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NATURAL HISTORY NOTES ON TWO INDIAN OCEAN STARFISHES IN SEYCHELLES : *PROTOREASTER LINCKI* (DE BLAINVILLE) AND *PENTACERASTER HORRIDUS* (GRAY)

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ABSTRACT

Populations of two starfish, *Protoreaster lincki* and *Pentaceraster horridus*, were studied during May 1976 in the Marine National Park of Seychelles. The relative abundance of the two species was in a ratio of nine *P. lincki* to one *P. horridus*. Size distributions of the two species showed a major mode at *ca.* 12.5 cm for *P. lincki* and at ca. 14.0 cm for *P. horridus*. There also were smaller individuals of *P. horridus* than *P. lincki* present suggesting that *P. horridus* may grow faster and not live as long as *P. lincki*.

Male *P. lincki* were smaller than females but sufficient data were not gathered to determine whether this was also true for *P. horridus*. On May 8, 17% of *P. lincki* in the sample spawned. None spawned on 16 May which may indicate the end of the natural spawning season. Some *P. horridus* spawned in each sample.

Of 245 *P. lincki* examined, seven had abnormal arm numbers : six had six arms and one had seven. All 27 *P. horridus* had five arms.

INTRODUCTION

THE purpose of this note is to present information on size structure, relative abundance, sexual dimorphism and spawning, and variation in arm number for two starfishes of the family Oreasteridae : *Protoreaster lincki* (de Blainville) and *Pentaceraster horridus* (Gray).

Collections of starfish were made during May 1976 in the sea grass beds to the South and West of Round Island, in the Marine National Park about 6 km to the East of Victoria, Mahe, Seychelles (55° 30′E ; 4° 37′S). A general description of the sea grass beds of Seychelles has been published by Taylor and Lewis (1970).

Assistance in the field was provided by Mr. Kurt Buchanan of the Marine National Park, and Mr. Brendon Grimshaw of Masion Moyenne, Moyenne Island. Permission to work in the park was kindly provided by Mr. S. M. Savy, Director, Department of Agriculture. This work was supported by the U. S. National Science Foundation (NSF DES75-10442) and by the State of California which granted me a sabbatical leave from San Diego State University. A draft of the manuscript was read and criticized by Dr. Deborah Dexter.

METHODS

Starfish were collected in water 0.5 m to 3.0 m deep on 8, 9 and 16 May 1976 during daylight hours using face-mask and snorkel. The sand bottom was covered by sea grasses, some coral rubble and isolated coral heads, as well as some patches of bare sand. Collecting times were about two hours per each day.

An effort was made to avoid bias in collecting individuals of different sizes so a size distribution would accurately reflect the structure of the population. Animals were placed in a basket attached to a float and were brought to shore to be sorted and measured. All starfish were collected so relative abundance could be calculated. Starfish were measured with calipers to the nearest millimeter from the tip of an arm to the opposite arm pit. After being measured, the starfish were returned to the grass beds.

RESULTS

Presence and Relative Abundance

A Total of 273 starfish were examined in the collections of 8, 9 and 16 May. Of the total, 245 or 89.7 % were *Protoreaster lincki*, 27 or 9.9% were *Pentaceraster horridus*, and one individual (0.4%) was *Culcita schmideliana* Retz.

Protoreaster lincki and *Culcita schmideliana* are listed as present in Seychelles by both Taylor (1968) and by Clark and Rowe (1971). Taylor lists no species of the genus *Pentaceraster* and Clark and Rowe list only *P. horridus*.

The populations of both *P. horridus* and *P. lincki* were variable with respect to color and spine development but individuals generally fit the key characters presented in Clark and Rowe (1971).

Size Structure

Size distributions were constructed for each collection and are shown in Table 1 for *Protoreaster lincki* and for *Pentaceraster horridus* in Table 2.

TABLE 1. *Size distributions of* Protoreaster lincki *to the south and west of Round Island, Mahe, Seychelles. Measurements are from arm tip to opposite arm pit. Values in the body of the Table are numbers of individuals observed in the stated size interval.*

Size (cm)	Date			
	8 May 1976	9 May 1976	16 May 1976	Total
8.51-9.00 ..			2	2
9.01-9.50 ..	1	1		2
9.51-10.00 ..			6	6
10.01-10.50 ..	5	1	5	11
10.51-11.00 ..	6	8	10	24
11.01-11.50 ..	8	5	5	18
11.51-12.00 ..	9	1	9	19
12.01-12.50 ..	9	10	11	30
12.51-13.00 ..	13	2	10	25
13.01-13.50 ..	11	3	8	22
13.51-14.00 ..	5	4	7	16
14.01-14.50 ..	8	4	6	18
14.51-15.00 ..	9	1	8	18
15.01-15.50 ..	7	1	5	13
15.51-16.00 ..	7	3	3	13
16.01-16.50 ..	2		2	4
16.51-17.00 ..	2	1		3
17.01-17.50 ..				
17.51-18.00 ..				
18.01-18.50 ..		1		1
Total ..	102	46	97	245

TABLE 2. *Size distribution of* Pentaceraster horridus *to the south and west of Round Island, Mahe, Seychelles. Samples from 8, 9, and .6 May 1976.*

Measurements are as in Ta'le 1. N=27.

