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Evaluation of litter traits in a crossing project of V-line and Baladi Red rabbits in Egypt

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Abstract

Four-years crossing scheme involving Spanish V-line (V) and Egyptian Baladi Red (B) rabbits was practiced to produce five genetic groups of V, B, ½B½V, $(½B½V)^2$, and $((½B½V)^2)^2$. A new line with a genetic structure of $((½B½V)^2)^2$ was synthesized and named APRI. A total of 2834 litters produced from 848 does pedigreed by 477 dams and 272 sires were used to evaluate litter size at birth (LSB) and weaning (LSW), litter weight at birth (LWB) and weaning (LWW), and pre-weaning litter gain (PLG). A generalized least square procedure (GLS) was used to estimate direct additive, direct heterosis, maternal heterosis, and direct recombination effect.

Heritabilities for litter traits were mostly low and ranging from 0.01 to 0.18, while the permanent environmental effects were mostly moderate and ranged from 0.09 to 0.33. Direct additive effects were mostly in favour of V-line does; indicating significant effects only for LSB and LWB by 23.0% and 24.2%, respectively, relative to the average of the means of V and B. All estimates for direct heterosis were significant and ranging from 20.0 to 27.7 %. The magnitudes of the estimates of maternal heterosis were mostly opposite to the magnitude of direct heterosis since the estimates were negatively unfavourable; ranging from -10.0 to 12.3 % comparing to the founder breeds.

Key words: additive effects, crossbreeding, heterosis, litter traits, rabbits, synthetic line

Introduction

In 2003, a co-operative crossbreeding rabbit project was established between Egypt and Spain to develop new line of meat rabbits suitable for hot climate. The V-line rabbits used in this project were crossed with an Egyptian Baladi Red (B). Traits related with productivity of the does, such as litter sizes and weights and milk production are considered the most important traits for an efficient production and some of these traits are objectives of selection to develop maternal lines of rabbits (Estany et al 1989: Gómez et al 1996; Rochambeau et al 1998; Baselga 2004). A deep knowledge involving crossbreeding parameters for these traits is lacking in hot climates (Khalil and Afifi 2000; Khalil et al 1995, 2004 and 2005; Al-Saef et al 2007). Thus, the objective of the present study was to estimate direct additive and heterotic effects, maternal heterosis, and recombination effects for litter traits in a crossbreeding program involving one Egyptian Baladi breed (B) and a Spanish V-line rabbits, that are the founders of the new line synthesized.

Material and methods

Animals and crossbreeding program

Four-years crossbreeding project involving Egyptian Baladi Red rabbits (B) and a Spanish V-line (V) was started in 2003 in Gimmeza and Shakha Experimental Rabbitries, which belong to Animal Production Research Institute (APRI), Agriculture Research Center, Ministry of Agriculture. In this scheme, Baladi Red bucks were mated with V line does to get F_1 of ½B½V, then does and bucks of this F_1 were mated to get F_2 of $(½B½V)^2$, followed by two generations of inter se mating to get a new synthetic line named APRI with genetic structure of $((½B½V)^2)^2$. Litters born in B, V, ½B½V, $(½B½V)^2$, and $((½B½V)^2)^2$ were 148, 1403, 171, 222, and 840, respectively. The bucks were randomly assigned to mate the does naturally with the restriction to avoid the matings of animals with common grandparents. A total of 2784 litters produced by 848 does pedigreed by 477 dams and 272 sires were used. Data collected were litter size at birth (LSB) and weaning (LSW), litter weight at birth (LWB) and weaning (LWW), and pre-weaning litter gain (PLG).

Housing and feeding

Rabbits of this work were raised in a semi-closed rabbitries. Breeding females and males were housed individually in wire cages with standard dimensions of 35 x 35 x 60 cm arranged in one-tire system allocated in rows along the rabbitry. The cage of each doe was equipped with a metal nest box for kindling and nursing the progeny up to weaning at four weeks of age. All cages of does and bucks were provided with feeders and nipple-drinkers.

Rabbits fed standard pelleted diet that offered ad libitum. The diet was composed from 32% barley, 21% wheat bran, 10% soybean meal, 22% hay, 6% berseem straw, 3% corticated cottonseed meal, 3% molasses, 1% limestone, 0.34% table salt, 0.3 minerals and vitamins, 0.06 methionine and 1.3% anti-coccidian. This diet provide 16.3% crude protein, 13.2% crude fiber, 2.5 either extract, 0.6 minerals mixture, 67.4% soluble carbohydrates and 2600 k cal / kg .

