were obtained. The arm length of the smallest sea star was 1.75 mm and the largest one was 26.25 mm. The mean arm length of each age class obtained by the size distribution analysis is shown in Fig. 7 and Table 1. The mean arm length of the four age classes estimated from the data of October were 6.25, 12.25, 15.75, and 20.75 mm. In November a new age class with a mean arm length of 3.25 mm in addition to 5 old age classes with mean arm lengths, 7.25, 12.25, 15.75, 19.25 and 24 mm. Data analysis of December, 1993 showed five age classes with mean arm length 4.25, 9.00, 13.5, 17.25 and 21.00 mm with disappearance of the oldest age class. The sample of January, 1994 showed four age classes only with mean arm lengths 4.75, 9.75, 13.75 and 17.75 mm and disappearance of the old age class and the population again restored four age classes as in October, 1993.

Table 1.

The mean arm length in mm for the different year classes of *A. burtoni* Gray population at the Wakrah Bay

Tear class	Oct., 1993	Nov., 1993	Dec., 1993	Jan., 1993
0^+	-	3.25	4.25	4.75
1^+	6.25	7.25	9.00	9.75
2^+	12.25	12.25	13.50	13.75
3^+	15.75	15.75	17.25	17.75
4^+	20,75	19.25	21.00	
5^+		24.00		

Analysis of the age structure of the sea star population using the body wall dry weight is shown in Fig. 8 and Table 2. Four to five normal curves were obtained from the data of each month. The body wall dry weight of the smalles sea star was 25 mg while that of the largest individual was 1.2 gm. The mean body wall dry weight of each age class estimated from the collected data in October, 1993, were 0.325, 0.550, 0.775 and 1.050 gm. In November, 1993 five age classes were obtained as a new age class representing the new recruitment has jointed the population with a mean body wall dry weight of 0.05 gm. in addition to the old four age classes that have mean body wall dry weight of 0.350, 0.575, 0.800 and 1.075 gm. The sample of December, 1993, showed also five age classes with mean body wall dry weight of 0.065, 0.350, 0.600, 0.800 and 1.025 gm.

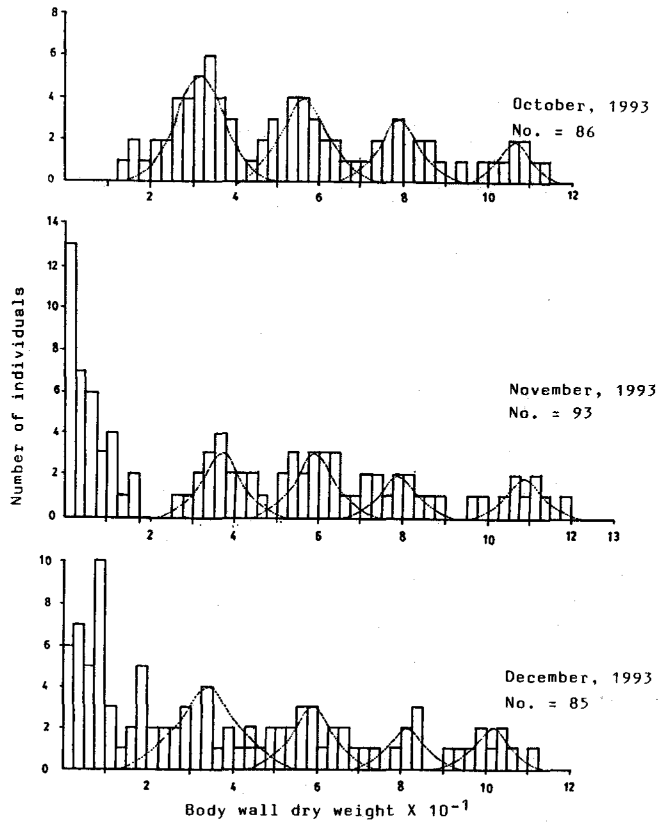

Fig. 8: Changes in the mean body wall dry weight of the different year classes of *A. burtoni* poplation during the period October-December, 1993.

Table 2

The mean body dry weight in grams for the different year classes of *A. burtoni* population at the wakrah Bay.

Tear class	Oct., 1993	Nov., 1993	Dec., 1993
0^+	----	0.05	0.065
1^+	0.325	0.350	0.350
2^+	0.550	0.575	0.600
3^+	0.775	0.800	0.800
4^+	1.050	1.075	1.025

Estimation of age structure of the sea star population using the total body dry weight during October, November, December, 1993 is shown in fig. 9 and Table 3. Fitting of normal curves to the collected data was very difficult as the data distributions around a restricted means can not be defined well. So, the analysis of these data showed that the sea star population has five age classes in October and six age classes in November and December. The total body dry weight for the smallest sea star was 0.025 gm, while that of the largest one was 1.400 gm. The means of the total body dry weight of the five age classes estimated from the data in October were 0.125, 0.275, 0.425, 0.650 and 0.950 gm, while, those of December were 0.075, 0.225, 0.375, 0.625, 0.775 and 1.25 gm.

