GROWTH OF *DOSINIA EXOLETA* (L.) (BIVALVIA) IN RAUNEFJORDEN, WESTERN NORWAY

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Marked and measured specimens of *Dosinia exoleta* were set out on an undisturbed sandy, shallow (2.3 m) bottom in the Eggholmane area near Bergen. These specimens were recollected three times at regular intervals during one year, and the increase in length and total weight was noted for each period. Growth was greatest during summer and early autumn. There was no registered growth between November and March, and many adult specimens even lost some weight during this period. The data also indicate that the growth season for older specimens starts later in the spring than for younger ones. There was no significant difference between the sexes. Growth in length was expressed by an asymptotic curve (max. length 51.3 mm).

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INTRODUCTION

Some bivalves form distinct 'growth bands' on their shells. In boreal areas these bands are often formed during the winter, when growth is reduced. So called 'disturbance rings' are, however, often formed in connection with spawning and because of certain environmental changes such as sporadic salinity or temperature fluctuations or both. It is often hard to distinguish these disturbance rings from the actual 'year rings'.

In connection with a study on population dynamics of *Dosinia exoleta* TUNBERG (1979) an attempt to find year rings on the shells was not successfull. The acetate peel method described by RHOADS & PANELLA (1970) was also used but failed. A growth experiment *in situ* with marked specimens was therefore carried out in a shallow, sandy area with a large natural population of *D. exoleta.*

MATERIAL AND METHODS

The study was performed in a shallow (2.3 m) area at Eggholmane (60°15′36″ N, 5°13′ E) in Raunefjorden about 15 km SW of Bergen (Fig. 1). The sediment consisted of medium to very coarse shell sand, with median grain diam. c. 0.85 mm in the surface (0–40 mm) layer (see fig. 4, point 5 in TUNBERG 1981). The $CaCO_3$ content of the sediment was c. 90 %.

The first collection, of 120 specimens, was performed 17 March 1976 with a suction sampler (described in TUNBERG 1979). The bivalves were kept in running sea-water in the laboratory. Length and total weight were measured on 99 of these specimens. Length was measured with vernier callipers to ± 0.1 mm, and the shells were wiped dry before they were weighed (± 0.01 g). They were marked with a quick-drying paint, and set out 20 March c. 3 m west of the collecting point. These specimens were recollected and measured three times, at regular intervals, during one year (Table 1).

A number of unmarked, mostly young, specimens (51), which were obtained at the first recollection (17 July) were measured, marked, and set out together with the remaining

Table 1. Time data of the growth experiment in 1976–77. Numerals in italics represent the additional 51 specimens added after period 1.

Dates	Collected: Unmarked	Collected: Marked Living	Collected: Marked Dead	Marked Lost	Replaced marked	Area m^2	Ind/m^2
17 Mar.	120	–	–	–	–	–	–
20 Mar.	–	–	–	–	99	0.8	–
17 Jul.	216	89	4	6	–	0.8	381
20 Jul.	–	–	–	–	89 + *51*	1.0	–
12 Nov.	298	76 + *39*	4 + 2	9 + *10*	–	1.0	413
24 Nov.	–	–	–	–	76 + *39*	1.0	–
15 Mar.	?	74 + *37*	–	2 + 2	–	1.0	?

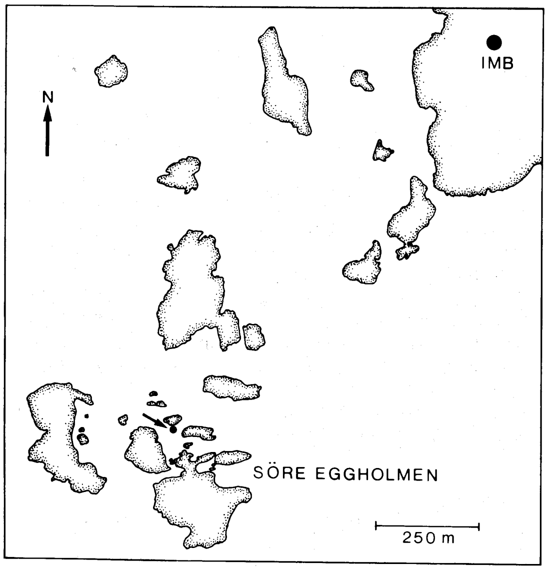

Fig. 1. The study site at Eggholmane. IMB = Institute (now Department) of Marine Biology.

