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GENETIC ANALYSIS FOR MILK YIELD AND COMPONENTS AND MILK CONVERSION RATIO IN CROSSING OF SAUDI RABBITS WITH V-LINE

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ABSTRACT

Four-year crossbreeding project involving Spanish maternal line called V-line (V) and Saudi Gabali (G) rabbits was carried out to produce six genetic groups of V, G, ½V½G, ½G½V, ¾V¼G and ¾G¼V. Interse matings for genetic groups of ½V½G, ½G½V, ¾V¼G and ¾G¼V were also practiced. Milk yields (MY) at intervals of 0-7 days (MY7), 7-21 days (MY21), 21-28 days (MY28), and 0-28 days (TMY) and milk components (MC) at 14 days of lactation (fat, protein, lactose, ash, and total solids), and milk conversion ratio (kg of litter gain per kg of milk suckled, MCR) were evaluated for 2540 litters of 854 does fathered by 142 sires and mothered by 351 dams. A repeatability animal model was used to estimate linear contrasts and expectations of solutions for the effect of doe genetic groups and to derive the estimate of direct (G^I) and maternal (G^M) additive effects, direct heterosis (H^I), maternal heterosis (H^M) and direct recombination effect (R^I) for different traits under the study. Heritabilities for MY traits and MCR were moderate and ranging from 0.18 to 0.27, while they were low or moderate and ranging from 0.09 to 0.28 for MC. The positive estimates of G^I for MY (5.8-12.6%) and MC (4.0-17.7%) and the negative estimate for MCR (-18.3%) were significantly high and in favour of V-line does. G^M were in favour of V-line dams; being 222 g, 0.67%, 0.63%, and –0.08 for MY21, total solids in milk, fat in milk, and MCR, respectively. All estimates of H^I for MY and MC were positive and most of them were significant ranging from 9.7 to 22.7 % for MY traits (P<0.05–0.001) and 3.2 to 15.8% for MC traits (P<0.05–0.01). Similar to the trend of H^I, the estimates of H^M for MY and MC were positively moderate and ranging from 7.4 to 15.2 % for MY traits and 1.9 to 8.3% for MC. The moderate and negative estimate of heterosis for MCR (–19.2% for H^I and –9.6% for H^M) was also favourable. The ranges in percentages of reduction in direct heterosis were negligible and ranging from 2.2 to 4.4% for MY traits and MCR and -3.4 to –9.6% for MC.

Key words: crossbreeding, milk yield and components, milk conversion ratio, Animal model.

INTRODUCTION

Milk production is one of the most important factors in evaluation every breeding doe in the commercial rabbitry. Poor milk producer does should be culled from the rabbitry. The milk components in each species are inherited to cover the rate of growth of the newborn mammals. The faster the rate of growth in rabbits, the more concentrated milk needed for this growth. For these reasons, it is important to state that yields and components of milk should be considered when selecting rabbits for future breeding. To date, genetic analysis concerning milk yields (MY) and components (MC), and milk conversion ratio (MCR) for crossbred rabbits raised in hot climate countries are scarce. The objective of the present study was to estimate direct (G^I) and maternal (G^M) additive effects, direct heterosis (H^I), maternal heterosis (H^M) and direct recombination effect (R^I) for MY and MC traits, and MCR in a crossbreeding project involving Spanish V-line rabbits and Gabali Saudi rabbits.

MATERIAL AND METHODS

Four-year crossbreeding project was started in October 2000 in the experimental rabbitry, Collage of Agriculture and Veterinary Medicine, El-Qassim region, King Saud University, Saudi Arabia.

Breeding plan and management

Rabbits used in this study represent one desert Saudi breed (Gabali, G) and one exotic breed (Spanish V-line, V). The breeding plan permitted simultaneous production of ten genetic groups. Distribution of number of litters born and weaned in these genetic groups is presented in Table 1. A total number of 2540 litters were born by 854 does, fathered by 142 sires and mothered by 351 dams. The bucks were randomly assigned to mate the does naturally with a restriction to avoid the matings of animals with common grandparents. Young rabbits were weaned at four weeks of age. Rabbits were raised in a semi-closed rabbitry.

