

GENETIC STUDIES ON SOME ECONOMIC TRAITS IN RABBITS 2-POST-WEANING BODY WEIGHT AND GROWTH RATE

HEKIL, AMAL M.¹, G. M. GEBRIEL², A. A. ENAB², I. A. HAMODA¹
AND F. H. ABDOU²

1. *Animal Production Research Institute, ARC, Ministry of Agriculture Dokky, Giza.*
2. *Faculty of Agriculture, Menofiya University.*

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Abstract

The main objective of the present study is to investigate some genetic aspects such as estimates of heritabilities, genetic and phenotypic correlations between body weight and body gain, genetic gain and heterotic effects of (Nzwzealand) white and (California) rabbits and their crosses. Results obtained could be summarized as follows: Heritability estimates for body weights were high and moderate at 4, 6, 10 and 12 weeks in NZW rabbits, and at 4 weeks in Cal rabbits. The values of NZW rabbits were 0.58, 0.63, 0.53 and 0.43, respectively. In Cal rabbits, the corresponding value was 0.61. The estimates of genetic correlation between records of the different post-weaning body weights and growth rates at different age stages were high and positive in NZW rabbits. Estimates of direct heterosis for body weight was mostly positive and evidenced the existence of heterotic effect as a result of crossing between NZW and Cal rabbits. The heterotic effect was significant ($P < 0.01$) on body weight at 4,6,8,10 and 12 weeks of age, and growth rate during 4 -6, 6-8, 8-10 and 4 -12. Maternal additive effect on post-weaning growth rate was in favour of NZW dams, and significant differences ($P < 0.01$) during 4-6, 6-8 and 4-12.

INTRODUCTION

Many countries bred crossbred rabbits to fulfill desperate need for production of rabbit meat. Specialized sire and dam lines are mated to produce either single crosses F1 and F2 from F1 crosses for crossbreeding programmes through the commercial level.

Crossbreeding is usually used to improve the overall efficiency of a production system by using breeds which have high genetic merit for different traits (complementation). Crossbreeding in commercial rabbit meat to be made by mating females mated to males with faster growth rate and better carcass characteristics (Campos *et al.*, 1980).

Crossbreeding has an advantage over the synthesis of breeds in utilizing the breed differences due to the expected segregation along with recombination of genes (Dickerson, 1992). These different constitutes have important potential sources of genetic improvement, which are reflected on the efficiency of human food production

from rabbits through the expansion of superior breeds, the gains in performance from complementary breed effects and heterosis in crossbreeding and the development of superior new breeds from selected combinations of several breeds (Hanafi and Iraqi, 2001).

MATERIALS AND METHODS

This experiment was carried out at the Rabbit Experimental Farm, Poultry Production Department, Faculty of Agriculture, Minufiya University, Shibin El-Kom, Egypt, to study some genetic aspects such as heritability estimates, genetic and phenotypic correlations between body weights and genetic gain and heterotic effects of New Zealand White (NZW) and Californian (Cal) rabbits and their crosses. Sixteen bucks (8 NZW and 8 Cal) and 48 doe (24 NZW and 24 Cal) were mated in two ways in order to produce a generation of two pure breeds and their crossbreds. They represent two different breed groups, New Zealand White (NZW) and Californian (Cal) purebred as well as (Cal x NZW) and (NZW X Cal) reciprocal crossbreds.

At the start of the experiment, the rabbits were healthy and free from internal and external parasites. The males and females were housed separately in individual-wired cages. The cage of each doe was provided with a metal nest box for kindling and nursing its progeny during the sucking period. Hygiene precaution was taken regularly. Mating started in October till the end of April. Each doe was transferred to the buck cage to be mated according to the mating plan of the experiment. Each doe was palpated after 12 to 14 days to determine pregnancy. The doe which failed to conceive was remitted to the same buck every other day until a service was observed. The nest boxes were supplied with rice straw on the 22nd day of pregnancy to provide a comfortable and warm nest for the young.

