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Body weight and growth rate in laboratory lines of *Poecilia reticulata* reared on two different diets

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Summary. Body weight and growth rate of fish from three laboratory lines fed with two different diets have been analyzed. The differences in response to the diets seem to be related to the different degree of genetic homogeneity of the lines considered. The most homogeneous line shows the greatest variation under the two diets for average body weight at 30 and 70 days as well as for growth rate. An effect of the parents' diet on their offspring was also observed. The increase in growth rate observed when fish are fed with the live food diet is amplified when the progenies derive from parents fed with the dry food diet. Moreover, an effect due to the mother's size is also evident on the mean values of body weight at 30 days. The persistence of this maternal effect on the offspring phenotype during post-embryonic development seems to depend on the degree of genetic homogeneity of the line considered-being the greatest in the most homogeneous line.

Key words: Fish – Inbreeding – Different diets – Growth pattern

Introduction

Many studies have been performed on the inheritance of body weight and growth pattern in mammals, most in mice.

The analysis of phenotypic variability by means of selection or inbreeding and crossbreeding techniques has shown that these characters are to some degree under separate genetic control (Roberts 1961; Wilson 1973) and are strongly influenced by such environmental factors as maternal effects (Falconer 1960; Brumby 1960; Moore et al. 1970).

In fish, the most comprehensive study of the genetics of growth rate has been performed by Moav and Wohlfarth (1976) for the common carp; their principal finding was that genetic control of growth rate was important but restricted to non-additive genes.

Analogous results have been obtained by Ryman (1972, 1973) on *Lebistes reticulatus* in his selection experiments for growth rate increase and decrease.

A study of the genetic control of the growth pattern on *Lebistes* has been performed by Vanelli et al. (1981) using laboratory inbred lines. Analysis of the phenotypic variability of body length and weight at different ages has shown a certain amount of genetic variation and a remarkable genotype-environment interaction.

In the present paper the influence of the environment on body weight and growth pattern has been considered using three laboratory lines of *Poecilia reticulata* obtained after inbreeding.

An analysis attempt has been performed on the effect of two different diets in relation to the degree of genetic homogeneity of the lines. A maternal effect on body weight, due to the different diet given to the offspring compared with that given to their parents, is also discussed.

Materials and methods

The effect of different diets on body weight and growth rate in *Poecilia reticulata* has been studied in three laboratory lines, A, B and C, obtained by eight generations of successive full-sib matings from a single inseminated female from a free-breeding population.

Fish were fed either with dry food (D.F. diet) or with live food (L.F. diet). The dry food was represented by the staple food TETRAMIN whose ingredients are: fish meal, yeast, cereals, shrimp meal, meat meal, algae meal and curd. In addition, other natural ingredients with high levels of chlorophyll and carotenoids were used. The live food was represented by newly hatched *Artemia salina* in the first period of the post-embryonic development and then by live *Tubifex* worms.

Fish from single females fed either with the D.F. diet or the L.F. diet were collected, put in different aquaria and reared on the same diet as their parents. Anesthetized individuals were weighed on a Mettler analytical balance at 30, 40, 50, 60, 70 days after birth. Table 1 shows the distribution of the observations and the number of families tested for each line and on each diet. The phenotypic variability of body weight at 30 and 70 days was partitioned using the hierarchical scheme of ANOVA as shown in Table 2.

In order to evaluate the effect due to the diet utilized in the preceding generation, progenies from parents fed with dry food were reared with live food and vice-versa. Also in this case, fish were weighed at 30, 40, 50, 60, 70 days after a birth with about 60 individuals for each line and each diet.

Because of the linearity of growth in the period of development considered, growth rate has been estimated by the linear regression coefficient of average body weight on age from 30 to 70 days.

For this experiment aquaria containing 12 l of water containing two-third tap water and one-third distilled water were used. The environmental temperature was maintained at $25 \pm 1\,^{\circ}C$ with a photoperiod of 12 h.

