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FEEDING EFFICIENCY IN CROSSBREEDING AMONG THREE OF THE STRAINS SELECTED IN SPAIN

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SUMMARY - A triallelic crossbreeding experiment was planned in order to estimate crossbreeding parameters for growth traits (liveweight and daily gain), feed intake and feed conversion from 32 to 60 days. Three selected Spanish strains were involved: maternal lines 11 and 55 and paternal line 44. No significant heterosis estimates were found. Marked direct additive genetic effects of specialized paternal line were contrasted. Purebred differences between Line 44 and the average of maternal lines were +90 g on weight at 32 days, +325 g at 60 days, +12 g/d on daily gain, +24 g/d on feed intake and -0.18 on feed conversion. Complementarity should be the choice to improve performances of young rabbits during the fattening period.

Key words: Crossbreeding, Growth traits, Feed conversion, Specialized strains

INTRODUCTION

Crossbreeding between lines selected on litter size in order to obtain a crossbred doe taking profit of heterosis in reproductive traits should be a usual technique in commercial rabbit farms (Brun and Saleil, 1994; Khalil *et al.*, 1995; Brun *et al.*, 1998). The crossbreeding scheme should be completed using as sire an individual coming from paternal lines, selected on growth traits. The objective of this last cross would improve the performances of young rabbits during the fattening period (Brun and Ouhayoun, 1990; Afifi *et al.*, 1994).

A crossbreeding experiment was started in Spain in 1996. Its main objective is to optimize the composition and the direction of the cross between maternal lines to obtain the best crossbred doe taking profit of heterosis on reproductive traits (Brun and Saleil, 1994; Brun et al., 1998). Performances of young rabbits mothered by crossbred does and sired by two different paternal lines will be recorded during their fattening period and after slaughter to detect differences between paternal lines. The experiment concerns five of the specialized lines selected in Spain coming from two public research institutions: the Department of Animal Science (U.P.V.) and the Unit of Rabbit Science (I.R.T.A.).

All these lines will be crossed among themselves in order to analyze the genetic effects and the heterosis effects on liveweights, daily gain, feed intake, and feed efficiency. The aim of this paper is to present preliminarv results of the first year, concerning Lines 11, 44 and 55.

MATERIAL AND METHODS

The experiment was carried out from July 1997 to April 1998, and concerned the offspring produced crossing animals from two maternal lines (lines A and V) and a paternal one (Line R). These parents came from the Department of Animal Science in Valencia. Gómez *et al.* (1998b) show details of the foundation, selection, diffusion and performances of these selected strains:

- *Line A* (named *11*): selected since 1980 on litter size at weaning with a family index with variable information (Baselga *et al.*, 1984).
- *Line R* (named *44*): selected on growth rate between 28 and 63 days since 1980 by an individual selection method (Estany *et al.*, 1992).
- *Line V* (named *55*): selected since 1982 on litter size at weaning. Breeding values are predicted with a repeatability animal model (Estany *et al.*, 1989).

Animals were bred under the conditions of the experimental farm of Unit of Rabbit Science. The first mating of does was about 4.5 months old. Dams were remated 11 days after kindling (semi-intensive rhythm). The offspring were weaned at 32 days. Then the animals were weighed and identified. Young rabbits were moved to collective cages (8 kids per cage) until the end of the fattening period. Cages usually contained of young rabbits coming from two or three litters of the same genetic type. A commercial diet was given *ad libitum*. Individual weights and collective feed consumption were weekly recorded. The collective feed conversion was recorded as the ratio between collective feed intake and collective weight gain. When a young rabbit died its weight was recorded. If it had lost weight, a null food intake was assumed.

Table 1 - Progeny produced under triallelic cross among *Line A* (*11*), *Line R* (*44*) and *Line V* (*55*)

(Types)	Dam	11	44	55
Sire				
11		11	14	15
44		41	44	45
55		51	54	55

(Number of cages)	Dam	11	44	55
Sire				
11		10	7	10
44		5	14	6
55		13	9	14

Diallelic crosses between lines produced nine different genetic types (Table 1). The recorded and calculated traits along the fattening period are shown on Table 2. The general linear model procedure (SAS, 1989) was used in the analyses because data were not balanced. The main factors were the season (two levels: summer and spring) and the genetic type (nine levels, see Table 1). The weight at weaning was included as covariate in these analyses in order to show the adjusted data. The Dickerson's model (1969) was used to estimate crossbreeding parameters of different traits. The direct heterosis (h^I), the direct genetic effect (g^I) and the maternal (plus grand-maternal) genetic effect (g^M+$g^{M'}$) were estimated through linear contrasts.

