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ESTIMATION OF SIRE TRANSMITTING ABILITIES FOR POST-WEANING GROWTH TRAITS IN NEW ZEALAND WHITE AND CALIFORNIAN RABBITS RAISED IN ADVERSE HOT CLIMATE EGYPTIAN CONDI TIONS USING AN ANIMAL MODEL

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ABSTRACT: *An experiment on two exotic breeds of New Zealand White (NZW) and Californian (CAL) rabbits was carried out to evaluate genetically post-weaning growth performance of these two breeds raised under the Egyptian environment. Data on 2291 of NZW and 1628 of CAL rabbits were used. Post-weaning growth traits investigated were body weight (at 5,6,8,10 and 12 weeks) and daily gains and livabilities (at the age intervals of 5-6, 6-8, 8-10 and 10-12 weeks). Variance components and sire heritabilities were estimated for these traits using Restricted Maximum Likelihood (REML) PROCEDURE. Sire transmitting abilities (STA) for these traits were estimated using a single-trait Animal Model (AM).*

For most growth traits of both breeds, estimates of the sire component of variance obtained using REML were low or somewhat moderate. The percentages of variation due to sire for growth traits estimated for NZW and CAL rabbits ranged from 0.0 to 12.5% for body weight, 1.7 to 13.1% for daily gain and 12.7 to 13.5% for livability. Although all heritability estimates in both breeds were generally low, heritability estimated for NZW rabbits were higher than those corresponding estimates for CAL rabbits. These estimates ranged from 0.049 to 0.501 in NZW vs 0.0 to 0.256 in CAL for body weight, 0.142 to 0.518 in NZW vs 0.070 to 0.184 in CAL for daily again and 0.106 to 0.502 in NZW vs 0.021 to 0.154 in CAL for livability. The differences between *minimum and maximum values of STA for post-weaning growth traits and livabilities were low or somewhat moderate. For body weight at different ages, there were about 81 to 85% of the sires in NZW (47 sires out of 59) and 77 to 80% in CAL (30 sires out of 39) representing an absolute difference of less than 40 grams. For daily gains in both breeds, the largest number of sires was found in the class with the smallest absolute difference in STA and the smallest number of sires was found in the class with the largest absolute difference. Among all growth traits, percentages of positive estimates of STA were nearly similar in both breeds and they ranged from 50.6 to 61.0% for body weights, 46.2 to 55.9 % for daily gains and 51.3 to 66.1 % for livability.*

INTRODUCTION

Sire evaluation using an animal model is being used extensively in dairy and beef cattle, swine and sheep but little in rabbits. In practice, evaluation of sires for post-weaning growth in rabbits is an important aspect for rabbit breeders, particularly for meat rabbits raised in adverse environment. In the last decade, genetic evaluation for data of post-weaning growth traits and livability in rabbits was often performed using a sire model or an animal model (Ferraz et al., 1991; Ferraz et al,1992; Hassan, 1995; Ferraz and Eler, 1996; Shebl et al, 1997). Henderson (1984) stated that genetic evaluation using an animal model (where all relationships among all animals are considered) would be most accurate than evaluation based on a sire model (which account only for relationship among sires). In most cases, evaluation was often performed using an Animal Model which requires good estimates of variance components (Ferraz et al., 1991; Ferraz et al, 1992; Hassan, 1995; Shebl et al, 1997). With balanced data, Restricted Maximum Likelihood (REML) produces the same estimators as ANOVA methods (Corbeil and Searle, 1976; Anderson et al., 1984). Therefore, ANOVA estimators have well known optimal properties in these circumstances. For unbalanced data and for very non-linear equations and records subjected to selection, REML is preferred to solve these equations iteratively (Meyer, 1991). For limited data in rabbits, particularly for NZW and CAL breeds raised in adverse environment, the situation may be differed.

The objectives of the present study were: (1) to evaluate post-weaning growth traits and livability of New Zealand White (NZW) and Californian (CAL) rabbits raised in adverse environment, (2) to estimate and compare variance components and sire heritabilities estimated by REML procedure for these traits, and (3) to estimate the sire transmitting abilities (STA) for these traits using an Animal Model (AM).

MATERIALS AND METHODS

The experimental work of this study was carried out at the experimental farm of the Faculty of Agriculture at Moshtohor, Zagazig University, Egypt. That work lasted for three consecutive years started in September 1989.

Animals and Breeding Plan

Locally-born rabbits of two foreign breeds being New Zealand White (NZW) and Californian (CAL) rabbits were used in this study. All animals included in the study were pedigreed. 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 sib matings. Each buck was given the chance to produce all his litters from the same females all over the period of the study.

Rabbitry and Management

All animals were treated and midicated similarly throughout the experimental period under the same managerial and climatic conditions. Breeding stock (does and bucks) were individually housed in wire cages with standard dimension arranged in one-tire batteries allocated in raw along the rabbitry with passages suitable for service. Cages of each doe were provided with metal nest boxes. Cages of bucks, does and nest boxes were cleaned and disinfected before each kindling regularly.

According to the breeding plan of the experiment, each doe was transferred to the buck's hutch to be bred. Each doe was weighted at each mating and palpated 10 days thereafter to detect pregnancy. Within 24 hours of kindling, litters were examined and recorded. Bunnies were weaned five weeks post-kindling to allow the maximum time for milk feeding. At weaning, litters were recorded and the young rabbits were ear tagged, weighed, separated from their dams and they housed in wire hutches in group individuals. Rabbits were always fed *ad libitum* and food was offered two times daily. A commercial pelted ration was provided in the morning and in the afternoon. The composition of that ration was 16.3% crude protein, 13.2% crude fiber, 2.5% fat (digestible energy = 2600 KCal/1 Kg ration). The ingredients of this ration were 33% barely, 21% Wheat bran, 10% Soya bean meal (44% C.P.), 22% hay, 6% berseem straw, 3% corticated cotton seed meal, 3.3 % molasses, 1% lime stone, 0.34% table salt, 0.3% minerals and vitamins and 0.06% methionine. In winter and early months of spring, berseem (*Trifolium alexandrinum*) was supplied at midday. Fresh clean water was available to rabbits at all times.

