Proceedings 4th World Rabbit Congress, 10-14 October 1988, Budapest Hungary, Vol. 2, 168-176

GROWTH PERFORMANCES AND CARCASS TRAITS IN THREE STRAINS OF RABBITS AND THEIR TWO-WAY CROSSES

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INTRODUCTION

In rabbit meat production, as well as in other animal productions, crossbreeding with specialized breeds or strains makes use of the complementarity between dam lines (or hybrids), having a good reproductive efficiency, and sire lines, with a good meat production efficiency. The choice of selection objectives within these specialized lines has been studied by several authors (SMITH, 1964 ; MOAV et HILL, 1966 ; ELSEN et SELLIER, 1976). In the case of dam lines selected for their prolificacy only, it has to be kept in mind that they contribute for one half at least to growth and carcass characteristics of their offsprings.

This study precisely aims at analysing these productive traits in the crosses of three strains of rabbits, two of which are selected for their prolificacy and commercialized to give hybrid dams, the third one being an unselected control. This study is part of a wider one of total productivity of these strains. No study of productive performances of these strains and their crosses had yet been carried out.

MATERIALS AND METHODS

1. Animals and experimental conditions

Three INRA strains were studied, A 1077, A 9077 and A 1066. The first two descended from the New Zealand White breed ; strain A 1077 has been selected for litter size at weaning since 1976 (MATHERON et ROUVIER, 1977) ; strain A 9077 is its unselected control (MATHERON et CHEVALET, 1977). Strain A 1066 descended from the Californian breed and has been selected for litter size at birth according to the same method as strain 1077. In the following, these strains will be respectively named "NZ", "C" (for "control") and "CA". The breeding animals used in this experiment came from the 14th selection generation. These strains had an intermediate body size ; however the "C" strain presented at its adult stage a body weight on average 10 % higher than the two others.

This study concerned 362 rabbits, with a majority of males, descending from a 3 x 3 factorial crossing design between these 3 strains. They were born between July the 13rd and August the 31st 1987 in litters of parity 1 (25 %), 2 (73 %) and 3 (2 %). They have been bred in the usual conditions of the experimental farm of the Station d'Amélioration Génétique des Animaux : weaning at 30 d., then transfered into a conventional growth room until the age of 79 days. Rabbits were housed in collective wire cages of 0.4 m2, in flat-deck and drop to drop drinking-trough. Each cage contained 5 to 6 rabbits of the same genotype. They were fed ad libitum with a diet made up of lucern (35 %), corn (36 %), oil-cake of soya (10 %) and sunflower (5.44 %), straw (10 %), complemented with methionin, minerals and vitamins (3.56 %). The diet contained 16.7 % of crude proteins, 16.4 % of cellulose (Weende) and 2700 kcal of digestible energy per kg.

The individual body weight was measured at weaning (30 d.) and at 79 d. ; individual food consumption was estimated on the average of total consumption by cage, taking mortality into account. Five series of rabbits, of similar size, were defined, according to birth period and rabbit number. When they were 79 days old, 152 males rabbits from second parity litters and from the series 3, 4 and 5 were slaughtered. They were bled by cutting the jugular vein and the carotid artery, after electro-anaesthesia (90 V, 2 sec.). Carcasses were chilled (+ 2°C) during 22 hours. Carcasses were then weighted. Their quality was estimated by weighing liver, perirenal fat, eatable part of hindleg deboned after vacuum cooking (OUHAYOUN et al., 1986).

Growth and consumption were analysed on all rabbits , body composition on a sample of them (table 1).

TABLE 1 : Rabbit number by sire and dam strain total and slaughtered, in brackets

		dam strain			All
		C	CA	NZ	
sire strain	C	60 (31)	33 (6)	37 (13)	130 (50)
	CA	52 (37)	39 (8)	42 (23)	133 (68)
	NZ	30 (8)	35 (19)	34 (7)	99 (34)
All		142 (76)	107 (33)	113 (43)	362 (152)

2. Statistical analysis

The analysis concerned the following variables :

Growth and consumption variables

LW30 : live weight at 30 days
LW79 : live weight at 79 days
ΔLW (1) : weight gain between 30 and 79 days
ADC : average daily food consumption
TC/Δ : total food consumption adjusted for ΔLW ; this variable estimates feed efficiency.