Milk yields and components and milk conversion ratio

Milk yields (MY) were recorded during the first seven days (MY7), 7-21 days (MY21), 21-28 days (MY28) and total 0-28 days (TMY). Litter size (LSB) and weight (LWB) at birth and litter size (LSW) and weight (LWW) weaning were also recorded and milk conversion ratio during the whole lactation period (MCR) was calculated ((LWW-LWB)/TMY). MY of does was recorded using weight-suckle-weight method. MC of fat, protein, lactose, ash and total solids (g/100g) were also estimated. In the evening of the day prior to collection, the pups were separated from their mothers to prevent suckling for a period of 12 hours before sample collection in the next morning. Milk samples were collected manually by gently massaging the mammary gland after two minutes of injection with 0.1 ml of oxytocin hormone to enhance maximum contraction of myoepithelial cells. Samples were taken per doe per litter in the morning of the 15th day of lactation. The samples were cooled and transferred immediately to the laboratory for chemical analysis. Milk sample for each litter born per doe was analysed for total solids, and ash according to procedures outlined in AOAC (1980). Fat was determined by Gerber method as described by CASE et al. (1985). Nitrogen was determined by the standard micro-Kjeldahl method (AOAC, 1980). A nitrogen conversion factor of 6.38 was used to calculate protein content. Lactose was determined by subtraction.

Models of analysis

The variance components of the random effects were firstly estimated by REML, using the SAS program (SAS, 1996). The REML estimates of the variance components were used to solve the corresponding mixed models using MTDFREML of single-trait animal model (BOLDMAN et al, 1995). Repeatability animal model in matrix notation used for analysing milk traits was:

$$y= Xb + Z_a u_a + Z_p u_p + e$$

Where y = vector of observed lactation trait for does, b= vector of fixed effects of genetic group of doe (ten levels; see Table 1), year-season of kindling (one year season every three months), and physiological status of the doe (five levels depending on the parity order and lactation state at the moment of insemination: 1 for nulliparous, 2 for primiparous lactating, 3 for multiparous lactating, 4 for primiparous non-lactating, 5 for multiparous non-lactating); u_a= vector of random additive effect of the doe, u_p= vector of random effects of the permanent environment (permanent non-additive effect); X, Z_a and Z_p are the incidence matrices relating records to the fixed effects, additive genetic effects, and permanent environment, respectively; and e= vector of random residual effects. The inverse of the numerator relationship matrix (A^{-1}) was considered; Var(a)= $A\sigma^2_a$, Var(p)= $I\sigma^2_p$ and Var(e)= $I\sigma^2_e$. Variance components of direct additive effect, permanent environment and error were estimated by DFREML procedure using the animal model.

Table 1. Number of litters born and weaned in different genetic groups.

Sire genotype	Dam genotype	Doe genetic group	Litters born	Litters weaned
V-Line (V)	V-Line (V)	V-line (V)	668	545
Gabali (G)	Gabali (G)	Gabali (G)	515	441
V	G	½V½G	260	231
G	V	½G½V	277	244
V	½G½V	¾V¼G	111	91
G	½V½G	¾G¼V	272	224
½V½G	½V½G	$(½V½G)^2$	132	125
½G½V	½G½V	$(½G½V)^2$	72	60
¾V¼G	¾V¼G	$(¾V¼G)^2$	74	49
¾G¼V	¾G¼V	$(¾G¼V)^2$	159	131
		Total	2540	2141

Genetic model and estimation of crossbreeding effects

The Dickerson's genetic model (DICKERSON, 1992) was used to demonstrate linear contrasts to derive the effects of direct additive of the doe (G^I), maternal additive of the dam of doe (G^M), direct heterosis in the crossbred doe (H^I), maternal heterosis in the crossbred dam (H^M), and direct recombination effect in the individual doe (R^I). The coefficients for G^I and G^M were calculated as the deviation of the proportion of V genes

(g^I_V) from the proportion of the G genes (G^I_G), i.e. $G^I = G^I_V - G^I_G$ and $G^M = G^M_V - G^M_G$, where G^I_V, G^I_G, G^M_V and G^M_G represent the proportion of V and G genes in the individual doe (I) and dam (M). To estimate the estimable crossbreeding genetic parameters of the lines (Table 2), the solutions got for D_i, represented as the vector $\hat{\mathbf{d}}$ and their matrix of estimated variance-covariance errors were used. We can assume, without losing generality that the solution for D_2 is zero and, consequently, the interpretation of $\hat{\mathbf{d}}$ in terms of the genetic parameters of the crosses is given in Table 2.

Table 2. Coefficients for genetic effects and interpretations of the estimable functions (EST) as function of the genetic parameters of the crosses.

