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Genetic Parameters of the Newly-Developed Egyptian APRI Rabbit Line Raised Under North-Delta Environment Using DF-REML Animal Model 1 Litter Weight Traits

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Abstract

Litter weight traits, (LW at birth; 21 and at weaning at 35 days post kindling), for two consecutive years on APRI improved native rabbits (a developed line rabbits derived from the paternal Spanish V-line and the maternal Egyptian Baladi Red breed), were genetically evaluated. The data of litter weights (LWB; LW21 and LWW) contained a total of 192 litters produced from 80 does pedigreed by 9 sires and 12 dams, were analyzed using Multi Trait Derivative Free Restricted Maximum Likelihood Animal Model (DFREML). The Mathematical model of the analysis comprised the effects of year-season combinations (YRS) and parity (P) as fixed, as well as animal and common litter as random effects.

Heritabilities of the considered doe traits were relatively low being 0.17, 0.04 and 0.11 for litter weights at birth; 21 days and weaning; resp. Furthermore, estimates of common litter effects were rather low being 0.2, 0.002 and 0.008 for litter weight at the same manner. From the previous heritability estimates, it can be concluded that family or within family selection could be more effective and valuable than individual selection to improve these traits of APRI does' rabbits under the Egyptian North-Delta climatic conditions.

Similarly, the ranges of APRI sires' transmitting ability (TA ± SE) for LWB, LW21 and LWW were 0.11 ± 0.02, 0.24 ± 0.06 and 0.81 ± 0.19 g with the accuracies being 0.51% for all litter weight traits. Interestingly, and though of the larger numbers involved, ranges of accuracies estimates (r_{AP}) of the predicted breeding value (BV) of APRI improved native rabbits were mostly higher in the dams data set followed by those of does.

Furthermore, significant moderate spearman correlation estimates were obtained among various ages' BV of the studied traits for the APRI does. These estimates of correlation, however, were age dependent and decreased as age advance, indicating correlated response to selection that should be considered in selection plans. Selection for LW may not be practically and realistically associated with a correlated improvement in the later-ages does' performance which in turn may have its impact on generation intervals and relatively amplify and enlarge selection costs.

In addition, estimated epigenetic trends (EP), for litter weight traits under study suggested that it is possible to achieve slow, but simultaneous improvement of litter traits with selection program in rabbits. LW traits recorded generally a negative EP trend during the majority of the year-seasons under study. However as regard to EP with parities, the high LW response was postponed to the later parities.

Keywords: *APRI improved native rabbits; litter weight; heritability estimates; variance components; epigenetic trend.*

Introduction

Genetic improvement of Egyptian rabbits for economically important traits, particularly doe litter traits, is an important component of an expected overall strategy to improve profitability and sustainability of broiler rabbits operations. Characterization factors that affect short and long-term genetic improvement, selection, and mating strategies in a population is essential to construct and then evaluate genetic improvement programs and determine areas that need to be amended and improved. The retarded or small genetic changes for rabbit doe litter traits under nation production suggest that selection and mating strategies used for genetic improvement in Egyptian rabbit populations had limited success. However, these population estimates of genetic trends provide no information on adaptation process and epigenetic trends that occurred within individual levels of environmental circumstances.

In animal breeding, knowledge of the genetic properties of the traits we are interested in is the first prerequisite in establishing a selection program. Estimation of genetic parameters is synonymous with the estimation of variance components. In this context, variance comprises not only the variance of an observation for a particular trait and individual but also covariances between traits as well as covariances between individuals for the same or different traits. Estimation of genetic parameters then involves partitioning of observational components, i.e. phenotypic covariances between relatives, into causal components such as variances due to additive genetic effects, dominance, epistasis and permanent and temporary environmental effects [1]. This utilizes the known degree of relationship between animals and the resulting expectations of covariances between them.

In estimating variance components by ML, data are generally assumed to have a multivariate normal distribution. Consider two traits with truncation selection on the first, i.e. whether or not an individual has a record for the second trait depends on the magnitude of the first record. As shown, for instance, by Curnow. [2] ML then exploits two properties of the multivariate normal distribution to obtain unbiased estimates of the covariance between traits and the variance of the second trait. Firstly, the regression of the second, indirectly selected trait, on the first, directly selected trait is unbiased. This goes true either the trait is measures at different ages of the animal life or for two very different traits. Secondly, the conditional variance of the second trait given the first, i.e. the variance about regression, is not affected by selection (no bias due to selection).

The Egyptian animal breeds, including native rabbit ones, are supposed to be a part of our national genetic resources wealth that must undergo more research and improvement, first to preserve them and second to reveal their distinguishing characteristic features and to promote them to compete with the exotic ones. It is therefore, the accurate determination of rabbits' genetic parameters and breeding values for most economic traits, of such populations, are essential for planning and to achieve success in their breeding plans and programs. Litter traits are of the utmost and supreme cost-effective prolificacy traits of the rabbit doe. Best linear unbiased prediction values (BLUP) estimated by different procedures for these traits, is an approach to predict breeding values of animals and to adjust simultaneously for fixed effects of the used model of analysis [3].

BLUP (or transmitting abilities which are, in principle, half that of the breeding values) for an economic trait is a fundamental selection tool for planning and attaining progress in breeding programs. Animal Model Method in modern scientific researches increasingly becoming the preferred method of BLUP estimation, because among other reasons, it accounts for both the relationship matrix and selection and downward bias in the data [4]. The animal models commonly fitted when estimating maternal effects include maternal genetic and permanent environmental effects, i.e. are the models suggested by Willham [5]. While it is conceptually easy to extend these to allow for direct-maternal, permanent environmental covariances, this might impose computational problems, especially for large, 'unstructured' (field) data sets.

