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PRODUCTIVE AND REPRODUCTIVE TRAITS IMPROVEMENT OF THE EGYPTIAN LOCAL STRAIN RABBITS BY THE CROSSING WITH TWO FOREIGN STRAINS

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ABSTRACT: The numbers of 1317 parities were analyzed to evaluate crossing effects among three breeds of rabbits. The tested breeds were New-Zealand White (NZW), Chinchilla (Ch) and Gabali (G). An incomplete dialed crossing mating design excluding the two reciprocal crosses between the two foreign breeds (♀Chx♂NZW, ♀NZWx♂Ch) was adopted. The traits studied were litter size (LS) at birth (LSB), litter size at 21 days (LS21) and litter size at weaning (LSW), litter weight (LW) at birth (LWB), litter weight at 21days (LW21) and litter weight at weaning (LWW). As well as, growth traits involved: individual body weight (BW) at 4 (BW4), 6 (BW6), 8 (BW8), 10 (BW10) and 12 (BW12) weeks of age. In addition, heterosis (H^I) was estimated for all traits studied. Effect of mating type was significant ($P < 0.05$) for LS, LW and BW traits. In purebreeds, G rabbits recorded the highest value of each ($P < 0.05$) LSB, LS21 and LSW (7.3, 5.9, and 5.8, respectively). In crossbreed, results showed that ♀Gx♂Ch recorded the highest value of each LSB, LS21 and LSW (7.5, 6.1, and 5.9, respectively). With respect to LW traits, in purebred rabbits, G recorded the highest LWB (411.9 g), while NZW recorded the highest LW21 and LWW (1745.4 and 2824.4 g, respectively). In crossbreeds, ♀Gx♂Ch showed the highest LWB (394.2 g), while ♀NZW x♂G recorded the highest LW21 and LWW (1836.5, 2917.1 g, respectively). ♀ New Zealand White x ♂Gabali rabbits and ♀Chx♂G rabbits recorded negative and non-significant estimates of heterosis (%) for LS and LW traits. Individual body weight traits were significantly influenced by mating type during the different ages. Both ♀NZWxG♂ and ♀ChxG♂ rabbits recorded positive and significant estimates of heterosis (%) for BW traits. Based on the results of the present study, it could be concluded that crossing between G does and Ch bucks improved LS and/or LW traits. Also, crossing between G bucks and NZW does improved growth traits, LWB and LW21.

Key words: Rabbits, litter size, gabali, crossbreeding, growth traits, heterosis.

INTRODUCTION

Rabbits are characterized as a small body size compared to other domestic animals. Moreover, does produce 30 to 40 young a year and these are sold at 2.2 to 2.4 kg at about 80 days (Lebas *et al.,* 1997). Rabbit meat is easier to digest and tastier than other meat types that are commonly consumed (Dronca *et al.,* 2013). Traits such as LS, LW and BW and DG are very important economic traits for meat production (Garcia *et al.,* 2006).

Crossbreeding is an effective means of changing the genetic of animal and exploiting genetic variation between populations (Ragab *et al.,* 2016). Crossbred litters obtained from mating G bucks with NZW doe were higher than those litters obtained from the back crossing (Khalil and Afifi, 2000). Moreover, significant positive estimates of H^I for LS and LW at birth

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and weaning were found (Khalil and Afifi, 2000). Many studies found that LSB, LSW, LWB and LWW for purebred or crossbred Gabali does were higher than those observed in Bouscat and Ch (Afifi, 1971; Afifi and Emara, 1989) and NZW rabbits (Khalil and Afifi, 2000).

Growth traits are important factors which affect the profitability of meat production (Soliman *et al.,* 2014). Also, body weight is an important economic character in the commercial rabbit industry. In this respect, numerous studies (Afifi *et al.,* 2000; Khalil and Afifi, 2000; Saleh *et al.,* 2005) found that BW improved by the crossing between local breeds and other standard breeds (*e.g.* NZW, Californian ... *etc.*). Also, El-Bayomi *et al.* (2012) found that crossing of Californian (Ca) males with NZW females improve BW due to heterotic effect. On the other hand, Afifi and Emara (1988) found that crossing among Bouscat, Giza White, White Flander and Baladi Red, decreased BW of crossbred groups at 5 to 12 weeks of age.

Therefore, the present study aimed to evaluate some productive and reproductive traits for seven genotypes of rabbits including G as a local breed, NZW and Ch rabbits as foreign breeds and their crosses under Egyptian conditions.

