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CROSSBREEDING PARAMETERS OF SOME PRODUCTIVE TRAITS IN MEAT RABBITS

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Abstract: A crossbreeding experiment using animals from C and R rabbit strains was conducted. Direct and maternal additive genetic effects and direct heterosis were estimated for some productive traits during the post-weaning growing period. Growth rate, daily feed consumption, and feed conversion ratio, between 32 to 60 days of age, were recorded for 1377 young rabbits. At 66 days of age, 736 animals were weighed and slaughtered in a commercial slaughter-house. No fastening was practiced. Carcasses were weighed 30 min after slaughter and then they were chilled (4ºC, 24 hours) and weighed again. Carcass yield and drip loss percentage were computed. Model of analysis included the genetic type effect (C, CxR, RxC, R), batch effect, parity effect, litter size at birth effect, live weight at 60 days as a covariate to adjust growth, consumption and feed efficiency for differences in live weight at 60 days of age, common environmental litter effects and the additive genetic effects. Main relationships between individuals were taken into account through the relationship matrix. Crossbreeding parameters were computed from linear contrasts between levels of genetic type effect following Dickerson's model. Despite the differences between genetic types found, the difference between direct additive genetic effects was only significant for live weight at 60 days and daily feed intake. Neither heterosis nor maternal effects were significant for any of the traits analyzed.

Key words: rabbit, crossbreeding parameters, growth, feed efficiency, carcass yield.

INTRODUCTION

Efficiency of meat production can be improved by taking advantage of the diversity of rabbit breeds through crossbreeding. Genetic parameters such as additive genetic effects and direct or maternal heterosis are generally important for maternal performance but they are not well known for post weaning performance of growing rabbits, especially for traits related to feed efficiency and carcass merit. Besides,

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crossbreeding parameters can differ dramatically among environments and they can also evolve with selection of the lines.

In meat rabbit production, post weaning daily weight gain or weight at the end of the fattening period are used as selection criteria of sire lines in most breeding programmes (Rochambeau *et al.*, 1989; Rafel *et al*. 1990; Estany *et al*, 1992). Feed efficiency is one of the most commercially important traits because post-weaning feeding accounts for around 40 % of total cost (Armero and Blasco, 1992). This trait is improved through the negative genetic correlation with growth rate (Moura *et al.*, 1997; Piles *et al.*, 2003) because direct selection is difficult and costly. Carcass yield is also an important trait in Spain, because carcasses are generally graded and the price is established according to this value in commercial slaughter- houses. The aim of the present study was to estimate heterosis and additive genetic, direct and maternal, effects on several post-weaning growth and feed efficiency traits using a diallel crossbreeding design involving two sire lines of different genetic origin.

MATERIAL AND METHODS

Animals and experimental conditions

A complete diallel cross between two lines of rabbit C and R led to the production of 4 genetic types of individuals (C, CxR, RxC and R).

Line C was set up in 1979 from five New Zealand White sources and a 6th strain formed by California x New Zealand White animals (Rafel *et al.*, 1990). It was selected for litter weight at 60 days by the independent culling levels method using as selection criteria litter weight at weaning and individual daily weight gain between 32 and 60 days of age. Since 1993, it has been selected for individual daily weight gain by individual selection.

Line R was created by mating animals from a California line with animals from another synthetic line created by mating two commercial populations of crossbred rabbits. It has been selected for increased post-weaning daily weight gain by individual selection since 1980 (Estany *et al*., 1992).