Youssef., *et al*. [6] reported that a selection program for broiler rabbits is being carried out in three Egyptian and one Saudi Arabian research centers, each of them having the task to develop lines of rabbits in their local conditions, in which efforts were assembled to develop new lines of meat rabbits, where heat stress is considered as one of the most important limiting factors to raise meat rabbits in these areas. One of these lines is the APRI line originated from the Spanish V line crossed with our local Baladi Red line, the synthetic APRI line is composed of 50% from the line V and 50% from the Baladi Red rabbits.

Performances obtained verified that the most stable and convenient trait in all synthetic lines influenced by line V is referring to the prolificacy, which has been around 9.0 total born, 8.5 born alive and 7.2 number weaned per litter in the majority of the locations. Post-weaning daily gains were also convenient and ranged from 18 - 34 g/day in different locations studied, Youssef., *et al*. [6]. In Egypt, some years ago, an effort was done creating the breeds of Giza White along with the Red, White and Black Baladies [7,8], but a permanent program for selection of them was not established.

Crossing between exotic and local breeds can be done to take advantage of the existent heterosis or hybrid vigor [9] and genic complementary effects [10] in the majority of economic traits. However, results of most crossbreeding experiments carried out in Egypt reported that crossing does of New Zealand White breed with bucks of local breeds was generally associated with heterotic effects on growth traits [11].

In 2003, a co-operative rabbit crossbreeding project was established between Egypt and Spain to develop new maternal line of meat rabbits suitable for hot climate. The V-line rabbits used in this project were crossed with an Egyptian Baladi Red (BR) rabbits. Traits related with productivity of the does, such as Litter size, gain and weight in addition to 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 [12-14].

This paper outlines a Derivative-Free REML Animal Model Algorithm to estimate the variance components; genetic parameters and BLUP values of the Litter gain (LS) traits in APRI improved native rabbits.

Materials and Methods

APRI, maternal line rabbits is an improved line rabbit breed which is reared in Sakha experimental rabbitery, Animal Production Research Institute (APRI), Agricultural Research Center, Ministry of Agriculture, Egypt, also V Spanish 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 [12], the V line was introduced to Sakhain 2002 and its selection criterion at then was changed to litter weaning weight as in the APRI line [6]. Field records Data of APRI line collected through two consecutive years (2008-2009) on doe litter weight traits at birth; 21 days and weaning at 35 days post kindling were used in this study. Breeding does and bucks were lodged separately in individual collective galvanized wire cages arranged back to back in single tier batteries provided with feeders and automatic nipple drinkers. Rabbit does houses were provided with feeders, automatic drinkers and nest boxes at 25 days after fertile mating. All rabbits were fed on the same commercial pelleted diet containing approximately 18% protein, 2.39% crude fat and 12.8% crude fiber. Feed and water were provided all the day long. Weaning of litter was done six weeks after kindling. Cages of entire group of animals were cleaned and disinfected regularly before each kindling. All through the experimental period, animals were medicated likewise and subjected to harmonious managerial and environmental conditions.

Breeding plan started in October 2008 and terminated at the end of spring 2009. Litter weight (LWB, LW21 and LWW) at birth, 21 and weaning at 42 days post kindling were recorded. For Breeding, each doe was transferred to the cage of its assigned buck to be bred, and palpated 10 days later, for successful pregnancy testing. Does that failed to conceive were returned to the same assigned buck to be rebred. Nest boxes were prepared for parturition with saw dust in the 25th day of the pregnancy.

Numbers of sires, does and dams along with number of litters are listed in Table 1.

Statistical and genetic analysis

Data collected on 192 litters produced from 80 does fathered by 9 sires and mothered by 12 dams of APRI line (Table 1). Starting mixed model procedure (Co) variance matrix, for every studied age (birth, 21 days post kindling and at weaning) of the litter weight, traits were obtained applying REML method of VARCOMP procedure of SAS, 2003. These starting values were used for the estimation of the more precise and reliable estimates of multi trait animal model variance and covariance components.

Data of does litter weight traits were analyzed using Derivative Free Restricted Maximum Likelihood Animal Model (DFREML) of Boldman (1995). The model adopted for analyzing the data comprised the effects of year-season combinations (as fixed effects) and parity effects in addition to additive genetic and permanent environmental (as random effects).

The following animal model (in matrix notation) was used:

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

Where:

where y = vector of observations on animal for does litter weight at birth, 21 and at weaning at 35 days post kindling (LWB, LW21 and LWW); b = vector of unknown fixed effect peculiar to year-season (5 levels); u_a = vector of random additive genetic effects of the animal for the i^{th} trait; u_c = vector of random permanent environmental effect (doe-parity combination); e = vector of random error; X, Z_a and Z_c are incidence matrices relating records of i^{th} trait to the fixed, random animal and random permanent environmental effects; resp.

r_{Ai} = the accuracies of the prediction of the I^{th} animal's breeding value; F_j = inbreeding coefficient of animals (assumed to be zero in case of unknown pedigrees); d_j= the j^{th} diagonal elements of the inverse of the appropriate block coefficient matrix; and α is a Starting Value = (σ^2_e / σ^2_a). It is then why this prior value should be estimated as precisely as possible cause if there are more than one maxima within the parameter space, but if there is only one maxima any starting values would give you the same maxima value.Standard errors of the predicted breeding values were also estimated for each individual as: ($S.E._p$) = $d^j \sigma^2_e$ where dj is the diagonal element of the inverse of the appropriate block coefficient matrix that respond to this animal and σ^2_e is the error variance.

Litters	Does	Dams	Sires
192	80	12	9

Table 1: *APRI improved native rabbit's data Structure.*

The relationship coefficient inverse matrix (A^{-1}) among animals was as proposed by Korhonen [15]. MTDFREML program of Boldman., *et al.* [16] applying the sparse matrix package, SPARSPAK (George and Ng 1984) [] was adopted for the analysis. A convergence criterion was assumed when the variance of the simplex of the log-likelihood values reached a constant value at a number of digits less than 10^{-4}. This implies that the occurrence of local maxima was checked by repeatedly restarting the analyses until the log-likelihood values did not change beyond the first 4 decimal digits. The MTDFREML evaluates also the proportions of additive genetic effects (heritability; h^2_a, permanent environmental effects (c^2), and error (e^2). Heritabilities in the narrow sense (h^2_a) are computed as: $h^2_a = (\sigma^2_a / \sigma^2_a + \sigma^2_c + \sigma^2_e.)$ Where: σ^2_a = additive genetic variance, σ^2_c = permanent environmental variance, and σ^2_e = errorvariance.

