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HERITABILITIES, REPEATABILITIES AND PERMANENT ENVIRONMENTAL EFFECTS FOR MATERNAL TRAITS IN BALADI RED AND NEW ZEALAND WHITE RABBITS

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ABSTRACT

An experiment was carried out to evaluate genetically maternal performance traits in Baladi Red and New Zealand White rabbits in terms of number born alive (**NBA**), litter size at birth (**LSB**), 21 day (**LS21**) and weaning (**LSW**), litter weight at birth (**LWB**), 21 day (**LW21**) and weaning (**LWW**), mean bunny litter weight at birth (**MBB**), 21 day (**MB21**) and at weaning (**MBW**), gain in litter from birth to 21 day (**LG21**) and from birth to weaning (**LGW**). Records of 352 litters from 111 does fathered by 16 sires and mothered by 47 dams in Baladi Red and 365 litters from 121 does fathered by 17 sires and mothered by 42 dams in New Zealand White were used in such evaluation. Data were analyzed for each breed separately using single-trait animal model to estimate heritabilities, repeatabilities, and permanent environmental effects.

Maternal performance traits tend to be lowly or moderately heritable and repeatable. Heritabilities for these traits in Baladi Red were slightly higher than those in New Zealand White. Heritability (or repeatability) estimates in Baladi Red rabbits for **NBA, LSB, LS21, LSW, LWB, LW21, LWW, MBB, MB21, MBW, LG21** and **LGW** were 0.09(0.12), 0.08(0.09), 0.16(0.18), 0.16(0.20), 0.13(0.17), 0.20(0.29), 0.22(0.30), 0.09(0.13), 0.10(0.18), 0.11(0.17), 0.10(0.18) and 0.12(0.21), respectively. The respective estimates in New Zealand Whit rabbits were 0.07(0.13), 0.06(0.10), 0.10(0.19), 0.16(0.24), 0.11(0.19), 0.17(0.31), 0.20(0.32), 0.07(0.15), 0.08(0.21), 0.09(0.21), 0.05(0.15) and 0.10(0.19). Ratios of permanent environmental effects for maternal performance traits in Baladi Red rabbits were slightly lower than in New Zealand White. These ratios were low and ranging from 0.01 to 0.09 in Baladi Red rabbits and from 0.04 to 0.13 in New Zealand White. Standard errors associated with ratios of heritability, permanent environmental effect and error variances were mostly reasonable.

Keywords: (Rabbits, maternal performance traits, animal model, heritability, repeatability, permanent environmental effects)

INTRODUCTION

Earlier articles reviewed by Khalil *et al.* (1986) and Rochambeau (1988) verified that heritability and/or repeatability estimates for pre-weaning maternal traits have shown broad ranges among different reports. Reasons may include real genetic differences among population, random variation, environmental dissimilarities and methods of estimation, etc. However, litter size and litter weight traits are greatly affected by the additive genetic effect as well as by maternal effects. Krogmeier *et al.* (1994) reported that maternal effects (genetic and environmental) for pre-weaning traits in rabbits may account for as much as 14% of the total phenotypic variance. Lukefahr and Hamilton (1997) reported that variance of non additive genetic and permanent environment were important for litter weaning weight. Thy added that the latter trait is an economically important composed trait of the doe.

New Zealand White rabbit is well known in Egypt as a meat-purpose breed that intensively spread allover the country. However, Baladi Red rabbits as a local meat-type breed are endangered of extinction since the total number of these rabbits are very limited now (Khalil, 1999 and Youssef, 2004). Unfortunately and regarding to the situation of danger of extinction in particular, genetic studies concerning Baladi Red rabbits are very limited. To establish selection program for genetic improvement of Baladi Red rabbits, knowledge of genetic parameter for these traits is required. For these reasons, an experiment was carried out to estimate heritability, repeatability and permanent environmental effect for some pre-weaning maternal traits in Baladi Red rabbits and New Zealand White using an animal model methodology. Discussing the effect of permanent environmental on these traits was taking into account with particular attention.

