J. King Saud Univ., Vol. 11, *Agric. Sci.* (2), pp.121-136, Riyadh (1419/1999)

Heterosis, Maternal and Direct Genetic Effects for Litter Performance and Postweaning Growth in Gabali Rabbits and Their Crosses Raised under Hot Climatic Conditions

M. H. Khalil
Department of Animal Production and Breeding, College of Agriculture and Veterinary Medicine, King Saud University, Al-Gassim Branch, Buraidah, Saudi Arabia

(Received 27/12/1417; accepted for publication 27/10/1418)

Abstract. A crossbreeding experiment was carried out involving Gabali (G) and New Zealand White (NZW) rabbits to estimate direct heterosis and direct and maternal additive effects on some litter traits and postweaning growth. Doe traits on 238 litters were: Litter size and weight at birth and weaning, milk yield at 21 days, total milk yield, and mortality rate at weaning. Data of body weight at 4, 6, 8, 10 and 12 weeks of age on 1300 weaned rabbits were collected. Data were analyzed using a linear mixed model taking A^{-1} into consideration. Season and parity had considerable effects on litter traits and body weights at different ages. Spring- kindlings recorded larger litter size and heavier weight of litter along with lower preweaning mortality than winter kindlings. Also, Spring-born rabbits recorded higher weights of body from weaning up to 12 weeks of age. Effect of teats number of dam constituted a significant source of variation in rabbit's growth at most studied ages. NZW breed had superior performance in terms of litter size and weight compared to G rabbits. Most litter traits and postweaning growth were not significantly affected by direct additive effects. Gabali-sired litters had similar direct additive effects compared to NZW-sired litters and consequently Gabali bucks could be used as sires in crossbreeding stratification systems under hot climatic conditions. Orthogonal contrasts showed that crossbred litters (or rabbits) obtained from mating G bucks with NZW does were generally associated with slight superiority compared to those litters (or rabbits) obtained from the reverse mating. The maternal additive effects on litter size and weight at birth were significantly in favor of Gabali rabbits, while breed maternity for litter traits measured after kindling was significantly in favor of NZW breed. After weaning, growth traits under study were not significantly affected by the maternal additive effects. Crossing of G rabbits with NZW was associated with significant positive direct heterosis for litter size and weight at birth and weaning. Slight negative estimates of direct heterosis were observed for milk yield at 21 days and total milk yield. However, insignificant negative direct heterosis was recorded for postweaning growth traits.

Introduction

Gabali rabbits raised under the Egyptian desert conditions (especially in Sinai) are characterized by a large litter size of 8-12 young and heavy body weight of 3.5-4.5 kg [1]. Crossbreeding between standard breeds and Gabali rabbits raised under the desert conditions is not widely carried out. To date, publications concerning crossbreeding of Gabali rabbits with standard breeds (e.g. New Zealand White) in Egypt are not available. Direct and maternal heterosis, maternal and direct additive effects from crossbreeding experiments including Gabali rabbits were expected to be important especially for post-weaning growth performance [2]. On the other hand, the New Zealand White breed was found to exhibit an outstanding maternal ability as related to behavior, fecundity and lactation [3-5]. Results of most crossbreeding experiments carried out in Egypt reported that crossing does of New Zealand White breed with bucks of local breeds were generally associated with considerable heterotic effects on most litter and growth traits [6-9]. Therefore, this study was conducted to evaluate the importance of heterosis, maternal and direct additive effects on some litter traits and postweaning body weights in a crossbreeding experiment involving New Zealand White and Gabali rabbits.

Material and Methods

A crossbreeding experiment was carried out in the Experimental Rabbitry at Moshtohor, Zagazig University, Egypt (about 27 km to the north of Cairo) during one production year started in November 1994.

Breeding plan and management

Rabbits used in this study represent one desert Egyptian breed (Gabali, G) and one exotic breed (New Zealand White, NZW). Details and description of general features of the two breeds have been reported [1]. Does and bucks of the NZW were descendants of NZW rabbits raised under the Egyptian conditions. At the beginning of the experiment (November, 1994), breeding does of each of the two breeds were randomly divided into two groups. First group of does of each breed was mated with bucks from their own breed while those of the second group were mated with bucks from the other breed. The bucks were randomly assigned to mate the does with a restriction to avoid the matings of animals with common grand-parents. Each buck was allowed to sire all his litters from the same does, i.e. separate bucks in each of the four breed groups were used.

The breeding plan permitted the simultaneous production of G, NZW, G × NZW and NZW × G litters in each parity. Matings started in November 1994 and stopped in April 1995. Distribution of breeding does and bucks and number of litters and bunnies born and weaned of the four different breed groups are presented in Table 1.

