Indian Journal of Marine Sciences
Vol. 8, March 1979, pp. 12-15

Growth Studies on *Clypeomorus clypeomorus* Jousseaume (Gastropoda : Cerithiidae) from the Visakhapatnam Coast

L MANMADHA RAO & D V RAMA SARMA
Department of Zoology, Andhra University, Waltair 530003

Received 6 October 1978; revised received 27 November 1978

Growth rate of *C. clypeomorus* has been measured employing analysis of population sampling and calculation of absolute growth rate. Height and age relationships of the snail are studied. Results show clear seasonal variation in growth rate of the snail, maximum shell height of 18 mm and survival period of 1 yr. It attains sexual maturity at shell height of 11-12 mm and breeding is continuous. The small size and relatively short life span may be due to early attainment of maturity and continuous reproductive activity.

Investigations have been made on the growth rate and the effect of growth on the shape of the shell in different molluscs[1-9]. Population sampling and absolute growth rate methods are important among the various methods[8,10-14] employed in the growth rate studies of molluscs. An attempt has been made here to study the growth rate in *Clypeomorus clypeomorus* Jousseaume employing both population sampling and absolute growth rate methods. Attempts have also been made to follow the height and age relationships and the changes in the form of the shell with growth of the animal.

Materials and Methods

Monthly observations were made during September 1974 to August 1975. Animals were collected at random from a unit area (1 m^2) at mean low water neaps. Different parameters such as shell height and breadth, width of the opening and height of the spire were measured to the nearest millimetre with a vernier calipers. The data thus obtained were used to draw the monthly height frequency distribution of the collection. Growth rate was determined from the shift in the modal length. Monthly mean values of the shell height were plotted to show the monthly population growth.

Absolute growth rate was studied by the method of Ward[8]. Observations were made in the laboratory on snails of 6 size groups (6,7,8,9,10 and 11 mm) employing 10 animals in each. Animals of each size group were placed separately in glass troughs (2 l). Small stones with the alga *Chaetomorpha*, collected from the same habitat of the snails, were placed in the troughs. Sea water was replaced once in every 24 hr.

Measurements were taken at monthly intervals and the mean shell height in each size group was calculated. These observations were made for 2 months only as the animals did not survive any longer under laboratory conditions.

To determine the composite picture of growth the above data were first plotted as the regression of height at time $t+1$ on height at time t using the equation

$$H_{t+1} = mH_t + i \quad \text{... (1)}$$

where m is the slope of the line and i the vertical intercept[15,16]. As a second step towards determining the height and age relationship of the snail von Bertalanffy[17] growth equation was used.

$$H_t = H\infty \; (1\text{-}e^{-k(t-t_0)}) \quad \text{... (2)}$$

where $H\infty$ is the asymptotic height, k the growth coefficient and t_0 the theoretical age at height zero. The other details in the methods employed are given at relevant places.

To study the changes in the shape of the shell as the snail grows in size, the method adopted by Russel[1] in *Patella vulgata* and Abe[5] in *Acmaea dorsuosa* was followed. Ratios of shell height to shell breadth, shell height to width of the aperture and shell height to height of the spire were calculated. Only the means of these ratios were taken for the presentation of the data. Mean ratios were arranged in 3 mm height groups to study variations in the form of the shell as the animal increases in height.

Results

Analysis of population—A total of 1200 (100 in each month) animals have been examined from September 1974 to August 1975. The shell height frequency for different months is illustrated in Fig. 1. The age classes in the population of *C. clypeomorus* are not distinctly clear. However, the presence of 2 modes in some of the samples suggests that there is more than one age group in the population. It is clear that young animals get added resulting in a numerical increase of the population in November and May, and many old well grown shells consequent on the death of snails harbour hermit crabs. The younger animals attain their breeding size within 5 months and start breeding soon after. The mean shell heights of various months are presented in Fig. 2. The mean shell height of the population in September is 14.94 mm. In October it reaches maximum of 15.84 mm. In November as more young animals are added to the population and as the older die off, mean shell height has dropped to 12.5 mm. In December there is a further decrease in the shell height to 11.6 mm due to the addition of younger animals in increased numbers. Later there is a gradual increase in the shell height up to April. The mean shell height has again fallen to 11.8 mm in May due to the addition of young animals to the population. Thereafter, there is a gradual increase. It is clear from Fig. 2 that the number of animals of larger size increase once in September-October and again in March-April. Large number of animals are added to the population twice a year, once in November and again in May.

Growth curves (absolute growth)—Results of observations made on the absolute growth rates of the snail are presented in Tables 1 and 2. Mean shell heights in the 6 size groups increase progressively from November to January with an average monthly increment of 1 mm.

