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Studies on live body weight and litter size in New Zealand White, Californian, Baladi rabbits and their crossbreds in Egypt

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SUMMARY - This study was carried out to investigate the effects of breed, crossbreeding, parity and month of kindling on live body weight and litter size of New Zealand White (NZW), Californian (CAL), Baladi (BAL) purebred rabbits and their crossbreds. The BAL rabbits had the lightest body weights and the smallest litter size up to 10 weeks of age. Crossing of BAL bucks with NZW and CAL does gave better results regarding body weight and litter size than using the reciprocal crosses. Parity and month of kindling had significant effects ($P<0.05$ or $P<0.01$) on body weight and litter size.

Key words: Crossbreeding, litter size, parity, kindling.

RESUME - "Etudes sur le poids vif corporel et la taille de la portée chez des lapins de race Néo-Zélandaise Blanche, Californienne, Baladi, et sur leurs croisements en Egypte". Cette expérience a été effectuée afin d'étudier l'effet de la race, du croisement, de la parité et du mois de mise bas sur le poids vif corporel et la taille de la portée de lapins de race pure Néo-Zélandaise Blanche (NZW), Californienne (Cal), Baladi (BAL) et sur les croisés. Les lapins BAL avaient les poids corporels les moins élevés, et la taille de la portée la plus petite jusqu'à l'âge de 10 semaines. Les croisements de mâles BAL par des femelles NZW et CAL ont donné de meilleurs résultats en ce qui concerne le poids corporel et la taille de la portée par rapport aux croisés réciproques. La parité et le mois de mise bas ont des effets significatifs (P<0,05 ou P<0,01) sur le poids corporel et la taille de la portée.

Mots-clés: Croisement, taille de la portée, parité, mise bas.

Introduction

Rabbits may play a significant role in solving the problem of meat shortage in a quick and efficient manner under such emergency circumstances. The gradual increase in consumption of rabbit meat in Egypt requires attention to improve the productivity of the available local breeds and of the imported ones. The cross-breeding between local and exotic breeds makes it possible to improve performance of rabbits quickly.

Recently, the New Zealand White (NZW) and California (CAL) breeds were introduced in Egypt. These breeds can have high growth rates comparable to the modern broiler chickens. Moreover, the two forementioned breeds and the derived hybrids showed a growth rate of over 40 g/day (Davidson, 1977).

The present study aimed at investigating some factors affecting live body weight and litter size of Baladi (BAL) rabbit (as a local strain) and two newly introduced medium-sized meat type breeds (NZW and CAL) and their crossbreds.

Material and methods

This study was carried out during the period from June 1988 to August 1989 at a private rabbitry for meat production located at Talkha City, El-Dakahila Governorate, Egypt. In addition to the purebreds, New Zealand White (NZW), Californian (CAL) and Baladi (BAL), the following crossbreds and their reciprocals were attended (NZW x Cal, CAL x NZW, NZW x BAL, BAL x NZW, CAL x BAL and BAL x CAL). The number of does and bucks assigned to the nine mating types is shown in Table 1.

Table 1: Number of does and bucks* used in the study.

Mating type	No. of does	No. of bucks
NZW x NZW	42	9
CAL x CAL	27	6
BAL x BAL	10	2
NZW x CAL	17	4
CAL x NZW	18	4
NZW x BAL	10	2
BAL x NZW	10	2
CAL x BAL	10	2
BAL x CAL	15	3
Total	159	34

* One buck was use for every five does.

Random mating was applied within each of the nine breed groups. After kindling, does were mated 10 days later to produce the next litter. Weaning of the litters was performed at four weeks after kindling. The breeding animals were individually housed in galvanized wire cages in a well ventilated building. All rabbits were fed *ad libitium* on a commercial pelleted diet throughout the experimental period containing 16.3% crude protein, 2.5% crude fat, 14.0% crude fiber and 2670 Kcal digestible energy/Kg. Fresh water was automatically available all the time by stainless steel nipples in each cage.

