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Comparison of growth and shell attributes of four generations of the pearl oyster *Pinctada fucata* (Gould) produced in the hatchery

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ABSTRACT

The growth parameters of four successive filial generations of laboratory bred, farm reared pearl oyster, *Pinctada fucata* (Gould) were studied to find out the significant differences in growth of their four generations. The relationships of different characters obtained from generations, and comparisons among them were studied from their respective regression coefficients. Morphometric characters of the four filial generations showed values of high significance as there were differences in the morphometric relationship within the generations and between the filial generations. The multiple regression analysis, and covariance analysis indicated the significance of the growth in DVM for the four generations in the order of, 2nd ($p = < 0.150$), 3rd ($p = < 0.200$), 1st ($p = < 0.300$) and 4th ($p = < 0.400$), whereas the growth in thickness exhibited significance only in the 2nd generation ($p = < 0.400$) and there was no significance in the other generations. The heritability (h^2) obtained from the Selection Response (Sr) and Selection Differential (SD) indicated that the shell attributes HL/(DVM + HL + T) exhibited comparatively higher heritability in the 1st and 2nd year, DVM/(DVM+HL+T) in 2nd year and DVM + HL + T in the 1st year in 3rd generation. The results were compared with similar studies on *P. fucata* carried out in Japanese waters.

Introduction

Seeds of pearl oyster, *Pinctada fucata* (Gould) were produced at the pearl oyster hatchery of CMFRI at Tuticorin (Alagarswami *et al.*, 1983, 1987). The spat produced in different batches at different periods in the hatchery at Tuticorin were reared to adult size in the farm (Chellam *et al.*, 1987). Previously the pearl oysters were collected from the natural pearl oyster paars and reared in the farms at Krusadai and Tuticorin in the Gulf of Mannar and their growth were studied by Devanesan and Chidambaram (1956), Chellam (1981) and Muthuraman and Dev (1988). The growth of the same species in the Gulf of Kutch was studied by Gokhale *et al.* (1954) and Narayanan and Michael (1968). Those studies were conducted on

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the pearl oysters of unknown age (mixed groups) from different paars and their spawning dates could not be traced. Chellam (1988) studied the growth of pearl oysters produced in the hatchery and reared in the farm at Tuticorin for three years. In order to improve the quality of the pearl oysters and the pearls, some attempts were made to study the different growth parameters of 4 filial generations produced in the hatchery and reared in the farm at Tuticorin. The growth parameters were analysed statistically by using the methods of Bagenal (1955) and Snedecor (1961) to find out the significance between and within the generations.

Materials and methods

The pearl oyster of the species *Pinctada fucata* was bred and the spat were produced in the pearl oyster hatchery at Tuticorin. They were transplanted to the farm after a month of nursery rearing when they grew upto 3-5 mm in DVM (Dorso Ventral Measurement) and further rearing was done in the farm in suitable net cages till they reached adult size (Chellam *et al.*, 1987).

The materials for the present study consisted of oysters belonging to four successive generations which were obtained through repeated spawnings, initially on 23.2.1983 (generation1) wherein the parent oysters were collected from the natural beds, subsequently generation 2 (from generation 1) on 16.8.1984), then generation 3 (from generation 2) on 15.2.1986 and generation 4 (from generation 3) on 22.4.1987. Controls were kept in the farm to study and estimate the heritability.

The morphometric measurements were taken with the help of a Vernier calipers corrected to 0.02 mm. The length of the animal in the study was indicated as the DVM. This is the greatest dimension of the oyster measured at right angles to the hinge line. Hinge length (HL) is the distance between the tips of the anterior and posterior ears along the hinge line and the thickness (T) was the maximum distance between the external surface of the two valves when both are closed. In generation 3 and 4 the total weight of the oyster was also taken corrected to 0.01 g with the help of a triple-beam balance. The data on shell attributes have been taken into consideration for estimating the heritability of the species as per Newkirk (1985) and Wada (1975).

Observations

Relationships

The growth rate in different filial generations in respect of DVM on month, thickness (T), hinge length (HL) and weight (Wt) was found by using regression analysis. The correlation coefficient 'r' values indicated very high significance ($p = < 0.001$) based on 29 months of observations. Very high significance was also exhibited by weight on month and weight on hinge length for the 3rd and 4th generations respectively. These are given in Table 1.

Intersib relationships

The morphometric characters of the 4 different generations revealed very high significance while comparing DVM, thickness, hinge length and weight between generations. Significance was while high among the 4 generations comparing the thickness on DVM. The relationship was also significant for DVM on T and Wt for the generation 3 and 4 as there were differences within the generations (Table 2).

