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Progress in Selection for Growth Rate in the European Oyster *Ostrea edulis*

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ABSTRACT: A selective breeding program with the European Oyster *Ostrea edulis* L. has been in progress at Dalhousie University since 1977. First generation selected lines were produced in 1977 and 1978. The selected parents came from the 1975 hatchery year class which were offspring of the original imports to Nova Scotia, considered here as the parental oysters. In both years, the parental oysters were respawned as control lines. Oysters from all lines, individually labelled within a few months of spawning, were stocked in lantern nets and grown in the field. Up to this time selection has been for growth rate only. The analysis of these lines will show the progress made in the early stages of this selective breeding program.

INTRODUCTION

Newkirk et al. (1977) and Losee (1979a) have studied heritability of larval growth rate in the American oyster *Crassostrea virginica* (Gmelin), and Lannan (1972, 1980) has reported on larval growth rate and survival in the Pacific oyster *C. gigas* (Thunberg). These studies indicate that there is considerable genetic variance for larval growth rate. Losee (1979a) has analyzed heritability of spat growth at 6 wk postsetting. These heritability studies give an indication that selection for improved growth rates will be successful; however, these are all studies on larval or juvenile oysters.

These are only a few documented cases of response to selection in oysters. The recovery of natural populations of *Crassostrea virginica* from epizootics of Malpeque Disease in eastern Canada and MSX in Delaware Bay demonstrates the response of oyster populations to a new selection pressure. The most encouraging evidence for commercial improvement comes from the studies of Haskin and Ford (1979) which indicate that artificial selection for MSX resistance (and probably for general vigor) resulted in greater genetic improvement than that which was occurring simultaneously in natural stocks.

There have been no reports of heritability or artificial selection with the European oyster *Ostrea edulis*. One difficulty with this species is that the female broods the larvae for a week or more making controlled crosses difficult. Preliminary experiments in our laboratory show that it is possible to produce fullsib families by conditioning pairs of individuals. As the production of fullsibs is a time consuming process, the primary emphasis has been to produce mass spawned lines using the spawning techniques presently employed in commercial hatcheries. The results of the first set of selected and control lines is the subject of the present paper.

MATERIALS AND METHODS

The oysters in this study were taken from the stock of the Nova Scotia Department of Fisheries (Canada). This stock originated in the Netherlands, was brought to Milford, Connecticut (USA) in 1946 by V. Loosanoff and then, several oyster generations later, to Ellerslie, Price Edward Island in 1968 by R. Drinnan. Several hundred of the first generation offspring produced by Drinnan in quarantine facilities were brought to the Pleasant Point Hatchery of the Nova Scotia Department of Fisheries in 1974. In 1975, mass spawning was used to produce the 1975 year class. The larvae were set on veneer rings coated with cement and subsequently grown on trays in Spanish Ship Bay, 220 km east of Halifax.

In 1977 a random sample of 470 oysters were taken from the 1975 year class. They were numbered and measured. From the heaviest 10 % (total wet weight) 5 selected lines were formed: 3 were spawned in 1977 and 2 in 1978. In each year a less intensively selected line was also spawned. Each year a control line was

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spawned, which was made up of 10 of the original broodstock individuals brought to Nova Scotia from Prince Edward Island, in other words a sample from the parental generation (P1 and P2).

Each spawning group was warmed up to 20 °C in a separate tank and fed cultured algae *(Thalassiosira pseudonana* and *Tetraselmis suecica).* Spawning occurred within 4 to 5 wk. When larvae were released they were removed from the spawning tank daily and a separate larval culture was set up for each larval release day and each spawning tank. The larvae were raised in 20 l polyethylene buckets following standard procedures (Walne, 1974; Helm, 1977). As the larvae approached setting size, pairs of scallop shells *(Placopecten magellanicus)* were put in the larval cultures and replaced daily. Each set of shells was labelled as to spawning group, day of release and day of setting. After 1 to 2 mo of growth in the laboratory at 18 °C and being fed cultured algae, the scallop shells were cut up with a bandsaw separating individual oysters, which were then labelled by gluing a number on the chip of scallop shell. Records were kept of individual numbers and larval data. It was not until early November in 1977 and September in 1978 that all spat had been cut up and were ready for initial measurements. At that time each individual was weighed and shell length and width were recorded.

The spat were held in the laboratory over winter at 18 °C and fed for several months then cooled to ambient temperature. In the spring the oysters were placed in lantern nets at sites near where the 1975 year class had been grown. In October or November each year all oysters were returned to the laboratory and weighed. In the following spring they were outplanted again.

The comparison of the offspring and the parents is best done at close to the same average size. To do this, we use the weights of the parental groups (selected parents) at the end of the 1978 growing season, 1977 offspring data from the fall of 1979 and 1978 offspring data from the fall of 1980. (Note that the selection was done at an earlier age of the parents and all parents had been spawned by fall 1978 but had been returned to the field for growout early in 1978.) In each case a standard score is calculated as:

$$\frac{\text{group mean} - \text{population mean}}{\text{S. D. population}}$$

In the case of the parents this is the selection intensity and for the offspring it is the standardized response to selection. The offspring were grown at different sites and these replicates had different mean weights. Thus, the standardized response to selection was calculated for each replicate and averaged.