The traits under study included live body weight at 4, 6 and 10 weeks of age and litter size at birth, 4, 6 and 10 weeks of age. The heterosis percentage (H %) in each crossbred was calculated using the following formula (Falconer, 1981):

$$H\ \% = \frac{(\text{Cross mean} - 1/2(\text{Parent}_1\ \text{mean} + \text{Parent}_2\ \text{mean}))\ *100}{1/2(\text{Parent}_1\ \text{mean} + \text{Parent}_2\ \text{mean})}$$

Because of the inequality and disproportionality of the subclass numbers of data, the method of analysis of variance for unweighted means (Snedecor and Cochran, 1967) was used. Data were analysed for the effects of breed group, parity and month of kindling. Differences between two means within the same factor were tested by t-test.

Results and discussions

Live body weight

At four weeks of age the three purebred groups; NEW, CAL and BAL, had approximately equal values of body weight. However, the BAL rabbits were significantly ($P<0.01$) lighter than NZW and CAL rabbits at 6 weeks of age. The CAL rabbits were significantly ($P<0.01$) heavier than NZW ones at 6 weeks, while an opposite situation was found at 10 weeks of age (Table 2). Similarly, Shawer (1963), Afifi

Table 2: Means and standard errors ($\bar{x}$, S.E.) of body weight (g) at 4, 6, and 10 weeks of age as affected by breed group, parity and month of kindling.

Classification	4 Wks			
	N	$\bar{X}$	S. E.	F. Value
Breed group (B)				15.16**
NZW	864	508.4	3.6^{ah}	
CAL	574	504.4	3.8^{ah}	
BAL	266	496.8	5.3^{ag}	
NZW x CAL	368	530.4	5.6^{hijk}	
CAL x NZW	468	525.9	5.9^{cilm}	
NZW x BAL	232	480.0	7.8^{dgn}	
BAL x NZW	302	519.2	2.5^{ejlo}	
CAL x BAL	219	479.1	5.0^{fn}	
BAL x CAL	377	514.6	6.3^{hkmo}	
Parity (P):				0.91
P_1	805	503.4	3.5	
P_2	802	501.0	4.0	
P_3	760	517.9	3.8	
P_4	576	516.1	4.2	
P_5	451	510.5	4.7	
P_6	276	511.0	4.1	
Month of kindling (M):				4.20**
Sep. - Oct.	410	518.0	5.0^{a}	
Nov. - Dec.	837	499.0	3.5^{be}	
Jan. - Feb.	649	488.9	5.1^{c}	
March - April	843	518.4	3.6^{a}	
May - June	633	523.4	4.4^{a}	
July - August	304	504.4	3.9^{dc}	
First order interaction:				
B x P				5.54**
B x M				5.14**
P x M				1.47
Second order interaction:				
B x P x M				2.25**

Table 2 (continuation): Means and standard errors ($\bar{X}$, S.E.) of body weight (g) at 4, 6, and 10 weeks of age as affected by breed group, parity and month of kindling.

Classification	6 Wks			
	N	$\bar{X}$	S. E.	F. Value
Breed group (B)				41.40**
NZW	819	889.7	4.6^{a}	
CAL	554	923.9	4.5^{bij}	
BAL	261	831.9	4.5^{cke}	
NZW x CAL	349	976.2	8.7^{d}	
CAL x NZW	452	934.5	7.5^{eim}	
NZW x BAL	224	833.5	8.1^{fkn}	
BAL x NZW	295	910.5	16.6^{ajm}	
CAL x BAL	211	827.0	6.7^{gim}	
BAL x CAL	365	952.9	5.4^{h}	
Parity (P):				7.1**
P_1	780	883.6	4.4^{a}	
P_2	767	889.5	5.4^{a}	
P_3	690	950.1	4.0^{b}	
P_4	559	930.8	6.4^{ce}	
P_5	429	914.3	6.5^{de}	
P_6	296	855.4	17.5^{a}	
Month of kindling (M):				7.6**
Sep. - Oct.	398	902.9	4.7^{a}	
Nov. - Dec.	768	856.5	9.6^{b}	
Jan. - Feb.	622	894.2	5.8^{a}	
March - April	817	924.1	9.7^{cf}	
May - June	608	929.9	5.7^{df}	
July - August	297	925.2	6.9^{ef}	
First order interaction:				
B x P				4.0**
B x M				4.2**
P x M				0.6
Second order interaction:				
B x P x M				1.6**