Data and models of analysis

The distribution of data collected according to breed and year of kindling are presented in Table 1. Data of growth traits utilized for analysis were 2291 offspring of 74 sires and 237 dams in NZW breed, while they were 1638 offspring of 48 sires and 145 dams in CAL. Body weights studied were weights at 5 (W5), 6 (W6), 8 (W8), 10 (W10) and 12 (W12) weeks of age, while daily gain involved gains at intervals of 5-6 (DG6), 6-8 (DG8), 8-10 (DG10) and 10-12 (DG12) weeks of age. Post-weaning livability at 6 (L6), 8 (L8), 10 (L10) and 12 (L12) weeks of age were also considered. Records of each specific age were taken on all alive offspring. Percentages of livability were treated subjected to arc-sin transformation to approximate normal distribution before being analysed.

Data of NZW and CAL breeds were analyzed separately using Mixed Model Least-Squares and Maximum Likelihood Mean Weighted Program of Harvey (1990). Post-weaning growth traits (body weight, daily gain and livability) were analyzed using the following model:

$$Y_{ijklm} = \mu + S_i + A_j + Y_{SPk} + B_l + e_{ijklm}$$

Where:

Y_{ijklm} = the observation on the ijklm rabbit,

μ = overall mean,

S_i = the random effect of the i^{th} sire,

A_j = the fixed effect of j^{th} sex,

Y_{SPk} = the fixed effect of k^{th} year-season-parity (31 classes),

B_l = the fixed effect of l^{th} litter size in which rabbit was born (10 classes), and

e_{ijklm} = the random deviation of m^{th} rabbit and assumed to be independently randomly distributed $(0, \sigma^2_e)$.

The absence of records in some subclasses did not permit the inclusion of all possible interactions. Estimates of variance components (σ^2_s & σ^2_e) were computed using REML (Meyer 1991). REML is an iterative method and the variance component for random effects are estimated appropriately. Iterations are continued using the estimators of sire and error variances from the preceding round of iteration until the estimates are stabilized. In the first round of iteration a guessed value of the ratio was used. Sire heritabilities (h^2s) were estimated as $[4 (\sigma^2s) / (\sigma^2s+ \sigma^2e)]$. The approximate standard error for h^2_S were calculated by the formula given by Becker (1984).

Sire transmitting ability

A 59 NZW and 39 CAL sires were used for estimating sire transmitting abilities (STA) for post-weaning growth traits (body weight, daily gain and livability). Each sire in each breed separately had at least 7 young. A Single-trait Animal Model program written by Misztal (1990) was used to estimate STA of different traits. Estimates of variance components estimated by REML were used in calculations. In this animal model, transmitting abilities for all animals with records and animals without records were considered. The linear mixed animal model used (in matrix notation) was:

$$Y = X\beta + Za + e$$

where Y= is an observational vector of rabbit, X= incidence matrix for fixed effects, β= vector of overall mean and fixed effects (sex, year-season-parity and litter size in which rabbit was born), Z= incidence matrix for random effects (direct genetic effect), a= vector of unknown additive genetic value, i.e. animal transmitting ability, e= vector of unknown random error $(0, \sigma^2e)$. The variance-covariance structure of the model was as follows:

$$\text{Var}\begin{bmatrix} a \\ e \end{bmatrix} = \begin{bmatrix} A\,\sigma^2_A & 0 \\ 0 & I\,\sigma^2_e \end{bmatrix}$$

Where A= the numerator relationship coefficient matrix, and I= an identity matrix with order equal to number of records for progeny.

RESULTS AND DISCUSSION

Means and variations of uncorrected records

Means, standard deviations (SD) and percentages of phenotypic variation (V%) for post-weaning growth traits (body weight, daily gains and livability) for New Zealand White (NZW) and Californian (CAL) rabbits are presented in Table 2. Means for growth traits in NZW and CAL rabbits increased with the advancement of age. The performance of body weight and gains in NZW was slightly higher than in CAL breed. Means of post-weaning body weights and daily gains for both breeds are nearly similar with the other Egyptian studies for the same two breeds (El-Maghawry et al., 1988; El-Maghawry, 1990; Khalil et al., 1993). Better post-weaning performance in NZW rabbits than in CAL was also declared by many studies in hot climate countries, particularly in Brazil (Ferraz et al 1991; Ferraz et al 1992). This is due to superiority of NZW dams in their postnatal maternal abilities (in terms of milk production, maternal behavior, caring ability, ... etc) than CAL dams.

Livabilities in NZW and CAL at different age intervals are similar (Table 2) and they are nearly similar to those corresponding estimates reported for the same two breeds raised in Egypt (Khalil et al., 1993). The estimates for NZW and CAL rabbits were 96% and 96% for L6, 93 % and 93% for L8, 91% and 91% for L10 and 89% and 88% for L12, respectively.

