CROSSBREEDING EFFECTS FOR CARCASS, TISSUES COMPOSITION AND MEAT QUALITY TRAITS IN A CROSSING PROJECT OF V-LINE WITH SAUDI GABALI RABBITS

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ABSTRACT

A five-year crossbreeding project involving Spanish maternal line called V-line (V) and Saudi Gabali (S) rabbits was carried out to produce 14 genetic groups of V, S, ½V½S, ½S½V, ¾V¼S, ¾S¼V, $(½V½S)^2$, $(½S½V)^2$, $(¾V¼S)^2$, $(¾S¼V)^2$, $((¾V¼S)^2)^2$, $((¾S¼V)^2)^2$, Saudi 2 (synthetic maternal line), and Saudi 3 (synthetic paternal line). A total number of 2770 rabbits produced by 91 sires and 402 dams were used to evaluate carcass components, tissue composition and meat quality traits. A generalized least square procedure was used to estimate additive and heterotic effects (direct, maternal, and grand-maternal). The estimates of direct additive effects were significant and in favour of V line rabbits for the majority of traits studied, ranging from 3.8 to 9.0% for slaughter and edible carcass components, 3.4 to 10% for non-edible traits, -3.1 to 9.8% for tissues compositions, and -14.9 to 2.5% for meat quality traits. Maternal additive effects were significantly in favour of V line by 1.66% for meat ether extract (11.1% relative to the average of the V line and Gabali as purebreds). Grand-maternal additive effects were not significant in most traits studied except dry matter and ash contents in meat since the effect of the V line was higher than the effect of the Gabali by 0.5% and 1.39%, respectively (0.7% and 15.4% of the respective averages of the pure breeds). Heterosis estimated for non-edible traits were mostly positive and only significant for head weight (direct and grand-maternal heterosis), fur weight (grand-maternal heterosis), lung weight (maternal and grand-maternal heterosis) and viscera weight (maternal and grand-maternal heterosis); the estimates were small relative to the average of purebreds reaching 6.4% as maximum value. Estimates of direct, maternal and grand-maternal heterosis for meat weight were found to be consistent and positive (3.9, 4.5 and 5.0%, respectively) associated with significant direct heterosis for fat weight (12.2%), maternal heterosis for meat bone ratio (4.5%), and maternal and grand-maternal heterosis for dry matter in meat. The estimates of direct heterosis for protein content in meat were significantly positive (1.4%), but the estimates for grand-maternal heterosis were significantly negative (-2.1%). For fat content in meat, the estimates of direct (-8.3%) and maternal heterosis (-11.9%) were significant, while for ash content the estimates for maternal (23.7%) and grand-maternal heterosis (30.1%) were significantly positive.

Key words: Rabbits, Crossbreeding, Carcass and meat quality, Additive effects, Heterosis.

INTRODUCTION

Unfortunately, reviewed studies concerning genetic analysis for carcass components and meat quality for rabbits raised in hot climate countries are scarce. Since 2000, a co-operative rabbit project was established between Saudi Arabia and Spain and the V-line rabbits used in this project were imported from Universidad Politécnica de Valencia in Spain to develop new lines of meat rabbits convenient for hot climate (Khalil *et al.*, 2007). Line V was then crossed with a local breed named Saudi Gabali. Nowadays, these synthetic lines have reached F_7 progeny. In this project, genetic analyses for some traits such as litter and lactation traits and feeding and semen parameters have been genetically evaluated (Khalil *et al*., 2004, 2005), while others such as carcass components are not. The objective of the present study was mainly to evaluate genetically carcass and meat quality traits in this project in terms of additive and heterotic effects (direct, maternal, and grand-maternal).

