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ESTIMATION OF HERITABILITY, REPEATABILITY AND PERMANENT ENVIRONMENTAL EFFECTS OF SOME LITTER TRAITS IN NEW ZEALAND WHITE AND CALIFORNIAN RABBITS UNDER EGYPTION CONDITIONS

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ABSTRACT

A study was carried out to evaluate genetically maternal performance traits in New Zealand White (NZW) and Californian (Cal) rabbits in terms of number born alive (NBA), litter size at each of birth (LSB), 21 days (LS21) and weaning (LSW), litter weight at each of birth (LWB), 21 days (LW21), and weaning (LWW), mean bunny litter weight at each of birth (MBB), 21 day (MB21) and at weaning (MBW). These traits studied were estimated from records of 956 litters in NZW and 490 litters in Cal rabbits in such evaluation. Data were analyzed for each breed separate using single-trait animal model to estimate heritabilitits, repeatabilities, and permanent environmental effects for the above-mentioned traits. Heritability estimates were ranged between 0.01 to 0.15 while the repeatability estimates were ranged from 0.07 to 0.27 for all traits studied in NZW and Cal rabbit breeds, respectively. Permanent environmental effect estimates were ranged from 0.1 to 0.15 in both breeds studied. In general, estimates of heritability, repeatability, and permanent environmental effects were low or moderate in the two breeds studied.

Keywords: Rabbits, animal model, heritability, repeatability, permanent environmental effect.

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INTRODUCTION

The heritability, repeatability and permanent environmental effect are very important in the progress of genetic and improvement of different breeds and in designing its breeding programs that allow the genetical evaluation of such a breed and study its genetic properties (Flaconar, 1989).

Heritability is a function of genetic component of variance providing information about the genetical nature of traits and extremely needed for genetical evaluation and selection strategies (Afifi *et al.*, 1998).

Earlier articles reviewed by Khalil *et al.* (1986) and Rochambeau *et al.* (1988) verified that heritability and/or repeatability estimates for pre-weaning maternal traits have shown broad range differences among population, random variation, environmental dissimilarities and methods of estimation, etc. they added that litter size and litter weight traits are greatly affected by the additive genetic effect as by maternal effects. Lukefahr and Hamilton (1997) reported that variance of non additive genetic and permanent environment were important for litter weaning weight.

Therefore the main objective of this study was to estimate heritabilities, repeatabilities, and permanent environmental effects for litter size and weight traits in NZW and Cal rabbit breeds, under Egyptian conditions by using single-trait animal model.

MATERIALS AND METHODS

Data was obtained from the rabbitry farm, National Rabbit Project, Animal Production Department, Faculty of Agriculture, Zagazig University, Egypt. The available records used were for three consecutive years from August 1986 to July 1988.

Rabbits and Management

The animals used in the current study were of the two pure breeds of NZW and Cal rabbits. In both breeds, productive and reproductive abilities were considered as criterion in the selection goal.

At the beginning of the breeding season, the breeding rabbits, within each breed, were divided into groups. Each one was of five does and one buck that were chosen to avoid mating between clone relatives (avoiding full- sib; half-sib offspring mating).

At mating, each doe was transferred to the assigned buck to be mated and returned back to its cage. Does were palpated 10 days post mating to detect pregnancy and those remained not pregnant were returned after palpation to the same buck for another service.

At the 33rd day of pregnancy, the birth was released by an injection of oxytocine (1 ml/doe) in case of the doe had not littered until then. Generally, all does were rebred 7 days after kindling. Within 12 hours from the beginning of delivery and after expulsion of the placenta, the number of rabbits in each litter were counted, weighed and the kids checked for suckling.

Data and Models of Analysis

Litter size traits (at birth, number born alive, 21 days and at weaning, (35 days), litter weight traits (at birth, 21 days and weaning) and mean bunny weight (at birth, 21 days and weaning).

The available data for the current study are shown in Table 1.