Table 2 - Recorded and calculated traits along the fattening period

	weaning	1st week	2nd week	3rd week	4th week	four weeks
Liveweight (g)	W0			W3	W4	
Feed intake (g/d)		FI01	FI12	FI23	FI34	FI04
Daily gain (g/d)		DG01	DG12	DG23	DG34	DG04
Feed conversion (g/g)		FC01	FC12	FC23	FC34	FC04

RESULTS AND DISCUSSION

The purpose of Table 3 is to summarize liveweights and traits measured along the fattening period. Animals of Line 55 were the lightest at weaning (Table 3). The adjusted data of young rabbits from Lines 11, 55 and their crosses were the lightest at the 53rd and at 60th days (Table 3), had the lowest daily feed intake (109<FI04<112 g) and daily gain (40.1<DG04<41.0 g/d). The behavior of Line 44 was the opposite. Young rabbits were the heaviest (W3 and W4). They showed the highest values of daily gain (global or weekly), feed intake (global or weekly), and the lowest global feed conversion (not different from types 45 and 41) (Tables 3, 4, 5 and 6).

Observed differences between types decreased including weight at weaning as covariate into the analysis model. The lowest and the highest raw values were: weight at 60 days (1756 g (type 55) and 2227 g (type 44)), daily weight gain (39.7-41.1g/d (types 55, 11, 51 and 15) and 52.7 g/d (type 44)), and feed intake (104-112 g (types 55, 11, 51 and 15) and 137 g (type 44)). No significant differences were found on global feed conversion. The covariate weaning weight was not significant on traits DG23 and DG34 (Table 4).

No significant differences were observed on weight at weaning between seasons (Table 3), but differences were noticed at the end of the fattening period, specially during the last week (W4). Differences on total daily gain (DG04) was mainly caused by differences during last week. A strong reduction on daily gain was observed in the summer (DG34 on Table 4). The daily feed intake (FI04) was 10 g higher in the spring (Table 3). Differences between third and fourth week of the fattening period explain this result (Table 5). In the summer, feed intake only increased 8 g in contrast with 24 g in the spring. In the summer, the conversion rate was lower than in the spring during the first three weeks (Table 6). No differences were observed during the last week (FC34) because of high rise happening in the summer (Table 6). All these exposed results are according to numerous reported scientific literature concerning seasonal effects on rabbit breeding (v.gr. Simplicio *et al.*, 1988; Chiericato *et al.*, 1993).

No heterosis effects were found in the different crosses (Tables 7 to 10) on the studied traits, apart from the positive heterosis (around 8%) on daily gain during the fattening period (DG04) in the 11 X 44 cross (Table 7). Gómez *et al.* (1998a) reported low heterosis effects in crossbreeding on weaning weight, weight at 60 days, and daily gain. French experiments also detected low heterosis effect on weaning weight (1.5-2%) (Brun and Rouvier, 1988; Brun, 1993).

Only the estimates of maternal genetic effects for DG34 (Table 8) and FC34 (Table 10) were statistically different from zero, reflecting that young rabbits mothered by does 55 grew faster (DG34) and had a 0.3 best feed conversion (FC34) during the last week than the descendants from does 44. However, Gómez *et al.* (1998a) reported significant maternal additive effects on daily gain, weaning weight and weight at 60 days when these lines were compared using a different data set and with an analysis model that also included parity order and litter size as main effects.

The only diferences found when the maternal lines were compared were on the weaning weight. The genetic additive effect on Line 11 was higher than on line 55 (98 g). But the opposite was observed by Gómez *et al.* (1998a). Main differences were observed comparing maternal and paternal lines. The direct genetic additive effects of line 44 (comparing with line 55) were +127 g on weaning weight, +353 g on weight at 60 days, +13 g/d on daily gain, +24 g on daily feed intake and -0.3 on feed conversion.

