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SELECTION FOR GROWTH AND NURSING ABILITY IN BALADI RED RABBITS -DIRECT RESPONSES

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ABSTRACT

A selection experiment, for high 4-week body weight and high litter weight at weaning (4 weeks), was carried out for three generations of Baladi Red rabbit. A total number of 18 bucks and 48 does were taken from the third generation of the base population to construct the initial generation of selection. The animals were randomly assigned to three mating groups, the first group (G) was established by selection for high individual body weight at 4 weeks of age and the second was established by selection for high litter weight at weaning (M), while the third was maintained as a randombred contemporary control (C) . The results obtained were as follow:

Individual body weights at 4 weeks of age (BW4) in line (G) were increased significantly ($P<0.01$) from 314.2 g at the first generation to 339.8 g at the third generation, while there were no significant differences in body weight at 4 weeks of age for the control line. Rabbits of the selected line gained 5.35% more than those of the control line at the third generation of selection.

Litter weights at weaning (LW4) in line (M) were increased significantly ($P<0.01$) from 1610.2 g at the first generation to 1654.1 g at the third generation, while there were no significant differences in litter weight at 4 weeks of age for the control line. Litter weights of selected line were 3.83% more than those of the control line at the third generation of selection.

Both BW4 and LW4 were significantly affected by generation, line and dam; while the effect of sire was not significant. No significant differences were detected between the expected and actual selection differentials for both characters (BW4 and LW4) through the three generations of selection. The realized response to selection for BW4 decreased from 4.6 g at the first generation to 2.1 g at the third generation, while that for LW4 decreased from 7.2 g at the first generation to 4.6 g at the third generation.

Heritability of BW4, calculated from the sire variance component was 0.26, and that calculated from the dam variance component was 0.54, while that obtained from the sire plus the dam variance components was intermediate between the two estimates, it was 0.40 and the realized heritability ranged between 0.49 and 0.63.

Heritability of LW4, calculated from the sire variance component was 0.34, and that calculated from the dam variance component was 0.56, while that obtained from the sire plus the dam variance components was intermediate between the two estimates, it was 0.45 and the realized heritability ranged between 0.53 and 0.67.

INTRODUCTION

Nowadays, most of the research work in the field of rabbit breeding has been foucused on methods of the genetic evaluation and the nature of response to selection. Selection is considered to be the most effective method for changing the genetic constitution of a population, when genes are acting additively.

The productivity of rabbits depends mainly on the number of young weaned per doe, which can be increased by maximizing the number of kindlings and minimizing the intervals between them, providing that the size of litters is maintained. The doe must be capable for producing a larg number of viable youngs at birth, has a high milk yield and nursing ability. Selection for large litter size may increase the number of born and weaned youngs, but it will also increase the mortality and variability in weaning weight due to inability of the doe to produce sufficient quantities of milk to support maximum growth (May and Simpson, 1975).

Rabbits have a number of characteristics; that would recognize them as meat- producing small animals, such as early sexual maturity, high prolificacy, relatively short gestation period and generation interval, fast growth, good ability to utilize forages and agricultural by-products, and high efficiency of feed utilization (Rao *et al.*, 1977; Taylor,1980; Hunt, 1980; Cheeke *et al.*, 1982 and Cheeke, 1986).

In Egypt, rabbit's meat is popular and its small carcass with a moderate price makes it more suitable for the majority of Egyptian families. Therefore, selection for increasing rabbit productivity can contribute in solving the current problem of increasing shortage on meat resources in Egypt.

The main objective of the present study was to measure the direct responses to selection for 4- week body weight of the offspring and the nursing ability of the doe, measred as standarized litter weight (5 individuals) at weaning in two different lines of Baladi Red rabbits.

MATERIALS AND METHODS

The data of the present study were obtained from the the rabbit production records of Experimental Rabbit Farm, Department of Animal Production, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt during three years of production starting at september 1990. The base population was established from randombred control population of Baladi Red rabbit. The animals were maintained by random mating (without intended selection for three generations) to avoid linkage disequilibrium as possible. From the third generation of the base population a total number of 18 bucks and 48 does were taken at random to form the initial generation for selection. Three lines were derived from the base population, the first line (G) was selected for high individual body weight at 4 weeks of age, the second one (M) was selected for high standardized litter weight (5 animals) at 4 weeks of age, while the third line (C) was maintained as a contemporary unselected control. The mating system in the base population was in a ratio of one male to three females, with a restriction to avoid full sisters and half sisters (paternal or maternal). Distribution of rabbits produced in each line and generation are presented in (Table 1).