MATERIALS AND METHODS

The experience was held at a private farm located about 60 km from Zagazig, Sharkia Governorate, Egypt (from 2014 to 2016). Rabbits were obtained from the farm Faculty of Agriculture, Zagazig University, Egypt. The study was carried out on three pure breeds of rabbits, local breed Gabali (G), New-Zeland White (NZW) and Chinchilla (Ch). For the purebreds, ten does and three bucks were used. While, for the crossbreds, fifteen does and four bucks from each breed were used. Three breeds dialed crossed design was constructed as presented in Table 1. As shown in Table 1, ♀Chx♂NZW and ♀NZWx♂Ch were absent because our aim was to evaluate G and their crosses.

Rabbits were housed under uniform conditions of management in hutches measuring (60 cm length, 60 cm width and 40 cm height) provided with manual feeder and a nipple system for watering. Metal nest box (40 x 40 x 40 cm) was attached to the doe's cage. Litters were weaned at 4 weeks of age. Lighting was available for a period of 14 hours/day throughout the experimental period. Rabbits were fed on commercial pelleted diets with the following characteristics: 18% crude protein, 13-14% crude fibers, 2400-2600 kcal/kg diet digestible energy.

Each doe was inserted to the buck's cage for mating. Doe, buck's number and date of mating were recorded. Each doe palpated for pregnancy 10 days after service. The expected date of kindling is recorded, for positively palpated does. While negative ones were remitted. On the 28th day of gestation, cleaning and installation of kindling box for mothers before kindling 4-5 days. Assessment of the litter, just after kindling was carried out and dead kits were taken away. Moreover, litter size, born alive and born dead was also recorded from birth until weaning at 4 weeks of age.

Heterosis (H^I) for all traits studied were estimated according to Dickerson theory (Dickerson, 1992). Such genetic model permits to derive a selected set of linear contrasts as for flowing:

H^I in units = [(NZW×G + G×NZW) - (NZW× NZW + G×G)]/2

H^I in units = [(Ch×G + G×Ch) - (Ch×Ch + G× G)]/2

H^I (%) = [(NZW×G + G×NZW) - (NZW×NZW + G×G)] / [NZW×NZW + G×G] (100).

H^I (%) = [(Ch×G + G×Ch) - (Ch×Ch + G×G)]/ [Ch× Ch + G×G] (100).

Where H^I heterosis in units.

Statistical Analysis

Statistical analysis was performed by means of the PROC GLM procedure of SAS (SAS, 2002). The Significance of the difference between the means was verified by Duncan's new multiple ranges test (Duncan, 1955). Using the following model:

$$Y_{ijklmn} = \mu + B_i + D_{ij} + C_j + S_l + P_m + e_{ijklmn}$$

Table 1. Number of bucks, does and bunnies distributed in the seven mating types of the study

Mating type	Bucks	Does	Bunnies born	Bunnies weaned
GxG	3	10	913	739
NZWxNZW	3	10	897	719
ChxCh	3	10	757	667
♀Gx♂NZW	4	15	1432	1210
♀Gx♂Ch	4	15	1413	1239
♀NZWx♂G	4	15	1248	1031
♀Chx♂G	4	15	1240	1060
Total	25	90	8066	6790

Where:

Y_{ijklmn} is the observation on the ijklmn the litter and growth traits (LSB, LS21, LSW, LWB, LW21, LWW, ……*etc.*); μ is the overall mean; B_i is the fixed effect of i^{th} breed group; D_{ij} is the random effect of j^{th} doe nested within the i^{th} breed group; C_k is the fixed effect of k^{th} year of kindling (k=1, 2); S_l is the fixed effect of the l^{th} season of kindling (l=1, 2, 3, 4); P_m is the fixed effect of m^{th} parity (l=1, 2, ..., 5); and e_{ijklmn} is the random error term.

RESULTS AND DISCUSSION

Litter Size and Litter Weight Traits

Mating type had significant ($P < 0.05$ or $P < 0.01$) effect on LS and LW traits as shown in Table 2. These results agree with those reported by Galal and Khalil (1994), Iraqi *et al.* (2010) and Hassanien and Baiomy (2011). It was observed that mating type effect was significant on LSB, LS at 14 days, LSW, LWB, LW at 14 days and LWW (Hassanien and Baiomy, 2011). Moreover, Iraqi *et al.* (2010) found that mating type had a significant ($P < 0.05$) effect on LSW and LWW in a crossbreeding experiment between NZW and G breeds. Conversely, mating type had non-significant effect on LSB alive and LWB alive (Iraqi *et al.,* 2010).