Data of each breed were separately analyzed by using single-trait animal model. MTDFREML Program of Boldman *et al.* (1995) was used. Variances obtained by REML Method of VARCOMP Procedure (SAS, 2001) were used as starting (guessed) values for estimation of variance components. Analyses were performed using this model (in matrix notation):

$$Y = Xb + Z_a U_a + Z_p U_p + e$$

Where: Y= Vector of observation; X = Incidence matrix of fixed effects; b= Vector of fixed effect of parity (7 levels) and season of kindling (4 levels), year of kindling (3 levels) and litter size at birth (11 levels) for analyzing litter traits; Z_a and Z_p = Incidence matrices respective to random direct additive effects and permanent environmental effects; U_a and U_p = Vectors of animals random effects and permanent environmental effects random, respectively; e = Vector of random errors.

The relationship coefficient matrix (A-1) among animals was considered in such single-traits animal model. MTDFREML Program of Boldman *et al.* (1995) was adapted to use the sparse matrix package, SPARSPAK (George and Ng, 1984). Convergence was assumed when the variance of the log-likelihood values in the simplex reach <10-12. Occurrence of local maxima was checked by repeatedly restarting the analyses until the log-likelihood did not change beyond the first decimal.

Table 1. Structure of the data analyzed for New Zealand White (NZW) and Californian (Cal) rabbit breeds studied

Item	N ZW	Cal
Number of litters	956	490
Total number of bunnies born	7024	3606
Total number of bunnies weaned	4422	2073

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

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

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

Where: σ^2_a, σ^2_p and σ^2_e are the variance due to effects of additive, permanent environment and error, respectively. Repeatedly was expressed as the ratio of variances by summing genetic and permanent environmental variances ($\sigma^2_a + \sigma^2_p$) to phenotypic variance ($\sigma^2_a + \sigma^2_p + \sigma^2_e$). Standard errors of heritability were computed using MTDFREML Procedure (Boldman *et al*., 1995).

RESULTS AND DISCUSSION

Means and Standard Deviations

Means, standard deviations, minimum and maximum values for litter size, litter weight and mean bunny weight traits of NZW and Cal breed rabbits are presented in Table 2. These means are within the ranges reported in the Egyptian studies by (El-Maghawry 1997; Ibrahim 1999 and Youssef *et al.*, 2003). Results in Table 1 showed that means of litter size traits and MBB and MB21 in Cal were slightly higher than NZW rabbits, However, the means of litter weight traits in NZW were slightly higher means than Cal rabbits.

Heritability Estimates (h^2)

Results in Table 3 showed that heritability (h^2) estimates for litter traits in NZW and Cal breed rabbits were low or moderate and ranged from 0.01 to 0.15 in NZW and Cal breeds and nearly similar in both breeds for most litter traits. These results were as reported in Egyptian studies on different breed groups of rabbits (Afifi *et al.*, 1998; Enab *et al.*, 2000; Nofal *et al.*, 2002; Youssef *et al.*, 2003 & 2008 and Farid *et al.*, 2004) and in

Table 2. Actual means, standard deviations (SD) and ranges of variation for some litter traits in New Zealand White and Californian breed rabbits

Traits	New Zealand White					Californian				
	No.	Mean	SD	Min	Max	No.	Mean	SD	Min	Max
LSB	956	7.3	2.4	1	14	489	8.2	2.5	1	13
NBA	898	6.8	2.5	1	14	462	7.7	2.5	1	13
LS21	831	5.9	2.2	1	12	432	6.3	2.1	1	11
LSW	828	5.4	2.4	1	12	427	5.8	2.0	1	11
LWB	956	420	134.4	45	871	489	415	129	60	780
LW21	831	1732	531	1600	3610	432	1635	539	450	3226
LWW	827	3496	1309	450	6450	427	3091	1197	270	6380
MBB	956	44	123	55	87	489	58	113	70	105
MB21	831	313	860	121	830	432	322	890	600	680
MBW	827	678	148	201	1450	427	655	150	540	1230

LSB = Litter size at birth, NBA = Number born alive, LS21 = Litter size at 21 days, LSW = Litter size at weaning, LWB, Litter weight at birth, LW21 = Litter weight at 21 days, LWW= Litter weight at weaning, MBB = Mean bunny weight at birth, MB21 = Mean bunny weight at 21days and MBW = Mean bunny weight at weaning.