Model of analysis and estimation of crossbreeding genetic effects

For all litter traits, data were analyzed using a single-trait animal model as:

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

where:

y = vector of records of litter trait,

b = vector of fixed effects of genetic groups of the doe (five levels), year-season of kindling (17 levels), and parity (five levels);

u_a = vector of random additive effects of the does and bucks in the pedigree,

u_p = vector of random effects of the permanent environment of the doe (permanent non-additive effect);

X, Z_a and Z_p = incidence matrices relating records to the fixed effects, additive genetic effects, and permanent environment, respectively; and

e = vector of random error.

Variance components of random effects were estimated by a derivate-free restricted maximum likelihood procedure using MTDFREML software of Boldmann et al

(1995). 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). To get the estimates of the crossbreeding genetic parameters of the lines (Dickerson 1992), a procedure of generalized least squares (GLS) was applied using the following linear model:

$$y = Xb + e, Var(y) = V$$

where:

y = vector of estimated groups means, using the genetic group of Baladi Red as a reference population;
X = incidence matrix,
b = vector of estimable crossbreeding genetic effects,
e = vector of random error, and
V = the error variance-covariance matrix of y.

The coefficients relating genetic crossbreeding parameters to the means of the genetic groups are showed in Table 1 (Dickerson 1992; Wolf et al 1995). Crossbreeding parameters of direct genetic effects $D = D_V - D_B$, direct (H^I) and maternal (H^M) heterosis and recombination effect (R^I) were estimated using CBE program of Wolf (1996).

Table 1. Genetic group of the does and their parents and coefficients of the matrix relating to the genetic group means of the does with the crossbreeding parameters

Ordinal	Doe genetic group	Sire genetic group	Dam genetic group	Mean μ	Coefficients of the matrix*				
					D_V	D_B	H^I	R^I	H^M
1	Baladi (B)	B	B	1	1	0	0	0	0
2	V-line (V)	V	V	1	0	1	0	0	0
3	½B½V	B	V	1	.5	.5	1	0	0
4	$(½B½V)^2$	½B½V	½B½V	1	.5	.5	.5	.25	1
5	$((½B½V)^2)^2$ APRI	$(½B½V)^2$ APRI	$(½B½V)^2$ APRI	1	.5	.5	.5	.25	.5

* *D_V and D_B = Direct additive genetic effects for V-line and Baladi Red breed, respectively; H^I = Direct heterosis; R^I = Direct recombination effect; H^M = maternal heterosis. APRI = New synthetic line referring to Animal Production Research Institute.*

Results and discussion

Overall actual means and variation

Means, standard deviations and minimum and maximum values for litter traits are presented in Table 2. For crossbreeding programs carried out in the Arabian countries involving V line rabbits, values reported by Khalil et al (2005) and Al-Saef et al (2007) in Saudi Arabia were slightly higher than those of the present study, while the values reported by Iraqi et al (2007) in Egypt were extremely lower. Consequently, these results could be encouraging factors to involve V-line in crossbreeding programs in Egypt and other hot climatic countries.

Table 2. Summary statistics for litter traits studied

Litter trait	No.	Mean	SD	Minimum	Maximum
LSB, young	2834	8.77	1.94	1	16
LSW, young	2740	6.09	1.48	1	12
LWB, g	2833	430	85	60	700
LWW, g	2740	3031	601	465	5720
PLG, g	2740	2599	572	145	5325

[+]LSB= Litter size at birth; LSW= Litter size at weaning; LWB= Litter weight at birth; LWW= Litter weight at weaning; PLG= pre-weaning litter gain

Genetic additive effects (h^2) and non-additive and permanent environmental effects (p^2)

Heritabilities for litter traits were mostly low and ranging from 0.01 to 0.18 (Table 3). Estimates of heritability got in the present study for litter traits are within the ranges cited in the literature estimated by an animal model (Ferraz et al 1992; Lukefahr et al 1996; Lukefahr and Hamilton 1997; Rastogi et al 2000; Sorensen et al 2001; El-Deghadi 2005; Khalil et al 2005).

The ratios of permanent environmental effects (p^2) were mostly moderate and ranged from 0.09 to 0.33 (Table 3). Similar estimates were reported by Lukefahr and Hamilton (1997), El-Raffa (2000), Sorensen et al (2001), El-Deghadi (2005) and Khalil et al (2005) using an animal model.

Table 3. Estimates of the proportion of the phenotypic variance due to genetic additive effects (h^2) and to non-additive and permanent environmental effects (p^2) with their standard errors (±SE) for litter traits studied

Litter trait[1]	h^2±SE	p^2±SE	e^2±SE
LSB	0.01±0.021	0.33±0.033	0.66±0.02
LSW	0.01±0.022	0.19±0.030	0.80±0.021
LWB	0.13±0.030	0. 11±0.024	0.76±0.02
LWW	0.18±0.005	0.18±0.020	0.64±0.019
PLG	0.05±0.024	0.09±0.023	0.86±0.02

[1]See Table 2.