Table 1. Number of bucks, does, litters and bunnies distributed in the four breed groups of the sudy

Mating type⁺	Bucks	Does	Litters weaned	Bunnies born	Bunnies weaned
NZW × NZW	15	50	160	1173	850
G × G	3	6	14	87	70
NZW × G	3	5	15	131	90
G × NZW	14	17	49	349	290
Total	47	126	238	1740	1300

⁺Breed of buck is listed before breed of doe.

Rabbits were raised in a semi-closed rabbitry. Breeding does and bucks were housed separately in individual wired-cages arranged in double-tier batteries (California cage) allocated in two rows along the rabbitry. At the time of breeding, each doe was transferred to the cage of her assigned buck for mating and returned to her own cage after being mated. Each doe was palpated 10 days thereafter to determine pregnancy and those who failed to conceive were returned to the same mating-buck for mating. Does were mated from the same assigned bucks 10 days after each kindling. On the 25th day of pregnancy, the nest boxes were supplied with rice straw to help the doe in preparing a warm comfortable nest for the bunnies of her litter. After kindling, litters were checked and recorded. Young rabbits were weaned at four weeks, ear tagged, sexed and transferred to standard progeny wire cages equipped with feeding hoppers and drinking nipples. Feeding practices in the rabbitry were described [10].

Data and statistical analysis

Litter traits of the present study were: litter size at birth (LSB) and weaning (LSW), litter weight at birth (LWB) and weaning (LWW), milk yield at 21 days (M21), total milk yield (TMY), and preweaning litter mortality (PM). The postweaning body weights were measured at 4, 6, 8, 10 and 12 weeks of age (W4,W6,W8,W10 and W12, respectively). Mortality percentages were subjected to arc-sin transformation to approximate normal distribution before being analyzed. Data were analysed using a linear mixed model taking the relationship coefficient inverse matrix (A^{-1}) into consideration.

Data of litter traits on 238 litters were analyzed using the following mixed model:

$$Y_{ijklm} = \mu + G_i + D_{ij} + A_k + P_l + e_{ijklm} . \qquad \text{(Model 1)}$$

Where Yijklm is the observation on the ijklmth litter trait (LSB, LSW, LWB, LWW, M21, TMY and PM); μ is the overall mean; G_i is the fixed effect of ith breed group; D_{ij} is the random effect of jth doe nested within the ith breed group, A_k is the fixed effect of the kth season of kindling (i=1,2); P_l is the fixed effect of lth parity (l=1,....,5); and e_{ijklmn} is the random deviation particular to the mth litter that assumed to be normally and independently distributed with mean zero and variance σ^2, i.e. NID (0, σ^2e). The sires of some does were not available in the data, therefore sire was not included in the model. The absence of records in some subclasses did not permit the inclusion of interaction (season × parity). Breed group was tested against doe within breed group. Other fixed effects were tested against the remainder.

Data of the postweaning growth traits were analyzed using the following sire model:

$$Y_{ijklmno} = \mu + G_i + S_{ij} + A_k + P_l + B_m + C_n + (GB)_{im} + (AB)_{km} + (PB)_{lm} + (BC)_{mn} + (AP)_{kl} + (AC)_{kn} + e_{ijklmno}$$

(Model 2)

Where $Y_{ijklmno}$ is the observation on the ijklmnoth weaned rabbit of the postweaning growth trait (W4, W6, W8, W10 or W12); μ is the overall mean, G_i is the fixed effect of the ith breed group, S_{ij} is the random effect of the jth sire nested within the ith breed group, A_k is the fixed effect of the kth season of birth (i=1,2); P_l is the fixed effect of the lth parity (l=1,....,5); B_m is the fixed effect of the mth sex; C_n is the fixed effect of the nth teats number of doe; and $e_{ijklmno}$ is the random deviation particular to the oth weaned rabbit, NID (0, σ^2e) along with all possible interactions of GB_{im}, AB_{km}, PB_{lm}, BC_{mn}, AP_{kl}, and AC_{kn}. The interaction between sire as random effect with other fixed effects was not permitted since all sires were not crossclassified with these fixed effects and consequently records in some subclasses were absent. Breed group was tested against sire within breed group. Other fixed effects were tested against the remainder.

Harvey's least-squares and maximum likelihood computer program [11] was used in both models (Model 1 and model 2). Accordingly, doe and progeny data were analyzed separately using the following mixed models (in matrix notation):

Model for doe traits:

$$\begin{bmatrix} X'R^{-1}X & X'R^{-1}Z \\ & Z'R^{-1}Z+I\sigma^2_e/\sigma^2_d \end{bmatrix}$$

Model for progeny traits:

$$\begin{bmatrix} X'R^{-1}X & X'R^{-1}Z \\ & Z'R^{-1}Z+A^{-1}\sigma^2_e/\sigma^2_d \end{bmatrix}$$

Genetic model and estimation of crossbreeding effects

Crossbreeding effects (maternal additive, direct additive and direct heterosis) on different litter traits and body weights were estimated according to Dickerson theory [12]. Such genetic model permits to derive a selected set of linear contrasts, i.e. direct additive effect, maternal additive effect and direct heterotic effect were estimated as:

Direct heterotic effect (units)

$$H^i_{NZWxG} = [(NZW \times G + G \times NZW) - (NZW \times NZW + G \times G)]$$

Maternal additive effect

$(G^m_{NZW} - G^m_G) = [(G \times NZW) - (NZW \times G)]$, i.e. reciprocal cross differences

Direct additive effect

$(G^i_{NZW} - G^i_G) = \{[(NZW \times NZW)+(NZW \times G)] - [(G \times G)+(G \times NZW)]\}$,

i.e. breed group of sire differences

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 Student's t-test.