Size (cm)	Number	Size (cm)	Number
6.01- 6.50	1	11.51-12.00	
6.51- 7.00		12.01-12.50	1
7.01- 7.50		12.51-13.00	1
7.51- 8.00	2	13.01-13.50	3
8.01- 8.50	1	13.51-14.00	6
8.51- 9.00	1	14.01-14.50	5
9.01- 9.50		14.51-15.00	2
9.51-10.00		15.01-15.50	2
10.01-10.50		15.51-16.00	
10.51-11.00		16.01-16.50	1
11.01-11.5)	1		

Comparisons of the size distributions of *P. lincki* were made using the Kolmogorov-Smirnov test for significance of difference of two cumulative frequency distributions (Tate and Clelland, 1957). Two distributions are compared, interval by interval, and the maximum difference between two intervals is tested for significance. For example, for α=0.05, the critical difference is :—

$$\text{Diff.}_{\alpha = 0.05} = 136\,(n_1 + n_2)\,/\,n_1\,n_2$$

where n_1 and n_2 are the number of observations in the two samples.

As shown in Table 3, none of the three size distributions is significantly different from the other two, so all were combined to form a single distribution (the Total column in Table 1). The combined distribution is unimodal and shows a slight positive skew. The mode is in the interval 12.01-12.50 cm. Small individuals were not present.

The combined size distributions of *Pentaceraster horridus* (Table 2) show a possible mode at 13.5 to 14.5 cm and the presence of much smaller individuals than *P. lincki*. The presence of smaller individuals and a mode at a larger size than *P. lincki* gives the size distribution a definite negative skewness. If the distributions represent normal and stable conditions then the larger number of small *P. horridus* suggest greater recruitment than in *P. lincki* and consequently also a higher mortality rate. The larger modal size for *P. horridus* may indicate a larger average maximum size than for *P. lincki* particularly if the mortality rate is higher for *P. horridus*. Such a positive relationship between mortality rate and maximum size has been suggested to exist in sea urchins (Ebert, 1975).

TABLE 3. *Test for significance of difference of shape or position of mode in the size distributions of* Protoreaster lincki *on 8, 9, and 16 May 1976 (data of Table 1) using the Kolmogorov-Smirnov test* (Tate and Clelland, 1975).

	Comparison		
	8 May vs. 9 May	8 May vs. 16 May	9 May vs. 16 May
Greatest difference between cum. freq. % curves ..	19.27	12.23	7.04
Significant diff. $\alpha = 0.05$	23.56	19.31	24.35

Fail to reject H_0 for all three comparisons so distributions may be combined as shown in Table 1.

Reproduction

Some *P. lincki* in the collections of 8 and 9 May began to spawn after they had been out of water for about half an hour. On 8 May, 17% of the collection spawned, on 9 May 8.7% spawned, and on 16 May no individuals were observed to spawn. Some individuals of *P. horridus* spawned on each day : two out of 11 on 8 May, two of seven on 9 May, and one of nine on 16 May.

Table 4 shows the number of individuals spawning on each sampling day. The null hypothesis was tested that number spawning was independent of sampling day, for both species, using 2 × 3 contingency tables. For *Protoreaster lincki* the null hypothesis was rejected ($X^2_{calc.} = 16.94$ with 2df ; $X^2_{\alpha = 0.05} = 11.34$) but for *Pentaceraster horridus* the null hypothesis was not rejected ($X^2_{calc.} = 0.79$ with 2df ; $X^2_{\alpha = 0.05} = 5.99$). This result indicates that probably the same per cent of the population of *P. horridus* spawned on each sampling date whereas this was not the case for *P. lincki* where 17% spawned on 8 May and none on 16 May.