Rabbits of nearly similar age were housed in one hutch with a maximum of 10 to 12 individuals. They were housed in galvanized wire cage batteries (60 x 50 x 40 cm). Nipple drinkers and feeders were provided to each cage. Each doe was housed separately in a cage with nest box (40 x 20 x 20 cm). Rabbits were kept as possible under the same environmental and managerial conditions. Rabbits were fed *ad libitum*, and ration was offered two times daily, while fresh water was available all times. The ration contained 19.0 % crude protein, 10.0 % crude fiber and 2800 DE Kcal/Kg ration.

Post-weaning body weight and growth rates up to 12 weeks of age were studied. Individual weaned rabbits were weighed to the nearest gram biweekly starting from 4 to 12 weeks of age. Relative growth rates (GR) were calculated

biweekly intervals up to 12 weeks. Relative growth rate was calculated according to formula given by Brody (1945) as follows :-

$$\text{Growth rate} = \frac{W_2 - W_1}{1/2 (W_1 + W_2)} \times 100$$

were:-

W1 = weight at the beginning of the period.

W2 = weight at the end of the period.

Statistical analysis

Heritability estimates

Each buck from NZW and Cal rabbits were mated with three does within the same breed. Litter size at birth (LSB) produced from 5.25 and 4.90 parities as average were about 89.64 and 86.81 in both NZW and Cal rabbits, respectively. Heritability was estimated by paternal half sib method according to Harvey (1990) with the following equation:-

$$h_s^2 = \frac{4\sigma_s^2}{\sigma_s^2 + \sigma_e^2}$$

Where: σ^2_s = Sire variance component σ^2_e = Residual variance component

Genetic and phenotypic correlations

Genetic and phenotypic correlations were estimated according to Harvey (1990) with the following equation:-

$$r_{G_{sxy}} = \frac{\text{COV}.s_{xy}}{\sqrt{v_{s_x} \cdot v_{s_y}}}$$

$$r_{p_{xy}} = \frac{\text{COV } p_{xy}}{\sqrt{V_{p_x} \cdot V_{p_y}}}$$

Which

$r_{G_{sxy}}$ = Genetic correlation between two considered traits (x and y),

$\text{Cov}.s_{xy}$ = Covariance of sire component between two traits,

v_{s_x} = Variance of sire component for the trait x,

v_{s_y} = Variance of sire component for the trait y,

$r_{p_{xy}}$ = Phenotypic correlation between two considered traits (x and y),

$\text{cov } p_{xy}$ = Phenotypic covariance between two traits,

V_{p_x} = Phenotypic variance for the trait x

V_{p_y} = Phenotypic variance for the trait y.

Analysis for crossbreeding data

Crossbreeding effects (purebred difference, direct heterotic effect, maternal additive effect and direct additive effect) on different traits were estimated according to the genetic model shown in the Table 1 according to Dickerson (1992).

Table 1. Genetic model of analysis for crossbreeding data.

Item	Genotype				
	NZW	Cal	NZW (M) x Cal (F)	Cal (M)x	NZW (F)
Purebred differences	1	-1	0	0	0
Direct heterosis effect	-1	-1	1	1 / (Devisor 2)	
Maternal additive effect	0	0	-1	1	
Direct additive effect	1	1	1	-1 / (Devisor 2)	

M : male F : female

* Buck or sire breed is listed before doe or dam breed.

Such genetic model permits to derive a selected sets of contrasts (Harvey, 1987 i.e. purebred difference, heterotic effect, maternal additive effective and direct additive effect). The following linear contrast of mating group least-squares means were computed to quantify differences alternates attributable to sire breed, dam breed and direct heterotic effects as follows:

Purebred differences

$$(G^i \text{ NZW} + G^m \text{ NZW}) - (G^i \text{ Cal} + G^m \text{ Cal}) = (\text{NZW} + \text{NZW}) - (\text{Cal} + \text{Cal})$$