Crossbreeding effects

The main objective of this study was to estimate the crossbreeding parameters in terms of direct additive, direct heterosis, maternal heterosis and recombination losses. Estimation of these crossbreeding parameters were carried out using the methodology explained in Material and Methods section and some estimates for the effects of recombination losses were non-expected. Particularly, the structure of our data was not well conditioned to estimate the recombination losses since the standard errors of these estimates were somewhat high. For this reason, we have decided to simplify the model of crossbreeding parameters by eliminating the effects of recombination losses. Accordingly, the column corresponding to this effect in Table 1 was eliminated. Consequently, results and discussion represented here refer to the estimates obtained for crossbreeding parameters with such simplified model.

In general, direct additive effects for litter traits studied were in favour of V line does (Table 4). Differences between line V and Baladi Red in direct additive effects were significant for two litter traits out of five (LSB and LWB, Table 4). These results evidenced that genes of line V had better direct additive effects on litter size and weight at birth.

Table 4. Estimates of differences between line V and Baladi Red breed in direct effects and their standard errors (±SE) for litter traits studied

Litter trait[1]	**Direct additive effects (D_V - D_B)**	
	Estimate ± SE	**%**[2]
LSB, young	1.78±0.48*	23.0
LSW, young	0.45±0.41 NS	8.1
LWB, g	95±21*	24.2
LWW, g	129±171 NS	4.5
PLG, g	33.5±168 NS	1.4

*[1] See Table 2, [2] Percentage of the difference referred to the average of the values for V line and Baladi Red breed, NS = Non-significant; * P<0.05*

Differences in direct additive effects for litter size and weight at birth were of considerable importance of 23.0% and 24.2% relative to the average of the founder genetic groups (Table 4). Crossing line V with Sinai Gabali in Egypt to get F_1 showed that line V was significantly superior to the Sinai Gabali for litter size and weight at birth (Iraqi et al 2007). In addition, Lukefahr et al (1983), García et al (2000), Khalil et al (2005) and El-Deghadi (2005) reported significant direct additive effects on litter traits. Khalil and Afifi (2000) and El-Deghadi (2005) in crossing experiment between NZW and Gabali rabbits reported that NZW rabbits had higher estimates of direct additive effects than Gabali rabbits for litter size and/or litter weight at birth and weaning (P<0.01 or P<0.001).

All estimates of direct heterosis verified that crossbred does were usually associated with significant and favourable heterotic effects on litter traits studied; the estimates ranged from 20.0 to 27.7 % (Table 5). All significant estimates were favourable from a production point of view. Crossbreeding experiments carried out in Egypt (e.g. Khalil et al 1995; Khalil and Afifi 2000; Abd El-Aziz et al 2002; El-Deghadi 2005) reported significant direct heterotic effects on litter size and weight traits. In addition, Baselga et al (2003) in an experiment of crossbreeding, involving three maternal lines, had significant direct heterosis for litter size at birth in two of the three possible simple crosses obtained. On the contrary, Iraqi et al (2007) in Egypt found that estimates of direct heterosis for litter size and weight at birth and weaning were not significant.

Table 5. Estimates of direct and maternal heterosis and their standard errors (±SE) for litter traits studied

Doe trait[1]	**Direct heterosis**		**Maternal heterosis**	
	Estimate ± SE	**%**[2]	**Estimate ± SE**	**%**[2]
LSB, young	1.85±0.48*	23.9	-0.37±0.45 NS	-4.8
LSW, young	1.54±0.41*	27.7	0.10±0.33 NS	1.8
LWB, g	108±21.2*	27.6	-39±17.4*	-10.0
LWW, g	800±171*	27.6	-346±140*	-12.0
PLG, g	495±165*	20.0	-306±135*	-12.3

*[1] See Table 2, [2] Percentage of the heterosis effects referred to the average of the values for V line and Baladi breed, NS = Non-significant; * P<0.05*

Most estimates of maternal heterosis were significantly unfavourable since the estimates were negative and ranging from 10.0 to 12.3 % relative to the average of the means of V and B (Table 5). The magnitudes of maternal heterosis are completely opposite to the magnitude of direct heterosis for these traits. Khalil et al (2004) and Al-Saef et al (2007) have reported significant maternal heterosis for pre-weaning litter traits.

Conclusions

- The use of an exotic line (line V), highly selected for litter size at weaning, and an Egyptian breed (Baladi Red), well adapted to hot climates, has led successfully to create a new line named APRI.
- This superiority in such synthetic line in the present study was verified since the estimates of direct heterosis obtained were of considerable importance for all litter traits studied.

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