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Heterotic Components of Carcass and Meat Quality Traits for Crossing Gabali with V-Line Rabbits

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Introduction

In the last decades, synthetic lines are being developed in hot climate countries (El-Raffa et al (2005); Al-Saef et al (2008); Youssef et al (2009); Iraqi et al (2009); Khalil (2010)). During the process of synthesis of new lines, it is common to have several genetic groups of animals, like the founders, F1, F2, backcrosses, other types of crossbreds and the synthetics. The use of a crossbred terminal sire is not justified if the crossbreeding parameters of the carcass traits are estimated for the paternal lines (Piles et al (2004)). Unfortunately, reviewed studies concerning crossbreeding genetic analysis for carcass traits and meat quality for crossbred rabbits raised in hot climate countries are scarce particularly in the Arabian countries. The objectives of the present study were: (i) To evaluate genetically some carcass traits (CT) and meat quality (MQ) in a crossbreeding project involving Spanish V-line (**V**) and Saudi Gabali (**S**) rabbits, and (ii) To estimate direct and maternal additive effects, direct heterosis, maternal heterosis and direct recombination effect for these economic traits.

Materials and Methods

Animals and management. Five-year crossbreeding project was started in September 2000 in the Rabbitry of Qassim University, Saudi Ara bia. At that time, a co-operative rabbit project was established between Saudi Arabia and Spain and rabbits of line V were exported from Spain (from Valencia Polytechnic University) to Qassim University to develop new lines of meat rabbits convenient for hot climate country (see the details in Al-Saef et al (2008)). Line V was then crossed with a local breed named Saudi Gabali (S). The bucks were randomly assigned to mate naturally the does with a restriction to avoid the matings of animals with common grandparents. Such crossbreeding plan permitted simultaneous production of 12 genetic groups as shown in Table 1. Details of the procedures and crossbreeding plan were described by Al-Saef et al. (2008)). The rabbits were managed in a semi-closed rabbitry where the environmental conditions were monitored; temperature ranged from 20 to about 32 °C, the relative humidity ranged from 20 to 50 % and the photoperiod was 16L: 8D. Does were mated 10 days after each kindling. Breeding does and bucks were housed separately in individual wired-cages. Young rabbits were weaned at four weeks of age, ear tagged, weighted, sexed and transferred to standard progeny wire cages. All cages are equipped with feeding hoppers and drinking nipples. Rabbits were fed a commercial pelleted diet during the whole period. On dry matter (DM) basis, the diet contained 18.5% crude protein (CP), 8.0% crude fiber (CF), 3.0% ether extract (EE) and 6.5% ash. Feed and water were available ad libitum.

Data set. A total number of 11745 rabbits fathered by 106 sires and mothered by 621 dams were weaned at 4 weeks of age and body weights were recorded biweekly thereafter up to 12 weeks of age. From these rabbits, a total of 2366 rabbits fathered by 91 sires and mothered by 402 dams were randomly chosen to be slaughtered at 12 weeks of age. The numbers of rabbits slaughtered in each genetic group are presented in Table 1. Preslaughter weight (PSW) and hot carcass weight (HCW) were recorded and dressing percentages (DP) were calculated. The offal representing heart + liver + kidneys (OW) was also weighed. For lean composition traits, all carcasses were divided longitudinally into two similar halves. The right half was separated into lean, fat and bone and meat to bone ratios were calculated. Lean of each half was separated and prepared for chemical analysis. Dry matter (DM) using an air-evacuated oven for 16 h, crude protein (Nitrogen x 6.25), ether extract (EE) and ash in the lean were determined according to the AOAC (1990).

Models of analysis. The variance and covariance components of the random effects were estimated by DFREML procedure using the VCE software (Kovač and Groeneveld (2003)). The following animal model (in matrix notation) was used:

$$\mathbf{y= Xb + Z_a u_a + Z_c u_c + e}$$

Where y = vector of measurements for the rabbits, b = vector of fixed effects of genetic group of rabbits (12 levels; see Table 1), and year-season of birth (20 levels), sex, parity order of the doe (five levels), and litter size in which the rabbits were born (9 levels); u_a = vector of random additive effect of the individual rabbit, u_c = vector of random effects of the litters in which the animal was born; X, Z_a and Z_c are incidence matrices relating the records to the fixed effects, additive genetic effects, and common litter environmental effects, respectively; and **e** is a vector of random residual effects.

