HETEROSIS, DIRECT AND MATERNAL ADDITIVE EFFECTS ON RABBIT GROWTH AND CARCASS CHARACTERISTICS

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ABSTRACT

A total of 142 male and female rabbits of two breeds, Californian (CA) and New-Zealand White (NZ), and their reciprocal crosses were used. This study aimed to estimate heterosis, direct and maternal additive effects as well as some non genetic effects on rabbit growth and carcass characteristics in order to identify the best crossbreeding plan to use for rabbit meat production under Quebec conditions. Kits used for this experiment were weaned at 5 weeks of age. Each rabbit was identified and weighed individually at weaning and at 63 days of age. During the fattening period, rabbits were placed in individual cages. Rabbits were slaughtered after 18 h fasting from feeds only. The commercial carcass including liver, kidneys and perirenal fat was weighed after 2 hours chilling at 4°C. After dissection, fore part, intermediate part and hind part of carcass were measured. Dressing out percentage was calculated as chilled carcass weight x 100/live weight. One of the hind legs was used to evaluate meat/bone ratio. Statistical analyses were performed using the procedure GLM of SAS. Results showed significant differences between breed types for individual live weight at 35 d, average daily gain, live weight at 63 d, fore part, intermediate part and hind part yields. Overall, for growth performances (ADG and live weight at 63 d) and hind part yield, breed types from NZ dams had better performances that those from CA dams. Concerning the intermediate part yield (and carcass yield, but non significantly) a different classification was observed, with better performances of CA sired breed types. There were no significant effects of breed type on commercial carcass weight, commercial carcass yield and meat/bone ratio. The lower the litter size at birth, the heavier the individual weight at weaning, at 63 d and the commercial carcass weight were. Rabbits coming from the 2nd parity litters were significantly heavier at weaning and had the highest commercial carcass weight. Crossbreeding parameters were calculated from linear contrasts between breed types means. Breed NZ had positive direct effects on growth rate and 63-d body weight but negative ones on carcass yield and the proportion of intermediate part of the carcass. Maternal and heterosis effects were generally non significant.

Key words: Breed type, Growth traits, Carcass traits, Rabbits, Meat/bone ratio.

INTRODUCTION

Nowadays, the marketing of the rabbit meat in Quebec is mainly based on whole carcasses. Diversification of the offered products by the presentation of cut parts constitutes a necessary avenue for the expansion of the production and to interest more consumers. For a long time, the dressing out percentage has been the most studied rabbit carcass trait. However, the carcass quality can be also defined by the proportion of the cut parts as loin, hind- and fore part (Larzul and Gondret, 2005). Another criterion of carcass quality is the meat/bone ratio of the carcass, which can be fairly well predicted by the meat/bone ratio of the hind leg (Blasco *et al*., 1992). Commercial rabbit meat is usually produced by a three-way cross involving crossbred dams mated to bucks from a sire line. The crossbred dams are obtained from mating males and females from two dam lines selected for litter size, while the sire lines are generally selected for growth rate, affecting carcass and meat quality (Baselga, 2004; Pascual *et al.*, 2004). This study aimed to estimate heterosis, direct and maternal additive effects as well as some non genetic effects (parity and litter size) on rabbit growth and carcass characteristics of two rabbits breeds (New Zealand White and Californian) in order to identify the best crossbreeding plan to use for rabbit meat production.