MATERIALS AND METHODS

This experiment was carried out at El-Kanater El-Khaireya experimental station, Animal Production Research Institute, Ministry of Agriculture, Egypt, for a period of two years (starting from September 1989 till June 1990). Locally born 17 sires, 42 dams from New Zealand White rabbits, 16 sires, and 47 dams from Baladi Red rabbits were used as the base population for this work. Distribution of sires, dams, does, and litters in the two breeds are presented in Table 1.

Table (1):. Structure of the data analyzed

Item	Baladi Red	New Zealand White
Number of sires	16	17
Number of dams	47	42
Number of does	111	121
Total number of animals in the pedigree file	161	166
Number of litters	352	365
Total number of bunnies born	2320	2597
Total number of bunnies weaned	1532	1659

Rabbits of this study were raised in a semi-closed rabbitry. Breeding does and bucks were housed separately in individual wired-cages with dimensions of 60 × 35 × 35 cm, allocated in two rows along the rabbitry. Cage of each doe was provided with a metal nest box for kindling. Each buck was mated naturally 3-4 does of the same breed. 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. Sire-daughter and full and half sib matings were avoided. At weaning age (35 days), the young rabbits were separated from their mothers' cages, sexed, weighted, ear-tagged and lodged in collectives cages in groups having automatic drinkers. All animals were fed *ad libitum* a pelleted ration containing 16.3% crude protein, 13.2% crude fiber and 2.5% fat. Berssem (*Trifolium alexandrium*) was supplied at midday during winter only. Cages of all animals were cleaned and disinfected before each kindling regularly. Manure was collected daily and removed outside the rabbitry.

Data and models of analysis:

Litters traits measured at birth were litter size, number born alive, litter weight, mean bunny weight in grams. At 21st day and weaning, litter size, litter weight and mean bunny weight per litter were also recorded. Weight gain in litter from birth to 21st day and weight gain in litter from birth to weaning were computed.

Data of each breed were analyzed separately using single-trait animal model (STAM). **MTDFREML** program of Boldman *et al* (1995) was used. Variances obtained by **REML** method of **VARCOMP** procedure (SAS 1996) were used as starting (guessed) values for the estimation of variance components. Analyses were done according to this model (in matrix notation):

$$Y = Xb + Z_aU_a + ZpUp + e$$

where:

Y = vector of observation;

X= incidence matrix of fixed effect;

b = vector of fixed effect of season (Autumn, Winter and Spring);

Z_a and Zp = incidence matrices respective to random direct additive effects and permanent environmental effects (permanent environmental effects defined as the combination of the doe of the litters and her parities, i.e. combination of doe x parity).

U_a and U_p= vectors of animal random effects and random permanent environmental effects, respectively;

e = vector of random errors.

The relationship coefficient matrix (A^{-1}) among animals was considered in such single-trait animal model (Korhonen 1996). The **STAM** was used to estimate proportions of direct additive genetic effects (representing heritability h^2_a), permanent environmental effects (p^2), and error (e^2) relative to the total phenotypic variance. Direct heritabilities (h^2_a) were computed as:

$$h^2_a = \sigma^2_A / (\sigma^2_A + \sigma^2_p + \sigma^2_e)$$

where: σ^2_A = direct additive genetic variance, σ^2_p = permanent environmental effects variance, and σ^2_e = error variance.

Repeatability was expressed as the ratio of variances by summing of additive genetic and permanent environmental effects ($\sigma^2_a + \sigma^2_p$) to total phenotypic variance ($\sigma^2_a + \sigma^2_p + \sigma^2_e$). Standard errors were computed for ratios of σ^2_a, σ^2_p and σ^2_e from **DFREML** analyses, but not for repeatability because the latter was not directly computed.

RESULTS AND DISCUSSION

To characterization each breed phonotypically, means, standard deviations, percentages of variation (V%) and range of variation in minimum and maximum values for maternal performance traits of the two breeds are presented in Table 2. The means in this study are within the ranges reviewed in the Egyptian studies (Afifi *et al*, 1992, Afifi *et al*., 1998; Afifi *et al*., 2001). Results in Table 2 reveal that maternal performance traits in Baladi Red were slightly lower than New Zealand White. Lower maternal performance in Baladi Red was expected since this native breed was not improved by selection. On the other hand, selection was practiced in New Zealand White. Blasco *et al*., (1992) ascribed the superiority of New Zealand White does in pre-weaning litter traits to their superiority in their pre-natal maternal performance in terms of ovulation rate, fetal survival, uterine capacity, intra-uterine environment associated with post natal maternal performance in terms of milk production maternal behavior, caring ability *etc*..

