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GENETIC PARAMETERS OF LITTER TRAITS OF ACCLIMATIZED NEW-ZEALAND WHITE RABBITS IN EGYPT

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ABSTRACT: The repeatability multi-trait animal model procedure (MTDFREML) was used to analyze 93 litters born to 36 does with pedigrees from 9 sires and 13 dams. Litter weight traits (LW), which included (litter weight at birth, LWB; litter weight at 21 days, LW21; litter weight at weaning, LWW) and litter weight gain (LWG) were (litter weight gain from birth to 21 days, LWG_{B_21}; litter weight gain from birth to weaning, LWG_{B_W}; litter weight gain from 21 days to weaning LWG_{21_W})on New-Zealand White (NZW) rabbits does for two consecutive years.

Heritability estimates (h^2_a) of LW were low to moderate ranging from 0.13 to 0.18. While h^2_a for LWG traits ranged from 0.09 to 0.15. Estimates of genetic correlations were highly significant (P<0.01), moderate and high ranging from (0.754 to 0.975).

As for rank correlation estimates obtained among breeding values were positive, moderate, and highly significant (P<0.01), ranging from (0.754 to 0.975). The ranges of the NZW does breeding values were 0.36, 0.63 and 0.81 kg for LWB, LW21 and LWW traits, were 86.0, 62.0 and 63.0 gm for LWG_{B_21}; LWG_{B_W} and LWG_{21_W} traits, respectively.

In addition, the percentages of positive breeding values estimated ranged from 48.7 to 69.2% for LW and from 29.0 to 73.1% for LWG traits. The epigenetic trend of litter traits (LWW and LWG) for NZW does properties influenced by the environmental conditions, genetic variations were observed in the arrangement of the parity and year-season effects. Additionally, mentioned that it is possible to achieve slow, but simultaneous improvement of litter traits with a selection program.

Conclusively, the current study showed that the selection for does of rabbits based on the highest 25% of breeding values will achieve a good selection plan in the future.

Keywords: Rabbits, litter traits, Heritability, Breeding values, Epigenetic

INTRODUCTION

The expected overall strategy to improve the profitability and sustainability of meat rabbit operations includes genetic improvement of economically important traits in Egyptian rabbits, particularly doe litter traits. Economically significant traits in animals are usually expressed as continuous variation, which is of great importance to breeders and producers alike. Many genes are responsible for these traits, and the cumulative effect of these genes, together with environmental influences (Hassan et al., 2015a). The potential for genetic improvement depends largely on the accuracy of the estimates of these traits' variance components and genetic parameters (Sakthivel et al., 2017).

Heritability, which is a function of variance components, informs about the genetic nature of a trait and is required for genetic evaluation and selection strategies. Individual phenotypic variation provides knowledge of the genetic status of traits and is required for genetic evaluation and determining selection strategies (El-Amin et al., 2011).

If there are no accurate estimates of genetic correlations, a study of the correlations between breeding values and ranks may provide an alternative solution. For this reason, an alternative study of the correlations between the resulting breeding values and ranks is from one point of view irrefutable and undeniable. (Hassan et al., 2015a).

Therefore, the main objectives of the study are to evaluate genetic parameters (e.g. variance components, heritability and prediction of the breeding values) as well as the epigenetic trend of litter weight traits in acclimatized (NZW) rabbits.

MATERIALS AND METHODS

Animals and data:

Data for this study were collected at the rabbit farm of Sakha experimental station, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. A total of 93 litters of New Zealand White (NZW) rabbits produced from 36 does pedigreed by 9 sires and 13 dams, were recorded for two sequential years beginning in October 2008 and was completed in late spring 2009.