MATERIALS AND METHODS

Animals

This experiment was carried out at the rabbitry of the *Centre de Recherche en Sciences Animales de Deschambault* (CRSAD) in Quebec from December 2006 to April 2007. A total of 142 male and female rabbits coming from two breeds, Californian (CA) and New Zealand White (NZ), and their reciprocal crosses were used. The four breed types compared were: CA x CA (27 rabbits), CA x NZ (62 rabbits), NZ x CA (15 rabbits) and NZ x NZ (38 rabbits), where the sire breed is given first. The initial parents of specific pathogen free New-Zealand purebred rabbits were acquired in Canada from the Charles River firm in 2002. CA purebred rabbits were introduced into the CRSAD rabbitry according to the caesarian procedure to minimize contamination. They were acquired in the United States from breeders of the American Rabbit Breeder Association (ARBA). Rabbits were housed in closed building in flat deck cages. Ventilation, temperature (18°C in maternity and 16°C in fattening in winter) and light (16 h light/24h in maternity and 8 h light/24h in fattening) were controlled. Does were mated first at 16 weeks of age and regularly the 10-12th day after parturition. The performance of these NZ and CA rabbits had been followed since 2004 (Ouyed *et al.*, 2007). The objective of the selection program applied is to improve litter size at weaning and live weight at 63 d of age. Kits were weaned at 5 weeks of age. At weaning, three young rabbits were randomly taken in each litter, identified and weighed individually. During the fattening period, rabbits were placed in individual cages to record their individual growth performances. Rabbits were fed *ad libitum* a commercial diet covering the requirements for growth (2375 kcal/kg metabolisable energy and 16% crude protein). Good quality water was available continuously from nipples. At the age of 63 d (±1 d), rabbits were individually weighed and again about 40 minutes before slaughter. They were slaughtered after 18 h fasting from feeds, at ages ranging between 62 and 65 d. Slaughterhouse was at 75 km from the experimental farm. The chilled carcass (commercial carcass weight) including liver, kidneys and perirenal fat (without head) was weighed after 2 hs chilling at 4°C. Carcasses were placed in identified bags and frozen at –18°C in order to be dissected. After thawing, carcasses were dissected by students of the *Ecole Hôtelière de la Capitale* (EHC) according to the norms of WRSA (Blasco and Ouhayoun, 1996). Fore part, intermediate part and hind part of carcass were measured. Dressing out percentage (commercial carcass yield) was calculated as chilled carcass weight x100/live weight. Fore part, intermediate part and hind part yields were expressed as percentage of chilled carcass weight. One of the hind legs was used to evaluate meat/bone ratio. Fresh hind leg, cooked hind leg (at standardized conditions under vacuum 80°C during 2.30 h as described by Blasco *et al.*, 1992), and hind leg bone were also weighed and the meat/bone ratio was calculated as (fresh hind leg weight-hind leg bone weight)/hind leg bone weight (Larzul and Rochambeau, 2004).

Analysed traits and statistical analysis

The analysis concerned the following variables: live weight at 35 d of age, average daily weight gain between 35 and 63 d, live weight at 63 d , commercial carcass weight at 63 d, commercial carcass yield, fore part yield, intermediate part yield, hind part yield and meat/bone ratio of the hind leg. The breed types means were estimated by analysis of variance with the fixed effects of the breed types (4 levels), parity (4 levels: 1st, 2nd, 3 to 5 and 6 or more) and litter size (4 levels: <4, 5 to 6, 7 and >8 kits), using the procedure GLM of SAS. For the analysis of the commercial carcass weight, the age at slaughter was taken as covariate. Dickerson's model (1969) was used to estimate the crossbreeding parameters: direct additive effects (g^I), maternal additive effects (g^M) and individual heterosis (h^I). They were estimated from linear contrasts between the breed types means according to coefficients given in Table 1, with the conditions: $g^I_{NZ} = - g^I_{CA}$; $g^M_{NZ} = - g^M_{CA}$. The g^I_{CA} is proportional to the mean difference between CA and NZ sired breed groups, g^M to the difference between reciprocal crossbreds and that h^I_{CAxNZ} is the mean deviation between crossbreds and purebreds groups.