Doe genotype[A]	EST	Direct Additive (G^I_{V-G})	Maternal Additive (G^M_{V-G})	Direct heterosis (H^I)	Maternal heterosis (H^M)	Recombination effect (R^I)
V-Line (V)	D_1-D_2	1.0	1.0	0.0	0.0	0.0
Gabali (G)	D_1-D_2	0	0	0.0	0.0	0.0
½V½G	D_3-D_2	0.5	0	1.0	0.0	0.0
½G½V	D_4-D_2	0.5	1.0	1.0	0.0	0.0
¾V¼G	D_5-D_2	0.75	0.5	0.50	1.0	0.25
¾G¼V	D_6-D_2	0.25	0.5	0.50	1.0	0.25
$(½V½G)^2$	D_7-D_2	0.5	0.5	0.50	1.0	0.50
$(½G½V)^2$	D_8-D_2	0.5	0.5	0.50	1.0	0.50
$(¾V¼G)^2$	D_9-D_2	0.75	0.75	0.375	0.50	0.375
$(¾G¼V)^2$	D_{10}-D_2	0.75	0.75	0.375	0.50	0.375

[A] Sire-breed listed first.

RESULTS AND DISCUSSION

Actual means and variations

To characterize the population phenotypically, means, standard deviations, minimum and maximum values for milk traits are presented in Table 3. However, wide phenotypic variations in all traits studied were observed. From a productive point of view, MY and MC showed moderate lactational performances particularly in hot climate areas. MCR was also sensible (0.74 kg gain per kg of milk suckled). In hot climate countries, little lower values for MY were got by KHALIL and AFIFI (2000) and much lower values were obtained by LAHARI and MAHJAN (1984), KHALIL (1994) and ABD EL-AZIZ et al (2002).

Additive and permanent environment effects and heritability estimates

Ratios of variance components of direct additive effect (or heritabilities, h^2) and permanent environment (P^2) to the phenotypic variances are presented in Table 3. The ratios of P^2 were moderate for MY and MCR, while these ratios were low for MC. Similar to the trend of permanent environment, heritabilities for MY traits and MCR were moderate, while they were low or moderate for MC traits (Table 3).

Direct (G^I) and maternal (G^M) breed additive effects

Estimates of G^I for most MY, MC and MCR were significantly moderate or high and in favour of V-line does (Table 4). This superiority of V-line does in G^I is attributable to favorable maternal abilities (GARCIA et al., 2000). LUKEFAHR et al (1983) in USA showed that estimates of G^I for MY traits were mostly in favour of Californian rabbits compared to New Zealand White rabbits.

Table 3. Actual means, standard deviations (SD), range of variation, and ratios of variance components for additive effect (or heritabilities, h^2±SE) and permanent environment (P^2±SE) to the total phenotypic variance for milk yields (grams) and components (g/100g) and milk conversion ratio.

Milk trait	No.	Mean	SD	Minimum	Maximum	h^2±SE	P^2±SE
MY7	2141	976	328	351	2674	0.20±0.08	0.23±0.06
MY21	2141	2438	928	588	6986	0.18±0.07	0.24±0.05
MY28	2141	934	332	14	2490	0.22±0.08	0.28±0.09
TMY	2141	4331	1344	1449	8533	0.21±0.08	0.25±0.07
MCR^A	2141	0.74	0.137	0.12	2.82	0.24±0.05	0.19±0.04
Fat	1587	12.9	2.3	4.40	23.1	0.20±0.08	0.08±0.07
Protein	1587	12.0	1.5	3.84	20.54	0.11±0.07	0.11±0.06
Lactose	1587	2.1	0.7	0.29	9.75	0.13±0.07	0.12±0.07
Ash	1587	2.2	0.3	0.76	4.32	0.09±0.07	0.06±0.08
TS^B	1587	29.1	3.0	17.81	43.57	0.28±0.07	0.12±0.07

^{A}MCR= Milk conversion ratio (kg of litter gain per kg of milk suckled); ^{B}TS= Total solids.

Most estimates of G^M for MY traits (MY7, MY28 and TMY) and MC traits (protein, fat, lactose, and ash of milk) were in favour of V-line dams (Table 4). The maternal superiority of V-line rabbits compared with other standard breeds has been demonstrated in the European studies (e.g. GARCIA et al., 2000). These results evidenced the fact that using V-line as a dam breed produced high performances in lactational performance compared to other dam breeds.

Direct (H^I) and maternal (H^M) heterosis

Estimates of H^I indicated that crossbred does were associated with an existence of heterotic effects in MY, MC and MCR (Table 5). H^I increments obtained in crossbred does were significant. The respective H^M increments obtained in crossbred dams were also significant. For MCR, the negative ratio was favourable; being -0.14 for H^I and –0.08 for H^M. These results indicate that crossbred does and dams gave favourable heterotic effects on MY, MC and MCR, i.e. higher milk production, richer in components, and lower in conversion ratio. Results of KHALIL and AFIFI (2000) revealed that crossing Gabali rabbits with NZW was associated with negative low non-significant heterotic effects on MY traits during the first 21 days of suckling and the whole period of lactation. ABD EL-AZIZ et al (2002) showed that direct heterotic effects on milk production traits were non-significant (0.12 to 2.4 %).

