Shell Shape Variation & Habitat Characteristics of *Littorina undulata* (Gray, 1839) from Mandapam Waters, East Coast of India

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Shell size, shape and lipthickness of *L. undulata* were studied. High percentage of the larger shells (C), smaller shells (A) and medium shells (B) was collected respectively from low water, high water and mid water mark. In high water mark, mean shell height was low compared to mid water and low water mark. High percentage (20.52%) of damaged shells was observed in low water mark when compared to mid water and high water mark. Abundance of damaged shells and high value of lipthickness were observed in C type shells, while low values were observed from type A. These shell characteristics were correlated with age and habitat features.

Shell shape, shell size and lipthickness show a high degree of variation in littorinids. These variations are found to exist between different and within a single population[1,2]. Information on shell size and shape variations of littorinids from Indian waters is scanty. This paper presents the relationships between variations in shell shape, size and lipthickness and ecological stress in a population of *Littorina undulata*.

Materials and Methods

Live specimens of *L. undulata* were collected from Mandapam rocky shores (lat. 9°16′40″N, long. 79°30′E) at low tide, on several occasions during Dec. 1984-March 1985. The samples were collected from low water mark, mid water mark and high water mark levels. Hand picking was done for the collection of snails from the crevices between and underneath boulders. Only adults, with shells larger than 11 mm in height, were selected for this study. The mean shell height and percentage of damaged shells were estimated from each water mark.

The shell characters were observed and measured using dial callipers with an accuracy of 0.1 mm. Three types of shells (A, B and C, Fig. 1) were observed in this population, and the percentage of damaged shells were also noted in each type.

The lipthickness was measured in the middle of the lip approximately 1 mm inside the aperture. It is assumed that lipthickness is representative of total shell thickness and strength of the shell[3,4]. The variation in lipthickness was obtained by applying t-test between shell types C and A, B and A; and C and B. Relative shell width (b/a), relative spire height [(a − c)/a] and relative aperture width (d/c) where a = shell height, b = shell width, c = aperture height and d = aperture width, were subjected to correlation analyses[5].

Results

The shell types (Fig. 1) A and C differ from each other in the shape at the basal part of the outer lip and size. The outer lip of the shells of A type merges with the body whorl at an acute angle near or above the broadest part. Type C shows shells with more lipthickness and are bigger in nature with rounded aperture. The lower suture of A is less deeper than type C. The aperture is narrower in A compared to C individuals.

Maximum value of lipthickness ($\bar{X}$ = 0.4404

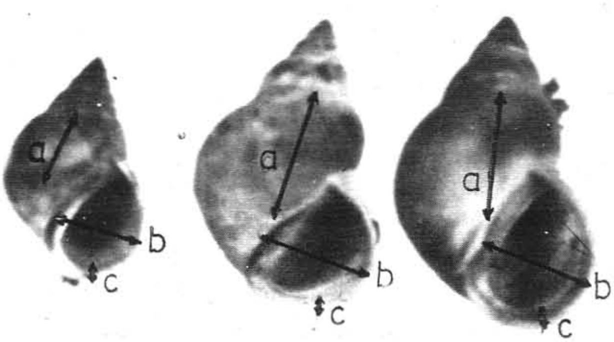

Fig. 1 — Shell types observed in *L. undulata* (a — spire height, b — aperture width, c — lipthickness)

*Present address: Central Electro-chemical Research Institute, Karaikudi 623 006, India mm) was observed in C type and minimum ($\bar{X}$ = 0.301) in type A. Values were significant between C and A, and B and A.

Larger, smaller and medium shells were respectively observed from low water, high water and mid water mark. Type C shells are available in all size groups except 11.0-11.9 mm. The percentage of type A individuals was relatively high for small specimens (11.0-15.9 mm). The proportion of type B individuals was high for the shell height intervals between 14 and 16.9 mm.