Studied traits:

The studied traits litter weight traits, LW (LWB= Litter weight at birth; LW21= Litter weight at 21 days; LWW= Litter weight at weaning) and litter weight gain, LWG (LWG_{B_21}= Litter weight gain from birth to 21 days; LWG_{B_W}= Litter weight gain from birth to weaning; LWG_{21_W}= Litter weight gain from 21 days to weaning)

Management:

Rabbits were raised in a semi-closed rabbitry. Breeding does and bucks were housed separately in individual wire cages with standard dimensions arranged in double-tier batteries type. According to the breeding plan, a buck was assigned at random for every 3-4 does for mating with a restriction of avoiding full-sib, half-sib, and parent-offspring mating. For breeding, each doe was transferred to a cage of its assigned buck to be bred and palpated 10 days later. Does failures to conceive return to the same buck to be re-mated. The offspring were weaned at the 28^{th} day of age, individually ear-tagged and moved to collective cages in groups of five rabbits. The rabbits were fed ad-libitum on a commercial pelleted ration, which provided 18% protein, 2.39%

crude fat and 12.8% crude fiber. Feed and clean water were provided all day long.

Statistical and genetic analysis:

Data were analyzed using a repeatability multi-trait animal model of doe litter traits using the derivatives restricted maximum likelihood (MTDFREML) Program of Boldman et al., (1995). Variances obtained by the Restricted Maximum Likelihood (REML) method of variance component (VARCOMP) procedure (SAS, 2003) were used as guessed values for the estimation of variance components. Analysis was done according to the following animal model:

$y = Xb + Z_a u_a + Z_{pe} u_{pe} + e$

Where: y = Vector of observations, b = Vector of fixed effects including year-season (4 levels) and parity (4 levels); u_a = Vector of random animal effects, u_{pe} = Vector of random permanent environmental effect (pe; doe–parity combination), e = Vector of random residual effects; X, Z_a and Z_{pe} are incidence matrices relating records to fixed, animal and permanent environmental effects, respectively.

Heritability was estimated as the following: ($h^2_a = \sigma^2_a / \sigma^2_p$), Where σ^2a and σ^2p are the variances due to effects of additive genetic and phenotypic, respectively.

Animals predicted breeding values (PBV):

The animals' predicted breeding values (PBV) using the best linear unbiased predictor (BLUP), peculiar accuracies (r_A), and standard errors (SE), were assessed using the same software (MTDFREML) of Boldman et al., (1995).

Epigenetic trend (EPG):

Epigenetic trends (as a sort of genetic by-environment interaction) were estimated using the method reported by Hassan, et al. (2013 and 2015a). Epigenetic trends were computed as the deviation of the mean of the BLUP values of the group of animals that were successful in reproducing under the environmental conditions they were subjected to, from the overall mean of an entire group of animals across all environmental situations' BVs, after regressing the BLUP values of participating animals across the different classes of the insinuated environmental conditions using SAS (2003). The resultant output was shown in graphs.

RESULTS AND DISCUSSION

Actual means, standard deviation, and coefficients of variation

Actual means, standard deviation and coefficients of variation for doe LW and LWG traits of the NZW rabbits are given in Table. 1.

In the majority of the NZW (acclimatized in Egypt) literature that is currently available, means of the LW and LWG traits are within ranges found by many researchers Rabie, et al., (2019), Amira El_Deghadi (2019), Mahmoud and Walid (2020) and Montes-Vergara (2021). These findings might be a sign of the doe's high reproductive capacity and good maternal abilities.

Coefficients of the variability of NZW rabbits for LW ranged from 32.69 to 39.30 % and LWG ranged from 37.22 to 64.10 %, like the findings by Amira El-Deghadi (2019) and El-Attrouny & Habashy, (2020). In contrast, the results in this study were higher than those reported by Montes-Vergara (2021). This may be caused by a variety of factors, including the doe's genetic makeup and non-genetic factors (e.g., year-season, parity, and management of the herd). Higher variation brought on by $LWG_{21\text{-}W}$ traits that allow for genetic improvement. Like the findings by Zaharaddeen and Kabir

(2018). The coefficient of variation for LW decreased with the advancement of age, while for LWG meaning became more significant as advanced age (Table 1). Amira El-Deghadi (2019) obtained comparable outcomes using APRI and NZW rabbits, respectively. This is attributed to variations in litter losses during the nursing stage as well as variations in postnatal growth of the litter up to weaning brought on by variations in their genotypes and milk production of their dams during the sulking stage.