Interestingly, G rabbits recorded the highest values of LSB, LS21 and LSW compared to NZW and Ch rabbits. On the other hand, Ch rabbits recorded the lowest estimates of LSB, LS21 and LSW. Differences in LSB between breeds and/or between does within breed could be due to the differences in uterine capacity, conception rate, or the differences in maternal effect between breeds and between does within the breeds and determined by the number of mature, fertilized and established ova (Argente *et al.,* 2003; Gad-Alla *et al.,* 2005; Nofal *et al.,* 2005; Pannu *et al.,* 2005).

Gabali rabbits had the highest ($p < 0.05$) estimate of LWB, while the NZW rabbits had the highest estimate of LW21 and LWW (Table 2). Khalil *et al.* (1995) found that NZW purebred had larger LS and heavier LW than the Baladi Red rabbits. Interestingly, Khalil (1994) found that NZW rabbits were higher in milk production and maternal ability compared with the local breeds; this could be the main cause of the poor performance for the local breeds.

As shown in Table 2, mating type had significant effects ($p < 0.05$ or $p < 0.01$) on LS and LW traits. Crossbred ♀Gx♂Ch rabbit had higher LSB, LS21 and LSW compared to the other crossbreds. While ♀Chx♂G rabbits recorded the lowest estimates for all LS traits and LWB and LWW (Table 2). On the other hand, ♀Gx♂Ch rabbits showed the highest ($p <0.05$) estimate of LWB. While ♀NZWx♂G rabbits recorded the highest estimates of LW21 and LWW. The superiority of crossbred LS and LW traits could be due to hybrid vigor which

Table 2. Least square means and tests of significance for litter traits and heterosis of NZW, Ch and G pure breeds and their crossing during the experimental period

Mating type (♀×♂)	LS at Birth	LS at 21 days	LS at Weaning	LW (g) Birth	LW (g) 21 days	LW (g) Weaning
NZW × NZW	7.03±0.19[a]	5.78±0.15[ab]	5.62±0.15[ab]	350.71±9.36[c]	1745.44±42.56[b]	2824.47±68.55[a]
Ch×Ch	6.55±0.16[b]	5.45±0.13[b]	5.39±0.14[b]	350.09±594[c]	1548.14±24.83[c]	2553.36±42.90[b]
G×G	7.36±0.18[a]	5.96±0.15[a]	5.87±0.15[a]	411.99±7.61[a]	1560.92±24.73[c]	2586.44±36.75[b]
NZW ×G	7.01±0.17[a]	5.94±0.15[a]	5.76±0.14[ab]	374.59±7.33[b]	1836.53±47.01[a]	2917.09±58.84[a]
Ch×G	5.70±0.10[c]	4.93±0.10[c]	4.64±0.10[c]	310.0±5.19[d]	1399.34±22.36[a]	2346.72±33.16[c]
G× NZW	7.19±0.13[a]	5.79±0.12[ab]	5.60±0.12[ab]	365.97±6.22[bc]	1546.77±21.19[c]	2580.12±36.39[b]
G×Ch	7.54±0.23[a]	6.06±0.12[a]	5.99±0.13[a]	394.25±6.33[a]	1589.23±23.28[c]	2650.30±36.04[b]
Sig	**	*	**	**	**	**
Heterosis						
$H^{I\ (NEW\text{-}G)}$ Sig	-0.10±0.32 NS	-0.005±0.48 NS	-0.07±0.46 NS	-11.07±19.26 NS	38.47±134.0 NS	43.15±164.84 NS
H%	-1.32	-0.09	-1.13	-2.90	2.33	1.59
$H^{I\ (CH\text{-}G)}$ Sig	-0.34±0.35 NS	-0.21±0.43 NS	-0.32±0.41 NS	-28.92±17.74 NS	-60.25±106.40 NS	-71.39±131.47 NS
H%	-4.82	-3.68	-5.60	-7.59	-3.88	-2.78

- Least square means ± S.E in the same column within bearing different superscripts differ significantly at P < 0.05.