Results

Components of the phenotypic variance of body weights at 30 and 70 days respectively, and their percentage contribution to the total variance are shown in Table 3.

In all the three lines analyzed, the percentage contribution due to genetic differences between families decreases during growth, whereas the percentage contribution due to differences between diets increases from 30 to 70 days.

Table 1. Distribution of the observations and number of families tested on each line and on each diet

		D.F. diet								L.F. diet									
A line	Family	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10
	Individuals	4	5	3	3	3	7	7	6	4	4	3	5	6	4	8	3	7	4
B line	Family	1	2	3						1	2	3	4						
	Individuals	9	9	8						9	15	12	9						
C line	Family	1	2	3	4					1	2	3	4	5					
	Individuals	3	6	7	7					11	6	9	14	13					

Table 2. Sources of variance, degrees of freedom and expected mean squares for hierarchical analysis on body weight

Sources of variation	A line		B line		C line	
	d.f.	Expected mean squares	d.f.	Expected mean squares	d.f.	Expected mean squares
Between diets	1	$\sigma_E^2 + 4.77\,\sigma_F^2 + 43\,\sigma_D^2$	1	$\sigma_E^2 + 10.14\,\sigma_F^2 + 35.5\,\sigma_D^2$	1	$\sigma_E^2 + 8.44\,\sigma_F^2 + 38.8\,\sigma_D^2$
Between families	16	$\sigma_E^2 + 4.77\,\sigma_F^2$	5	$\sigma_E^2 + 10.14\,\sigma_F^2$	7	$\sigma_E^2 + 8.44\,\sigma_F^2$
Within families	68	σ_E^2	64	σ_E^2	67	σ_E

Table 3. Components of variance and percentage contribution of each component to the total variance

	A line				B line				C line			
	30 days		70 days		30 days		70 days		30 days		70 days	
σ_E^2	2.041	34%	30.033	46%	3.639	71%	18.644	37%	0.477	14%	16.051	50%
σ_F^2	3.483	57%	18.495	28%	0.632	12%	−0.461	−0.9%	3.130	96%	13.386	42%
σ_D^2	0.542	9%	17.263	26%	0.826	16%	32.621	64%	−0.312	−9%	2.553	8%
σ_T^2	6.066		65.791		5.097		50.804		3.265		31.990	

σ_E^2 = component of variance due to differences between individuals
σ_F^2 = component of variance due to differences between families
σ_D^2 = component of variance due to differences between diets
$\sigma_T^2 = \sigma_E^2 + \sigma_F^2 + \sigma_D^2$ = total variance

On the other hand, the three lines are different with regards to weight of the single components to the total variance. In fact, the genetic differences that are pronounced in the C line, are scarcely appreciable in the B line. The difference due to the effect of diets are more evident in the B line than in the C line (Fig. 1).

The mean values of body weight at 30 and 70 days are reported in Table 4. From these values it is evident that the live food diet causes an increase of the body weight compared with the dry food diet; moreover, this increase is different for the three lines.

In Table 4 the growth rates shown by the lines fed different diets are also shown. Fish fed with live food show a greater growth rate than those fed with dry food; furthermore, the B line greatly modifies its growth rate under the two different diets, whereas in the C line this variation is smaller.

From the results reported in Table 4 it can be seen that the association between the growth rate and the average body weight of the lines at 30 days is dependent on the diet used.

