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PRELIMINARY GENETIC ANALYSES OF CALDES LINE: A SELECTION EXPERIMENT FOR A GLOBAL OBJECTIVE

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ABSTRACT

Genetic parameters of traits of interest in Caldes Line, selected using an independent culling levels method (litter weight at weaning of the dam and individual daily weight gain) were estimated by REML. Heritabilities were very low for litter weight at weaning (0.02 (s.e. 0.005)) and for reproductive traits (from 0.03 to 0.10). Repeatabilities were lower than 0.23. Values of heritability were moderate for growth traits: 0.27 (0.016) for daily weight gain and 0.14 and 0.23 for individual weights at weaning and at 60 days old. Magnitude of litter effects was very important (0.26 to 0.49).
Genetic progress was estimated using BLUP/REML techniques. Genetic trend of litter weight at weaning (30.7 g per litter and per year) was the result of positive genetic responses of litter size at weaning (0.03 pups per litter and per year) and individual weight at weaning (11 g per pup and per year). Direct genetic trend of daily gain was around 1.06 g/d per year with an indirect response of individual weight at 60 d old (38 g per rabbit and per year).
Selection for a global objective has achieved a response in growth traits without impairment of litter size at weaning.

INTRODUCTION

A selection experiment was designed in order to obtain a multipurpose synthetic strain (Valls *et al.*, 1985). The experiment was also valuable in studying the efficiency of selection for a global objective (litter weight at 60 days), and assessing the possibility of using a selection model with overlapping generations. Caldes line was selected by an independent culling levels method trying to improve a synthetic trait: litter weight at 60 days, using as selection criteria the litter weight at weaning and the individual daily weight gain (between 32 and 60 days). The selection objective of the strain changed after nine years of selection, in 1993, and nowadays line Caldes is only selected for daily gain.
The Caldes strain was set up in 1979 from five New Zealand White sources and a 6th strain formed by California x New Zealand White animals. Foundation and selection methods were described by Rafel *et al.* (1988, 1990). Demographic and phenotypic analyses were presented in Oregon (Ramon *et al.*, 1992; Utrillas *et al.*, 1992). Rochambeau *et al.* (1988) described another selection experiment for a global objective in rabbits, using litter weight at weaning per doe and per year as the synthetic trait. Some preliminary genetic analysis (Rochambeau *et al.*, 1992) and demographic studies (Rochambeau *et al.*, 1999) have been reported.
Our main objective now is to complement the previous work, estimating the genetic parameters, and trying to provide some clues about direct genetic trends, especially litter weight at weaning and daily gain, and indirect responses of correlated traits. Estimates of genetic variances were obtained using REML, under multitrait animal models in order to include simultaneously the information of the traits which gave rise to the selection decisions (Sorensen and Johansson, 1992).

MATERIAL AND METHODS

The constitution of the flock, the animal management system and the farming conditions are described in previous reports (Rafel *et al.*, 1988, 1990; Utrillas *et al.*, 1992). Overlapping generations, reproduction groups and fortnightly batches are the most relevant features of the management. The former was chosen in order to facilitate a full occupation of cages and to reduce generation intervals (10.6 months according to Ramon *et al.* (1992)). The second one makes it easy to better manage inbreeding (Rochambeau, 1990).

Selection objective was litter weight at 60 days, using an independent culling levels selection method. Does were ranked taking into account litter weights at weaning, using a selection index with repeated measurements (Values of the parameters were heritability equal to 0.05 and repeatability equal to 0.20). Individual daily gain was calculated between 32 and 60 days, and an individual selection method was applied. Bucks were selected from the 50% best-ranked dams and also from the fastest-growing 15% males. Females came from the top 80% in the ranking of litters and from the 25% of the females with the highest values of daily gain.

A total of 43,125 individual body weight controls and 6,925 parturitions from 1983 to 1992 were included in the analysis. The pedigree file included 43,308 individuals.

Individual traits studied were weight at weaning (32 d) (**IWW**), individual daily gain (**IDG**) and individual weight at 60 days old (**IWS**). Total litter size at birth (**LSB**), number born alive (**LSBA**), litter size at weaning (**LSW**) and litter weight at weaning (**LWW**) were considered as doe traits. Every parturition with at least one young rabbit born was included. Litters were reconstituted, limiting the first litter to a maximum of 8, and the remaining litters to a maximum of 10. Surplus animals were eliminated 2 days after birth.

Next, we present possible fixed effects which may be included in the mixed models: LSBA: litter size at birth born alive, was only included in the model when IWW was the trait analysed, with ten levels (<6, 6, 7, …12, 13, >13); SEX: Sex was observed at 60 days: male or female. Individuals who died during the fattening period had another sex level; OP: parity order, with six levels; BATCH: 228 levels, grouping the individuals raised at the same time; BK: kindling batch. The model considers 86 batches of animals weaned within 6-week periods (minimum 56 records per batch) and LE: Lactation effect or physiological state of the doe at mating. First level is for nulliparous does. Remaining levels are assigned according to the length of the lactation-pregnancy overlap (>18 or <7 days) and the size at weaning of the last litter (<5, 5-9, >9)(Gómez *et al.*, 1996). More than 20% of the data were from first litters. Possible random effects were LITTER: common litter effect. This is shared by individuals weaned in the same litter; PERMANENT: non-additive genetic effect plus permanent environmental effect associated with the doe, and ANIMAL: animal direct genetic effect.