Wide phenotypic variations in all maternal performance traits of both breeds were observed (Table 2). Percentages of variation (V%) in both breeds were nearly similar and moderate; ranging from 16 to 34 in Baladi Red and 14 to 35 % in New Zealand White. Estimates of V% recorded by Farid *et al*., (2000) showed a general trend indicating that variations in pre-weaning litter traits were also moderate or high. In both breeds, V% values for traits measured at birth were lower than traits measured at 21 days and weaning. These figures indicate that variations in maternal performance traits in both breeds were found to be increased with the advancement of age. Similar results were reported by Lukefahr (1982), Khalil *et al*., (1987) and Afifi *et al*., (1998). This was attributed to differences in litter losses during the suckling period. Blasco *et al*, (1992) attributed the variation in maternal performance traits at birth to the variation in ovulation rate, embryo and fetal survival and uterine capacity. But, the increase in V% for maternal performance traits at weaning may be due to differences in post-natal growth of the litters, genetic differences and variation in milk production of their does during the suckling period (Khalil 1994). However, the higher variation in litter traits at 21 days and at weaning than at birth would lead to greater phenotypic improvement in these traits by selection associated with good management during the suckling period.

Heritability:

Estimates of heritability for maternal performance traits in Baldi Red rabbits and New Zealand White are shown in Table 3. Heritability estimates for most traits in Baladi Red rabbits were to some extent higher than in New Zealand White. Khalil *et al* (1987) attributed this trend to the reduction in variability within exotic breeds through previous intensive selection, while local breeds were not subjected to such selection.

Table 2. Means, standard deviations (SD), coefficients of variation (V%), minimum and maximum values for maternal performance traits in Baladi Red New and Zealand White rabbits

Trait	Symbol of trait	Baladi Red					New Zealand White				
		Mean	SD	Min.	Max.	V%	Mean	SD	Min.	Max.	V%
Litter size traits:											
At birth	**LSB**	6.6	1.8	1	11	28	7.1	1.8	1	11	26
Number born alive	**NBA**	6.0	1.7	0	10	29	6.5	1.7	0	10	26
At 21 day	**LS21**	4.9	1.5	1	9	32	5.2	1.5	1	9	28
At weaning	**LSW**	4.4	1.4	1	9	31	4.5	1.5	1	9	32
Litter weight traits (grams):											
At birth	**LWB**	298	63	60	485	21	334	73	80	590	22
At 21 day	**LW21**	1500	432	420	2620	29	1670	516	390	3615	31
At weaning	**LWW**	1940	543	520	4560	28	2113	646	560	4100	31
Mean bunny weight traits (grams):											
At birth	**MBB**	47	7	30	80	16	48	7	32	80	14
At 21 day	**MB21**	317	55	202	750	17	323	52	181	750	16
At weaning	**MBW**	461	90	313	999	19	479	112	316	1600	23
Gain in litter weight traits (grams):											
From birth to 21 day	**LG21**	1203	403	200	2295	34	1337	466	265	3145	35
From birth to weaning	**LGW**	1645	515	310	4280	31	1779	601	415	3650	34

In both breeds, direct heritabilities for most traits investigated were low and/or relatively moderate (0.06≤0.22; Table 3). For litter size traits at various ages, heritability estimates were nearly similar in both breeds and varied from 0.08 to 0.16 in Baladi Red rabbits and 0.06 to 0.16 in New Zealand White. These estimates are in agreement with those reported by Afifi *et al*, (1992) in Egypt. In the European and USA studies, heritability for litter size traits in rabbits is generally around 0.1 (Blasco *et al*., 1992; Lukefahr *et al*., 1996; Lukefahr *et al*., 1997; Lukefahr and Hamilton, 1997; Rochambeau, 1997; Rostogi *et al*., 2000). Low heritability of litter size is further reflected in low response to selection (Poujardieu *et al*., 1994; Rochambeau 1994; Gomez *et al*., 1996). Other studies (Khalil *et al*., 1987; Krogmeier *et al*., 1994; Ayyat *et al*, 1995) reported moderate to high heritability values, but these estimates were associated with rather high standard errors.