Results and Discussion

Season

Season of kindling contributes significantly to the variation of most litter traits and postweaning body weights except TMY and W4 (Tables 2 and 3). F-ratios obtained for season effect on litter size and weight at birth and at weaning were high. This reflects the effect of season of kindling on prenatal maternal ability along with their postnatal milk production.

For most traits, spring-kindlings recorded larger size and heavier weight of litter compared to winter kindlings (Tables 2 and 3). In addition, litters born in spring had lower PM than those litters born in winter. Lactation ability (M21 and TMY) of spring-kindlings was also higher. Similarly, most Egyptian reviewed studies [e.g. 10;13] showed a general trend indicating that litter size and weight and milk production per litter had a curvilinear relationship with season of kindling. These traits seemed to be low in the first month of the year of production (during October or November, i.e. during autumn) and increased during winter and early months of spring and decreased again at the end of the year of production (during May and thereafter). This reflected the pattern of seasonality of weather conditions. In this experiment, feed availability was not of considerable importance since pregnant and suckling does were fed on pelleted ration all the year round, while seasonality had a considerable contrast importance. Khalil [13] stated that seasonality can exert their effects on weaning weight of the rabbits in the amount of milk produced by the suckling dams and on growth performance at later ages (through the quantity and quality of the directly ingested food, the appetite of the young and food utilization during the postweaning months).

Parity

The pattern of parity effect on litter traits and postweaning body weights appeared inconsistent (Tables 2 and 3). Most Egyptian studies also showed inconsistent trend for the effect of parity on these traits in rabbits [7; 10; 13; 14]. Khalil [10] stated that parity had a curvilinear relationship ($P<0.05$ or $P<0.01$) with milk production, litter size and weight and litter gain. High LWW in the first parity may be attributed to that PM was low (14.3) in the first parity compared to the other parities (Table 2).

Table 2. Least-squares means (+SE) of litter traits+ in different season, parity and teat number subclasses

Independent variable	N	LSB	LWB	LSW	LWW	M21	TMY	PM
Season of kindling								
Winter	78	6.25+0.45	320+27	3.40+0.47	2123+288	1978+197	3219+277	39.7±5.2
Spring	160	7.57+0.40	450+25	5.47+0.43	3328+259	2473+172	3525+248	26.4±4.6
F-ratio		7.7***	20.1***	20.1***	15.5***	4.5*	1.0 ns	5.0*
Parity								
1st	50	8.06+0.72	579+44	6.87+0.73	3668+463	2299+339	2196+451	14.3±8.7
2nd	78	7.45+0.51	459+31	5.08+0.53	2894+329	2533+231	3059+318	28.6±6.0
3rd	56	7.53+0.46	417+29	4.14+0.49	2554+300	2262+207	3648+289	43.5±5.4
4th	27	6.48+0.60	305+37	2.75+0.62	1872+389	1654+280	3148+378	50.1±7.2
5th	27	5.02+0.84	267+51	3.25+0.85	2638+541	2379+401	4809+529	28.8±10
F-ratio		2.4*	7.5***	4.6***	2.8*	2.9*	5.2***	4.7***
Remainder mean squares	df=107	2.41	9042	2.38	998614	579047	964819	376

+ LSB= Litter size at birth, LSW = Litter size at weaning, LWB = Litter weight at birth, LWW =Litter weight at weaning, M21= Milk yield at 21 days, TMY= Total milk yield, and PM= Preweaning litter mortality.
ns= non-significant (P>0.05); *=P<0.05; **=P<0.01; ***=P<0.001.