Table 4: Estimates of direct (G^I) and maternal (G^M) additive effects and their standard errors (SE) for milk yields (grams) and components (g/100g) and milk conversion ratio.

Milk trait	G^I_{V-G}		G^M_{V-G}	
	Units±SE	G^I %^{A}	Units±SE	G^M %^{B}
MY7	59±3.2^{NS}	5.8	6±3.9^{NS}	0.6
MY21	242±8.9**	9.3	222±11.1*	8.3
MY28	122±4.2*	12.6	18±6.2^{NS}	2.0
TMY	295±12.9*	11.4	255±16.2^{NS}	5.5
MCR	-0.13±0.002**	-18.3	-0.08±0.001**	-10.8
Fat	1.24±0.021***	9.6	0.63±0.027**	5.0
Protein	0.47±0.014*	4.0	0.24±0.017^{NS}	2.0
Lactose	0.38±0.007*	17.7	0.10±0.01^{NS}	4.7
Ash	0.13±0.002^{NS}	6.1	0.03±0.003^{NS}	1.4
TS	1.22±0.027***	4.2	0.67±0.035*	2.3

$^A G^I$%= [G^I in units / (average of V + V-sired crosses)] x 100.
$^B G^M$ % = [G^M in units/(average of G + G-dammed crosses)] X 100.
NS= Non-significant, *= $P<0.05$, **= $P<0.01$, ***= $P<0.001$.

Direct recombination effects (R^I)

Estimates of R^I for the majority of lactation traits (Table 5) were insignificant and indicate that epistatic recombination losses for these traits in crossbred does were negligible. Moreover, these estimates of R^I were mostly different to those estimates of H^I (Table 5). These negligible estimates of R^I indicate that there is a potential advantage to use crossbred does and bucks including V-line genes to develop parental lines (maternal and paternal lines having more available heterosis) to be used in hot climate countries. However, informations in the literature concerning estimates of R^I in rabbits are scarce.

CONCLUSIONS

(1) The favourable estimates of direct and maternal heterosis in the present study would be an encouraging factor for the rabbit producers in hot climate countries to use crossbred does and dams on commercial scale; i.e. crossing V-line with G rabbits was associated with an improvement in milk production along with a reduction in conversion ratio of milk to litter gain.

(2) Insignificant recombination effects for most milk yields and components gave an impression to conclude that crossbred does resulting from crossing V-line with native breeds of rabbits in hot climate countries could be effective to develop synthetic maternal line characterized by high milk production associated with rich components and consequently higher productivity in does could be attained.

Table 5: Estimates of direct (H^I) and maternal (H^M) heterosis and direct recombination losses (R^I) and their standard errors (SE) for milk yields (grams) and components (g/100g) and milk conversion ratio.

Milk trait	Direct heterosis		Maternal heterosis		Recombination effect	
	Units±SE	H^{I} %^{A}	Units±SE	H^{M} %^{B}	Units±SE	(R^{I}/H^{I})%
MY7	109±3.7*	10.3	150±5.6***	14.2	-2.4±2.8^{NS}	-2.2
MY21	250±10.3**	9.7	187±15.8*	7.4	-6.3±8.1^{NS}	-2.5
MY28	191±4.9***	22.7	127±7.4***	15.2	-10.2±3.8^{NS}	-5.3
TMY	450±15.0**	10.0	349±23.0*	7.8	-13.7±11.7^{NS}	-3.0
MCR	-0.14±0.002**	-19.2	-0.08±0.005**	-9.6	0.032±0.002^{NS}	4.4
Fat	0.97±0.025*	7.8	0.24±0.038 ^{NS}	1.9	-0.091±0.019^{NS}	-9.3
Protein	0.95±0.016*	8.1	0.89±0.025***	7.6	-0.032±0.013^{NS}	-3.4
Lactose	0.32±0.009**	15.8	0.17±0.014***	8.3	-0.023±0.072^{NS}	-7.1
Ash	0.13±0.003*	6.0	0.05±0.005 ^{NS}	2.2	-0.012±0.025*	-9.6
TS	0.91±0.030^{NS}	3.2	1.71±0.051**	6.1	-0.083±0.256*	-9.1

^{A}H^{I}%= [H^{I} in units / parents] x 100; ^{B}H^{M}%= [H^{I} in units / parents] x 100
NS = Non-significant: * = P < 0.05; ** = P < 0.01 ; *** = P < 0.001.

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