To obtain a composite picture of growth the results of absolute growth rates were first plotted as the regression of the height at time $t+1$ on height at time t using the eq. 1. Values of H_t and H_{t+1} in the equation can be obtained directly from the results of absolute growth rates in Table 1. The values thus obtained are given in Table 2. The constants *m* and *i*, calculated by the method of least squares, are 0.8714 and 2.2429 respectively.

The relationship between H_{t+1} and H_t is linear and the line describing the relationship intercepts the 45° diagonal at an H_t value of 17.6 mm. This value is an estimate of the maximum theoretical height which *C. clypeomorus* can possibly attain and it coincides fairly closely with the field observations. The maximum shell height recorded in the course of this study is 18 mm.

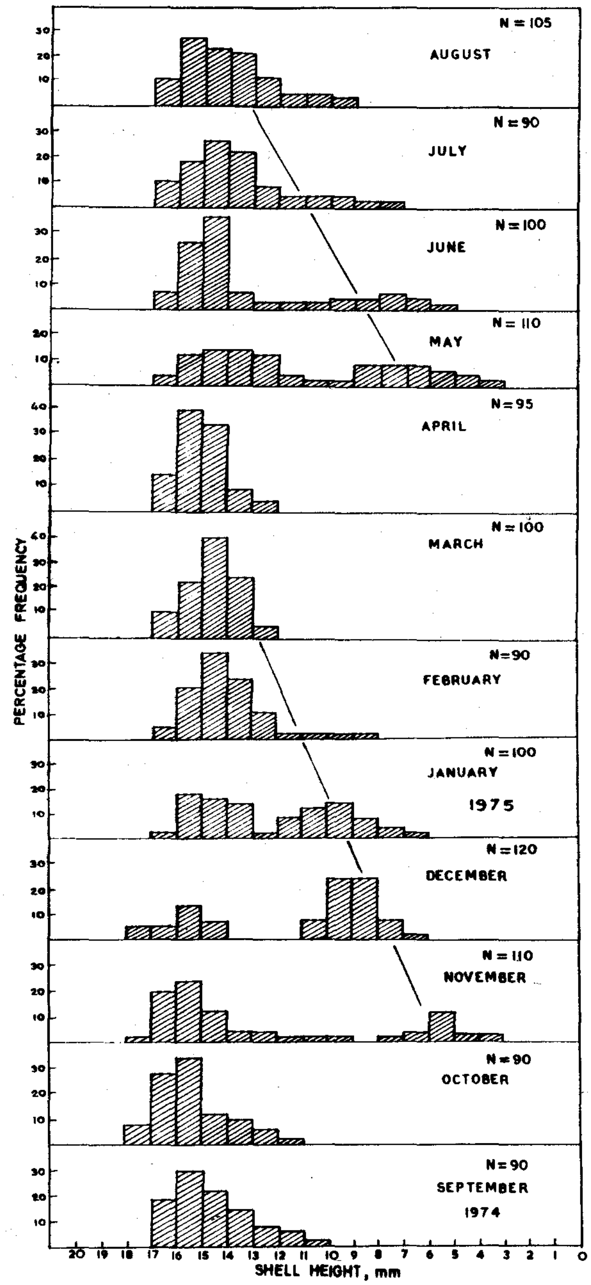

Fig. 1—Shell height frequency distribution of *C. clypeomorus* from September 1974 to August 1975

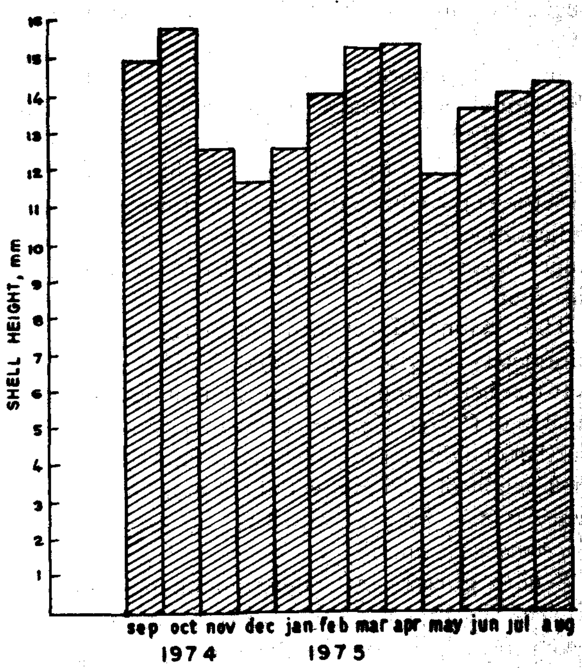

Fig. 2—Mean shell heights of *C. clypeomorus* in different months

Table 1—Absolute Growth in Shell Height of Different Size Groups

[Number of animals in each size group is 10]

