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Heterosis, maternal and direct effects for postweaning growth traits and carcass performance in rabbit crosses

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Introduction

Diversity of rabbit breeds offers the opportunity to increase efficiency of meat production through crossbreeding. Although heterosis and the effects of crossbreeding are generally great for maternal performance (i. e. preweaning litter performance), their effects on postweaning performance of growing rabbits and carcass merit should not be ignored. In the last ten years, New Zealand White rabbits were introduced to Egypt and were used in crossbreeding experiments with our local breeds (HASSAN 1988; OUDAH 1990; EL-DESOKI 1991). For postweaning growth and carcass performance, the genetic and economic potential benefits associated with crossbreeding using New Zealand White rabbits in an optimal breed combinations has not been adequately investigated in Egypt. Therefore, this study was conducted to evaluate the importance of heterosis, maternal and direct sire effects on postweaning growth and carcass performance in a crossbreeding experiment involving New Zealand White and Baladi Red rabbits.

Material and methods

A crossbredding experiment was carried out in Gezireit El-Sheir Experimental Station at El-Kanater El-Khairia (about 12 km to the north of Cairo) during two consecutive years beginning in September 1988. The station belongs to the Animal Production Research Institute, Ministry of Agriculture, Egypt.

Animals and breeding plan

Rabbits used in this study represent one local Egyptian breed (Baladi Red, BR) and one exotic breed (New Zealand White, NZ). Dams and sires of the exotic breed (New Zealand White) were descendants of the NZ rabbits raised under the Egyptian conditions. At the beginning of the first year of the experiment (September 1988), breeding dams of each of the two breeds used were divided at random into two groups. Does of the first group in each breed were mated with bucks from their own breed while those of the second group were mated with bucks from the other breed. According to the breeding plan, bucks were assigned at random to breed the dams with a restiction to avoid the mating of animals with common grandparent. Throughout the two years of this study, each sire was allowed to sire all his bunnies from the same dams. The breeding plan permitted the simultaneous production of BR, NZ, BR × NZ and NZ × BR rabbits. Matings in each year of production started in September and stopped in May.

Rabbits were fed *ad libitum* a pelleted ration. Pellets were 1 cm long and with 4 mm diameter. The composition of the ration was 16.3 % crude protein, 13.2 crude fiber and 2.5 % fat (digestible energy = 2600 kcal/1 kg ration). The ingredients of the ration were

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32 % barely, 21 % wheat bran, 10 % soya bean meal (44 % C.P.), 22 % hay, 6 % berseem straw, 3 % corticated cotton seed meal, 3 % molasses, 1 % lime stone, 0.34 % table salt, 0.3 % minerals and vitamins and 0.06 % methionine. Berseem *(Trifolium alexandrinum)* was supplied at mid-day during winter only. Fresh clean water was provided at all times.

Data

Data of individual body weights of 2153 weaned rabbits were collected during the post-weaning period at 5, 6, 8, 10, 12 weeks of age. Daily gains in intervals of 5–6, 6–8, 8–10 and 10–12 weeks were computed. Carcass performance of 213 male rabbits (one male from each doe) was recorded at 12 weeks of age. These rabbits were fasted (for approximately 16 hours) and slaughtered. Preslaughter weight and the weight after complete bleeding were recorded and the blood weight was calculated. Carcass was opened after skinning and enterials were removed and weight of carcass (including giblets, i. e. liver, heart and kidneys together) was recorded. The weight of giblets as well as those of head, fur and viscera were recorded for each animal. The carcass yield (hot carcass together with giblets) and dressing percentage for each rabbit were calculated (FENNEL et al. 1990; BLASCO et al. 1992). Dressing percentage was subjected to arc-sine transformation to approximate normal distribution before being analyzed.