Table 3. Variance components for direct additive effect (direct heritabilities, h^2), permanent environmental effects (P^2) and repeatability estimates (t) for litter traits in NZW and Cal rabbit breeds

Litter traits	$h^2 \pm SE$	$P^2 \pm SE$	t
New Zealand White:			
LSB	0.14 ± 0.07	0.01 ± 0.07	0.15
NBA	0.08 ± 0.06	0.05 ± 0.06	0.13
LS21	0.04 ± 0.02	0.13 ± 0.06	0.17
LSW	0.10 ± 0.07	0.09 ± 0.08	0.19
LWB	0.15 ± 0.09	0.13 ± 0.09	0.27
LW21	0.06 ± 0.03	0.11 ± 0.05	0.17
LWW	0.03 ± 0.06	0.15 ± 0.06	0.18
MBB	0.13 ± 0.07	0.01 ± 0.07	0.14
MB21	0.01 ± 0.03	0.15 ± 0.07	0.16
MBW	0.05 ± 0.04	0.07 ± 0.07	0.12
Californian:			
LSB	0.14 ± 0.12	0.01 ± 0.09	0.15
NBA	0.11 ± 0.09	0.01 ± 0.09	0.12
LS21	0.01 ± 0.82	0.14 ± 0.09	0.15
LSW	0.15 ± 0.10	0.07 ± 0.05	0.22
LWB	0.09 ± 0.06	0.10 ± 0.08	0.17
LW21	0.03 ± 0.10	0.15 ± 0.11	0.18
LWW	0.01 ± 0.08	0.06 ± 0.08	0.07
MBB	0.05 ± 0.09	0.12 ± 0.09	0.17
MB21	0.06 ± 0.08	0.07 ± 0.08	0.13
MBW	0.02 ± 0.08	0.13 ± 0.09	0.15

LSB = Litter size at birth, NBA = Number born alive, LS21 = Litter size at 21 days, LSW = Litter size at weaning, LWB = Litter weight at birth, LW21 = Litter weight at 21 days, LWW= Litter weight at weaning, MBB = Mean bunny weight at birth, MB21 = Mean bunny weight at 21days and MBW = Mean bunny weight at weaning.

other non Egyptian studies (Blasco *et al.*, 1992; Lukefahr *et al.*, 1996; Lukefahr and Hamilton, 1997 and Rastogi *et al.*, 2000).

Low heritabilities of litter size traits (ranged from 0.04 to 0.14 in NZW and ranged from 0.01 to 0.15 in Cal ones) are further reflected in low response to selection (Poujardieu *et al.,* 1994; and Gomeza *et al.*, 1996). Low estimates of h^2 for these traits also may be due to higher permanent environment and/or non-additive genetic effects for all litter size traits (El-Maghawry, 1997).

Heritability values for litter weight traits tended to be Low in both breeds (ranged from 0.01 to 0.15 in NZW rabbits and ranged from 0.01 to 0.09 in Cal ones) as reported by (Lukefahr *et al.*, 1996; Lukefahr and Hamilton, 1997; Rastogi *et al.,* 2000;, Iraqi, 2008, Al-Saef *et al.*, 2008 and Youssef *et al.*, 2003 and 2008).

Permanent Environmental Effects (p^2)

The proportion of permanent environmental effect (p^2) associated with their standard errors (SE) for litter traits in NZW and Cal rabbits are shown in Table 3.

In both breeds, these proportions were low and ranged from 0.01 to 0.13 in NZW rabbits and from 0.01 to 0.14 in Cal rabbits for litter size at different ages studied. While, the values for litter weight traits were ranged from 0.01 to 0.15 in NZW and from 0.06 to 0.15 in cal rabbits.

