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GENETIC TREND IN SELECTION FOR LITTER WEIGHT IN TWO MATERNAL LINES OF RABBITS IN EGYPT

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Abstract: An analysis was carried out to evaluate the results of the selection program of a new synthetic maternal line of Egyptian APRI rabbits and the Spanish V line. The selection criterion was litter weaning weight in both lines based on Best Linear Unbiased Prediction (BLUP) estimations under a repeatability animal model. The studied traits were: litter birth weight, litter weaning weight (at 28 d) and pre-weaning litter gain. Heritability estimates were generally low (0.09 to 0.11) and comparable in both lines. Low to moderate estimates of repeatability were observed for all studied traits (0.15 to 0.31). Estimates of genetic correlations were high (0.77 to 0.97), while permanent environmental effects correlations were mostly lower than genetic correlations (0.47 to 0.87). The genetic trends were also estimated using mixed model methodology and were significant and comparable (34.2 and 32.5 g) for the selected trait (litter weaning weight) in APRI and V lines, respectively. Furthermore, correlated genetic trends were significant (*P*<0.05) for other litter weight traits. These results indicate that the current selection program has been effective in achieving genetic improvement in litter weight traits.

Key Words: rabbits, lines, selection, mixed model, litter weight.

INTRODUCTION

Litter weight and mean kit weight at different ages are important traits in commercial farms (Abou Khadiga, 2004). Litter weaning weight is a particularly important composite trait of the doe because it is affected by litter size, kit viability, the doe's mothering and milking ability and growth response of the litter (Lukefahr and Hamilton, 1997). Traits related with doe productivity, such as litter sizes and weights and milk production are considered selection objectives in developing maternal rabbit lines (Estany *et al*., 1989; Gómez *et al*., 1996; Rochambeau *et al*., 1998; Baselga, 2004). Selection for litter weaning weight could, in theory, be more interesting than selection for litter size at birth or weaning, since this type of selection allows litter size and other traits such as milk production to be considered. Nevertheless, few experiments considering litter weaning weight as a main selection criterion in rabbit lines have been reported (Gómez *et al*., 2000; Moura *et al*., 2001; Salaun *et al*., 2001; Khalil *et al*., 2005; Youssef *et al*., 2008a).

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The objective of this study was to estimate the genetic trends for litter weight traits in two maternal lines of rabbits selected for litter weight at weaning in Egypt.

MATERIALS AND METHODS

Animals and studied traits

Animals belonging to two maternal lines of rabbits, the APRI and V lines were involved in this experiment. The APRI line was founded by mating Baladi Red (BR) bucks to V line does, obtaining the F_1, F_2 and then F_3, starting the selection at this generation (Youssef *et al*., 2008a). The records of F_1 and F_2 were not considered in the subsequent analyses, since they were far from the genetic equilibrium. F_3 was chosen as the starting point as a compromise between approximation to equilibrium and applicability.

The APRI line is reared in Sakha experimental rabbitry, Animal Production Research Institute (APRI), Agricultural Research Center, Ministry of Agriculture, Egypt. The V line was founded in 1981 in Spain (Polytechnic University of Valencia) as a synthetic line by crossing the progeny of four specialized maternal lines that had been selected to increase litter size at weaning (Estany *et al*., 1989). A replicate of the V lines was established in 2002 in Sakha and the selection criterion was changed to litter weaning weight as in the APRI line (Youssef *et al*., 2008a). The data used in this study were taken from the collected records of APRI and V line rabbits during the period from September 2003 to May 2008. They correspond to a total of 3306 litters (1400 for APRI and 1906 for V line) from six generations, the traits recorded being: litter birth weight (LBW), litter weaning weight (LWW, at 28 d) and pre-weaning litter gain (PLG). The distribution of animals in the set of both lines is shown in Table1.

Selection program

Selection in both lines started after three generations of random mating to approximate genetic equilibrium in the new formed APRI line. LWW was the selection criterion in both lines. The genetic evaluation was carried out using BLUP (Best Linear Unbiased Prediction) under a repeatability animal model (Quaas, 1984). Values of 0.10 and 0.16 were considered for heritability and repeatability, respectively. The females of the next generation were selected from the progeny of 31-36% of the best evaluated matings based on the average of the predicted breeding values of their parents, while the males were selected within sire. At least one male from the progeny of each sire was selected in order to diminish inbreeding depression throughout the generations.

