Age, growth and morphometry of the limpet *Cellana eucosmia* (Mollusca: Gastropoda) From the Gulf of Suez

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A total of 750 specimens of *Cellana eucosmia* were measured for growth, age determination and intra and interspecific variations in its shell morphometry. The longevity of *Cellana eucosmia* was extended to 5 years. The values of von Bertalanffy growth parameters \( (L_\infty , K \text{ and } t_0) \) were estimated by two different methods. The growth increment was 38% and 4.9% of the asymptotic length \( (L_\infty = 44.1 \text{ mm}) \) during the I-II year and IV-V year, respectively. The average value of relative coefficient of condition \( (Kn) \) was about 1.3. The average ratio of posterior to anterior shell sloping walls was 1.499. The regression constants \( A \) and \( B \) for the various relationships of shell length to breadth, height and sloping walls, were studied.

Limpets represent a major rocky fauna of the intertidal regions. The growth rate of many species of limpets has been studied using different techniques such as labeled animals, \(^1\) annual growth rings, \(^2\) and the distribution of size cohorts. \(^3\) The tidal height has an effect on the growth rate of limpets and causing their intra and interspecific variations. \(^4\) Moreover, seasonal changes, food availability and sexual maturation have been found to induce some morphometric changes in limpets. \(^5\) *Cellana eucosmia* is one of the common limpets in the intertidal rocky beaches of the northwestern region of the Red Sea. The present work aims to study the longevity, growth parameters and various shell morphometric relationships of this species and also for comparison of stocks from various localities.

**Materials and Methods**

A total of 750 limpets of *Cellana eucosmia* (Mollusca: Gastropoda) were collected from Ain Soukha on Gulf of Suez (lat. 29°-30° N, long. 32°-33° E) from January to April 1996. The collected specimens were brought back to the lab where the shell length \( (L) \), maximum shell breadth \( (B) \), shell height \( (H) \) and lengths of shell sloping at the anterior \( (L_1) \) and posterior \( (L_2) \) extremities were measured using vernier calipers (Fig. 1). The total body wet weight \( (TW) \) and the shell weight \( (SHW) \) were noted. The age at different animal lengths were determined by the analysis of polymodal length-frequency distributions using the modified (integrated ) Petersen method. \(^6\) In this method, limpets were divided into size groups of 2 mm length intervals. The theoretical growth in length was computed using the following equation:

\[
L_t = L_\infty [1 - e^{-K(t-t_0)}]
\]

where \( L_t \) is the length at age \( t \), \( L_\infty \) is the asymptotic length, \( K \) is the growth coefficient and \( t_0 \) is the age at which the length is nil. The constants \( L_\infty \) and \( K \) were calculated by applying the method of Walford \(^7\) and Gulland & Holt \(^8\) to the empirical length-age data obtained by the integrated method. The growth parameter \( (t_0) \) was determined graphically, based on the following equation:

\[
t_0 = 1/K \text{ Loge} \left( \frac{(L_\infty - L_t)/L_\infty}{} \right) + t
\]

where, \( L_t \) is the length at age \( t \).

The regression constants \( (a=\text{intercept}, n=\text{slope}) \) of the length-total wet weight and the length-shell weight equations were computed using WTLN-computer program. \(^9\) These equations were:

\[
TW = aL^n, \quad SHW = aL^n, \quad L_1^n, \quad L_2^n
\]

where \( TW \) and \( SHW \) are the total weight and shell weight, respectively; \( L \) is the limpet length; \( (a, n) \) and \( (a_1, n_1) \) are the intercepts and slopes of the length-total weight and length-shell weight, respectively.
The relative coefficient of condition (Kn) measures various ecological and biological factors that affect the growth rate, reproduction, degree of fitness, and suitability of the environment with regard to the feeding condition. Kn was calculated from the equation\(^{13}\):

\[
Kn = \text{observed weight} / \text{calculated weight}
\]

The linear regression equation (\(L = A + B\), where \(A\) and \(B\) represent the intercept and the slope of straight line, respectively) was used to estimate the relationships between the shell length to shell breadth, height, and anterior and posterior shell sloping walls.

The Students’ \(t\)-test was used to investigate the deviation of the shell allometry from the isometric B value (\(B=1\)).

**Results**

**Population structure, age and growth**—The frequency distribution of the different size groups for 750 specimens of the limpet Cellana eucosmia is shown in Fig. 2. There are at least 4 cohorts with pronounced two peaks for limpets with average lengths 15 and 19 mm. Application of the integrated method \(^{8}\) to the length-frequency data (Fig. 2) indicated that the longevity of this limpet may extend to 5 years. The average estimated length at each of these age groups were 11.0, 27.8, 35.0, 40.0 and 42.2 mm.

The values of the growth parameters \(L_\infty\), \(K\) and \(t_e\) for C. eucosmia were 44.1 mm, 0.6893 \(y^{-1}\) and 0.4508 \(y\), respectively by using Walford method \(^{10}\), while these values were 44.2 cm, 0.6603 \(y^{-1}\) and 0.4419 \(y\), respectively by using Gulland & Holt method \(^{11}\). On the other hand, the calculated lengths for different age groups by using these two methods are summarized in Table 1.

The growth increment of this species decreases as the limpet grows older. For example, it is increased in length from 11 mm for the first year to 27.8 mm in the second year (about 38% of \(L_\infty\)),

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*Fig. 1—Dorsal (a) and lateral (b) views of Cellana eucosmia shell. [L=length; B=breadth; H=height; \(L_1\) and \(L_2\)=lengths of shell sloping at anterior and posterior extremities; \(a\)=anterior end; \(p\)=posterior end].