Table 3. Least-squares means (±SE) of postweaning body weights+ in different season, parity and Teat number subclasses

Variable	W4		W6		W8		W10		W12	
Season of birth										
Winter	555	578±36	487	771±39	424	1042±49	353	1351±58	275	1656±61
Spring	745	588±34	681	836±36	663	1101±46	568	1428±57	483	1828±55
F-ratio	0.28^{ns}		6.8**		3.8*		4.6*		14.9***	
Parity										
1st	270	546±34	243	755±37	225	1005±48	180	1329±59	161	1640±60
2nd	415	568±35	362	775±37	319	1038±47	279	1391±58	229	1742±58
3rd	302	593±35	273	812±37	288	1073±48	238	1442±59	191	1778±60
4th	175	596±36	159	798±40	154	1085±51	116	1335±64	94	1704±67
5th	138	615±39	116	878±44	116	1157±56	108	1451±67	83	1845±72
F-ratio	2.6*		3.9**		3.5**		3.9**		4.3**	
Teats number										
5-6	32	498± 51	26	736± 64	26	927±78	16	1268±111	14	1630±133
7	123	635±37	114	838± 41	108	1155±52	84	1483±64	69	1812± 66
8	855	587±34	775	795± 36	711	1068±45	601	1353±57	498	1730± 56
9	155	593±37	137	816± 41	130	1101±52	114	1369±63	94	1749± 64
10	135	604±37	116	832± 42	112	1128±54	106	1476±65	83	1790± 69
F-ratio	2.8*		1.4^{ns}		2.8*		5.1***		1.3^{ns}	
Sex										
Males	653	594±35	573	825±38	537	1098±48	441	1395±61	346	1718±66
Females	647	572±35	595	782±38	550	1045±48	480	1384±58	412	1765±57
F-ratio	1.0^{ns}		2.2^{ns}		2.1^{ns}		0.05^{ns}		0.6^{ns}	
Breed x Sex	ns		***		***		***		**	
Sex x Season	ns		ns		ns		ns		ns	
Sex x Parity	ns		**		*		**		**	
Sex x Teats number	**		ns		ns		ns		ns	
Season x Parity	***		***		***		***		ns	
Season x Teats number	***		**		**		*		ns	
Remainder df	1229		1097		1016		851		688	
Remainder mean squares	22380		35896		51392		59634		64039	

+W4= Body weight at 4 weeks, W6= Body weight at 6 weeks, W8= Body weight at 8 weeks, W10= Body weight at 10 weeks, and W12= Body weight at 12 weeks.
ns= non-significant; *= P<0.05; **= P<0.01; ***= P<001.

However, F-ratios obtained showed that parity had considerable effect on the variation of all litter traits and postweaning growth performance. From kindling up to weaning, Khalil [10] reported that variation in litter traits measured during this period for different parities may be associated with the lactation ability of the doe as well as her ability to care and suckle her young till weaning.

Teats number

Does with 5 and 6 teats recorded the lowest body weights at 4 weeks and up to 12 weeks of age (Table 3). On the other hand, pattern of other teat-number subclasses (from 7 teats up to 10) was inconsistent. However, results of the present study indicate that number of teats is one of the most important factors affecting postweaning growth in rabbits.

Interactions

Most postweaning body weights were significantly affected by interactions of breed × sex, parity × sex, and sex × teats number (Table 3). Also, interactions of season x parity and season × teats number were considerable important. Therefore, body weight produced in a certain season and in a specific parity (or with a certain teats number) may represent a considerable advantage. Information on the effect of such interactions on body weights are not available in the literature for the comparison with the present results.

Mating-type means

Mating-type least squares means and comparisons among purebreds for litter traits and postweaning growth are given in Tables 4 and 5. The NZW x NZW matings resulted in a larger litter size and heavier litter weight compared to the G x G matings (Tables 4 and 5). The linear contrasts evidenced that NZW breed had superior performance in terms of LSW and LWW ($P<0.05$) and LWB ($P<0.001$) compared to G rabbits. These results were expected and reflected the superiority of NZW rabbits in fertility, maternal behavior, milk production, pre-weaning growth and survival. On the other hand, postweaning body weights at 8, 10 and 12 weeks of age were slightly higher in G rabbits than NZW rabbits (Table 4). Further research is needed to identify the genetic aspects of lactation performance in NZW and G breeds taking into account the genetic association between milk yield and other litter traits.

Heterotic effects

Estimates of direct heterosis (calculated in actual units and as percentages) for different traits are given in Tables 4 and 5. These estimates indicated that crossing between NZW and G rabbits was usually associated with an existence of heterotic effects on litter size and weight, especially those traits measured at kindling. Direct heterosis was significant for LSB, LWB, LSW and LWW. Results of the different crossbreeding experiments carried out in Egypt [15;16;8] revealed that heterotic effects were evidenced in most of the possible crossbreds for litter size and litter weight. However, increasing parity influence (non-genetic maternal) on litter and milk traits due to age seems to be reflected in a decrease in direct heterosis.

Estimates of heterosis for size and weight productivity of litter showed that heterotic effects decreased with advance of litter's age (Table 4). Estimates of heterosis for LSB, LWB, LSW and LWW were positive and ranged from 15.6 to 18.8%. Estimates for milk production (M21 and TMY) and postweaning body weights (W4, W6, W8, W10 and W12) were negative and low.