Genetic parameters and genetic trend

As it was not possible to maintain control lines, mixed model methodology (Henderson, 1973) was used to estimate the genetic trend and as selection applied for litter weaning weight, this trait was included in all analyses in order to avoid biased estimates due to selection (Sorensen and Johanson, 1992). The first step was to define the mixed model to analyze the data, get the Restricted Maximum Likelihood (REML) estimates of the variance and covariance components and with these estimates obtain the prediction of the additive values of all animals. The averages of the predicted additive values in each generation were

Table 1: Total number of bucks, does, sires, dams, litters and minimal number of does per generation (M).

Line	Bucks	Does	Sires	Dams	Litters	M
APRI	184	428	110	120	1400	75
V	237	560	211	198	1906	77

regressed on generation number to estimate the genetic trend. Under several assumptions - the complete relationship matrix should be known, as well as the variance components before selection - these averages are unbiased estimates of the genetic means (Sorensen and Kennedy, 1984).

The following repeatability animal model in matrix notation was used:

$$y = Xb + Za + Zp + e$$

where, y is the vector of observations; b is the vector of fixed effects of year-season (20 levels) and physiological state of doe at mating (3 levels), taking into account if the doe at mating was nulliparous, was lactating the previous litter or was not lactating; a is the vector of additive genetic effects of animal; p is the vector of the non-additive genetic plus permanent environmental effects of the doe that affect all its parities, which hereafter will be called permanent environmental effects; and e is a vector of residual random effects. The matrix X is the incidence matrix for the fixed effects and Z is the incidence matrix relating observations to animals. Data of summer and spring seasons were merged in some generations due to lack of summer data.

REML (co)variance components were estimated by fitting series of multivariate animal models (allowing to estimate correlations among non selected-for traits) using WOMBAT software (Meyer, 2006).

RESULTS AND DISCUSSION

Only the results directly concerned with the response to selection are presented. Some effects factored into the models, such as year-season or the physiological state of the doe at mating are not reported, but their estimates were within the range of those found in the literature.

Descriptive statistics of the complete set of data for litter weight traits are presented in Table 2. The present results were in the range of reviewed estimates (Abou Khadiga, 2004; Costa *et al*., 2004; El-Deghadi, 2005; Al-Saef *et al*., 2008; Youssef *et al*., 2008b).

Genetic parameters

Heritability estimates of all traits were generally low and similar in both lines with ranges of 0.09 to 0.11 in APRI and 0.09 to 0.10 in V line (Table 3). Similar results (around 0.1) were reported by several authors (Rastogi *et al*., 2000; Costa *et al*., 2004; El-Deghadi, 2005; Iraqi *et al*., 2006; Gad 2007).

Estimates of the ratio of the variance of permanent environmental effects to the phenotypic variance (p^2) tended to be lower than h2 for most traits, except for LBW where the value of p^2 was twice higher than h^2 in both lines. This could be devised from the estimates of repeatability (r) for all traits in both lines (Table 3). The pattern of p^2 values was very similar in both lines and ranged from 0.06 to 0.21. The higher

Table 2: Descriptive statistics of the experiment. Number of records (N), mean (μ), standard deviation (σ) and range for litter weight (g) traits.

	LBW	LWW	PLG
N	3306	3096	3096
μ	472	3218	2746
σ	85	626	597
Range	80-770	475-6215	110-5754

LBW: Litter birth weight, LWW: Litter weaning weight, PLG: Pre-weaning litter gain.

Table 3: Estimates of genetic parameters (±standard error) for litter weight traits in APRI and V lines.

	LBW	LWW	PLG
APRI line			
h^2	0.11±0.01	0.10±0.01	0.09±0.01
r	0.31±0.03	0.16±0.03	0.15±0.03
σ^2_P	8835±222	435900±13077	236299±8270
V line			
h^2	0.10 ±0.01	0.09±0.01	0.10±0.01
r	0.31±0.01	0.15±0.01	0.16±0.02
σ^2_P	5389±255	309725±9992	155957±6601

h^2: heritability, r: repeatability, σ^2_P: phenotypic variance, LBW: Litter birth weight, LWW: Litter weaning weight, PLG: Pre-weaning litter gain.

values of p^2 in LBW rather than in the other traits could be attributed to the fact that LBW could be more influenced by prenatal maternal performance of the doe. The newly born kits seemed to be still affected by their mother's uterine environment. The present results confirm those of Lukefahr and Hamilton (1997), Rastogi *et al*. (2000), Al-Saef *et al*. (2008), Nofal *et al*. (2008) and Youssef *et al*. (2008b). The latter authors found that h^2 estimates were higher than those of p^2 for most of litter weight traits.