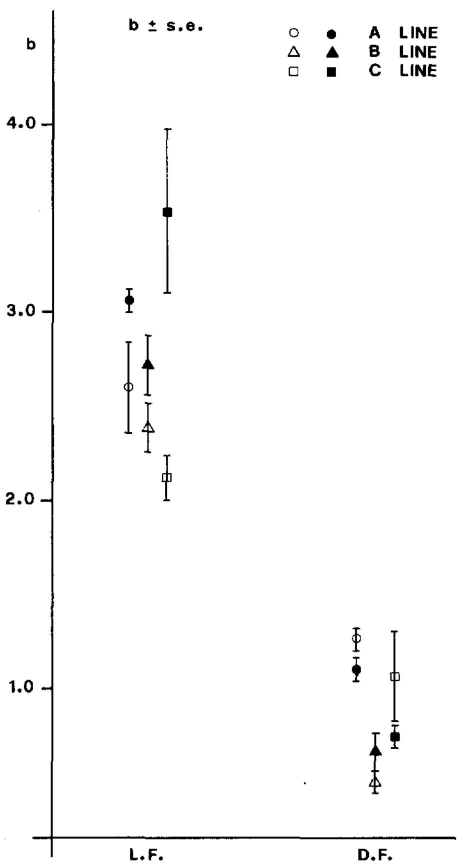

Fig. 1. Growth rates of progenies fed with the same diet for two subsequent generations (*light symbols*) or with a diet different from that of their parents (*dark symbols*). *L.F.* = progenies fed with live food. *D.F.* = progenies fed with dry food

Table 4. Mean values of body weight and growth rates of the three lines on the two different diets

	D.F. diet	L.F. diet
30 days	$\bar{x} \pm$ s.e.	$\bar{x} \pm$ s.e.
Line A	2.22 ± 0.225	4.38 ± 0.390
Line B	1.26 ± 0.202	3.05 ± 0.312
Line C	1.28 ± 0.168	2.71 ± 0.208
70 days	$\bar{x} \pm$ s.e.	$\bar{x} \pm$ s.e.
Line A	7.14 ± 0.777	14.91 ± 0.908
Line B	3.24 ± 0.505	12.58 ± 0.656
Line C	5.79 ± 1.660	11.12 ± 0.634
Growth rate	b ± s.e.	b ± s.e.
Line A	1.25 ± 0.039	2.60 ± 0.224
Line B	0.48 ± 0.065	2.41 ± 0.115
Line C	1.05 ± 0.235	2.11 ± 0.090

Thus, when the fish are fed with live food, the growth rate is proportional to the mean value of body weight in all lines. When the fish are fed with dry food, this proportionality is evident only for the A and B lines whereas in the C line a high growth rate is accompanied by a low average body weight.

The growth rates shown by the progenies fed with dry food (D.F.) do not seem modified by the different diet used for their parents. On the other hand, fish fed with live food (L.F.), whose parents have been reared with dry food, show a greater growth rate than those fed with live food for two subsequent generations.

The mean values of body weight at 30 and 70 days of these different groups of fish are shown in Fig. 2.

Average body weight at 30 and 70 days of the progenies' parents reared on dry food is not different from that shown by fish whose parents have been fed with live food (Fig. 2b).

A different behaviour is found when the fish of the different lines are fed with live food (Fig. 2a).

In the B line, the average body weight at 30 days of progenies from parents fed with dry food is lower than that of fish reared with live food for two subsequent generations. This difference disappears at 70 days because of the different growth rates shown by these groups of fish. In the A line, the average body weight at 30 days is the same for the two types of progenies considered, whereas at 70 days fish from parents fed with dry food show a greater body weight, owing to a greater growth rate. In the C line, fish from parents fed with dry food already show a greater average body weight at 30 days than those reared with live food for two subsequent generations.

Discussion

The inbreeding applied for eight successive generations starting from a single inseminated female from a free-