Body composition variables

CW : carcass weight
TLW : total hindleg weight
ELW : eatable weight of hindleg
FW : perirenal fat weight
LiW : liver weight

Analyses of variance were performed following two models.

Model 1 : with serie, rabbit genotype and interaction as fixed effects

Model 2 : with serie, dam strain, sire strain and their interactions as fixed effects.
This model therefore splits the rabbit genotype effect of model 1 into three components : dam, sire and dam x sire interaction effects.

In order to adjust growth and consumption for differences in live weight at 30 days, LW30 was introduced as covariate, either in model 1 or 2. This aims at eliminating indirect genetic effects along with common environment influences on rabbits from the same litter. Body composition variables have been also adjusted for differences live weight at 79 days. This allows for an estimation of dressing percentage, in one hand and of the proportions of muscle, fat and liver in the carcass (OUHAYOUN, POUJARDIEU et DELMAS, 1986).

3. Genetical analysis

DICKERSON'S model (1969) was used to estimate the genetic parameters of all traits in this crossbreeding experiment : direct and (maternal + grand maternal) additive genetic effects (gI and gM+M', respectively) ; individual heterosis (hI) (BRUN et ROUVIER, 1984).

RESULTS

1. Growth and feed consumption

Table 2 gives the statistical significance of the effects included in models 1 and 2. All traits varied with rabbit genotype. Dam effect and sire x dam interaction accounted mostly for offspring effect. Interaction between serie and rabbit genotype affected all traits, except TC/Δ. For two of them, L79 and ΔLW, two components of that interaction were not significant : serie x sire type and serie x dam type. Interactions between serie and genotype are being tested in an experiment on hand.

When adjusting variables for differences in LW30 (table 3), dam genotype and its interaction with sire one had no longer an effect upon LW79 and ΔLW. Between genotypes variations in LW79 and ΔLW therefore arose from variations in LW30. However, the performance of rabbit genotypes remained different as to feed efficiency. Their differences arose from dam type effect and its interaction with sire type effect. Rabbits descending from C-dams consumed more feed and converted it less efficiently (table 4).

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TABLE 2 : Growth and consumption : results of variance analysis

	Model 1			Model 2				
Characters	Serie (S)	Rabbit genotype (RG)	Interaction S x RG	Sire Strain (SS)	Dam Strain (DS)	Interactions		
						SxSS	SxDS	SSxDS
LW_{30}	*	**	**	NS	**	NS	**	**
LW_{79}	NS	**	*	NS	**	NS	NS	*
ΔLW	NS	*	**	NS	**	NS	NS	NS
ADC	NS	**	**	NS	**	**	**	**
TC/Δ	*	*	NS	NS	**	**	*	**

NS P > 0.05 ; * 0.01 < P < 0.05 ; ** P < 0.01

TABLE 3 : Growth and consumption results of covariance analysis (covariate : LW30)

	Model 1				Model 2					
Characters	Serie (S)	Rabbit genotype (RG)	Interaction S x RG	b(1)	Sire Strain (SS)	Dam Strain (DS)	Interactions			b(1)
							SxSS	SxDS	SSxDS	
LW_{79}	NS	NS	**	**	NS	NS	*	*	NS	**
ΔLW	NS	NS	**	**	NS	NS	*	*	NS	**
ADC	NS	**	**	**	NS	**	**	**	**	**
TC/Δ	*	**	**	**	NS	**	*	**	**	**

(1) regression coefficient NS P > 0.05 ; * 0.01 < P < 0.05 ; ** P < 0.01

TABLE 4 : Growth and consumption : effects of sire, dam and rabbit genotypes estimated in covariance analysis (covariate : LW30)

