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Some Preliminary Observations on the Biology of *Strongylocentrotus lividus* (Lamarck)

By

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INTRODUCTION

The sea urchins have been widely used for embryological studies due to reasons of convenience. Thus their developmental features are well known. The sea urchins have also been used as a source of food, (Kjerskog-Agersborg 1943, Scattergood 1947). However as Harvey (1956) and Comfort (1956) have remarked, very little is known of the biology of sea urchins.

Elmhurst (1922), Aiyar (1925), Moore (1934 - 1937), Bull (1938), Nataf (1954), Lewis (1958), and Swan (1958, 1961) have contributed to this field in a number of genera.

Moore (1934 - 1937) has studied growth in *Echinus esculentus* in different habitats. Swan (1961) has made a study of the growth rate in *Strongylocentrotus droebachiensis*. Bull (1938) has studied growth of *Psammechinus miliaris* under aquarium conditions. Nataf (1954) has studied growth in *Psammechinus miliaris* and *Paracentrotus lividus*. Lederer has studied nutrition in *Strongylocentrotus purpuratus*.

The present study of *Strongylocentrotus lividus* is an attempt to add to the knowledge in this field with particular reference to a tropical species of whose biology little is known.

The aim of the study was to examine the growth of the animals in relation to the development of their gonads, to elucidate the food preferences of the sea urchins and to study their associations with other animals.

Material and Methods

The study was made on the sandstone reef at Duwa, Negombo. This reef is continuous with the shore at its southern end and angles out from there to a distance of about 300 feet forming a barrier at the mouth of the lagoon. The patterns of zonation on this reef have been recorded by Arudpragasam and Ranatunga (1966). The reef flat is covered with a carpet of algae, consisting mainly of bands or patches of *Padina, Hypnea, Ceratium, Jania, Dictyota* and *Ulva*. The reef surface of the colony was slightly depressed and had a growth of *Jania, Centroceros, Padina, Ulva*, and *Gelidium*, whose distribution and quantity was not constant but varied during the period of the study. The colony selected for study was situated on the last large rock, (Figure 1) about 60 feet from land.

The criteria used to select the colony were :—

(1) Sufficiently well defined and so situated that is could be readily identified at each visit.

(2) Containing a large proportion of the smallest size of sea urchains occuring on the reef at the time the study was begun.

A detailed map of the sea urchins in their burrows was made. Each was assigned a number. No tagging was used as previous attempts at tagging had failed, no tagged individuals being found at subsequent visits. Bimonthly visits were made to the reef at spring low tides to make recordings. The measurements taken were diameter of test, diameter of burrow at it's widest point, depth of burrow at it's margin.

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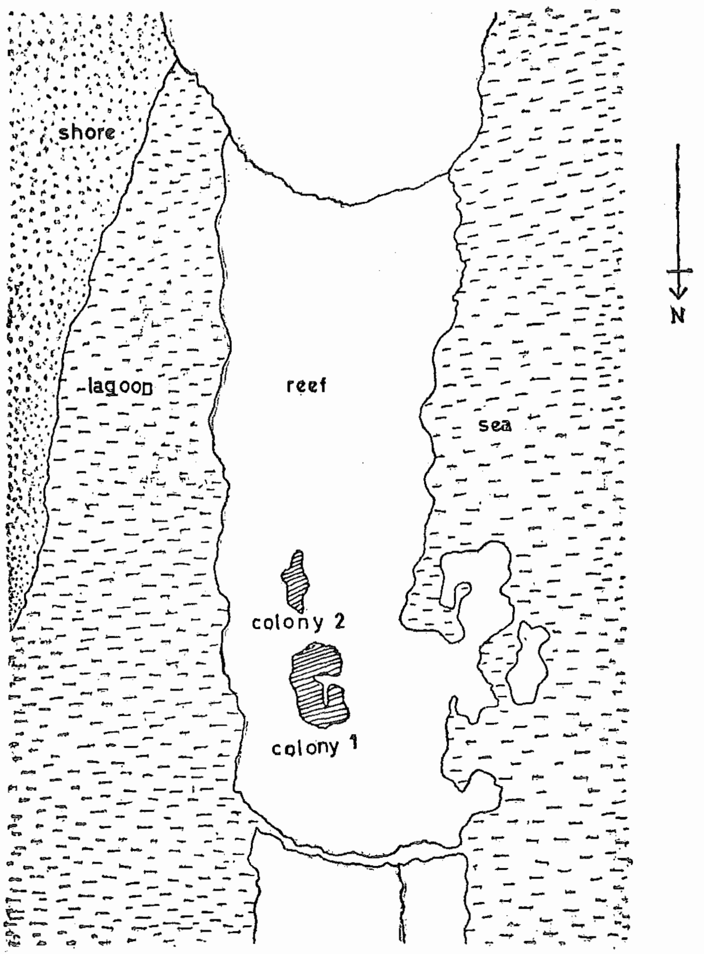

FIGURE 1.