Estimates of phenotypic variation (V%) for post-weaning growth traits in both breeds are moderate or relatively high (Table 2). The estimates in NZW ranged from 22.9 to 27.5%, 30.0 to 33.2% and 18.7 to 33.5% for body weight, daily gain and livability, respectively while they ranged from 23.0 to 49.2%, 28.9 to 32.7% and 18.8 to 33.7% for the corresponding traits in CAL rabbits. The estimates in both breeds tended generally to decrease as the rabbit advanced in age; i.e. variation percentages for body weight and daily gain at earlier ages were higher than these estimates at older ages. A reverse trend of V% was observed for livability traits in both breeds. The estimates for NZW and CAL, respectively averaged 28.5 and 36.2 % for early ages of post-weaning growth (5 and 6 weeks) compared with 26.4 % and 26.9 % for later age (12 weeks). Such high estimates of V% lead us to conclude that improvement of growth traits in NZW and CAL rabbits through phenotypic selection is quiet possible. Estimates in V% of the Egyptian studies (Khalil et al, 1987; EL-Maghawry,1990; Khalil et al.,1993) showed a general trend indicating that variation in post-weaning body weights and gains of a certain breed of rabbits decreased with advancing of rabbit's age. This trend was expected since rabbits at young age (5 or 6 weeks) are more sensitive to the non-genetic maternal effects (in terms of lactation, mothering ability, litter size,.... etc) which decrease with advance of age. Also, it could be due to the consequence of the expression of the combination of non-genetic maternal environment (which decreases with advance of age) and the genetic factors (Khalil et al, 1986).

Non-genetic aspects

For each breed separately, least squares means of growth traits in different year-season-parity subclasses are numerous to be represented here. However, post-weaning body weights, gains and livabilities were significantly varied ($P<0.001$) in different year-season-parity subclasses (Tables 3&4).

Post-weaning growth traits of NZW and CAL rabbits born during autumn were significantly higher than those born during winter and spring. High values of F-ratios in ANOVA reveal also that litter size in which rabbit was born contributed significantly to the variance of most body weights and gains of NZW and CAL rabbits. Therefore, litter size at birth was one of the most important non-genetic maternal factors influencing post-weaning growth performance of such two breeds of rabbits. With NZW and CAL rabbits raised in Egypt, El-Maghawry (1990) found that litter size at birth had significant effects ($P<0.05$ or $p<0.01$) on body weights and/or gains at different ages. For selection and improvement policies in NZW and CAL rabbits raised in Egypt, deriving some sets of litter-size-correction factors for post-weaning weights and gains is recommended (Khalil et al., 1993).

Least squares means given in Table 5 indicate that the highest weights of body were recorded by rabbits born in small-sized litters (≤ 5 young). For daily gains and livability traits, no definite trend could be drawn in different litter-size subclasses in both breeds (Tables 6&7).

Variance components

For both breeds, differences in all post-weaning growth traits due to sire effect were high and significant except weight at 6 weeks in CAL (Tables 3&4). In Egypt, some investigators reported non-significant sire effect on growth traits in rabbits (Khalil & Khalil, 1991; El-Maghawry, 1990; Khalil et al., 1993), while others reported significant effect (Khalil et al., 1987). Khalil et al. (1987) with

Bouscat rabbits found that sire affected significantly most growth traits ($P \leq 0.05$), while it had no significant effect on weight at 12 weeks. Khalil et al (1993) with NZW and CAL rabbits reported insignificant sire effect on post-weaning body weights and daily gains from 5 up to 12 weeks at different age stages ($P<0.001$), but El-Maghawry (1993) with NZW reported significant sire effects for most post-weaning daily gains studied. For CAL rabbits, the later author found that sire effects on post-weaning daily gains were non-significant .

The variance components estimated using REML along with percentages of variation (V%) attributed to the sire and remainder for post-weaning growth traits in NZW and CAL rabbits are shown in Table 8. For most post-weaning growth traits of both breeds, percentages of sire component of variance obtained by REML procedure were low or relatively moderate, reflecting the large environmental components of variance associated with the sire (Khalil et al., 1987). The estimates for NZW rabbits ranged from 1.2 to 12.5% for body weights, 3.7 to 13.1% for daily gains and 3.2 to 13.5% for livability traits. The respective estimates in CAL ranged from 1.7 to 6.3%, 1.7 to 4.4% and 0.0 to 2.1%. However, reviewed percentages of variation estimated by REML show that the contribution of sire was generally low or moderate (Lukefahr, 1992; El-Raffa, 1994; Hassan, 1995). These reviewed estimates ranged from 3.77 to 13.01% for body weights and 13.44% for daily gains and 4.01% for livability in NZW. This low variation of sire may be due to that system of feeding and management practices might have masked the full expression of non-genetic paternal differences of sire.

Sire heritabilities

Sire heritabilities estimated for post-weaning growth traits in NZW and CAL rabbits are given in Table 8. In general, heritability values decreased from weaning weight at 5 weeks up to 12 weeks. Earlier (5-6 weeks) and later (12 weeks) individual weights seem to be good traits for selection due to moderate estimates of h^2. This notation is in agreement with those reported by Khalil et al. (1986) and Ferraz et al. (1991). However, sire heritabilities in the present study were similar to those estimates obtained in some Egyptian studies (Khalil et al., 1987; Afifi et al., 1992; Khalil et al., 1993). Other studies on NZW and CAL breeds raised in hot Brazilian climatic conditions showed low sire heritabilites for post-weaning growth traits (Ferraz et al., 1991 & Ferraz et al., 1992; Ferraz and Eler, 1996).

Sire heritabilities estimated by REML procedure for most growth traits in NZW and CAL rabbits were low or relatively moderate (Table 8). Small estimates of most sire heritabilities obtained here for post-weaning growth traits could be attributed: (1) to the small sample size of progeny per generation (Ferraz et al., 1992; Khalil et al., 1993), (2) to the small number of progeny per sire (El-Maghawry, 1990; Ferraz et al., 1991&1992; Khalil et al., 1993), (3) to the non-randomness in the distribution of progeny within sire groups (Khalil et al., 1993), and (4) to the sampling error (Khalil et al, 1986). The systematic matings generated a homogenous number of progeny per sire and a sufficient number of sires providing connections between cells. With balanced data, Reverter et al. (1994) noted that REML produces the same estimators as ANOVA methods (Corbeil and Searle, 1976; Anderson et al., 1984).

