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CORRELATED RESPONSE ON GROWTH TRAITS IN A LINE SELECTED FOR LITTER SIZE AT WEANING*

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ABSTRACT

An evaluation of the correlated response on growth traits was carried out in a line of rabbits selected for litter size at weaning . The evaluation was performed comparing contemporarily young of six generations apart, generation 15 and generation 21. The contemporary comparison was possible because techniques of cryopresevation (vitrification) and transfer were used in generation 15. In other paper (García et al. 2000) a significant difference of 0.53 weaned young /litter was estimated between generations 21 and 15. In this paper the traits studied were: weights at weaning (28d) and every post- weaning week weight for five weeks, daily weight gains, feed consumption and conversion indexes during the same period. An animal model with non genetic maternal effects was used for the analysis that involved more than 1854 rabbits. No significant differences between generation 15 and 21 were found for any trait, using as covariate total litter size at birth.

INTRODUCTION

The programmes of genetic improvement of rabbits for meat production develop maternal lines commonly selected for litter size at birth or weaning (Matheron and Rouvier, 1977; Baselga et al. 1984) to be used in crossbreeding to get crossbred does.

Traits related with growth, such as weight at weaning, post-weaning daily gain or conversion index of feed in live weight are important in meat rabbit production because of their relationship with the viability of the young or the efficiency of the production itself.

There is a scarce literature concerning genetic correlations between litter size traits and reproductive traits (Brien, 1986; Camacho, 1988; Camacho and Baselga, 1991) that is not very conclusive but point that these correlations must be weak and positive or negative depending on the line or population. This means that correlated responses favourable or unfavourable can be expected on growth traits when selecting for litter size traits. Rochambeau et al. (1994) and Rochambeau (1998) have found in lines selected for litter size for eighteen generations or more that the weaning weight has been reduced with undesired consequences on adult weight of the does.

The objective of this experiment is to estimate the correlated response on weights, daily gains, feed consumption and feed efficiency in a line selected for litter size at weaning,

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comparing contemporarily animals belonging to two different generations, six generation apart.

MATERIAL AND METHODS

The animals used in this experiment were line V rabbits that were unselected progeny either of animals of the generation 15 or of the generation 21.

Line V is a maternal line of rabbits selected for litter size at weaning, being the animals genetically evaluated by a BLUP under an animal-repeatability model (Estany et al 1989). The selection is conducted in non overlapping generations and embryos of generation 15 were kept vitrified (Vicente and García-Ximénez, 1996) until the time of generation 21. At this time the vitrified embryos were developed and mated between them. Their unselected progeny was called V15 and the unselected progeny of animals of the generation 21 was called V21.

The rabbits were weaned 28 d after birth and then placed in collective cages housing nine young each cage. At weaning and at every seven days after weaning for five weeks, total weight of the rabbits and feed consumption in each cage were recorded. When a rabbit died, the date and the weight at death were also registered . Only cages with at least seven young alive at the end of the five weeks period were considered in the experiment (206 cages). The dates of death and the weights of the dead rabbits were used to compute the estimated total weight of the rabbits in the cage at the beginning of the week, excluding the dead rabbits, and the estimated feed consumption during the week with the same exclusion.

The traits studied , all of them computed as rabbit averages within cages were:
$W_{i,}$ i=0 to 5, weight at the i^{th} post-weaning week.
DG_i i=1 to 5, daily weight gain between weaning and the i^{th} post-weaning week.
FC_i i=1 to 5, daily feed consumption between weaning and the i^{th} post-weaning week
CI_i i=1 to 5, conversion index of feed in live weight from weaning to i^{th} post-weaning week .

The data were analysed solving a mixed model (Henderson, 1984) that for all traits had the same fixed and random effects and, also, the covariate total litter size at birth. The only difference between traits was that the model for the conversion index traits included as second covariate the weight at the end of the period referred for the conversion index.

The fixed factors were: parity order (1, 2 and $\geq$3); year-season (1 to 5) and generation number (V15,V21) that is the factor, principal objective of this experiment. The random factors were: the animals, related between them through their parents; and the non genetic maternal effects.

Table 1. Heritability (h^2) and non genetic maternal component (m^2) used for the solution of the mixed models for the different traits.