At weaning age (32 days), 320 animals from lines C and R were housed in individual wire cages in the experimental farm of the Institut de Recerca i Tecnologia Agroalimentàries (IRTA). These animals were born in January 2001. The farm has isolated roof and walls, controlled lighting and ventilation, and a cooling-system to avoid high temperatures in summer. During the fattening period (32 to 60 days of age), animals were fed *ad libitum* with a commercial pelleted diet (16.4% raw protein, 4% fat, 15.2% fiber). Fresh water was always supplied *ad libitum*. Individual weights and feed consumption were recorded weekly. Then, 19 and 23 females and 12 and 13 males form lines C and R respectively, were allocated to reproductive wire cages and fed with 180 g/d of another pelleted diet (16% raw protein, 4.3% fat, 17% fiber). Does followed a semi-intensive reproductive rhythm (first mating at four and a half months of life and reproductive cycles of 42 days). Offspring were born between July 2001 and April 2002. After weaning, they were also housed and fed in the same conditions as their parents during the fattening period. Individual weights and feed consumption were also recorded weekly. Data of individuals with symptoms of illness were excluded from the analysis. At 66 days of age, animals were weighed and slaughtered in a commercial slaughterhouse. No fastening was practiced. Animals were bled by cutting the jugular vein and the carotid artery after electrical stunning. Carcasses were weighed after slaughter and then they were chilled (4ºC, 24 hours) and weighed again.

Experimental design

A 2 x 2 diallel crossing design was applied. Bucks were randomly assigned to does but repeated matings and matings between related individuals were avoided.

Traits

GR: growth rate between 32 and 60 days of age (g/d).

DFI: daily feed intake between 32 and 60 days of age (g/d).

FCR: Fed conversion ratio between 32 and 60 days of age.

LW: Live weight at 60 days of age (g).

SW: Slaughter weight (g).

CCW: Chilled carcass weight (g).

DoP: Dressing out percentage (%). DoP= 100 x CCW / SW.

DLP: Drip loss percentage (%). DLP=100 x (HCW-CCW)

Statistical analysis

The number of records per genetic type (C, CxR, RxC, and R) for each trait is shown in table 1. The following mixed model was applied:

$$\boldsymbol{y=X\beta +Zu+Wp+e}$$

where: y is the data vector, β is a vector containing the genetic type effect (4 levels), batch effect (10 levels), parity effect (first, second and third or more), litter size at birth effect (8 levels: less than 6, six levels from 6 to 11, and more than 11) and LW as a covariate to adjust growth, consumption and feed efficiency for differences in live weight at 60 days of age. p is a vector containing the environmental common litter effects (335 levels), u is a vector containing the additive genetic effects. There were 1625 animals in the pedigree file containing individuals, parents, and grandparents to take into account the main relationships between individuals. X, Z and W are the corresponding incidence matrices and e is the vector of residuals.

Crossbreeding parameters were computed from linear contrast between levels of genetic type effect. The model of DICKERSON (1969) was chosen:

$$y_{ij} = \mu + \frac{g_i + g_j}{2} + m_j + \delta h_{ij} + e_{ij}$$

where y_{ij} is the mean performance of offspring of sire line i mated with dam line j, is

μ the mean of parental lines, g_i (g_j) is the direct additive genetic effect of the i^{th} sire line (the j^{th} dam line), m_j is the maternal genetic effect of the j^{th} dam line, h_{ij} is the direct heterosis of the cross between lines i and j, δ is 1 for crosses between lines $i \neq j$ and 0 for lines $i=j$, e is the residual effect.

RESULTS AND DISCUSSION

Descriptive statistics

Table 1 shows the number of records of each genetic type (C, CxR, RxC, R), and some descriptive statistics (overall mean, standard deviation and coefficient of variation) of the traits analyzed. In Spain, there is a demand for light carcasses. Live slaughter weight and chilled carcass weight averaged 2670g and 1574g respectively. These values are high but correspond to animals that are used as sires in terminal crosses, not as commercial fryers. Most of the traits had a coefficient of variation around 0.14. DoP and DLP had small and large coefficient of variation respectively (0.03 and 0.29).

Table 1: Number of records by genetic type (C, CxR, RxC, R), overall mean, standard deviation and coefficient of variation (CV) of the traits analyzed.

