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ESTIMATION OF SIRE AND PATERNAL GRAND DAMS BREEDING VALUES FOR GROWTH TRAITS IN NEW ZEALAND WHITE AND CALIFORNIAN RABBITS USING THE ANIMAL MODEL

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*A total of 2257 bunnies of New Zealand White (**NZW**) and 1748 of Californian (**CAL**) weaned rabbits were used to evaluate genetically the growth performance of these two exotic breeds raised in adverse environment. Postweaning body weights at 5, 6, 8, 10 and 12 weeks and livability at the intervals of 5-6, 6-8, 8-10 and 10-12 weeks were studied. Variance components and heritabilities (h^2) were estimated. Breeding values for growth traits were also estimated for sires and paternal granddams using an animal model. Heritabilities in CAL rabbits were generally higher than those in NZW. Estimates of h^2 in NZW ranged from 0.228 to 0.718 for body weights and from 0.002 to 0.112 for livability, while the respective estimates in CAL ranged from 0.266 to 0.552 and from 0.055 to 0.177. The ranges in estimates of sire breeding values (SBV) for body weights at 5, 6, 8, 10 and 12 weeks of age were 161, 111.4, 134.4, 419.8 and 660 grams in NZW rabbits and 216.1, 181.4, 213.5, 415.2 and 465.4 grams in CAL rabbits, respectively. For livability, the ranges in SBV were 2.0, 15.8, 3.6 and 0.8% at 6, 8, 10 and 12 weeks of age in NZW and 7.6, 25.2 and 8.2% at 6, 8 and 12 weeks in CAL rabbits, respectively. Generally, ranges in estimates of SBV recorded by CAL rabbits were relatively higher than those recorded by NZW rabbits for most body weights, while the reverse trend was observed for livability. Ranges in estimates of breeding values for paternal granddams were lower than those obtained for sires themselves for most traits.*

Keywords: Rabbits, growth traits, heritabilities, breeding values, sires, paternal granddams.

A goal of rabbit breeders is to increase genetic merit of their animals. Information from genetic evaluations plays an important role in determining the best animals to be used in the next generation. Recently, the so called animal model (AM) has become the model of choice for the genetic evaluation of rabbits by BLUP (Ferraz *et al,* 1991&1992; Lukefahr, 1992; Ferraz and Eler, 1994 & 1996; Hassan, 1995; Khalil *et al*, 2000; Youssef *et al*, 2000). Fitting additive genetic effects for each animal, it allows males and females to be evaluated simultaneously taking into account all available relationships between animals (Meyer, 1989). Using the animal model with full pedigree information available on each candidate for selection should lead to higher genetic progress. Animals evaluated by animal model provided accurate list of best linear unbiased prediction (BLUP) of breeding values. Also, a simultaneous evaluation of animals with and without records (e.g. sires, dams, paternal granddams, ...etc) in which the genetic merit of all relatives plus the animal's own performance will be obtained, i.e. animal's genetic merit will be attained (Westell and Van Vleck, 1987; Meyer, 1989). For rabbits in Egypt, individuals with or without records were recently evaluated quite accurately by the animal model through the performance of their relative's information (Khalil *et al*, 2000).

In the last two decades, New Zealand White (NZW) and Californian (CAL) rabbits are two well known meat-purpose rabbit breeds extensively spread all over Egypt. Studies concerning estimation of breeding values for postweaning growth traits and livability in these two standard breeds raised in hot climate country are limited (Hassan, 1995; Khalil *et al*, 2000). The objectives of the present study were: (1) to estimate variance components and heritabilities for postweaning growth performance of New Zealand White (NZW) and Californian (CAL) rabbits raised under adverse environment in hot climate, and (2) to estimate the breeding values for postweaning growth traits and livability for animals without records (sires and paternal granddams) in each breed separately.

MATERIAL AND METHODS

Animals and management:

Rabbits of two foreign breeds viz. New Zealand White (NZW) and Californian (CAL) rabbits were used in the present study. These rabbits were raised in the experimental rabbitry of the Faculty of Agriculture at Moshtohor, Zagazig University, Egypt. Data was available for four consecutive years started in September 1989. Females within each breed were randomly grouped at the beginning of the first breeding season of the experimental period into groups ranging from 3 to 6 does according to the available numbers. For each group of does, a buck from the same breed was assigned at random with a restriction of avoiding parent-offspring and sibs matings. Each buck was given the chance to produce all his litters from the same females all over the period of the study. Management, rabbitry and feeding were descibed previously by Khalil *et al* (2000).

