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Age and growth of the echinoid *Sphaerechinus granularis* from the Algerian coast

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The growth bands in the plates of the echinoid *Spharechinus granularis* settled on the Algerian coast were analysed. Two distinct groups of sea urchins were identified with different growth patterns related to the period of recruitment, i.e. spring or autumn. The growth rate of the autumn cohort was higher over the year following the first winter after settlement. From the second winter there was little growth difference between the two cohorts. Compared to populations from Atlantic sites, the Algerian population has a lower growth rate and reduced longevity.

The sea urchin *Spharechinus granularis* (Lamarck) is known from the north-western Atlantic ocean from the Gulf of Guinea to the English Channel, and in the Mediterranean Sea. In the Atlantic ocean, this species shows a yearly recruitment corresponding to its major spawning (Guillou & Michel, 1993). Its growth has been investigated, in the Bay of Brest and the Glénan Islands (Brittany, France) through the analysis of growth bands corresponding to changes in optical density induced by seawater temperature fluctuations (Lumingas & Guillou, 1994; Jordana et al., 1997). These studies have indicated: (i) the fast growth of this species during the first years of life compared to other temperate sea urchins; (ii) significant growth differences between populations corresponding to phenotypic responses to variable environmental conditions. Data on the ecology of this sea urchin in the Mediterranean Sea are scarce (Harmelin & Duval, 1983). The species has two spawning periods (Fenaux, 1972) but there is no study of its growth because of the difficulty of obtaining reliable diameter-at-age estimates by size-frequency analysis. Thus, the large densities of *S. granularis* in the Bay of Algiers (Algeria) provide an opportunity to investigate its growth within this ecosystem by applying the method of growth rings previously used in the Atlantic ocean. The study reported here was thus aimed to establish a growth model of the population of *S. granularis* from the Bay of Algiers. The comparison of this population with the Atlantic ones previously studied aimed to estimate growth differences between northern and southern populations within the normal range of this species. This led to research of periodic marks on the sea urchin plates of the Algerian population and to test the assumption that they represent annual age marks.

Between May 1995 and May 1996 sea urchins were sampled from a *Posidonia oceanica* (L.) sea grass, 5–7 m deep, located in the Bay of Tamentfoust in the eastern part of the Bay of Algiers. The seawater temperature ranged from 15°C in February to 25°C in August. Divers collected sea urchins monthly among *Posidonia* leaves and roots and under blocks. Sea urchin density varied from 4.9 to 1.4 ind m^{-2} in August and January respectively. Two annual spawning periods were observed in this species, the first in spring and the second, more obvious, in autumn (Fenaux, 1972; D. Soualili, unpublished data). To study changes in the population demographic structures, sea urchin diameters were measured and classified into 5-mm size-classes. To determine growth rate, 166 specimens were collected just after the formation of the winter zone (May 1995 and 1996). The back-calculation technique was used to estimate the previous size-at-age of the sea urchin population (reviewed by Lumingas & Guillou, 1994). This technique was applied once the growth zones (also named growth rings) had been read on the third interambulacral plates according to the age determination method perfected by Lumingas & Guillou (1994) for this species in the Bay of Brest and applied in the Glénan Islands by Jordana et al. (1997).

The monthly diameter-frequency distributions indicated two recruitment periods (Figure 1). Juveniles of about 22 and 12 mm in diameter were observed in July and November 1995, respectively. The overlap of the cohorts corresponding to individuals above 50 mm did not permit distinction of the oldest year-classes. To estimate growth, the thickness of the sectioned plates (P) and the corresponding test diameter (D) were measured at the time of capture, then the plate thickness (P_i) at the time of each ith ring formation for i=1, 2, ... N was recorded. To back-calculate the different D_i (the diameters at the time of the ith ring formation), the relationship between (D) and (P) had to be established. In the present study, the best description was provided by the following equation:

$$f(P) = D = 78.9(1 - \exp^{-0.7P}) \quad (N = 166, R^2 = 0.73) \qquad (1)$$

The assumption of normality and independence of the error was justified by the Durbin–Watson test (d=1.85; $P>0.05$). The different D_i were calculated from this equation using the Francis (1990) formula, which gave:

$$D_i = D(1 - \exp^{-0.7P_i})/(1 - \exp^{-0.7P_c}). \qquad (2)$$

Using the 166 P-D observed data provided us with an estimation of 788 D_i. Unfortunately, the mean D_1 corresponding to the first winter ring (24.3 ±5.4 mm) did not agree with the mean size of the first juvenile cohort observed on the diameter-frequency distributions (12 mm in November) (Figure 1). A detailed analysis of the diameter-frequency distributions of individuals

