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GENETIC ANALYSIS FOR MILK PRODUCTION TRAITS IN NEW ZEALAND WHITE RABBITS RAISED IN EGYPT

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An experiment was carried out on 373 lactation records from 126 does of New Zealand White rabbit (NZW) breed to assess the effects of genetic and non-genetic factors affecting milk production. Milk production traits (g) of each doe were recorded during the 1st week (MP1), 2nd week (MP2), 3rd week (MP3) and 4th week (MP4) week of lactation and during the whole lactation (TMY). A repeatability animal model was used based on covariance analysis model. Means of milk yield were increased gradually from the 1st week up to the 3rd week of lactation, and then declined in the 4th week. Most of milk production traits, generally, increased with the advancement of parity from the 1st to 3rd parity, then relatively decreased from 3rd to 5th parity and increased again to reach the peak at 7th parity. Effect of the linear regression coefficient of milk production at certain week of lactation on their litter size at that week was significant (P<0.01) for all the studied traits. Percentages of direct additive genetic effects for milk production traits were mostly low and the highest percent was 5.3% for MP3, followed by MP1 (3.7%). Percentages of permanent environmental effects were higher during the 1st week of lactation (8.2%) and gradually decreased thereafter to reach the minimum during the 3rd week (0.5%). Heritability estimates for milk production traits were low and ranged from 0.001 for TMY to 0.05 for MP3. Repeatability estimates for milk production traits were also low and ranged from 0.002 for TMY to 0.119 for MP1. Milk production during the 3rd week of lactation is closely correlated with total milk yield (0.84; P<0.01). In general, the same trends for permanent environmental correlations between milk production traits were obtained.

Keywords: Rabbits, milk production, heritability, permanent environmental effects, repeatability, genetic and permanent correlations.

Milk production, litter milk efficiency and lactation patterns for NZW rabbits were studied by many investigators (El-Maghawry et al., 1993; El-Sayiad, 1994; Khalil, 1993; Nasr, 1994 and Khalil et al, 2004). Early litter growth and mortality rate in rabbits depend in part on the intrinsic ability of the doe to provide adequate milking ability with better maternal environment. Milk yield of the doe is the major pronounced postnatal maternal component influencing pre-weaning litter growth in terms of litter size and litter weight (Nasr, 1994; El-Raffa et al. 1997).

Litter weight at birth and number of sulking kits both influencing milk production of doe rabbit strongly (El-Maghawry et al., 1993 and Pascual et al., 1996). With increasing litter weight at birth, milk production increases as a consequence of the uterine induction. Likewise, milk production of does could be increased as the number of suckling kids increased (Bolet et al., 1996 and Petersen et al., 1996). Ayyat et al. (1995) and Lukefahr et al. (1996) stated that milk production might be limited by additive gene effects and being positively correlated with litter weight at birth (Lukafahr et al., 1983; Khalil, 1994; Petersen, 1996 and Singh, 1994), permits the assumption that the effect of the number of the assigned kids to the nursing doe on milk production is not independent on the litter weight at birth.

Estimates of heritability and repeatability for litter traits have a broad range among reports, as reviewed by Khalil et al. (1986). Few reports on genetic analysis for milk production traits using repeatability animal model are available in the Egyptian literature (Hassan, 2005). The aims of this experiment were: (1) to estimate some non-genetic effects (parity and year-season) affecting milk production traits in NZW rabbits, (2) to regress linearly milk production on litter size at different weeks of lactation (3) to estimate heritability, repeatability and genetic and permanent environmental correlations for lactation traits using repeatability single trait animal model of covariance analysis.

Materials and Methods

Animals and management:

This experiment was carried out at the Rabbitry of Faculty of Agriculture at Moshtohor, Benha University, Egypt during the period from 2001 to 2003 on New Zealand White (NZW) breed. This breed came from Bank El-Nil rabbitry since 1994. Bucks and does were individually housed in wire cages with standard dimensions arranged in one-tire batteries allocated in rows along the rabbitry with passages suitable for service. Each buck was mated to 4 or 5 does (at 6 month of age).