Purebred differences between maternal lines (11-55) were not significant for studied traits. The differences between paternal Line 44 and the average of maternal lines (Lines 11 and 55) were of the same order than genetic additive effects: + 90 g on weight at 32 days, +325 g on weight at 60 days, +12 g/d on daily gain, +24 g/d on feed intake and -0.18 on feed conversion. The growth performance of lines 11, 44 and 55 has been compared by different authors. There are reported differences for weaning weight at 28 lying between 54 g (Feki *et al.*, 1996) and 65 g (Gómez *et al.*, 1998b) and 111 g when young rabbits were weaned at 32 days (Gómez *et al.*, 1998a). The differences on weight at the end of the fattening period were higher than the current ones (between 383 and 482 g at 63 days (Feki et al., 1996, Ramon et al., 1996; Gómez et al., 1998b) and 481 g at 60 days (Gómez et al., 1998a)). Feki *et al.* (1996) also observed the highest feed intake of line 44 (15-17 g) but also the lowest feed conversion (-0.2 - -0.4).

Complementarity and not heterosis is the way to take profit of genetic diversity between these strains when the objective is to improve the performances of young rabbits during the fattening period. Line 44 is widely used in Spain as a buck strain, but to mate crossbred does. It is necessary to have finished the whole crossbreeding experiment in order to arrive to general conclusions.

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Table 3- Least square means (and standard errors) by genetic type and season of the traits weight at weaning (W0), at 53 days (W3) and at 60 days (W4) and daily gain (DG04), daily feed intake (FI04) and feed conversion (FC04) during all the fattening period using W0 as covariate

Type	W0	W3	W4	DG04	FI04	FC04
11	710 abc (31)	1533 a (19)	1838 a (22)	40.1 a (.80)	109 a (2.5)	2.73 bc (.059)
14	777 cd (38)	1646 b (24)	1961 b (27)	44.6 c (.98)	120 b (3.0)	2.77 c (.067)
15	729 bcd (31)	1562 a (19)	1861 a (21)	41.0 ab (.76)	111 a (2.8)	2.70 bc (.062)
41	814 d (45)	1664 bc (28)	1958 b (32)	43.8 bc (1.3)	116 ab (3.6)	2.61 ab (.079)
44	771 cd (26)	1809 d (16)	2164 d (18)	52.2 e (.68)	134 c (2.1)	2.54 a (.051)
45	732 bcd (39)	1693 bc (24)	2045 c (28)	47.6 d (.98)	122 b (3.1)	2.56 ab (.073)
51	690 ab (27)	1550 a (17)	1850 a (19)	40.7 a (.68)	112 a (2.1)	2.74 c (.046)
54	725 bcd (33)	1717 c (21)	2020 bc (23)	46.4 cd (.84)	122 b (2.7)	2.71 bc (.060)
55	651 a (26)	1559 a (17)	1836 a (19)	40.3 a (.70)	109 a (2.2)	2.72 bc (.049)
Season						
summer	720 (13)	1645 (7.8)	1920 a (8.9)	43.4 a (.33)	112 a (1.0)	2.59 a (.023)
spring	746 (21)	1632 (13)	1977 b (15)	44.7 b (.53)	122 b (1.7)	2.77 b (.040)

Least square means within column and effect that do not share a common letter differ (P<0.05)

Table 4- Least square means (and standard errors) by genetic type and season of daily gain (g/d) during the first (DG01), second (DG12), third (DG23) and last week (DG34) of the fattening period using W0 as covariate

Type	DG01	DG12	DG23	DG34
11	38 a (1.8)	39 a (1.5)	42 a (1.7)	42 ab (1.4)
14	42 ab (2.1)	45 bc (1.8)	47 ab (2.1)	46 bc (1.7)
15	38 a (1.7)	42 ab (1.7)	44 a (2.0	44 ab (1.4)
41	40 ab (2.8)	46 bc (2.1)	47 ab (2.4)	45 ab (2.1)
44	47 c (1.5)	53 d (1.2)	55 c (1.4)	51 d (1.2)
45	41 ab (2.1)	47 c (1.8)	52 bc (2.0)	50 cd (1.8)
51	38 a (1.5)	38 a (1.5)	42 a (1.7)	43 ab (1.2)
54	44 bc (1.8)	46 c (1.5)	52 bc (1.8)	44 ab (1.5)
55	38 a (1.5)	39 a (1.2)	44 a (1.4)	41 a (1.2)
Season				
summer	41.7 (.72)	44.3 (.58)	46.5 (.65)	41.1 a (.57)
spring	39.7 (1.1)	43.8 (1.1)	48.0 (1.3)	48.8 b (.94)

Least square means within a column and effect that do not share a common letter differ (P<0.05)

Table 5- Least square means (and standard errors) by genetic type and season of daily feed intake during the first (FI01), second (FI12), third (FI23) and last (FI34) week of the fattening period using W0 as covariate.