TABLE 1. *Growth of 4 filial generations on different characters subjected to regression analysis and respective 'r' values (r = correlation coefficient, n = no. of months)*

Filial generations	Characters	'r'	n
1	DVM on month	0.9543	29
2	,,	0.9576	29
3	,,	0.9587	29
4	,,	0.9572	29
1	Thickness on month	0.9727	29
2	,,	0.9756	29
3	,,	0.9755	29
4	,,	0.9774	29
1	Hinge length on month	0.9509	18
2	,,	0.9383	18
3	Weight on month	0.9833	18
4	Weight on hinge length	0.9820	18

The regression coefficient (b) of the DVM on month of the four filial generations were compared by covariance analysis and the results are given in model Table 3. Similar studies were conducted for the variables DVM on month, T on month, T on DVM, DVM among generations and T among generations and were found to be highly significant (Table 4).

The growth data on DVM and thickness of the four filial generations were again subjected to multiple regression analysis and covariance analysis employing Gauss multipliers as per the formula given by Snedecor (1961).

$$y = \bar{y} + \text{by } 1.234\ (x_1 - \bar{x}_1) + \text{by } 2.134\ (x_2 - \bar{x}_2) + \text{by } 3.124\ (x_3 - \bar{x}_3) + \text{by } 4.123\ (x_4 - \bar{x}_4)$$

The equations obtained by this analysis are given in Table 3 along with the 't' values obtained from the respective regression coefficients and sample standard deviation of regression coefficient (sb) for the four filial generations. The 't' values of DVM for the different generations indicated that the significance in the case of growth of DVM for the generations was in the order, 2nd ($p = < 0.150$), 3rd ($p = < 0.200$), 1st ($p = < 0.300$) and 4th ($p = < 0.400$), whereas the growth in thickness exhibit significance only in the 2nd generation ($p = < 0.400$) and there is no significance in the other generations (Table 5).

TABLE 2. *Comparison of generations on different characters and respective 'r' values*

Filial generations	Characters	'r'	n
1 on 2	DVM	0.9890	29
1 on 3	,,	0.9920	29
1 on 4	,,	0.9905	29
2 on 4	,,	0.9876	29
3 on 4	,,	0.9964	29
2 on 3	,,	0.9821	29
1 on 2	Thickness	0.9884	18
1 on 3	,,	0.9935	18
1 on 4	,,	0.9949	18
2 on 3	,,	0.9832	18
2 on 4	,,	0.9875	18
3 on 4	,,	0.9970	18
3 on 4	Hinge length	0.9950	18
3 on 4	Weight	0.9820	18
1	Thickness on DVM	0.9931	29
2	,,	0.9908	29
3	,,	0.9906	29
4	,,	0.9893	29
3	DVM on Thickness	0.9959	29
4	,,	0.9970	29
3	DVM on weight	0.9952	18
4	,,	0.9908	18

TABLE 3. *Comparison of the regression coefficients (b) of the DVM on month of the four filial generations by covariance analysis*

Parameters		DVM on Month				Deviation from regression				
	f	Σx^2	Σxy	Σy^2	Reg.coef.	f	Σd^2	MS mean square	F	p
Generation 1	18	570	1638.5600	5171.7506	2.8747	17	461.4368	27.1433		
2	18	570	1791.6350	6141.7256	3.1432	17	510.2309	30.0136		
3	18	570	1668.2288	5312.2071	2.9267	17	429.7732	25.2808		
4	18	570	1577.1100	4762.4449	2.7669	17	398.8028	23.4590		
Within						68	1800.2437	26.4742		
Reg. coeff.						3	42.818	14.2727		
Common	72	2280.0	6675.5338	21388.1282		71	1843.0617	25.9586	5.0557**	<0.001
Adjusted means						3	393.7160	131.2387		
Total	75	2280.0	6675.5338	21781.8442		742	236.7777			

** Highly significant

F ratio = 5% 1%
3.80 2.72 4.04

TABLE 4. *Comparison of the regression coefficients (b) of the different generations in the four filial generations by covariance analysis*

Characters	Deviation from regression	
	F	p
DVM on month (Dorso-ventral measurement)	5.0557**	< 0.001
Thickness (T) on month	28.79**	< 0.001
Thickness on DVM	25.91**	< 0.001
DVM among generations	13.51**	< 0.001
Thickness among generations	30.28**	< 0.001

** Highly significant.

Growth among generations

The growth of oysters of the four filial generations for two years indicated that the percentage growth increments decreased from generation 1 to generation 4. By keeping the first year DVM of the generation 1 as the base, the second year growth gain of the four filial generations was worked out. The gain was 23.5, 20.6, 19.6 and 8.3% respectively for generation 1 to 4, similarly the percentage growth gain in T was also found to decline from generation 1 to 4 and was 45.5, 22.5, 11.5 and 6.8% respectively. In the case of HL, the growth gain was 24.8, 6.8, 12.3 and –1.1% for generation 1 to 4.