Heritability values for litter weight traits tended to be low or moderate and ranged between 0.13 and 0.22 in Baladi Red rabbits and between 0.11 and 0.20 in New Zealand White (Table 3). These estimates are in agreement with those reported in studies carried out in Egypt (Afifi *et al*., 1992; Ayyat *et al*, 1995; Afifi *et al*, 1998). On the other hand, lower heritability estimates for litter weight traits (0.02 – 0.09) were recorded by Lukefahr *et al*., (1996) and Lukefahr and Hamilton (1997) in USA and Rastogi *et al*., (2000) in Trinidad.

Estimates of heritability for mean bunny weight and litter gain traits were tightly close to each other since these estimates ranged from 0.09 to 0.12 in Baladi Red rabbits and 0.07 to 0.10 in New Zealand White (Table 3). Rastogi *et al*., (2000) attributed the low heritabilities in litter weight traits to the negative covariance between direct and maternal effects.

The reasonable precision of the estimates of heritability for most pre-weaning maternal performance traits, as judged by their standard errors, indicate that these estimates will be useful in scheming the selection programs for Baladi Red rabbits particularly for litter weight at weaning. On the other side, the low heritability estimates obtained for the other maternal traits in this study indicate that the relative importance of direct additive genetic effect is low and the improvement in these traits could be realized by the improvement in environment and management of the litter after kindling, because the period from birth to weaning is most sensitive to environment and management changes (Farghaly, 1996).

Permanent environmental effect (p^2):

The proportions of permanent environmental effect (p^2) associated with their standard errors (SE) for maternal performances traits are presented in Table 3. In both breeds, these proportions were low and ranged from 0.05 to 0.14. Very small magnitudes in permanent environmental effect may be a result of the small number of does used in both breeds. In general, the small values of p^2 may be attributed partially to the large temporary environmental variation (including climatic, sanitary, managerial conditions, etc.) which could not be considered in the mathematical model of analysis (Moura *et al*, 1991).

Table (3): Ratios of variance components for direct additive effects (direct heritabilities, h^2_a), permanent environmental effects (p^2), and error (e^2) to the total phenotypic variance and repeatability estimates (t) for maternal performance traits in Baladi Red and New Zealand White rabbits

Litter trait	h^2_a±SE	p^2±SE	e^2±SE	t
Baladi Red:				
LSB	0.08±0.06	0.01±0.03	0.91±0.45	0.09
NBA	0.09±0.06	0.03±0.03	0.88±0.43	0.12
LS21	0.13±0.06	0.05±0.05	0.82±0.49	0.18
LSW	0.16±0.08	0.04±0.04	0.80±0.45	0.20
LWB	0.13±0.09	0.04±0.04	0.83±0.49	0.17
LW21	0.20±0.10	0.09±0.05	0.71±0.45	0.29
LWW	0.22±0.10	0.08±0.05	0.70±0.44	0.30
MBB	0.09±0.06	0.04±0.04	0.87±.0.44	0.13
MB21	0.10±0.08	0.08±0.06	0.82±0.43	0.18
MBW	0.11±0.08	0.07±0.07	0.82±0.42	0.18
LG21	0.10±0.07	0.07±0.05	0.83±0.43	0.17
LGW	0.12±0.07	0.09±0.05	0.79±0.28	0.21
New Zealand White:				
LSB	0.06±0.05	0.04±0.04	0.90±0.40	0.10
NBA	0.07±0.05	0.06±0.04	0.87±0.40	0.13
LS21	0.10±0.06	0.09±0.06	0.81±0.49	0.19
LSW	0.16±0.07	0.08±0.06	0.76±0.40	0.24
LWB	0.11±0.06	0.08±0.07	0.81±0.39	0.19
LW21	0.17±0.07	0.14±0.07	0.69±0.31	0.31
LWW	0.20±0.09	0.12±0.06	0.68±0.32	0.32
MBB	0.07±0.04	0.08±0.05	0.85±0.32	0.15
MB21	0.08±0.06	0.13±0.06	0.79±0.30	0.21
MBW	0.09 ±0.06	0.12±0.09	0.79±0.36	0.21
LG21	0.05±0.03	0.10±0.04	0.85±0.30	0.15
LBW	0.10±0.06	0.09±0.06	0.81±0.30	0.19

SE= Standard errors for each ratio.