Type	FI01	FI12	FI23	FI34
11	77 a (2.7)	100 ab (3.5)	125 ab (3.5)	142 a (4.6)
14	85 bc (3.2)	113 cd (4.0)	135 cd (4.2)	145 a (5.8)
15	77 a (2.6)	102 abc (4.4)	126 abc (4.1)	142 a (4.6)
41	78 ab (3.8)	108 bcd (4.7)	133 bcd (5.0)	145 a (6.9)
44	87 c (2.2)	126 e (2.9)	151 e (2.9)	167 b (4.0)
45	81 abc (3.3)	110 bcd(3.9)	139 d (4.2)	155 ab (5.9)
51	79 ab (2.3)	97 a (3.3)	120 a (3.5)	145 a (4.1)
54	82 abc (2.8)	115 d (3.6)	139 d (3.6)	150 a (5.0)
55	76 a (2.3)	97 a (2.8)	125 ab (2.9)	141 a (4.1)
Season				
summer	78 (1.0)	105 (1.3)	128 a (1.3)	136 a (1.9)
spring	82 (1.8)	110 (2.5)	137 b (2.7)	161 b (3.1)

Least square means within a column and effect that do not share a common letter differ (P<0.05)

Table 6- Least square means (and standard errors) by genetic type and season of feed conversion during the first (FC01), second (FC12), third (FC23) and last (FC34) week of the fattening period using W0 as covariate.

Type	FC01	FC12	FC23	FC34
11	2.00 bc (.052)	2.56 (.073)	2.98 (.070)	3.39 (.096)
14	2.05 c (.062)	2.53 (.083)	3.01 (.084)	3.29 (.121)
15	2.02 bc (.049)	2.44 (.092)	2.90 (.081)	3.32 (.095)
41	1.92 abc (.073)	2.35 (.097)	2.89 (.099)	3.30 (.143)
44	1.82 a (.042)	2.38 (.059)	2.77 (.058)	3.16 (.084)
45	1.97 abc (.063)	2.33 (.082)	2.74 (.083)	3.11 (.122)
51	2.08 c (.043)	2.52 (.069)	2.85 (.070)	3.36 (.084)
54	1.88 ab (.053)	2.51 (.075)	2.72 (.072)	3.45 (.104)
55	2.02 bc (.043)	2.52 (.058)	2.88 (.058)	3.46 (.084)
Season				
summer	1.88 a (.020)	2.36 a (.028)	2.77 a (.027)	3.28 (.040)
spring	2.07 b (.034)	2.56 b (.052)	2.95 b (.053)	3.34 (.065)

Least square means within a column and effect that do not share a common letter differ ($P<0.05$)

Table 7- Estimation by linear contrasts (and standard errors) of genetic aditive effects (gl), maternal additive genetic effects (gM+gM'), direct heterotic effects (h^l) and purebred differences (l) for weight at weaning (W0) and at 60 days (W4) and daily gain (DG04), daily feed intake (FI04) and feed conversion (FC04) during all the fattening period using W0 as covariate.

		W0 (g)	W4 (g)	DG04 (g/d)	FI04 (g/d)	FC04 (g/g)
g^l	11-55	98 (57)*	13 (41)	0.1 (1.5)	-2 (4.9)	-0.03 (0.11)
	44-55	127 (64)*	353 (46)*	13 (1.6)*	24 (5.2)*	-0.32 (0.12)*
$g^M+g^{M'}$	11-55	-39 (41)	-12 (29)	-0.3 (1.0)	1 (3.5)	-0.04 (.077)
	44-55	-7 (52)	-26 (36)	-1.2 (1.3)	0 (4.1)	0.14 (.094)
h^l	11 x 44	-109 (71)	83 (51)	3.8 (1.9) *	6 (5.7)	-0.11 (0.13)
	11 x 55	-58 (57)	-36 (40)	-1.3 (1.5)	-5 (4.8)	0.0 (0.11)
	44 x 55	-35 (63)	-65 (44)	-1.5 (1.6)	-1 (5.0)	-0.0 (0.12)
l	11-55	60 (40)	2 (28)	-0.2 (1.1)	0 (3.3)	0.01 (.075)
	44-55	120 (37)*	327 (27)*	12 (1.0)*	24 (3.1)*	-0.18 (.072)*

* Significantly different from zero at 0.05

Table 8- Estimation by linear contrasts (and standard errors) of genetic aditive effects (gl), maternal additive genetic effects (gM+gM'), direct heterotic effects (hl) and purebred differences (l) for daily gain (g/d) during the first (DG01), second (DG12), third (DG23) and last week (DG34) of the fattening period using W0 as covariate.

