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ESTIMATION OF CROSSBREEDING EFFECTS FOR SOME LITTER TRAITS IN CROSSING OF NEW ZEALAND WHITE WITH EGYPTIAN GABALI RABBITS

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A crossbreeding experiment was carried out involving New Zealand White (N) and Egyptian Gabali (G) rabbits to produce six genetic groups of NN, GG, ½G½N, ½N½G, ¾G¼N and ¾N¼G. Estimates of direct (G^I) and maternal (G^M) additive effects, direct (H^I) and maternal (H^M) heterosis and direct recombination effects (R^I) were genetically evaluated for litter size at birth (LSB) and weaning (LSW) and litter weight at weaning (LWW).

N rabbits had superior performance in litter size and weight compared to G rabbits. Crossbred litters obtained from mating N bucks with G does were generally associated with superiority compared to those litters obtained from the reverse mating. In most cases, genetic group of ½N½G gave larger litter size and heavier litter weight compared to the other genetic groups. The estimates of crossbreeding effects for LSB, LSW and LWW were 2.62, 7.52 and 12.37 % for G^I, –2.34, 9.56 and –7.50 % for G^M, 9.5, 19.2 and 15.8 % for H^I, –4.31, 3.43 and –3.77 % for H^M, and 45.5, 17.8 and 23.8 % for R^I, respectively. The estimates of direct additive effects were moderate or high and in favour of N rabbits and consequently N bucks could be used as sires in crossbreeding stratification systems under hot climatic conditions. The estimates of G^M for all traits were somewhat low and in favour of G rabbits. Crossbred dams recorded favourable maternal heterotic effects on litter size at weaning and unfavourable maternal heterotic effects on litter size at weaning, i.e. crossbred dams recorded larger litter size at weaning associated with a reduction in litter weight at weaning than their crossbred daughters. Estimates of direct recombination effects for litter size and weights at weaning were insignificant and indicate that epistatic recombination effects for crossbred litters during the suckling period were negligible.

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Key words: Egyptian Gabali rabbits, crossbreeding, litter size and weight, direct and maternal additive, heterosis, recombination effects.

Direct and maternal heterosis, direct and maternal additive effects and direct and maternal recombination losses for reproductive efficiency from crossbreeding experiments including Gabali rabbits were of considerable importance (Ali, 1998; Abdel-Aziz, 1998). The New Zealand White was found to exhibit an outstanding maternal ability as related to behavior, fecundity and lactation. Results of most crossbreeding experiments carried out in Egypt reported that crossing of New Zealand White breed with Gabali or other local breeds were generally associated with considerable heterotic effects on most litter and growth traits (Oudah, 1990; El-Desoki, 1991; Khalil *et al*, 1995; Ali, 1998; Abdel-Aziz, 1998).

The objective of the present paper was to estimate direct (**G^I**) and maternal (**G^M**) additive effects and direct (**H^I**) and maternal (**H^M**) heterosis as well as direct recombination loss (**R^I**) for litter size at birth (**LSB**), litter size at weaning (**LSW**) and litter weight at weaning (**LWW**) in crossbreeding experiment involving New Zealand White (**N**) and Egyptian Gabali (**G**) rabbits.

MATERIALS AND METHODS

A crossbreeding project involving New Zealand White (**N**) and Egyptian Gabali (**G**) rabbits was started in September 1994 in the experimental rabbitry, Faculty of Agriculture at Moshtohor, Zagazig University, Egypt.

Breeding plan and management:

Rabbits involved in this crossbreeding experiment represented desert Egyptian Gabali rabbits (came from north Sinai and raised in the rabbitry of Maryout Experimental Station, Desert Research Center since 1991) and New Zealand White (bought from Bank El-Nil rabbitry). The breeding plan permitted the simultaneous production of **NN, GG, ½G½N, ½N½G, ¾G¼N** and **¾N¼G** litters. Matings started in September 1995. Distribution of breeding does and their sires, dams and bucks as well as number of litters of the six genetic groups are presented in Table 1. The bucks were randomly assigned to mate the does with a restriction to avoid the matings of animals with common grandparents. Each buck

