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HETEROSIS, MATERNAL AND DIRECT ADDITIVE EFFECTS FOR LITTER PERFORMANCE AND POSTWEANING GROWTH IN GABALI RABBITS AND THEIR F_1 CROSSES WITH NEW ZEALAND WHITE

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ABSTRACT

: A crossbreeding experiment was carried out involving Gabali (**G**) and New Zealand White (**NZW**) rabbits to estimate direct heterosis (**H^I**) and direct (**G^I**) and maternal (**G^M**) additive effects on some litter traits and postweaning growth. Data on litter traits of 314 litters (litter size and weight at birth and weaning, milk yield at 21 days and total milk yield) and body weight (at 4, 6, 8, 10 and 12 weeks of age) of 1300 weaned rabbits were analyzed using a linear mixed model. **G^I** did not significantly affect most litter traits and postweaning growth. **G**-sired litters had similar direct additive effects compared to **NZW**-sired litters and consequently **G** bucks could be used as sires in crossbreeding stratification systems under hot climatic conditions. 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 estimates of **G^M** for litter size and weight at birth were significantly in favour of **G**-rabbits, while breed maternity for litter traits measured after kindling was significantly in favour of **NZW** breed. After weaning, growth traits were not significantly affected by **G^M**. Crossing of **G** rabbits with **NZW** was associated with significant positive estimates of **H^I** for litter size and weight at birth and weaning. Slight negative estimates of **H^I** were observed for milk yield at 21 days and total milk yield. However, insignificant negative estimates of **H^I** were 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 (GALAL and KHALIL, 1994). 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 (KHALIL, 1996). On the other hand, the New Zealand White breed was found to exhibit an outstanding maternal ability as related to behavior, fecundity and lactation (LUKEFAHR et al, 1983ab; OZIMBA and LUKAFAHR, 1991). 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 (OUDAH, 1990; EL-DESOKI, 1991; AFIFI et al, 1994; KHALIL et al, 1995). Therefore, this study was conducted to estimate direct (**G^I**) and maternal (**G^M**) additive effects and direct heterosis (**H^I**) for 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.

Rabbits used in this study represent one desert Egyptian breed (Gabali, **G**) and one exotic breed (New Zealand White, **NZW**). Each buck was allowed to sire all his litters from the same does. The breeding plan permitted the simultaneous production of **G, NZW, G x NZW** and **NZW x G** litters in each parity. Matings in this experiment 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 genetic groups are presented in Table 1.

Rabbits were raised in a semi-closed rabbitry. Breeding does and bucks were housed separately in individual wired-cages.. Does were mated from the same assigned bucks 10 days after each kindling. 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 by KHALIL (1994).

Data of litter traits included litter size at birth (**LSB**) and weaning (**LSW**), litter weight at birth (**LWB**) and weaning (**LWW**), milk yield at 21 days (**M21**) and total milk yield (**TMY**), while data of postweaning growth included body weights at 4, 6, 8, 10 and 12 weeks of age (**W4**, **W6**, **W8**, **W10** and **W12**, respectively). Data of litter traits on 314 litters(Table 1) were analyzed using the following mixed model (HARVEY, 1990):

$$Yijklm = \mu\mu + Gi + Dij + Ak + Pl + eijklm \qquad \textbf{(Model 1)}$$

Where Yijklm is the observation on the ijklmth litter trait (**LSB, LSW, LWB, LWW, M21** and **TMY**); $\mu\mu$ 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 (k=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, **NID** (**0**, $\sigma\sigma^2_e$).

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

Genetic group+	Bucks	Does	Litters weaned	Bunnies born	Bunnies weaned
NZWxNZW	15	50	160	1173	850
GxG	8	26	56	348	280
NZWxG	8	25	60	524	360
GxNZW	14	37	98	698	580
Total	55	138	374	2743	2070

+Breed of buck is listed before breed of doe.