		DG01	DG12	DG23	DG34
g^l	11-55	0.2 (3.2)	4 (3.0)	-0.0 (3.4)	2 (2.6)
	44-55	6.6 (3.6)	16 (3.0)*	12 (3.4)*	16 (2.9)*
$g^M+g^{M'}$	11-55	-0.1 (2.2)	-3 (2.2)	-2 (2.5)	-0.6 (1.8)
	44-55	2.8 (2.8)	-1 (2.4)	-1 (2.7)	-6 (2.3)*
h^l	11 x 44	3.4 (4.2)	1 (3.3)	4 (3.8)	2 (3.2)
	11 x 55	-0.7 (3.2)	-2 (2.9)	0.0 (3.3)	-4 (2.6)
	44 x 55	-0.8 (3.5)	-1 (2.9)	-5 (3.3)	-3 (2.8)
l	11-55	0.0 (2.3)	1 (1.9)	-2 (2.2)	1 (1.8)
	44-55	9.4 (2.2)*	15 (1.8)*	11 (2.1)*	10 (1.7)*

* Significantly different from zero at 0.05

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Table 9- Estimation by linear contrasts (and standard errors) of genetic aditive effects (gI), maternal additive genetic effects (gM+gM'), direct heterotic effects (hI) and purebred differences (I) for daily feed intake during the first (FI01), second (FI12), third (FI23) and last (FI34) week of the fattening period using W0 as covariate.

		FI01	FI12	FI23	FI34
g^I	11-55	-2 (4.9)	9 (7.1)	6 (7.0)	-2 (8.7)
	44-55	9 (5.4)	26 (6.7)*	27 (7.0)*	31 (9.8)*
$g^M+g^{M'}$	11-55	3 (3.4)	-5 (5.4)	-6 (5.2)	3 (6.1)
	44-55	1 (4.3)	4 (5.3)	-1 (5.6)	-4 (7.8)
h^I	11 x 44	0 (6.1)	6 (7.5)	7 (7.9)	19 (11)
	11 x 55	-3 (4.9)	-2 (7.0)	3 (6.9)	-5 (8.6)
	44 x 55	0 (5.2)	-2 (6.5)	-1 (6.8)	3 (9.4)
I	11-55	1 (3.5)	3 (4.4)	-0.0 (4.4)	1 (6.1)
	44-55	11 (3.2)*	30 (4.1)*	27 (4.2)*	26 (5.8)*

* Significantly different from zero at 0.05

Table 10- Estimation by linear contrasts (and standard errors) of genetic aditive effects (gI), maternal additive genetic effects (gM+gM'), direct heterotic effects (hI) and purebred differences (I) for feed conversion during the first (FC01), second (FC12), third (FC23) and last (FC34) week of the fattening period using W0 as covariate.

		FC01	FC12	FC23	FC34
g^I	11-55	-0.1 (.093)	-0.05 (.15)	0.1 (.14)	-0.1 (.18)
	44-55	-0.1 (.103)	-0.31 (.14)*	-0.1 (.14)	-0.6 (.20)*
$g^M+g^{M'}$	11-55	0.1 (.065)	0.08 (.11)	-0.0 (.10)	0.0 (.13)
	44-55	-0.1 (.082)	0.17 (.11)	-0.0 (.11)	0.3 (.16)*
h^I	11 x 44	-0.2 (.120)	0.05 (.16)	-0.1 (.16)	-0.0 (.23)
	11 x 55	-0.1 (.092)	0.11 (.14)	0.1 (.14)	0.2 (.18)
	44 x 55	-0.0 (.100)	0.05 (.14)	0.2 (.13)	0.0 (.20)
I	11-55	-0.0 (.066)	0.04 (.092)	0.1 (.089)	-0.1 (.12)
	44-55	-0.2 (.062)*	-0.14 (.085)	-0.1 (.084)	-0.3 (.12)*

* Significantly different from zero at 0.05