Statistical analysis

Data of individual body weight and daily gain were analyzed (HARVEY, 1990) using the following linear model:

$$Y_{ijklmno} = \mu + B_i + D_j + A_k + S_l + P_m + R_n + (BD)_{ij} + (BA)_{ik} + (BS)_{il} + (BP)_{im} + (BR)_{in} + (DA)_{jk} + (DS)_{jl} + (DP)_{jm} + (DR)_{jn} + (AS)_{kl} + (AP)_{km} + (AR)_{kn} + (SP)_{lm} + (SR)_{ln} + (PR)_{mn} + e_{ijklmno} - (Model\ 1).$$

Where B_i = fixed effect of i^{th} breed of sire; D_j = fixed effect of j^{th} breed of dam; A_k = fixed effect of year of birth; S_l = fixed effect of l^{th} season of birth; P_m = fixed effect of m^{th} parity; R_n = fixed effect of n^{th} sex of young and $e_{ijklmno}$ = random deviation of o^{th} rabbit $(0,\sigma^2 e)$ along with all possible interactions. To get the linear contrasts of breed groups of post-weaning body weights and gains, data were analyzed using a model including breed group, year of birth, season of birth, parity, sex and all possible interactions (Model 2).

Pre-slaughter weight and weights of hot carcass, fur, head, giblets, viscera and blood as well as dressing percentage were analyzed using the following two linear models:

$$Y_{ijklmo} = \mu + B_i + D_j + A_k + S_l + P_m + (BD)_{ij} + (BA)_{ik} + (BS)_{il} + (BP)_{im} + (DA)_{jk} + (DS)_{jl} + (DP)_{jm} + (AS)_{kl} + e_{ijklmo} - (Model\ 3).$$

$$Y_{iklmo} = \mu + G_i + A_k + S_l + P_m + (GA)_{ik} + (GS)_{il} + (GP)_{im} + (AS)_{kl} + e_{iklmo} - (Model\ 4).$$

Where G_i = fixed effect of i^{th} breed group. All other effects included in these two models are defined previously in Models 1 and 2.

The following linear contrasts (DICKERSON 1992) of mating type least squares means were computed to quantify differences attributable to direct sire breed, maternal breed and direct heterotic effects as (HARVEY 1990):

Purebred differences:

$$(NZ \times NZ) - (BR \times BR) = [(G^i{}_{NZ} + G^m{}_{NZ}) - (G^i{}_{BR} + G^m{}_{BR})]$$

Direct heterosis effect (units):

$$H^i{}_{NZ \times BR} = [(NZ \times BR + BR \times NZ) - (NZ \times NZ + BR \times BR)]$$

Maternal additive effect (i. e. reciprocal cross differences):

$$(G^m{}_{NZ} - G^m{}_{BR}) = [(BR \times NZ) - (NZ \times BR)]$$

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

$$(G^i_{NZ} - G^i_{BR}) = [[(NZ \times NZ) + (NZ \times BR)] - [(BR \times BR) + (BR \times NZ)]]$$

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

All traits were abbreviated and symbols are given in Table 1. Means, standard deviations (SD) and coefficients of variation (CV) of individual postweaning body weights and gains and carcass performance (across all breed groups) are presented in this table. Including giblets (i. e. liver, heart and kidneys) in the carcass increased dressing percentage from 51 % to 55 % and consequently a higher saleable portion was obtained. If the head was included in carcass calculations of the present study (BLASCO et al. 1992) the dressing % would increase to be 62 %. On the other hand, a small proportion of non-edible carcass of about 33 % (fur + blood + viscera) was obtained (Table 1).

Estimates of CV ranged from 10.3 to 40.2 % which mean that improvement of growth traits in rabbits (i. e. body weight and daily gain) through phenotypic selection is quite possible. CV for body weights and gains tended to decrease in value as the rabbit advanced in age, e. g. estimates of CV are 24.1 % for BW5 and 40.2 % for DG1 compared with 10.3 and 23.1 % for the same traits at 12 weeks of age (Table 1). Reviewed estimates of CV (KHALIL et al. 1987; AFIFI and EMARA 1990) showed a general trend indicating that variation of postweaning weights in growth of a certain breed of rabbits decreased with advancing age. The CV's of these reviewed studies averaged 19.7 % at 5 weeks compared to 16.7 % at 12 weeks

Table 1. **Actual means, standard deviations (SD), coefficients of variation (CV%) of postweaning body weights and daily gains and carcass traits**