Trait[1]	W_0	W_1	W_2	W_3	W_4	W_5	Dg_i	FC_i	CI_i
h^2	0.13	0.14	0.15	0.16	0.18	0.20	0.25	0.20	0.20
m^2	0.17	0.16	0.15	0.14	0.12	0.10	0.05	0.10	0.10

[1] $W_{i,}$ weight at the i^{th} post-weaning week.; DG_i,FC_i and CI_i, daily weight gain, feed consumption and conversion index between weaning and the i^{th} post-weaning week.

Because the data analysed were averages within cages, the model took into account that in a cage there were 7-9 different rabbits of several parity orders and dams. The parameters used for the random factors are in the range accepted in the literature (Estany et al. 1992) and are shown in the Table 1. The significance of the regression coefficients of the covariates and the difference between effects of the same factor was tested lying in the F distribution . The α used for the statistical tests was 0.05

RESULTS AND DISCUSSION

In a companion experiment to this one, using the same methodological approach to estimate responses to selection, but referred to litter size traits (García et al, 2000) it was found that selection of line V for litter size was effective, and a significant difference of 0.53 weaned young/litter between generations 21 and 15 was reported.

Table 2. Generalized least square means (gr) of generation of selection (V15, V21) and covariate effect (total litter size, gr/young born) for weights at different postweaning weeks, i (W_i).

Trait	V15[1]	V21	Covariate[2,3]
W_0	492 ± 12	488 ± 11	-20.8 * ± 2.1
W_1	760 ± 18	740 ± 16	-26.4 * ± 3.0
W_2	1036 ± 20	999 ± 19	-28.5 * ± 3.5
W_3	1346 ± 25	1295 ± 23	-28.0 * ± 4.3
W_4	1625 ± 26	1569 ± 24	-32.3 * ± 4.4
W_5	1879 ± 25	1831 ± 23	-39.3 * ± 4.3

1. Means within trait and factor with different letters are statistically different

2. Covariate mean=10.9 young 3. * Covariate effect is significant

The least square means for different post-weaning weights, concerning generation number effects (V15,V21) , estimated at a constant total litter size at birth of 10.9 young/litter are shown in Table 2 , together with the regression coefficients of the covariate on them. The effect of the covariate was always significant and negative, being the estimated values of the regression coefficients of the same order that the ones reported by García and Baselga (1999). The comparison between generations 21 and 15 was not significant for any weight between weaning and five weeks post-weaning, meaning that selection for litter size at weaning has not modified these traits when they are compared at the same litter size. In a previous experiment (García and Baselga, 1999) involving rabbits coming directly from vitrified embryos, no significant differences were found for weight at five weeks post-weaning between generations 21 and 15 of line V, agreeing with the result of this paper, but a significant difference favouring generation 21 was found in the weight at weaning (W_0) in apparent contradiction of the present results and others reported in the literature (Rochambeau et al, 1994). However, our two experiments had a very big difference in total litter sizes at birth. The previous one had, for the animals coming from vitrified embryos of both generations a total litter size at birth more than 4 young lower than the rabbits coming from the natural process of reproduction and perhaps this fact could explain the different results obtained in both experiments. Bolet et al. (1996) have also shown the effect of high litter sizes diminishing weaning weight and Rochambeau et al.(1994) found a correlated negative genetic trend in weaning weight when they analysed data of two lines selected for litter size for eighteen generations, but they did not include total litter size as a covariate in the models.

One important question concerning the diminution of weights from birth to adulthood when litter size increases is the possible limitations of the doe capacity to meet the needs for very high performances. This consideration has meant, in some cases, the modification of the objective of selection in some maternal lines, including in the objective the weight at 63 d, in addition to litter size performances (Rochambeau, 1998) trying to increase at the same time litter size and weights. Nevertheless, the least square means given in Table 2 , taking into account that they are means of favourable and not favourable year seasons , different pariry orders (including nulliparous does) and referred to a litter size of 10.9 young/litter, reveal that line V, no matter its specialisation as a maternal line, exhibits a high potential for growing.

The least square means for post-weaning daily gain are given in the Table 3. The results are similar to the ones discussed for weights in the sense that the comparison between generations was not significant at any week from weaning to five weeks post-weaning if the comparison is done at the same litter size at birth. Because the regression coefficients of litter size on daily gain traits have been always significant and negative, the differences between daily gains of both generations, no corrected by litter size, would had been significant. In the experiment of García and Baselga (1999) the comparison between generations on daily gain for the whole period of fattening and the regression coefficient of total litter size were both not significant. It is accepted in the literature that post-weaning daily gains are lowely affected by maternal and litter effects (Camacho and Baselga ,1991) and it means that low, no significant effects of litter size would be expected. However there are some variability on the reported results, some of them no significant (Torres et al, 1992) and some of them negative and significant(Feki et al.1996). It seems that the value of this regression is dependent on the degree of digestive normality during the fattening. If there were not digestive troubles the regression coefficients would be negligible and these would increase in absolute value and signification if the troubles increase, but we have not direct proof of it.