MATERIALS AND METHODS

Animals and crossbreeding plan

Five-years crossbreeding project involving a desert Saudi Gabali (S) and a Spanish V-line (V) was started in September 2000 in the experimental rabbitry, College of Agriculture and Veterinary Medicine, Al-Qassim University in Saudi Arabia. Eighty pedigreed does and sixteen pedigreed bucks of V-line rabbits were imported from Universidad Politécnica de Valencia (Spain) in September 2000. V-line is a maternal rabbit line selected for number of young weaned per litter for 21 generations (Estany *et al*., 1989), while Saudi Gabali is a Saudi breed raised under the desert conditions, especially in Najd area, and rabbits of this breed are characterized by litter size of 6-8 young, mature body weight of 3.2-3.8 kg and the ability to survive and adapt to produce and reproduce under hot environment. Details of housing, feeding, procedures and crossbreeding plan used in the project to form new synthetic lines were described by Khalil *et al.* (2007). This crossbreeding plan permitted simultaneous production of 14 genetic groups of V, S, ½V½S, ½S½V, ¾V¼S, ¾S¼V, $(½V½S)^2$, $(½S½V)^2$, $(¾V¼S)^2$, $(¾S¼V)^2$, $((¾V¼S)^2)^2$, $((¾S¼V)^2)^2$, Saudi 2 [synthetic maternal line with a genetic structure of $((¾V¼S)^2)^2$) inter se mated] and Saudi 3 [synthetic paternal line with a genetic structure of $((¾S¼V)^2)^2$ inter se mated].The bucks were randomly assigned to mate the does naturally with the restriction to avoid the mating of animals with common grandparents. A total number of 2770 rabbits produced by 91 sires and 402 dams were slaughtered.

Data set

Data used in this study have been recorded from November 2000 until July 2005. At 12 weeks of age, rabbits were slaughtered and hot carcasses were weighed and dressing percentages were calculated. The head, fur, offal (representing heart+liver+kidneys) and viscera were also weighed. For lean composition traits, the right half of the carcass was separated into lean, fat and bone. Lean of each half was separated and prepared for chemical analysis. Dry matter (using an air-evacuated oven for 16 h), crude protein (N x 6.25), ether extract and ash in the lean were determined according to the A.O.A.C. (1990).

Statistical analysis and estimation of crossbreeding genetic parameters

The animal model (in matrix notation) used for analysing carcass and meat quality traits was:

$$y= Xb + Z_a u_a + Z_c u_c + e$$

Where, y = vector of observed trait for the slaughtered rabbit, b= vector of fixed effects of genetic group of slaughtered rabbit (14 levels), and year-season of birth of the slaughtered rabbit (20 levels), sex, parity order of the doe (five levels), and litter size at birth (9 levels); u_a = vector of random additive effect of the individual rabbit, u_c = vector of random effects of the litter in which the animal was born (non-additive litter common effect); X, Z_a and Z_c = incidence matrices relating the records to the fixed effects, additive genetic effects, and common litter environment, respectively; and e = vector of random residual effects.

$Var(u_a)= A\sigma^2_a$, where A is the numerator relationship matrix, $Var(u_c)= I\sigma^2_c$ and $Var(e)= I\sigma^2_e$.Variance components of the random effects were estimated using MTDFREML software of Boldmann *et al*. (1995). Heritability estimates and common litter effects for different traits used in this study were given in Al-Saef *et al.* (2007). These estimates were used to solve the corresponding mixed model equations, obtaining solutions for the genetic group means and their error variance–covariance matrix, using the PEST program (Groeneveld, 2006). A procedure of generalized least squares (GLS) was applied to get the estimates of the crossbreeding genetic parameters using the following linear model:

$$y = X\mathit{b} + e, \quad Var(y) = V$$

Where, y was the vector of estimated groups means, given as difference to the second genetic group (Saudi Gabali); X was a incidence matrix relating y to b (Dickerson, 1992), b was the vector of estimable crossbreeding genetic parameters, e was the vector of residual effects, and V was the error variance-covariance matrix of y. The components of b were the difference between direct additive effects between V and G ($D=D_V-D_S$), the difference between maternal additive effects between V and G ($M=M_V-M_S$), the difference between grand-maternal additive effects between V and G ($GM=GM_V-GM_S$), direct (H^I), maternal (H^M), and grand-maternal (H^{GM}) heterosis.