Sire Strain \ Dam Strain	C	CA	NZ	
C	616 2272 34,2 105 5090	544 2259 33,9 105 5119	577 2244 33,6 100 4893	588 2238 33,5 100 5065
CA	611 2288 34,5 109 5289	567 2154 31,8 96 4791	635 2258 33,9 105 5128	601 2233 33,4 103 5056
NZ	683 2223 33,2 107 5229	601 2176 32,2 101 4985	534 2275 34,2 98 4742	607 2221 33,1 102 4982
	629a 2268 34,1 107a 5171a	570b 2197 32,6 101b 4976b	585b 2218 33,1 100b 4932b	(1)LW_{30} (g) LW_{79} (g) (2)ADG (g/d) ADC (g/d) TC/Δ (g/g)

(1) estimates of LW_{30} result from variance analysis
(2) ADG = average daily gain, instead of ΔLW used previously
marginal estimates with different superscripts are different (P < 0.05)

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2. Body composition

Statistical significance of the effects included in models 1 and 2 is given in table 5. Except liver weight, all body composition traits depended on individual genotype. Like for growth traits, the individual genotype effect seemed to be determined by dam and sire x dam interaction effects, the sire effect being not significant. The pattern of significance of the effects on liver weight in models 1 and 2 was surprising.

TABLE 5 : Body composition : analysis of variance

Characters	Model 1			Model 2				
	Serie (S)	Rabbit genotype (RG)	Interaction S x RG	Sire Strain (SS)	Dam Strain (DS)	Interactions SxSS	SxDS	SSxDS
CW	NS	**	**	NS	**	**	NS	**
TLW	NS	**	*	NS	**	**	NS	**
ELW	NS	**	**	NS	**	**	NS	**
FW	NS	*	**	NS	*	*	NS	*
LiW	NS	NS	NS	NS	**	*	NS	*

By introducing LW79 as covariate (table 6), the genetic structure of individual genotype effect was altered : slaughter yield was then affected by sire genotype and no longer by dam one. Sire genotype also became significant for the weight of the edible part of the hindleg. As for carcass fatness estimated in our study from the latest part of fat deposition, dam effect and its interaction with sire one was no longer significant. Taking into account the high residual variance of this trait in rabbit, biological significance of this result has to be kept under caution. Rabbits with a CA parent, particularly the sire, displayed the higher slaughter yield and the higher muscle yield, estimated from hindleg dissection (table 7).

TABLE 6 : Body composition : analysis of covariance (covariate : LW79)

Characters	Model 1				Model 2					
	Serie (S)	Rabbit genotype (RG)	Interaction S x RG	b(1)	Sire Strain (SS)	Dam Strain (DS)	Interactions SxSS	SxDS	SSxDS	b(1)
CW	**	*	NS	**	**	NS	NS	NS	NS	**
ELW	**	**	NS	**	*	**	NS	NS	NS	**
FW	NS	*	NS	**	NS	NS	NS	NS	NS	**
LiW	NS	NS	NS	**	NS	NS	NS	NS	NS	**

(1) regression coefficient NS $P > 0.05$; * $0.01 < P < 0.05$; ** $P < 0.01$

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TABLE 7 : Body composition : effects of sire, dam and rabbit genotypes estimated in covariance analysis (1) (covariate : LW79)

Sire Strain \ Dam Strain	C	CA	NZ	
C	1338 156 20,4 98	1352 165 16,0 89	1321 149 21,8 99	1341b 156c 19,9 99
CA	1354 159 18,1 99	1364 162 21,0 97	1356 158 18,3 97	1360a 160a 18,5 100
NZ	1344 156 23,2 91	1342 156 21,8 99	1342 156 16,3 95	1347b 158b 22,0 94
	1350 158b 20,5 98	1365 162a 18,9 103	1341 154c 19,0 95	CW (g) ELW (g) FW (g) LIW (g)

marginal estimates with different superscripts are different (P < 0.05)

SYNTHESIS AND DISCUSSION

1. Additive genetic effects (table 8)

Figure 1 schematizes the relative position of the three strains for direct (or individual) and maternal genetic effects on some traits. In this study, growth and consumption traits exhibited more between strain additive variation than carcass traits.