Animals predicted transmitting abilities (TA_i);their accuracies (r_{Ai}), and standard errors SE_{Ai}:

The (co)variances matrix estimated using MTDFREML analysis is used by the same software for the prediction of breeding values, their accuracies (r_{Ai}), and standard errors SE_{Ai}. The accuracies of BLUP for each individual were estimated according to the equation suggested by Henderson [17].

Accuracy in predicting breeding values is simply an estimate of the correlation between an individual's breeding (A) and phenotypic (P) Values, calculated in animal model applying the formula $r_{Ap} = (1 + F - d^j \alpha\ a)^{0.5}$. It is a sort of correlation that quantifies the ability to predict individual breeding value from some measure and here this measure is its phenotypic value. It is called also the accuracy of the selection scheme and it is used to select parents. A simple statistics study for all the last parameters were introduced to give an idea of the entire animals', sires', dams' and does' minimum, maximum, average value, range in addition to positive records number, percentage, ranges, minimum, maximum, and average values for all the traits under consideration which could give a large idea of the potential of the population evaluated. Another study of the realized association effect between T_{Ai}; epigenetic and Environmental trends was established and presented in graph forms as follows:

Realized association (Correlation) effect study between BLUP values and ranks

The transmitting abilities (BLUP) estimated by MTDFREML as well as their estimated ranks are used to estimate the Product moment, (for BLUP's), and Spearman, (for BLUP ranks), realized association (correlation) coefficients among the studied litter traits for entire group of animals; sires; dams and does.

Epigenetic Trend

Genetic improvement of rabbits for economically important traits, particularly litter traits, is an important component of an overall strategy to improve profitability and sustainability of rabbits operations. Characterization of factors that affect genetic improvement, selection, and mating strategies in a population is essential to evaluate genetic improvement programs and determine areas that need to be improved. These small genetic changes for reproduction suggest that selection and mating strategies used for genetic improvement in Egyptian rabbit populations had limited success. However, these population estimates of genetic trends provide no information on genetic trends that occurred as acclimatization and adjustment to individual environmental situations. Genetic changes may vary among these situations within a population. Within prevailing-environment genetic trends could be higher, similar, or lower than the genetic trend of the overall population. Factors that influence genetic improvement may vary across environmental situations. Classification of farms according to the genetic trend of their cows would help identify factors that contributed to higher or lower litter traits performance levels in individual herds. Differences among such situations (e.g. parity, Month or season of kindling, etc...) were found to be important for on farm litter traits' performance [18,19]. These differences among classes of distinctive environmental situations may affect litter traits genetic improvement within rabbit populations. Factors that affect the genetic improvement within classes of environmental situations will help identify common factors that influence genetic improvement across populations in Egyptian rabbit populations. Inclusion of these factors in genetic evaluation models could improve the accuracy of genetic predictions and help increase the genetic trend toward higher production and improvement. Thus, the objective of this part was to characterize and give better understanding to the factors influencing genetic change for an economic trait yield within rabbit's population in North-Delta Egyptian countryside.

In this respect, the study of the changes in short-term-genotypic adaptation, amendment and/or reformation of the involved genes' controlling the traits considered caused by mechanisms other than changes in the underlying DNA sequence due to environmental effects (e.g. year-season combinations, 5 classes and parities, four classes) are labeled as "epigenetic trends". Epigenetic trend (as a sort of genetic by environment interaction) were estimated using the method reported by Hassan., *et al*. [18,19] adapted from that cited by Legates and Myers. [20]. After regressing the BLUP values of the engaged animals across the different classes of the insinuated environmental situations using SAS merge statement [21], epigenetic trends are typically calculated as the deviation of the mean of the BV's of the particular group of animals succeeded to re-produce under the environmental situations they were subjected to, from the overall mean of entire group of animals' across all environmental situations' BVs. The resultant output was then plotted in graphs to represent the general trend of the behavior of a specific trait under changeable classes of the fixed effect under consideration (i.e. year season, YRS and parity, P).

Environmental Trend (ENV)

Estimated as the result of subtracting TA's ofLW values of an animal from its observed phenotypic values of the same traits, all as deviations from the overall means of the whole tested rabbit population environmental divergences. The resultant Litter weight (ENV_LW) values are regressed matching their respective year-season combinations (YRS) and parity effects (P) as done with the epigenetic trends. Thereafter, they evaluated the same way done with epigenetic trends.

Results and Discussion

Means and coefficients of variation of uncorrected records, and Least Square means

Overall actual means of LW traits in APRI improved native rabbits, standard deviations and coefficients of variation (CV%) during the suckling period are presented in table 2 for data comparing purposes. Means of litter weight traits (LWB, LW21 and LWW) in this study were within the ranges reviewed in most of the Egyptian studies [22-24], while, it was higher than Abdel-Kafy., *et al*. [25] Coefficients of variability (CV%) ranged from 31.29 to 36.23% for litter weight. The eminent data variability may reveal that new APRI line rabbits have a relatively substantial variability and it could possibly constitute a rich genetic resource to work upon (which was relatively higher than that for Baladi Black rabbits in the CV% of LW traits. In the study on Baladi Black rabbits done by Abdel-Kafy., *et al*. [25], they reported that such native breed of rabbits with its high performance is ready to be given more attention for genetic improvement.