Although all estimates of heritability are generally low, heritabilities estimated for all growth traits and livabilities in NZW rabbits are higher than the corresponding estimates in CAL rabbits (Table 8). The heritabilities ranged from 0.087 to 0.299 in NZW vs 0.00 to 0.277 in CAL for body weights, 0.137 to 0.304 in NZW vs 0.087 to 0.177 in CAL for daily gains and 0.154 to 0.281 in NZW vs 0.072 to 0.154 in CAL for livability rates.

Sire transmitting ability (STA)

Considering all sires of both breeds, the minimum and maximum estimates of STA along with their ranges are presented in Table 9. For body weights of NZW at 5, 6, 8, 10 and 12 weeks, there were differences of 143.3, 165.3, 106.2, 72.8 and 118.2 grams, respectively. The same trend of differences was observed for daily gains (6.30, 4.41, 3.94 and 6.56 grams, respectively) and livability (30.2, 26.7, 24.2 and 15.4 % respectivily). Using the Animal Model, STA estimated by Hassan (1995) ranged from -78 to 90 grams for weaning weight and from -8.9 to 10.7% for livability in NZW rabbits. When considering the top ten percent of sires (Table 9), we can find that the differences between maximum and minimum values in STA were smaller than that when considering all the sires list. For most growth traits in both breeds, the differences in STA of the top ten percent of sires were moderate.

Table 10 shows the distribution of the absolute differences among the estimates of STA. For body weight at different ages, there were about 81 to 85% of the NZW sires (47 sires out of 59) and 77 to 80% of the CAL sires (30 sires out of 39) representing an absolute difference of less than 40 grams. For daily gains of both breeds, the largest number of sires was found in the smallest absolute difference and the smallest number of sires was found in the largest absolute difference. Similar trends were observed for livability in NZW and CAL rabbits., Hassan (1995) reported that there were 16.3, 23.3 and 7% of the sires having absolute differences of <10, 10-30 and 30-50 grams for weaning weight, respectively and 11.6, 27.9 and 9.3% of the sires having absolute differences of <1, 2-5 and 6-10% for livability at weaning.

Among all sires in both breeds, percentages of sires with positive estimates of STA ranged from 46.2 to 61.0% for body weights, 46.2 to 55.9% for daily gains and 51.3 to 66.1 % for livability (Table 11). The positive estimates of STA in NZW rabbits were higher than the corresponding estimates in CAL rabbits, i.e. genetic improvement of post-weaning growth traits through sires selection in NZW rabbits could be more effecting than in CAL rabbits. Among all growth traits, the largest percentages of positive STA were recorded for livabilities followed by daily gains and body weights.

Conclusion

- Moderate means of post-weaning growth traits reported here and those reviewed from literature for NZW and CAL rabbits raised in Egypt indicate that the genetic potentiality of these two standard breeds raised in adverse environment is not completely expressed in Egypt. This is due to NZW and CAL rabbits were raised in Egypt under unsuitable climatic and managerial conditions. Also, genotype-environment interaction could be a limiting factor.
- Although the performance of these two breeds is moderate, they could be used as an effective meat-type breeds in adverse environment. Moreover, these moderate rates of growth are one of the encouraging factors to use these exotic breeds in Egypt on a large scale of commercial production.
- From the genetic point of view, there is a potentiality for a moderate improvement in post-weaning growth traits in NZW and CAL rabbits raised in adverse environment through sires selection. Short generation interval in these two breeds of rabbits could accelerate this improvement.

Table 1. Distribution of data of post-weaning growth traits collected according to breed and year of kindling.

Item	New Zealand White			Californian		
	1st year +	2nd year	3rd year	1st year	2nd year	3rd year
Number of sires	23	28	23	17	16	15
Number of dams	70	85	82	62	42	41
Number of litters born	242	192	182	205	91	91
Number of litters weaned	167	153	171	138	71	77
Number of bunnies born	1706	1274	1136	1366	572	570
Number of bunnies weaned	1201	578	512	970	328	340

+First year started in September 1989, while second and third years started in September 1990 and September 1991, respectively.

Table 2. Means, standard deviations (SD) and errors (SE) and percentages of variation (V%) for Post-weaning growth traits at different ages in New Zealand White and Californian rabbits.

Trait+	New Zealand White					Californian				
	No.	Mean	SD	SE	V%	No.	Mean	SD	SE	V%
Body Weight (grams):										
W5	2465	560.8	161.0	3.24	24.7	1380	518.5	156.1	4.20	26.8
W6	2465	658.9	209.8	4.23	27.5	1380	621.0	315.1	8.48	49.2
W8	2373	934.0	257.7	5.29	24.1	1328	868.8	237.7	6.52	24.0
W10	2314	1242.0	355.7	7.39	25.4	1295	1156.2	301.1	8.37	23.0
W12	2251	1604.2	419.2	8.83	22.9	1260	1491.1	404.9	11.41	23.0
Daily Gain (grams):										
DG6	2465	15.8	5.9	0.12	33.2	1380	15.6	5.8	0.16	32.7
DG8	2373	18.7	7.0	0.14	32.8	1328	17.3	6.1	0.17	30.5
DG10	2314	21.5	7.6	0.16	31.6	1295	20.4	6.6	0.18	28.9
DG12	2251	25.4	8.6	0.18	30.0	1260	24.3	8.6	0.24	30.8
Livability (%):										
L6	2465	0.96	0.19	0.004	18.7	1380	0.96	0.19	0.005	18.8
L8	2465	0.93	0.24	0.005	24.4	1380	0.93	0.24	0.006	24.5
L10	2465	0.91	0.28	0.006	29.4	1380	0.91	0.28	0.007	29.7
L12	2465	0.89	0.31	0.006	33.5	1380	0.88	0.32	0.009	33.7

+W5= 5-week weight; W6= 6-week weight; W8= 8-week weight; W10= 10-week weight; W12= 12-week weight; DG6= 5-6 week gain, DG8= 6-8 week gain; DG10= 8-10 week gain; DG12= 10-12 week gain; L6= livability at 6 weeks; L8= livability at 8 weeks; L10= livability at 10 weeks; L12= livability at 12 weeks.