Managment and measurements:

At birth, youngs of rabbits were permanently identified by toe-otching and weighied to the nearest 0.1 g. The litters were standardized to five youngs, with two males and three females being saved as possible.

Table (1) Distribution of offspring produced among generations and lines of selection

Generation	Line			Total
	G	M	C	
0	100	100	50	250
1	106	102	54	262
2	104	108	48	260
3	96	100	46	242
Total	406	410	198	1014

Litters having three or four youngs at birth were augmented to five by choosing foster youngs of the same age and similar weights, while litters with less than three youngs were discarded. The rest of foster youngs were excluded from the measurements. Weaning was practiced at 4 weeks of age, where litter weights at weaning were recorded to the nearest 0.1 g . In line (G) one buck and one doe were selected from their respective family, while in line (M) the whole litter was selected according to its deviation from generation mean for the same trait. In the third line (C) one buck and one doe were randomly chosen from each family, and used as parents for the next generation. Three does were mated to one buck which were chosen at random, avoiding full sisters and half sisters (paternal or maternal). Does that failed to conceive were returned to the same buck few days later until the conception was successfully performed.

Feeding the flock:

Rabbits were routinely fed *ad libitum* all the year round on mash ration of about 16% total protein and 60% starch equivalent. Berseem was supplied at mid-day in winter only. Fresh , clean water was available all time.

Statistical analysis:

Data were analyzed by using Harvey's least-squares and maximum Likelihood computer program (Harvey, 1987). The following model was adopted:

$Y_{ijkmn} = \mu+G_i+L_m+S_{ij}+D_{ijk}+ e_{ijkmn}$, where:

μ = the overall mean,

G_i= the effect of generation i = 1, - 3,

L_m= the effect of line m = 1, -2,

S_{ij} = the effect of sire j^{th} within the i^{th} generation,

D_{ijk} = the effect of k th dam within the j^{th} sire within the i^{th} generation,

e_{ijkmn} = the random error.

Henderson method was utilized to estimate the genetic variance components for the two traits studied (Henderson, 1953). Significant differences between means of each trait were separated according to Duncan's Multiple Range Test (SAS, 1988). The realized response to selection was estimated using the following formula:

$$R_t = [G_t + M_t - G_{t-1} + M_{t-1}] - (C_t - C_{t-1})$$

where R_t = realized gain due to selection in t^{th} generation and G, M and C = average performance of the selected and control populations (Guill and Washburn, 1974).

RESULTS AND DISCUSSION

Direct response to selection for individual body weight (BW4):

Preweaning growth represents a major part of the whole growth in mammals. Therefore, the study of the different factors affecting growth is useful in planning selection and breeding programs, directed towards maximizing the efficiency of growth during this period (Afifi *et al.*, 1985).

The average body weight at 4 weeks of age (BW4) after three generations of selection were 338.4±6.8 and 321.2±13.2 g for the selected and control lines, respectively (Table 2). BW4 for the rabbits of selected line increased by 5.35 % than that of control line at the end of the study. The estimated percentage of variability for this trait was lower in the selected line (10.20%) than control line (20.30%) (Table 2). Hilmy (1991) and Oudah (1990) estimated Baladi Red rabbits weaning weights as 340.0 and 497.0 g. Many investigators reported that Giza White and Bouscat rabbits weaning weights were 260.1 g and 434.3 g (Ghany *et al.*, 1969; Afifi *et al.*, 1985; Khalil *et al.*, 1987a , c; and Khalil,1989).

Table (2) Actual means, standard deviations (S.D) and coefficients of variation (C.V) for body weight at 4 weeks of age (BW4) and litter weight at 4 weeks of age (LW4) among three lines of Baladi Red rabbits

Traits	Line					
	G		M		C	
	Means±S.D	C.V%	Means±S.D	C.V%	Means±S.D	C.V%
BW4	338.4±6.8	10.20	----	----	321.2±13.2	20.30
LW4	----	----	1701.3±18.3	28.16	1638.5±16.0	10.18

The least-square means for (BW4) in the G line increased significantly ($P< 0.01$) from 314.2±1.4 g at the first generation of selection to 339.8±1.2 g at the third generation (Table 3). On the other hand, the average body weight at 4 weeks of age in the C line fluctuated randomly from generation to another, however, there were no significant differences between means of the first (313.2±1.6 g) and the third generation (315.1±1.4 g). Abdallah and Shemies (2000) reported that early selection for body weight in NZW rabbits was efficient by the use of body weight at 4, 5 and 6 weeks of age together with the growth rate between 4 and 6 weeks. On the other hand, Shemies (1999) and Shemies and Abdallah (1998 and 2000) reported that selection using body weight only at marketing appeared to be efficient than at weaning.