Trait	Abbreviation	No.	Mean	SD	CV%
Body weight and gain (gm)					
5-week weight	BW5	2161	415.0	106.0	24.1
6-week weight	BW6	2028	555.0	130.6	22.1
8-week weight	BW8	1812	853.0	153.0	17.0
10-week weight	BW10	1699	1150.0	159.3	13.3
12-week weight	BW12	1677	1443.0	155.0	10.3
5–6 weeks daily gain	DG1	2028	19.2	8.1	40.2
6–8 weeks daily gain	DG2	1812	20.7	5.0	23.9
8–10 weeks daily gain	DG3	1699	20.7	5.0	23.6
10–12 weeks daily gain	DG4	1677	21.0	4.9	23.1
Carcass traits					
Pre-slaughter weight (gm)	SW	+	1479	151	10
Hot carcass weight (gm)	HCW		816	104	13
Dressing %++	D%		55		
Giblets weight (gm)	GW		59	14	23
Head weight (gm)	HW		104	18	17
Fur weight (gm)	FW		160	36	21
Blood weight (gm)	BW		51	16	30
Viscera weight (gm)	VW		296	80	25

+ Number of rabbits slaughtered were 213.

++ Dressing percentage is not associated with standard deviation and coefficient of variation since they are the retransformed estimate of those of arc-sin means.

of age. This trend is expected since rabbits at young age (5 weeks) are more sensitive to the non-genetic maternal effect which decrease with advance of age. It also may be due to the consequence of the expression of the combination of non-genetic maternal environment and the genetic factors.

Year and season of birth

High F-ratios given in Table 2 indicate that season of birth is one of the most important non-genetic factors affecting postweaning body weights and gains. These values indicated also that the magnitude of the season effect decreased, in general, as age of the rabbit advanced (F-ratio for BW6 was 20.2, and 9.2 for BW12). An evidence for such considerable season effect was given by many Egyptian studies (e. g. EL-QEN 1988; HASSAN 1988; AFIFI and EMARA 1990; EL-DESOKI 1991). On the other hand, year and season of birth contribute little ($P>0.05$) to the variation of most carcass traits (Table 3).

Postweaning growth performance of rabbits born during autumn are generally higher than those born during winter and spring. In Egypt, there is a general trend indicating that growth performance of rabbit increased from autumn to winter, then decreased thereafter during April and May. Such seasonal variations in growth performance could be explained by the amount and nutritive value of the available greens and by the temperature prevailing during these seasons. KHALIL et al. (1987) stated that seasonality can exert their effects on weaning weight through 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).

Least-squares means obtained here showed that the pattern of change of year or season effect on carcass traits was inconsistent. However, autumnand winter-born rabbits recorded the highest edible carcass (e.g. HCW, GW and HW), while spring-born rabbits

Table 2. **F-ratios of least squares analysis of variance of factors affecting body weight** (BW) **and daily gain** (DG) **at different age intervals** (model 1)