Table 3. F-ratios of least-square ANOVA of factors affecting post-weaning body weights in New Zealand White and Californian rabbits.

Source	D.F	W5	W6	W8	W10	W12
New Zealand white:						
Sire	58	3.5***	4.0***	2.3***	2.8***	1.8***
Sex	1	1.1ns	0.6ns	0.9ns	0.6ns	0.0ns
Year-season-parity	30	8.9***	11.0***	13.0***	13.1***	15.2***
Litter size at birth	9	16.1***	12.0***	11.2***	5.8***	5.5***
Remainder d.f		2366	2366	2274	2215	2152
Remainder mean squares		19243	32893	50654	99841	135199
Californian:						
Sire	38	2.7***	1.0ns	1.8**	1.4*	2.7***
Sex	1	2.9ns	3.0ns	0.9ns	0.1ns	1.1ns
Year-season-parity	30	5.2***	2.3***	8.1***	7.2***	9.7***
Litter size at birth	9	16.7***	3.0**	9.5***	8.2***	5.3***
Remainder d.f		1301	1301	1249	1216	1181
Remainder mean squares		19244	93506	43305	70428	117187

Traits as defined in Table 2.
ns= non-significant; *= P<0.05; **= P<0.01; ***= P<0.001.

Table 4. F-ratios of least-square ANOVA of factors affecting daily gains and livabilities in New Zealand White and Californian rabbits.

		Daily gain in weight+				livability+			
Source	D.F	DG6	DG8	DG10	DG12	L6	L8	L10	L12
New Zealand white:									
Sire	58	4.0***	2.4***	2.2***	2.6***	3.8***	3.0***	2.9***	2.5***
Sex	1	3.3ns	2.6ns	0.4ns	0.2ns	0.6ns	0.2ns	0.4ns	0.0ns
Year-season-parity	30	12.3***	16.9***	14.9***	17.4***	4.2***	3.8***	4.8***	4.5***
Litter size at birth	9	4.6***	2.3*	2.1*	2.9**	0.6ns	1.1ns	1.2ns	1.4ns
Remainder d.f		2366	2274	2215	2152	2366	2366	2366	2366
Remainder mean squares		27.48	37.5	46.12	57.73	3.2	5.2	7.1	8.9
Californian:									
Sire	38	2.1***	2.3***	1.6*	2.3***	2.0***	1.5*	1.6*	2.1***
Sex	1	1.1ns	0.4ns	0.4ns	3.9*	0.7ns	0.4ns	0.4ns	0.0ns
Year-season-parity	30	8.4***	10.7***	8.6***	10.1***	3.6***	3.1***	3.9***	3.9***
Litter size at birth	9	2.2*	1.1ns	1.5ns	1.5ns	0.8ns	0.9ns	1.5ns	1.4ns
Remainder d.f		1301	1249	1216	1181	1301	1301	1301	1301
Remainder mean squares		25.9	27.0	34.82	56.12	3.3	5.3	7.1	9.2

Traits as defined in Table 2.

ns= non-significant: *= P<0.05; **= P<0.01; ***= P<0.001.

Table 5. Lest square means of post-weaning body weights in different litter-size subgroups in New Zealand White and Californian rabbits.

Litter size	W5		W6		W8		W10		W12	
at birth	No.	Mean ± SE	No.	Mean ± SE	No.	Mean ± SE	No.	Mean ± SE	No.	Mean ± SE
New Zealand White :										
2	29	494±39.7	29	799±39.5	28	1143±47.2	28	1436±65.2	28	1818±76.1
3	26	372±31.4	26	784±41.7	26	1004±49.3	25	1366±69.3	25	1621±80.9
4	151	594±27.5	151	688±23.9	146	960±25.4	140	1273±33.9	136	1619±40.1
5	208	610±26.5	208	700±22.8	204	994±23.6	201	1249±30.8	196	1640±36.5
6	439	569±14.5	439	666±20.3	425	922±19.8	412	1225±24.9	403	1585±29.5
7	513	555±14.4	513	646±20.1	496	915±19.4	482	1206±24.4	465	1574±28.9
8	489	532±14.4	489	617±20.2	457	896±19.5	446	1189±24.5	431	1569±29.1
9	314	596±25.4	314	576±21.4	302	826±21.6	294	1107±27.7	284	1440±32.9
10	177	526±27.4	177	608±23.9	172	883±25.4	171	1180±33.4	169	1528±39.3
≥11	119	508±29.0	119	601±25.8	117	851±28.1	115	1179±37.7	114	1502±44.1
Californian :										
2	13	780±43.0	13	848±90.4	13	1143±63.1	13	1431±79.9	13	1600±107.4
3	25	582±32.7	25	666±66.3	25	924±47.3	23	1287±61.3	23	1649±084.3
4	85	624±21.6	85	695±38.2	83	949±29.7	80	1267±36.7	78	1534±056.1
5	116	620±20.3	116	665±34.7	108	988±28.0	105	1255±34.4	103	1624±053.4
6	267	509±16.6	267	561±23.1	256	832±21.1	245	1084±24.9	233	1431±043.6
7	234	500±17.2	234	589±25.0	223	828±22.1	218	1102±26.1	211	1404±044.8
8	337	495±06.3	337	573±22.0	324	827±205	317	1117±23.8	314	1420±042.4
9	196	512±18.0	196	575±27.7	190	860±23.5	189	1095±28.1	182	1445±046.9
10	51	422±26.3	51	498±50.5	50	747±37.2	50	987±46.3	48	1248±067.0
≥11	56	535±26.2	56	576±52.0	56	836±38.3	55	1114±48.1	55	1441±068.6

Traits as defined in Table 2.