SANDSTONE REEF AT DUWA

The test was measured at its greatet diamenter. The measurements were made with a pair of engineer's dividers, with fine long extremities and a plastic ruler graduated in millimeters. The readings were taken to the nearest 0.5 mm.

Ten sea urchins beloning to the same size class as the majority of the individuals selected for the study on growth were collected from the immediately surrounding areas at each collection. The gut and gonads were dissected out on shore. The gonads were fixed in Bouin's fluid in sea water and transfered to the laboratory. They were measured in the laboratory and the greatest width and greatest length recorded in each case. The gonads were embedded in Celloidin and Paraffin Wax, sectioned at 4–6 μ. and stained in Heindenhein's Haematoxylin by the rapid method using Ferric Alum as a mordant.

The study was commenced on the 13th, of December, 1966. Prior to this, work on the reef was not possible due to the mousoon conditions. These condtions cause heavy wave action which submerges the reef during this pericd. The study was concluded on the 27th of May, 1967 when the monsoon commenced again. During this period two colonies were successively studied, the second one being chosen when the first had been reduced by mortality to too few individuals. The second colony also from the same rock very close to the first, about 15ft. to the south of the first colony consisted mainly of individuals falling within the most frequent size range of the first colony at the previous reading.

RESULTS

I. Growth Rate

Table I shows the mean growth rate of the sea urchins from 13th December, 1966 to 13th February, 1967 in five groups of size ranges—5-10; 10-15; 15-20; 20-25; and 25-30mm. and as mean % increase in test diameter.

TABLE I

The mean growth rate of *S. lividus* between 13th December, 1966 and 13th February, 1967

Size Range	*Number*	*Growth Rate*			*Percent increase in test Diameter*
		Range	*Mean*	*Std. Dvn.*	
5-10mm.	1	—	2.3	—	30.6
10-15mm.	2	1.5-1.3	1.4	0.031	11.2
15-20mm.	7	1.2-0.48	0.75	0.229	4.3
20-25mm.	6	0.96-0.42	0.65	0.163	2.4
25-30mm.	8	0.69-0.11	0.34	0.180	1.3

As expected the rate of increase of the test of the sea urchins decreases with increase in diameter of the test. That is, the larger the sea urchin the slower the rate of growth. Thus the sea urchins would commence life with a rapid rate of growth which gradually drops off.

II. Devolopment of Gonad

Table II shows the monthly growth for the period December to March together with the state of the gonads. The state of the gonads is shown both in terms of mean volume as well as mean diameter of the gametocyte. In estimating the gametocyte diameter after differentiation of the gonads into testes and ovaries, the oocyte diameter was used. The sexes could be recognised from about the end of February. Figure 2 shows representative sections of the gonads.

From Table II it becomes apparent that there is a drop in growth rate as the gonads start developing. The state of development of the gametocyte remains more or less constant from January to February, but the volume of the gonad increases while the growth rate decreases.

The pattern of growth shown by the sea urchins, with a decrease in rate of growth related to increase in size, has been demonstrated for other genera and is the general pattern that applies to all animals.

The observed change in volume of the gonads from January to February, 1967 while the gametocytes showed no change in development, as indicated by diameter, indicates an increase in total tissue of the gonads. This is shown graphicaly in Figure 3. This period also shows continued reduction in the growth rate of the animals themselves as illustrated in the same figure.