Source of variation	df	BW5	BW6	BW8	BW10	BW12	DG1	DG2	DG3	DG4
Breed of sire (BS)	1	0.01	0.4	0.9	10.40**	9.3***	1.0	16.8***	3.9*	0.03*
Breed of dam (BD)	1	0.01	0.2	0.3	0.01	0.1	3.4	0.8	0.9	2.50
Year of birth (Y)	1	44.40***	51.9***	33.4	13.10***	2.6	30.3***	1.8	11.4**	20.70***
Season of birth (S)	2	11.10***	20.2***	18.2***	10.90***	9.2***	15.5***	4.2*	5.7**	2.00
Parity (P)	4	1.20	2.9	2.0	1.30	0.7	6.4***	1.6	4.2**	0.50
Sex	1	2.00	0.6	1.3	0.20	0.4	0.1	3.1	0.1	0.70
BS × BD	1	3.10	8.6**	16.7***	20.00***	25.0***	16.7	12.9**	3.2	0.40
BS × Y	1	7.80**	5.7**	5.6*	3.80	1.3	0.7	0.5	0.3	1.10
BS × S	2	3.70**	3.3	5.9*	5.10**	6.3**	0.6	5.7**	0.2	0.60
BS × P	4	2.00	0.6	0.9	1.80	2.4*	0.3	2.2	2.3	1.20
BS × sex	1	0.01	0.1	0.1	0.01	0.1	0.4	0.1	0.1	1.40
BD × Y	1	23.30**	8.9**	8.5**	15.40***	15.5***	4.9*	1.3	5.6*	0.20
BD × S	2	0.80	0.6	1.3	0.90	1.1	0.1	0.6	0.9	2.70
BD × P	4	2.70**	0.7	0.4	0.50	0.9	1.5	1.8	1.0	1.80
BD × sex	1	1.7	1.5	3.1	1.70	2.1	1.9	2.9	0.1	0.40
Y × S	2	4.10**	4.3*	3.1	0.90	1.1	3.7*	0.7*	1.5	2.30
Y × P	4	5.20**	6.8**	4.8**	6.30***	7.5***	3.8**	2.8	1.6	1.40
Y × sex	1	0.20	0.2	0.1	0.01	0.1	0.6	0.2	0.9	1.30
S × P	8	1.20	1.8	1.2	1.30	2.0*	3.1**	1.0	1.1	2.20
S × sex	2	0.60	0.4	0.5	0.60	1.3	0.6	0.2	0.3	0.50
P × sex	4	0.60	0.6	0.9	1.30	0.5	0.7	2.6*	0.5	1.30
Remainder df		2112	1979	1763	1650	1628	1979	1763	1650	1628
Remainder mean squares		9967	15010	21025	23304	22228	15010	21025	23304	22228
R^2 of Model		0.13	0.14	0.13	0.11	0.10	0.11	0.06	0.07	0.07

Table 3. **F-ratios of least squares analysis of variance of factors affecting carcass traits** (Mode 3)

Source of variation	df[+]	SW	HCW	D%	GW	HW	FW	BW	VW
Breed of sire (BS)	1	0.5	2.70	5.60*	0.4	0.2	10.2**	1.8	5.70*
Breed of dam (BD)	1	1.6	0.01	5.20*	1.1	0.1	0.6	3.0	3.60
Year of birth (Y)	1	6.4*	3.60	0.02	0.1	0.5	0.1	0.1	8.10**
Season of birth (S)	2	0.9	0.40	0.07	2.9	3.0	4.2*	2.1	1.30
Parity (P)	4	1.7	0.80	0.40	0.8	0.6	0.3	2.0	1.60
BS × BD	1	0.9	1.30	1.80	0.1	2.7	0.1	1.0	0.01
BS × Y	1	0.3	0.70	1.50	0.1	0.7	6.2*	0.9	3.70
BS × S	2	0.2	0.20	0.10	3.3*	0.1	0.2	0.7	0.20
BS × P	4	0.3	0.20	0.40	1.5	0.8	0.8	0.4	0.90
BD × Y	1	1.3	1.80	0.40	0.8	0.3	0.2	0.1	1.00
BD × S	2	0.9	0.60	0.60	0.1	0.2	1.4	0.7	0.10
BD × P	4	2.0	2.10	1.20	1.7	1.5	1.6	1.3	0.30
Y × S	2	0.2	1.10	3.90	1.2	1.2	0.8	0.6	2.60
Remainder mean squares		22754	10935	3.4	179	318	108	241	5584
R^2 of model		0.14	0.16	0.24	0.18	0.18	0.29	0.15	0.22

[+] Remainder degrees of freedom was 186

had the lowest carcass performance. This was expected since the decreased growth performance of spring born rabbits leads to low weight and percentage of carcass. In Egypt, results of El-Qen (1988), Hassan (1988) and El-Sayaad et al. (1990) indicated that winter-born rabbits recorded the highest carcass performance.

Parity

Postweaning body weights and gains and carcass performance varied from parity to parity, but no consistent pattern was observed. Also, parity effects constituted an insignificant source of variation in carcass performance and rabbit's growth at the different ages, with the exception of DG1 and DG3 ($P<0.01$ or $P<0.001$). The significant changes in postweaning daily gain are mostly a reflection of the efficiency of the dam as a mother.