Table (3) Least-square means and standard errors (S.E) for body weight at 4 weeks of age and litter weight at 4 weeks of age among three lines of Baladi Red rabbits

Independant variables Generation	BW4				LW4			
	G		C		M		C	
	No.	M±S.E	No.	M±S.E	No.	M±S.E	No.	M±S.E
1st	98	314.2±1.4	46	313.2±1.6	100	1610.2±8.5	46	1601.8±6.5
2nd	100	332.1±1.6	42	314.0±1.3	102	1641.7±9.7	42	1604.2±7.8
3rd	90	339.8±1.2	42	315.1±1.4	94	1654.1±6.0	42	1607.1±6.0
Sex:								
Males	142	340.2±1.9	60	328.2±2.1	152	1642.3±7.9	60	1630.2±5.6
Females	146	312.5±2.0	70	306.3±2.5	144	1601.2±6.9	70	1593.1±7.5

The least-square aanalysis of variance for factors affecting BW4 showed that generation, line and dam had significant effects (P<0.01) on this trait. The sire had no significant effect on BW4 (Table 4). The same trend of response was observed for dam effect on pre-weaning body weights (Mostageer *et al.*, 1970; El-Amin, 1974; Mgheni *et al.*, 1982; Blasco *et al.*, 1983; Khalil *et al.*, 1987a and El-Fiky *et al.*, 1996) working with different breeds of rabbits.

The dam variance component was higher than that of the sire for BW4 (Table 5). However, the percentage of variation (V%) due to the dam effect (40.16%) was larger than that of the sire effect (23.62%).

Table (4) F-ratios and test of significant for factors affecting body weight at 4 weeks of age and litter weight at 4 weeks of age of Baladi Red rabbits

S.O.V.	d.f	BW4	d.f	LW4
		F-ratios		F-ratios
Gen.	2	32.7**	2	39.7**
Sire:Gen.	110	2.6	114	2.8
Dam:(S):(G)	203	41.9**	218	73.9**
Line	2	42.1**	2	58.2**
Remainder D.F	514		523	
Remainder M.S		1.8		2.9

Table (5) Variance components (σ^2) and percentage of variation (V%) estimated for random effects on body weight at 4 weeks of age and litter weight at 4 weeks of age of Baladi Red rabbits

Traits	Sires		Dam : Sires		Remainder	
	σ^2_S	V%	$\sigma^2_{D:S}$	V%	σ^2_e	V%
BW4	3.0	23.62	5.1	40.16	4.6	36.22
LW4	2.8	25.45	4.2	38.18	4.0	36.36

The actual and expected selection differentials, realised response and realised heritability for BW4 are presented in (Table 6). Comparisons of the actual to the expected selection differentials indicated very small insignificant differences. This observation suggests that natural selection had a relatively inconsiderable influence on the response to the third generation of selection for body weight at 4 weeks of age. The realised response for BW4 was decreased from 4.6 g at the first generation to 2.1g at the third generation of selection because of the decrease of the genetic variance; especially the additive genetic variance, from the first generation to the third generation of selection.

Table (6) Actual and expected selection differentials, realized responses (g) and realized heritability for body weight at 4 weeks of age and litter weight at 4 weeks of age among two selected lines of Baladi Red rabbits

Generation	Actual		Expected		Realized response		Realized h^2	
	G	M	G	M	G	M	G	M
0	54.9	73.8	52.8	68.9	---	---	---	---
1	52.5	70.9	50.3	66.2	4.6	7.2	0.51	0.53
2	50.6	68.2	54.0	64.1	3.2	5.4	0.63	0.61
3	---	---	---	---	2.1	4.6	0.49	0.67

Heritability estimates for BW4 were computed by different methods. The h^2_S estimate (0.26±0.19) was less than that of h^2_D (0.45±0.11). Because of the non - additive effects; primarily dominance and maternal, which normally result in the h^2_D estimates being considerably larger than h^2_S estimates, this pattern was observed in the current study (Table 7). However, the h^2_D estimates was 0.19 larger than h^2_S. The estimate of $h^2_{(S+D)}$ for BW4 (0.40±0.08) was intermediate between those of h^2_S and h^2_D. A higher estimates (ranged between 0.52 and 0.85) of heritability (h^2_S & h^2_{S+D}) for weaning weights in different breeds of rabbits has been reported by Mostageer *et al.*, (1970); El-Amin, (1974); Blasco *et al.*, (1983); Khalil, (1989) and El-Fiky *et al.*, (1996). On the other hand, Enab (2001) reported lower estimates of heritabilities for BW4 of New Zealand and Californian rabbits (0.24 and 0.21). The realized heritability (h^2 = R/S) estimated for BW4 in the present study ranged between 0.49 and 0.63 (Table 6).