Models for growth traits (**IWW**, **IDG** and **IWS**) consisted of

$$Y = LSBA \text{ (only for IWW)} + SEX + PO + BATCH + litter + animal + error$$

and mixed model for doe's traits (**LSB**, **LSBA**, **LSW**, **LWW**) was

$$Y = BK + LE + permanent + animal + error$$

No contrasts between levels of fixed effects will be discussed. Variance components were estimated by REML with VCE software (Neumaier and Groeneveld, 1998), using multitrait animal models. Only reproductive traits or growth traits were jointly analysed. Estimates of genetic parameters could be biased because selected traits (**LWW** and **IDG**) were not included simultaneously with the other traits in all the analyses. Breeding values of different traits were predicted. These values were averaged per year (and not per 'generation', because the population was managed in overlapping generations) in order to represent the genetic progress. Estimated genetic responses are dependent on the genetic parameters (REML estimates) and on the model (Sorensen and Johansson, 1992).

RESULTS AND DISCUSSION

Phenotypic description

Figure 1 shows yearly averages of prolificacy traits (**LSB**, **LSBA** and **LSW**) and litter weights at weaning (**LWW**) per doe and per year, taking as zero the average values during the first year. Raw averages were 9.4 (**LSB**), 8.7 (**LSBA**), 6.7 (**LSW**) and 5090 g (**LWW**). **LSB** and **LSBA** lines are more or less close depending on the mortinatality. No phenotypic advances were appreciated in does' traits, except for litter weight at weaning (35 g per litter and per year), in spite of a small reduction of litter size at weaning (-0.025 pups per year). Yearly phenotypic improvement of growth traits was important for daily gain (1 g/d per year) and for liveweight at 60 days old (29 g per year), but it was very low for weight at weaning. Raw averages for individual weight at weaning and at 60 days old were 756 and 1896 g, with a value of 41.6 g/d for daily gain during the fattening period. Daily gain and liveweight at 60 days have increased, around 1 g/d and 29 g per year respectively. Individual weight at weaning is stationary since 1987, without any significant variation (Figure 2).

Figure 1

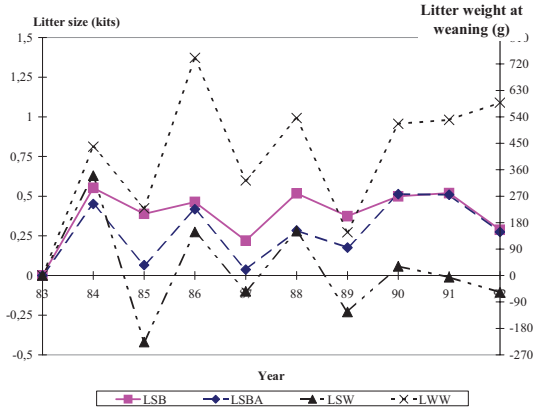
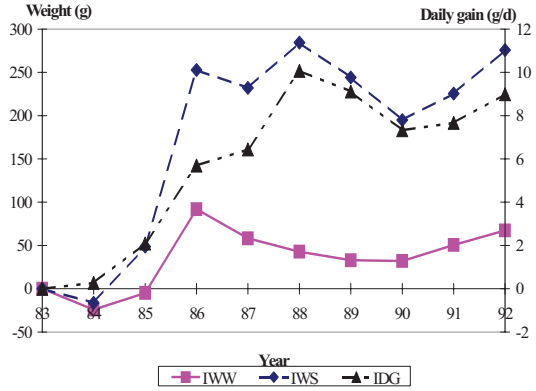


Figure 2



Figures 1 & 2 - Phenotypic values (using first year as origin) for litter size at birth, total (**LSB**) or born alive (**LSBA**), litter size at weaning (**LSW**) and litter weight at weaning (**LWW**). Id. for individual weight at weaning (**IWW**), at 60 days old (**IWS**) and daily gain (**IDG**)

Genetic parameters and approximate genetic responses

Tables 1 and 2 present the values of heritability for traits studied, the values of genetic correlations and the ratio of permanent effect variance to phenotypic variance for doe traits, and the ratio of litter effect variance to phenotypic variance for individual traits. Genetic parameters of productive and reproductive traits have been widely reported by several rabbit research teams using REML software.

Table 1 - Values (and standard errors) of heritabilities (on the diagonal), genetic correlation (above the diagonal) and ratio of permanent effect variance to phenotypic variance ($\mathbf{p^2}$) for doe traits: litter size at birth (**LSB**), born alive (**LSBA**), litter size at weaning (**LSW**) and litter weight at weaning (**LWW**).