The does were assigned randomly according to the available numbers. Does were mated in the bucks' cage and logged individually. Sire-daughter, full and half sib matings were avoided. Each doe was palpated 10 days thereafter to detect pregnancy. Those, which failed to conceive, were returned to the same mating-buck at the day of test. Metal nest boxes were provided at 27 days after fertile mating. Does were remated 10 days after kindling. Weaning of litter was done four weeks after kindling. Breeding animals were fed *ad libitum* on a pelleted rabbit ration containing 17.7 % crude protein, 13 % crude fiber and 2.54 % fat. In winter and early months of spring, berseem (*Trifolium alexandrium*) was supplied at midday. Cages of all animals were cleaned and disinfected regularly before each kindling. All animals were medicated similarly and they were subjected to the same managerial and climatic conditions throughout the experimental period.

Data and models of analysis

Data collected on 373 litters produced from 126 does fathered by 35 sires and mothered by 67 dams of NZW breed (Table 1). Milk production (g) and litter size of each doe were recorded weekly during the first, second, third, and fourth week of lactation. Milk yield was recorded as an average for the weight of both doe and bunnies before and after suckling. Accordingly, the bunnies were separated from their mothers at 15.00 pm, thereafter the bunnies were allowed to suckle at 8.00 am in the next day. The average of the differences between weight of each doe and bunnies before and after suckling were calculated, as well as total milk production during the whole four weeks of lactation was calculated.

Table 1. Structure of the data analyzed for New Zealand White rabbits

Item	Numbers
Sires	35
Dams	67
Does	126
Litters	373
Total number of animals in the pedigree file	**207***

*This number is less than of the total summing because of some dams represented twice (as a doe and as a dam in the next generation).

Data were analyzed using repeatability single trait animal model of covariance analysis (Boldman et al., 1995). Variances and covariances obtained by REML method of VARCOMP procedure (SAS 1996) were used as starting (guessed) values for the estimation of variance and covariance components. Analyses were done according to the general model:

$$\mathbf{y = Xb + Za + Zc + e,}$$

where: y = vector of observations; X= incidence matrix of fixed effects (parity and year-season); b = vector of fixed effects including linear regression coefficient on litter size, parity (7 levels) and year-season (8 levels); Za and Zc = incidence matrices corresponding to random effects of direct additive and permanent environment (doe effect), respectively; e = vector of random errors.

Heritability (h^2) and repeatability (t) were computed based on the following equations:

$$h_a^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_{Pe}^2 + \sigma_e^2} \quad \& \quad t = \frac{\sigma_a^2 + \sigma_{Pe}^2}{\sigma_a^2 + \sigma_{Pe}^2 + \sigma_e^2}$$

where σ_a^2, σ_{Pe}^2 and σ_e^2 are the variances due to effects of direct additive genetic, permanent environment and error, respectively. Repeatability was expressed as the ratio of variances by summing additive genetic and permanent environmental variances ($\sigma^2_a + \sigma^2_{pe}$) to total phenotypic variance ($\sigma^2_a + \sigma^2_{pe} + \sigma^2_e$). Standard errors of heritability were computed using MTDFREML procedure (Boldman et al., 1995). Genetic correlation was computed as the correlation between the predicted breeding values of each two traits studded.

RESULTS AND DISCUSSION

Means:

Results in Table 2 show that the highest milk production was during the 3rd week of lactation (1136.7 g) and the lowest (644.1 g) was during the 1st week. These results are agreeable with findings of Blas and Galvez (1973), Khalil (1993), El-Sayiad (1994) and Nasr (1994). While, Abo El-Ezz et al. (1981) and El-Maghawry et al. (1993) found that the peak of milk yield in NZW was attained at the 2nd week.

Means of milk production were increased gradually from the 1st week up to the 3rd week of lactation, and then declined in the 4th week. Rate of change in milk production was increased by 49.6% from the 1st to 2nd week and 17.9% from the 2nd to 3rd week of lactation. This indicates that the maximum rate of change in milk yield in NZW rabbits was done from the 1st to 2nd week. Conversely, it is decreased by –22.8% from the 3rd to 4th week of lactation. This may be due to the coincident decrease in milk amount produced by the doe during late pregnancy as a result of suckling or dry ration consumed by the young (El-Maghawry et al., 1993).

Variations:

Coefficients of variability (CV %) for milk production during different weeks of lactation were high and varied from 42.4% for MP2 to 60.3% for MP4. This confirms that milk production in rabbits is subjected to many effects such as genetic make up of the does, non-genetic effects (litter size at birth, year-season, parity and management of the herd). These estimates are in agreement with the results of El-Maghawary et al. (1993) and Khalil (1993).

Table 2: Actual means, standard deviations (SD) and coefficients of variation for milk production in New Zealand White rabbits.