The 3 strains ranked as follow for direct effects on body weight (except LW30) and adjusted feed consumption : C > CA > NZ. The correlation between direct effects on final weight and direct effects on feed efficiency during growth was therefore found negative : "C" genes determined a faster growth, at the price of a lesser feed efficiency, "NZ" genes gave the contrary. This antagonism between rate and efficiency of growth was in agreement with the results of OUHAYOUN (1978) who compared strains differing in adult body size and of OLLIVIER et HENRI (1978) in swine breeding. The three strains had the same ranking for their maternal effects on the three traits LW30, TC/Δ and LW79 : C > NZ > CA. The antagonism between growth rates and feed efficiency worked at the level of maternal effects as well. The strains CA and NZ ranked inversely for direct and maternal effects. This result was congruent with previous ones obtained by BRUN et ROUVIER (1988) on these two strains for individual weight at weaning and later in their life time. The ranking of stains for maternal effects on growth was just opposite to that for number of ova shed (BOLET et al., 1988). The latter arose on one hand from breed differences in ovulation rate between CA and NZ (HULOT et MATHERON, 1981) and on the other hand from selection for litter size in these strains (MATHERON et ROUVIER, 1977).

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With regard to carcass characteristics, the extent of direct and maternal variation is less important. Only slaughter yield exhibited significant individual additive variation : "C" strain had the heaviest adult body weight ; in spite of their highest 79 d. weight, their ponderal maturity was smaller, resulting in a lesser slaughter yield (CANTIER et al., 1969).

2. Heterotic effects

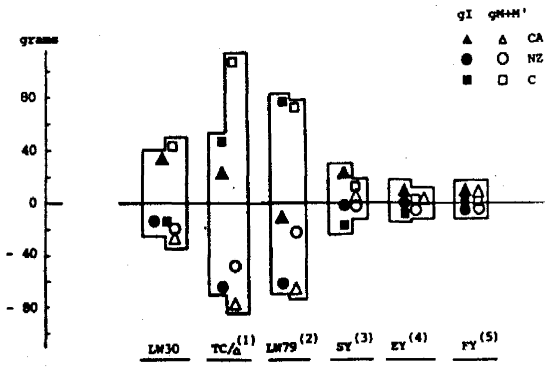
An heterotic effect was observed for all growth traits, averaging 5 %. As far as growth was concerned, this was favourable, but it was not the case for feed efficiency. This proceeded from the antagonism mentioned before. On average, carcass traits did not exhibit heterosis. However, the crosses involving strain C gave rise to high sire x dam interaction on fatness : crossbreeding CA and C resulted in a 18 % heterotic effect (less fat) while crossing NZ and C resulted in more fatness. These were the original results for this kind of traits, well known for its additive genetic determinism.

TABLE 8 : Genetic parameters of growth and carcass traits (g) according to Dickerson's model

		LW_{30}	TC/Δ		ΔLW		CW	ELW	FW
		(1)	(1)	(2)	(1)	(2)	(3)	(3)	(3)
g^I	C	-14b	118a	46a	50a	90a	-18bc	-3	0
	CA	+28a	26b	21a	-21b	-41b	21a	3	1,3
	NZ	-14b	-114c	-67b	-29b	-49b	- 3ab	-0	-1,3
$g^{m+m'}$	C	41a	149a	106a	49a	30a	9	2	0,6
	CA	-31b	-110b	- 80b	-50c	-36c	5	2	0,4
	NZ	-22b	- 75b	- 50b	-14b	- 3b	-6	-4	-0,9
h^I	CA x NZ	12 *	8 *	6 *	4 *	0	0	-1	8
	NZ x C	10 *	6 *	3 *	1	- 2	-1	-2	23 *
	CA x C	- 2	5 *	5 *	6 *	4 *	0	2	-18 *
	overall mean	7 *	6 *	5 *	4 *	1	0	0	4