	LSB	**LSBA**	**LSW**	**LWW**
	0.10 (0.008)	0.97 (0.013)	0.45 (0.101)	-0.06 (0.084)
		0.07 (0.007)	0.62 (0.088)	0.12 (0.092)
			0.03 (0.003)	0.65 (0.071)
				0.02 (0.005)
$\mathbf{p^2}$	0.12 (0.008)	0.12 (0.007)	0.11 (0.003)	0.12 (0.005)

Table 2 - Values (and standard errors) of heritabilities (on the diagonal), genetic correlations (above the diagonal) and ratio of litter effect variance to phenotypic variance ($\mathbf{c^2}$) for the individual traits: weight at weaning (**IWW**), daily gain during the fattening period (**IDG**) and liveweight at 60 days old (**IWS**)

	IWW	IWS	IDG
	0.14 (0.014)	0.784 (0.022)	0.47 (0.044)
		0.23 (0.015)	0.91 (0.010)
			0.27 (0.016)
$\mathbf{c^2}$	0.49 (0.006)	0.41 (0.006)	0.26 (0.005)

Estimated heritabilities for reproductive traits were low, like previous estimates in other populations, from 0.10 (s.e. 0.008) for litter size at birth to 0.03 (s.e. 0.003) for litter size at weaning. The value of heritability for LWW was the lowest, 0.02 (s.e. 0.005). Repeatabilities of the traits were not higher than 0.23. The estimates are of the same magnitude as those recently reported in other selected populations (Baselga *et al.*, 1992; Ferraz *et al.*, 1992, Ferraz and Eler, 1996; Gómez, 1994; Gomez *et al.*, 1996; Rochambeau *et al.*, 1994).

Values of heritability were moderate for growth traits: 0.27 (0.016) for daily gain and 0.14 and 0.23 for individual weights at weaning and at 60 days. Magnitude of litter effects was very important (0.26 to 0.49), as in Ferraz and Eler (1996). Argente *et al.* (1999) published higher values for IWW (0.24-0-25) with high litter effects (0.52-0.58), but other papers estimated similar heritabilities to ours (Estany *et al.*, 1992; Ferraz and Eler, 1996), or lower ones (Rochambeau *et al.*, 1994).

Genetic trend in litter weight at weaning (30.7 g per litter and per year) was the result of positive genetic responses in individual weight at weaning (11 g per pup and per year) and litter size at weaning (0.03 pups per litter and per year, in Figure 3). No genetic trend was observed for litter size at birth (total or born alive)(Figure 3). Similar increases in litter size at weaning have been reported by Baselga *et al.* (Line V, 1992) or by Poujardieu *et al.* (Line A2066, 1994) on specialised reproductive strains. The ability of does to raise litters has also been improved, because genetic response in litter size at weaning was higher than response on litter size at birth.

Figure 3

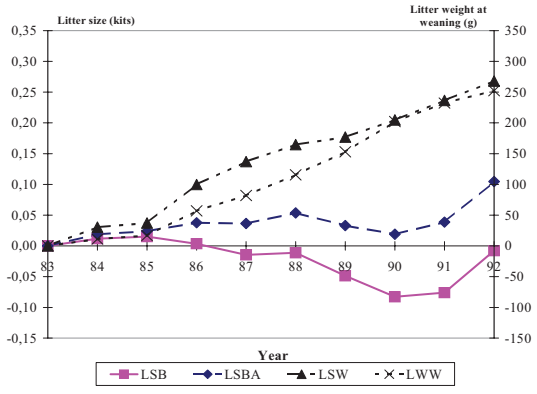
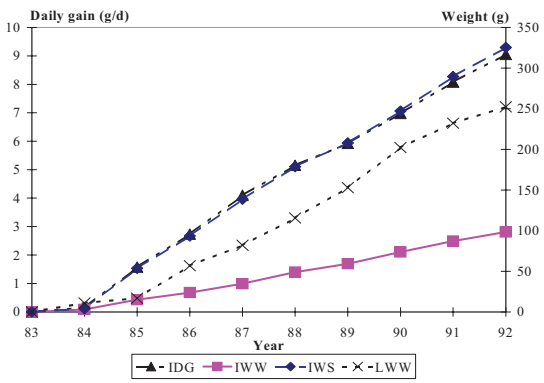


Figure 4



Figures 3 & 4 - Genetic response for litter size at birth, total (**LSB**) or born alive (**LSBA**), litter size at weaning (**LSW**) and litter weight at weaning (**LWW**). Id. for individual weight at weaning (**IWW**), individual weight at 60 days old (**IWS**) and daily gain (**IDG**)

Direct response of daily gain was around 1.06 g/d per year, with an indirect response in individual weight at 60 d old (38 g per rabbit and per year). Some experiments where **IDG**

has undergone selection caused a reduction in **LSW** (Rochambeau *et al.*, 1989); but other experiments presented positive values (Camacho and Baselga, 1990). Reported estimates of genetic correlations between litter size and growth traits in rabbits are very limited (Camacho, 1989; Gómez *et al.*, 1998). In Caldes strain, selection for litter weight at 60 days achieved positive responses on growth rate, but maintaining high reproductive performances.

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