The DFREML estimates of the variance components were used to solve the corresponding mixed models to estimate heritabilities and common litter effects. The procedure of generalised least squares (GLS) using the PEST package (Groeneveld (2006)) was used to detect the estimable crossbreeding genetic parameters of the lines. The estimable parameters as stated by Dickerson (1992)

Table 1. Genetic groups and number of rabbits slaughtered in each genetic group at 12 weeks of age.

Ordinal number	Rabbit genetic group	Sire genetic group	Dam genetic group	Grand-dam group	Rabbits slaugh	Rabbits chemically analyzed
1	V-line (V)	V-Line	V-Line	V	276	234
2	Saudi (S)	Saudi (S)	Saudi (S)	S	275	232
3	½V½S	V	S	S	223	203
4	½S½V	S	V	V	260	216
5	¾V¼S	V	½S½V	V	141	129
6	¾S¼V	S	½V½S	S	204	158
7	$(½V½S)^2$	½V½S	½V½S	S	113	111
8	$(½S½V)^2$	½S½V	½S½V	V	157	145
9	$(¾V¼S)^2$	¾V¼S	¾V¼S	½S½V	173	155
10	$(¾S¼V)^2$	¾S¼V	¾S¼V	½V½S	202	198
11	$((¾V¼S)^2)^2$	$(¾V¼S)^2$	$(¾V¼S)^2$	¾V¼S	197	189
12	$((¾S¼V)^2)^2$	$(¾S¼V)^2$	$(¾S¼V)^2$	¾S¼V	145	137
	Total				2366	2107

Table 2. Estimates of direct (G^I) and maternal (G^M) additive effects and their standard errors (±SE) for carcass and meat quality traits

Trait	Direct additive effects		Maternal additive effects	
	Units±SE	G^I %[a]	Units±SE	G^M %[b]
Carcass and tissues composition traits:				
PSW, g	123±45*	5.3	12.0±**4.4**	0.5
HCW, g	70.2±38.9	5.6	22.9±24.2	1.8
DP	-1.28±0.55*	-2.4	0.17±0.35	0.3
OW, g	11.01±3.95*	11.4	2.60±2.58	2.7
MW, g	41.4±29.1	4.7	17.6±18.3	2.0
FW, g	-0.24±2.29	-0.8	0.17±1.76	0.6
BW, g	29.28±7.76*	11.5	0.30±5.53	0.1
MBR	-0.181±0.118	-5.1	-0.006±0.090	-0.2
Meat quality:				
DM	-0.75±0.24*	-2.7	-0.01±0.18	0.0
CP	-0.32±0.26	-1.5	-0.33±0.19	-1.5
EE	-0.32±0.24	-6.6	0.24±0.18	4.9
Ash	-0.069±0.054	-3.6	0.061±0.041	3.2

[a]G^I%= [D^I in units / (average of V line and Gabali rabbits)] x 100.
[b]G^M % = [M^D in units/(average of V line and Gabali rabbits)] X 100.
*= P<0.05.

are representing the differences between direct genetic effects of the lines, differences between maternal genetic effects of the lines, individual heterosis, maternal heterosis and recombination losses.

Results and Discussion

Direct (G^I) **and maternal** (G^M) **additive effects**. Table 2 shows that the estimates of direct and maternal genetic effects for CT were mostly in favour of V line rabbits, but the estimates for MQ traits were in favour of S rabbits. The estimates of G^I for PSW (123±45), DP (-1.28±0.55), OW (11.01±3.95), BW (29.284±7.763) and DM of the meat (-0.75±0.24) were significant, while the estimates of G^M were not significant.