Table 1. Mating groups and number of sires, dams, does, bucks and litters used in different genetic groups of the study

Mating group⁺			Sires	Dams	Does	Bucks	Litters
Sires	Dams	Does					
N	N	N	43	78	159	52	373
G	G	G	8	9	18	9	53
G	N	½G½N	37	50	73	21	252
N	G	½N½G	10	12	24	9	64
G	½N½G	¾G¼N	3	7	9	6	27
N	½G½N	¾N¼G	14	25	39	11	171
Total			115	181	322	108	940

⁺ N = New Zealand White; G = Egyptian Gabali; Breed of buck listed first.

was allowed to sire all his litters from the same does, i.e. separate bucks in each of the six genetic groups were used. Rabbits were raised in semi-closed rabbitry. Breeding does and bucks were housed separately in individual wired-cages arranged in flat-deck batteries allocated in three rows along the rabbitry. All cages are equipped with feeding hoppers and drinking nipples. Each doe was palpated 12 days thereafter to determine pregnancy and those failed to conceive were returned to the same mating-buck. After kindling, litters were checked and recorded. Young rabbits were weaned at four weeks, ear tagged, sexed and transferred to standard progeny wire cages. Rabbits were fed on a commercial grower pelleted diet during the whole experimental period. On dry matter (**DM**) basis, diet contained 18.5% crude protein (**CP**), 8.0% crude fiber (**CF**), 3.0% ether extract (**EE**) and 6.5% ash. Feed and water were available *ad libitum*.

Data collected and model of analysis:

Litter size at birth (**LSB**), litter size at weaning (**LSW**) and litter weight at weaning (**LWW**) were analyzed using the following mixed model (Harvey, 1990):

$$Y_{ijklm} = \mu + G_i + D_{ij} + YS_k + P_l + e_{ijklm}$$

Where Yijklm is the observation on the ijklmth trait; μ is the overall mean; G_i is the fixed effect of ith genetic group; D_{ij} is the random effect of jth doe nested within the fixed effect of ith genetic group; YS_k is the fixed effect of the kth year-season of kindling combination; P_l is the fixed effect of lth parity; and e_{ijklm} is the random deviation particular to the mth litter, **NID (0, σ^2e)**.

Genetic model and estimation of crossbreeding effects:

Coefficients presented in Table 2 for the expected contribution of genetic effects (in **G** or **N** and their crosses) were computed according to Dickerson (1992). To

Table 2. Coefficients of expected contribution for genetic effects in different groups of purebreds and crossbreds

Sire genotype	Dam Genotype	Doe Genotype⁺	Direct Additive (G^I_{N-G})	Maternal Additive (G^M_{N-G})	Direct heterosis (H^I)	Maternal heterosis (H^M)	Recombination effect (R^I)
N	N	N	1	0	0	-0.5	0.5
G	G	G	-1	0	-1	-0.5	0.5
G	N	½G½N	0	1	1	-0.5	0.5
N	G	½N½G	0	-1	0	-0.5	0.5
G	½N½G	¾G¼N	-0.5	0	0.5	1	-1
N	½G½N	¾N¼G	0.5	0	-0.5	1	-1

⁺ Sire-breed listed first.

find the appropriate linear functions of breed group class means to use in order to estimate the genetic effects of interest, expression of the mean performance of breeds and crosses in terms of their genetic expectations were calculated as shown in Table 2. The general approach used to estimate the crossbreeding parameters (Komender, 1988) was:

$$\mathbf{M} = \mathbf{X}\,P$$

Where **M** is a vector of least-square means of genetic groups in the experiment, ***P*** is a vector of crossbreeding estimates and **X** is a design matrix including the expected contribution of genetic effects to the mean of each genetic group. The genetic effects were derived as:

$$P = X^{-1} M$$

For data of the two generations, the following genetic components were derived:

$\mathbf{G^I}$= Individual (direct) additive effect of the doe:

$$G^I_N - G^I_G = NN - GG - GN + NG$$

$\mathbf{G^M}$= Maternal additive effect of the dam of doe:

$$G^M_N - G^M_G = GN - NG$$

$\mathbf{H^I}$= Direct heterosis in the crossbred doe:

$$H^I = (GN + \tfrac{3}{4}G\,\tfrac{1}{4}N) - (GG + \tfrac{3}{4}N\,\tfrac{1}{4}G)$$