Direct heterotic effect or direct hetrosis (units)

$$H^i (\text{NZW} \times \text{Cal}) = [(\text{NZW} \times \text{Cal} + \text{Cal} \times \text{NZW}) - (\text{NZW} \times \text{NZW} + \text{Cal} \times \text{Cal})]$$

Maternal additive effect (i.e. reciprocal crossbred difference)

$$(G^m \text{ NZW} - G^m \text{ Cal}) = [(\text{NZW} \times \text{Cal}) - (\text{Cal} \times \text{NZW})]$$

Direct additive effect (i.e. breed group of sire differences)

$$(G^i \text{ NZW} - G^i \text{ Cal}) = [(\text{NZW} \times \text{NZW}) + (\text{NZW} \times \text{Cal})] - [(\text{Cal} \times \text{Cal}) + (\text{Cal} \times \text{NZW})]$$

Where

G^i and G^m represent direct additive and maternal additive effects, respectively, of the subscripted genetic group. Each single degree of freedom contrast was tested for significance with the students t-test.

Genetic gain

The expected genetic gains (ΔGE) were calculated according to the following formula.

$$\Delta GE = S h^2$$

Where: S = Selection differentials. h^2 = Heritability of the traits.

RESULTS AND DISCUSSION

1. Paternal heritability

Estimates of heritabilities for body weight and growth rate are presented in Tables 2 and 3. These estimates indicate that heritability estimates for body weights were high and moderate at 4, 6, 10 and 12 weeks in NZW rabbits, and at 4 weeks in Cal rabbits. Low estimates were observed at 8 weeks in NZW rabbits, and at 6, 10 and 12 weeks of age in Cal rabbits. The values of heritability estimated of NZW rabbits were 0.58, 0.63, 0.15, 0.53 and 0.43 at 4, 6, 8, 10 and 12 weeks, respectively. In Cal rabbits, the corresponding values were 0.61, 0.09, 0.11 and 0.23 at 4, 6, 10 and 12 weeks of age, respectively. These high estimates of heritability at 4 weeks of age would indicate that response to selection for body weight at 4 weeks is promising. Individual weight seems to be good trait for selection due to the relatively high estimates of heritability. Moreover, Abdou *et al.* (2006) suggested that higher estimates of sire heritability for weaning weight indicated that selection for weaning weight will give greater improvement in body weight at marketing. Also, they indicated that the importance to plan specialized selection programmes of sires.

On the other hand, El-Raffa (2005) reported that the moderate and low heritability estimates of the body weight could be explained by the small amount of genetic variability in the population and the moderate standard of hygiene and the uniformity of the environment.

Estimates of heritabilities for post-weaning growth rate were (0.79 vs 0.90), (0.35 vs 0.36), (0.44 vs 0.49), (0.20 vs 0.48) and (- vs 0.78) during intervals 4-6, 6-8, 8-10, 10-12 and 4-12 weeks of age of both NZW and Cal rabbits, respectively. These estimates agree with those estimated by Youssef, 2004 and El-Deghadi, 2005.

2. Genetic correlation and Phenotypic correlation

a. Genetic correlation (r_G)

The estimates of genetic correlation (r_G) between records of the different post-weaning body weights and growth rates at different age stages were high and positive between body weight at 4 wk and growth rate during periods 8-10 and 10-12 wk (Table 4). The same trend was noticed between body weight at 6 wk and growth rate during periods 8-10 and 10-12 wk, and between body weight at 10 wk and growth rate during period 10-12 wk, low and positive between body weight at 12 wk and growth rate during period 4-12 wk in NZW rabbits. In Cal rabbits, there were high and negative genetic correlations between body weight at 4 wk and growth rate during periods 4-6, 6-8, 8-10 and 10-12 wk, between body weight at 6 wk and growth rate during periods 6-8, 8-10 and 10-12 wk, between body weight at 8 wk and growth rate during period 10-12 wk. Low and negative correlations were noticed

between body weight at 8 wk and growth rate during period 8-10 wk, between body weight at 10 wk and growth rate during period 10-12 wk and between body weight at 12 wk and growth rate during period 4-12 wk (Table 4). These estimates fall within the range of reviewed estimates obtained by Enab, 2001 and El-Raffa., 2005.