Data and models of analysis:

Data of postweaning growth traits were collected on all bunnies of different dams at weaning and up to 12 weeks of age. The distribution of data collected according to breed and year of kindling are presented in Table 1. Data of growth traits used for analysis were 2257 offspring of 68 sires and 150 dams in New Zealand White rabbits, while they were 1648 offspring of 51 sires and 123 dams in Californian. Body weights studied were weights at 5, 6, 8, 10 and 12 weeks of age. Postweaning livability at 6, 8, 10 and 12 weeks of age were also recorded.

Data of New Zealand White and Californian breeds were analyzed separately. Body weights and livability were analyzed using the following sire model (Harvey, 1990):

$$Y_{ijklmn}=\mu+S_i+YS_j+P_k+A_l+B_m+e_{ijklmn} \quad \text{----------------} \quad \text{(Model 1)}$$

Where: Y_{ijklmn}= the observation on the ijklmn[th] rabbit, μ = overall mean, S_i= random effect of the i[th] sire, YS_j= fixed effect of j[th] year-season of birth, P_k= fixed effect of k[th] parity, A_l= fixed effect of l[th] sex, B_m= fixed effect of m[th] litter size at birth, e_{ijklmn}= random error. The minimum variance normal quadratic unbiased estimates (MINQUE) for sire (σ^2_s) and error (σ^2_e) as described by Henderson (1984) were calculated from the sire model (Harvey, 1990). Searle (1989) stated that iterative MINQUE estimators are equal to REML estimators for the 1st iteration and therefore σ^2_s and σ^2_e were obtained as REML estimators. Sire (h^2_S) heritabilities were estimated for postweaning growth traits as $h^2 = (4\sigma^2_s)/(\sigma^2_s+\sigma^2_e) = \sigma^2_A/\sigma^2_P$ where σ^2_A= additive genetic variance and σ^2_P= total phenotypic variance. Approximate standard errors for heritability were calculated by the formula given by Becker (1984).

Common litter effect (C) is defined as the combination of the dam of the progeny and its parity which was born in it. To estimate the common litter effect, data of postweaning growth were analyzed for the second time using the following mixed model:

$$Y_{ijklmn}=\mu+C_i+YS_j+P_k+A_l+B_m+e_{ijklmn} \quad \text{--------------} \quad \text{(Model 2)}$$

Table 1. Distribution of weaned progeny and their sires and dams according to breed and year of kindling for postweaning growth traits.

Items	New Zealand White					Californian				
	1st year	2nd year	3rd year	4th year	Total	1st year	2nd year	3rd year	4th year	Total
No. of sires	15	27	18	8	68	12	18	15	6	51
No. of dams	36	57	34	23	150	40	39	31	13	123
No.of progeny Weaned					2257					1748

Where: C_i is the random common litter effect, YS, P, A, and B were described previously in model 1. Model 2 was used to obtain the value of the intraclass correlation (r_c) of the common litter effect ($\sigma^2{}_c$) to utilize it in obtaining $\frac{1-r_c}{r_c}$.

The estimates of common litter effect were used as starting values in the analysis of growth traits using the animal model.

Breeding values (BV) estimated by the animal model:

The single-trait animal model program written by Misztal (1990) was used in estimating the breeding values for sires (SBV) and paternal granddams (PGDBV). Variance (co) components obtained by models 1 and 2 were used as stating values in the animal model to obtain the breeding values. In this situation, BLUP estimates obtained are taking into account the relationships coefficient matrix (A^{-1}). The animal model (in matrix notation) used was:

$$\mathbf{Y} = \mathbf{X}\beta + \mathbf{Z_a A} + \mathbf{Z_c C} + \mathbf{e}$$

Where **Y**= the observational vector of weaned rabbit; **X** = the incidence matrix for fixed effects as previously described in the sire model; β = the vector of fixed effects (year-season, parity, sex and litter size at birth); $\mathbf{Z_a}$ = the incidence matrix for random effects (direct genetic effect); **A** = the vector of random effect (direct additive genetic value) associated with the incidence matrix $\mathbf{Z_a}$, i.e. sires or paternal granddams breeding values; $\mathbf{Z_c}$ = the incidence matrix for random common litter effect; **C** = the vector of common litter effect associated with the incidence matrix $\mathbf{Z_c}$; **e** = the vector of random errors. Consequetly, var (A) = $A\sigma^2{}_A$, var (C) = $I_c\sigma^2{}_c$ and var(e) = $I_e\sigma^2{}_e$, where **A** = The numerator relationship matrix, $\mathbf{I_c}$ = an identity matrix with order equal to number of animals, $\mathbf{I_e}$ = an identity matrix with order equal to number of records, $\sigma^2{}_A$ = additive genetic variance, $\sigma^2{}_C$ = variance of common litter effect, and $\sigma^2{}_e$ = random error.