$\mathbf{H^M}$= Maternal heterosis in the crossbred dam:

$$H^M = (\tfrac{3}{4}N\,\tfrac{1}{4}G + \tfrac{3}{4}G\,\tfrac{1}{4}N) - \tfrac{1}{2}(NN + GG + GN + NG)$$

$\mathbf{R^I}$= Direct recombination effect in the individual doe:

$$R^I = \frac{1}{2}[(NN + GG + GN + NG) - 2(\frac{3}{4}N\frac{1}{4}G + \frac{3}{4}G\frac{1}{4}N)]$$

The standard errors were computed for all the genetic effects using the inverse matrix of the sub-class numbers and the error standard deviation.

RESULTS AND DISCUSSION

Genetic-groups comparisons:

Least square means of genetic groups and comparisons among purebreds for different traits are given in Table 3. Genetic group of **½N½G** resulted in a larger litter size and heavier litter weight compared to the other genetic groups. **G** rabbits were similar to **N** rabbits in litter size at birth and at weaning, while **N** rabbits had relatively heavier litter weight at weaning than **G**. These results were expected and reflected the superiority of **N** rabbits in milking ability.

Genetic-group significantly affected litter size and weight at weaning (Table 4). Similarly, Khalil *et al* (1995) found that mating group constituted a significant source of variation in liter size and weight at weaning. On the contrary, Afifi *et al* (1976ab), Lukefahr *et al* (1983a&b), Afifi and Emara (1984), Oudah (1990) and Abd El-Aziz (1998), all working on crossbreeding experiments found that genetic group showed insignificant effects on most litter traits studied.

Direct breed additive effect (G^I)

The linear contrasts of G^I for litter size and weight at weaning were significant and in favour of **N** rabbits (Table 5). Such differences in G^I between the two breeds lead to state that **N** buck-breed produced litters with larger size and heavier weight at weaning than the **G** buck-breed and therefore **N** rabbits could be used as a buck-breed in crossbreeding programs in Egypt. The percentages of G^I for litter size and weight at weaning were moderate (Table 5), being 7.52 and 12.37 % for **LSW** and **LWW**, respectively. Abd El-Aziz (1998) found that **G**-sired litters had larger **LSB** and heavier **LWW** as compared to **N**-sired litters, while **N**-sired litters had larger **LSW**. Khalil and Afifi (2000) reported that New Zealand White rabbits had higher estimates of G^I than Gabali rabbits for litter weight at birth and weaning ($P < 0.01$ or $P < 0.001$) in crossbreeding experiment involving the two breeds.

Maternal breed additive effect (G^M):

The percentages of G^M for pre-weaning litter traits were low or moderate (Table 5); being –2.34, -9.56 and –7.5 % for **LSB**, **LSW** and **LWW** ($P<0.05$), respectively. The estimates of G^M were mainly in favour of **G** dams. This unexpected reverse trend was observed also by Abd El-Aziz (1998) who reported that litters of dams gave larger **LSB** and **LSW** compared to **N** dams. This might be true since **N** rabbits raised in Egypt for a long period and had a reduction in pre-weaning litter performance due to the decrease in milk production compared to **G** rabbits. Opposite to the present results, there was a general trend indicating that

Table 3. Purebred and crossbred least-squares means (±SE) for litter size at birth (LSB), litter size at weaning (LSW) and litter weight at weaning (LWW)

Trait+	NN	GG	½G½N	½N½G	¾G¼N	¾N¼G
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
LSB	6.81±0.13	6.80±0.32	7.02±0.16	7.18±0.32	7.02±0.44	6.60±0.20
LSW	5.18±0.14	5.30±0.33	5.52±0.17	6.05±0.33	6.00±0.45	5.21±0.20
LWW	3252.5±85	3096.7±203	3175.4±101	3416.7±198	3387.4±274	2963.5±125

Table 4. F ratios (F) of least-squares ANOVA of factors affecting litter size at birth (LSB), litter size at weaning (LSW) and litter weight at weaning (LWW)

Source	DF	F-ratio		
		LSB	LSW	LWW
Genetic group	5	0.959^NS	2.036*	1.465*
Does within genetic group	316	1.358***	1.301**	1.344***
Parity	4	3.997**	2.921*	2.641*
Year-season	5	1.376	3.776**	2.958**
Remainder	609			
Error mean squares		3.491	3.875	1391808

NS = Non-significant,* = P<0.05, ** = P<0.01 and ***= P<0.001.