Data on 2070 weaned(Table 1) rabbits for postweaning growth traits were analyzed using the following sire model (HARVEY, 1990):

$$Y_{ijklmno} = \mu\mu + G_i + S_{ij} + A_k + P_l + B_m + C_n + (GB)_{im} + (AP)_{kl} + (AB)_{km} + (AC)_{kn} + (PB)_{lm} + (BC)_{mn} + e_{ijklmno} \qquad \textbf{(Model 2)}$$

Where $Y_{ijklmno}$ is the observation on the ijklmnoth weaned rabbit of the postweaning growth trait (**W4, W6, W8, W10** and **W12**); $\mu\mu$ is the overall mean, G_i is the fixed effect of the i^{th} breed group, S_{ij} is the random effect of the j^{th} sire nested within the i^{th} breed group (taking the relationship coefficient inverse matrix $\mathbf{A^{-1}}$ into consideration), A_k is the fixed effect of the k^{th} season of birth (k=1,2); P_l is the fixed effect of the l^{th} parity (l=1,....,5); B_m is the fixed effect of the m^{th} sex; C_n is the fixed effect of the n^{th} teats number of doe (n= 5,6,… 10); and $e_{ijklmno}$ is the random deviation particular to the o^{th} weaned rabbit, NID (**0**, $\sigma\sigma^2_e$) along with all possible interactions of GB_{im}, AP_{kl}, AB_{km}, AC_{kn} , PB_{lm} and BC_{mn}. Breed group was tested against sire within breed group, while other fixed effects were tested against the remainder.

Crossbreeding effects of direct additive ($\mathbf{G^I}$), maternal additive ($\mathbf{G^M}$) and direct heterosis ($\mathbf{H^I}$) for different litter traits and body weights were estimated according to Dickerson theory (DICKERSON, 1992). Such genetic model permits to derive a selected set of linear contrasts and therefore $\mathbf{G^I}$, $\mathbf{G^M}$ and $\mathbf{H^I}$ were estimated as:

Direct additive effect:

$$(G^I_{NZW}-G^I_G)= \{[(NZW \times NZW) + (NZW \times G)] - [(G \times G)+(G \times NZW)]\}$$

Maternal additive effect:

$$(G^M_{NZW} - G^M_G) = [(G \times NZW) - (NZW \times G)]$$

Direct heterotic effect (units):

$$H^I \text{ in units} = [(NZW \times G + G \times NZW) - (NZW \times NZW + G \times G)]/2$$

$$H^I (\%) = [(NZW \times G + G \times NZW) - (NZW \times NZW + G \times G)] / [NZW \times NZW + G \times G](100)$$

Where $\mathbf{G^I}$ and $\mathbf{G^M}$ 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

Direct additive effect (G^I)

The linear contrasts of $\mathbf{G^I}$ for most litter and postweaning growth traits were insignificant (Tables 2&3). Such limited differences in $\mathbf{G^I}$ between the two breeds lead to state that **G** could be used as a buck-breed in crossbreeding programmes.

NZW had higher estimates of $\mathbf{G^I}$ than **G-**for litter weights at birth (P<0.001 and at weaning(P<0.10). High estimates of $\mathbf{G^I}$ for litter traits lead to indicate that **NZW** breed could be used as a terminal sire breed for litter traits measured at kindling. In France, an experiment (1970) showed that Californian-sired litters had higher estimates of $\mathbf{G^I}$ for pre-weaning litter traits than that of **NZW-**sired litters (ROUVIER and BRUN, 1990). A reverse trend was observed in an experiment performed 20 years later (BRUN, 1993). Also, the American study by LUKEFAHR et al (1983a) showed that estimates of $\mathbf{G^I}$ for pre-weaning litter traits (**LSB, LWB, LSW** and **LWW**) were mostly in favour of Californian vs **NZW.** They added that direct Flemish Giant effects on pre-weaning litters were positive and high compared with **NZW**.

For post-weaning growth traits the $\mathbf{G^I}$ effects were only significant for the weight at 12 weeks, being the value of **G** breed higher thn the one of the **NZW** (Table 3). Such superiority of **G**-sired rabbits in $\mathbf{G^I}$ may be an encouraging factor for the rabbit breeder in hot climate countries to use their native breeds in any crossbreeding stratification system. Estimates of $\mathbf{G^I}$ presented in Table 5 indicate also that $\mathbf{G^I}$ at later age (**W12**) was significantly in favour of **G** breed. At later ages, MASOERO et al (1985) evidenced such significant $\mathbf{G^I}$ in **NZW**, Californian, Burgundy Fawn, Flemish Giant, Argenté de Champagne and Blue Vienna and their crosses.