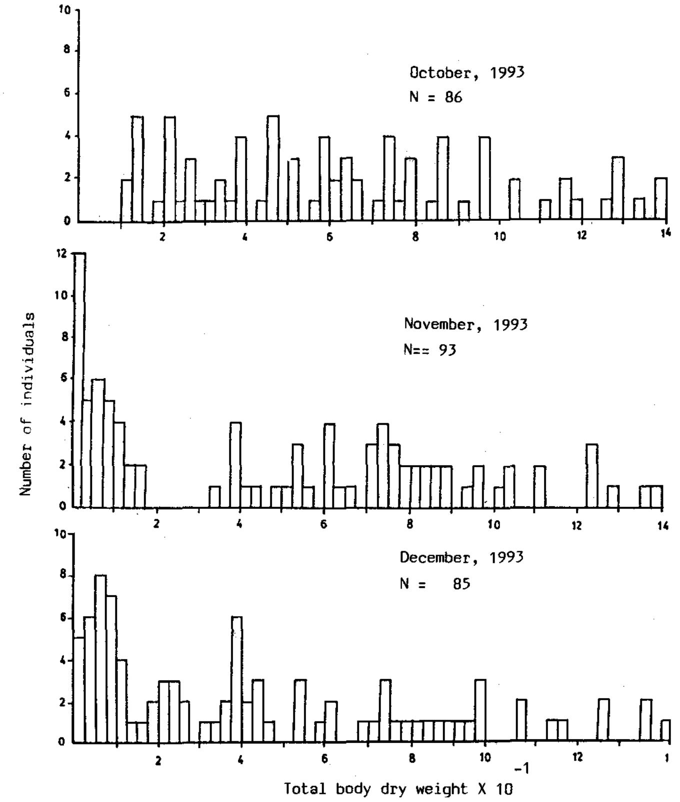

Fig 9: Frequency of the total body dry weight of *A. burtoni* population at the Wakrah Bay during the period October-December, 1993.

Table 3

The mean total body dry weight in grams for the different year classes of *A. burtoni* population at the wakrah Bay

Tear class	Oct., 1993	Nov., 1993	Dec., 1993
0^+	----	0.050	0.075
1^+	0.125	0.175	0.225
2^+	0.275	0.350	0.375
3^+	0.425	0.575	0.625
4^+	0.625	0.750	0.775
5^+	0.950	1.050	1.125

The variation in the weight of the different body components i.e. body wall, gonads and pyloric caeca and total body are shown in Table 4. From this table, the three sea stars that have gradual increase in their arm length (12.10, 12.15 and 12.35 mm) have gradual increase in body wall dry weights (0.261, 0.291 and 0.294), while their gonads and pyloric caeca dry weight exhibited gradual decrease (0.014, 0.007 and 0.002 for the gonads and 0.062, 0.034

and 0.24 for pyloric caeca). These variations reflected on the total body dry weight of each sea star and the smallest one of the three had the heaviest body dry weight. Also, the three sea stars with arm length 14.55, 14.65 and 14.90 mm showed a gradual increase in the body wall dry weight 0.409, 0.430, and 0.485 gm, respectively. On the other hand, the smallest of the three sea stars (of 14.55 mm arm length) had the heaviest gonadal dry weight (0.016 gm) and the median sized sea star (14.65 mm arm length) had the heaviest pyloric caeca dry weight (0.75 gm).

Table 4

Variations in the weight of the body components; body wall gonads and pyloric caeca; in sea stars having nearly eaual arm lengthes.

Arm lenght	B.W.D.W.	G.D.W.	P.C.D.W.	T.B.D.W.
12.10	0.261	0.014	0.062	0.337
12.15	0.291	0.007	0.034	0.332
12.35	0.294	0.002	0.024	0.320
14.55	0.409	0.016	0.039	0.464
14.65	0.430	0.003	0.075	0.508
14.90	0.485	0.014	0.047	0.546

** B.W.D.W. means: body wall dry weight, C.D.W. Gonads dry weight, P.C.D.W. pyloric caeca dry weight and T.B.D.W. Total body dry weight.

Mortality of The Species

Changes in number of different age classes of *A. burtoni* estimated from the samples of November, 1993 and January, 1994 are shown in Fig. 10. From this figure one can see that, there is a decrease in number of sea stars of each age class that is well defined in the 0^+ age class. In addition, the oldest age class was disappeared from the population during December, 1993 and January, 1993 (see Fig. 7).