Table 5. Estimates of direct (G^I) and maternal (G^M) additive effects for litter size at birth (LSB), litter size at weaning (LSW) and litter weight at weaning (LWW)

Trait	Direct additive			Maternal additive		
	Units	SE	G^I%	Units	SE	G^M%
LSB	0.1799	0.04	2.62 NS	-0.1626	0.03	-2.34 NS
LSW	0.4122	0.04	7.52*	-0.5363	0.03	-9.56*
LWW	397.1	24.8	12.36**	-241.4	17.6	-7.50*

G^I%= [G^I in units / (average of N + N-sired crosses)]x100

$G^M\%$= [G^M in units / (average of **G** + **G**-dammed crosses)]x100
^{NS} = Non-significant, * = P<0.05, ** = P<0.01.

litters mothered by exotic breeds recorded better performance than litters mothered by native breeds. Crossbreeding experiments carried out in Egypt (Afifi and Khalil, 1989; Oudah, 1990; Khalil *et al*, 1995; Khalil and Afifi, 2000) indicated desirable additive maternal breed effect in New Zealand White rabbits for pre-weaning litter traits compared to other breeds.

Direct heterosis (H^I):

Estimates of H^I calculated in actual units and as percentages for different traits are given in Table 6. The estimates of were 9.5, 19.2 and 15.8 % for **LSB**, **LSW** and **LWW**, respectively. These estimates were positive and significant for all traits of the study; indicating that crossing between **N** and **G** rabbits was associated with an existence of direct heterotic effects in crossbred preweaning litters of individual does of the present study. However, results of the present study are in agreement with Abd El-Aziz (1998) with the same crossbreeds and for the same traits. Results of the different crossbreeding experiments carried out in Egypt (Afifi and Emara, 1984; Afifi and Khalil, 1989; El-Desoki, 1991; Khalil *et al*, 1995; Khalil and Afifi, 2000) revealed also that heterotic effects were evidenced in most of the possible crossbreds for litter size, litter weight, and milk yield.

Maternal heterosis (H^M):

Estimates of H^M calculated in actual units for different traits are given in Table 6. The estimates were negative for **LSB** and **LWW**, but it was positive and significant for **LSW**. The parental epistasis in the second-generation (F_2) may be responsible for these low estimates of maternal heterosis. The positive estimate of maternal heterosis for litter size at weaning is favourable and indicating that crossbred dams could produce larger litter size associated with lighter litter weight at weaning than their crossbred daughters. Results of the different crossbreeding experiments carried out in Egypt (i.e. Afifi *et al*., 1976ab; Afifi and Emara, 1984) revealed that maternal heterotic effects were evidenced in most of the crossbred dams for litter size and litter weight.

Direct recombination effect (R^I):

At kindling, estimate of direct recombination effects (R^I) for litter size at birth was significant (Table 7) and was quietly different to that estimate of direct heterosis. This notation implies that dominance effects on this trait recorded at kindling were of considerable importance. At weaning, negative direct recombination loss for litter size at weaning

(Table 7) reveal that crossbred does with **N** genes could mother does with lower litter size at weaning than purebred **N** does when both groups of does were mated to bucks from the same **N**

Table 6. Estimates of direct (H^I) and maternal (H^M) heterosis for litter size at birth (LSB), litter size at weaning (LSW) and litter weight at weaning (LWW)

Trait	Direct heterosis			Maternal heterosis		
	Units	SE	H^I%	Units H^M%		SE
LSB	0.6439	0.048	9.5*	-0.2932	0.04	-4.31*
LSW	1.0052	0.051	19.2**	0.1798	0.05	3.43*
LWW	502.6	17.6	15.8**	-119.7	27.7	- 3.77*

H^I%= [H^I in units / (average of **NN** + **GG**)]x100
H^M%= [H^M in units / (average of **NN** + **GG**)]x100
^{NS} = Non-significant, * = P<0.05, ** = P<0.01.