Trait	Overall Mean	SD	CV
lwb	0.38	0.12	31.29
lw21	1.52	0.48	31.55
lww	2.67	0.97	36.23

Table 2: *Overall Means, standard deviations (SD) and coefficients of variability (CV%) of litter weights at birth; 21 days and weaning at 6 wks. (LWB, LW21 and LWW) for the APRI improved native rabbits.*

Parity and Year-season combinations effect

Parity and year-season combinations (Table 3) had no effect on all litter weight traits, while YS showed significant effects on LWW. Also parity has an effect on only LWB. El-Meghawry showed a significant effect of parity on LSW. Parity and year-season combinations effects in our study showed inconsistent and no significant source of variation in most litter weight traits. This may be due to the changes in physiological efficiency of the doe with advance of age. These agreed with results of El-Raffa., *et al*. [26,27].

Variance component estimates (σ2): From a statistical point of view, variance components, generated mostly, but not merely, from analysis of variance procedures, are commonly used in formulating appropriate designs or establishing quality control procedures (i.e. decision making). In Statistical genetics it is simply used in estimating genetic parameters. If the data are balanced, the ANOVA estimators have many appealing properties amongst them the simplicity of calculation and the straightforward concept. However, in unbalanced data situations, as what breeders have to deal with in animal breeding, these properties are hardly hold true which creates number of problems in arriving the correct decisions. In unbalanced situations two general classes of estimators have sparked breeders' attention: (1) Maximum Likelihood (ML), Restricted Maximum Likelihood (REML), and the latter procedure are what is being applied herein; and (2) minimum norm and minimum variance quadratic unbiased estimation (MINIQUE and MIVQUE). In addition to estimation problems in unbalanced situations, the notion of robust estimation which takes care of the influence of outliers in addition to the underlying statistical assumptions is of crucial consequence.

	No.	LWB		LW21		LWW	
		LS-Mean	SE	LS-Mean	SE	LS-Mean	SE
MU	192	0.40	0.01	1.42	0.08	2.44	0.12
Parity		sig		Not sig		Not sig	
1st	85	0.35	0.02	1.41	0.10	2.39	0.17
2nd	44	0.40	0.02	1.45	0.12	2.54	0.22
3rd	32	0.44	0.02	1.45	0.14	2.47	0.25
4th	31	0.40	0.03	1.35	0.14	2.38	0.27
Year-Season (Yr-S)		Not sig		Not sig		Sig	
83 (Yr1-Summer)	20	0.38	0.03	1.30	0.17	2.13	0.32
84 (Yr1-Autumn)	33	0.40	0.02	1.44	0.14	2.52	0.25
91 (Yr2-Winter)	31	0.41	0.02	1.62	0.13	2.98	0.24
92 (Yr2-Spring)	108	0.40	0.01	1.31	0.09	2.14	0.15

Table 3: *Least Square means, LS-Mean (+SE) of litter weights at birth; 21 days and weaning at 6 wks. (LWB, LW21 and LWW) for the APRI improved native rabbits.*

An inconsistent trend was observed in APRI improved native rabbits, for LW additive genetic variance (σ^2_A; diagonal elements) as values and as proportion of the total observed variance (Table 4). Though, seemed generally to be age dependent and curvilinear, its ratios increased as 21 days post kindling and decreased thereafter at weaning at 5weeks. Post-kindling. However; litter traits as fitness and transitional traits are expected to be marginal with consumed additive genetic variance due to that they are being continually subject to natural selection.

In this respect, the phenotypic variance, (diagonal elements) of litter weight traits show a consistent trend of being age dependent and increased as the period after kindling increased (Table 4).

Permanent environment of LW traits was found to be very low in magnitude. Conversely, Youssef., *et al*. [28] reported that litter weight traits are greatly affected by the additive genetic and maternal effects. In this respect, Khalil., *et al*. [29] reported that the low percentages of sire variance component reflect the large environmental component of variance associated with the doe during kindling and raising of its litters to weaning. He also added that since milk production and subsequently litter gain are of the fitness traits and are influenced by litter size, it is supposed that the additive variance has been diminished through long term natural selection.Though variance component estimates differed among Egyptian rabbit populations, estimated values suggest that genetic selection for milk production would be feasible in these populations.

	Additive genetic (σ^2A) variance			Phenotypic Variances And Covariances			% Uncorrelated Random Effects		
	LWB	LW21	LWW	LWB	LW21	LWW	LWB	LW21	LWW
LWB	0.005	0.012	0.040	0.031	0.111	0.238	0.200	0.210	-0.010
	16.70%								
LW21	0.012	0.026	0.090	0.111	0.645	1.226	0.210	0.002	0.970
		40.30%							
LWW	0.040	0.090	0.310	0.238	1.226	2.730	-0.010	0.970	0.008
			11.48%						

Table 4: *Additive genetic (σ2A) and phenotypic co-variance, percentages of permanent environment as proportion of the phenotypic variance of litter weight traits at birth; 21 days and weaning at 6 wks. (LWB, LW21 and LWW) for APRI improved native rabbits.*

Heritability estimates: Heritability can be estimated in principle by three different methods (a) from the phenotypic likeness between relatives, (b) the realized heritability from the results of selection experiments and finally (c) by comparisons between the size of the phenotypic variance within genetic lines and of the population mating at random. It is in fact only the first method that is being used in DF-REML animal model (i.e. from the phenotypic likeness between relatives). If the breeder chooses individuals to be parents of the next generation merely according to their phenotypic values, his success in changing the characteristics of the population can be predicted only from the knowledge of the degree of correspondence between these phenotypic values and breeding values. This degree of correspondence is measured by one of the very important genetic parameter, heritability. The ratio of the total genetic variations to the total phenotypic or observed variance is termed the coefficient of heritability in the broad sense. However the heritability estimated by the animal model algorithms under REML procedure is dissimilar, it is the ratio of the additive genetic variations to the total observed variance or the heritability in the narrow sense. The additive genetic variance component is the chief determinant of the likeness among relatives.