89 marked specimens (see Table 1). After each recollection the bivalves were replaced on an undisturbed substrate c. 1 m from the preceding area.

The linear regression analyses were executed by using the program BMDP1R described in DIXON (1975). The formula of von Bertalanffy (BEVERTON & HOLT 1957) was used when asymptotic growth was calculated. The constant k of this formula was calculated according to CRISP (1971).

RESULTS

Growth of *D. exoleta* varied during the year, but there was no significant difference between the sexes (covariance analyses, 0.05 level). As described earlier, the marked specimens were placed on the sediment surface and had to burrow themselves into the substrate. Of the 99 specimens set out 20 March, 40 had burrowed themselves next day. On 22 March 46 specimens were still seen on the sediment, but all specimens had 'disappeared' 28 March. It is uncertain, however, whether a few specimens were killed by predators during the time on the sediment surface. Of the 99 specimens set out 20 March 1976, 74 were left at the end of the survey period, 15 March 1977.

The relationship between length (X) and weight (Y), of the 140 specimens set out 20 July, was expressed by means of a power curve:

$$Y = 6.2 \times 10^{-5} X^{3.44} \quad (R^2 = 0.9836)$$

Length

Growth in length during different periods of the year is presented in Table 2 and Fig. 2. During period 1

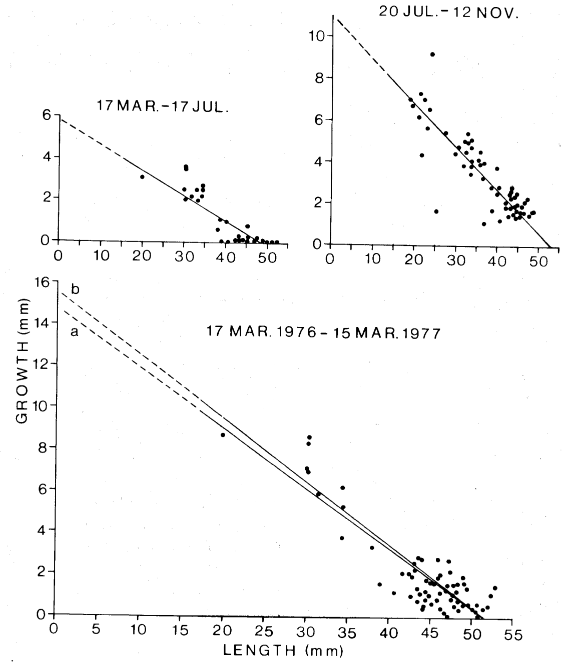

Fig. 2. Growth during separate periods and yearly growth in 1976–77 (Table 3). X-axis = shell length at the beginning of each period (initial length), Y-axis = growth during the periods. Line a, the regression line of Table 2. Line b, combination of the regression lines of periods 1 and 2 (see the text).

(see Table 2) the increase in length was small; specimens larger than c. 40 mm showed an almost negligible growth. Because of the large number of specimens with no growth at all, the angle of the regression line is probably too small. This is also true when the regression line was calculated for the 74 specimens that went through the whole survey period (Fig. 2, line a).

By combining the equations of periods 1 and 2 it was possible to use the data achieved from the 51 specimens that were added after period 1. Since there was no growth in period 3, this combination represents growth for the whole survey period. The resultant equation is:

$$Y = 15.55 - 0.30X$$

Table 2. Shell growth in the three periods and yearly growth in 1976–77, expressed by linear regressions; Y = aX + b where Y = growth in mm, and X = shell length in mm at the beginning of each period (initial length).

	Period	N	a	b	R^2
1	17 Mar.–17 Jul.	89	– 0.1213	5.7646	0.7026
2	20 Jul.–12 Nov.	115	– 0.2072	10.9815	0.8005
3	24 Nov.–15 Mar.	111	No increase in length		
	17 Mar.–15 Mar.	74	– 0.2845	14.6809	0.7787

The angle of this line (Fig. 2, line b) is somewhat greater than that of line a and it ought to be more representative than the latter one. This equation was used when yearly growth was calculated (see below).

The length of the larvae at settling in the fam. Veneridae is c. 190–220 μm (STAFFORD 1912; REES 1950; QUAYLE 1952; ANSELL 1961).