Table 4. Estimates of mating type Means (±SE), heterosis (H^i), maternal additive effect (G^m) and sire additive effect (G^i) of litter traits[+]

Item	N	LSB	LWB	LSW	LWW	M21	TMY	PM
Mating type[++]								
NZWxNZW	160	6.75±0.22	403±13.7	4.58±0.24	2849±143	2320±92	3482±136	29±
GxG	14	5.91±0.81	305±50.2	3.49±0.89	2206±524	2235±331	3383±497	38±
NZWxG	15	8.32±0.82	444±50.4	4.63±0.89	2746±526	1963±326	3111±497	39±
GxNZW	49	6.65±0.49	389±30.5	4.97±0.54	3099±318	2384±196	3512±300	24±
Significance		*	ns	ns	ns	ns	ns	ns
Purebred differences $[(G^i_{NZW}+G^m_{NZW})-(G^i_G+G^m_G)]$		0.8+0.5ns	97+29***	1.1+0.5*	644+311*	85+37ns	98+36ns	-8.6+6.1ns
Heterosis contrast								
H^i_{NZWxG} units		$1.2+0.3^{***}$	$62+19^{**}$	$0.8+0.3^{**}$	$395+24^{*}$	$-104+55^{ns}$	$-122+21^{ns}$	$-2.0+3.9^{ns}$
Percentage		18.3	17.5	18.8	15.6	-4.6	-3.5	-6.0
Maternal additive effect								
$(G_m^{NZW}-G^m_G)$		$-1.7+0.5^{***}$	$-55+28^{*}$	$0.3+0.4^{ns}$	$353+97^{*}$	$421+26^{*}$	$401+92^{*}$	$-15+5.7^{**}$
Sire additive effect								
$(G^i_{NZW}-G^i_G)$		$1.3+0.3^{***}$	$76+19^{***}$	$0.4+0.3^{ns}$	$145+21^{ns}$	$-168+16^{ns}$	$-249+26^{ns}$	$3.4+4.0^{ns}$

[+]Abbreviations as defined in Table 2.
[++]Buck-breed listed first
ns=non-significant (P>0.05); *=P<0.05; **=P<0.01; ***=P<0.001.

Crossing of NZW with G was associated with a reduction in PM (Table 4), i.e. an improvement in pre-weaning viability of the doe will be attained. Similarly, other investigators [7; 8; 16] reported that crossbreeding was associated with a reduction in the rate of PM.

Maternal additive effect

At kindling, maternal breed effects on litter size and weight at birth (expressed as the differences between reciprocal crosses) were statistically significant and they were mainly in favor of G breed (Table 4). Under hot climatic conditions, Khalil [8;13] attributed such favorable maternity in G breed to that local breeds (e.g. Baladi, Gabali, etc.) have better prenatal maternity (due to ovulation rate, ova wastage, embryonic mortality, embryo survival, uterine capacity) than exotic breeds (e.g. Bouscat, Californian, etc.).

After kindling, breed maternity was significantly in favor of NZW breed for LWW, M21, TMY and PM. Crossbreeding experiments carried out in Egypt [8 ; 9; 16; 17] indicated that maternal additive effects on pre-weaning litter traits were not significant. For post-kindling litter traits, litters of the GxNZW matings had better performance than those from the NZW x G matings (Tables 4 and 5). This indicated also that using of NZW rabbits as dam-breed with G as a sire-breed gave an advantage for the litter performance in terms of larger litter size and heavier litter weight at weaning along with lower mortality rate. This superiority of NZW does is attributable to favorable maternal abilities. This might be due to increased milk production levels compared to G does. However, most of the Egyptian findings reported a general trend indicating that litters mothered by exotic breeds (e.g. New Zealand White, Californian, Chinchilla, etc.) recorded better performance than litters mothered by native breeds (e.g. Giza White and Baladi rabbits). This evidenced the superiority of exotic breeds in their maternity (in terms of milk production, maternal behavior and care for young). For most pre-weaning litter traits, the maternal superiority of NZW breed compared with other standard breeds has been demonstrated in the American studies, e.g. [3; 4; 5] and in the European studies, e.g. [18, 19, 20], i.e. using NZW as a dam breed produced high performances in litter size, weight and mortality rate compared to other dam breeds.