Heritability estimates using REML method for LW traits in APRI improved native rabbits, were relatively low, from 0.13-0.14, table 3. These estimates were comparable with those ranges reported by El Raffa. [30], Baselga and Garcia. [31], Youssef., *et al*. [28], Nofal., *et al*. [32], Iraqi., *et al*. [24], Gad. [33], Gharib., *et al*. [34] and Iraqi. [35]. These low h^2 figures may be attributed to the consumption of the additive genetic variance due to natural selection which consequently led to inflated non additive genetic and environmental factors (i.e. constitute the major source of variation reported herein for those traits). In this respect, Khalil., *et al*. [29] concluded that environmental conditions and non-additive genetic effects play a large role in doe litter traits in rabbits. Therefore, such diminished estimates for heritability for these traits may reveal higher non additive genetic effects for all studied litter traits. Such low heritability traits do not support individual selection and therefore, family and within family selection could play a role especially with the presence of genetic evaluation for each animal (i.e. BLUP). Also crossbreeding it too often associated with heterosis and performance improvement in such fitness traits. Marker assisted selection would be the preferred technique but on the other hand it is still very expensive and not veritably available under the Egyptian condition.

Indirect selection for litter traits from its component traits as a consequence of their nature as composite traits could be an alternative solution key especially in the positively high correlated traits. However, using actual transmitting ability of animals from reliable models of estimation would enhance more the genetic response.

Genetic Correlation

Sometimes basic information needed in the improvement plan is that when selection for one particular trait, how much correlated genetic change is expected on other character not selected for, a measure of which is provided by a population parameter, genetic correlation. This parameter depends largely upon the degree of association between the two characters especially this due to the pleiotropic effects of genes controlling them. This type of association is permanent, while there is another impermanent or temporary type which is due to that genes controlling the two characters are arranged on the same chromosome and the degree for this type of association depends on the crossover distance between those genes. The larger this distance is the faster is this dissolving.

All estimates of genetic correlations among litter weights (Table 5) were high and positive. Thus we may build the strategy on selection criteria on these traits. Values of genetic correlations extracted from animal model procedures are of limit practical usefulness and to some extent hard to elucidate and unreliable. The covariance yielded by multi trait animal model is in most cases doubtful and debatable and did not clearly differ from zero especially when the number of traits involved in the analysis exceeds from one to two. A comparable conclusion has been reached at by Luiting and Urf. [36] who determined that an alternative method is acceptable in a breeding program if no reliable estimates of genetic correlations are available?

This is why an alternative study of the correlations among the resultant transmitting ability, values and ranks, is from one point of view indisputable and undeniable. However, when such study is to be done (i.e. estimating correlations among the resultant transmitting ability), it is foreseeably better to be a resultant from single trait animal models analysis (a paradigm not used in this paper).

Heritabilities and genetic correlations				Environmental as a proportion of total variance			
	LWB	LW21	LWW		LWB	LW21	LWW
LWB	0.170			LWB	0.630		
LW21	0.900	0.040		LW21	0.890	0.960	
LWW	9.000	0.990	0.110	LWW	0.910	0.930	0.880

Table 5: *Heritabilities (h^2, in bold on diagonal) and genetic correlations (below diagonal), permanent environment and the error as proportion of the phenotypic variance of litter weight traits at birth; 21 days and weaning at 6 wks. (LWB, LW21 and LWW) for APRI improved native rabbits.*

Animal Evaluation

Transmitting abilities (TA's); Accuracies (r_{AP}) and Standard error (SE_{Ai}): Only the phenotypic value of individuals can be directly measured, but it is the breeding values that determine their influence on the next generations. Estimates of APRI improved native rabbits transmitting abilities (Statistically BLUP's), their accuracies (r_{AP}) and Standard errors ($SE_{Ai)}$ for litter weights traits generated from the animal model analysis, are presented in table 6. Selection emphasis can be applied differently to various ancestors. Generally, fewer males are needed for reproduction purposes than females. Thus, producers can be stringently strict about their requirements for males than for females. Only the very best (top 1%) sires and dams will be used to produce future sires in most species. The next females, however, will be offspring of sires in the top 25% of the species and of dams in the top 75% of the population. This is because nearly all females are kept for breeding purposes, while most males are culled or sent to market at an early age. These figures can vary inconsequentially from one species to another.

From results presented in table 6, it is obvious that the minimum and maximum values as well as difference between them (ranges) of TA are age dependent and they increased as the period post kindling lengthened till weaning at 5 wks of doe's bunnies age. On the contrary, the number of positive records though age dependent but they decreased as the period post kindling lengthened. Fortunately, the percentage number of positive records (n+) for the whole, does' and dams' data didn't get behind or set down the border of 25% (which is the maximum expected number of replacement females). However and as for sires, the situation is different since they were at the border of (2 sires) 22%. Putting in mind that the replacement rate of sires is far less from that of dams, these figures could be convenient if breeding plan is about elevating the population levels of litter weights. The trend consistency of positive records may reveal that there may be a positive association between the traits on the animals of positive records, which will be dealt with in the part of association studies between BLUP's of litter weight traits. The later conclusion, if true will help the breeders of these native rabbits to make their decision of selecting early in bunnies life based on the birth BLUP values. This of course would reduce the generation intervals and cuts down the breeding costs. Nevertheless, the SE_{Ai} values are relatively high at early ages which may impose difficulty of making such a decision of early selection but fortunately again the reliability or accuracies (r_{AP}) of the higher records are outstandingly high (not presented in tables).In this respect the higher the r_{AP} values, the more reliable is the BLUP's and the more certain the breeder is about the results of the selection decision. Generation interval is the average age of a sire or dam when a potential replacement progeny is born. Shortening the generation interval generally results in faster genetic change. Generation intervals depend largely on reproductive capacity of the species, but any technology that allows the breeding value of an animal to be estimated earlier in life will shorten the generation interval. Reproductive capacity of a species may be changed with any technology helps to get more offspring per mating, to use fewer males or females, or to reduce the length of time to age at first breeding.