Table 7. Estimates of direct recombination effect (R^I) for litter size at birth (LSB), litter size at weaning (LSW) and litter weight at weaning (LWW)

Trait	Direct recombination effect		
	Units	SE	(R^I/H^I)x100
LSB	0.2932*	0.044	45.5
LSW	-0.1797^{NS}	0.046	-17.8
LWW	119.7^{NS}	27.7	23.8

^{NS} = Non-significant,* = P<0.05.

purebred. The insignificant effects for direct recombination loss for litter size and weight at weaning (Table 7) indicate that epistatis recombination losses for these traits recorded at weaning in crossbred rabbits were negligible. Information in the literature concerning estimates of direct recombination effects of crossbreeding experiments in rabbits is scarce. Most of these available results are contradicted.

CONCLUSIONS

(1) Since post-kindling litter performance in New Zealand White and Egyptian Gabali rabbits were not significantly different in their breed performance, one may use New Zealand White as sires. For commercial rabbits industry in Egypt, Gabali does could be used in terminal crossbreeding system.

(2) Crossing Egyptian Gabali rabbits with New Zealand White was associated with direct heterotic effects in litters of individual does.

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

(4) The low or negative estimates of maternal heterosis recorded for pre-weaning litter traits indicate that genetic differences in these traits in crossbred does produced by crossbred or purebred dams are very limited.

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تقدير تأثير الخلط على بعض صفات خلفة البطن في خلطة أرانب النيوزيلندي الأبيض مع الجبلي المصري

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أجريت تجربة خلط بين أرانب النيوزلندي الأبيض (N) وأرانب الجبلي المصري (G) لأنتاج ٦ مجموعات تربوية *NN، GG، ½G½N ½N½G ¾G¼N ¾N¼G*. وذلك لتقدير التأثير التجمعي الفردي (G^I) والأمي (G^M) وكذلك قوة الهجين في الفرد (H^I) وفي الأم (H^I) وأيضا تأثير إعادة توليف الجينات في الفرد (R^I) لصفات عدد خلفة البطن عند الميلاد والفطام ووزن البطن عند الفطام.

وقد أوضحت النتائج تفوق أرانب النيوزيلندي الأبيض على أرانب الجبلي في الصفات المدروسة، وأعطت خلطة الأرانب الناتجة من ذكور نيوزيلندي وإناث جبلي أفضل النتائج بصفة عامة عن الخليط العكسي.

وقد كان التأثير التجمعي الفردي (G^I) لصفات عدد خلفة البطن عند الميلاد ووزن خلفة البطن عند الفطام ٢،٦٢ و ٧،٥٢ و ١٢،٣٧ % على التوالي بينما كانت نتائج التأثير التجمعي الأمي (G^M) –٢،٤٣ و٩،٥٦ و–٧،٥ % على التولي، كما كانت نتائج قوة الهجين الفردية (H^I) ٩،٥ و ١٩،٢ و ١٥،٨ % على التوالي وكانت قوة الهجين في الأم (H^I) –٤،٣١ و ٣،٤٣ و– ٣،٣٧% على التوالي، أما قيم التأثير الاندماجي فقد كانت ٤٥،٥ و –١٧،٨ و ٢٣،٨% على التوالي.

هذا وقد أوضحت نتائج تقديرات التأثير التجمعي الفردي أنها ما بين متوسطة وعالية وفي صالح الأرانب النيوزيلندي الأبيض وبالتالي فأنه يمكن استخدام ذكور أرانب النيوزيلندي الأبيض في استراتيجيات نظم الخلط تحت ظروف المناطق الحارة.

كما كانت تقديرات قيم تأثير إعادة توليف الجينات (R^I) لصفتي عدد ووزن الخلفة عند الفطام غير معنوية مما يشير إلى إن تأثير إعادة توليف الجينات في خلال فترة الرضاعة يمكن تجاهله.