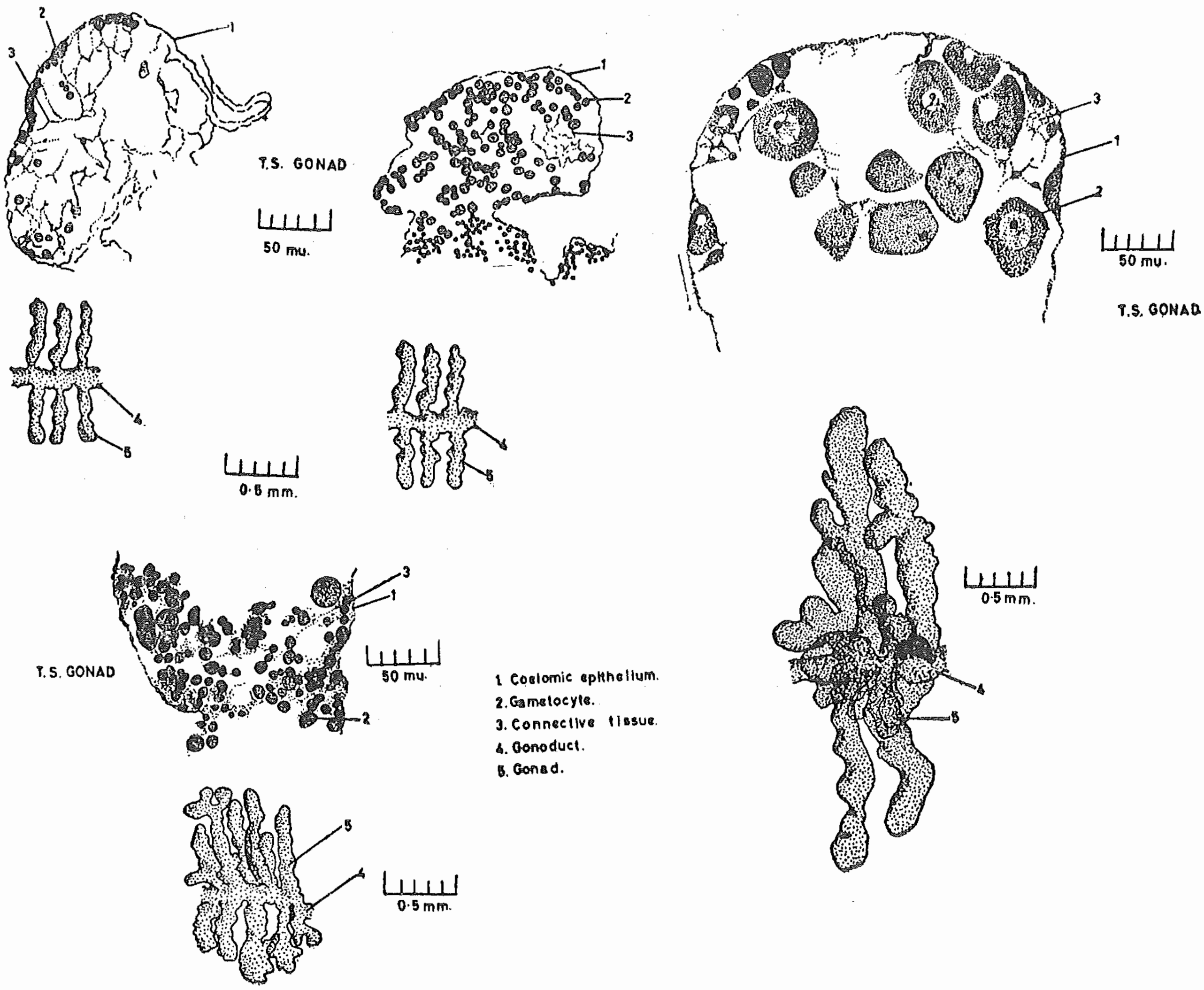

Fig. 2.—Representative Sections of Gonads of *Strongylocentrotus lividus*

TABLE II

Monthly growth rate of *S. lividus* for the period December to March and the State of the gonads during this period

Month	*number*	*Growth Rate*			*Gonad*			
		Range	*Mean*	*Std. Dvn.*	*Gametocyte Diameter (MU)*			*Mean Vol.*
					Range	*Mean*	*Std. Dvn.*	(cc)
Dec.	25	14.5 to 0.5	8.1	3.99	4.86 to 2.53	3.56	0.55	0.25
Jan.	23	13.0 to 0.00	2.98	1.57	16.15 to 6.25	12.06	2.67	0.43
Feb.	13	10.5 to 0.00	1.65	0.78	13.22 to 6.42	11.80	1.83	0.79
Mar.	12	1.00 to 0.00	1.04	0.75	51.53 to 38.91	45.28	3.89	1.33
Apr.	—	—	—	—	51.56 to 42.81	46.31	2.69	1.89
May	—	—	—	—	66.55 to 54.08	61.45	3.37	—