Table (7) Heritabilites (h^2) estimates and standard errors (S.E) for body weight at 4 weeks of age and litter weeight at 4 weeks of age of Baladi Red rabbits

Traits	Sires	Dam : Sires	Full-sibs
	h^2_S ± S.E	$h^2_{D:S}$ ± S.E	$h^2_{(S+D)}$ ± S.E
BW4	0.26±0.19	0.54±0.11	0.40±0.08
LW4	0.34±0.25	0.56±0.16	0.45±0.20

Direct response to selection for litter weight (LW4):

In multiparous species, the reproductive performance is usually determined through several different traits such as age of doe at first parity, number of services per conception, service period, gestation length, litter size at birth and weaning , and litter weight at birth and weaning (Vrillon *et al*, 1979; Kadry and Afifi, 1983 and Afifi and Kadry, 1985).

The average litter weights at 4 weeks of age (LW4) after three generation of selection were 1701.3±18.3 and 1638.5±16.0 g for the selected and control lines, respectively (Table 2). The mean weight of litters (LW4) of selected line increased by 3.83 % than that of the control line at the end of the study. The estimated percentage of variability for this trait was higher in the selected line (28.16%) than that of the control line (10.18%) (Table 2). Many investigators reported an estimate ranged between 1382 g and 2592 g for litter weaning weight (5 weeks) of Baladi Red rabbits (Khalil, 1980; Afifi and Emara 1984 a&b; Mohammed, 1989 and Hilmy, 1991).

The least-square means for LW4 in the G line increased significantly ($P< 0.01$) from 1610.2±8.5 g at the first generation of selection to 1654.1±6.0 g at the third generation (Table, 3). On the other hand, the average litter weight at 4 weeks of age in the C line fluctuted randomly from generation to another, but no significant differences were detected in that respect between the first and the third generations .

The least-square analysis of variance for factors affecting LW4 showed that generation, line and dam had significant effects ($P< 0.01$) on this trait, but the sire had insignificant effect (Table 4).

The dam variance component was higher than that of the sire for LW4 (Table 5). However, the percentage of variation (V%) due to the dam effect (38.18%) was larger than that of the sire effect (25.46%).

The actual, and expected selection differentials, realised response and realised heritability for LW4 are presented in Table, 6. Comparisons of the actual to the expected selection differentials indicated very small insignificant differences. This observation suggests that natural selection had a relatively inconsiderable influence on the response to third generation of selection for litter weight at 4 weeks of age. The realised response for LW4 was decreased from 7.2 g at the first generation to 4.6 g at the third generation of selection because of the decrease of the genetic variance, especially the additive genetic variance, from the first to the third generation of selection.

Heritability estimates for LW4 was computed by different methods. The h^2_S estimate (0.34±0.19) was less than that of h^2_D (0.56±0.16). Due to the non - additive effects; primarily dominance and maternal, which normally result in the h^2_D estimates being considerably larger than h^2_S estimates, this pattern was observed in the current study (Table 7), and is in agreement with that observed by El-Fiky *et al* (1996) . However, the h^2_D estimates was 0.22 larger than h^2_S. The estimate of $h^2_{(S+D)}$ for LW4 (0.45±0.20) was intermediate between those of h^2_S and h^2_D. A wide range from 0.20 to 0.99 of heritability estimates for weaning weight of rabbits has been reported by Mgheni and Christensen,(1985); Khalil *et al.* (1987b) and Enab, 2001. Khalil *et al* (1987b) reported that litter traits measured at weaning were moderatly or highly heritable in Bouscat and Giza White rabbits, respectively. This

moderate or high estimates of heritabilities for preweaning litter gain suggest that direct selection for preweaning litter gain will give effective genetic improvement in this trait. This is because litter gain is known to be an excellent criterion for the milk yield of the doe. On the other hand, direct selection for litter size in rabbits has not produced positive results, as reported by Rochambean *et al* (1994) and Poujardieu *et al* (1994) who estimated a response to selection by only 0.06 rabbit per generation.The realized heritability (h^2 = R/S) estimated for LW4 in the present study ranged between 0.53 and 0.67 (Table 6).

CONCLUSION

It was concluded that selection for both body weight at early ages as well as litter weight at weaning proved to be most efficient selection criteria for genetic improvement in rabbit breeding programs.

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الإنتخاب لصفتى النمو والمقدرة الأمية فى الأرانب البلدية الحمراء -الإستجابة المباشرة .