RESULTS AND DICUSSION

Components of variance and heritabilities:

The variance components and heritabilities (h^2) estimated for postweaning growth traits in NZW and CAL rabbits are presented in Table 2. For all body weights in both breeds at different ages, estimates of h^2 were moderate or relatively high, indicating that sire additive variance is of considerable importance and consequently postweaning growth traits of NZW and CAL rabbits could be improved by selection of sires based on performance of their progenies. These favorable estimates of h^2 for postweaning growth traits of NZW and CAL rabbits raised in adverse environment are similar to those obtained by the other Egyptian studies (e.g. Afifi *et al*, 1992; Khalil *et al*, 1993; Khalil *et al*, 2000). This will be an encouraging factor to improve growth performance of these standard breeds raised in hot climate through selection of sires. On the other hand, most of the studies carried out on these two breeds in moderate environment showed that h^2 for postweaning growth traits were low or somewhat moderate (e.g. Ferraz *et al*, 1991&1992).

Heritabilities in CAL rabbits are generally higher than those in NZW (Table 2). The estimates of h^2 for body weights ranged from 0.117 to 0.718 in NZW rabbits, while they ranged from 0.258 to 0.552 in CAL rabbits. A reversible trend was observed for livability traits where CAL rabbits recorded somewhat higher estimates of h^2 than those recorded in NZW. The estimates ranged from 0.002 to 0.117 in NZW vs 0.043 to 0.177 in CAL.

Estimates of heritability in NZW and CAL rabbits of the present study can greatly influenced by the structure of data. For the same two breeds (i.e. NZW and CAL), the extremely small differences in heritabilities were also observed in other studies (e.g. Ferraz *et al*, 1991 in USA; Khalil *et al*, 2000 in Egypt). The explanation may be due to that a comparatively balanced design and an efficient data structure was used. These systematic matings generated a homogenous number of progeny per sire and a sufficient number of sires which lead to provide connections between cells. McCarter *et al* (1987) found that the estimates of heritability from designed experiments were higher than those estimates from field data.

Computational parameters attained in estimation of breeding values:

The number of iterations and equations attained in evaluation of NZW and CAL sires and paternal granddams using an animal model for body weights and livability are presented in Table 3. For NZW rabbits, the number of equations and iterations recorded for body weights averaged 566 equation and 226 iteration, while livability traits recorded 558 equation and 319

Table 2. Additive genetic (σ^2_A) and error (σ^2_e) variances and heritabilities (h^2) estimated by the sire model for postweaning growth traits in New Zealand White and Californian rabbits

Trait	New Zealand White			Californian		
	σ^2_A	σ^2_e	h^2+SE	σ^2_A	σ^2_e	h^2+SE
Body weight:						
5-week	6885	19386	0.326±0.106	10657	18676	0.499±0.179
6-week	4985	20659	0.228±0.076	7749	20175	0.454±0.165
8-week	7154	28559	0.236±0.078	15643	24428	0.552±0.195
10-week	40508	46266	0.718±0.108	14728	33053	0.427±0.157
12-week	28232	78475	0.330±0.107	14728	51649	0.266±0.102
Livability:						
6-week	0.4	0.032	0.011±0.004	0.004	0.039	0.055±0.002
8-week	0.004	0.034	0.112±0.039	0.008	0.038	0.177±0.069
10-week	0.4	0.030	0.012±0.004	⊕	⊕	⊕
12-week	0.62	0.026	0.002±0.002	0.004	0.030	0.069±0.023

⊕ Negative estimate of sire component of variance set to zero.

Table 3. Numbers of iterations and equations obtained in evaluation of postweaning growth traits in New Zealand White and Californian rabbits using the animal model

Traits	New Zealand White		Californian	
	No. of iterations	No of equations	No. of iterations	No of equations
Body weight:				
5 weeks	441	572	125	410
6 weeks	184	567	453	403
8 weeks	229	565	1043	405
10 weeks	196	564	1002	404
12 weeks	79	564	207	401
Livability:				
6 weeks	208	565	146	404
8 weeks	406	561	138	404
10 weeks	289	557	⊕	⊕
12 weeks	262	557	428	399

⊕ Negative estimate of sire component of variance set to zero.

iteration. The corresponding figures recorded by CAL rabbits averaged 405 and 566 for body weights, while they averaged 402 and 237 for livability.