The magnitude and signs of the unexpected correlations obtained in the present study may be due to sampling errors. In this respect, Khalil *et al.*, (1986) concluded that bias in (r_G) estimates may be due to a lack of appropriate correction factors for possible environmental influences and selection.

b. Phenotypic correlation (r_P)

All possible phenotypic correlation (r_P) estimates between body weights and growth rates at different ages in both NZW and Cal rabbits are presented in Table (4). In general, there were high and negative phenotypic correlation observed between body weight at 4 wk with growth rates during periods 4-6, 6-8 and 8-10 wk. The same trend was noticed between body weight at 6 wk with growth rates during periods 6-8 and 8-10 wk with, and between body weight at 8 wk with growth rates during period 8-10 wk period. The moderate genetic and negative correlation was observed between body weights at 4, 6, 8 and 10 wk with growth rate during period 10-12 wk, and between body weight at 12 wk with growth rate during periods 4-12 wk in both NZW and Cal rabbits Table (4). These estimates are nearly similar with those obtained by (El-Raffa, 2005).

However, positive (r_P) between two weights do not necessarily indicate that selecting on one of these weights will lead to an improvement in the other, because a phenotypic correlation is not always a reliable estimate of the genetic relationship existing between traits. An environmental effect upon two weights could be strong and positively correlated that a negative genetic correlation is masked. Therefore, it is admitted that the phenotypic correlation is not a satisfactory guide to the expected correlated genetic response of traits under selection. The genetic correlation is the sole one to be used for such prediction. In practice, high or moderate and positive estimates of phenotypic correlation in the present and reviewed studies between growth traits at different ages give a considerable advantage for rabbit breeders in their management and culling decisions.

3. Genetic improvement

The expected genetic gain for body weight are presented in Table 5.

The expected genetic gain in NZW breed would be:

- + 29.06 (g) in body weight at 4 weeks of age.
- + 17.57 (g) in body weight at 6 weeks of age.
- + 4.62 (g) in body weight at 8 weeks of age.

- + 17.84 (g) in body weight at 10 weeks of age.
 - + 18.67 (g) in body weight at 12 weeks of age.
- The expected genetic gain in Cal breed would be:
- + 51.56 (g) in body weight at 4 weeks of age.
 - + 6.54 (g) in body weight at 6 weeks of age.
 - + 11.04 (g) in body weight at 10 weeks of age.
 - + 25.48(g) in body weight at 12 weeks of age.

It is clear that if one standard deviation of selection pressure is applied directly to body weight at 4 weeks of age, it can be expected that a genetic increase in body weight at 4, 6, 8, 10 and 12 weeks of age of 29.06 vs 51.56, 17.57 vs 6.54, 4.62 vs 0.00, 17.84 vs 11.04 and 18.67 vs 25.48 g in both NZW and Cal rabbits, respectively. Khalil (1986) working with Giza White and Bauscat rabbits, showed that selection at 6 weeks of age led to high expected correlated response to direct selection for weight at later ages. The expected genetic gain per generation from a single trait selection for body weight traits with a selection differential of one standard deviation unit in NZW breed would be +21.64 g in body weight at 4 weeks of age, +40.55 g in body weight at 8 weeks of age and +50.68 g in body weight at 12 weeks of age. The expected genetic progress in Cal breed would be +16.20 g in body weight at 4 weeks of age, +21.43 g in body weight at 8 weeks of age and +24.59 g in body weight at 12 weeks of age. It is clear that if one standard deviation of selection pressure is applied directly to body weight at 4 weeks of age, it can be expected a genetic increase in body weight at 4 weeks of age of 21.64 and 16.20 g in NZW and Cal rabbits populations, respectively. Similarly, with one standard deviation of selection pressure applied directly to body weight at 8 and 12 weeks of age, one can expect a genetic increase of 40.55 and 50.68 g in NZW population and 21.43 and 24.59 g in Cal population, respectively (Enab *et al.*, 2000).