جمال الدين يوسف عطا الله
قسم الإنتاج الحيوانى - كلية الزراعة - جامعة الأزهر - مدينة نصر - القاهرة

تم إجراء تجربة إنتخاب لصفتى وزن الجسم عند عمر٤ أسابيع ووزن البطن (الخلفة) عند عمر الفطام (٤ أسابيع) فى الأرانب البلدية الحمراء لمدة ثلاثة أجيال . تم إستخدام عدد ١٨ ذكر و ٤٨ أنثى من الجيل الثالث للعشيرة الأساسية (النواة) لتكوين الجيل الأول وقسمت الأرانب عشوائيا إلىثلاث مجاميع تزاوجية ، المجموعة الأولى للإنتخاب لصفة وزن الجسم عند عمر ٤ أسابيع والمجموعة الثانية للإنتخاب لصفة وزن الخلفة (٥ أرانب) عند عمر ٤ أسابيع والمجموعة الثالثة لتكوين خط غير منتخب معاصر ومقارن للخطين المنتخبين وقد أظهرت الدراسة النتائج التالية:

١ - ازداد وزن الجسم عند عمر ٤ أسابيع زيادة معنوية فى الخط المنتخب من ٣١٤,٢ جم فى الجيل الأول إلى ٣٣٩,٨ جم فى الجيل الثالث بينما لم يلاحظ وجود فروق معنوية فى هذة الصفة فى الخط المقارن حيث كانت٣١٣,٢ جم فى الجيل الأول وفى الجيل الثالث كانت٣١٥,١ جم.

٢ - ازدادت أوزان الجسم فى الخط المنتخب لهذة الصفة بحوالى٥,٣٥% عن أوزان الجسم فى الخط المقارن فى الجيل الثالث من الإنتخاب.

٣ - كان تأثير الجيل والخط والأم على صفة وزن الجسم عند عمر ٤أسابيع معنويا بينما لم يكن للآباء تأثير معنوى على هذه الصفة.

٤ - لم يكن هناك إختلافات معنوية بين الفارق الإنتخابى الفعلى والمتوقع خلال الأجيال الثلاثة من الإنتخاب لهذة الصفة ونقصت الإستجابة لفعل الإنتخاب من ٤,٦ جم فى الجيل الأول إلى ٢,١ جم فى الجيل الثالث.

٥ - كانت قيم المكافىء الوراثى لصفة وزن الجسم عند عمر ٤ أسابيع والمحسوبة من مكون التباين الأموى (٠,٤٥) أكبر من تلك المحسوبة من مكون التباين الأبوى (٠,٢٦) بينما كانت قيم المكافىء الوراثى المحسوبة من مكون التباين الأبوى والأموى معا وسط بين القيمتين (٠,٤٠) أما قيمة المكافىء الوراثى الواقعى فتراوحت بين (٠,٤٩-٠,٦٣).

٦-- ازداد وزن البطن (الخلفة) عند عمر الفطام زيادة معنوية فى الخط المنتخب من١٦١٠,٢ جم فى الجيل الأول إلى ١٦٥٤,١ جم فى الجيل الثالث بينما لم يكن هناك فروق معنوية فى هذة الصفة فى الخط المقارن حيث كانت ١٦٠١,٨ جم فى الجيل الأول وفى الجيل الثالث كانت ١٦٠٧,١ جم.

٧-- ازداد وزن البطن (الخلفة) فىالخط المنتخب بحوالى ٣,٨٣% عنه فى الخط المقارن فى الجيل الثالث من الإنتخاب.

٨- كان تأثير الجيل والخط والأم على صفة وزن البطن (الخلفة) عند عمر الفطام معنويا بينما لم يكن للآباء تأثير معنوى على هذه الصفة.

٩- لم يكن هناك إختلافات معنوية بين الفارق الإنتخابى الفعلى والمتوقع خلال الأجيال الثلاثة من الإنتخاب لهذة الصفة ونقصت الإستجابة لفعل الإنتخاب من٧,٢ جم فى الجيل الأول إلى٤,٦ جم فى الجيل الثالث.

كانت قيم المكافىء الوراثى لصفة وزن البطن (الخلفة) عند عمر الفطام والمحسوبة من مكون التباين الأموى (٠,٥٦) أكبر من تلك المحسوبة من مكون التباين الأبوى (٠,٣٤) بينما كانت قيم المكافىء الوراثى المحسوبة من مكون التباين الأبوى والأموى معا وسط بين القيمتين (٠,٤٥) أما قيمة المكافىء الوراثى الواقعى فتراوحت بين (٠,٥٣-٠,٦٧).