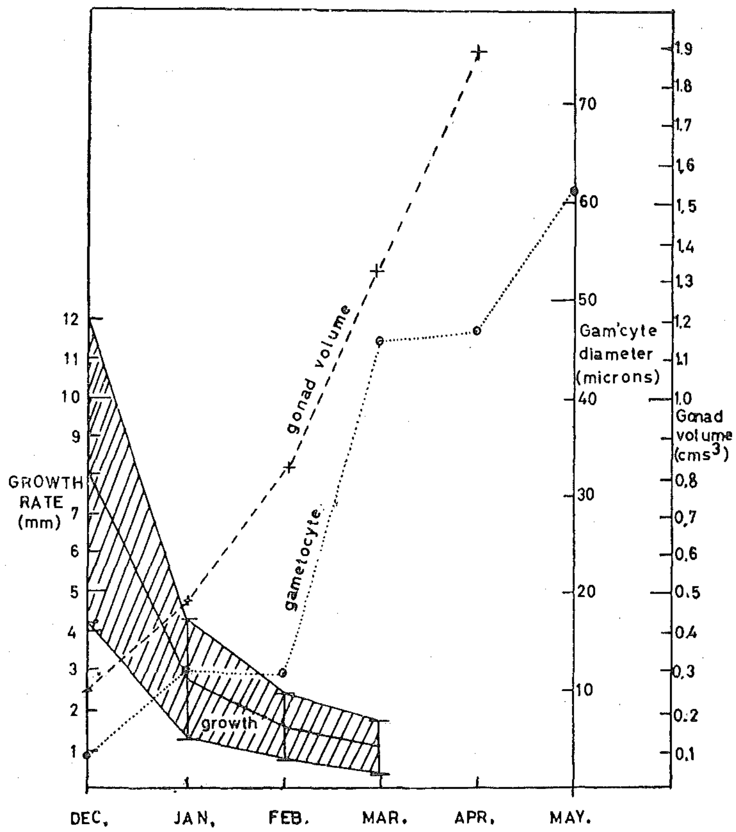

FIGURE 3.

Fig. 3.—Relative changes in volume of Gonads, gametocytes Development and the Growth Rate of the *Serongylocentrotus lividus*

III. Food Preferences

Table III shows the percentage frequency of occurrence of the various algae found in the guts of the sea urchins by microscopical examination.

It is apparent that the commonest and thus presumably the most preferred types of food ingested are *Ceramium*, *Sargassum* and *Polysiphonia*.

Table IV shows the frequency of occurrence in three catogories—over 60% occurrence, between 30 and 60 % occurrence and below 30% occurrence.

The examination of the gut contents shows that the only material ingested is algal. No animal remains were found in the contents of the guts of the sea urchins examined. However, in an exploratory study, when the animals were kept in aquaria they were found to ingest dying fish. The fish were held against the side of the tank by the spines while pieces were torn off with the teeth.

TABLE III—Percentage Frequency of Occurrence of Algae in the Guts

Algae	*Percent. Freq. Occ.*
Ulva	36
Polysiphonia	60
Colonial Green	36
Padina	8
Volvox	16
Dictyota	16
Zygnema	4
Ceramium	80
Oscillatoria	24
Diatoms	24
Jania	40
Levellia	12
Sargassum	60
Ulothrix	12
Mutebaria	4
Siphonostruvia	4
Chaetomorpha	8
Chaetophora	8
Oedogonium	8

TABLE IV—Categorised Frequency of Occurrence of Algae in the Guts

Percent. Freq. Occ.	*Algae*
0-30	Padina, Volvox, Dictyota, Zygnema, Oscillatoria, Diatoms, Levellia, Ulothrix, Mutebaria, Siphonostruvia, Chaetomorpha, Chaetophora, Oedogonium
30-60	Ulva, Jania, Colonial Green
60-100	Ceramium, Sargassum, Polysiphonia

IV. Animal Associations

Figures 4 and 5 are histograms representing the numbers of animals associated with the sea urchins. In figure 4, percentage relative frequency of occurrence of the animals associated is recorded. In figure 5, percentage frequency of occurrence of associated animals per sea urchins is recorded.

These show that the highest degree of association is with Trochids. Trochids occur fairly widely scattered over the reef, as do other animals found associated with the sea urchins. They occur on the floor of the burrow around the oral surface of the urchins.

The pistol shrimp (Fam. Alpheidae), although recorded with a low frequency, has been found in a number of studies on the ecology of the reef, only in association with the sea urchins. They lie camouflaged among the spines of the sea urchins. Due to their black colour they blend perfectly into the outline of the sea urchins and are not readily seen unless flushed out.