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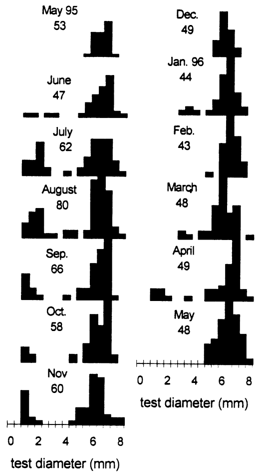

Figure 1. Diameter-frequency distributions of *Sphaerechinus granularis* from Tamenfoust (Algeria) between May 1995 and May 1996 (diameters were classified into 5-mm size-classes and the number of individuals is given below the name of the sampling month).

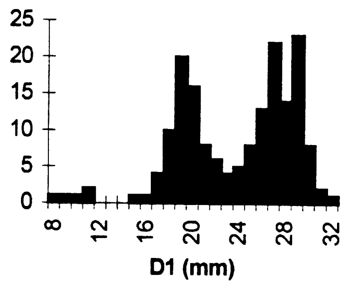

Figure 2. Diameter-frequency distribution (D_1 back-calculated) of *Sphaerechinus granularis* at the time of formation of the first winter zone estimated from the 166 sea-urchins collected from Tamenfoust (Algeria) in May 1995 and May 1996.

with only one ring (D_1 frequency distribution) showed a bimodal structure (Figure 2) consistent with the existence of two recruitments per year resulting from the two observed spawnings.

This observation allowed us to isolate two groups of sea urchins respectively corresponding to spring and autumn recruitments. The back-calculation analysis applied to these groups gave results more in agreement with the values deduced from histograms. The mean diameter of the spring cohort during the first winter was significantly longer (ANOVA $P<0.001$) than that of the autumn: 28.7 and 19.7 mm, respectively. However, when the second winter ring was forming in the plates, the mean sizes were very close. The spring cohort diameter (45.5 ±0.8 mm) was not significantly different (ANOVA $P>0.05$) from the autumn (45.1 ±0.9 mm). Consequently, the autumn cohort grew faster than the spring one over the next year. The Von-Bertalanffy growth equations were fitted to the back-calculated diameter-at-age data. This gave a better assessment of growth curve parameters than the observed data (for the autumn cohort $r^2=0.9$ vs 0.78 and for the spring cohort $r^2=0.9$ vs 0.82). It indicated a maximum age of seven winters for the two cohorts and a maximal size ~75 mm (Figure 3).

The comparison with Atlantic populations sampled at the same depth highlighted significant differences (Figure 3) (Guillou et al., 1997). Maximum sizes were lower and longevity reduced in the Mediterranean sea relative to the Atlantic ocean since in Brittany all the populations studied show a maximal size above 95 mm and live at least ten years (sometimes 16 years in the Bay of Brest). However, from the second winter following sea urchin settlement, the growth rate of the Algerian population was significantly reduced by comparison with the one observed

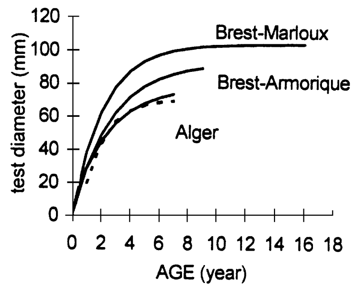

Figure 3. Von Bertalanffy growth curves of *Sphaerechinus granularis* from Tamenfoust (Algeria) fitted from back-calculated data. The two upper curves represent the two populations of the Bay of Brest (Brittany, France) and the two lower ones the populations of the Bay of Algiers separated in an autumn cohort (dotted line) and a spring cohort (continuous lines).

in the populations from Brittany. Neither the quality nor the amount of available food which are usually considered to be the main factors determining sea urchin growth rate (Lawrence & Lane, 1982), can explain the differences detected here. On the Algerian coast, *Sphaerechinus granularis* population lives in a *Posidonia* meadow that provides it with an important and regular food source. This differs from the populations in Brittany that graze macrophytic algae which fluctuate in biomass seasonally. Furthermore, the low Atlantic ocean temperatures in winter which reduce grazing capacity (Guillou & Michel, 1994) are not experienced by the Mediterranean population.

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