Table 5. Estimates of mating-type means (± SE), heterosis (H^i), maternal additive effect (G^m) and sire additive effect (G^i) of postweaning body weights+

	W4		W6		W8		W10		W12	
	N	Estimate + SE	N	Estimate + SE	N	Estimate + SE	N	Estimate + SE	N	Estimate + SE
Mating type++										
NZW X NZW	850	591+22	750	807+23	701	1065+30	695	1378+35	444	1711+36
G X G	70	587+56	66	796+62	62	1084+83	46	1405+95	44	1812+87
NZW X G	90	572+99	82	820+83	72	1073+105	50	1411+114	46	1718+103
G x NZW	290	584+51	270	798+52	252	1063+66	230	1364+76	224	1726+72
Significance		ns		ns		ns		ns		ns
Purebred differences										
$[(G^i_{NZW} + G^m_{NZW})-$ $(G^i_G + G^m_G)]$		$4.2+2.1^{ns}$		$5.7+2.7^{*}$		$-18.8+3.4^{ns}$		$-27.8+4.2^{ns}$		$-100.5+4.7^{*}$
Heterosis contrast:										
H^i_{NZW}, Units		$-10.4+3.6^{ns}$		$-10+1.8^{ns}$		$-6.5+2.2^{ns}$		$-3.7+2.7^{ns}$		$-39.0+2.9^{ns}$
Percentage		-1.8		0.7		-0.6		-0.3		-2.2
Maternal additive effect										
$(G^m_{NZW} - G^m_G)$		$12.2+8.9^{ns}$		$-20.8+2.5^{ns}$		$-10.1+3.2^{ns}$		$-47.1+3.9^{ns}$		$7.8+4.2^{ns}$
Sire additive effect										
$(G^i_{NZW} - G^i_G)$		$-3.9+1.4^{ns}$		$15.3+1.8^{ns}$		$-4.3+2.2^{ns}$		$9.6+2.8^{ns}$		$-54.2+3.1^{*}$

+Abbreviations as defined in Table 3.

++Buck-breed listed first

ns=non-significant (P>0.05); *= P<0.05; **=P<0.01; ***=P<0.001.

Maternal additive effects on all postweaning body weights were not significant (Table 5), i.e. both breeds of the present study could be used as breed of dam. In Egypt [6], it was found that postweaning growth of rabbits mothered by NZW breed are nearly similar to those rabbits mothered by Baladi Red breed. Since maternity of G rabbits was higher than NZW maternity for most body weights of the present study (Table 5), therefore, it may be effective to use G as a breed of dam in any crossbreeding stratification system in hot climatic regions.

Negative estimate of maternal additive effect for body weight at weaning (W4) may indicate that G^m was in favor of NZW breed. This result was expected and it reflects the superiority of milking ability of NZW rabbits compared to G rabbits. As age increases, the non-maternal environmental influences become the determining factor in this respect. Litter size is an example of these specific maternal environmental effects that persisted almost through the growth period of the rabbit.

Direct additive effect

The linear contrasts of direct additive effect for most litter and postweaning growth traits were not significant (Tables 4 and 5), i.e. little contribution of sire breed effects in the inheritance of these traits was observed. Such limited differences in direct effects between the two breeds lead to state that G could be used as a buck-breed in crossbreeding programmes.

The NZW buck-breed generally produced litters with larger size and heavier weight at birth ($P<0.001$) and at weaning ($P<0.10$) than the G buck-breed (Tables 4 and 5), i.e. NZW-sired litters had higher direct sire values than G-sired litters. The observed direct paternity effects on litter trait lead to indicate that NZW breed could be used as a terminal sire breed for litter traits measured at kindling. In France, a cold climate country, an experiment (1970) showed that Californian-sired litters had higher direct genetic effects on pre-weaning litter traits than that of NZW-sired litters [20]. A reverse trend was observed in an experiment performed 20 years later [21]. Also, an American study [3] showed that direct paternity effects on pre-weaning litter traits (LSB, LWB, LSW, LWW, and PM) were mostly in favor of Californian litters vs litters sired by NZW rabbits. In addition, direct Flemish Giant paternity effects on pre-weaning litters were positive and high compared with litters of NZW paternity. In Brazil, a hot climate country, minor differences in litter traits were attributed to NZW vs Californian sires [22].

Postweaning growth performance at 4, 6, 8 and 10 weeks of age of NZW-sired rabbits was not significantly different from rabbits sired by G breed, while significant difference was detected at 12 weeks (Table 5), i.e. sire-breed effects were of some importance at later stages of growth (at 12 weeks and thereafter). Such superiority of G-sired rabbits in G^i may be an encourage factor for the rabbit breeder in hot climate countries to use their native breeds in any crossbreeding stratification system. Sire-breed linear contrast presented in Table 5 indicates also that additive paternity at later age (W12) was significantly in favor of G breed. At later ages, [18] evidenced such significant G^i in NZW, Californian, Burgundy Fawn, Flemish Giant, Argenta de Champagne and Blue Vienna and their crosses.

Conclusion

1) Maternal additive effects appear to be, in general, more important than paternal additive effects in influencing most preweaning litter traits and postweaning growth performance. However, most estimates of linear contrasts for maternal additive effects are higher compared to those estimates of paternal additive direct effects (Tables 4 and 5). Other investigators [3; 4; 6; 7; 8] confirmed this trend.

2) Since post-kindling litter performance in New Zealand White and Gabali rabbits are not significantly different in their breed paternal performance, one may use either of the two breeds as sires. For rabbits industry, Gabali bucks could be used in terminal crossbreeding system especilly in areas of hot climate.