The intersection of the line b (Fig. 2) with the Y-axis represents length at an age of one year, and the intersection with the X-axis represents maximum length (51.3 mm). Asymptotic growth is thus expressed by the following equation:

$$L_t = 51.3\ (1 - e^{-0.36t})$$

where L = length in mm, t = time in years.

This growth curve is presented in Fig. 3 (curve a). Fig. 3, curve b shows seasonal growth. The length after the first period of growth after spatfall is somewhat uncertain, since it was necessary to assume even growth during the whole period 2, from which equation this growth was calculated. Period 3, however, showed no growth at all, so growth probably ceased before 12–24 Nov. (and started later than 15 March). By the use of the calculated values of Fig. 3, curve b, however, it was possible to calculate growth between the winter resting periods (Table 3) i.e. when the so-called 'winter rings' are formed. In order to find age or winter rings of *D. exoleta* 150 unmarked specimens were examined and the existing rings were counted and measured. The number and lengths varied so much, however, that it was impossible to find a correlation between age and ring numbers. CROZIER (1914) tried to determine the age of *Dosinia discus* (REEVE) by counting the rings, but found no correlation between shell size and ring number. KRISTENSEN (1956), however, presents a growth table of *D. exoleta* based on ring measurements, which does not differ much from the results of this analysis.

The shells were also cut and the acetate peel method described by RHOADS & PANELLA (1970) was used. It was not possible, however, to find any correlation between these inner bands and shell size.

Weight

The weight increase was individually different, but a maximum limit may be discerned. During period 1 the increase was moderate, specimens with an initial weight of 5–10 g showed the greatest absolute increase. The highest individual increase was 2.81 g (initial weight 7.08 g). There was a very high weight increase during period 2 for almost all specimens, but the highest increase was noted for specimens with an initial weight of c. 8–20 g. The highest individual increase was 6.04 g (initial weight 14.37 g). As expected there was a very small increase in period 3. As a matter of fact many specimens, mostly those over 40 g, lost weight in this period. During the whole survey period, specimens with an initial weight of 6–12 g showed the highest absolute increase. The highest individual increase, 9.18 g, was noted for a specimen with an initial weight of 11.40 g.

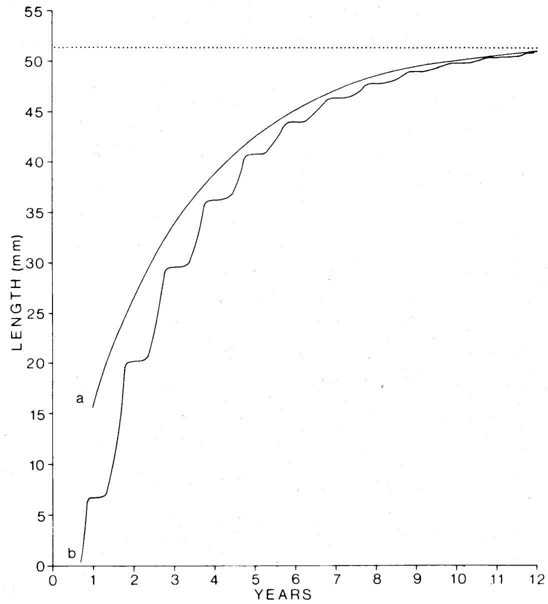

Fig. 3. a, growth curve of the shell based on the von Bertalanffy equation, where the X-axis represents years of age. b, seasonal growth of a potential larva settled in Aug.–Sept., based on the equations of Table 2. The dotted line shows the asymptotic value (51.3 mm).

Fig. 4 shows the percentage weight increase. During period 1 specimens with an initial weight of c. 20 g and more showed no or a moderate increase, but specimens of less than c. 20 g increased more, the lower the initial weight was. As shown earlier growth was strong in period 2. The increase in weight in specimens weighing more than c. 20 g was relatively high, but the difference between the largest and smallest specimens of this group was not pronounced. On the other hand specimens with an initial weight of less than c. 20 g showed higher

Table 3. Shell length at the yearly winter resting periods (see the text).