The estimates of p^2 were slightly lower in Baladi Red rabbits than in New Zealand White with the exception of mean bunny weight at birth and litter weight gain from birth to weaning which were in favor of Baladi Red rabbits. However, proportions of p^2 were within the ranges of 0.10 to 0.22 reported by Rastogi *et al.*, (2000) and grater than the ranges of 0.0 to 0.10 reported by Lukefahr and Hamilton (1997).

In both breeds, the proportions of p^2 were generally low at the early ages and increased thereafter with advancing of age till 21 days. This may be to variation in milk production since the pattern of change in pre-weaning litter traits has also the same curvilinear pattern in milk production; reaching its peak at 21 days. Khalil (1994) and Afifi *et al.*, (2000). observed the same conclusion.

Repeatability (t):

Repeatability estimates for most litter traits were low or moderate in magnitude and tended to be slightly higher in New Zealand White than in Baladi Red (Table 3). This is because the estimates of permanent environmental effect were slightly higher in New Zealand White than in Baladi Red (Table 3). In both breeds, a general trend was observed for the repeatability estimates of litter traits to be increased with the advancing of age of the litter.

Repeatability in both breeds for litter size at weaning (0.24 in New Zealand White and 0.20 in Baladi Red) were moderate, favorable and slightly higher than the estimates for litter size traits measured before weaning (ranging from 0.10 to 0.19 in New Zealand White and 0.09 to 0.18 in Baladi Red). Repeatability values for litter size in this study tended to be close to or within the range of values reported in the literature (Lukefahr *et al*., 1983; Moura *et al*., 1991; Afifi *et al*., 1992; Khalil, 1994; Ayyat *et al*, 1995; Lukefahr and Hamilton, 1997 and Rastogi *et al*., 2000).

The estimates of repeatability for litter weight traits at various ages were moderate and ranging from 0.19 to 0.32 in New Zealand White and 0.17 to 0.30 in Baladi Red rabbits. However, all estimates for litter weight traits in both breeds were relatively higher than estimates for litter size traits (Table 3). Afifi *et al.* (1992) reported that repeatability estimates for litter weight at various ages were relatively higher than that for litter size at the corresponding ages. The estimates of repeatability for litter weight traits in this study were in the ranges of values reported by Moura *et al* (1991), Khalil (1994), Ayyat *et al* (1995) and Lukefahr and Hamilton (1997). Based on the repeatability estimate of 0.32 in New Zealand White and 0.30 in Baladi Red for litter weight at weaning, this trait could potentially be used, as a culling criterion to improve doe herd productivity in terms of litter mass production, *i.e.* litter weight at weaning is an economically important composite trait for the doe. This is because litter weight at weaning is affected by litter size, kit viability, mothering and milking ability, and growth response of the litter (Lukefahr and Hamilton, 1997).

Although the maternal genetic variance was not partitioned in our model of analysis, this source of variance could be included in the permanent effects variance, and thus be reflected in our estimates of repeatability. For all pre-weaning maternal performance traits, the estimates of repeatability were higher than the estimates of heritability and consequently other permanent contributions to doe production besides direct additive genetic effects could be suggested (e.g. maternal additive and non-additive genetic, direct non-additive genetic, epistatic and environmental effects).

Error proportions (e^2):

The estimates of e^2 were nearly similar in both breeds and ranging from 0.68 to 0.90 in New Zealand White and 0.73 to 0.91 in Baladi Red rabbits (Table 3). These high estimates of e^2 for pre-weaning maternal performance traits may be due that some factors might be neglected in the mathematical model of analysis.

CONCLUSIONS

- Since this is the first attempt to characterize Baladi Red rabbits genetically in terms of pre-weaning maternal performance traits using updated animal model methodology. the moderate and favorable estimates of heritability for litter weight at 21 day and at weaning (0.20 for litter weight at 21 day and 0.22 for litter weight at weaning) could be an encouraging factor to improve pre-weaning maternal performance of does in Baladi Red rabbits through selection, *i.e.* direct selection for litter weight at weaning would be effective to get reasonable genetic response.
- The low estimates of p^2 reflected that pre-weaning litter trait could not be affected considerably by permanent environmental effect.
- Further studies involving large data sets particularly in Baladi Red rabbits are needed to yield more precise permanent environmental effects, heritability and repeatability estimates.