Heritability estimate (h^2_a)

Table 2 provides heritability estimates for traits related to litter weight and litter gain weight. Estimates of h^2a values were low to moderate ranging from 0.13 to 0.18 for LW traits, while for LG traits, h^2a was most of them were low ranging from 0.09 to 0.15. These ranges fell within the examined estimates of Abou Khadiga et al., (2012), Amira El-Deghadi (2019) and Shehab EL-Din (2022). The low h^2a estimates for LW traits resulting from the low relative importance of additive genetic factors are consistent with these studies. Hassan et al., (2015 a& b) on APRI line rabbits observed low h^2_a varied from (0.13 to 0.14) for LG, while LW traits ranged from (0.04-0.17), and they suggested that to improve these traits, family or intra-family selection may be more beneficial and effective than individual selection. Amira El-Deghadi (2019) on NZW rabbits found that estimates of h^2a for litter low-level characteristics ranged from 0.07 to 0.20 for litter weights and from 0.10 to 0.15 for litter gain traits. El-Attrouny and Habashy (2020) on NZW rabbits observed that h^2_a for LW (B, 21 and WW) were 0.14, 0.09 and 0.06, respectively. Fatma Behiry et al., (2021) on APRI line rabbits found that h^2_a for both LWB and LWW were 0.08. Abdel-Kafy et al., (2012) on APRI rabbits found that h^2_a for LW (B, 21 and WW) were 0.01, 0.08 and 0.09, respectively. Thus, the present estimates of h^2_a are consistent with those of Egyptian researchers under the same conditions. This could be attributed to the effects of non-genetic factors, which are the main source of variation for all studied litter traits but were not considered.

Genetic correlation (r_g):

Table 3 displays estimates of genetic (r_g) correlations between litter traits. Positive, moderate to high, and positive estimates of the correlation between LW and LWG traits ranged from (0.63 to 0.99), except this between LWG $_{B\_21}$ and LWG $_{21\_W}$ (0.35). In this regard, we might base the strategy on these traits as selection criteria. These results were comparable to those reported by Shehab EL-Din (2022) found that high and positive, (r_g), correlations between LWB and LWW were (0.610), LWB and LWG were (0.530) and between LWW and LWG were (0.990). These findings concur with those of Hassan et al., (2015a) reported that all estimates of r_g were high and positive, between LWB and LW21 (0.900), LWB and LWW (0.900) and LW21 and LWW (0.990), Additionally, Hassan et al. (2015b) found that all estimates of genetic correlations high and positive, (r_g), correlations between LWG_{B_W} & LWG_{21_W} were (0.920), LWG_{B_21} & LWG_{B_W} were (0.720) and LWG_{B_21} & LWG_{21_W} were (0.390).

On the other hand, Abdel-Kafy et al., (2012) found negative genetic correlations among litter weight traits. This negative genetic correlation means that an improvement in one of these traits would result in the deterioration of the other; agreed to Sorhue et al., (2014). While phenotypic correlations (r_p) among litter traits were positive with statistically significant (P<0.001), moderate to high which ranged from (0.456 to 0.800) & (0.451 to 0.847) for LW traits and LWG traits. These traits reported similar trends. Hanaa et al., (2014), El-Attrouny and Habashy (2020), Fatma Behiry et al., (2021) and Shehab EL-Din (2022) on a different breed of rabbits.

Predicted breeding values of doe (PBV):

Animal breeding values, minimum, maximum and percentages of the top 25% estimates for doe litter traits are presented in Table 4. The ranges of the NZW animal PBV were 0.359, 0.628 and 0.813 kg for LWB; LW21; LWW traits, and 86.0, 62.0 and 63.0 gm for LGB_21; LGB_W; LG21_W traits, respectively. Shehab EL-Din (2022) found that the ranges of PBV were 90.51, 638.9 and 580.5 gm for LWB: LWW and PLWG (pre-weaning litter gain) traits, respectively. Amira El-Deghadi (2019) observed that transmitting ability estimates were 85.20, 666.87 and 828.20 gm for LWB LW21day and LWW traits, respectively. and were 749.15, 635.38 and 880.54 gm for LWG_{B_21}, LWG_{B_W} and LWG_{21_W} traits, respectively. Hassan et al., (2015a&b) reported that the transmitting ranges of the APRI does were traits.0.15±0.02, 0.343±0.05 and 1.167±0.18 kg for litter weight and were 0.67±0.19, 0.340±0.13 and 0.10±0.12 gm for litter weight gain traits. They suggested that these variations can introduce the possibility of making the correct culling decision and selecting the best rabbits from those having positive estimates of transmitting ability for growth and litter size traits. Fortunately, the percentages of positive PBV estimates ranged from 48.7 to 69.2% for litter weight and from 29.0 to 73.1% for litter gain weight, while the ranges of PBV estimates for the top 25% of animals were ranging from 0.116 to 0.3089 for LW traits so LWG was ranging from 0.173 to 2.592 (Table 4). The present results agree with Hanaa et al., (2014), Amira EL-Deghadi, (2019) and Hassan et al., (2015a&b). These results are high enough to allow for genetic improvement bearing in mind that about 25% will be selected as a parent for replacement each year season.