The parental lines P1 and P2 are control lines, being contemporaneous samples of the parental generation from which the selected lines were drawn. Thus the standardized score for these lines are fixed at zero and the scores for the other lines are determined as deviations from them. For the offspring this was accomplished by calculating standard scores of the observed mean weights and adding the absolute value of P1 and P2 respectively to the selected lines in the 1977 and 1978 sets.

RESULTS

Observed means and standard scores for both parents and offspring are given in Table 1. Mean weight and equivalent selection intensity of both 1977 and 1978 parents was measured in fall 1978. At this time the average of the whole year class was 38.9g. There are no comparable data available for the parents of the control lines P1 and P2 as these were 9 yr old in 1978. However, as mentioned above, the selection intensity of these lines is set at zero. Mean weights of offspring of the 1977 set observed in 1979 and the 1978 set observed in 1980 show selected lines to be larger than the respective control lines.

Table 1. *Ostrea edulis.* Observed mean weights (g) and selection intensity of selected and control parents, and mean weights (g) and standardized response of offspring

Year	Line	Parents		Offspring	
		Mean weight	Selection intensity	Mean weight	Standardized response
1977	1	69.9	1.85	36.2	0.72
	2	56.6	1.05	32.7	0.49
	3	57.0	1.09	33.8	0.51
	4	53.3	0.86	33.4	0.62
	P1	–	0.00	26.2	0.00
1978	5	66.7	1.65	29.1	0.15
	6	59.8	1.25	32.6	0.44
	7	42.5	0.22	31.0	0.26
	P2	–	0.00	26.9	0.00

The pattern of response can be seen by plotting the standardized response against the selection intensity of each line (Fig. 1). There is variation in response among the lines, particularly Line 5 is low compared to the others. However, the correlation coefficient for these data is significant: $r = 0.67$ ($P<0.05$).

DISCUSSION

The results of these 2 sets of first generation selected lines show an improvement in growth rate of the European oyster *Ostrea edulis.* As might have been expected, there has been considerable variability in response which is attributable to a number of factors.

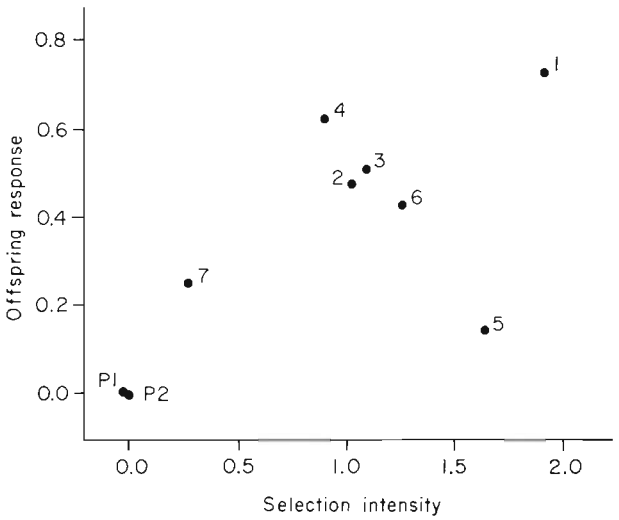

Fig. 1. *Ostrea edulis*. Plot of standardized response to selection of offspring against selection intensity of parent oysters. Numbers indicate lines as found in Table 1

Oysters tend to be highly variable in growth rate, probably because of both genetic and environmental effects. In this case small samples of parents in mass spawning tanks where there was no control over the spawning probably resulted in few adults contributing to each brood of larvae, i. e. few genotypes. The broods of larvae were collected daily and in these lines there were 2 to 5 of larval releases. Based on the number of larvae released and the pattern of release (usually larvae were released on one day followed by few or no larvae) there was probably only 1 female releasing on most days. There may have been several males contributing sperm. However, considering all the lines, there were 33 larval releases suggesting that there were at least as many females and probably more males. Thus the overall pattern of response to selection is indicative of genetic gain.

The spawning methods used here are such that the oysters are not forced to spawn before or after peak maturity. Rather, the females probably spawned when they reached peak condition. The larvae of *Ostrea edulis* are released at 160 to 180 µm, thus, most broods of larvae are quite viable and produce a high percentage of spat. Helm et al. (1977) have shown this to be so and unpublished data from our lab confirm this. Thus, the situation is quite different from that reported by Lannan (1980) with *Crassostrea gigas* where the mean survival was very low and with high variability resulting in many broods producing virtually no spat.

In spite of the variation in performance among lines it is significant that none of the selected lines was smaller than their respective control line. The range in sizes of the selected lines was from 8 % to 38 % larger than the control lines with an average of 23 %. It should be noted that this size was chosen for comparison in order to include both sets. Newkirk (unpubl.) has shown a high correlation between individual sizes in the second and subsequent years. Thus, the selection gains observed here are indicative of those that will be observed at market size. The correlation between the size of an individual at an age much less than 2 yr and its size at 3 (when most of a year class would be marketed) is considerably less than between sizes at 2 and 3 yr (Newkirk, 1981; Newkirk and Haley, 1982). Thus, it would appear that 2 yr is an acceptable compromise age of selection – old enough to be indicative of performance to market size yet less than that age resulting in a reduction of the generation time. This has been confirmed with the 1977 set of selected lines which have remained 23 % larger than the control line while the whole group of 1977 lines averaged 599.

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