Table 6. Lest square means of post-weaning daily gains in different litter-size subgroups in New Zealand White and Californian rabbits.

Litter size at birth	DG6 No.	DG6 Mean + SE	DG8 No.	DG8 Mean + SE	DG10 No.	DG10 Mean + SE	DG12 No.	DG12 Mean + SE
New Zealand White:								
2	29	19.6±1.0	28	21.2±1.3	28	22.4±1.4	28	27.1±1.6
3	26	17.5±1.2	26	17.2±1.3	25	21.9±1.5	25	24.5±1.7
4	151	16.4±0.7	146	18.7±0.7	140	21.4±0.8	136	23.5±0.9
5	208	14.8±0.7	204	19.1±0.7	201	21.1±0.7	196	25.7±0.9
6	439	15,6±0.6	425	18.3±0.5	412	21.0±0.6	403	24.9±0.7
7	513	15.6±0.6	496	18.4±0.5	482	21.2±0.6	465	24.7±0.7
8	489	15.0±0.6	457	18.5±0.5	446	21.6±0.6	431	25.8±0.7
9	314	14.4±0.6	302	17.0±0.6	294	19.5±0.7	284	23.2±0.8
10	177	14.7±0.7	172	18.6±0.7	171	20.7±0.8	169	24.0±0.9
≥11	119	15.5±0.8	117	18.2±0.8	115	22.0±0.9	114	25.2±1.0
Californian								
2	13	780±43.0	13	19.7±1.6	13	18.8±1.8	13	28.6±2.3
3	25	582±32.7	25	17.2±1.2	23	20.8±1.4	23	26.4±1.8
4	85	624±21.6	83	16.5±0.8	80	19.4±0.8	78	22.0±1.2
5	116	620±20.3	108	17.8±0.8	105	19.6±0.8	103	24.0±1.1
6	267	509±16.6	256	16.6±0.6	245	18.7±0.6	233	23.2±0.9
7	234	500±17.2	223	16.6±0.6	218	19.7±0.6	211	23.2±0.9
8	337	495±06.3	324	16.4±0.6	317	19.9±0.6	314	23.5±0.9
9	196	512±18.0	190	17.0±0.7	189	19.1±0.6	182	23.9±1.0
10	51	422±26.3	50	15.7±1.0	50	17.4±1.0	48	20.6±1.4
≥11	56	535±26.2	56	15.4±1.0	55	17.7±1.1	55	21.6±1.5

Traits as defined in Table 2.

Table 7. Lest square means of livability in different litter-size subgroups in New Zealand White and Californian rabbits.

Litter size at birth	No.	L6 Mean ± SE	L8 Mean ± SE	L10 Mean ± SE	L12 Mean ± SE
<u>New Zealand White :</u>					
2	29	0.94±0.03	0.93±0.04	0.92±0.05	0.91±0.06
3	26	0.95±0.04	0.88±0.05	0.87±0.05	0.79±0.06
4	151	0.94±0.02	0.89±0.02	0.85±0.03	0.82±0.03
5	208	0.96±0.02	0.96±0.02	0.92±0.02	0.90±0.03
6	439	0.96±0.01	0.92±0.02	0.90±0.02	0.86±0.02
7	513	0.95±0.01	0.91±0.02	0.86±0.02	0.83±0.02
8	489	0.94±0.01	0.91±0.02	0.87±0.02	0.84±0.02
9	314	0.93±0.02	0.90±0.02	0.86±0.02	0.82±0.02
10	177	0.94±0.02	0.91±0.02	0.89±0.03	0.87±0.03
≥11	119	0.95±0.02	0.91±0.03	0.88±0.03	0.82±0.03
<u>Californian</u>					
2	13	0.92±0.05	0.90±0.06	0.91±0.08	0.81±0.09
3	25	0.91±0.04	0.81±0.05	0.78±0.05	0.74±0.06
4	85	0.92±0.02	0.87±0.03	0.86±0.03	0.82±0.04
5	116	0.87±0.02	0.84±0.02	0.80±0.03	0.79±0.04
6	267	0.90±0.01	0.86±0.02	0.81±0.02	0.78±0.03
7	234	0.90±0.01	0.86±0.02	0.82±0.02	0.77±0.03
8	337	0.92±0.01	0.88±0.02	0.86±0.02	0.83±0.03
9	196	0.90±0.02	0.88±0.02	0.82±0.02	0.80±0.03
10	51	0.94±0.03	0.92±0.03	0.91±0.04	0.86±0.05
≥11	56	0.95±0.03	0.91±0.04	0.91±0.04	0.92±0.05

Traits as defined in Table 2.

Table 8. Estimates of variance components and sire heritabilities (h^2) estimated using and REML for post-weaning growth traits in New Zealand White rabbits.