(1) from variance analysis ; (2) from covariance analysis (covariate LW_{30})
(3) from covariance analysis (covariate LW_{79})

FIGURE 1 : Relative position of direct (gI) and maternal (g M+M') additive genetic effects of the three strains studied



(1) Total consumption adjusted for LW30 and ΔLW
(2) Sum of 1st and 5th columns of table 8
(3) Slaughter yield (carcass weight adjusted for LW79)
(4) Edible yield of hindleg (edible weight of hindleg adjusted for LW79)
(5) Fat yield (pertrenal fat weight adjusted for LW79)

CONCLUSION

In the conditions of this experiment, significant between strain variations on growth performances and carcass traits have been pointed out. The unselected control strain (C) exerts favourable direct and maternal effects on growth, but unfavourable on feed efficiency. With respect to carcass quality, strain CA seems to transmit the best direct effects on slaughter yield and meat yield of the carcass. An experiment on hand will allow to prove these results.

ACKNOWLEDGEMENTS

We are grateful to LEBAS F. for his contribution to this experiment, as also the staff of both laboratories who bred and controled the rabbits, particularly J. FALIERES, A. FALOURD, Z. FALUS, Véronique TARTIE and Gisèle FORT.

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Genetic variation of growth between 30 and 79 days and feed consumption (per cage) has been analysed on 362 rabbits (essentially males) from a factorial crossing design between three INRA-strains : 1077 (NZ) and 9077 (C) (New Zealand White) and 1066 (CA) (Californian). Carcass, perirenal fat, hindleg and its edible fraction and liver have been weighted on 152 males. Introducing 79 d. body weight as covariate allows for the analysis of slaughter yield, carcass fatness and muscularity. All weights (body, feed consumption and carcass components) depends on dam genotype but not on sire one : rabbits having a 9077 dam have grown faster, consumed more feed and converted it less efficiently. Their carcass and its components were correlatively heavier. Sire strain had a significant effect on slaughter yield and carcass muscularity, with a superiority of 1066 strain. Direct and maternal genetic effects along with individual heterosis have been estimated. Whatever the genetic effect, an antagonism was found between growth rate and feed efficiency.

PERFORMANCES D'ENGRAISSEMENT ET QUALITES BOUCHERES DE LAPINS DE TROIS SOUCHES ET DE LEURS CROISEMENTS RECIPROQUES

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La variation génétique de la croissance entre 30 et 79 jours et de la consommation alimentaire (par cage) est analysée sur 362 lapins (essentiellement mâles) issus d'un plan factoriel de croisement entre les souches INRA 1077 (NZ), 9077 (C) (Néozélandaise Blanche) et 1066 (CA) (Californienne). Sur 152 mâles sont analysés les poids de la carcasse, du gras périrénal, de la fraction comestible du membre postérieur et du foie. L'introduction du poids vif à 79 jours en covariable permet d'analyser le rendement à l'abattage, l'adiposité et la muscularité de la carcasse. Toutes les variables pondérales, y compris des éléments de la carcasse, sont influencées par le type génétique de la mère mais non par celui du père : les lapereaux de mère 9077 ont une vitesse de croissance supérieure, consomment plus d'aliment et le transforment moins efficacement. Leur carcasse et ses constituants sont corrélativement plus lourds. Le rendement en carcasse et la muscularité de la carcasse dépendent eux du type génétique du père, avec une supériorité de la souche 1066 utilisée comme père. Les effets génétiques additifs directs et maternels ainsi que l'hétérosis individuel sont estimés. Quel que soit l'effet génétique considéré, on retrouve entre ces souches un antagonisme entre vitesse de croissance et efficacité alimentaire.