However, sires TA estimates are superior when compare with does and dams' data. This could be advantageous yet again, since sires constitute almost 50% of the hereditary of the next generation of animal and needless to say this native rabbit populations. The later presumption coupled with an elevated selection intensity pressure of the sires may reveal that the additive genetic makeup of the next generation of this native rabbit population is expected to be larger than that would think of based on dams', does' or whole population data (i.e. is expected to yield a greater LW traits selection response). In this respect, El-Raffa., *et al*. [26] reported that differences between minimum and maximum values of the top 25% sire breeding value estimates are the backbone for any planned selection strategy to improve economic traits.

Realized genetic correlation estimates among breeding values and its Rank correlations: Correlation studies (Product Moment for BLUP values and Spearman for BLUP ranks) among the breeding values of LW traits Estimates for all, does', dams' and sires' data are presented in table 7. These figures expresses another sort of genetic correlation that differs from that resulted from multi-trait animal model analysis in that the former expresses realized association between sires transmitting abilities while the later expresses estimated expected additive genetic association between loci involved in the inheritance of the two traits under consideration (either temporary due to that these loci are carried on the same chromosomes or permanent due to that some of these loci may have control on both traits). However, the later is very sensitive to the number of traits involved in the animal model analysis and the value between a particular two traits diminishes drastically as the number of traits analyzed increases. The later conclusion may make the animal model resultant association from different multi-trait analyses are doubtful and questionable they express at all the expected genetic correlation and may be they express the ratio of correlated changes when selecting for varying number of traits, or because when optimizing the resultant BLUP's this optimization does not go as well to the resultant genetic correlation and may we need another multi-parameter multi-dimensional optimization process.

However, data of table 7 revealed that the ranges of bivariate Product Moment or Spearman association coefficients between LW traits were generally high, positive in direction. On the other hand, both Product Moment and Spearman association coefficients were comparable and equivalent to each other which makes them interchangeable and replaceable to each other without noticeable scarification of reliability especially when data is sizeable (i.e. large sized populations).

Values of both correlation parameters are by no means age dependent and reveal that correlated response for selection from one trait to the other is quite feasible (Table 7).

Epigenetic Trend

Epigenetic Trend (EGT): The Character of economic importance in animals which normally show continuous variation, are of immense concern to both breeders and producers. Such characters are controlled by a large number of genes, each in the infinitesimal, theory having small similar and supplementary effect on the character. The cumulative effects of such genes, coupled with environmental effects produce continuous variation in the phenotypic values of individual. Sarakul., *et al*. [37] Estimated genetic trend for the complete population and at farm level basis along with per year and per month genetic change of milk yield in an effort to identify the factors that influencing genetic change for multi-breed Thai cows. They were motivated to carry on this study bases on an earlier one done by Koonawootrittriron., *et al*. [38] and Koonawootrittriron., *et al*. [39] who found a retarded genetic trend in Thailand dairy cows during the last two decades. Genetic change must be measured to determine the success of a breeding program. There are many different trends that could be monitored. Genetic change is estimated by averaging the EBVs of particular groups of animals. For example, the trend in all females that had offspring by year of birth of the offspring. A slightly different trend would be all females born in a particular year, even though some of them may never have progeny themselves. The trend in sires used for breeding could also be calculated. Genetic trend in each pathway of selection may be of interest. Thus, genetic trend must be carefully defined and interpreted.

		All Data			Does Data			Dams Data			Sires Data		
		At Birth	At 21 days	At Wean-ing	At Birth	At 21 days	At Weaning	At Birth	At 21 days	At Weaning	At Birth	At 21 days	At Weaning
No.		91			80			12			9		
MAX values of	TA	0.06	0.134	0.459	0.06	0.134	0.459	0.019	0.043	0.147	0.022	0.049	0.168
	SE	0.07	0.16	0.56	0.06	0.14	0.49	0.07	0.16	0.56	0.07	0.16	0.54
	r_{Ai}	0.83	0.83	0.84	0.84	0.83	0.84	0.84	0.83	0.84	0.77	0.77	0.77
MIN values of	TA	-0.092	-0.206	-0.708	-0.092	-0.206	-0.708	-0.072	-0.161	-0.555	-0.083	-0.186	-0.64
	SE	0.04	0.09	0.31	0.04	0.09	0.31	0.04	0.09	0.31	0.05	0.1	0.35
	r_{Ai}	0.00	0.00	0.00	0.49	0.49	0.49	0.00	0.00	0.00	0.26	0.26	0.26
Range of	TA	0.152	0.34	1.167	0.152	0.34	1.167	0.091	0.204	0.702	0.105	0.235	0.808
	SE	0.03	0.07	0.25	0.02	0.05	0.18	0.03	0.07	0.25	0.02	0.06	0.19
	r_{Ai}	0.84	0.83	0.84	0.35	0.34	1.184	0.84	0.83	0.84	0.51	0.51	0.51
Positive Records													
Num-ber		25	23	23	22	20	20	5	4	4	2	2	2
%		27.47	25.47	25.47	27.50	25.00	25.00	41.67	33.33	33.33	22.22	22.22	22.22
TA	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.12	0.00	-0.01	-0.02
	Range	0.06	0.134	0.458	0.06	0.134	0.458	0.003	0.007	0.024	0.024	0.054	0.184
SE		0.01	0.03	0.11	0.00	0.01	0.04	0.02	0.05	0.19	0.00	0.01	0.03
r_{Ai}		0.09	0.08	0.09	0.09	0.08	0.09	0.04	0.03	0.04	0.07	0.07	0.07

Table 6: *Transmitting abilities (TA, Minimum, Maximum, and range); Standard Errors (SE_{Ai}) and Accuracies (r_{Ai}) of transmitting abilities in addition to positive records ()of litter weight traits at birth; 21 days and weaning at 6 wks. (LWB, LW21 and LWW) for APRI improved native rabbits.*

EBVs are used to determine which animals will be parents of the next generation. To optimize genetic improvement, the EBVs can be used to determine which male to breed to each female, such that the offspring are comprised of the highest possible average breeding value. Breeding strategies are concerned with the design of an efficient breeding program that maximizes genetic change under a certain set of conditions over the next few generations. What happens when conditions are changed or when restrictions are relaxed! Breeding strategies require a comprehensive understanding of such nonconforming recalcitrant, but still frequent, situations as well as the biology of the species or the production system.