RESULTS AND DISCUSSION

Direct, maternal and grand-maternal additive effects

Table 1: Estimates of direct, maternal and grand-maternal additive effects (differences 'V-S' between V and Saudi Gabali line effects) and their standard errors (±SE) for carcass and meat quality traits

Trait[1]	Direct additive effects		Maternal additive effects		Grand-maternal additive effects	
	Estimate ± SE	%[2]	Estimate ± SE	%[2]	Estimate ± SE	%[2]
PSW (g)	123± 45*	5.3	12±44	0.5	-1±36	-0.0
Edible carcass components:						
HCW (g)	120±30*	9.0	12±29	0.9	6±24	0.5
DP (%)	2.09±0.43*	3.8	0.26±0.41	0.0	0.27±0.34	0.0
OW (g)	4.19±3.24	4.4	-0.28±3.14	-0.3	2.11±2.60	2.2
Non-edible carcass components:						
HW (g)	12.09±3.78*	5.5	2.63±3.66	1.2	-1.14±3.02	-0.5
FURW (g)	7.54±5.99	3.4	7.02±5.83	3.1	1.52±4.87	0.7
LW (g)	9.66±2.00*	10.0	-2.05±1.97	-2.1	-0.05±1.67	-0.0
VW (g)	29.2±9.9*	7.7	-16.2±9.6	-4.3	5.4±7.9	1.4
Tissues composition in the carcass:						
MW (g)	61±22*	6.2	18±21	1.8	2±18	0.0
BW (g)	26±8*	9.8	-1±8	-0.4	-0±7	-0.0
FW (g)	0.25±2.29	1.0	0.78±2.21	3.1	-0.75±1.84	-3.0
MBR	-0.12±0.12	-3.1	0.06±0.12	1.6	0.02±0.10	0.5
Meat quality traits:						
DM (%)	-0.99±0.30*	-3.3	-0.35±0.29	-1.2	0.50±0.24*	1.7
CP (%)[++]	1.87±0.91*	2.5	-1.34±0.90	-1.8	-0.65±0.75	-0.9
EE (%)[++]	-0.06±0.87	-4.0	1.66±0.87*	11.1	-0.80±0.74	-5.3
Ash (%)[++]	-1.34±0.60*	-14.9	-0.38±0.58	-4.2	1.39±0.49*	15.4

[1] PSW= Pre-slaughter weight, HCW= Hot carcass weight, DP= Dressing percent, OW= Offal weight, HW= Head weight, FURW= Fur weight, LW= Lung weight, VW= Viscera weight, MW= Meat weight, BW= Bone weight, FW= Fat weight, MBR= Meat to bone ratio, DM= Dry matter, CP= Crude protein, EE= Ether extract; [2]Percentage of the difference referred to the average of the values for V line and Saudi Gabali breed; *significant at α=0.05

The estimates of direct additive effects were significant for the majority of traits (Table 1). In general, the effects for V line were higher than the effects for Saudi Gabali, but the effects for dry matter and ash contents in the meat were higher for Saudi Gabali. The percentages of these effects ranged from 3.8 to 9.0% for slaughter and edible carcass components, 3.4 to 10% for non-edible carcass components, -3.1 to 9.8 % for tissues compositions, and -14.9 to 2.5 % for meat quality traits.

The maternal additive effect was significant only for ether extract content in the meat; the difference between V line and Saudi Gabali was 1.66% (11.1% relative to the average of V line and Saudi Gabali as purebreds, Table 1). Piles *et al.* (2004) found that maternal genetic effects were not significant for dressing out percentage, drip loss weight and chilled carcass weight. The grand-maternal additive effects were only significant for some meat quality traits of dry matter content and ash contents in meat (Table 1). In both traits, the effects for V line was higher than the effect of Saudi Gabali by 0.5% and 1.39%, respectively (0.7% and 15.4% of the respective averages of the pure breeds).

Direct, maternal and grand-maternal heterosis

Estimates of direct, maternal and grand-maternal heterosis are shown in Table 2. For edible carcass components, estimates of direct heterosis were not significant, but for maternal heterosis the estimates were positively significant for hot carcass weight and dressing percentage. However, the relative importance of these effects were practically negligible (2.4 and 1.3%). For grand-maternal heterosis, the estimates were significant for pre-slaughter weight (96 g, 4.0%) and dressing percentage (-0.70% and -1.3% relative to purebreds). The opposite signs for pre-slaughter weight and for dressing percentage explained the non significance heterosis obtained for hot carcass weight (Table 2). All these results showed that the chance to improve edible components of the carcass by crossing could be limited. However, most estimates of heterosis obtained from experiments in USA, Egypt and France (Lukefahr *et al*., 1983; Brun and Ouhayoun, 1989; Afifi *et al*., 1994; Khalil and Afifi, 2000) indicated that crossbreeding in rabbits was associated with little improvement in the carcass performance.