High genetic correlations observed in the present study among different body weights in NZW and Cal rabbits indicated high possibility of improving these weights through proper breeding programs. Early selection can be also done as a prediction to increase and improve older weights, and this has the advantages of saving time and efforts. Generally, results of the present experiment are promising to improve most of the studied traits.

Genetic trends was 0.03 weaned rabbits per generation for strain B selected on individual growth rate between 28 and 77 days (Estany *et al.*, 1989). That is the expected direct genetic gain per generation in rabbits selected for weaning weight, slaughter weight and average daily gain was 26.03 g (4.80% of the adjusted mean), 133 g (8.38%) and 1.58 g (6.80%), respectively (Moura *et al.*, 1991). The realised

genetic gain per generation was 0.5-0.8 g per day in lines selected for post-weaning growth rate (Rouvier, 1991).

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4. Crossbreeding and heterosis

a. Mating groups effect

Crossbred genotype (NZW buck \times Cal doe or Cal buck \times NZW doe) had significantly ($P < 0.01$) body weight higher than that purebred at all ages studied (Table 6). However, body weight at all ages studied was nearly similar in both crossbreds. Meanwhile, growth rate at all ages intervals studied was observed to be significantly ($P < 0.01$) affected by breed groups genotype (Table 7). In this respect, El-Deghadi (2005) with different local and exotic breed groups of rabbits and their crosses proved that breed group effect on weaning body weight and post-weaning body weight and daily gain up to different ages ranging from 12 to 24 weeks of age was significant.

b. Direct additive (buck breed) effect

Estimates of linear contrasts of additive (sire breed) effect on weaning and post-weaning body weight and daily gains were mostly, significant and in favour of NZW for weaning and post-weaning body weights (Table 8). This means that paternity of NZW rabbits are better than that of Cal ones. In this respect, direct additive effect was significant and in favour of NZW for post-weaning growth rate up to 12 weeks of age (Table 9). El-Deghadi (2005) found that the dominance effects (heterosis) were positive and significant at 4 and 8 weeks of age, and values at 4 weeks was obviously higher (17.4 – 32.3%) than at 8 weeks (3.6 – 13.9%). He added that the heterosis were positive ($P < 0.01$) in the period 4-8 weeks of age, while the values were negative and significant in the period 8-12 weeks

These results may indicate that Cal rabbits could be used as a breed of sire in crossbreeding programs when using both NZW and Cal rabbits.

c. Maternal additive effects

Linear contrast of maternal additive effect showed significant ($P < 0.01$) differences in favour of NZW for most body weight traits of the study. This means that NZW -damed rabbits were heavier than those of Cal -damed ones at most ages studied (Table 8). Maternal additive effect on post-weaning growth rate was in

favour of NZW dams, and significant differences ($P < 0.01$) during 4-6, 6-8 and 4-12, but not significant during 8-10 and 10-12 wk (Table 9). All these results might refer to the better maternity of NZW dams than those of Cal ones. In this respect, most Egyptian crossbreeding studies revealed that post-weaning growth of rabbits mothered by dams of exotic breeds (e.g. Bouscat, White Flander, NZW, Cal) exceeded significantly those mothered by dams of local breeds (e.g. Baladi, Baladi Black and Baladi Red).

However, other crossbreeding experiments carried out in Egypt indicated that maternal additive effect on most post-weaning body weight and gains were statistically not significant (Afifi and Emara, 1990 Youssef, 1992). Likewise, non-Egyptian crossbreeding results of New Zealand White with both Japanese rabbits (Oetting *et al.*, 1989) and that rabbits (Rochambeau *et al.*, 1989) indicated that the maternal breed effects on post-weaning weight and gain were in favour of New Zealand White but without significant differences.