Sire-breed and direct effect

Growth performance (weights and daily gains) at early ages (5 and 6 weeks) of NZ-sired rabbits was not significantly different from rabbits sired by BR breed, while significant differences were evidenced during the later ages of 10 and 12 weeks (Table 2), i. e. sire-breed effects were of importance for postweaning growth. Sire-breed linear contrasts presented in Table 4 indicate that NZ-sired rabbits are significantly superior in BW10 ($P<0.001$), BW12 ($P<0.01$) and DG3 ($P<0.05$). At 6 and 8 weeks of age, direct genetic effects were also pronounced in favour of NZ sires. An evidence for the significant sire-breed effect on growth traits was obtained by Masoero et al. (1985) with New Zealand White, Californian, Burgundy Fawn, Flemish Giant, Argenta de Champagne and Blue Veina. NZ-sired rabbits were heavier in weights and gains compared to BR-sired rabbits. El-Desoki (1991) reported that NZ-sired progeny were superior to those sired by Baladi rabbit for body weights and gains to 12 weeks of age. Such superiority of NZ-sired rabbits suggests to use this breed in crossbreeding.

Carcass performance of BR- and NZ-sired rabbits were significantly different in their D% ($P<0.05$), FW ($P<0.01$) and VW ($P<0.05$), i. e. sire-breed effects were of considerable importance in the variation of some carcass traits. Edible carcass traits (HCW, D%, GW, HW and FW) were in favour of NZ-sired rabbits along with lighter non-edible carcass wastes of blood and viscera were observed (Table 5). In particlular, NZ-sired rabbits are

Table 4. **Estimates of mating type means, heterosis (H^i) maternal (G^m) and direct effect (G^i) for body weight and daily gain at different ages** (Model 2)

Item	BW5		BW6		BW8		BW10		BW12		DG1		DG2		DG3		DG4	
	N	Mean±SE	N	Mean±SE	N	Mean±SE	N	Mean±SE	N	Mean±SE	N	Mean±SE	N	Mean±SE	N	Mean±SE	N	Mean±SE
R^2 of model		0.13		0.15		0.14		0.12		0.12		0.12		0.08		0.07		0.07
Mating type[*]																		
NZ × NZ	699	415±5.4	654	547±6.9	587	841± 9.2	548	1142± 9.9	540	1435± 9.7	654	18.2±0.4	587	20.5±0.3	548	21.1±0.3	540	21.2±0.3
BR × BR	364	415±6.5	345	549±8.2	308	833±10.8	291	1118±11.6	285	1410±11.4	345	18.7±0.5	308	19.8±0.4	291	20.1±0.4	285	20.6±0.4
NZ × BR	461	424±6.9	435	573±8.7	392	893±11.2	362	1192±12.1	359	1486±11.9	435	20.8±0.5	392	22.3±0.4	362	21.1±0.4	359	20.8±0.4
BR × NZ	637	426±7.3	594	567±9.1	525	869±11.9	498	1166±12.9	493	1463±12.6	594	19.6±0.6	525	20.9±0.4	498	20.9±0.4	493	21.2±0.4
Significance		ns		**		***		***		***		***		***		ns		ns
Purebred differences {($G^i_{NZ} + G^m_{NZ}$)-($G^i_{BR} + G^m_{BR}$)}		-0.3± 7.1		-2.1± 9.0		9.2±11.2		23.3±12.3		25.1±11.9*		-0.6±0.6		0.6±0.4		0.9±0.4*		0.5±0.4
Heterosis contrast $H^i_{NZ \times BR}$ (units)		20.7±11.3		44±14.2**		87.4±17.8***		97.7±19.4***		105.3±19.0***		3.5±0.9***		2.9±0.7***		0.8±0.6		0.3±0.6
percentage		2.5%		4.0%		5.2%		4.3%		3.7%		9.5%		7.2%		2.0%		0.7%
Maternal effect ($G^m_{NZ} - G^m_{BR}$)		2.3± 8.5		-6.1±10.7		-23.4±13.4		-26.0±14.5		-23.4±14.2		-1.2±0.7		-1.3±0.4**		-0.2±0.5		0.4±0.5
Direct sire effect ($G^i_{NZ} - G^i_{BR}$)		-2.7±11.0		4.0±13.9		32.6±17.4		49.3±18.9***		48.5±18.5**		0.6±0.9		2.0±0.6***		1.2±0.6*		0.1±0.6

[*] Buck-breed listed first
ns = nonsignificant, * = P<0.05; ** = P<0.01; *** = P<0.001