Trait	Sire		Remainder			$h^2 \pm$S.E
	σ^2_s	v%	σ^2_e	v%	σ^2_e/σ^2_s	
Body Weight:						
W5	1849	8.7	19343	91.3	10.5	0.349±0.120
W6	4743	12.5	33118	87.5	7.0	0.501±0.165
W8	1792	3.4	51059	96.6	28.5	0.136±0.049
W10	1242	1.2	100878	98.8	81.2	0.049±0.018
W12	2407	1.7	136078	98.3	56.5	0.070±0.026
Daily gain:						
DG6	4.18	13.1	27.68	86.9	6.6	0.518±0.170
DG8	1.80	4.6	37.71	95.4	20.9	0.182±0.065
DG10	1.72	3.7	46.52	96.4	27.0	0.142±0.053
DG12	3.19	5.2	58.06	94.8	18.2	0.208±0.074
Livability:						
L6	0.5	13.5	3.2	86.5	6.4	0.502±0.018
L8	0.4	7.0	5.3	93.0	13.2	0.277±0.097
L10	0.4	5.2	7.3	94.8	18.2	0.212±0.076
L12	0.3	3.2	9.1	96.8	30.3	0.106±0.039

Traits as defined in Table 2.

Table 9. Estimates of variance components and sire heritabilities (h^2) estimated using REML for post-weaning growth traits in Californian rabbits.

Trait	Sire		Remainder			
	σ^2_s	v%	σ^2_e	v%	σ^2_e/σ^2_s	$h^2 \pm$S.E
Body Weight⁺:						
W5	1121	5.5	19206	94.5	17.1	0.221±0.097
W8	1002	2.3	43456	97.7	43.4	0.090±0.041
W10	1195	1.7	70368	98.3	59.9	0.067±0.031
W12	8052	6.3	118028	93.7	14.6	0.256±0.112
Daily gain⁺:						
DG6	0.97	3.6	25.87	96.4	26.7	0.144±0.065
DG8	0.53	1.8	28.51	98.2	54.0	0.073±0.034
DG10	0.62	1.7	34.98	98.3	56.4	0.070±0.032
DG12	2.64	4.4	56.60	95.6	21.4	0.178±0.079
Livability⁺:						
L6	0.04	1.2	3.4	98.2	85.0	0.041±0.019
L8	0.03	2.2	5.4	97.8	180	0.021±0.010
L10	0.1	1.3	7.2	98.7	72.0	0.035±0.016
L12	0.2	2.1	9.3	97.9	46.5	0.088±0.040

[a] Negative estimate of sire component of variance was obtained for **W6**.

⁺Traits as defined in Table 2.

Table 10 : Minimum and maximum estimates of sire transmitting abilities estimated by an Animal Model for post-weaning growth traits in New Zealand White and Californian rabbits.

Trait[+]	New Zealand White				Californian			
	All sires			Top 10 % of sires	All sires			Top 10 % of sires
	Minimum	Maximum	Range	Range	Minimum	Maximum	Range	Range
Body Weight (grams):								
BW5	-91.7	51.6	143.3	13.6	-48.2	48.9	97.1	28.7
BW6	-109.7	55.6	165.3	14.5	a	a	a	a
BW8	-59.9	46.3	106.2	21.1	-31.1	34.6	65.7	22.5
BW10	-34.0	38.8	72.8	23.8	-37.9	34.7	72.5	25.7
BW12	- 61.0	57.2	118.2	30.6	-232.8	93.7	326.5	56.0
Daily Gain (grams):								
DG1	-3.15	3.15	6.30	2.13	-1.21	1.31	2.52	0.94
DG2	-1.75	2.66	4.41	1.71	-1.08	1.00	2.08	0.67
DG3	-2.19	1.75	3.94	0.77	-1.01	0.75	1.76	0.47
DG4	-3.33	3.23	6.56	2.11	-2.09	2.75	4.84	2.05
Livability(%):								
L6	-20.2	10.0	30.2	6.1	-2.7	1.4	4.1	0.9
L8	-18.4	8.3	26.7	4.4	-1.5	1.5	3.0	1.1
L10	-15.6	8.6	24.2	4.9	-3.4	2.5	5.9	1.7
L12	-9.7	5.7	15.4	2.6	-7.2	4.2	11.4	2.3

[+]Traits as defined in Table 2.

Number of sires used for evaluation were 59 and 39 sires in New Zealand White and Californian rabbits, respectively.

[a] Negative estimate of sire component of variance set to zero.

Table 11. The distribution of the absolute difference among sire transmitting ability (STA) estimated using an Animal Model for post-weaning growth traits in New Zealand White and Californian rabbits.

Trait[+]	Absolute difference	NZW No. of sires	NZW %	CAL No. of sires	CAL %	Trait	Absolute difference	NZW No. of sires	NZW %	CAL No of sires	CAL %
Body weight (grams):						**Daily gain in weight:**					
W5	<10	15	25.4	9	23.1	**DG1**	<0.5	22	37.3	26	66.7
	10-19	7	11.9	13	33.3		0.5-1.0	16	27.1	9	23.1
	20-29	12	20.3	7	18.0		>1.0	21	35.6	4	10.3
	30-39	10	17.0	4	10.3						
	40-49	6	10.2	6	15.4	**DG2**	<0.5	24	40.7	33	84.6
	50-59	5	8.5	0	00.0		.5-1.0	17	28.8	4	10.3
	>60	4	6.8	0	00.0		>1.0	18	30.5	2	5.1
W6	<10	15	25.4	a	a	**DG3**	<0.5	25	42.4	30	76.9
	10-19	7	11.9				.5-1.0	14	23.7	8	20.5
	20-29	7	11.9				>1.0	20	33.9	1	2.6
	30-39	12	20.3			**DG4**	<0.5	11	18.6	8	20.5
	40-49	8	13.6				.5-1.0	19	32.2	19	48.7
	50-59	4	6.8				>1.0	29	49.2	12	30.8
	>60	6	10.2								
						Livability (%):					
W8	<10	17	28.8	19	48.7	**L6**	<5	42	71.2	21	53.9
	10-19	15	25.4	11	28.2		5-10	13	22.0	10	25.6
	20-29	14	23.7	6	15.4		>10	4	6.8	8	20.5
	30-39	6	10.2	3	7.7						
	40-49	6	10.2	0	0.0	**L8**	<5	47	78.7	26	66.7
	50-59	1	1.7	0	0.0		5-10	8	13.6	9	23.1
	>60	0	0.0	0	0.0		>10	4	6.8	4	10.3
W10	<10	27	45.8	18	46.2	**L10**	<5	45	76.3	15	38.5
	10-19	21	35.6	10	25.6		5-10	12	20.3	15	38.5
	20-29	7	11.9	7	18.0		>10	2	3.4	9	23.1
	30-39	4	6.8	4	10.3						
	>40	0	0.0	0	0.0	**L12**	<5	51	86.4	6	15.4
							5-10	8	8.5	5	12.8
W12	<10	15	25.4	4	10.3		>10	0	0.0	28	71.8
	10-19	15	25.4	3	7.7						
	20-29	14	23.7	7	18.0						
	30-39	8	13.6	6	15.4						
	40-49	4	6.8	1	2.6						
	50-59	2	3.4	3	7.7						
	>60	2	3.4	15	38.5						