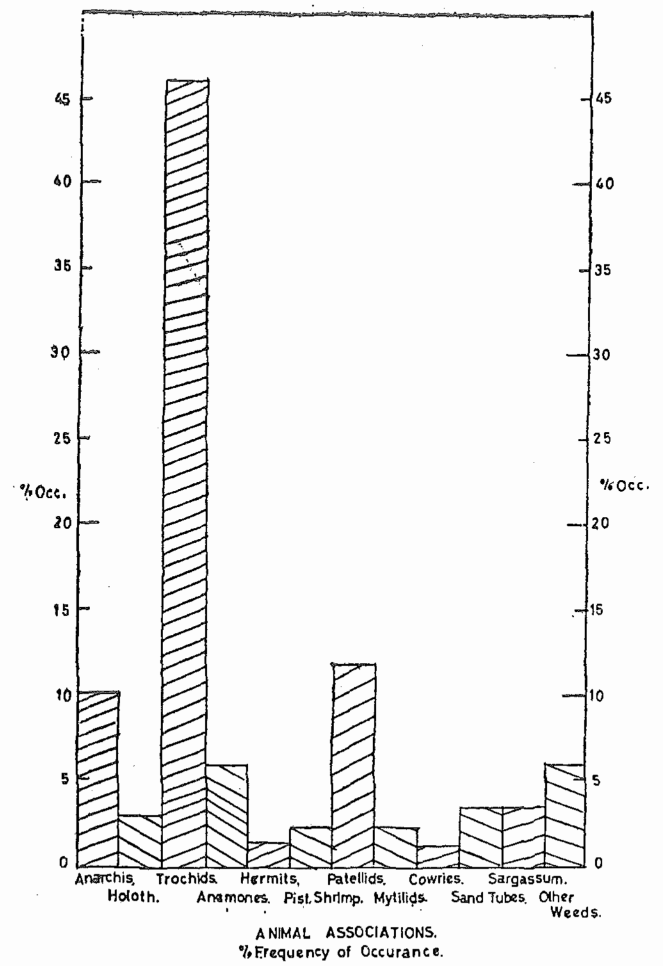

Fig. 4.—Animal Association—% Frequency Occurrence.

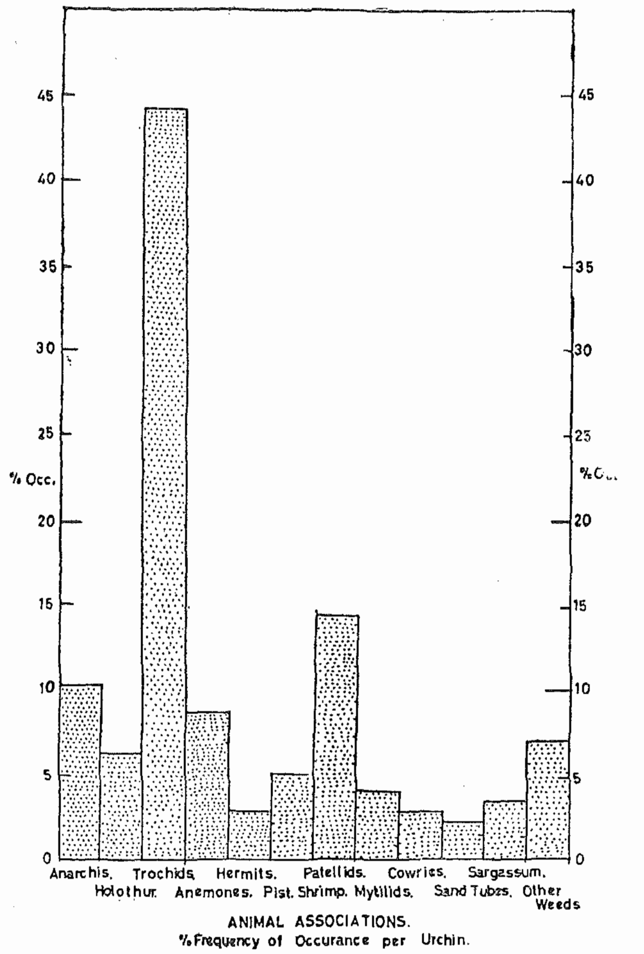

Fig. 5.—Animal Association—% Frequency of Occurrence per urchin.