Low to moderate estimates of repeatability were observed for litter weight traits in the current study (Table 3). Ranges of values were 0.15 to 0.31 in both lines. The relatively higher estimate of repeatability for LBW in both lines is a result of the higher values of p^2 in this trait compared with the other traits. Comparable results (0.09-0.21) were obtained by many authors (Lukefahr and Hamilton, 1997; Rastogi *et al*., 2000; Al-Saef *et al*., 2008; Nofal *et al*., 2008; Youssef *et al*., 2008b).

Correlations

Genetic and permanent environmental correlations among litter weight traits in both lines were generally high, especially between LWW and other traits (Table 4). This means that when selecting for LWW we also expect relatively important correlated responses in LBW and PLG.

Estimates of genetic correlations ranged from 0.77 to 0.97 and 0.80 to 0.94 in APRI and V lines, respectively. The current estimates seem to be somewhat higher than those obtained in Egyptian studies

Table 4: Estimates of genetic (above diagonal) and permanent environmental (below diagonal) correlations for litter weight traits (±standard error) in APRI and V lines.

	LBW	LWW	PLG
APRI line			
LBW	-	0.89±0.17	0.77±0.20
LWW	0.87±0.23	-	0.97±0.18
PLG	0.47±0.17	0.89±0.27	-
V line			
LBW	-	0.92±0.16	0.85 ±0.21
LWW	0.86±0.15	-	0.94±0.14
PLG	0.65±0.14	0.86±0.15	-

LBW: Litter birth weight, LWW: Litter weaning weight, PLG: Pre-weaning litter gain.

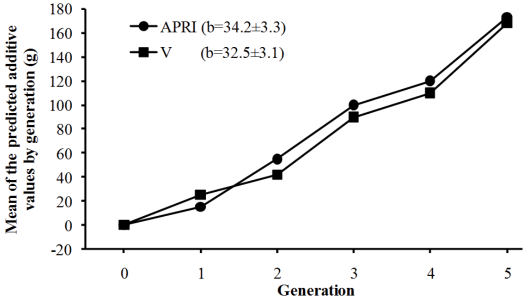

Figure 1: Genetic trend (b) of litter weaning weight in APRI and V lines.

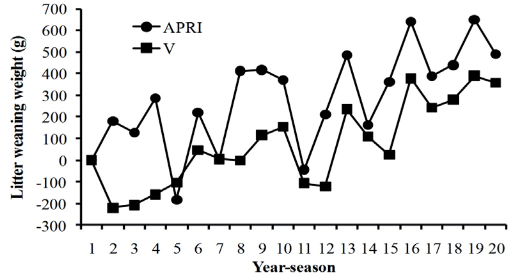

Figure 2: Year-season trend of litter weaning weight in APRI and V lines, starting from summer 2003 to spring 2008.

by El-Feky *et al*. (2001), El-Deghadi (2005) and Gad (2007). These differences could be due to breed and environmental differences between the current experiment and the previous ones, as well as methods and models of analysis. The current high estimates of genetic correlation between LBW and LWW in both lines (around 0.9) could lead to the conclusion that most genes affecting litter birth weight may have an effect on the corresponding traits at later ages. Values of permanent environmental effect correlations were generally high but lower than genetic correlations. The ranges were 0.47 to 0.91 and 0.65 to 0.86 in APRI and V line rabbits, respectively.

Genetic and environmental trends

Few experimental results are so far available to estimate selection response or genetic trend for litter weight in rabbits using BLUP estimations. The genetic trend of LWW, calculated as the regression of the mean of the predicted additive values by generation on generation number is plotted in Figure 1. Similar genetic trends of LWW in APRI (34.2±3.3 g) and V (32.5±3.1 g) lines were found. Likewise, positive correlated genetic trends of LBW (5.7±0.6 and 6.1±0.5 g) and PLG (26.9±3.2 and 24.8±3.1 g) were observed in APRI and V lines, respectively. All regression coefficients were significant ($P<0.05$). The current results are comparable to those obtained by Moura *et al*., (2001) and Bolet and Saleil (2002a), lower than those obtained by Bolet and Saleil (2002b) and Khalil *et al*. (2005). Differences in genetic trends throughout the experiments could be attributed to different populations and surrounding conditions.

Environmental changes in LWW largely reflected seasonal variations in production (Figure 2). Year-season fluctuations were found in both lines. Generally, the dissimilarity among year-seasons in LWW could be attributed to the variation in climatic conditions.

CONCLUSIONS

Positive estimates of genetic trends in the present study indicate the expectations of success of the current breeding program, which should be continued and upgraded.

The high genetic correlations between litter weaning weight (as a selection criterion) and the other traits indicate that similar relative improvements could be expected in all traits.

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