Years	Length (mm)	Years	Length (mm)	Years	Length (mm)
1	6.8	5	40.8	9	48.9
2	20.3	6	44.0	10	49.7
3	29.7	7	46.3	11	50.2
4	36.3	8	47.8	12	50.6

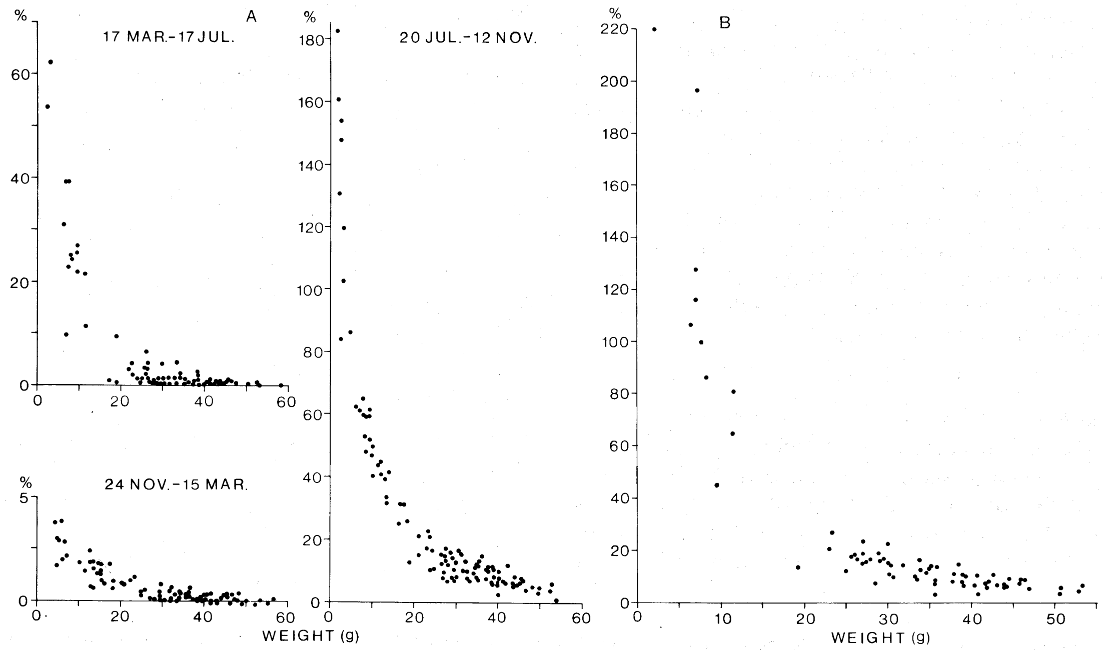

Fig. 4. Percent total weight increase of three periods (A), and the whole study period of one year (B).

increase the lower the initial weight was. The greatest decrease of growth rate in period 3, compared with the two former periods, was consequently noted for smaller specimens.

DISCUSSION

The specimens used in this study were undoubtedly disturbed during collection and treatment in the laboratory. Observations on other species show that they form disturbance rings after similar treatment (ORTON 1926; SEGERSTRÅLE 1960). Another disturbance factor was the natural population of *D. exoleta* in the study area. When the marked specimens were set out it resulted in a very dense population of the species. This problem could have been avoided by first removing the other specimens of *D. exoleta* before the marked ones were set out. This was not done, however, since it would have destroyed the natural conditions of the substrate for a long time.

A weakness of the regression analysis was the small number of young specimens used in the study, especially in period 1 (for practical reasons). The intersection of the extrapolated line of Fig. 2 with the Y-axis is therefore somewhat uncertain, which results in a corresponding uncertainty of growth during the first year. It should also be stressed that growth for many years is based on data for one particular year only.

The low or non-existent growth of older specimens during period 1 is noteworthy. Growth is probably affected by ripening of the gonads which occurs during this period (TUNBERG 1979). LAMMENS (1967) also showed that the growth periods were different between young and old specimens of *Macoma baltica* (L.). It should be stressed that the lowest water temperature of the study area was noted in March–April.

Maximum length (asymptotic value) was 51.3 mm, which is somewhat low in relation to maximum length in the natural population of this area (TUNBERG 1979).

Growth was calculated assuming settling in August–September (TUNBERG 1979). The time for settling varies and accordingly length also varies during the first winter. QUAYLE (1952) found that the shell length when the first ring of *Venerupis pullastra* (MONTAGU) was formed, varied between 0.4 and 7.0 mm. Specimens that settle late or have a low growth rate during the first season grow faster than others during following seasons, and after a few years reach the same length as others. This ‘catching up’ phenomenon has been described by e.g. PRATT & CAMPBELL (1956). That this could be a general phenomenon of marine bivalves can not be ruled out (LAMMENS 1967).

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