Trait	C	CxR	RxC	R	Mean	SD	CV
LW	435	295	211	436	2411	343	0.14
GR	435	295	211	436	55.6	7.5	0.13
DFI	435	295	211	436	160	30	0.19
FCR	435	295	211	436	2.87	0.36	0.13
SW	198	217	130	191	2671	362	0.14
CCW	198	217	130	191	1574	223	0.14
DoP	198	217	130	191	58.9	1.6	0.03
DLP	198	217	130	191	2.23	0.65	0.29

LW: live weight at 60 days of age, GR: growth rate, DFI: daily feed intake, FCR: feed conversion rate, SW: slaughter weight, CCW: chilled carcass weight, DP: dressing percentage and DLP: drip loss percentage.
C = C line, R = R line

Breed type comparison

Table 2 shows estimated mean and standard error of levels of genetic type effect (C, CxR, RxC, R) for all traits analyzed. Significant differences between genetic types were observed in all of them except in GR, FCR and DLP. Kits of genetic type C were lighter at 60 days of age, grew slower and ingested less feed than kits of genetic type R, CxR and RxC. Slaughter weight and CCW followed the same pattern: animals belonging to group C were lighter than animals from groups CxR and R, being the values for the intermediate group RxC. A significant difference was also found in DoP between genetic types CxR and R the lower value corresponding to genetic type R and genetic types C and RxC being the intermediate between them. No differences between the two types of crossbred animals were found for any trait. These results agree with those reported in previous experiments for LW and CCW, comparing the same lines of selection. RAMON *et al*. (1996) and GOMEZ *et al*. (1998) reported differences in live weight at 60 and 63 days of age, CCW, GR and DP, among other carcass quality traits. Animals from line R, selected exclusively for increased growth rate, were heavier at all ages (313 g and 347 g), had a heavier carcass (133 g), grew faster (6.4 g/d) and had a lower FCR (0.2) and DoP (2.8 %)

Table 2: Mean and standard error (in brackets) of the estimated genetic type effects (C, CxR, RxC, R) of the traits analyzed.

Trait	C	CxR	RxC	R
LW	2331 (27) [a]	2459 (31) [b]	2429 (34) [b]	2460 (27) [b]
GR (g/d)	55.4 (0.4)	54.9 (0.4)	55.8 (0.5)	55.8 (0.4)
DFI (g/d)	158 (1) [a]	159 (1) [ab]	162 (1) [b]	161 (1) [b]
FCR	2.84 (0.03)	2.89 (0.03)	2.89 (0.04)	2.90 (0.03)
SW (g)	2549 (44) [a]	2704 (41) [b]	2620 (45) [ab]	2701 (44) [b]
CCW (g)	1505 (27) [a]	1595 (25) [b]	1541 (28) [ab]	1579 (27) [b]
DoP (%)	58.9 (0.2) [ab]	59.0 (0.2) [b]	58.8 (0.2) [ab]	58.5 (0.2) [a]
DLP (%)	2.2 (0.1)	2.2 (0.1)	2.2 (0.1)	2.3 (0.1)

LW: live weight at 60 days of age, GR: growth rate, DFI: daily feed intake, FCR: feed conversion rate, SW: slaughter weight, CCW: chilled carcass weight, DP: dressing percentage and DLP: drip loss percentage.
C = C line, R = R line.
Means within a row with different superscripts differ (P<0.05).

with respect to animals from line C, selected for a history of litter weight. Some of the differences between lines R and C could be partly explained by the different origin of the lines and by the more intensive process of selection for individual growth rate in line R, leading to heavier animals throughout all the growth period, higher adult weight and less mature animals at slaughter weight (PILES *et al*., 2000; BLASCO *et al*., 2003).

Additive genetic effects and direct heterotic effects

Table 3 shows mean and standard error of the estimated direct heterosis effect (h), direct additive genetic effect (d_C-d_R) and maternal genetic effect (m_C-m_R) in lines C and R, for all traits. Despite the differences found between genetic groups, the difference between additive genetic effects was only significant for DFI. Neither heterosis nor maternal effects were significant for any of the traits analyzed in agreement with GOMEZ *et al*. (1999) who analyzed data of animals from line R and two other dam lines of different genetic origin. LUKEFAHR *et al*. (1986) and MEDELLÍN and LUKEFAHR (2001), in studies involving large and medium size breeds, showed

Table 3: Mean and standard error (in brackets) of the estimated direct heterosis effect (h), direct additive effect (dC-dR) and maternal genetic effect (mC-mR) in lines C and R, of the traits analyzed.