Rank correlation (r_s):

The results of the correlation study Spearman for BLUP rankings among breeding values for does' litter traits estimates are shown in Table 5. The r_s correlation was highly significant (P≤ 0.001) and generally positive, moderate, and high, ranging for LW traits between (0.754 and 0.975) and (0.936 to 0.989) for LWG traits. The same trend was found by Hanaa et al., (2014), Hassan et al., (2015 b), Amira El-Deghadi (2019) and Shehab EL-Din (2022).

Amira El-Deghadi (2019) observed that r_s were favorable, moderate to high, and varied from (0.22 to 0.94) for litter sizes and litter weights traits. Furthermore, Shehab EL-Din (2022) found that highly significant r_s (P≤ 0.001), positive, moderate, and high between litter weights and litter weights gain traits and ranged from 0.540 to 0.980. On the other hand, the r_s coefficients are comparable and equal, which allows them to be interchanged and replaced without significant impact on reliability, especially when the data size is large (Hassan et al., 2015 b).

Epigenetic trends (EPG):

Epigenetic trends for litter weight (EPG_LW) and litter weight gain (EPG_LWG), which are influenced by parity (P) and year-season combinations (YS), epigenetic trends that are estimated as a deviation from the overall BLUP values' mean of the entire tested rabbit population were shown in Figures 1 to 4. The results in Figure 1, showed that all litter weight traits' genetic changes with parity effects generally produced equivalent and comparable patterns (the first three parities produced positive trends across all ages, while the parity four produced negative trends), which may generally indicate analogously related (genotype X environment) interactions in improving NZW rabbits. The significant compatibility between physiological and reproductive maturity development is thought to be the cause of the high NZW litter weights EPG at the first, second, and third parities. With minor variations across rabbit breeds, rabbits perform better at certain parities. This finding agrees with the results of Hassan et al., (2010; 2013 & 2015 a).

Figure 2, showed that all LWG traits' genetic changes with parity effects gave generally equivalent and comparable patterns (the first parity gave a positive trend while the remaining parities gave negative trends of all ages), which may generally reveal analogously related (genotype X environment) interaction in improving NZW rabbits. Also noticed the same pattern Hassan et al. (2010& 2015b). Results in Figure 3, showed that LWB and LW21 traits' genetic variation with year-season (YS) effects once more produced a corresponding pattern. YS 11, (1st Year-autumn), produced a positive trend, indicating that the effects of the environment were very favorable during these months, particularly feeding and mild infections close to the high year temperature. While all the others produced YS 14 negative trends (1st Year-summer). The former situation's expected explanation is that this performance is consistent with the high rate of bunny deaths caused by heat stress in the summer or a lack of green forage of all YS and positive trends were again produced by LWW genetic change with Year-season (YS) effects, except for YS 23, (2nd Year-spring), which produced negative trends and temperature. Therefore, it is possible that these animals' inability to express themselves was caused by their poor rearing conditions, especially the feeding and slight infections brought on by the hot weather. This finding agrees with the results estimated by Hassan et al., (2010; 2013 and 2015 a).

Figure 4, showed that the genetic variation in LWG traits along with Year-Season (YS) effects once more produced a pattern similar to YS 11, (1st Year-autumn), YS 14, (1st Year-summer) and YS 23, (2nd Year-spring) gave a positive trend, indicating that these months' environmental effects were very favorable. However, during severe environmental circumstances YS 22, (2nd Year-winter) gave negative trends with more deterioration during the cold weather of winter. Hassan et al., (2010& 2015 b).