Size group	Height of shell in November (mm)	Av. increment in shell height (mm)	
		December	January
1	6	1.5	1.2
2	7	1.3	1.1
3	8	1.2	1
4	9	1.1	0.9
5	10	1	0.8
6	11	0.8	0.7

Table 2—Values of H_t and H_{t+1}

H_t (mm)	H_{t+1} (mm)	H_t (mm)	H_{t+1} (mm)
6	7.5	9.2	10.2
7	8.3	10	11
7.5	8.7	10.1	11
8	9.2	11	11.8
8.3	9.4	11.8	12.8
9	10.1		

As a second step towards determining the height and age relationship of the snail eq. 2 was used. $H\infty$ and k in the equation can be obtained as $H\infty = i/(1-m)$ and $k = (-\log_e m)$ and the values calculated are 17.66 and 0.3119 respectively. As for the other parameter t_0 to be calculated in the equation, Ward[8] found that t_0 in the key-hole limpet, *Fissurella barbadensis*, is negligible. Similar observations were also made by others[18,19].

In *C. clypeomorus* the age cannot be obtained from the annual rings because of the continuous and slow growth of the snail. Direct observation on the newly settled snails is not possible as the veliger larvae failed to settle in the laboratory aquaria. However, there are indications (Table 1) that the growth rate in the early stages is very rapid suggesting that t_0 is negligible in this snail.

The estimated growth in terms of various parameters is given in Table 3. The relationship between height and age of the snail indicates that the growth of *C. clypeomorus* occurs in a sigmoid fashion. Further, it indicates that the snails attain the maximum shell height of 17.5 mm within 12 months of age and hence it may be presumed that the life span of *C. clypeomorus* is about 1 yr.

Relative growth—After determining the growth rate of shell height, the increments in different shell dimensions have been calculated by linear regression equations using the method of least squares. In the present study the following relationships are described: Shell height/shell breadth; shell height/width of the opening; and shell height/height of the spire. Average breadth, width of the opening and height of the spire of various size groups during the study period are given in Table 4.

Shell height/shell breadth: Relation between the shell height and shell breadth is linear and the regression equation for this is

$$B = 0.65\ H - 0.27$$

where B is breadth and H shell height in mm.

Shell height/width of opening: Mean widths of the opening against the mean shell heights showed a linear straight line regression and the equation for the above relationship is

$$WO = 0.36\ H - 0.13$$

where WO is width of the opening and H shell height in mm.

Shell height/height of spire: Mean heights of all the spires against the mean shell height also showed a linear relationship and the regression equation for this is

$$S = 0.60\ H - 0.33$$

where S is height of the spire and H shell height in mm.

Table 3—Estimated Growth (mm) in Various Parameters

Age (months)	Shell height	Shell breadth	Width of opening	Height of spire
2	7.9	4.9	2.7	4.4
4	12.35	7.7	4.3	7.1
6	14.7	9.3	5.2	8.6
8	16.2	10.2	5.7	9.5
10	16.9	10.6	6	9.9
12	17.2	10.8	6.1	10.1

Table 4—Average Breadth, Width of Opening and Height of Spire of Various Size Groups during September 1974 to August 1975

[All values are in mm]

Size group	Breadth of shell	Width of opening	Height of spire
3- 3.9	2.5	1.5	2
4- 4.9	2.7	1.6	2.1
5- 5.9	3.7	2	3
6- 6.9	4.3	2.3	3.3
7- 7.9	4.8	2.5	3.9
8- 8.9	5.6	2.9	5.2
9- 9.9	6.3	3.1	5.7
10-10.9	6.9	3.5	6.3
11-11.9	7.4	3.7	6.8
12-12.9	7.7	4.1	7.2
13-13.9	8.1	4.6	7.8
14-14.9	8.8	5	8.5
15-15.9	9.3	5.8	9
16-16.9	10.3	6	9.4
17-17.9	10.6	6.1	9.7

Changes in shape of shell with growth—Changes in the shape of the shell of the snail as it grows in height were studied by taking the mean ratios of dimensions of the shell and by arranging them in different height groups as shown in Table 5.

Ratio of height to breadth: This ratio increases steadily from young animals to adult animals indicating that the shell grows in breadth steadily along with the growth in height, which is uniform throughout the growth period.

Ratio of height to width of opening: A steady increase in this ratio is seen from 3-6 mm size group to 9-12 mm size group. After 9-12 mm size group the ratio decreases slightly and is almost constant in the remaining 2 size groups. This indicates that up to 9-12 mm the growth in the shell height is more rapid compared to the growth of the opening (aperture). Afterwards the aperture gets thickened and so the width increases.