3) Single cross resulted from mating Gabali sires with New Zealand White dams is recommended and producers and processors could potentially benefit economically through commercial production by this simple cross.

References

[1] Galal, E.S.E. and Khalil, M.H. "Development of Rabbit Industry in Egypt". *Options Mediterraneennes,* Spain 8 (1994), 43-56.

[2] Khalil, M.H. "Breeds of Rabbits in Desert Regions". *Symposium on Development of Rabbits in Sinai.* Sinai, Egypt 24-27 September, 1996 (in Arabic).

[3] Lukefahr, S., Hohenboken, W.D., Cheeke, P.R. and Patton, N.M. "Doe Reproduction and Preweaning Litter Performance of Straightbred and Crossbred Rabbits". *Journal of Animal Science,* 57,No.5 (1983a), 1090-1099.

[4] Lukefahr, S., Hohenboken, W.D., Cheeke, P.R. and Patton, N.M. "Characterization of Straightbred and Crossbred Rabbits for Milk Production and Associative Traits". *Journal of Animal Science*, 57, No 5 (1983b), 1100- 1107.

[5] Ozimba, C.E. and Lukefahr, S.D. "Comparison of Rabbit Breed Types of Postweaning Litter Growth, Feed Efficiency and Survival Performance Traits". *Journal of Animal Science,* 69 (1991), 3494-3500.

[6] Afifi, E.A., Khalil, M.H., Khadr, Amina, F. and Youssef, Y.M.K. "Heterosis, Maternal and Direct Effects for Postweaning Growth Traits and Carcass Performance in Rabbit Crosses". *Journal of Animal Breeding and Genetics*, 111 (1994), 138-147.

[7] El-Desoki, A.E.M. "Study of the Effect of Some Genetic and Environmental Factors Affecting Meat Yield from Some Foreign and Local Breeds of Rabbits and Their Crosses". *M.Sc. Thesis, Faculty of Agriculture*, Mansoura University, Egypt, 1991.

[8] Khalil, M.H., Afifi, E.A., Youssef, Y.M.K. and Khadr, A.F. "Heterosis, Maternal and Direct Genetic Effects for Litter Performance and Reproductive Intervals in Rabbit Crosses". *World Rabbit Science,* 3,No. 3 (1995), 99-105.

[9] Oudah, S.M. "Studies on Some Rabbit Breeds and Their Crosses". *M.Sc. Thesis, Faculty of Agriculture,* Mansoura University, Egypt, 1990.

[10] Khalil, M.H. "Lactational Performance of Giza White Rabbits and its Relation with Preweaning Litter Traits". *Animal Production*, 59 (1994), 141-145.

[11] Harvey, W.R. *User's Guide for LSMLMW*. Mixed Model Least Squares and Maximum Likelihood Computer Program. *PC-Version* 2. Ohio State University, Columbus, USA (Mimeograph), 1990.

[12] Dickerson, G.E. *Manual for Evaluation of Breeds and Crosses of Domestic Animals*. Food and Agriculture Organization of the United Nations, Rome, 1992.

[13] Khalil, M.H., Afifi, E.A. and Owen, J.B. "A Genetic Analysis of Litter Traits in Bouscat and Giza White Rabbits". *Animal Production*, 45 (1987), 123- 134.

[14] Sedki, A.E. *Some Behavioral Studies on Rabbits. M.Sc. Thesis*, Faculty of Agriculture, Zagazig University, Egypt, 1991.

[15] Afifi, E.A. and Emara, M.E. "Litter Weight in Local Egyptian and Exotic Breeds of Rabbits and Their Crosses". *Proceeding 3rd World Rabbit Congress*, 4-8 April 1984, Rome, Italy, Vol. QG1, (1984), 126-135.

[16] Afifi, E.A. and Khalil, M.H. "Observations on Purebred and Crossbred Litters of Giza White and Grey Giant Flander Rabbits in Egypt". *Journal of Applied Rabbit Research*, 12 (1989), 273-277.

[17] El-Qen, R.Y.N. *Genetic and Environmental Studies on Rabbits. MSc. Thesis*, Faculty of Agriculture, Tanta University, Egypt, 1988.

[18] Masoero, G., Ubertalle, A., Mazzocco, P. and Battaglini, L.M. "Terminal Crossing of New Zealand White and Californian Rabbits. (2) Characteristics on the Live Animal". *Annalidell Istituto Sperimentale per la Zootecnia*, (Animal Breeding Abstract, 55, No. 1264), 18, No. 2 (1985), 93-109.

[19] Partridge, G.G., Foley, S. and Corrigall, W. "Reproductive Performance in Purebred and Crossbred Commercial Rabbits". *Animal Production*, 32 (1981), 325-331.