If incidence of spawning in the collections reflects normal conditions in the field, then it would seem that *P. lincki* was at the end of its spawning season and I sampled the last edge ; whereas *P. horridus* either has a longer season or it has a season shifted later in the year relative to *P. lincki.*

Numbers of males and females and their sizes, based on spawning individuals, are shown in Table 5. The Wilcoxon two-sample test was used to test the hypothesis that median size of males was not significantly different from females. For *Protoreaster lincki*, calculated U was 14 and $U_{crit.}$ was equal to 21 at $\alpha = 0.02$ so H_0 was rejected and I conclude that the sexes do not have the same median size. Inspection of the data indicates that males are smaller than females. Mean size for males is 14.3 cm and is 15.8 cm for females. Median sizes of males and females of *Pentaceraster horridus* are not significantly different. The calculated value of U is 2 which has an associated probability of 0.4 ; however, the sample is too small for this analysis to have much meaning and further study may show that there is a sexual size difference similar to *P. lincki.*

TABLE 4. X^2 *test to determine whether number of individuals spawning is independent of the sampling date.*

	Protoreaster lincki						
	8 May 1976 obs.	8 May 1976 exp.	9 May 1976 obs.	9 May 1976 exp.	16 May 1976 obs.	16 May 1976 exp.	Total
number spawning ..	17	8.74	4	3.94	0	8.31	21
number not spawning ..	85	93.26	42	42.06	97	88.69	224
	102		46		97		245

X^2 calc. = 16.94, df = 2 ; $X^2_{\alpha = 0.01}$ = 11.34 ; therefore reject H_0.

	Pentacerator horridus						
number spawning ..	2	2.03	2	1.30	1	1.67	5
number not spawning ..	9	8.96	5	5.70	8	7.33	22
	11		7		9		27

X^2 calc. = 0.79, df = 2 ; $X^2_{\alpha = 0.05}$ = 5.99 ; therefore fail to reject H_0.

A single act of spawning was observed in the field on 9 May. A female *P. lincki* was seen in an arched position with the disc raised. Eggs were being released in strings not from single gonopores but from numerous sites along the interarm regions of the disc.

Variation in Arm Number

All 27 *Pentaceraster horridus* present in the collections had five arms and no individuals were seen during my five week stay in Seychelles which had other than five arms. *Protoreaster lincki*, on the other hand, showed variation in arm number. Of the 245 individuals in the collections, six had six arms and one had seven (Table 6). The individual with six arms collected on 16 May did not have all arms complete to the mouth. Two arms fused before reaching the mouth so there were only five ambulacral grooves entering the mouth region. The other 6-armed individuals and the 7-armed animal all had the same number of grooves entering the mouth as they had arms.

Although not taken in the samples, a 4-armed individual was seen as well as other 6-armed animals. The observed frequency of atypical arm numbers is 2.8% of the entire sample of *P. lincki*. If this same percentage were true for *P. horridus*, I would expect about only one of the 27 individuals to have had an atypical arm number. Only a larger sample would show whether the two starfish species differ with respect to the frequency of atypical arm number.

TABLE 5. *Measurements of male and female starfishes. Sex determined by observing spawning individuals held out of water for about one half hour.*

	Protoreaster lincki					
	Size (cm) : tip of arm to opposite arm pit					
Males	12.78	13.08	13.51	13.85	14.11	14.35
	14.42	14.59	14.70	14.86	14.93	16.61
Females	14.41	14.71	15.39	15.53	15.66	15.74
	15.82	16.62	18.32			
	Pentaceraster horridus					
Males	14.00	14.81				
Females	12.73	14.02	14.17			

TABLE 6. *Variation in arm number of* Protoreaster lincki. *Samples from* 8, 9, *and* 16 *May* 1976.

	Number of animals			
Number of arms	8 May 1976	9 May 1976	16 May 1976	Total
5	98	44	96	238
6	4	1	1	6
7		1		1

Observations of atypical arm number would be of interest because most of the atypical numbers are probably due to damage during early post-metamorphosis and so a comparison of arm numbers should be one measure of the species' perception of its environment : the harsher the environment (either physically, biotically, or both) the greater would be the number of individuals with atypical arm numbers.

DISCUSSION

The two starfishes, *Protoreaster lincki* and *Pentaceraster horridus* in Seychelles, appear to show many of the characteristics of other starfishes and, based on the observations which were made, there are no real surprises.

The size structure showing very few or no small individuals appears to be common for tropical, hard-bottom asteroids and suggests long life and general low recruitment (Yamaguchi, 1973).

Sexual dimorphism with males smaller than females is known in other starfish. In *Asterina* sp. (Delavault, 1966; Buslé, 1969) it is interpreted as due to protandery. Size differences associated with sex have been shown in *Asterias rubens* (Vevers, 1952) and interpreted as due to differential death rates. Different growth rates and maximum sizes of the two sexes also would explain the size differences.

A reproductive season in April-May is not an unreasonable time for these animals based on the few records of spawning of other echinoderms in the Indian Ocean (Boolootian, 1966).

A possible problem with interpreting presence of spawning individuals in samples as indicating reproductive season is given by Crump (1971) who showed, with *Patiriella regularis*, that even when the gonads were small and recovering from the past spawning period, removing the animals from water and permitting them to dry would induce them to shed gametes. The change in number of *P. lincki* which shed gametes on the different days would argue against this explanation for this species. However, for *P. horridus* it is not possible to dismiss this potential criticism and, indeed, the only way to determine spawning season is to examine the population for an entire year.

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