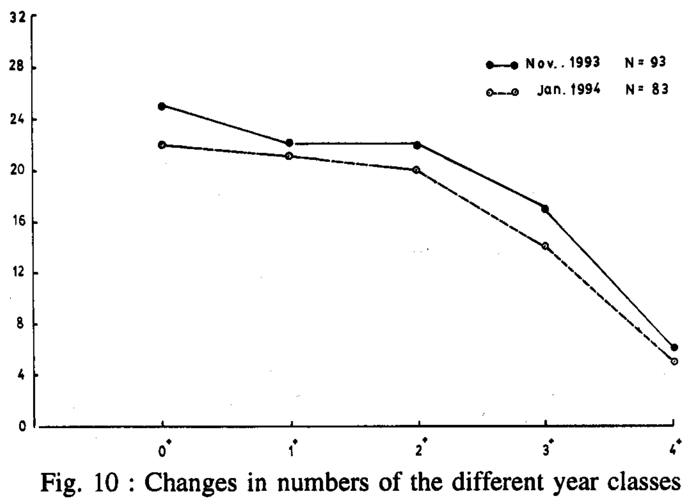

Fig. 10 : Changes in numbers of the different year classes of *A. burtoni* during November, 1993 and January, 1994.

DISCUSSION

Field studies on population ecology of sea stars are relatively few [10,18 and 26-30]. This is because of the considerable migration and relatively low density of the sea stars for quantitative sampling except in case of outbreaks and closed populations. Also, many investigators failed to find any growth rings on the skeletal material of the sea stars considerable to that of the sea urchins [27 and 31-33]. In addition, Crump and Emsom stated that, recognition of age groups from size frequency distribution is often difficult and should be made with extreme care [18].

Family Asterinidae includes 10 species belonging to genus *Asterina*. The population traits of these species are very interesting. Four of them are gonochoristic namely A. pectinifera [34], *A. regularis* [35], *A. coronata japonica* [36] and *A. burtoni* [37]; one gonochoristic and hermapphroditic *A. batheri* (38); one protandric hermaphrodite *A. gibbosa* [19] and four hermaphroditic species, *A. phylactica* [19], *A. scobinata* [39], *A. exigua* [35] and *A. minor* [10]. Also *A. pectinifera* and *A. regularis* broadcast small sized eggs (170-200 um) in sea water, *A. coronata japonica* and *A. batheri* lay large sized eggs (400-600 um) that float at the water surface, *A. burtoni* lays large sized eggs (450-500 um) that sink to bottom. The other five species, *A. phylactica, A. scobinata, A. exigua* and *A. minor lay* large sized eggs (300-500 um) as egg masses on the lower surfaces of the stones and some of them are brooders. So, the sea star *A. burtoni* does not pass a long pelagic dispersal stage; as the eggs sink after liberation; and its populations are restricted to the intertidal zone. This make the study of the sea star population available.

Most of the authors that studied the biology and/or population ecology of the sea stars used different measuring characters such as, the body wet weight, arm length and body dry weight. Crump and Emson [18] warned from using the size freqency distribution for evaluating the population age classes in sea stars. On the other hand, Pearse [40] and McClintock *et. al.,* [11] concluded that, the wet weight of a single individual can differ up to 40% between successive weighing where the weight changes over the time may not reflect actual growth of organic tissue.

Therefore, in this work, it was attempted to find the best method to estimate the population age structure of A. burtoni using the three parameters; arm length, body wall dry weight and total body dry weight. The best fitted normal curves for the different age classes of the sea star population that obtained from the data on the body wall agree with that on the arm length. On the other hand, the data on the total body dry weight were misleading as the individual variation of the gonads and pyloric caeca affect directly the total body dry weight and indirectly the data aggegation around a definite means. So, the most reliable parameter for studying the population ecology of the sea stars seems to be the body wall dry weight. However, the latter requires collection of a large number of the sea stars that will cause a destruction to the sea star populations. In addition, obtaining data on body wall dry weight is a tedious method. So, arm length is the most feasible way for studying the population traits of sea stars.

Analysis of the population structure of *A. burtoni* using the two measuring means, arm length and body wall dry weight indicated that, the sea star population has at least four age classes similar to the brooding sea star *A. phylactica* [19] and exceeds by one age class the semibrooding species *A. minor* [20]. On the other hand, the fourth well studied asterinid species *A. gibbosa* has seven age classes [41]. So, *A. burtoni* is a small sized species, lays large eggs and have a short life span like the brooding species though it is gonochoristic similar to the large sized species.

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