Table 5. **Estimation of mating-type means, heterosis, maternal effect and direct effect of carcass traits** (Model 4)

Item	N	SW Mean±SE	HC Mean±SE	D% Mean±SE	GW Mean±SE	HW Mean±SE	FW Mean±SE	BW Mean±SE	VW Mean±SE
R^2 of model		0.14	0.16	0.22	0.18	0.18	0.29	0.20	0.29
Mating type[1]									
NZ × NZ	73	1472±21	826±14	56.0	61±1.9	102±2.4	168±4.6	47±2.1	277±10
BR × BR	43	1495±24	799±17	53.2	58±2.2	102±2.9	154±5.4	57±2.5	337±12
NZ × BR	39	1546±33	851±22	55.0	59±2.9	108±3.8	176±7.1	52±3.3	306±16
BR × NZ	58	1509±39	827±27	55.0	59±3.5	106±4.6	153±8.6	53±4.0	316±19
Significance		ns	ns	***	ns	ns	*	*	**
Purebred differences $[(G^i_{NZ} + G^m_{NZ}) - (G^i_{BR} + G^m_{BR})]$		-23±32	26±22	2.7***	3.2±2.8	0.5±3.7	14±6.9*	-9.3±3.2**	-60±16***
Heterosis contrast									
$H^i_{NZ \times BR}$, units		87±60	52±41	0.7	-0.8±5.3	9.5±7.0	8±13.1	1.0±6.1	8±29
Percentage		2.9%	3.2%	0.7%	-0.7%	4.7%	2.5%	1.0%	1.1%
Maternal effect $(G^m_{NZ} - G^m_{BR})$		-38±50	-24±34	0.0	0.2±4.5	-1.5±5.8	-23±11.0	0.7±5.1	9±25
Direct sire effect $(G^i_{NZ} - G^i_{BR})$		15±59	50±41	2.8*	4.0±5.5	2.5±7.0	37±13.0**	-10.0±6.0	-69±29*

[1] Buck-breed listed first
ns = nonsignificant, * = P<0.05; ** = P<0.01; *** = P<0.001

superior in D% (P<0.05) and FW (P<0.01). Such favourableness leads to conclude that NZ rabbits could be used as a terminal sire breed. In Egypt, results of El-Qen (1988) with Bouscat, Flander and their crosses showed that there are slight differences in carcass traits between these breeds. Hassan (1988) found that carcass performances of offspring from Baladi Black and BR bucks are better than these native breeds when used as dams. Some European studies (e. g. Niedwiadek and Kawinska 1982; Brun and Ouhayoun 1989) reported slight differences in carcass performance between NZ and Californian sired rabbits. In Californian vs NZ sire-breed contrast, an American study (Lukefahr and Ozimba 1991) reported that Californian sired rabbits were lighter than NZ-sired rabbits for pre-slaughter weight and carcass weight, although the differences were not significant.

Dam-breed and maternal effect

Least-squares means of the present study show that postweaning growth and carcass performance of rabbits mothered by NZ breed are nearly similar to those rabbits mothered by BR breed. Maternal breed effects on most postweaning weights and gains were not significant (Table 4), i. e. both breeds of the present study could be used as breed of dam. Post-weaning growth of BR-mothered rabbits is generally higher than NZ maternity (Table 4). Therefore, it may be effective to use BR as a breed of dam in any crossbreeding stratification system for producing broiler rabbits with heavy weights and carcasses. Results of the present and reviewed studies showed that dams of NZ breed may not be the best dam-breed for post-weaning growth traits in rabbits. In Europe, Niedwiadek and Kawinska (1982) and Brun and Ouhayoun (1989) found that carcass performances of rabbits from NZ and Californian dams were not significantly different. For Californian vs NZ dam breed contrast, Lukefahr et al. (1983) in USA found that rabbits from Californian dams were lighter in pre-slaughter weights (P<0.05), carcass weights and giblets percentages (P<0.01). Lower blood and viscera wastes were recorded by BR-mothered rabbits than for NZ-mothered rabbits. These results were expected because BR rabbits originated from Giants which has superior breed maternity (during the period of postweaning growth in terms of growth and survival) compared to NZ breed.