Milk trait[+]	No.	Mean	SD	CV
MP1	373	644.1	322.5	50.1
MP2	353	963.8	408.8	42.4
MP3	344	1136.7	531.9	46.8
MP4	326	877.0	528.4	60.3
TMY	373	3538.0	1216.4	34.4

[+] MP1, MP2, MP3, MP4 and TMY= milk production during the first, second, third and fourth weeks of lactation and total milk yield, respectively.

Parity effect:

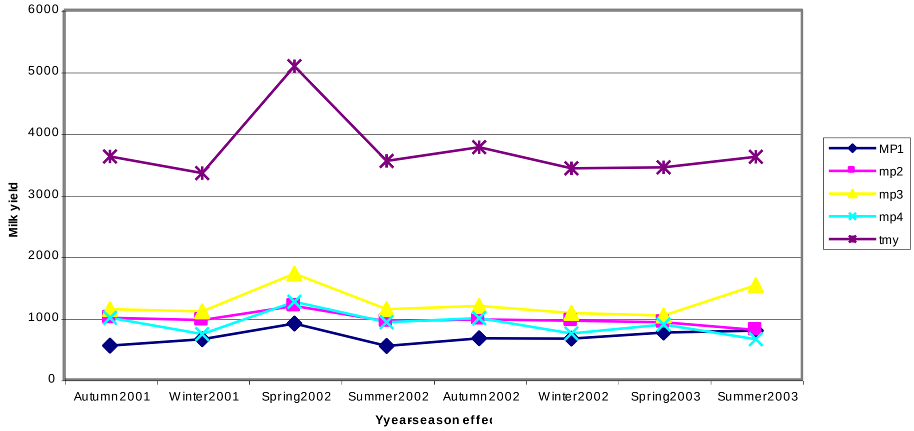
Figure 1 shows that most of milk production traits, generally, increased with the advancement of parity from the 1st to 3rd parity, then relatively decreased from 3 to 5 parity and increased again to reach the peak at 7th parity. Nasr (1994) found that the milk yield increased gradually from the second parity up to the seventh and eighth parities in NZW does. Similar results were obtained by Abo El-Ezz et al. (1981), El-Maghawry et al. (1993) and Lukefahr et al. (1983) in different breeds of rabbits. They demonstrated that milk yield increased as parity and (or) age of doe advanced. The effect of parity on milk production traits in this study was significant ($P<0.01$) for only MP1. Abo El-Ezz et al. (1981), McNitt and Lukefahr (1990) and Khalil (1994) reported that parity tended to influence lactation yield in a curvilinear manner ($P<0.05$ or $P<0.01$), since milk yield increased steadily up to the seventh parity and declined thereafter.

Year-season effect:

Figure 2 shows the effect of year-season combination on milk production. In general, milk production slightly declined from autumn 2001 to winter 2001, then increased to reach the peak during spring 2002 and fluctuated thereafter during the rest year-season combinations. The highest milk production during spring 2002 may be due to that environmental conditions (i.e. temperature and humidity) were favorable. The effect of year-season on milk production was significant ($P<0.01$) for only MP1. The same result was found by Nasr (1994) and Ayyat et al. (1995).

Figure 1 is missed.

Figure 2: Trend of year -season effect on milk production in New Zealand White rabbits



Litter size effect:

Litter size was the most important non-genetic maternal factor influencing (P<0.01) milk production through the suckling period (El-Maghawry et al., 1993 and El-Sayiad, 1994). Estimates of linear regression coefficient of milk production at certain week of lactation on their litter size at that week show that an increase in litter size by one bunny has resulted in an increase in lactation by 42.9, 84.4, 102.4, 84.6 and 306.9 g milk for MP1, MP2, MP3, MP4 and TMY, respectively (Table 3). Moreover, estimated linear regression coefficient of the milk production at certain week of lactation on their litter size at that week was significant (P<0.01) for all the studied traits. McNitt and Lukefahr (1990) reported that, as the number of bunnies the litter increased, milk yield increased in a curvilinear manner (P<0.01). Lukefahr et al. (1983) reported a correlation coefficient of 0.78 between total 21-day lactation yield and litter size at 21 day. Also Torres et al. (1979) obtained a correlation of 0.95 between the same two variables at 25 day. Pascual et al. (1996) stated that litter size affected milk yield significantly (P<0.001) since milk yield increased when the number of bunnies' increased, i.e. linear relation could be plotted between milk production and number born per litter. The post-natal effects of a large litter size may evoke great tactile stimulation of the teats and indirectly enhance milk secretion through increasing prolactin release (Lukefahr et al., 1983). Also, increased suckling intensity in large litters may allow more complete evacuation of remainder milk through greater oxytocin release due to increase afferent nerve stimulation for the teats (Cowie, 1969; Linzell et al., 1972).