Classification	10 Wks			
	N	$\bar{X}$	S. E.	F. Value
Breed group (B)				108.80**
NZW	772	1607.0	12.7^{a}	
CAL	530	1570.3	8.5^{bij}	
BAL	243	1331.6	9.0^{c}	
NZW x CAL	332	1689.7	9.7^{dl}	
CAL x NZW	435	1702.1	15.2^{el}	
NZW x BAL	214	1366.6	6.3^{fm}	
BAL x NZW	277	1564.1	12.5^{gin}	
CAL x BAL	205	1375.3	5.9^{hm}	
BAL x CAL	344	1547.0	9.0^{ikn}	
Parity (P):				2.58*
P_1	725	1556.3	8.2^{a}	
P_2	739	1531.5	9.1^{bd}	
P_3	684	1617.1	9.5^{c}	
P_4	534	1564.7	12.5^{a}	
P_5	407	1542.7	18.7^{ad}	
P_6	263	1551.4	14.5^{ad}	
Month of kindling (M):				4.83**
Sep. - Oct.	374	1562.3	9.1^{a}	
Nov. - Dec.	740	1532.1	9.6^{bf}	
Jan. - Feb.	598	1568.8	10.1^{ag}	
March - April	769	1581.8	12.6^{cg}	
May - June	577	1598.4	9.1^{dg}	
July - August	294	1523.6	15.2^{ef}	
First order interaction:				
B x P				4.36**
B x M				2.96**
P x M				3.65**
Second order interaction:				
B x P x M				1.83**

* Significant at 0.05 level. ** Significant at 0.01 level.
Means within each effect within each age followed by the same letter do not differ significantly, otherwise they do.

(1971), Tag-El-Din (1979) and El-Maghawry *et al.* (1988) obtained significant breed differences, while Nossier (1970) reported no significant breed differences in body weight.

Generally, among the six crossbreeds obtained the CAL x NZW and NZW x CAL rabbits were the heaviest at the three ages studied. It was obvious to notice that crossbred rabbits sired by BAL bucks were considerably heavier (P<0.01) than those mothered by BAL does by about 7.8-13.5%.

Crossbreeding resulted in positively little heterosis percentages for all crossbreeds, except those which were mothered by BAL does where negative and little heterosis was obtained in most cases (Table 3). In the literature available crossbreeding showed slight effect on body weight as reported by Zelnik (1973), Giavorini *et al.* (1978), Tag-El-Din (1979) and Trojan and Mach

Table 3: Heterosis and reciprocal effects (%) of body weight and litter size.

Traits	NZW x CAL	CAL x NZW	NZW x BAL	BAL x NZW	CAL x BAL	BAL x CAL
Body weight at:						
4 wks.	4.7	3.9	- 4.5	3.3	- 4.3	2.8
6 wks.	7.7	3.1	- 3.2	5.8	- 5.8	8.5
10 wks.	6.4	7.1	3.4	6.5	- 5.2	6.6
Litter size at:						
Birth	1.40	0.0	- 6.6	15.3	- 9.2	2.10
4 wks.	0.00	- 3.2	- 5.0	10.0	- 8.2	3.30
6 wks.	0.83	- 4.1	- 1.8	12.3	- 9.1	- 0.83
10 wks.	0.00	- 1.7	- 6.1	6.1	- 9.6	0.87

(1982). On the contrary significant improvement in body weight by crossbreeding was found by Kawinska *et al.* (1969) and Afifi (1971).

The parity had no significant effect on body weight of young at 4 weeks, but it had significant effects (P<0.01) at 6 weeks and 10 weeks of age (Table 2). The third litter recorded the heaviest weights at all ages studied. Wanis (1958), Casady *et al.* (1962), Santoro and Hernandez (1967) and Nossier (1970) reported significant effects. However, Khalil *et al.* (1987) found no pattern of parity on body weight of rabbits at weaning and up to 10 weeks of age.