CONCLUSION

The results revealed that litter traits are affected by environmental conditions as evidenced by the influence of EPG changes, low estimates of h^2_a for doe litter traits reflect being too frail to be exploited by individual selection and showed that the selection for does of rabbits based on the highest 25% of PBV will achieve a good selection plan in the future for NZW rabbits.

Table (1): Overall means, standard deviations (SD) and coefficients of variability (CV%) of litter traits of NZW rabbits**.**

Traits	**Mean**	**SD**	**CV%**
Litter weight traits			
Litter weight at birth, LWB (kg)	0.33	0.13	39.30
Litter weight at 21 days, LW21(kg)	1.43	0.48	33.83
Litter weight at weaning, LWW (kg)	1.96	0.64	32.69
litter weight gain traits			
Litter weight gain from birth to 21days, LG_{B_21} (gm/dy)	52.0	20.0	38.59
Litter weight gain from birth to weaning, LG_{B_W} (gm/dy)	57.0	20.0	37.22
Litter weight gain from 21 days to weaning, LG_{21_W} (gm/dy)	78.0	50.0	64.10

Table(2): Additive genetic (σ^2_a), permanent environmental (σ^2_P),phenotypic (σ^2_P) co-variance and heritability of litter traits of NZW rabbits.

Trait	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_P	h^2_a±SE
Litter weight traits					
LWB	0.0886	0.0001	0.6062	0.6949	0.13±0.001
LW21	0.3270	0.0017	1.7242	2.0529	0.16±0.001
LWW	0.1667	0.0032	0.7432	0.9132	0.18±0.001
litter weight gain traits					
LG_{B_21}	0.1975	0.0057	1.1560	1.3593	0.15±0.01
LG_{B_W}	0.1061	0.0175	1.0142	1.1378	0.09±0.01
LG_{21_W}	0.1605	0.0038	1.0456	1.2098	0.13±0.01

Traits as defined in Table 1.

Table (3): Estimates of genetic (above the diagonal) and phenotypic correlations (below the diagonal) between the litter traits of NZW rabbits

	LWB	**LW21**	**LWW**		LG_{B_21}	LG_{B_W}	LG_{21_W}
LWB		0.990	0.720	LG_{B_21}		0.630	0.350
LW21	0.623^{***}		0.810	LG_{B_W}	0.779^{***}		0.950
LWW	0.456^{***}	0.800^{***}		LG_{21_W}	0.451^{***}	0.847^{***}	

Traits as defined in Table 1, *****= ($p<0.001$)**.**

Table (4): Animal predicted breeding values (PBV); maximum, minimum, range; Standard Errors (SE) and Accuracies (r_A) & percentages of the positive records (+) as well as the range of the top 25% of litter traits of NZW rabbits.

Trait	**Maximum**			**Minimum**			**range**	**Top 25%**	
	PBV	**SE**	**r_A**	**PBV**	**SE**	**r_A**		**% + Records**	**range**
Litter weight traits(kg)									
LWB	0.179	0.24	0.65	-0.18	0.23	0.65	0.36	48.72	0.12
LW21	0.292	0.45	0.60	-0.336	0.46	0.60	0.63	56.41	0.26
LWW	0.396	0.30	0.69	-0.417	0.29	0.76	0.81	69.23	0.31
litter weight gain traits									
LWG_{B_21}	36.0	0.35	0.61	-50.0	0.29	0.76	86.0	29.03	1.53
LWG_{B_W}	25.0	0.25	0.64	-37.0	0.25	0.65	62.0	54.84	0.17
LWG_{21_W}	27.0	0.33	0.58	-36.0	0.32	0.60	63.0	73.12	2.59

Traits as defined in Table 1.

Table (5): Estimates of a person (above the diagonal) and rank correlations (below the diagonal) among between breeding values estimates between the litter traits of NZW rabbits.