DISCUSSION

(*a*) Growth and Maturation

The trend of reduction in the growth rate may be due to the increase in size of the animals as shown earlier. But, coupled with the reduction in growth rate there is development of the gonads. This could contribute to the reduction in growth rate, the material available from feeding being diverted to its sexual development. Moore (1937) working on *Echinus esculentus* has shown that the sea urchins stop growing when the gonads start maturing. Thus it appears that this is the cause for the reduction in growth rate in *Strongylocentrotus lividus*, but a further study, with particular reference to the pattern shown by individuals which survive the breeding season is necessary before any definite conclusions can be made in this respect.

The gonads of *Strongylocentrotus lividus* reaching maturity with the onset of the monsoon indicates a seasonal cycle of development. A similar monsoonal cycle has been demonstrated for other inter-tidal rocky shore fauna, particularly Patellids and Littorinids by Atapattu (1968). Since this study was confined mainly to first year individuals a confirmatory study including sea urchins of other year groups needs to be carried out.

(*b*) Food Preferences and Animal Associations

Hyman (1955) records that regular sea urchins ingest a variety of food materials. They are herbivorous, carnivorous and scavenging. Parker (1932) records that *Strongylocentrotus droebachienses* eats mostly plants but also ingests animal corpses. He also records instances where dead fish are eaten, their bodies being pinned to the sides of the tanks as observed in *S. lividus.* Lasker and Giese (1954) state that *S. purpuratus* in nature feeds on algae and other plants but in the laboratory would eat a variety of vegetables and meats. These observations could be interpreted as having been due to the artificial conditions imposed on the animals by their confinement to tanks. On the other hand it is also likely, and probably more so, that the lack of animal remains in the guts of sea urchins from their natural environment, is due to their inability to obtain such food. The sea urchins lack the means of trapping more active animals nor can they move fast. Under the conditions of life of these urchins any dead or dying animals could probably get washed out of reach of the sea urchins by wave action or be more easily captured by more active scavengers such as hermit crabs and crafs. However, it is possible that in calmer waters they could obtain such materials. This is probably the reason for the observation that the sea urchins show a variety of dietary habits. It is thus possible that the inter-tidal sea urchins hitherto believed to be herbivourous may be really omnivorous. This question merits further study.

From the percentage frequency of occurrence of the weeds in the gut contents of the sea urchins it appears that they are obtaining large amounts of *Ceramium, Sargassum and Polysiphonia.* Further, from an examination of the occurrence of weeds in the vicinity of the colonies it becomes apparent that *Sargassum* does not grow near the colonies. This alga grows on the reef only in the infra-littoral fringe (Arudpragasam and Ranatunga 1966). Hence it may be that the weeds are getting broken off and being carried to the sea urchins on whose spines they would stick. In this way the weed, would be made available by wave action to the sea urchins studied. On the other hand there is also the possiblity that the sea urchins are making foraging movements out to the edge of the reef in search of food. That this is not likely is shown by the fact that the sea urchins do not appear to leave their burrows. This is indicated by the fact that although no tagging was used in this study it was possible to obtain consistent readings of test diameter throughout the study. This would not have been likely if the animals had been making such extensive movements as they do not appear to have any obvious powers of orientation which would be required for them to navigate back to their burrows. However, further field studies should be made on this aspect.

The comparatively high occurrence of Trochids with the sea urchins with respect to other associated animals appears significant. It may be that the Trochids enter the burrows of the sea urchins to gain shelter from the wave action which is a feature of this region of the shore. On the other hand, the Trochids may be benefitting by the association but what the nature of the benefit is, is not clear at present. It has been observed that the Trochids tend to occur mostly on the floor of the burrows, near the oral surface of the sea urchin. Whether this fact has any significances is not clear.

There is also the possibility that the Trochids could be indirectly aiding the sea urchins in their burrowing into the rocks. The sea urchins burrow by scraping the surface of the rocks using both their teeth and their spines. It is also generally agreed that algae play a large part in binding debris together and preventing or slowing down erosion on reefs. The Trochids, by grazing on the algae that grow on the periphery of the base of the burrow, which the sea urchin itself could not reach with it's oral apparatus, could be aiding the sea urchin in its burrowing, by preventing compacting of the substrate.

The definite association of the pistol shrimp with the sea urchins appears to be one of protection for the shrimp. As mentioned earlier the shrimps are not readily visible unless flushed out from among the spines of the sea urchins. Thus they would not be readily visible to a predator and any predator that attacks the shrimp among the spines of the sea urchin would be exposing itself to the danger of being impaled upon the spines.

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