The month of kindling significantly (P<0.01) affected body weight of young at 4, 6 and 10 weeks of age (Table 2). The heaviest live weights at 4 weeks were recorded for rabbits kindled during May - June followed by those of March - April and September - October months in a descending order. At 6 weeks of age, the heaviest weights were obtained for the rabbits kindled during May - June followed by those of June - August and March -April months in the same order. At 10 weeks, the heaviest weights were recorded for rabbits kindled during May - June followed by those of March - April and January - February months in a descending order. The month of kindling was found to have an effect on live weight of rabbits during the growing period as showed by Wanis (1958), Casady *et al.* (1962), Shawer (1963), Nossier (1970) and Csonka and Szendro (1984). However, El-Maghawry *et al.* (1988) found no significant effect on body weight at weaning.

The first order interactions between either breed group, or parity and month of kindling in respect of live body weight were significant (P<0.01) at 4, 6 and 10 weeks of age, except that between parity by month of kindling at 4 and 6 weeks of age. The second order interactions between the previous three factors were significant (P<0.01) for body weight at 4, 6 and 10 weeks of age.

LITTER SIZE

Distribution of litters according to birth litter size

When calculating the frequency of litters according to size for less than 6, 6-8 and 9 and more young (Table 4) it could be seen that among purebreds, the NZW litters, which comprised less than 6 young per litter, were more frequent (26.4%) than those occurred in CAL (15.1%) and BAL (8.9%). Among the crossbred litters, the CAL and NZW ones sired by BAL bucks and having less than 6 young per litter were less frequent (17.7%) than the average of reciprocal crosses (21.5%). The overall mean of crossbred litters having less than 6 young per litter was approximately equal to that of purebred ones, being 22.1 and 20.0%, respectively.

The litters of 6-8 young were more frequent in the purebred BAL litters (82.2%) than in CAL (53.8%) or NZW ones (45.9%). Among crossbred litters sired by BAL bucks, the litters of 6-8 young were less frequent (55.8%) than the litters mothered by BAL does (62.0%). The overall mean of purebred litters of 6-8 young was approximately equal to that of crossbred ones: being 54.1 and 54.3%, respectively.

The litters of 9 or more young were more frequent in CAL (31.1%) and NZW (27.7%) rabbits than in the BAL ones (8.9%). It was interesting to find that the crossbreds mothered by BAL does gave in average a lower value (3.8%) of litters with 9 or more young than those sired by BAL bucks (26.5%). The frequency of purebred litters of 9 or more young was higher than that of the crossbred ones, being 25.9 and 23.6%, respectively.

Litter size changes during the growing period

At all ages, the CAL rabbits had the largest litters followed by NZW and BAL rabbits in a descending order (Table 5). Differences in litter size between CAL and NZW were not significant. However, the superiority of CAL over BAL rabbits with respect to litter size was significant (P<0.01) at birth and at 10 weeks of age (Table 5). Significant breed differences in litter size were reported also by Shawer (1963). However, Nossier (1970), Afifi (1971), Tag-El-Din (1979) and Tag-El-Din and Ali (1989) reported non-significant breed differences in that respect.

Cross of NZW and CAL rabbits and its reciprocal were nearly equal in litter size at birth, 4, 6 and 10 weeks. It was obvious that crossbreds where the BAL rabbits were used as does resulted in smaller litter size than the general mean. However, higher litter size than the general mean resulted from using BAL rabbits as buck breed, at all ages studied. Consequently it is better to use BAL as bucks in crossbreeding experiments than using them as does. Results of Table 3 confirmed this conclusion, since it shows that the heterosis percentages at all ages studied were almost negative where BAL rabbits were used as does and were positive when BAL rabbits were used as bucks. Crossbreeding was associated with positive improvement in litter size as reported by Afifi (1971), Tag-El-Din (1979) and Mach (1986). On the other hand, negative heterosis results in litters size were obtained by Ponce and Menchaca (1985).