Trait	hCR	dC- dR	mC- mR
LW (g)	49 (27)	-99 (46) **	-29 (37)
GR (g/d)	-0.3 (0.4)	-1.3 (0.7)	0.9 (0.6)
DFI (g/d)	1 (1)	-6 (2) **	3 (2)
FCR	0.02 (0.03)	-0.05 (0.06)	0.00 (0.05)
SW (g)	36 (33)	-67 (63)	-84 (46)
CCW (g)	26 (20)	-19 (39)	-55 (28)
DoP (%)	0.20 (0.18)	0.60 (0.33)	-0.2 (0.2)
DLP (%)	- 0.06 (0.08)	-0.10 (0.15)	0.01 (0.11)

LW: live weight at 60 days of age, GR: growth rate, DFI: daily feed intake, FCR: feed conversion rate, SW: slaughter weight, CCW: chilled carcass weight, DP: dressing percentage and DLP: drip loss percentage.
C = C line, R = R line.
**P<0.01

that additive genetic effects were higher in magnitude than maternal genetic effects or direct and maternal heterotic effects on individual live weight at 56 or 70 days of age. However, BRUN and OUHAYOUN (1989), AFFIFI *et al*. (1994) and ABDEL-GHANY *et al*. (2000), in studies involving medium-sized breeds, found that maternal breed effects were comparable to or higher than additive genetic effects for individual growth. BRUN *et al*. (1992), EIBEN *et al*. (1996), SZENDRO *et al*. (1996) and MEDELLIN and LUKEFAHR (2001) observed direct heterosis effect in live weight at different ages (from 2.4 % to 6.8 %), in GR (from 4.8 % to 7.3 %) and also in DoP (from 1 % to 2.3 %) in crosses between strains of different composition.

Non-genetic effects

Least square means of the levels of the different environmental effects were also estimated. Batch was the most important effect. Summer had a negative effect on feed intake because of high temperatures, leading to low values of live weights, growth rate and carcass weight as other authors have reported (TORRES *et al*., 1992; FEKI *et al*., 1996). Batch effect was also significant on feed efficiency and drip loss percentage as in TORRES *et al* (1992), FEKI *et al*. (1996) and GOMEZ *et al*. (1998). Parity effect was low, the higher difference between levels, with respect to the overall mean, being for DFI (7.5 %). Litter size effect was also small, the higher difference between levels being for CCW (23 % of the mean).

In conclusion, direct additive genetic effects, but not heterosis and maternal genetic effects, were found for growth, consumption and carcass traits in a complete diallel cross between two large-size lines of rabbit, both selected for growth rate during the fattening period.

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REFERENCES

ABDEL-GHANY A.M., HASSAN N.S., AMIN A.A. 2000. Heterosis, direct and maternal abilities of post-weaning daily gain in weight traits of two Egyptian native breeds on account of crossing with New Zealand White rabbits. In: *Proc. 7th World Rabbit Congress, Valencia, Spain, pp 325-331.*

Afifi E.A., Khalil M.H., Khadr A.F., Youssef Y.M.K. 1994. Heterosis, maternal and direct effects for post weaning growth traits and carcass performance in rabbit crosses. *Journal of Animal Breeding and Genetics, 111:138-147.*

Armero E., Blasco A. 1992. Economic weights for rabbit selection indices. *Journal of Applied Rabbit Research, 15:637-642.*

Blasco A., Piles M., Varona L. 2003. A Bayesian analysis of the effect of selection for growth rate on growth curves in rabbits. *Genetic, Selection and Evolution, 35: 21-42.*

Brun J.M., Ouhayoun J. 1989. Growth performance and carcass traits in three strains of rabbits and their two-way crosses. *Annales de Zootechnie, 38:171-179.*

Brun J.M., Bolet G. Ouhayoun J. 1992. The effects of crossbreeding and selection on productive and reproductive traits in a triallel experiment between three strains of rabbits. *Journal of Applied Rabbit Research, 15: 181-189.*

Brun J.M., Ouhayoun J. 1994. Qualités bouchères de lapereaux issus d'un croisement diallèle de 3 souches: interaction du type génétique et de la taille de portée d'origine. *Annales de Zootechnie, 43: 173-183.*

Dickerson G. 1969. Experimental approaches in utilizing breed ressources. *Animal Breeding Abstracts*, 37: 191-202.