Based on results of Tables 4&5, maternal-breed effects appear to be less important than paternal-breed effects in influencing most growth and carcass traits. Most estimates of linear contrasts for maternal-breed effects are low in comparison with the estimates of paternal-breed direct effects.

Sire-breed × dam-breed interaction

F-ratios given in Table 2 showed that the effect sire-breed × dam-breed interaction on body weights increased as the rabbit's age advanced, while a reverse trend was observed for daily gains. Effects of interaction between sire-breed and dam-breed were siginifcant (P<0.01 or P<0.001) for most weights (Table 2) which is a reflection of considerable non-additive breed effects. Such significant interaction could be considered in the planning work to produce heavy weights of commercial broiler rabbits. Opposite to growth traits, this interaction contributed little to the variation of all carcass traits (Table 3), i. e. little heterotic effects could be expected.

Heterotic effects

Direct heterosis contrasts given in Table 4 indicated heterotic effectgs on all body weights and daily gains. Heterosis percentages ranged from 2.5 % to 5.2 % for body weights and from 0.7 % to 9.5 % for daily gains. Such superiority of crossbred rabbits over their parental breeds points to considerable non-additive genetic breed effects. Heterosis contrasts were significant for BW5, DG3 and DG4 (P<0.05), BW6 (P<0.01) and BW8, BW10, BW12, DG1 and DG2 (P<0.001). Most of the crossbreeding experiments carried out in Egypt (e. g. AFIFI 1971; KOSBA et al. 1985; OUDAH 1990; EL-DESOKI 1991) indicated also the presence of postweaning heterotic effects in body weights and gains of rabbits at different ages.

Crossing was generally associated with insignificant heterotic effects on all carcass traits (Table 5). Insignificant positive direct heterotic effect was observed for SW, HCW, D%, HW, FW, BW and VW. When heterosis deviations were expressed on a percentage basis, they ranged from –0.7 % to 4.7 % for edible carcass traits (carcass, giblets and head) and from 1.0 % to 2.5 % for non-edible carcass traits (fur, blood and viscera). However, most estimates of heterosis obtained from experiments in USA, Egypt and France (LUKEFAHR et al. 1983; EL-QEN 1988 and HASSAN 1988; BRUN and OUHAYOUN 1989, respectively) indicated that crossbreeding is associated with a little improvement in the carcass performance.

Other interactions

Most of the interactions between different factors were found to be significant for growth traits (Table 2), while they were insignificant for most carcass traits (Table 3). Interaction of sire-breed × year of birth and sire-breed × season of birth caused significant effects on most body weights studied. This is difficult to comprehend and it may reflect unique fluctuations. Dam-breed × year and year × parity interactions had also considerable effects on postweaning body weights. Sire-breed × parity and dam-breed × parity interactions affected BW12 (P<0.05) and BW5 (P<0.01), prespectively. Sire-breed × year of birth interaction was significant for FW (P<0.05). Also, sire-breed × season interaction significantly affected GW and G% (P<0.05) and, again, interpretation is barely possible.

Conclusion

Since growth and carcass performance in New Zealand White and Baladi Red rabbits are not significantly different in their breed maternal performance, one may use either of the two breeds for providing dams for broiler rabbits characterized by high growth and heavy carcass. NZ dams may not be the best dam-breed, but using of NZ breed in terminal cross-breeding is to be recommended in the rabbit industry (OUDAH 1990; EL-DESOKI 1991; OZIMBA and LUKEFAHR 1991). Furthermore, considerable heterosis obtained here could be utilized for producing commercial broiler rabbits characterized by heavy weight and carcass. Single cross resulted from mating NZ sires with BR dams is recommended and producers and processors could potentially benefit economically through commercial production by this simple cross.

Summary

A crossbreeding experiment was carried out in Egypt using a local breed (Baladi Red, BR) and New Zealand White (NZ) to estimate direct heterosis, maternal additive effects and direct sire effects on some growth and carcass traits in rabbits. Data of body weight (at 5, 6, 8, 10, 12 weeks) and daily gains (at intervals of 5–6, 6–8, 8–10, and 10–12 weeks) on 2153 weaned rabbits were collected. Carcass performance at 12 weeks of age (weight and percentages of carcass, giblets, head, fur, blood and viscera) on 213 male rabbits was evaluated.