Table 3: Actual means and their coefficient of variation of litter size and estimates of linear regression coefficient (b) of milk production at certain week of lactation on their litter size at that week in New Zealand White rabbits.

Trait[+]	Mean of litter size	SD	CV	b
MP1	6.22	2.26	36.32	42.9**
MP2	6.08	2.19	36.10	84.4**
MP3	5.89	2.20	37.29	102.5**
MP4	5.76	2.16	37.46	84.6**
TMY	6.00	2.14	35.60	306.9**

[+] Traits as defined in Table 2.
** = $p<0.01$

Random effects:

Results in Table 4 showed that percentages of direct additive genetic variance were generally low for milk production traits and the highest one (5.3%) was for MP3, followed by MP1 (3.74%), but the lowest was for TMY (0.0001). This indicates that selection for NZW does during the 3rd week of lactation (compared with other weeks of lactation) could be effective to improve milk production traits. Generally, smaller percentages of direct additive genetic variance in this study may be due to a larger random permanent environmental variance than additive genetic variance, which is associated with the doe during kindling and resign a litter to weaning (Khalil et al. 1987). This reflects the importance of permanent environmental variance than direct additive genetic variance for milk production in rabbits (Khalil et al., 2004).

Permanent environmental effects were high (0.082) during the 1st week of lactation and gradually decreased thereafter to reach the minimum (0.005) during the 3rd week (Table 4). This indicates the importance of permanent environmental effect at early stage of lactation in rabbits than later ones. Lukefahr et al. (1996) and Hassan (2005) obtained the same trend. Permanent environmental effects in this study were higher than findings of Hassan (2005) and lower than reported by Khalil et al. (2004).

Heritability and repeatability estimates:

Heritability (h^2) estimates for milk production traits in NZW were low and ranged from 0.001 for TMY to 0.05 for MP3 (Table 5). Low estimates of h^2 in this study may be due to the homogeneity (it is may be occurred because the population of NZW was small and closed during the period from 1995 to 2003) of does' performance in milk production and/or to the higher effects of

Table 4: Estimates of direct additive genetic, permanent and error variances as well as heritability (h^2) and repeatability (t) estimates for milk production traits in New Zealand White rabbits.

Trait[+]	Additive	%	Permanent	%	Error	%	Phenotypic	Heritability	Repeatability (t)
MP1	3315.03	3.7434	7236.83	8.1719	78005.96	88.1	88557.82	0.04±0.032	0.119
MP2	0.236	0.0002	7464.91	5.6480	124704.4	94.4	132169.6	0.002±0.057	0.056
MP3	12403.44	5.2961	1153.45	0.4925	220642.9	94.2	234199.8	0.05±0.023	0.058
MP4	3975.67	1.5688	6128.87	2.4184	243324.4	96.0	253428.8	0.02±0.023	0.04
TMY	0.757	0.0001	0.0449	0.0000	1075514	100.0	1075515	0.001±0.031	0.00

[+] Traits as defined in Table 2.

Table 5: Genetic[*] (above diagonal) and permanent environmental (below diagonal) correlations between traits of milk production.

Traits correlated[+]	**MP1**	MP2	**MP3**	**MP4**	**TMY**
MP1		0.047	0.281**	-0.535**	0.143*
MP2	0.229**		0.437**	0.181**	0.619**
MP3	0.187*	0.232**		0.136**	0.838**
MP4	-0.044	0.155	0.191*		0.442**
TMY	0.385**	0.523**	0.738**	0.467**	

[+] Traits are as defined in Table 2.

[*] Genetic correlation was computed as the correlation between each two traits of the predicted breeding values of the doe.

permanent environment than additive genetic ones in this population. In this respect, reviewed estimates of h^2 for milk production traits in NZW rabbits ranged from 0.001 to 0.121 (Lukefahr et al., 1996; Hassan, 2005).

Repeatability estimates for milk production traits were low and ranged from 0.002 for TMY to 0.119 for MP1 (Table 4). It is clear that repeatability estimate was the highest during the 1st week and gradually decreased with advancement of week of lactation. Khalil (1993) found that repeatability estimates for lactation traits in Giza White rabbits were low and ranged from 0.083 to 0.189.