- Values are significant at * P < 0.05; ** P < 0.01; *** P < 0.001 - NS = Not-significant

- LSB= Litter size at birth; LS21 =litter size at 21days; LSW=litter size at weaning; LWB =litter Weight at birth; LW21= litter Weight at 21days; LWW= litter Weight at weaning; NZW= New Zealand White rabbits; Ch = Chinchilla rabbits; G = Gabali; H^I = heterosis.

showed in different ages of kits (Rashwan *et al.,* 1995; Abdel-Azeem *et al.,* 2007). Ragab *et al.* (2016) stated that, crossing can improve LS traits in rabbits.

Table 2 showed that estimates of H^I were negative and not significant for all LS and LW traits. The negative values H^I for the traits studied may be more due to some higher means in the local G breed than in the foreign NZW and Ch breeds (Khalil and Afifi, 2000). Crossing of G with NZW rabbits was associated with significant positive estimates of H^I for LSB, LWB and LWB, LWW (Khalil and Afifi, 2000). Therefore, our results and other study (Ragab and Baselga, 2011) suggest that commercial rabbit producers utilize breeds selected for the traits of economic interest rather than on a popular breed.

Growth performance

Table 3 presents the effect of mating type of (NZW), (Ch) and (G) breeds on growth traits in different age periods. Results showed that mating type had significant (P < 0.05 or p < 0.01) effect on post-weaning growth traits as shown in Table 3. Purebred (NZW) recorded the highest values of BW4, BW6, BW8, BW10 and BW12. While (G) rabbits recorded the lowest values of BW4, BW6 and BW8. Moreover, Ch rabbits recorded the lowest values of BW10 and BW12 compared to other purebreds. In crossbreeding experiment carried out in Egypt, and using NZW and Baladi Black, Abdel-Ghany *et al.* (2000) observed that, the effect of mating type was generally significant for weaning and post-weaning BW traits.

Table 3. Least square means and tests of significance for individual body weight (g) traits and heterosis of NZW, Ch and G pure breeds and their crossing during the experimental period

Mating type (♀×♂)	body weight (g) BW4	BW6	BW8	BW10	BW12
NZW × NZW	516.43±11.14[ab]	933.41±13.11[a]	1328.91±15.26[a]	1714.11±17.03[a]	2049.22±14.49[bc]
Ch×Ch	504.63±9.68 [bc]	843.61±8.99[c]	1204.69±8.66[d]	1549.86±9.35[c]	1927.01±8.33[e]
G×G	462.62±7.64[d]	812.14±5.01[d]	1181.9±6.40[d]	1564.44±6.39[c]	1940.95±6.55[e]
NZW ×G	535.14±9.32[a]	938.49±10.53[a]	1343.41±12.08[a]	1743.85±12.73[a]	2143.30±17.06[a]
Ch×G	533.0±7.09[a]	886.61±8.93[b]	1262.78±9.45[c]	1646.52±10.28[b]	2024.49±10.30[c]
G× NZW	529.95±7.36[a]	880.14±7.48[b]	1296.23±8.9[b]	1671.72±8.07[b]	2070.05±8.19[a]
G×Ch	464.83±6.28[d]	825.46±6.05[cd]	1205.46±6.18[d]	1565.80±9.27[c]	1980.63±6.66[d]
Sig	**	**	**	**	**
			Heterosis		
H^{I} (NEW-G) Sig	43.02±12.10 *	36.54±13.83 **	64.42±15.05 **	68.51±16.21 **	111.59±14.36 **
H%	8.79	4.19	5.13	4.18	5.59
H^{I} (CH-G) Sig	15.29±8.56 **	28.16±8.13 **	40.82±8.72 **	49.01±11.02 **	68.58±10.23 NS
H%	3.16	3.40	3.42	3.15	3.55

- Least square means ± S.E in the same column within bearing different superscripts differ significantly at P < 0.05.
- Values are significant at * P < 0.05; ** P < 0.01; *** P < 0.001 - NS = Not-significant
- Growth traits: BW4 = body weight at 4 weeks; BW6 = body weight at 6 weeks; BW8 = body weight at 8 weeks; BW10 = body weight at 10 weeks; BW12 = body weight at 12 weeks; H^{I}= heterosis.

Results in Table 3 show that ♀NZWx♂G crossbred recorded the highest (p <0.05) values of BW4, BW6, BW8, BW10 and BW12. While, ♀Gx♂Ch crossbred recorded the lowest values of BW6, BW8, BW10 and BW12. From these results, it is clear that the ♀NZWx♂G hybrid surpassed the ♀Chx♂G hybrid for BW traits. The obtained results partially agree with the findings reported by Youssef (1992), Afifi *et al.* (1994), Abdel-Ghany *et al.* (2000) and Abou Khadiga *et al.* (2008).