Result of the present study may lead to state that when using NZW and Cal rabbits in crossbreeding, it is better to use NZW rabbits as breed of dam.

d. Crossbreeding and heterotic effect

Crossbreeding between New Zealand White and Californian rabbits was generally associated with improvement in body weight of the growing rabbits post-weaning daily gain up to 12 weeks of age. Estimates of direct heterosis for body weight was mostly positive and had the evidence of the existence of heterotic effect as a result of crossing between New Zealand White and Californian rabbits. The heterotic effect was significant ($P < 0.01$) on body weight at 4,6,8,10 and 12 weeks of age (Table 8), and growth rate during 4 -6, 6-8, 8-10 and 4 -12, but was not significant during 10-12 weeks period (Table 9).

Most crossbreeding experiments carried out on rabbits in Egypt indicated the presence of similar heterotic effects in weaning and post-weaning body weight and daily gain at different ages and stages (El-Desoki, 1991 and Youssef, 1992). On the country, other crossbreeding studies showed that crossing of rabbits was of little importance for improving their body weights and gains (Khalil, 1980 and El-Qen, 1988). In this respect Afifi and Emara (1988) with four breeds of rabbits and their crosses were not able to evidence the heterotic effect on post-weaning livability up to 16 weeks of age since most of the crossbred combinations showed negative heterosis percentages.

Zaky (2001) indicated that heterosis was insignificant for litter traits studied in crosses of NZW and Cal rabbits (litter size at birth and at weaning and litter weight at birth and at weaning), positive heterosis was obtained individual birth weight, individual weaning weight, litter size at birth, average birth and weaning weight. He

added that relatively small amount of heterosis was observed in the average weight of progeny at birth. It may be explained partly by the fact that birth weights in rabbits are negatively affected by the size of the litter at birth. Litter genetic variation between NZW and Cal might explain the litter heterosis that was obtained for litter traits.

Table 2. Sire heritability (h^2_s) for body weight at different ages of both New Zealand White and Californian rabbits.

Body weight	New Zealand White Mean \pm S.E	Californian Mean \pm S.E
4 WK	0.587 \pm 0.441	0.611 \pm 0.460
6 WK	0.633 \pm 0.467	0.090 \pm 0.112
8WK	0.145 \pm 0.150	_____
10WK	0.533 \pm 0.415	0.107 \pm 0.130
12WK	0.429 \pm 0.532	0.234 \pm 0.225

Table 3. Sire heritability (h^2_s) for growth rate (%) at different periods of both New Zealand White and Californian rabbits.

Growth rate	New Zealand White Mean \pm S.E	California Mean \pm S.E
4-6 WK	0.793 \pm 0.266	0.898 \pm 0.285
6-8 WK	0.346 \pm 0.271	0.360 \pm 0.184
8-10WK	0.441 \pm 0.202	0.493 \pm 0.226
10-12WK	0.196 \pm 0.118	0.478 \pm 0.222
4-12WK	_____	0.782 \pm 0.279

Table 4. Genetic (r_G) and phenotypic (r_P) correlation between body weights and growth rates at different ages and periods of both New Zealand White (NZW) and Californian (Cal) rabbits.

Body weight and growth rate	NZW		Cal	
	r_G	r_P	r_G	r_P
4 WK &				
4-6WK				
6-8WK	-----	-0.59	-0.91	-0.74
8-10WK	-----	-0.51	-0.72	-0.55
10-12WK	0.76	-0.49	-0.58	-0.49
	0.58	-0.36	-0.84	-0.25
6WK&				
6-8WK	-----	-0.53	-0.81	-0.57
8-10WK	0.81	-0.51	-0.42	-0.43
10-12WK	0.59	-0.36	-0.76	-0.26
8WK&				
8-10WK	-----	-0.54	-0.17	-0.41
10-12WK	-----	-0.35	-0.52	-0.29
10WK&				
10-12WK	-----	-0.34	-0.12	-0.29
12WK&				
4-12WK	0.09	-0.23	-0.13	-0.21

Table 5 . Means of selected (S), control (C), selection differential (S.D), sire heritability (h^2) and genetic gain (G.G) for body weights at different ages of both New Zealand White (NZW) and Californian (Cal) rabbits.