The parity had significant (P<0.01) effects on litters size at birth, 4, 6 and 10 weeks (Table 4). Litter size gradually increased from the first parity up to the fifth with respect to litter size at birth and 4 weeks.

Table 4: Distribution of litters according to litter size at birth in all breed groups.

Breed		Litter size at birth					
Group		1-4	5	6	7	8	≥9
NZW	n	25.0	14.0	13.0	25.0	30.0	41.0
	%	16.9	9.5	8.8	16.9	20.2	27.7
CAL	n	5.0	9.0	17.0	24.0	9.0	29.0
	%	5.4	9.7	18.3	25.8	9.7	31.1
BAL	n	0.0	4.0	17.0	18.0	2.0	4.0
	%	0.0	8.9	37.9	40.0	4.4	8.9
Average of purebreds	n	30.0	27.0	47.0	67.0	41.0	74.0
	%	10.5	9.5	16.4	23.4	14.3	25.9
NZW x CA	n	4.0	10.0	10.0	14.0	9.0	15.0
	%	6.5	16.1	16.1	22.6	14.5	24.2
CAL x NZW	n	10.0	12.0	8.0	7.0	10.0	30.0
	%	13.0	15.5	10.4	9.1	13.0	40.0
NZW x BAL	n	2.0	8.0	11.0	14.0	4.0	1.0
	%	5.0	20.0	27.5	35.0	10.0	2.5
BAL x NZW	n	3.0	1.0	4.0	15.0	10.0	14.0
	%	6.4	2.1	8.5	31.9	21.3	29.8
CAL x BAL	n	2.0	5.0	12.0	15.0	3.0	2.0
	%	5.1	12.8	30.8	38.5	7.7	5.1
BAL x CAL	n	3.0	13.0	7.0	10.0	17.0	16.0
	%	4.5	19.7	10.6	15.2	25.8	24.2
Average of crossbreds	n	24.0	49.0	52.0	75.0	53.0	78.0
	%	7.3	14.8	15.7	22.6	16.0	23.6
Total Average	n	54.0	76.0	99.0	142.0	94.0	152.0
	%	8.8	12.3	16.0	23.0	15.3	24.6

However, the largest litters were recorded in the fourth and sixth parity when litter size was measured at 6 and 10 weeks after kindling. Significant effects of parity on litter size were reported also by Broeck and Lampo (1975) and Tag-El-Din and Ali (1989). Afifi and Khalil (1989) noted that changes in litter size at birth caused by parity effects may be due to changes in the physiological efficiency of the does which occur with advancing of parity, especially those related to ovulation, implantation and prenatal survival rates and also to differences in the intra-uterine environment during pregnancy. However, Afifi *et al.* (1982), El-Maghawry *et al.* (1988) and Afifi and Khalil (1989) observed that parity effects on litter size were not significant.

Litter size at birth, 4, 6 and 10 weeks was significantly ($P<0.01$) affected by the month of kindling (Table 5). It increased as month of kindling advanced from September - October to May - June and decreased thereafter during July and August. Similarly, El-Khishin *et al.* (1951), Afifi *et al.* (1982) and Afifi and Khalil (1989) found that there was a tendency for litter size to be low in early season of production (September - October), to increase as month of kindling advanced until reaching its maximum and decreased thereafter at the end of the year of production. However, no influence of month of kindling on litter size was reported by El-Maghawry *et al.* (1988) and Tag-El-Din and Ali (1989).

All the first and second order interactions between breed group, parity and month of kindling at all ages studied were not significant except that of parity by month of kindling at birth, and that of breed group by month of kindling at 4 weeks where they were significant ($P<0.01$).