Ratio of height to height of spire: In this case a steady decrease is noticed from 3-6 mm size group to 12-15 mm size group. However, in case of adults this ratio is observed to increase. This indicates that after 12-15 mm size, the shell height increased because of the growth of the outer lip of the aperture of the body whorl, while the growth of the spire is negligible, where as the shells below 12-15 mm size it was vice versa.

Table 5—Variations in the Ratios Height/Breadth, Height/Width of the Opening and Height/Height of the Spire with the Growth of the Snail

Size group (mm)	Height/ breadth	Height/width of opening	Height/height of spire
3- 6	1.38	2.5	1.8
6- 9	1.5	2.9	1.77
9-12	1.5	3	1.66
12-15	1.57	2.83	1.65
15-18	1.64	2.82	1.78

Discussion

There is no indication of a clearcut seasonal variation in the growth rate of *C. clypeomorus*. It appears to be steady throughout the year unlike in earlier reports on other molluscs[8,18–23].

Comparison of the shell height and age relationship of *C. clypeomorus* with the closely related *Cerithium* species of Florida, shows that the members of the latter genus attain shell heights more than that of *Clypeomorus*, but the life span appears to be same in both the cases. *C. clypeomorus* attains a maximum shell height of 18 mm and survives for about 1 yr. It is an established fact that in tropical waters the animals are subjected to higher temperatures which results in increased initial growth, precocious maturity and shortening of life span of the organisms[24]. Ward[8] has attributed the smaller size of the limpets at Barbados to the intensive reproductive activity of the animals. Observations made while studying the breeding habits have shown that *C. clypeomorus* attains sexual maturity at a shell height of 11-12 mm and the breeding is continuous. Further from the sigmoid growth curve it is seen that the animals measuring 11-12 mm height are about 5 months old. Therefore, the small size and relatively short life span of *C. clypeomorus* may be due to the early attainment of maturity and nearly continuous reproductive activity of the animals on the Visakhapatnam coast.

Acknowledgement

The authors thank the CSIR for awarding J.R.F. to one of them (L.M.R.) during the tenure of which the present work had been done. Thanks are due to Prof. K. Hanumantha Rao, Head of the Department, for his interest and to the authorities of Andhra University for the facilities provided.

References

1 Russel E S *Proc Zool Soc Lond* **97** (1909) 235.
2 Orton J H *J mar Biol Ass UK* **15** (1928) 863.
3 Fischer-Piette E *J Conchyliologie* **84** (1941) 300.
4 Comfort A *Proc malac Soc Lond* **31** (1957) 219.
5 Abe N *Sci Rep Tohoku Univ* **7** (1932) 347.
6 Hamai I *Sci Rep Tohoku Univ* **12** (1937) 71.
7 Graham A & Fretter V *J mar Biol Ass U K* **26** (1947) 590.
8 Ward J *Bull mar Sci* **17** (1967) 299.
9 Wilbur K M & Owen G *Physiology of mollusca* Volume 1 (Academic Press, New York & London) 1964, 211.
10 Rao H S *Rec Indian Mus* **38** (1936) 473.
11 Rao H S & Raja K C K E *Rec Indian Mus* **38** (1936) 499.
12 Houbrick R S *Nautilus* **88** (1974) 14.
13 Kubo K *J Tokyo Univ Fish* **34** (1953) 119.
14 Sakai S *Bull Jap Soc Scient Fish* **28** (1962) 89.
15 Walford L A *Biol Bull* **90** (1946) 141.
16 Taylor C C *J Cons Perm Int Explor Mer* **25** (1959) 93.
17 Bertalanffy L von *Hum Biol* **10** (1938) 181.
18 Balaparameswara Rao M *Studies on some aspects of the biology of the limpet Cellana radiata (Gastropoda:Prossobranchia) of the Waltair coast* Ph.D. thesis, Andhra University, Waltair, 1970.
19 Rama Sastry R V *Studies on the biology of a littoral snail Turbo intercostalis Menke (Gastropoda:Turbinidae) of the Waltair coast* Ph.D. thesis, Andhra University, Waltair, 1970.
20 Newman G G *Investl Rep Div Sea Fish S Afr* **67** (1968) 1.
21 Loosanoff V L *Address to National Shell Fisheries Ass Atlantic city, New Jersy* 1952.
22 Rao K V *Proc Indo-Pacific Fish Coun* II (1951) 94.
23 Abraham K C *J Zool Soc India* **5** (1953) 163.
24 Naylor E in *Advances in marine biology* edited by F.S. Russel and C.M. Yonge, Volume 13 (Academic Press, New York & London) 1965, 63.