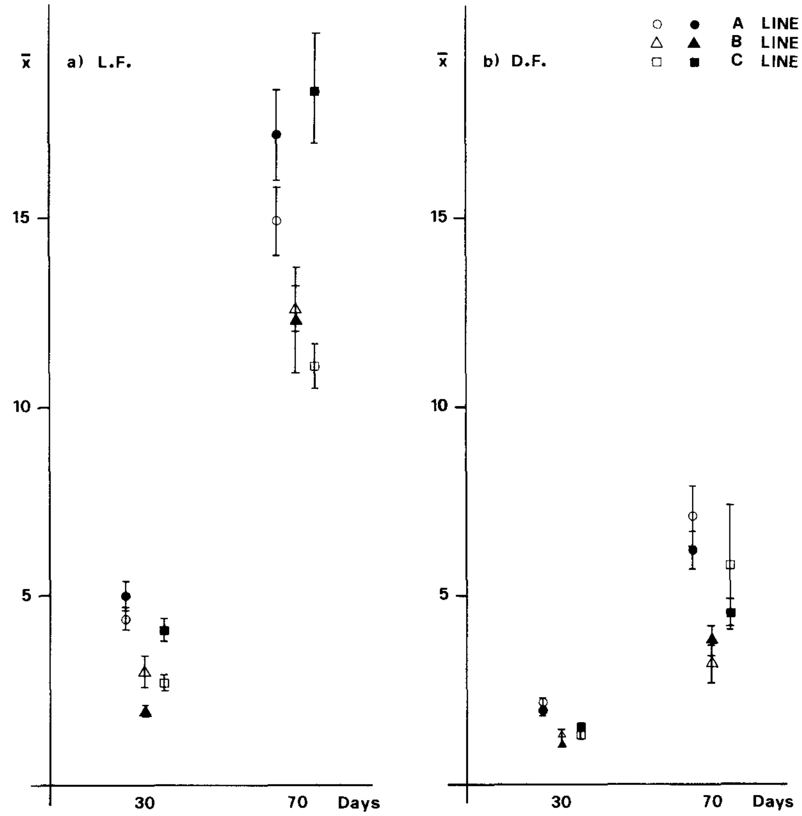

Fig. 2a, b. Mean values and standard errors of body weight at 30 and 70 days of progenies fed with the same diet for two subsequent generations (*light symbols*) or with a diet different from that of their parents (*dark symbols*). **a** *L.F.* = progenies fed with live food. **b** *D.F.* = progenies fed with dry food

breeding population of *Poecilia reticulata* has produced lines in which a reduction in the number of progenies can be observed. As a consequence, the results reported in this paper are referred to rather limited data.

The analysis of the phenotypic variability of the body weight trait in three lines reared with two different diets for at least two subsequent generations, has shown that the genetic component of the phenotypic expression of this trait appears to be masked during the growth, according to the results obtained by Vanelli et al. (1981).

The live food diet causes an increase in the body weight compared with the dry food diet; yet this increase is different for the three lines analyzed. The B line, in which the percentage contribution to the total variance due to differences between families is very small, shows the greatest variation in average body weight under the two different diets, while the C line, in which this percentage contribution is the greatest, differentiates very little under the two diets. It seems possible that the reaction on the two diets is proportional to a different degree of genetic homogeneity shown by the lines.

Also for the growth rate, as well as for the weight, the greatest variation between the two diets has been observed in the most homogeneous line and vice-versa. This analogy of behaviour between the trait and the growth rate could suggest a common genetic control. Yet, from the results reported in Table 4, the association between the average body weight at 30 days and the growth rate for the C line appears to be different as regard the diet utilized. It seems more likely that, according to the results obtained by Vanelli et al. (1984) on the analysis of trait-growth rate association in several inbred lines of *Poecilia reticulata,* the weight and the growth rate are under different genetic control and that this total or partial independence is evident only under particular environmental conditions.

An effect in the offspring due to the diet given to their parents has also been demonstrated.

Differences in growth rate have been observed when progenies reared with live food from parents fed with dry food have been compared with fish fed with live food for at least two subsequent generations. Moreover, a sort of maternal effect or, at any rate, due to the mother's size seems to be evident from the comparison between the average body weight that these progenies show at 30 days (Fig. 2a).

Also, the maintenance of this effect on the offspring's phenotype during the post-embryonic development seems to be related to the degree of genetic homogeneity of the line considered, as it is the most persistent in the most homogeneous line and vice-versa.

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