Genetic and permanent environmental correlations:

Genetic correlation between milk production traits at different weeks of lactation (Table 5) ranged from low (0.047) between MP1 and MP2 to high (0.84) between MP3 and TMY. This indicates that milk production during the 3rd week of lactation is closely correlated with total milk yield ($P<0.01$). Thus, one would recommend the rabbit breeders to select the does according to milk yield of the third week of lactation to obtain genetic progress of total milk production in NZW does.

Hassan (2005) showed that milk production traits in NZW rabbits were mostly genetically correlated. On the other hand, moderate and negative genetic correlation (-0.535) between milk yield during the 1st and 4th weeks of lactation was obtained in this study. This indicates that as milk production increased during the first week (because increasing the activity of mammary gland gradually), the milk production decreased during the 4th week because of the inhibition of the prolactin hormone by oestrogens and progesterone which due to that most of the does were in the late periods of pregnancy at that time (Lebas, et al. 1997) and the increase of dry ration consumed by the young simultaneously.

In general, the similar trend for permanent environmental correlations between milk production traits was obtained.

CONCLUSIONS

- Analysis of covariance using repeatability single trait animal model for milk production traits gave a good idea of linear regression of milk yield at certain week of lactation on their litter size at that week during the periods of lactation.
- In spit of the permanent environmental variance in this study was somewhat low for most milk production traits, but it was higher than direct additive genetic variance. Therefore, this effect could be considered in repeatability animal model analysis to obtain more accurate estimates of additive genetic variance.

- Estimate of heritability for milk production in the 3rd week of lactation was the highest compared with the other traits. Thus, it is recommended that selection of NZW does at that week could be effective to improve total milk yield in NZW rabbits under hot climate conditions.

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الملخص العربي

أجريت التجربة على ٣٧٣ من سجلات إنتاج اللبن لأمهات أرانب النيوزيلندي الأبيض لتقدير العوامل الوراثية والغير وراثية التى تؤثر على صفات إنتاج اللبن.
وقد تم قياس كمية إنتاج اللبن لكل أم من الأرانب خلال كل من الإسبوع الأول والثاني والثالث والرابع وكذلك إنتاج اللبن الكلي طوال فترة الرضاعة.

تم تحليل بيانات التجربة باستخدام برنامج نموذج الحيوان على أساس تحليل التغاير بين الصفات. وقد أظهرت النتائج زيادة في معظم صفات إنتاج اللبن بتقدم ترتيب بطن الولادة وذلك من البطن الأولي وحتى الثالثة ثم تناقص من البطن الثالثة وحتى الخامسة ثم عاود الزيادة من الخامسة وحتى السابعة، كما أظهرت تقديرات معامل الإنحدار الخطي معنوية لصفات إنتاج اللبن خلال الأسابيع المختلفة على صفة حجم البطن خلال نفس هذه الأسابيع. كما كانت النسبة المئوية للتأثيرات الوراثية التجمعية معظمها منخفضة، حيث كانت أعلى قيمة لها ٥.٣ % لصفة إنتاج اللبن خلال الأسبوع الثالث ثم يليها صفة إنتاج اللبن خلال الأسبوع الأول حيث سجلت ٣.٧ %.

كما أوضحت النتائج إن النسبة المئوية لقيم ال تباين البيئى الدائم كانت الأعلى قيمة خلال الأسبوع الأول (٨.٢%) ثم انخفضت تدريجيا بعد ذلك حتى الأسبوع الثالث (٠.٥). كما كانت قيم المكافئ الوراثي منخفضة حيث تراوحت بين ٠.٠٠١ لصفة إنتاج اللبن الكلي إلى ٠.٠٥ لصفة إنتاج اللبن خلال الأسبوع الثالث من الرضاعة. كما أظهرت النتائج قيما منخفضة للمعامل التكراري والتي تراوحت بين ٠.٠٠٢ لصفة إنتاج اللبن الكلي إلى ٠.١١٩ لصفة إنتاج اللبن الكلي خلال الأسبوع الثالث من الرضاعة. وقد أظهرت النتائج أيضا أن صفة إنتاج اللبن خلال الأسبوع الثالث مرتبطة بقوة (٠.٨٤) معنويا مع صفة إنتاج اللبن الكلي. وقد وجد نفس الإتجاة بصفة عامة لقيم معاملات الإرتباط للتباين البيئي الدائم بين صفات إنتاج اللبن.