Mean shell height of *L. undulata* was 13.9, 15.2 and 17.2 mm respectively in high, mid and low water mark. High percentage of damaged shells (20.52%) was observed from low water mark when compared to mid water and high water levels (15.9%) as in Table 1. While the percentage of C type shells collected from low water mark was 91%, the corresponding values for A and B type shells at high water and mid water mark levels were 95% and 86%.

Assuming that the relationship between shell height and relative spire height is not a linear one[5], a regression analysis was made which yielded the following relationship

$$Y = \frac{a-c}{a} \quad \text{and} \quad x = a$$

Correlation coefficient *r* (Fig. 2) gave reliable estimate for the level of significance and *t* test was used to test the significance of *r* value. Significant value ($P<0.05$) was observed between shell height and relative spire height (r= 0.4054) and between shell height and relative aperture width (r= 0.4755). Between shell height and relative shell width the *r* value (− 0.2063) was not significant ($P>0.05$). The regression of relative spire height on shell height and of relative aperture width on shell height contributed considerably to total variance. On the other hand, the variance due to regression of relative shell width contributed only slight total variance.

Table 1 — Number of Different Shell Types and Damaged Shells for the Various Size-Groups (Shell Height — Interval 1 mm) of *L. undulata.*

Shell height (mm)	Shell Types No.			Damaged Shells No.		
	A	B	C	M_A	M_B	M_C
11.0-11.9	10	2	0	0	0	3
12.0-12.9	36	9	5	0	0	18
13.0-13.9	33	22	6	0	2	5
14.0-14.9	54	33	28	5	6	2
15.0-15.9	42	52	23	1	3	7
16.0-16.9	7	34	22	6	1	1
17.0-17.9	9	15	28	2	4	2
18.0-18.9	1	4	25	0	6	0
19.0-19.9	0	4	8	1	0	0
20.0-20.9	0	0	4	0	3	0
21.0-21.9	0	0	2	0	1	0

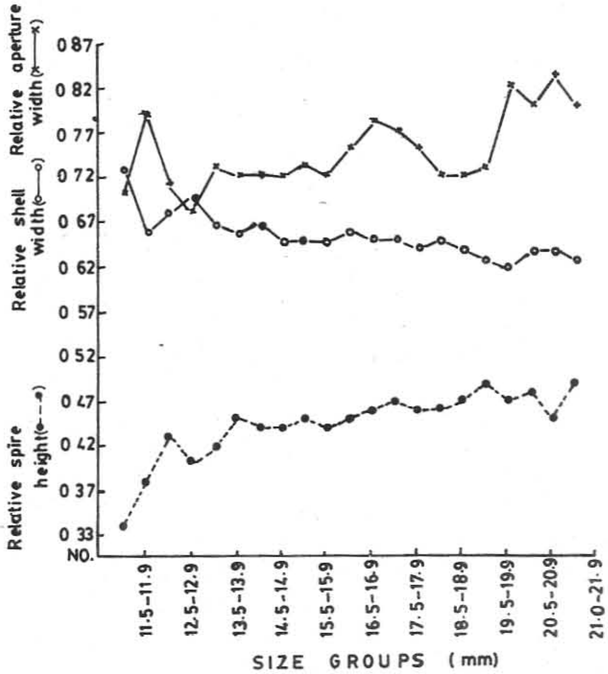

Fig. 2 — The relationship between shell height (size groups) and relative aperture, relative shell width and spire height

Discussion

In the present study, high percentage of C type (larger) shell were found in low water mark and A type (smaller) shells in high water mark contrary to earlier reports[6,7]. The present results agree well with that of Heller[1] and, Elner and Raffaelli[8]. This could be due to more intense crab predation at lower shore levels selecting against small shells[8]. Due to the thigmotactic behaviour to reduce desiccation hazard, the A type of shells were found in high water mark[9].