Table 3. Generalized least square means(gr/d) of generation of selection (V15, V21) and covariate effect (total litter size ,gr/d.young born) for daily gains from weaning to different post-weaning weeks, i (DG_i).

Trait	V15[1]	V21	Covariate[2,3]
DG_1	37.7 ± 1.3	35.8 ± 1.2	-0.54* ± 0.22
DG_2	38.6 ± 0.9	36.5 ± 0.9	-0.52* ± 0.16
DG_3	40.1 ± 0.9	37.8 ± 0.9	-0.41* ± 0.15
DG_4	39.8 ± 0.7	38.2 ± 0.7	-0.42* ± 0.13
DG_5	39.2 ± 0.6	37.9 ± 0.6	-0.54* ± 0.11

[1].Means within trait and factor with different letters are statistically different [2]. Covariate mean=10.9 young [3]. * Covariate effect is significant

The comparison between generations 15 and 21 referring daily feed consumption (Table 4) did not show significance during the five weeks of fattening when the comparison was done at a constant total litter size but the regression coefficients of the covariate were negative and significant during all the period, being their values around -1gr/d.young born. The results obtained by García and Baselga (1999) agree completely with the results got in this experiment both in the comparison between generation as in the effect of the covariate.

The comparison between generations for the conversion index has been done at a total litter size of 10.9 young/litter and at a constant final weight in the week of reference (Table 5). In these conditions the comparisons have been always no significant as it was in García and Baselga (1999). The effects of the covariate litter size were no significant and the effects of the weight at the end of the week of reference were negative and significant during the first three week and lost the significance afterwards. This covariate kept its significance and sign for the whole period in the experiment of García and Baselga (1999).

Table 4. Generalized least square means (gr/d) of generation of selection (V15,V21) and covariate effect(Total litter size, gr/d.young born) for daily feed consumption from weaning to different post-weaning weeks, i (FC_i).

Trait	V15[1]	V21	Covariate[2,3]
FC_1	65.5 ± 1.9	63.1 ± 1.8	-0.97 * ± 0.35
FC_2	77.0 ± 1.8	74.8 ± 1.7	-1.16 * ± 0.33
FC_3	88.5 ± 2.0	86.0 ± 1.9	-0.90 * ± 0.36
FC_4	99.0 ± 2.0	95.3 ± 1.9	-1.08 * ± 0.36
FC_5	106.8 ± 2.0	103.5 ± 1.9	-1.22 * ± 0.36

[1]. Means within trait and factor with different letters are statistically different [2]. Covariate mean=10.9 young [3]. * Covariate effect is significant

Table 5. Generalized least square means(gr/gr) of generation of selection (V15,V21) and covariate effects(total litter size,gr/gr.young born and W_i,gr/gr.gr) for conversion index until different post-weaning weeks, i (CI_i).

Trait	V15[1]	V21	Covariate1[2]	Covariate2[3]	Cov2-Mean
CI1	1.75 ± 0.06	1.79 ± 0.05	-0.013 ± 0.012	-0.0007 * ± 0.0002	763
CI2	2.00 ± 0.05	2.04 ± 0.04	-0.016 ± 0.09	-0.0005 * ± 0.0002	1041
CI3	2.22 ± 0.04	2.26 ± 0.04	-0.013 ± 0.08	-0.0004 * ± 0.0001	1342
CI4	2.48 ± 0.04	2.49 ± 0.04	-0.007 ± 0.009	-0.0001 ± 0.0001	1642
CI5	2.72 ± 0.05	2.73 ± 0.04	0.004 ± 0.010	0.0000 ± 0.0001	1904

[1].Means within trait and factor with different letters are statistically different [2]Covariate1 mean=10.9 young
[3]. * Covariate effect is significant

The conclusion of this experiment evaluating, in the line V, the correlated effects of selection for litter size at weaning on growth, feed consumption and feed efficiency traits is that doing the evaluation to constant litter size there are not correlated effects, and consequently we have to admit that the differences found in these traits between generations of the line compared contemporarily are due to their differences in litter size.

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