Breeding values for sires:

The relationship coefficient matrix (A^{-1}) among sires were considered in estimation of sire breeding values (**SBV**) for postweaning body weights and livability. The minimum and maximum estimates of SBV in addition to their ranges are presented in Table 4. CAL sires generally recorded higher ranges in estimates of SBV for body weights and livability than those ranges recorded for NZW sires. The ranges in NZW vs CAL sires were 161 vs 216.1 grams, 111.4 vs 181.4 grams, 134.4 vs 213.5 grams, 419.8 vs 415.2 grams and 660 vs 465.4 grams for body weights at 5, 6, 8, 10 and 12 weeks of age, respectively. For livability, the same trend was observed where estimates of SBV for livability averaged 6.6% in NZW vs 15% in CAL sires. Using an animal model, SBV estimated by Hassan (1995) ranged from -78 to 90 grams for weaning weight (4 weeks) and from -8.9 to 10.7% for livability in NZW rabbits raised in Egypt. Using a sire model, Shebl *et al* (1997) with data of three lines of rabbits raised in Germany (N line originated from New Zealand White, Z line originated from mating various local German strains, and G line was developed from Giant breed), ranges in SBV of postweaning body weights at 8, 12 and 16 weeks of age in G line were the largest, followed by N line and Z line. In this study, the ranges in SBV in N, Z and G lines, respectively were 267, 253 and 473 grams for 8-week weight, 341, 280 and 488 grams for 12-week weight, and 304, 99 and 542 grams for 16-week weight.

Estimates of SBV obtained by the animal model for most traits (Table 4) were relatively low and this may be due to the inclusion of common litter effect in the animal model. Using an animal model, Khalil *et al* (2000) reported a similar trend who stated that ranges in SBV for body weights at 5, 6, 8, 10 and 12 weeks of age in NZW were 143.3, 165.3, 106.2, 72.8 and 118.2 grams. For livability traits in their study, NZW sires recorded also higher ranges in SBV compared with CAL sires where the estimates averaged 24.1% for NZW vs 6.1% for CAL.

Breeding values for paternal grand dams:

The minimum and maximum estimates of breeding values and their ranges for paternal granddams in NZW and CAL rabbits (Table 5) indicate that the estimates obtained for paternal grand-dams were of the same trend obtained for sires (Table 4). In NZW rabbits, the ranges of paternal granddams breeding values for body weights were 91, 71.8, 96.6, 268.2 and 438.8 grams at 5, 6, 8, 10 and 12 weeks of age, respectively. The corresponding ranges for body weights in CAL rabbits were 197.6, 201.4, 197.2, 148.6 and 178.8 grams at 5,

Table 4. Minimum and maximum estimates of sire breeding values (SBV) estimated by animal model for postweaning growth traits in New Zealand White and Californian rabbits

Traits	New Zealand White[+]			Californian[+]		
	Minimum	Maximum	Range	Minimum	Maximum	Range
Body weight (grams):						
5-week	-78.6	82.4	161.0	-110.5	105.6	216.1
6-week	-54.0	57.4	111.4	-84.1	97.3	181.4
8-week	-63.8	70.4	134.4	-105.6	107.8	213.5
10-week	-140.8	279.0	419.8	-212.0	203.0	415.2
12-week	-247.0	413.0	660.0	-253.4	212.2	465.4
Livability (%):						
6-week	-1.0	1.0	2.0	-4.8	2.8	7.6
8-week	-11.6	4.4	15.8	-18.4	6.6	25.2
10-week	-1.8	1.6	3.6	⊕	⊕	⊕
12-week	-0.4	0.4	0.8	-5.4	3.0	8.2

[+] Numbers of sires used for evaluation were 68 and 51 for NZW and CAL, respectively.

⊕ Negative estimate of sire component of variance set to zero.

Table 5. Minimum and maximum estimates of breeding values for paternal grand-dams obtained by the animal model for postweaning body weights and livabilities in New Zealand White and Californian rabbits

Traits	New Zealand White			Californian		
	Minimum	Maximum	Range	Minimum	Maximum	Range
Body weight (grams):						
5-week	-30.8	51.4	91.0	-52.2	145.4	197.6
6-week	-28.6	43.8	71.8	-60.8	140.6	201.4
8-week	-45.6	51.0	96.6	-63.4	133.6	197.2
10-week	-142.4	125.8	268.2	-34.0	114.4	148.6
12-week	-150.8	287.8	438.8	-53.4	125.4	178.8
Livability (%):						
6-week	-0.6	0.8	1.4	-3.0	1.6	4.6
8-week	-5.4	5.8	11.0	-8.4	3.6	12.0
10-week	-1.0	1.2	2.2	⊕	⊕	⊕
12-week	-0.2	0.2	0.4	-3.2	3.6	6.8

⊕ Negative estimate of sire component of variance set to zero.