Estimates of coefficients of variation (CV) for most growth and carcass traits were high and ranged from 10.0 to 40.2 %. Sire-breed was of considerable importance in the variation of growth traits and some carcass traits, while dam-breed contributed little. Sire-breed × dam-breed interaction affected ($P<0.01$ or $P<0.001$) most body weights and gains studied, while it contributed little to the variation of carcass traits. The purebred NZ resulted in rabbits with heavier weights and carcass and with lighter non-edible carcass (blood and viscera) compared to the BR. Heterosis percentages for most growth traits were significant and ranged from 2.5 % to 5.0 % for body weights and from 0.7 % to 9.5 % for daily gains. Insignificant positive direct heterosis was observed for most carcass traits. Crossbred rabbits from NZ sires with BR dams were superior to from the reciprocals. Maternal-breed effects on most weights and gains were insignificant, while sire-breed contrasts for some weights and gains proved significant. Postweaning growth and carcass performances of BR-mothered rabbits generally surpassed the NZ mothered, while NZ-sired rabbits were superior at later ages. High edible carcass was observed for BR-sired rabbits, while more non-edible carcass wastes (blood and viscera) for NZ-sired rabbits. Maternal-breed effects appeared to be less important than paternal-breed effects in influencing most weights, gains and carcass traits studied.

Zusammenfassung

Heterosis, maternale und direkte Wirkungen bei Wachstums- und Schlachtkörpermerkmalen in Kaninchenkreuzungen

Der Kreuzungsversuch wurde mit lokalen ägyptischen Rassen (BR) und Neuseeland Weißen (NZ) zur Schätzung direkter Heterosis, maternaler additiver Wirkungen, direkter Vater-Wirkung auf einige Wachstums- und Schlachtkörpermerkmale von Kaninchen durchgeführt. Angaben über Körpergewicht (5, 6, 8, 10, 12 Wochen) und Zuwachs (Intervalle 5 bis 6, 6 bis 8, 8 bis 10, 10 bis 12 Wochen) wurden von 2153 abgesetzten Kaninchen gewonnen. Die Schlachtkörperleistungen bei 12 Wochen Alter (Gewicht und Anteil von Schlachtkörper, Kopf, Pelz, Blut und Innereien) stammen von 213 männlichen Kaninchen. Schätzungen der Variationskoeffizenten (CV) für meiste Wachstums- und Schlachtkörpermerkmale waren hoch und bewegten sich zwischen 10 und 40,2 %. Vaterrasse hatte erheblichen Einfluß auf Unterschiede in Wachstumsrate und einige Schlachtkörpermerkmale, während die Mutterrasse weniger beigetragen hat. Interaktion zwischen beiden beeinflußte die meisten Körpergewichts- und Zuwachsleistungen, während sie wenig zur Variabilität der Schlachtkörpermerkmale beigetragen hat. Reinrassige NZ waren schwerer und hatten weniger nicht nutzbare Schlachtkörperteile (Blut und Eingeweide) verglichen mit BR. Heterosis-Prozente für die meisten Wachstumsmerkmale waren signifikant und schwankten zwischen 2,5 und 5 % für Körpergewicht, 0,7 bis 9,5 % für Zuwachs. Insignifikante positive direkte Heterosis wurde für die meisten Schlachtkörpermerkmale beobachtet. Kreuzungskaninchen von NZ Vätern waren den reziproken überlegen. Maternale Wirkungen auf meiste Gewichtsmerkmale waren insignifikant, während Vaterrassenkontraste hierfür signifikant waren. Zuwachs- und Schlachtkörperleistung von BR gesäugten Kaninchen haben im allgemeinen die von NZ gesäugten übertroffen, während von NZ Böcken gezeugte in späteren Altersabschnitten überlegen waren. Hohe Werte für Schlachtkörper wurden für BR gesäugte

Kaninchen gefunden, während mehr nicht verzehrbare Abfälle (Blut und Eingeweide) bei NZ gezeugten vorhanden war. Maternale Rassenwirkungen schienen weniger wichtig als paternale zu sein.

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