When exposed to air, the littorinids avoid desiccation by completely withdrawing into the shell and by secreting mucous which binds them firmly to their substratum. Thin and light shells (A) survive better at highwater. Here the mucous film could easily hold the shell for a long period of time as observed in *L. nigrolineata* and *L. rudis*[1]. In highwater mark, type A shells are protected from predators and so percentage of damaged shells are less in this type. Since the small, light shells easily confine themselves in cracks and crevices, they are protected against predators than the large one which are more vulnerable to damage. High percentage of damaged shells is observed from C type in low watermark level due to the crab predation[1,3,4,10].

The difference in shell lipthickness between A type and C type, and A type and B type was well pronounced ($t = 3.4167$; $P < 0.05$ and $t = 2.8997$; $P < 0.05$ respectively). The shell lipthickness was high in C type and low in A type. The variation was mainly due to the increased size of the animal which is necessary for the animal's protection against predation. Biological significance of a large, heavy shell (lipthickness is high) appears to be its stronger resistance to attacks by the shore crabs *Neoepisesarma* sp. and *Scylla serrata*. This observation agrees well with that of Vermeij[11] and Raffaelli[12].

Shell height and relative aperture width show a positive correlation. As a result, in larger shells, the aperture width is large. Hence this shell could accomodate larger mass of foot muscles. The increase of relative aperture width provides greater area of adherence of the foot to the rock and consequently it offers stronger resistance to wave and wind force.

As a result of growth, A type shell gradually becomes C type. During this process, increase in aperture width causes a relative decrease in aperture height. Both these changes are due to shell shape variation which is solely attributable to their consistency with the habitat. The correlation coefficient of relative spire height and relative aperture width on shell height are significant as a result of shell shape variation. But the shell height bears a negative correlation with relative shell width, as the relative shell width does not influence the shell shape variation.

In older individuals the shells become thicker because of the increased secretion of calcium carbonate. During growth, change in the base of the outerlip, increase in relative aperture width and decrease in relative aperture height influence the angle of joining of outerlip at the top, making it less acute. Present observations on shell shape variation confirm and amplify earlier work by Peter Von Marion[5]. These changes take place along with the gradual increase in the thickness of the outerlip. The shell shape variation takes place when the animals of A type gradually become B and C type, with the simultaneous movement to low water mark where their variation in shape is much needed to overcome ecological stresses like wind, wave action and predation. The shore level size gradient results in a pattern of distinct zones of littorinids, but it may also lead to differences in the degree of intraspecific competition, food availability and predation in different parts of an animal's vertical range. In fact, the variation due to age and adaptation of shell characters to their ecological demand may account for a greater proportion of the total variation.

A further study regarding, shell shape variation and their probable ecological causes may help understand the nexus between littorinids and their habitat.

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References

1 Heller J, *J Zool Lond*, **179** (1976) 201.
2 Goodwin J & Fish J D, *J Moll Stud*, **43** (1977) 241.
3 Raffaelli D, *J Moll Stud*, **44** (1978) 166.
4 Maruthamuthu S, G A Thivakaran, K Sriraman & Kasinathan R, *Indian J Mar Sci*, **14** (1985) 160.
5 Peter V, *J Moll Stud*, **47** (1981) 99.
6 Raffaelli D & Hughes R N, *J Ani Ecol*, **47** (1978) 71.
7 Raffaelli D, *The determinants of zonation patterns of Littorina neritoides and the Littorina saxatilis species-complex*, Ph.D. thesis, University of Wales, 1976.
8 Elner R W & Raffaelli D G, *J Exp Mar Biol Ecol*, **43** (1980) 151.
9 Sudarshan R & Neelakantan B, *Indian J Mar Sci*, **10** (1981) 385.
10 Edithzibser & Vermeij J, *J Exp Biol Ecol*, **31** (1978) 155.
11 Vermeij G J, *Ecology*, **53** (1972) 693.
12 Raffaelli D, *J Moll Stud*, **48** (1982) 342.