Epigenetic trends which are estimated as a deviation from the overall BLUP values' mean of the whole tested rabbit population for Litter weight (EPG_LWt) traits as affected by parity (P) and year-season combinations (YS) were illustrated in figures 1 and 2. Results shown in figures 1, revealed that all LW traits' genetic change with Parity effects gave generally equivalent and comparable patterns (the first parity of all ages gave negative trends while the remainder parities gave positive trends), which may generally reveals analogous related (genotype X environment) interaction in APRI improved native rabbits. The high APRI litter weight epigenetic trend at the second and third parities is apparently due to substantial compatibility between physiological, reproductive maturity, development. Rabbit better performance is reached at these specific parities with slight differences between rabbit breeds [18,19].

	All Data	LWB	LW21	LWW	Does' Data	LWB	LW21	LWW
Spearman Correlation Coefficients	LWB		1.000	1.000	LWB		1.000	1.000
			< .0001	< .0001			< .0001	< .0001
	LW21	0.999		1.000	LW21	0.999		1.000
		< .0001		< .0001		< .0001		< .0001
	LWW	0.998	0.999		LWW	0.997	0.998	
		< .0001	< .0001			< .0001	< .0001	
	N = 203 observation				N = 203 observation			
	Sires' Data	LWB	LW21	LWW	Dams' Data	LWB	LW21	LWW
	LWB		1.000	1.000	LWB		1.000	1.000
			< .0001	< .0001			< .0001	< .0001
	LW21	1.000		1.000	LW21	0.999		1.000
		< .0001		< .0001		< .0001		< .0001
	LWW	1.000	1.000		LWW	0.985	0.986	
		< .0001	< .0001			< .0001	< .0001	
	N = 9 observation				N = 51 observation			

Table 7: *Realized genetic Correlation Coefficients (above Diagonal: Product Moment between BLUP values; below Diagonal: Spearman between BLUP ranks) of litter weight traits at birth; 21 days and weaning at 6 wks. (LWB, LW21 and LWW) for all, does', dams' and sires' data of APRI improved native rabbits.*

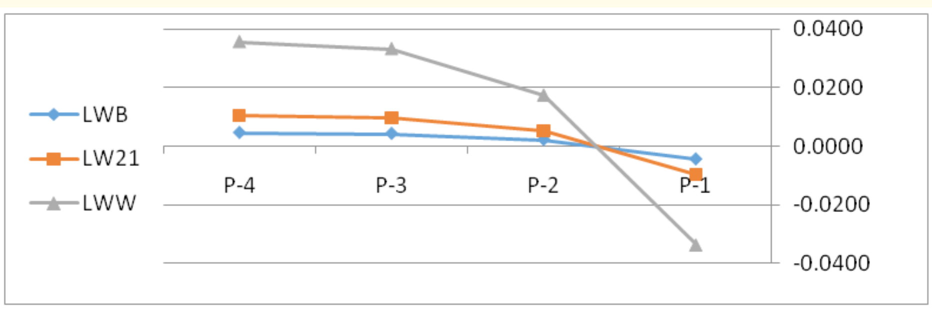

Figure 1: *Epigenetic trend of BLUP values of LW traits regressed against parity.*

Results in figure 2, revealed that all LW traits' genetic change with Year-season (YRS) effects once again gave a comparable pattern YRS 93, (2nd Year-Summer)gave a step-by-step progressive negative trends while all the rest gave approximately no or positive trends), which may possibly divulges comparable equivalent (genotype X environment) interaction in APRI improved native rabbits. The prominent epigenetic trend is that for YRS 83 (1st Year-summer). The expected explanation for the former situation is that this performance is in conformity with the high loss of bunnies due to hot stress in summer months. The positive (high) LW epigenetic trend during autumn and winter is evidently comprehensible as the animals are exploiting the favorable proximate conditions and have the favorable fodder diets like clover and/or alphalpha fresh hay.

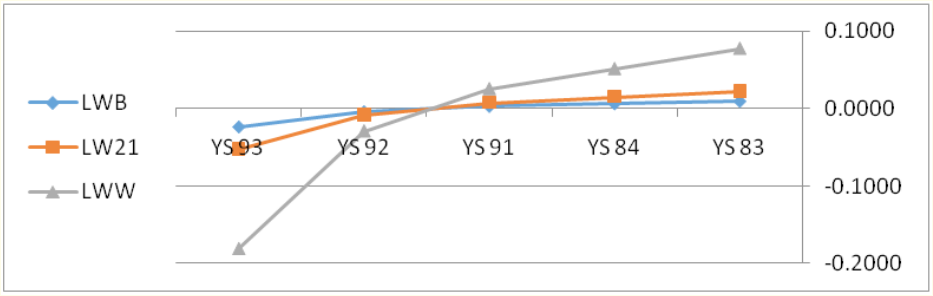

Figure 2: *Epigenetic trend of BLUP values of LW traits regressed against Year-season.*

Fatmah [40] revealed that epigenetic trends for post weaning body weights regressed against parity at all ages under her thesis study were near zero. She added that, this could be due to that there were only three parity classes or that post-weaning growth traits is inconsiderably affected by parity because the maternal effect at these ages would be weak.