	LWB	**LW21**	**LWW**		**LG_{B_21}**	**LG_{B_W}**	**LG_{21_W}**
LWB		0.943^{***}	0.412^{***}	**LG_{B_21}**		0.979^{***}	0.954^{***}
LW21	0.975^{***}		0.962^{***}	**LG_{B_W}**	0.965^{***}		0.995^{***}
LWW	0.754^{***}	0.849^{***}		**LG_{21_W}**	0.936^{***}	0.989^{***}	

Traits as defined in Table 1.

Fig. (1): EPG of BLUP values of LW traits regressed against parity

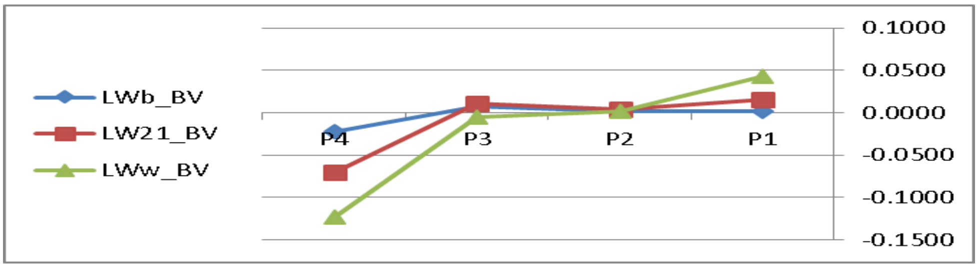


Fig. (2): EPG of BLUP values of LG traits regressed against parity

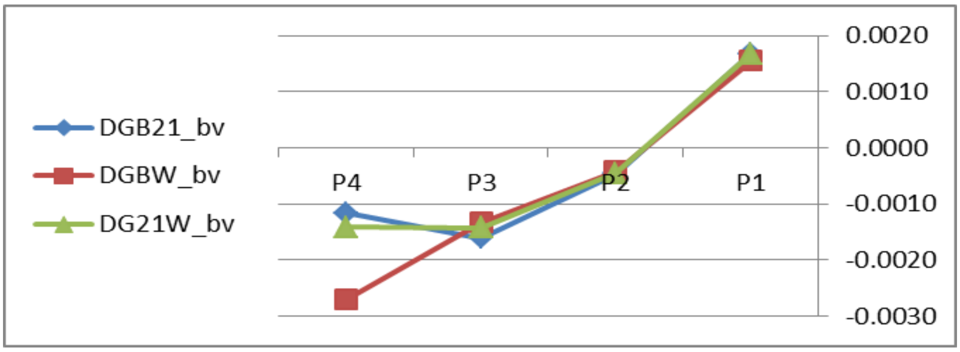


Fig. (3): EPG of BLUP values of LW traits regressed against Year-season

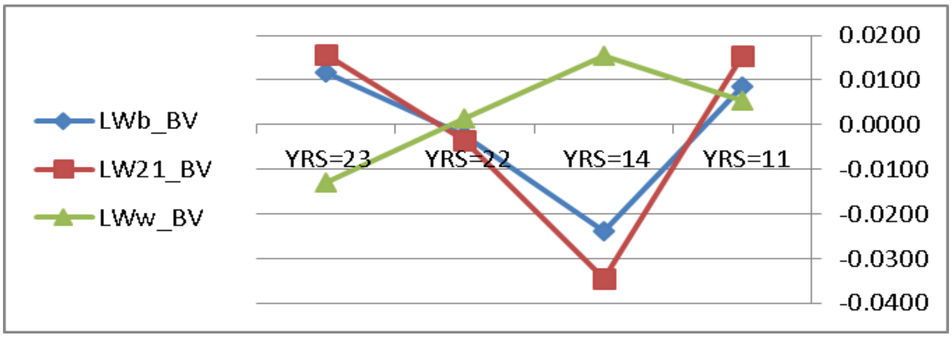
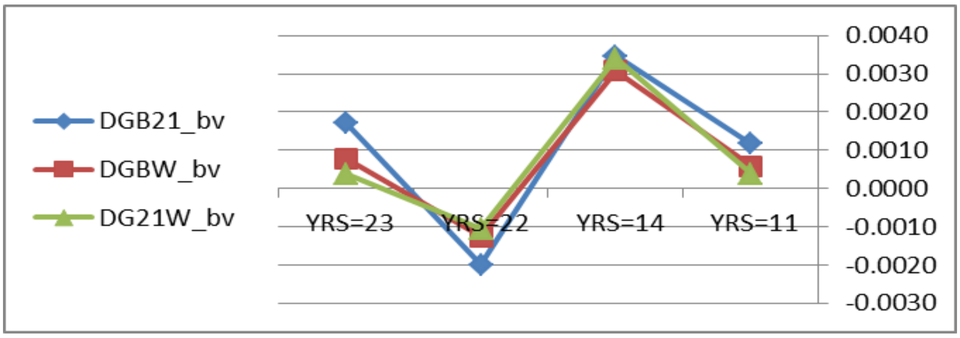