Crossbreds ♀NZWx♂G showed high positive H (%) for BW4, BW6, BW8, BW10 and BW12 (Table 3). In this respect, crossbreds line v x local Baladi showed positive heterosis for BW (Abou-Khadiga, 2004; Attalah, 2006). Furthermore, direct heterosis for BW were mainly positive and ranged from 1.3 to 14.5% (Khalil and Bolet, 2010). Also, Abdel-Ghany *et al.* (2000) and Afifi *et al.* (1994) found that heterosis (%) ranged from 2.7 to 9.5% for post-weaning BW by crossing NZW with Baladi Black or Baladi Red in Egypt. Moreover, El-Bayomi *et al.* (2012) found that CaxNZW rabbits recorded positive and high estimates of heterosis for BW.

Conclusions

Since LS, LW and growth traits in NZW and G rabbits were not significantly different in their breed performance. Moreover, LS traits improved as a result of crossing G does with Ch bucks. Also, LW and growth traits improved when NZW does were crossed with Gabali bucks. All these results suggest, the importance of using G rabbits as a paternal or a maternal line in crossing with the foreign breeds to improve the productive and reproductive performance of rabbits under Egyptian conditions.

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تحسين الصفات الإنتاجية والتناسلية لسلالة الأرانب المصرية المحلية بواسطة التهجين مع سلالتين أجنبيتين

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تم تحليل عدد ١٣١٧ بطن لتقييم تأثير الخلط بين ثلاث سلالات من الأرانب، السلالات المختبرة كانت النيوزيلاندى الابيض والشنشلا والجبلى، تم التزاوج والخلط بين الثلاث السلالات ما عدا الخلط بين النيوزيلاندى الأبيض والشنشلا والخلط العكسى بينهم، وكانت الصفات المدروسة: حجم البطن عند الميلاد، وعند ٢١ يوم، وعند الفطام، وكذلك وزن البطن عند الميلاد، وعند ٢١ يوم، وعند الفطام، بالاضافه الى صفات النمو والتى شملت وزن الجسم عند ٤، ٦، ٨، ١٠، ١٢ اسبوع من العمر، وقدرت قوة الهجين لكل الصفات المدروسة، تأثير نوع التزاوج كان معنوى لحجم ووزن البطن ووزن الجسم فى السلالات النقية، حيث سجلت الارانب الجبلى أعلى حجم للبطن عند الولادة، وعند٢١ يوم، وعند الفطام (٧,٣٦، ٥,٩٦، ٥,٨٧ على الترتيب)، فى الخلطان أوضحت النتائج أن تزاوج أمهات الجبلى مع ذكور الشنشلا أعطت أعلى تقدير لحجم البطن عند الولادة، وعند٢١ يوم، وعند الفطام (٧,٥٤، ٦,٠٦، ٥,٩٩ على الترتيب)، وفيما يتعلق بصفات وزن البطن فى الارانب النقيه سجلت الارانب الجبلى أعلى وزن للبطن عند الولادة (٤١١,٩٩ جرام)، بينما فى السلالات الخليطه تزاوج أناث الجبلى مع ذكور الشنشلا أظهرت أعلى قيمه لوزن البطن (٣٩٤,٢ جرام)، بينما تزاوج أناث النيوزيلاندى مع ذكور الجبلى سجلت أعلى وزن للبطن عند ٢١ يوم وعند الفطام (١٨٣٦,٥، ٢٩١٧,١ جرام على الترتيب)، وتزاوج أناث النيوزيلاندى مع ذكور الجبلى وأناث الشنشلا مع ذكور الجبلى أعطت قيم سالبه وغير معنويه لقوه الهجين الخاصه بصفات حجم ووزن البطن، صفات وزن الجسم تأثرت معنويا بنوع التزاوج خلال الاعمار المختلفه، عند تزاوج كلا من أناث النيوزيلاندى مع ذكور الجبلى وأناث الشنشلا مع ذكور الجبلى سجلت تقديرات معنويه لقوه الهجين الخاصه بصفات وزن الجسم، وأخيراً بالاعتماد على النتائج الموجودة فى هذا البحث أستنتاجنا أن الخلط بين أناث الجبلى وذكور الشنشلا حسنت حجم البطن و/ أو وزن البطن، أيضا الخلط بين ذكور الجبلى وأناث النيوزيلاندى حسنت صفات النمو ووزن البطن عند الميلاد وعند ٢١ يوم.

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