6, 8, 10 and 12 weeks of age. The ranges for livability traits were 1.4, 11.0 and 0.4% in NZW vs 4.6, 12.0 and 6.8% in CAL at 6, 8 and 12 weeks, respectively.

Conclusions:

(1) The present evaluation for growth traits in New Zealand White and Californian rabbits raised in Egypt using an animal model are accurate because: (a) animal model considered here the genetic merit of all relatives (Lukefahr, 1992), (b) it has minimum predicted error variance (PEV) with unbiased estimates (Ferraz and Eler, 1996), (c) it considered the effects of common litter environment (Ferraz *et al*, 1991&1992; Baselga *et al*, 1992), (d) it used the information from all known relationships among animals to predict the genetic merit of each animal (Wiggans and Misztal, 1987; Van Raden and Wiggans, 1991), and (e) breeding values could be obtained for animals without records, e.g. sires and paternal granddams.

(2) High ranges in breeding value for most growth traits obtained in the presnt study for New Zealand White and Californian rabbits may lead to state that evaluation of sires or paternal granddams based on records of their progenies may be effective in improvement of growth performance of these two breeds.

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تقدير القيم التربوية للأباء و أباء الأمهات لصفات النمو لأرانب النيوزيلندي و الكاليفورنيا

باستخدام النموذج الحيواني

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الملخص العربي

استخدم سلالتين أجنبيتين من الأرانب هما النيوزيلندي الأبيض و الكاليفورنيا وذلك لعدد ٢٢٥٧ نيوزيلندي أبيض ؛ ١٧٤٨ كاليفورنيا من الأرانب المفطومة وذلك لتقييم أداء نمو هذه السلالات وراثيا. وكانت صفات وزن الجسم عند أعمار ٥ ,٦ , ٨ , ١٠ , ١٢ أسبوع و نسبه الأحياء عند فترات ٥-٦ , ٦-٨ , ٨-١٠ , ١٠-١٢ أسبوع هي محل الدراسة. وتم تقدير مكونات التباين و الكافيء الوراثى. كما تم حساب القيم التربوية لصفات النمو للأباء و أباء الأمهات (paternal granddams) و ذلك باستخدام النموذج الوراثى للحيوان Animal Model. وعامة فان قيم المكافئ الوراثى كانت أعلى في سلاله الكاليفورنيا عنه في سلالة النيوزيلندي الأبيض. تراوحت قيم المكافئ الوراثى في سلالة النيوزيلندي الأبيض ما بين ٠,٢٢٨ - ٠,٧١٨ لصفة وزن الجسم , ٠,٠٠٢ – ٠,١١٢ لصفة نسبة الأحياء. بينما تراوحت القيم في سلالة الكاليفورنيا ما بين ٠,٢٦٦ – ٠,٥٢٢ , ٠,٠٥٥ – ٠,١٧٧ . كانت قيم المدى بين أعلى و أقصى قيمة تربوية للآباء في سلالة النيوزيلندي الأبيض ١٦١ , ١١١,٤ , ١٣٤,٤ , ٤١٩,٨ , ٦٦٠ جرام لصفة وزن الجسم عند أعمار ٥ , ٦ , ٨ , ١٠ , ١٢ أسبوع على التوالي بينما كانت قيم المدى في سلالة الكاليفورنيا ٢١٦,١ , ١٨١,٤ , ٢١٣,٥ , ٤١٥,٢ , ٤٦٥,٤ جرام . بالنسبة لصفة نسبة الأحياء لسلالة النيوزيلندي الأبيض كان المدى للقيم التربوية للأب هي ٢ , ١٥,٨ , ٣,٦ , ٠,٨ عند أعمار ٥ , ٦ , ٨ , ١٠ , ١٢ أسبوع على التوالي بينما كان المدى في سلالة الكاليفورنيا ٧,٦ , ٢٥,٢ , ٨,٢ % عند أعمار ٦ , ٨ , ١٢ أسبوع على التوالي . وعامة فان المدى للقيم التربوية كان أعلى نسبيا في سلالة الكاليفورنيا عنه في سلالة النيوزيلندي الأبيض لمعظم صفات الجسم بينما كان العكس بالنسبة لصفة نسبة الأحياء . كانت قيم المدى للقيم التربوية لأباء الأمهات (paternal granddams) أقل منه في الآباء نفسها لمعظم الصفات المدروسة.