Eiben C., Szendrõ Z.S., Allain D., Thebault R.G., Radnai I., Biró-Németh E., Lanszki J. 1996. Study of the performance of normal hair, angora and their reciprocal crossbred rabbits: 3. Growth and carcass traits. In: *Proc. 6th World Rabbit Congress, Toulouse, France, 1996, Vol 1, 351-357.*

Estany J., Camacho J., Baselga M., Blasco A. 1992. Selection response of growth rate in rabbit for meat production. *Genetics, Selection, Evolution, 24: 527-537.*

Feki S., Baselga M. Blas E., Cervera C., Gómez E.A. 1996. Comparison of growth and feed efficiency among rabbit lines selected for different objectives. *Livestock Production Science, 45:87-92.*

Gomez E.A., Rafel O., Ramon J. 1998. Caractères de croissance dans le croisement de trois souches de lapin sélectionnées en Espagne. In: *Proc. 7èmes Journées de la Recherche Cunicole Française., Lyon, France, 1998, pp. 33-36. ITAVI Ed., Paris.*

Gomez E.A., Rafel O., Ramon J., Baselga M. 1999. Feeding efficiency in crossbreeding among three of the strains selected in Spain. *Cahiers Options Méditerranéennes, 41: 153-158.*

Lukefahr S.D., Cheeke P.R., Patton N.M., Grobner M.A. 1986. Genetic, maternal and seasonal factors affecting 56-day market weight in rabbits. *Journal of Animal Science, 63:195 (Abstract).*

Medellin M.F., Lukefahr S.D. 2001. Breed and heterotic ffects on post weaning traits in Altex and New Zealand White straightbred and crossbred rabbits. *Journal of Animal Science, 79:1173-1178.*

Moura A.S.A.M.T., Kaps M., Vogt D.W., Lamberson W.R. 1997. Two-way selection for daily gain and feed conversion in a composite rabbit population. *Journal of Animal Science, 75:2344-2349.*

Piles M., Blasco A. Pla M. 2000. The effect of selection for growth rate on carcass composition and meta characteristics of rabbits. *Meat Science, 54: 347-355.*

Piles M., Gomez E.A., Rafel O., Ramon J., Blasco A.. 2003. Elliptical selection experiment for the estimation of genetic parameters of the growth rate and feed conversion ratio in rabbits. *Journal of Animal Science, 82: 654-660.*

Rafel O., Tran G., Utrillas M., Ramon J., Perucho O., Ducrocq V., Bosch,A. 1990. Sélection pour un objectif global (poids de la portée à 60 jours) en générations chevauchantes dans une lignée blanche synthétique de lapins. Etude de la variabilité non génétique de la taille et du poids de portée a différents stades. *Options Méditerranéennes, série Séminaires nº 8, pp75-82.*

Ramon J., Gómez E. A., Perucho O., Rafel O., Baselga M. 1996. Feed efficiency and post weaning growth of several Spanish selected lines. In: *Proc. 6th World Rabbit Congress, Toulouse, France, 1996, 2:351-353.*

Rochambeau H., de la Fuente L. F., Rouvier R. 1989. Sélection sur la vitesse de croissance post-sevrage chez le lapin. *Genetic, Selection, Evolution, 21:527-546.*

Szendrõ Z.S., Biró-Németh E., Radnai I., Jensen N.E., Kenessey A. 1996. The performance of Danish White and Pannon White purebred and reciprocal crossbred rabbits. In: *Proc. 6th World Rabbit Congress, Toulouse, France, 1996. Vol 2: 359-364.*

Torres C., Baselga M., Gómez E.A. 1992. The effect of weight daily gain selection on gross feed efficiency in rabbit. In: *Proc. 5th World Rabbit Congress, Corvallis, USA, 1992, Vol B: 884-888.*