Body weight	NZW					Cal				
	S	C	S.D	h^2	G.G	S	C	S.D	h^2	G.G
4 WK	559.21	509.76	49.5	0.587	+ 29.06	524.9	440.51	84.39	0.611	+ 51.56
6 WK	789.42	761.66	27.76	0.633	+ 17.57	765.55	692.89	72.66	0.090	+ 6.54
8 WK	1023.48	991.06	31.88	0.145	+ 4.62	1017.53	922.10	95.47		
10 WK	1262.46	1228.99	33.47	0.533	+ 17.84	1252.94	1149.73	103.21	0.107	+ 11.04
12 WK	1492.34	1448.83	43.52	0.429	+ 18.67	1481.11	1372.22	108.89	0.234	+ 25.48

Table 6. Least square means (LSM± S.E) of body weight at 4, 6, 8, 10 and 12 weeks of age (g) in both NZW and Cal. rabbits and their crosses.

Genotype Body weight (g)	NZW		Cal		NZW(♂) x (♀)Cal		Cal(♂) x (♀)NZW	
	No.	LSM ± S.E (g)	No.	LSM ± S.E (g)	No.	LSM ± S.E (g)	No.	LSM ± S.E (g)
4 wk	390	523.29 ± 14.027	331	468.75 ± 14.542	358	588.07 ± 14.427	357	589.68 ± 14.948
6 wk	390	769.38±13.692	331	708.95±14.322	358	842.74±14.175	357	843.16±14.765
8 wk	366	998.32±15.074	317	950.55±15.881	337	1087.45±15.647	340	1080.43±16.332
10 wk	339	1237.93± 16.070	298	1180.03±16.912	320	1326.23±16.628	327	1317.81±17.330
12 wk	327	1471.92±17.126	295	1404.17±18.057	312	1570.66±17.699	323	1555.41±18.449

♂ = Male ♀ = Female

Table 7. Least square means (LSM± S.E) of growth rate during periods 4-6, 6-8, 8-10, 10-12 and 4-12 weeks of age (g) in both NZW and Cal. rabbits and their crosses.

Genotype Growth rate	NZW		Cal		NZW(♂) x (♀)Cal		Cal(♂) x (♀)NZW	
	No.	LSM ± S.E (g)	No.	LSM ± S.E (g)	No.	LSM ± S.E (g)	No.	LSM ± S.E (g)
4-6 wk	390	38.27±1.001	331	41.22±1.029	358	35.76±1.023	357	35.51±1.054
6-8 wk	366	25.65±0.515	317	28.98±0.530	337	25.22±0.525	340	24.52±0.537
8-10 wk	339	21.23±0.461	298	21.64±0.469	320	19.73±0.465	327	19.81±0.474
10-12 wk	327	17.21±0.345	295	17.28±0.351	312	16.86±0.347	323	16.52±0.353
4-12 wk	327	94.83±1.483	295	99.96±1.524	312	90.94±1.504	323	89.96±1.545

♂ = Male ♀ = Female

Table 8. Heterosis for body weight at 4, 6, 8, 10 and 12 weeks of age of both New Zealand White and Californian rabbits and their crosses (Mean \pm S.E).

Body weight	Direct additional	Direct heterosis	Maternal additional	Paternal additional
BW4	27.27 \pm 1.341	46.43 \pm 0.95**	26.46 \pm 1.897	28.07 \pm 1.897
BW6	30.22 \pm 1.763	51.89 \pm 1.25**	30.01 \pm 2.495	30.43 \pm 2.494
BW8	23.89 \pm 2.030	54.75 \pm 1.44**	27.40 \pm 2.689	20.38 \pm 2.869
BW10	28.95 \pm 2.306	56.52 \pm 1.62**	33.16 \pm 3.239	24.74 \pm 3.238
BW12	33.88 \pm 2.625	62.49 \pm 1.842**	41.50 \pm 3.682	26.25 \pm 3.681

* significant at ≤ 0.05 ** highly significant at ≤ 0.01

Table 9. Heterosis for growth rate during periods 4-6, 6-8, 8-10, 10-12 and 4-12weeks of age of both New Zealand White and Californian rabbits and their crosses (Mean \pm S.E).