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*Fig. 2—Length frequency distributions and the hand fitted curve showing growth of populations of C. eucosmia.*
while it was increased only from 40.0 to 42.2 mm for the IV-V age groups (about 4.9% of L_{ao}).

Length-weight relationships—The collected specimens of C. eucosmia ranged in length from 6.0 to 42.0 mm with an average of 19.5 mm. Their total wet weight varied between 0.030 and 8.598 g with an average of 1.020 g. The calculated values for the regression constants of the length : total wet weight (a and n) and shell weight (a1 and n1) are [1.071x\times 10^{-4} & 3.0066] ; [7.214x\times 10^{-5} & 2.930], respectively. The values of correlation coefficient (r) for these relationships are 0.996 and 0.951, respectively (Fig. 3). The relative coefficient of condition (Kn) for C. eucosmia ranged from 0.911 to 1.429 with an average of 1.309 for specimens measuring 6.0-42.0 mm.

Shell allometry—The relationships of the shell length with the shell breadth for C. eucosmia were allometric (P < 0.05), indicating slower increase in the breadth than the length of the animal and consequently the shell becomes more ovate as it grows in length (Table 2). Similar allometric relationships were found for the shell length with the anterior and posterior shell sloping walls of this species. This may indicate that most of the increase in anterior and posterior sloping walls extend horizontally leading to longer rather than higher shells. The shell length-shell height relationship was allometric for C. eucosmia, while that of the anterior-posterior sloping walls was isometric. Moreover, the average value of the ratio between the posterior sloping wall (L_{2}) and the anterior one (L_{1}) was 1.499. In general this ratio decreased slightly as the animal grew in size (Fig. 4). Similarly, the ratio of L_{2} to shell length (L) decreased as the limpet grow in size. However, the ratio of L_{1} + L_{2} to shell length increased as the limpet grew in size.

Discussion

The longevity of limpets varied from less than one year as in Notoacmea concinna to more than 30 years as in Narella concinna. In the present study, the maximum age of Cellana eucosmia is up to 5 years. The life spans of the related species C. radiata and C. karachiensis were 4 and 6 years, respectively. On the other hand, the growth parameter (K) measures the rate of diminution of

<p>| Table 1—Observed and calculated lengths for different age groups using von Bertalanffy growth formula (VBGF) and the increment in observed length of C. eucosmia |</p>
<table>
<thead>
<tr>
<th>Age in years</th>
<th>Mean observed length (mm)</th>
<th>Calculated length (VBGF) (mm)</th>
<th>Increment in observed length (mm)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>11.0</td>
<td>13.90</td>
<td>16.8</td>
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<td>2</td>
<td>27.8</td>
<td>28.95</td>
<td>7.2</td>
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<td>35.0</td>
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<tr>
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<td>40.0</td>
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<td>5</td>
<td>42.2</td>
<td>42.19</td>
<td></td>
</tr>
<tr>
<td>\Sigma d^2</td>
<td>12.04</td>
<td>8.19</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3—Length : total wet weight (--) and shell weight (--)-relationships for C. eucosmia. (*)=mean observed total wet weight; (A)=mean observed shell weight.

| Table 2—Regression constants, slope (B) and intercept (A), for various shell measurement relationships together with the t-test for isometry for C. eucosmia. |
| Relationship | N   | A           | B        | t-test | P    |
| L-B          | 220 | -0.4029     | 0.7985   | -15.89 | <0.05|
| L-H          | 220 | -0.5865     | 0.3479   | -26.82 | <0.05|
| L-L_{1}      | 220 | -1.5876     | 0.5306   | -27.39 | <0.05|
| L-L_{2}      | 220 | -0.5892     | 0.586    | -22.35 | <0.05|
| L_{1}-L_{2}  | 220 | 3.5771      | 1.1326   | 3.89   | >0.05|

[L = shell length; B = shell width; H = shell height; L_{1} and L_{2}=lengths from apex to the anterior and posterior ends of the shell respectively; P<0.05=significant difference; P>0.05=No significant difference; isometric B value=1.0].
growth with the increase in age. Its value increases with the decrease in the life span of the animal. It was found that this parameter ranged from 0.66-0.69 in *C. eucosmia* while it varied from 0.44-0.45 in *C. karachiensis*. Moreover, there were pronounced differences in the growth rate within the different species of limpets. It ranged from 11-42 mm in the present species, while it was 10-53 mm and 20-39 mm in *C. karachiensis* and *C. radiata*, respectively.

The relative coefficient of condition (Kn) was relatively higher for specimens of *C. eucosmia* from the Red Sea than those of *C. karachiensis* from the Gulf of Oman. This is probably due to the abundance of bare rocks in areas from which limpets were collected from the Red Sea. The growth rate of the limpet *Patella vulgata* was found to be higher on bare rocks which probably reflected the case with which moving and grazing can be achieved.

The limpet shell measurements may be used for interspecific differentiation. The ratio of $L_2$ to $L_1$ of the present specimen *C. eucosmia* was 1.499, which appeared higher than that reported for *C. karachiensis* (1.298). Lower value of this ratio (1.213) was reported for the limpet *P. vulgata*. The shell of *C. eucosmia* becomes narrower and lower in proportion to their length as the relationships of length to breadth and height were allometric. Similar results were obtained for *C. karachiensis*. On the other hand, in both *C. radiata* and *P. vulgata* the shell becomes broader and higher in proportion to their length and breadth with growth of limpets.

The similarities and differences in shell morphometry of various species of limpets can be attributed to the nature of their habitats and the influence of the environmental conditions on their growth and shell proportions.

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References