Table 1: crossbreeding parameters as linear combinations of breed types means

	Breed types (sire breed given first)			
	CA x CA	CA x NZ	NZ x CA	NZ x NZ
Direct additive effect (g^{I}_{CA})	0.5	0.5	-0.5	-0.5
Maternal additive effect(g^{M}_{CA})	0	-0.5	0.5	0
Individual heterosis (h^{I}_{CAxNZ})	-0.5	0.5	0.5	-0.5

$g^{I}_{NZ} = - g^{I}_{CA}$; $g^{M}_{NZ} = - g^{M}_{CA}$

RESULTS AND DISCUSSION

Growth performances and carcass quality

Average rabbits performances (mean±s.d.) were 1011±132 g for live weight at weaning, 44±5 g/d for average daily gain (ADG), 1164±115 g for commercial carcass weight, 53±2% for commercial carcass yield, 35±1%, 30±2% and 29±2% for hind part, fore part and intermediate part yield respectively. Meat/bone ratio was 6±1 on average. Results shows significant differences between breed types for individual live weight at 35 d, ADG, live weight at 63 d, fore part, intermediate part and hind part yields (Table 2). Overall, for growth performances (ADG and live weight at 63 d) and hind part yield, breed types from NZ dams had better performances than those from CA dams.

Table 2: Rabbits growth and carcass traits about four breed type

	Breed type (sire breed given first)				Prob.			MSE
	CA x CA	CA x NZ	NZ x CA	NZ x NZ	Breed type	litter size	parity	
Rabbits, no.	27	62	15	38				
Live weight at 35 d (g)	1017c	1128a	1062bc	1101ab	<0.01	<0.0001	<0.001	103
Average daily gain (g/d)	42.5b	46.9b	45.9ab	48.3a	<0.01	<0.01	<0.05	4.7
Live weight at 63 d	2210b	2427a	2347a	2443a	<0.001	<0.0001	<0.01	182
Commercial carcass weight 63 d (g)	1174	1253	1202	1245	ns	<0.0001	0.001	98
Commercial carcass yield (%)	55.5	53.8	53.0	53.5	ns	ns	ns	2.9
Fore part yield (%)	30.9a	29.2c	30.4abc	30.4ab	<0.05	<0.05	ns	2.3
Intermediate part yield (%)	30.4ab	31.1a	29.3bc	29.1c	<0.0001	<0.05	ns	1.9
Hind part yield (%)	34.8b	35.0b	35.0b	36.1a	<0.01	ns	ns	1.6
Meat/bone ratio of the hind leg	6.1	6.3	5.7	6.1	ns	ns	ns	1.3

Means with different letters on the same row differ significantly (P<0.05); ns= no significant; MSE = mean square error

Concerning the intermediate part yield a different classification was observed, with better performances of breed types having CA as sire line. The same trend can be observed for carcass yield, although not significantly. Prayaga and Eady (2003) reported that CA purebreds and crossbreds had the lowest performance in all individual growth and slaughter traits except for dressing out percentage. Also, Lukefahr *et al.* (1983) reported higher dressing percentage in rabbits coming from Californian lines compared to the New-Zealand White lines. Breed type differences for carcass traits have often been reported (Lukefahr *et al.*, 1983; Ozimba and Lukefahr, 1991; Nofal *et al.*, 2004). Comparing Pannon White (PW) and Danish White (DW), Nofal *et al.* (2004) obtained higher dressing percentage on PW x DW crossbreds while DW purebreds had the lowest. There was no significant effect of breed type on meat/bone ratio of the hind leg. Litter size at birth significantly affected individual weight at 35 d, ADG, live weight at 63 d and commercial carcass weight. The lower the litter size at birth, the heavier the individual weight at weaning, at 63 d and the commercial carcass weight, as reported by Orengo *et al.* (2004). For carcass qualities, rabbits coming from litters of 4 kits alive or less had the best fore part yield (31.7%) while the rabbits from litters of 7 kits were better for intermediate part yield (30.7%). Litter size had no effect on carcass yield, hind part yield and meat/bone ratio. Concerning parity effect, rabbits coming from 2nd litters were heavier at weaning and had the highest carcass weight, in agreement with the results of Prayaga and Eady (2003). They obtained significantly higher carcass weight in 2nd and 3rd parity litters than in 1st and 4th ones. Concerning growth rate, rabbits for the 1st and 3rd to 5th litter were better than rabbits from other litters (47.9 and 44.8 vs. average 44.5). There was no significant effect of parity on carcass qualities and meat/bone ratio.