Table 5: Means and standard errors ($\bar{x}$, S.E.) of litter size at birth, 4, 6 and 10 weeks of age as affected by the breed group, parity and month of kindling

		Birth			4 Wks.			6 Wks.			10 Wks.		
Classification	**N**	**$\bar{x}$**	**S.E.**	**F. val.**	**$\bar{x}$**	**S.E.**	**F. val.**	**$\bar{x}$**	**S.E.**	**F. val.**	**$\bar{x}$**	**S.E.**	**F. val.**
General mean	617	7.1	0.08		6.1	0.08		5.9	0.08		5.7	0.07	
Breed group(B):				3.60**			1.7			1.31			2.18*
NZW	148	7.0	0.20^{acg}		6.1	0.19		5.7	0.18		5.6	0.18^{abcd}	
CAL	93	7.4	0.17^{af}		6.3	0.18		6.2	0.17		6.0	0.17^{a}	
BAL	45	6.7	0.16^{ghi}		5.9	0.17		5.7	0.13		5.5	0.13^{bfghi}	
Average of purebreds	286	7.0	0.12		6.1	0.12		5.9	0.11		5.7	0.11	
NZW x CAL	62	7.3	0.24^{aej}		6.2	0.22		6.0	0.20		5.8	0.17^{aej}	
CAL x NZW	77	7.2	0.28^{aegk}		6.0	0.29		5.8	0.29		5.7	0.29^{aekt}	
NZW x BAL	40	6.4	0.19^{bhl}		5.7	0.18		5.6	0.03		5.4	0.16^{cfjkmn}	
BAL x NZW	47	7.9	0.33^{cfjkm}		6.6	0.34		6.4	0.12		6.1	0.23^{ago}	
CAL x BAL	39	6.4	0.19^{dil}		5.6	0.16		5.5	0.02		5.2	$0.14^{d'lm}$	
BAL x CAL	66	7.2	0.22^{aegm}		6.3	0.20		6.0	0.05		5.8	0.19^{aino}	
Average of crossbreds	331	7.1	0.11		6.1	0.11		5.9	0.11		5.7	0.10	
Parity (p):				10.3**			3.8**			4.24**			3.60**
P_1	159	6.2	0.15^{a}		5.3	0.14^{a}		5.1	0.14^{a}		5.0	0.13^{a}	
P_2	130	7.2	0.17^{bg}		6.3	0.16^{be}		6.0	0.16^{bg}		5.8	0.15^{bg}	
P_3	123	7.4	0.19^{cg}		6.3	0.19^{bc}		6.1	0.19^{cg}		6.0	0.18^{dg}	
P_4	91	7.5	0.19^{dg}		6.6	0.19^{ce}		6.3	0.19^{dg}		6.0	0.20^{eg}	
P_5	70	7.7	0.23^{eg}		6.7	0.24^{de}		6.2	0.24^{eg}		6.1	0.19^{eg}	
P_6	44	7.3	0.25^{fg}		6.3	0.20^{be}		6.2	0.20^{fg}		6.01	0.20^{fg}	
Month of kindling (M):				4.49**			5.4**			6.12**			5.01**
Sep. - Oct.	89	6.2	0.23^{a}		4.9	0.21^{a}		4.7	0.04^{a}		4.7	0.19^{a}	
Nov. - Dec.	144	6.8	0.15^{bgh}		5.8	0.14^{bg}		5.3	0.33^{a}		5.5	0.13^{bg}	
Jan. - Feb	104	7.1	-0.18^{cgij}		6.3	0.18^{chij}		6.1	0.18^{bfgh}		5.8	$0.17^{cg'}$	
March- April	130	7.7	0.19^{dkl}		6.5	0.23^{chrl}		6.4	0.20^{cfi}		6.2	0.19^{dh}	
May - June	98	7.6	0.19^{eikm}		6.7	0.18^{eik}		6.5	0.18^{dgi}		6.2	0.17^{eh}	
July - August	52	7.2	$0.19^{fhj'm}$		6.0	0.19^{fgjl}		5.8	0.14^{eh}		5.7	0.13^{fg}	
First order interaction:													
B x P				**0.59**			**1.30**			**1.29**			**0.33**
B x M				**0.92****			**2.10****			**0.98**			**1.05**
P x M				**12.44**			**0.01**			**0.08**			**0.48**
Second order interaction:													
B x P x M				**0.07**			**0.30**			**0.36**			**0.39**

* Significant at 0.05 level. ** Significant at 0.01 level.
Means within each effect within each age followed by the same letter do not differ significantly, otherwise they do.

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