Age and growth

The difference in age and growth of *P. fucata* has been studied from the data on DVM, HL and T of all the four filial generations as per Bagenal (1955). The growth in DVM, HL and T obtained by this species in subsequent years from 1st to 6th year using the parameters L_∞ and K are given in Table 6. In general the growth of this species is the faster

TABLE 5. *Multiple regression equation describing the growth in DVM and thickness with relation to age on months for the four generations of* Pinctada fucata

Sl.No.	Characters	Equation	Generation		
1	DVM	Age (months) = –0.4550–0.3142 G I + 0.3248 G 2+ 0.6139 G 3 – 0.3555 G 4	Gen. 1	1.0331	< 0.300**
			Gen. 2	1.6093	< 0.150****
			Gen. 3	1.4400	< 0.200***
			Gen. 4	0.8907	< 0.400*
2	Thickness	Age (months) = 0.8208 - 0.2543 G I + 0.3769 G 2+ 0.3012 G 3 + 0.4030 G 4	Gen. 1	0.4474	> 0.500
			Gen. 2	1.0944	> 0.400*
			Gen. 3	0.3919	> 0.500
			Gen. 4	0.3882	> 0.500

*, **, ***, **** : Degree of significance increase with number of stars. $G_1 - G_4$ = Generation 1 - 4.

TABLE 6. *Estimated growth of different characters of the four generations for consecutive 6 years on growth parameters* L_∞ *and* K

Characters	Generation	Growth parameters		Estimated growth					
		α	K	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
DVM (mm)	1	67.41	1.0901	44.8	59.8	64.8	66.5	67.1	67.3
"	2	65.59	1.1551	44.9	59.1	63.5	64.5	64.9	65.4
65.5									
"	3	66.64	1.0472	43.3	58.4	63.8	65.6	66.3	66.5
"	4	57.40	1.0612	37.5	50.5	55.0	56.6	57.1	57.3
HL (mm)	3	56.57	1.1659	38.9	51.1	54.9	56.0	56.4	56.5
"	4	52.85	1.1128	35.5	47.1	51.0	52.2	52.7	52.8
T (mm)	1	36.56	0.6299	17.1	26.2	31.0	33.6	35.0	35.7
"	2	30.27	0.7215	15.6	23.1	26.8	28.6	29.5	29.9
"	3	29.73	0.6861	14.8	22.2	25.9	27.8	28.8	29.3
"	4	25.61	0.7230	13.2	19.6	22.7	24.2	24.9	25.3

when they were grown in the same locality and this is indicated by the covariance analysis.

The multiple regression analysis shows that the order of significance in the growth of DVM of different generations of pearl oyster was 2nd, 3rd, 1st and 4th respectively. In regard to growth in thickness and age and growth, the 2nd generation showed faster and differential growth. The environmental conditions such as temperature, salinity, dissolved oxygen, pH and productivity prevailed during the time of culture of different generations did not show much variation and the significance in growth observed in the 2nd generation may be due to reasons other than the environmental factors mentioned above.

The shell attributes showed a general declining trend from generation 1 to 4 in the character DVM + HL + T and in T/(DVM + HL + T) which are the two important factors in the growth of pearl oysters. In the former case the value decreased from 110.97 mm in generation 1 to 90.70 mm in generation 4 in the first year and from 141.89 to 115.75 mm in generation 1 to 4 in the second year and in the latter case, the relationship was high at 0.172 and 0.196 in the first and second years for the first generation and decreased to 0.148 and 0.176 mm in the 4th generation for the first and second years (Table 7). Wada (1975) found in Japanese pearl oysters the shell attributes DVM + HL + T to be 61.1 and 106.2 mm in the first and second years and that of T/(DVM + HL + T) as 0.132 and 0.160 mm in the first and second years. This shows that the pearl oysters of the Indian waters grew faster than the Japanese oysters in both the years in all generations which may be due to the tropical conditions of the Indian waters.

The study on the heritability of shell characters of generation 2 and 3 indicated that the values were always high in the first year than the second year oysters. As far as the shell shape was concerned, not much difference in the heritability was noticed in HL/(DVM+HL + T) and T/(DVM + HL + T) (Table 8) in the first and second year of age. This was almost the same in the Japanese oysters (Wada, 1975) (Table 8). The ratio of the selection response to the mean of the parent generations (per cent gain) was high for oysters of one year old except the attribute T/(DVM + HL + T) when the high value was obtained in the second year only (Table 8). The study of the four successive filial generations indicated a declining trend in the shell attributes from the parent to the offspring in all the four generations indicating that successive breedings of the laboratory bred oysters may not have the required growth characters than those of the previous parents. Furthermore, the present study suggests that for obtaining desirable oysters with better growth characters, the laboratory bred and farm reared oysters should be cross bred with oysters from the wild stock frequently. Velayudhan (1987) suggested that selective breeding between laboratory bred oysters with oysters obtained from the wild stock may help in obtaining oysters of improved quality for pearl culture.

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