Table 2. Genetic group means (+SE) and estimates of direct additive effect (G^I), maternal additive effect (G^M) and direct heterosis (H^I) of litter traits$^+$

Item	LSB	LWB	LSW	LWW	M21	TMY
Genetic group^{++}:						
NZWxNZW	6.75±±0.22	403±±13.7	4.58±±0.24	2849±±143	2320±±92	3482±±136
GxG	5.91±±0.81	305±±50.2	3.49±±0.89	2206±±524	2235±±331	3383±±497
NZWxG	8.32±±0.82	444±±50.4	4.63±±0.89	2746±±526	1963±±326	3111±±497
GxNZW	6.65±±0.49	389±±30.5	4.97±±0.54	3099±±318	2384±±196	3512±±300
Significance	*	NS	NS	NS	NS	NS
Direct additive effect:	2.52^{***}	152^{***}	0.8^{NS}	291^{NS}	-336^{NS}	-598^{NS}
Maternal additive effect:	-1.7^{***}	-55^{*}	0.3^{NS}	353^{*}	421^{*}	401^{*}
Heterosis						
H^I	1.2^{***}	62^{**}	0.8^{**}	395^{*}	-104^{NS}	-122^{NS}
H^I (%)	18.3	17.5	18.8	15.6	-4.6	-3.5

$^{++}$Buck-breed listed first NS= Non-significant (P>0.05); *=P<0.05; **=P<0.01; ***=P<0.001.

Table 3. Genetic group means (+SE) and estimates of direct additive effect (G^I), maternal additive effect (G^M) and direct heterosis (H^I) for post-weaning body traits$^+$

Item	W4	W6	W8	W10	W12
Genetic group^{++}:					
NZWxNZW	591±±22	807±±23	1065±±30	1378±±35	1711±±36
GxG	587±±56	796±±62	1084±±83	1405±±95	1812±±87
NZWxG	572±±99	820±±83	1073±±105	1411±±114	1718±±103
GxNZW	584±±51	798±±52	1063±±66	1364±±76	1726±±72
Significance	NS	NS	NS	NS	NS
Direct additive effect:	-7.9^{NS}	32.7^{NS}	-8.6^{NS}	19.2^{NS}	-108.4*
Maternal additive effect:	12.2^{NS}	-21.8^{NS}	-10.1^{NS}	-47.1^{NS}	7.8^{NS}
Heterosis :					
H^I	-10.4^{NS}	-7.5^{NS}	-6.5^{NS}	-3.7^{NS}	-39^{NS}
H^I (%)	-1.8	-0.9	-0.6	-0.3	-2.2

$^{++}$ Sire-breed listed first NS= Non-significant (P>0.05); *= P<0.05.

Maternal additive effect (G^M)

Estimates of $\mathbf{G^M}$ for litter sizes and weights at birth were significant and they were mainly in favour of **G** breed (Table 2). After kindling, $\mathbf{G^M}$ was significantly in favour of **NZW** breed for **M21, TMY** and **LWW**. This superiority of **NZW** does is attributable to favorable maternal abilities and an increased levels of milk production compared to **G** does. Crossbreeding experiments carried out in Egypt (AFIFI and KHALIL, 1989; OUDAH, 1990; KHALIL et al, 1995) indicated that estimates of $\mathbf{G^M}$ for pre-weaning litter traits were insignificant. However, most of the Egyptian findings reported a general trend indicating that litters mothered(*direct plus maternal additive effects*)by exotic breeds (e.g. **NZW**, 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, maternal superiority of **NZW** breed compared with other standard breeds has been demonstrated in the American studies (e.g. LUKEFAHR et al, 1983ab; OZIMBA and LUKAFAHR, 1991) and in the European studies (e.g. PARTRIDGE et al, 1981; MASOERO et al, 1985; ROUVIER and BRUN, 1990), i.e. using NZW as a dam breed produced high performances in litter size and weight compared to other dam breeds.

Maternal additive effects on all postweaning body weights were insignificant (Table 3). In Egypt, AFIFI et al (1994) found that postweaning growth of rabbits mothered by **NZW** breed are nearly similar to those rabbits mothered by Baladi Red breed.

Direct heterosis (H^I)

Estimates of H^I (calculated in actual units and as percentages) for different traits are given in Tables 2&3. The estimates indicated also that crossing between **NZW** and **G** rabbits was usually associated with an existence of heterotic effects on litter size and weight measured at kindling.and at weaning Estimates of H^I were significant for **LSB**, **LWB**, **LSW** and **LWW**. Different crossbreeding experiments carried out in Egypt (AFIFI and EMARA, 1984; AFIFI and KHALIL, 1989; KHALIL et al, 1995) revealed that heterotic effects for litter size and litter weight were evidenced.

Estimates of H^I 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.

Conclusions

(1) Since post-kindling litter performances in New Zealand White and Gabali rabbits were not significantly different in their breed 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.

(2) Single cross resulted from mating Gabali sires with New Zealand White dams is recommended and producers and processors could attained economic benefits of commercial production through using of this simple cross.

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