Direct additive effects

Breed NZ had favorable direct effects on post-weaning growth and 63-d body weight, but unfavorable effects on carcass yield, resulting in the absence of breed differences for direct effects on carcass weight (Table 3). The yield of intermediate part of the carcass also showed unfavorable effects of the NZ breed, but the fore part and the hind part yields did not show any breed differences for direct effects. The positive effect of strain NZ (relatively to strain CA) on growth rate, market body weight and its negative effect on carcass yield are in agreement with the results of Brun and Ouhayoun (1994) involving the same breeds.

Table 3: Crossbreeding parameters on some growth and carcass traits

	Direct additive effects (g^I_{CA})	Maternal additive effects (g^M_{CA})	Direct heterosis (h^I_{CAxNZ})
Live weight at 35 d (g)	-9 ± 22	-33 ± 15*	36 ± 23
Daily weight gain (g/d)	-2.4 ± 1.0*	-0.5 ± 0.7	1.0 ± 1.0
Live weight at 63 d (g)	-76 ± 38*	-40 ± 27	60 ± 40
Commercial carcass weight 63 d (g)	-15 ± 21	-21 ± 15	15 ± 22
Commercial carcass yield (%)	1.4 ± 0.6*	-0.4± 0.4	-1.1 ± 0.6
Fore part yield (%)	-0.3 ± 0.5	0.6 ± 0.3	-0.9 ± 0.5
Intermediate part yield (%)	1.6 ± 0.4**	-0.9 ± 0.3*	0.4 ± 0.4
Hind part yield (%)	-0.6 ± 0.3	-0.0 ± 0.2	-0.4 ± 0.4
Meat/bone ratio of the hind leg	0.3 ± 0.3	-0.3 ± 0.2	-0.1 ± 0.3

$g^I_{NZ} = - g^I_{CA}$; $g^M_{NZ} = - g^M_{CA}$

Maternal additive effects

Maternal effects were generally not significant except for live weight at weaning, negatively influenced by CA dams (Table 3). The absence of maternal effects for body weights recorded beyond weaning is in agreement with several literature findings (Medellin and Lukefahr, 2001; Piles *et al.*, 2004), while some others indicates significant maternal influence until the market age (Brun and Ouhayoun, 1989 and 1994; Afifi *et al.*, 1994). Surprisingly, maternal effects affected the yield of intermediate part of the carcass, with negative effects of the CA breed. Concerning this trait, the opposition between direct and maternal effects is noticeable.

Direct heterosis (h^I)

Despite, no significant heterosis effect was found. crossbreds tended to have a higher 63-d live weight, a lower carcass yield and a lower fore part proportion in the carcass. The absence of heterotic effects was expected for this kind of traits and is in agreement with several studies (Piles *et al.*, 2004). Some studies however revealed significant heterosis for growth rate and body weight, but at values generally fewer than 5% of the parental mean (Brun and Ouhayoun, 1989; Medellin and Lukefahr, 2001).

CONCLUSIONS

In spite of rather small rabbit numbers, our study revealed significant differences between breed types for many growth and carcass traits. When analysed by Dickerson’s genetic model, the differences sum up as follows: Breed NZ had positive direct effects on growth and breed CA had positive effects on carcass yield and loin proportion in the carcass. Maternal effects affected live weight at weaning but also loin proportion with favorable effects of breed NZ. Heterosis was not significant. Concerning the choice of a breeding plan, these preliminary results point to a complementarity between the breeds CA and NZ, and to the use of crossbreeding. More information is needed in order to make a decision, concerning reproductive performances and exploring other sire breeds.

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