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المكافئ الوراثي والمعامل التكراري والتأثير البيئي الدائم لصفات الأم في أرانب البلدي الأحمر والنيوزيلندي الأبيض

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أجريــت تجــربة لتقيــيم صفات الأم وراثيا في كل من أرانب البلدي الأحمر والنيوزيلندي الأبيض، حيث كانت تلك الصفات هي: عدد الأرانب المولودة حية وحجم خلفــة البطن عند كل من الميلاد واليوم الــ ٢١ من الميلاد والفطام، وكذلك وزن خلفة البطــن ومتوسط وزن البطن عند نفس الأعمار السابقة، كما تم تقدير الزيادة في وزن خلفــة البطــن في الفترة من الميلاد وحتى اليوم الــ٢١ من الميلاد ومن الميلاد وحتى الفطام.

اســتخدم في هذه التجربة بيانات ٣٥٢ بطن من ١١١ أنثي نتجت من ١٦ أب و ٤٧ أم من أرانب البلدي الأحمر و٣٦٥ بطن من ١٢١ أنثى نتجت من ١٧ أب و٤٢ أم من أرانب النيوزيلندي الأبيض.

تــم تحلــيل البــيانات إحصائيا لكل سلالة على حدة باستخدام نموذج الحيوان وحــيد الصــفة، لــتقدير قيم المكافئ الوراثي والمعامل التكراري والتأثير البيئي الدائم لصفات خلفة البطن قبل الفطام.

أوضحت النتائج أن قيم المكافئات الوراثية والمعاملات التكرارية لصفات الأم تــتراوح بيــن المنخفضــة والمتوسطة وقد كانت قيم المكافئ الوراثي (أو قيم المعامل الــتكراري) المقدرة لأرانب البلدي الأحمر لصفات: عدد المولود حي وحجم الخلفة عند الميلاد واليوم الــ ٢١ من الميلاد وعند الفطام ووزن الخلفة عند الميلاد واليوم الــ٢١ من الميلاد والفطام ومتوسط وزن الخلفة عند الميلاد واليوم الــ٢١ من الميلاد والفطام هــي والــزيادة فــي وزن خلفة البطن في الفترة من الميلاد وحتى اليوم الــ٢١ ومن المــيلاد ومــن الميلاد وحتى الفطام ٠,٠٩ (٠,١٢)، ٠,٠٨ (٠,٠٩)، ٠,١٦(٠١٨.)، ٠,١٦(٠,٢٠)، ٠,١٣(٠,١٧)، ٠,٢٠(٠,٢٩)، ٠,٢٢(٠,٣٠)، ٠,٠٩(٠,١٣) ، ٠١٠٠. (٠,١٨)، ٠,١١(٠,١٧)، ٠,١٠(٠,١٨)، ٠,١٢(٠,٢١)، علــى الترتيب، كما كانت قيم هذه الصفات في سلالة النيوزيلندي الأبيض ٠,٠٧(٠,١٣)، ٠,٠٦(٠,١٠)، ٠,١٠ (٠,١٩)، ٠,١٦(٠,٢٤)، ٠,١١(٠,١٩)، ٠,١٧(٠,٣١)، ٠,٢٠(٠,٣٢) ٠,٠٧(٠,١٥) ٠,٠٨(٠,٢١)، ٠,٠٩(٠,٢١)، ٠,٠٥(٠,١٥)، ٠,١٠(٠,١٩)، على الترتيب.

كمــا كانت نسب التباين البيئي الدائم لصفات الأم أقل نسبيا في سلالة البلدي الأحمر عنها في سلالة النيوزيلندي الأبيض. حيث كانت منخفضة إلى حد ما وتراوحت مــن ٠,٠١ إلــى ٠,٠٩ فــي ســلالة البلدي الأحمر ومن ٠.٠٤ إلى ٠,١٣ في سلالة النيوزيلندي الأبيض