[+]Traits as defined in Table 2.

[a] Estimates of **STA** were not obtained due to that estimate of sire component of variance was negative.

Table 12. Percentages of positive sire transmitting ability estimated using an Animal model for post-weaning growth traits in New Zealand White and Californian rabbits.

	NZW		CAL	
	No. of sires	%	No of sires	%
Body Weight (grams):				
BW5	33	55.9	19	48.7
BW6	33	55.9	a	a
BW8	30	50.6	18	46.2
BW10	30	50.6	20	51.3
BW12	36	61.0	19	48.7
Daily gain (grams):				
DG1	31	52.5	21	53.9
DG2	30	50.6	18	46.2
DG3	33	55.9	19	48.7
DG4	29	49.2	18	46.2
Livability (%):				
L6	39	66.1	23	59.0
L8	35	59.3	24	61.5
L10	36	61.0	20	51.3
L12	22	54.2	22	56.4

Traits as defined in Table 2.

[a] Estimates of STA were not obtained due to that negative estimate of sire component of variance was obtained.

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الملخص العربي

تقدير المقدرة التمريرية للأباء لصفات النمو لأرانب النيوزيلندي الأبيض والكاليفورنيا المرباة في الظروف المصرية للمناخ الحار باستخدام نموذج الحيوان

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**معهد بحوث الإنتاج الحيواني – مركز البحوث الزراعية

أجريت هذه الدراسة في مزرعة كلية الزراعة بمشتهر على سلالتين من الأرانب هما النيوزيلندي الأبيض والكاليفورنيا بهدف تقييم الأداء الوراثي لصفات وزن الجسم ومعدلات النمو ونسبة الأحياء في الفتره من عمر ٥ الى ١٢ أسبوع ، أستخدم فى ذلك التقييم عدد ٢٢٩١ أرنب نيوزيلندى ، ١٦٢٨ أرنب كاليفورنيا مفطوم. كما تم تقدير مكونات التباين وكذلك المكافئ الوراثي لهذه الصفات بطريقة معظمة الاحتمال المقيدة (REML) كما قدرت قيم المقدرة التمريرية للأباء لهذه الصفات باستخدام نموذج الحيوان وحيد الصفة Single-trait Animal Model

أظهرت النتائج أن مكونات التباين والمقدرة من الأباء بطريقة (REML) كانت منخفضة أو متوسطة إلى حد ما حيث تراوحت النسبة المئوية للتباين الراجع إلى الأب لصفات النمو في كل من السلالتين بين صفر إلى ١٢.٥% لأوزان الجسم ومن ١,٧ إلى ١٣.١% لمعدلات الزيادة فى الوزن ومن ١٢.٧ إلى ١٣% لنسبة الأحياء. وبالرغم من أن تقديرات قيم المكافئ الوراثي لتلك الصفات في كل من سلالتي النيوزيلندي الأبيض والكاليفورنيا كانت منخفضة إلا أنها كانت أعلى في سلالة النيوزيلندي الأبيض عنها في سلالة الكاليفورنيا. وقد تراوحت قيم المكافئ الوراثى فى سلالة النيوزيلندى بين ٠,٠٤٩ إلى ٠,٥٠١، ٠,١٤٢ إلى ٠,٥١٨، ٠,١٠٦ إلى ٠,٥٠٢ لصفات وزن الجسم

ومعدلات النمو ونسبة الأحياء على التوالى. بينما كانت القيم المناظرة فى سلالة الكاليفورنيا تتراوح من صفر إلى ٠,٢٥٦، ٠,٠٧ إلى ٠,١٨٤، ٠,٠٢١ إلى ٠,١٥٤ على التوالى. وقد أظهرت النتائج أيضا أن الفروق بين أعلى قيمة وأقل قيمة للمقدرة التمريرية للأباء بالنسبة لصفات النمو ونسبة الأحياء كانت منخفضة أو متوسطة إلى حد ما. وقد أظهرت النتائج أن ٨١-٨٥% من الآباء النيوزليندى لها إنحراف مطلق مقداره أقل من ٤٠ جم فى وزن الجسم بينما أظهرت من ٧٧-٨٠% من الأباء الكاليفورنيا نفس المقدار من الإنحراف. كما كانت نسبة القيم الموجبة للمقدرة التمريرية للأباء متساوية تقريبا في كلا السلالتين المستخدمتين في هذه الدراسة حيث تراوحت النسبة من ٥٠,٦ إلى ٦١% لصفات وزن الجسم، ومن ٤٦,٢ إلى ٥٥,٩% لصفات معدلات النمو، ومن ٥١,٣ إلى ٦٦,١% لصفات نسبة الأحياء.