Environmental Trend (Env _LW)

If all the variation is attributable to environment, selection of phenotypically superior individuals would not result in any alteration in the next generation. Environment trends are calculated by subtracting BLUP values of LW traits from the phenotypic values of the same traits. The resultant values are then treated the same as done before with epigenetic trends (i.e. regressing against Year-Season, Yr_S and parity, P) to get the environmental changes due to both effects (i.e. Yr_S and P).Litter weight (*Env* _LW) traits as affected by Year-season combinations (Yr_S) and parity (P) were illustrated in figures 3 and 4. The two graphs revealed that Litter weights of the tested rabbit population have an obvious trend that the changes due to parity are more drastic than that due to year-season combinations effects. Nevertheless, across evaluated ages as the litters becomes older the changes seems to get more profound and radical making it obvious to divide the pre-weaning period as to the sensitivity to environmental situations into early and late pre-weaning periods. While at the early pre-weaning period the suckling mothers play a role in smoothing the sensitivity to the difference in environments, the late pre-weaning period the individual capability of the bunnies appear as more reflection and meticulousness to environmental situations [41].

As regard to Litter weights environmental by Year-season combinations changes, Figure 4 showed that litter weight traits of the tested APRI rabbit population have a positive environmental trend during the first and the second season of the second year (February till June), meaning that the effects of environment was highly favorable and propitious during these months, also it may be due to the miscellaneous factors that cannot be accounted for in the model, thus these animals perhaps did not express themselves as a result of inadequate rearing environment especially feeding and slight infections around the high year temperature. However these traits decreased sharply during the third season, (first year-from September through November). Such detected adverse or undesirable environmental effect during autumn (negative trend) may be due to extended summer hot climate stress or to the lack of green fodders the downgrade quality of elongated-stored ones the problem that is distinctive to the Egyptian rabbit production situations [42].

Negative environmental trend in the third season (September till November-Figure 4), was observed. The high LW performance of the tested population versus environment trends are evidently comprehensible as the animals are, in these periods, exploiting the favorable proximate conditions and also the favorable abundant fodder diets like alpha.

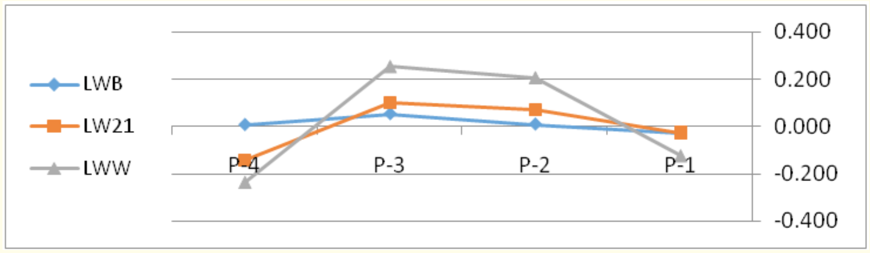

Figure 3: *LW traits environmental values trend as regressed against parity.*

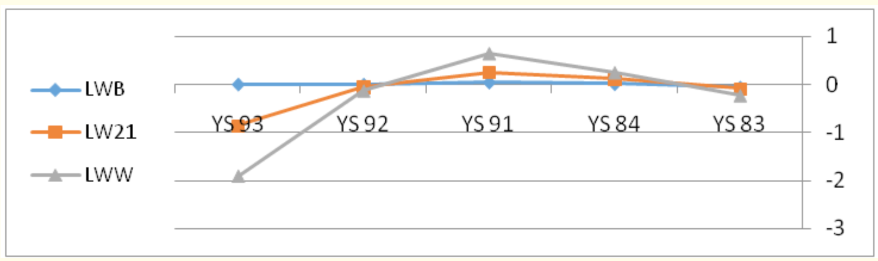

Figure 4: *LW traits environmental values trend as regressed against Year-season.*

As for environment X parity interaction, data of environment trends presented in Figure 3, The effects of environment was low and not clear for LWB in the 1st, 2nd, 3rd and 4th parities, otherwise, it started to have negative trends especially in the 1st and 4th ones. In case of LW21 and LWW, Positive environment trend seems to concentrate in the 2nd and 3rd parities, seemingly because at the 1st parity Animals are in their first production season with their reservoirs unexhausted; or because does may have an adequate rearing and managerial conditions.

Conclusion

A large scale multi-breed genetic improvement program in Egypt was created since 2005 with the involvement of the V-line rabbits from Spain; through collaboration with College of Agriculture, Benha University and Animal Production Research Institute ended with creation of APRI improved native rabbits in 2011. A genetic evaluation system was implemented in the subsequent years. Estimated breeding values (EBV) are routinely computed for economically important traits (doe, sire and early post-weaning growth traits) in the Animal Production Research Institute. The EBV using animal models are then periodically published using data collected from 3 stations located across the Egyptian country (specially Sakha in the middle of Delta), El-Gemmiza belonging to Tanta Governorate and Seds in Benny-Suaf Governorate; Upper-Egypt). Genetic predictions published by this genetic evaluation programs are useful for sire and dam selection under Egyptian environmental conditions.

As a clarification of the whole idea about the epigenetic changes in response to the environmental situations, it seems that when the environmental situations are harsh, the first priority of the animal's biological system is to maintain its life at the expense of production (low epigenetic trend). Likewise, when the situations are optimum, it is the time for the biological system to express its whole genetic capabilities expressed as epigenetic trend. However, and most frequently, the environmental situations are neither harsh nor optimum and these are the situations when the epigenetic, though still working, is not noticeable.

Current data revealed that such native breed of rabbits with its Potential performance is ready to be given more attention for genetic improvement through selection (especially with the large additive component of variance at weaning) and crossbreeding with sensibly and conscientiously chosen standard breeds to produce resourceful broiler rabbits especially with the large components of non-additive genetic component of the studied litter weight traits. However, backcrossing with the founder breeds either the locale to improve quite a bit the acclimatization to Egypt environment or to the standard to increase the and hot weather environment and percentage of blood contribution and in both cases to stabilize the performance against segregation.

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