Fig. (4): EPG of BLUP values of LG traits regressed against parity



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الملخص العربى

المقاييس الوراثية لصفات خلفة البطن للأرانب النيوزيلندي البيضاء المتأقلمة في مصر

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تم تحليل بيانات 93 بطن تم إنتاجها من 36 انثى منسبة لعدد 9 اباء ذكور و13 ام، باستخدام نموذج الحيوان متعدد الصفات (MTDFREML). صفات وزن خلفة البطن والتي تضمنت (وزن الخلفة عند الميلاد، وزن الخلفة عند 21 يوم و وزن الخلفة عند الفطام) بالإضافة الزيادة في وزن الخلفة (الزيادة في وزن الخلفة من الميلاد حتى الفطام، الزيادة في وزن الخلفة من الميلاد إلى 21 يومًا والزيادة في وزن الخلفة من 21 يومًا للفطام) في الأرانب النيوزيلندية البيضاء (NZW) لمدة عامين متتاليين. كانت تقديرات قيم المكافئ الوراثي منخفضة إلى متوسطة وتراوحت بين 0.13 إلى 0.18 لصفات وزن خلفة البطن. بينما، كانت تقديرات قيم المكافئ الوراثي منخفضة وتراوحت بين 0.09 إلى 0.15 لصفات الزيادة في وزن خلفة البطن. كانت تقديرات الارتباطات الوراثية عالية المعنوية ومتوسطة وعالية وتتراوح من (0.754 إلى 0.975). أما بالنسبة لتقديرات ارتباط الرتب التي تم الحصول عليها بين القيم التربوية فكانت موجبة ومتوسطة وعالية المعنوية وتتراوح من (0.754 إلى 0.975).

وفيما يتعلق بنتائج القيم التربوية (الاناث) الأرانب النيوزيلندية البيضاء فقد كان المدى لهذه القيم 0.36، 0.63 و 0.81 كجم لصفات(وزن الخلفة عند الميلاد ، وزن الخلفة عند 21 يوم و وزن الخلفة عند الفطام) و كانت 86.0 ، 62.0 و 63.0 جراما لصفات (الزيادة في وزن الخلفة من الميلاد إلى 21 يومًا ، الزيادة في وزن الخلفة من الميلاد حتي الفطام و الزيادة في وزن الخلفة من 21 يومًا للفطام) على التوالي . بالإضافة إلى ذلك، تراوحت النسب المئوية للقيم التربوية الموجبة من 48.7 إلى 69.2٪ لصفات وزن خلفة البطن وتراوحت من 29.0 إلى 73.1٪ لصفات الزيادة في وزن خلفة البطن.. أما بالنسبة لتأثر الأداء الوراثى لقيم BLUP لصفات خلفة البطن (الاناث) الأرانب النيوزيلندية البيضاء بالظروف البيئية المحيطة ممثلة فى ترتيب بطن الولادة وتأثير التوافقيات بين المواسم السنة، فقد لوحظت الاختلافات وراثية في ترتيب التكافؤ وتأثير التوافقيات بين السنة وموسم الولادة. بالإضافة إلى ذلك أنه من الممكن تحقيق تحسين بطيء لصفات خلفة البطن ولكن متزامن مع الانتخاب.

التوصية: أظهرت نتائج هذه الدراسة أن اختيار مجموعات الأرانب على أساس أعلى 25 ٪ من القيم التربوية سيحقق خطة اختيار جيدة لبرامج الانتخاب في المستقبل.