Growth rate	Direct additional	Direct heterosis	Maternal additional	Paternal additional
RG4-6	1.47 \pm 0.130	-2.05 \pm 0.092**	-1.347 \pm 0.184	-1.60 \pm 0.184
RG6-8	-1.67 \pm 0.133	-1.22 \pm 0.080**	-1.32 \pm 0.159	-2.02 \pm 0.159
RG8-10	-0.21 \pm 0.085	-0.83 \pm 0.06**	-0.25 \pm 0.120	-0.17 \pm 0.120
RC10-12	-0.04 \pm 0.071	-0.28 \pm 0.050	-0.13 \pm 0.100	-0.21 \pm 0.100
RG4-12	-2.58 \pm 0.167	-3.47 \pm 0.12**	-2.08 \pm 0.234	-3.06 \pm 0.234

* significant at ≤ 0.05 ** highly significant at ≤ 0.01

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دراسات وراثية على بعض الصفات الاقتصادية في الأرانب 2-أوزان الجسم ومعدلات النمو بعد الفطام

أمل مغاوري عبد الرازق هيكل¹، جودة محمد جبريل² ، أحمد عبد الوهاب عنب² ،
ابراهيم عبد السلام حمودة¹، فاروق حسن عبده²

١ . معهد بحوث الانتاج الحيوانى - مركز البحوث الزراعية - الدقى - الجيزة

٢ . قسم انتاج الدواجن - كلية الزراعة - جامعة المنوفية

تم اجراء هذا البحث بهدف دراسة بعض القياسات الوراثية مثل تقدير المكافئ الوراثى والأرتباط الوراثى والمظهرى والعائد الوراثى لكل من أوزان الجسم ومعدلات النمو بعد الفطام وكذلك دراسة تأثير قوة الخلط فى نوعين من الأرانب الأجنبية وهما النيوزيلاندى الأبيض والكاليفورنيا وخليطهما.

وأظهرت النتائج مايلى: وجد أن قيم المكافئ الوراثى بالنسبة لأوزان الجسم كانت عالية أو معتدلة عند أعمار 4، 6، 10 و 12 أسبوع من العمر، حيث كانت على الترتيب (58و ، 63و ، 53و ، 43و) فى الأرانب النيوزيلاندى الأبيض وعند عمر 4 أسابيع (61و) بالنسبة للأرانب الكاليفورنيا 0 وجد أن الأرتباط الوراثى كان عاليا وموجبا وذلك بين وزن الجسم ومعدلات النمو خلال الفترات المختلفة من العمر وذلك فى الأرانب النيوزيلاندى الأبيض. وجد أن التأثير المباشر للخلط كان موجبا بالنسبة لأوزان الجسم 0 أوضحت النتائج أن هناك تأثيرا معنويا (باحتمال 01 و) ناتج من تأثير الخلط وذلك بالنسبة لجميع أوزان الجسم وجميع فترات معدلات النمو المدروسة 0 وجد أن التأثير الأسمى المضيف كان معنويا (باحتمال 01 و) لمعظم أوزان الجسم فى الأرانب النيوزيلاندى الأبيض مما يعنى أن الأمهات من الأرانب النيوزيلاندى الأبيض كانت أثقل من الأمهات من الأرانب الكاليفورنيا عند معظم فترات العمر المدروسة 0 وجد أن التأثير الأسمى المضيف لمعدلات النمو كانت أفضل ولها تأثيرا معنويا (باحتمال 01 و) خلال الفترات 4-6، 6-8 و 4-12 أسبوع من العمر 0 وجد أن التأثير الخطى المضيف بالنسبة للذكر لأوزان الجسم ومعدلات النمو كان معنويا لأرانب النيوزيلاندى الأبيض .