Estimates of G^I were moderate with 5.6, 11.4, 4.7, and 11.5% in favour of V-line rabbits for HCW, OW, MW, and BW, respectively. On the other hand, the estimates for meat compositions traits were somewhat low and ranged from 1.0 to 6.6% and in favour of S rabbits. Rabbits of V line were higher in G^I by 11.01 and 29.3 g for OW and BW than S rabbits, respectively and the estimate for DP was lower (-1.3 %). Rabbits of V-line had less G^I for DM of the lean (0.746±0.237) than S rabbits.

For most CT, estimates of G^M were not significantly in favour of **V**-line dams (Table 2). Piles et al. (2004) found that estimates of G^M were also not significant for dressing out percentage, drip loss weight and chilled carcass weight when the paternal lines were studied.

Direct (H^I) and maternal (H^M) heterosis and direct recombination effects (R^I). Estimates of H^I and H^M for most CT (HCW, OW, FW, and BW) were significant (Table 3). Neither individual heterosis, nor H^M and $\mathbf{R^I}$ for MQ traits were significant (Table 3). Favorable positive H^I estimates of 38.4 g, 4.9 g, 3.8 g and 8.6 g were observed for HCW, OW, FW and BW, respectively (Table 3). Piles et al. (2004) didn't found individual heterosis for CT in Spain. In Egypt, Afifi et al. (1994) found that

Table 3. Estimates of direct (H^I) and maternal (H^M) heterosis and direct recombination effects (R^I) and their standard errors (SE) for carcass and meat quality traits.

Trait[+]	Direct heterosis		Maternal heterosis		R^I in units±SE
	H^I in units±SE	H^I %[a]	H^M in units±SE	H^M %[b]	
Carcass and tissues composition traits:					
PSW, g			28.0±15.2		2.1
HCW, g			38.4±16.9*		3.1
DP			0.22±0.25		0.4
OW, g			4.90±1.85*		5.1
MW, g			19.0±12.9		2.2
FW, g			3.80±1.34*		13.4
BW, g			8.59±4.15*		3.4
MBR			-0.046±0.068		-1.3
Meat quality:					
DM	0.04±0.13	0.1	-0.28±0.24	-1.0	0.46±0.61
CP	0.27±0.15	1.3	-0.08±0.28	-0.4	0.06±0.71
EE	-0.26±0.13	-5.4	-0.18±0.25	-3.7	0.27±0.64
Ash	0.027±0.031	1.4	-0.045±0.055	-2.4	0.058±0.139

[a]H^I%= [H^I in units / (average of V line and Saudi Gabali rabbits)] x 100.
[b]H^M % = [H^M in units/(average of V line and Saudi Gabali rabbits)] X 100.
*= P<0.05.

direct heterosis percentages ranged from 1.0 to 4.7 % for carcass traits in crossing New Zealand White X Baladi Red rabbits. However, most estimates of heterosis obtained in USA, Egypt, and France (Lukefahr et al. (1983); Brun and Ouhayoun (1989); Khalil and Afifi (2000)) indicated that crossbreeding in rabbits was associated with a little improvement in the carcass performance.

HCW, OW, FW and BW showed non-favorable negative estimates of $\mathbf{H^M}$ of -65.5 g, -6.7 g, -5.3 g and – 12.2 g, respectively; indicating that crossbred dams gave significant negative $\mathbf{H^M}$ ranging from 4.8 to 18.7% (Table 3). The estimates were also negative and of little importance for most MQ traits. Brun and Ouhayoun (1989) in France reported also that crossbred dams gave a little improvement in the carcass performance.

Recombination losses of 268 g, 27.5 g, 15.9 g and 67.5 g and 130.4 g were significant for HCW, OW, FW and BW, respectively (Table 3). This notation implies that dominance effects on these traits were of considerable importance. Reviewed values for $\mathbf{R^I}$ in some crossbreeding experiments are often not significant (e.g. Masoero et al. (1992); Al-Saef et al (2008)).

Conclusions

Direct and maternal genetic effects for weights of hot carcass, meat, offal, and bone were in favour of V line rabbits, but these estimates were in favour of the Saudi rabbits for meat quality traits. Heterotic effects for weights of hot carcass, fat and bone were moderate and concluding that crossing V line with Saudi Gabali rabbits could be beneficial.

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