[20] Rouvier, R. and Brun, J.M. "Crossbreeding and Selection Experiments with Rabbits: An Overview from Studies in France about Litter Traits". *Options Mediterraneennes*, Serie Seminaire, Spain. 8 (1990), 29-34.

[21] Brun, J.M. "Parameters du Croisement Entre 3 Souches de lapin et Analyse de la Reponse a une Selection sur la Taille de Portee: Caracteres des Portees a la Naissance et au Sevrabr". *Genet.Sel. Evol.*, 25 (1993), 459-474.

[22] Carregal, R.D. "Evaluation of Heterosis, Combining Ability and Maternal and Reciprocal Mating Effects in Rabbits". *Proceeding of 2nd World Rabbit Congress*, Barcelona, Spain, April (1980), 213-220.

قوة الخلط والتأثيرات المباشرة والأمية لأداء ولدة البطن وصفات النمو بعد الفطام لأرانب الجبلي وخلطاتها المرباة تحت ظروف المناخ الحار

ماهر حسب النبي خليل

قسم إنتاج وتربية الحيوان، كلية الزراعة والطب البيطري بالقصيم،
جامعة الملك سعود، المملكة العربية السعودية

(قدم هذا البحث للنشر في ٢٧/١٢/١٤١٧هـ؛ وقبل للنشر في ٢٧/١٠/١٤١٨هـ)

ملخص البحث. أجريت تجربة خلط بين أرانب سلالتي الجبلي والنيوزيلندي الأبيض، وذلك لتقدير قوة الخلط المباشرة والتأثيرات التجمعية المباشرة والأمية لبعض صفات خلفة البطن وصفات النمو بعد الفطام. اشتملت صفات الولدة لعدد ٢٣٨ بطناً على: عدد الولدة ووزنها في البطن عند الميلاد والفطام، إنتاج الحليب خلال ٢١ يوما من الرضاعة، إنتاج الحليب الكلى، معدلات النفوق من الميلاد وحتى الفطام. تم تجميع بيانات النمو بعد الفطام لوزن الجسم على عدد ١٣٠٠ أرنب عند عمر ٤، ٦، ٨، ١٠، ١٢ أسبوعاً. تم تحليل البيانات باستخدام النماذج المختلطة التي تأخذ في الاعتبار معكوس مصفوفة معامل القرابة بين الأفراد والتي تسمى A^{-1}. كان لتأثير ترتيب الولادة مدلول ملحوظ على صفات ولدة البطن ومعدلات النمو بعد الفطام. ولقد سجلت ولادات الربيع أعلى معدل لعدد الولدة، وأثقل وزن في خلفة البطن مع أقل معدل للنفوق مقارنة بولادات الشتاء. كذلك سجلت الأرانب المولودة في الربيع أعلى أوزان للجسم من الفطام حتى عمر ١٢ أسبوعا. وكان لتأثير عدد حلمات الأم أثر واضح ومعنوي في تباين نمو الأرانب عند الأعمار المختلفة.

لقد تفوقت سلالة النيوزيلندي في أدائها بالنسبة لصفتي عدد الخلفة ووزنها في البطن مقارنة بالأرانب الجبلي. ولم تتأثر معنويًا معظم صفات ولدة البطن والنمو بعد الفطام بالتأثير التجمعي الأبوي.

تماثل إلى حد ما التأثير التجمعى لسلالة الأب في البطون الناتجة من ذكور جبلي لتلك الناتجة من ذكور نيوزيلندي ، وبالتالي يمكن استخدام ذكور الجبلي كطلائق في نظم تخطيط برامج الخلط تحت ظروف المناخ الحار.

ولقد أوضحت نتائج المقارنات المستقلة بأن البطون (أو الأرانب) الناتجة من تلقيح ذكور الجبلي مع إناث نيوزيلندي كانت إلى حد ما مصحوبة بتفوق طفيف مقارنة بتلك البطون (أو الأرانب) الناتجة من التلقيح المعاكس . ولقد كان للتأثير التجمعى الأمي تأثير معنوي على صفتي عدد الولدة ووزنها في البطن عند الميلاد وفى صالح الأرانب الجبلي ، في حين كان هذا التأثير معنويًا وفى صالح سلالة النيوزيلندي في الصفات التي قيست بعد الميلاد وحتى الفطام. على الجانب الآخر لم تتأثر معنويًا كل صفات نمو الجسم تحت الدراسة بالتأثير التجمعى الأمي. ولقد صاحب الخلط بين النيوزيلندي والجبلي تفوقا ملحوظا موجبا في قوة الخلط المباشرة لصفات عدد الولدة ووزنها في البطن عند الميلاد والفطام ، في حين لوحظ تغير طفيف سالب في قوة الخلط المباشرة لصفات إدرار الحليب عند ٢١ يوماً ، والإدرار الكلى للحليب. على الجانب الآخر تم تسجيل قوة خلط غير معنوية سالبة لصفات النمو بعد الفطام .