These observations are supported by those of Ferraz *et al.* (1992); Iraqi (2008); Iraqi *et al.* (2008) and Youssef *et al.* (2003 & 2008) showed that, the proportions of p^2 for litter size traits were 0.01 to 0.09 in both Baladi Red and New Zealand White rabbits. On the other hand, Iraqi and Youssef (2006) estimated the variances of p^2 for litter size traits were 2.36, 8.88 and 4.31 for LSB, LWB and LSW, respectively. Moreover, proportion of p^2 was the highest for LSB compared to additive genetic variance for the same trait while, Rasogi *et al.* (2000) found that breeds reported higher estimates of p^2 (0.22, 0.20 and 0.16 for LSB, LS21 and LSW, respectively.

Lukefahr and Hamilton (1997) reported that variances of non additive genetic and permanent were important for doe body weight and also for litter weaning weight; they stated that the litter trait is an economically important composite trait of the doe to be used in selection. This is because litter weaning weight affecting by litter size and kit viability, mothering and milking ability and growth response of the litter

The differences in values of p^2 in different studies may be attributed to differences in breeds, herds, ages of doe, number of observations, number of litters per doe, environmental condition… etc (Farid, 2004).

Repeatability Estimates (t)

Results in Table 3 showed that estimates of repeatability in NZW rabbits were higher than the corresponding estimates of CAL rabbits for NBA, LS21, LWB, LWW and MB21 traits. However, the estimates of repeatability in CAL rabbits were higher for LSW, LW21, MBB and MBW. In general, repeatability estimates in this present study were low and moderate.

These results are in accordance with those reported by Khalil (1986 & 1993); Yamani *et al.* (1994); Ahmed (1997) and Farid *et al.* (2000).

In general, since estimates of repeatability were numerically greater than those of heritability, other permanent contributions (e.g., maternal additive and non-additive genetic, direct non-additive genetic, epistetic, and environmental effects) to production besides direct additive genetic effects are suggested. (Lukefahr and Hamilton, 1997).

Conclusions

In spite of estimates of heritability for traits of LSB, LWB and MBB in NZW breed rabbits and LSB, LSW in Cal breed rabbits were high was compared with another traits studied. Therefore, selection of NZW and Cal rabbit breeds does could be effective to improve these traits under the Egyptian conditions.

The low estimates of P^2 reflected that pre-weaning litter traits could not be completely affected considerably by permanent environmental effect.

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تقدير المكافئ الوراثى والمعامل التكرارى والتأثير البيئي الدائم لبعض صفات خلفة البطن فى أرانب النيوزيلندى الأبيض والكاليفورنيا تحت الظروف المصرية

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أجرى تحليل سجلات سابقة لتقييم صفات الأم وراثيا فى كل من ارانب النيوزيلنــدى الأبيض والكاليفورنيا، حيث كانت تلك الصفات هى : عدد الأرانب المولــودة حيــة وحجــم البطن عند كل من الميلاد واليوم ٢١ من الميلاد والفطام وكذلك وزن البطن ومتوســط وزن الأعمار السابقة. تم استخدام بيانات ٩٥٦ بطن من سلالة النيوزيلندى الأبيض و٤٩٠ بطن من أرانب الكاليفورنيا. وحللت البيانات إحصائيا لكل سلالة على حــدة بإســتخدام نمــوذج الحيوان وحيد الصفة لتقدير المكافئ الوراثى والمعامل التكرارى والتــأثير البيئــى الــدائم لصفات البطن قبل الفطام. كانت قيم المكافئ الوراثى تتراوح بين ٠,٠١ إلى ٠,١٥ فى كــل الصفات التى تم دراستها لكل من سلالة النيوزيلندى الأبيض وسلالة الكاليفورنيا. كانت قيم المعامل التكرارى تتراوح بين ٠,١٢ إلى ٠٢٧ و ٠,٠٧ إلى ٠,٢٢ فى سلالة النيوزيلندى الأبيض وسلالة الكاليفورنيا على الترتيب لكل الصفات محل الدراسة. كما تراوحــت نســبة التباين البيئى الدائم لصفات الأم من ٠,٠١ إلى ٠,١٥ فى كلا السلالتين. بصــفة عامــة، كانت قيم المكافئ الوراثى، المعامل التكرارى والتباين البيئ الدائم منخفضة أو متوسطة فى كلا السلالتين محل الراسة.