Table 2: Estimates of direct, maternal and grand-maternal heterosis and their standard errors (±SE) for carcass and meat quality traits

Trait[1]	Direct heterosis		Maternal heterosis		Grand-maternal heterosis	
	Estimate ± SE	%[2]	Estimate ± SE	%[2]	Estimate ± SE	%[2]
PSW (g)	42±23	1.8	31±22	1.3	96±28*	4.0
Edible carcass components:						
HCW (g)	28±15	2.1	32±15*	2.4	30±18	2.3
DP (%)	0.39±0.21	0.7	0.71±0.21*	1.3	-0.70±0.26*	-1.3
OW (g)	3.07±1.62	3.2	0.51±1.60	0.5	3.89±2.00	4.1
Non-edible traits:						
HW (g)	5.13±1.88*	2.4	2.98±1.87	1.4	5.81±2.32*	2.7
FURW (g)	5.13±3.03	2.2	1.38±2.98	0.6	11.80±3.73*	5.3
LW (g)	0.61±1.06	0.6	4.55±1.03*	4.6	4.69±1.28*	4.7
VW (g)	-0.9±4.9	-0.0	18.3±4.9*	4.8	24.4±6.1*	6.4
Tissues composition in the carcass:						
MW (g)	38±11*	3.9	44±11*	4.5	49±14*	5.0
BW (g)	3±4	1.1	-1±4	-0.4	7±5	2.6
FW (g)	3.04±1.14*	12.2	-1.24±1.13	-5.0	1.73±1.41	6.9
MBR	0.07±0.06	1.8	0.17±0.06*	4.5	0.06±0.07	1.6
Meat quality traits:						
DM (%)	0.06±0.15	0.2	0.50±0.15*	1.7	0.79±0.18*	2.6
CP (%)	1.04±0.45*	1.4	-0.18±0.46	-0.2	-1.59±0.59*	-2.1
EE (%)	-1.25±0.44*	-8.3	-1.79±0.45*	-11.9	-0.83±0.58	-5.5
Ash (%)	0.37±0.0.29	4.1	2.13±0.29*	23.7	2.71±0.37*	30.1

[1] See table 1; [2] Percentage of the heterosis referred to the average of the values for V line and Saudi Gabali breed. NS= non-significant, *significant at α=0.05.

Concerning non-edible traits, heterosis estimates were mostly positive and only significant for head weight (direct and grand-maternal heterosis), fur weight (grand-maternal heterosis), lung weight (maternal and grand-maternal heterosis) and viscera weight (maternal and grand-maternal heterosis). These estimates relative to the average of the purebreds were small reaching 6.4% as maximum value. Also, the positive signs of heterosis obtained for these traits were economically unfavorable. In reference to heterosis for tissue composition of the carcass, the estimates of direct, maternal and grand-maternal heterosis for meat weight were found to be consistent and positive (3.9, 4.5 and 5%, respectively). Estimates of direct heterosis for fat weight (12.2%) and the maternal heterosis for meat bone ratio (4.5%) were significant (Table 2). Heterosis for meat quality traits seemed more important, increasing a little in dry matter content since maternal and grand-maternal heterosis were significant. In average, the estimates of direct heterois for protein content in meat were significantly positive (1.4%), but the estimates for grand-maternal heterosis were significantly negative (-2.1%). For fat content in meat, the estimates of direct (-8.3%) and maternal heterosis (-11.9%) were significant, while for ash content the estimates for maternal (23.7%) and grand-maternal heterosis (30.1%) were significantly positive.

CONCLUSIONS

Differences in direct additive effects were frequent for the studied traits and generally in favor of V line, while maternal and grand maternal additive effects were less important and only appeared to be significant in some meat quality traits.

Heterosis found in this experiment are of small importance, particularly for edible carcass components and non edible traits. For the traits related to the tissue compositions, the importance was consistent, and for meat quality traits the importance was considerable.

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