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DOE LITTER PERFORMANCE OF BOUSCAT AND GIZA WHITE RABBITS

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Data on 849 Bouscat (B) and Giza White (G) litters, collected from October 1975 to September 1983, were used to examine the effects on non-genetic factors on some litter traits and to estimate the repeatability for these traits. Parity, month of kindling and litter size at birth were the non-genetic factors investigated. Traits studied included litter weight at birth and at weaning, preweaning mortality and mean bunny weight at weaning. Fifty-two sires and 210 daughters (paternal half-sisters) were used for the analy sis of these traits. Weaning litter weight and mean bunny weight increased (P<0.01 or P<0.001) as parity advanced. No pattern of parity effects on preweaning mortality was observed. There was a general tendency for litter weight and mean bunny weight to be low when kindling took place in the early months of the year of production (October and November) and to increase (P<0.001) as month of kindling advanced and to decrease again with kindling at the end of the year of production during April and May. Preweaning mortality decreased (P<0.001) as month of kindling advance till March (P<0.001) thereafter during April and May. Litter weight at birth and at weaning increased (P<0.01) with the increase of litter size at birth. Mean bunny weight at weaning increased (P<0.01) as litter size at birth decreased. Birth-litter-size effects on preweaning mortality were very limited (P>0.05). The sire of the doe affected significantly all litter traits studied, with the exception of preweaning mortality in the B breed. Doe litter traits were of low repeatability with the exception of litter weight at weaning in G does (0.32+0.07). Culling of does based on a single production record would not therefore be advised.

Litter size and mean bunny weight are regarded as the most important elements that contributing to litter weight producti vity in rabbits. Also, preweaning litter loss manipulates the number and total weight of rabbits per litter at weaning and consequently the number of kilograms weaned per doe per year of production. Evidence in the literature (Afifi *et al.*, 1976a & b; Khalil, 1980; Afifi *et al.*, 1982b; Emara, 1982; Lukefahr *et al.*, 1983a&b) reported that parity and month of kindling are the most important non-genetic factors affecting litter traits in rabbits. Therefore, statistical adjustment for the significant managerial and temporary environmental influences affecting repeated traits could improve genetic evaluation of doe productivity.

Rouvier *et al* (1973), Suh et al. (1978), Lukefahr *et al.* (1983a&b), Lukefahr *et al.* (1984), Lahiri (1984), Khalil and Man sour (1987), Khalil *et al.* (1988) and Afifi *et al.* (1989) reported that repeatability estimates of litter traits were generally low or moderate.

The objectives of the present study were (1) to examine the effects of parity, month of kindling and litter size on the performance of litter traits, (2) to quantify differences in such litter traits due to sire of doe and does within sire, and (3) to estimate repeatabilities for doe production traits.

MATERIALS AND METHODS

Data on does of the French Bouscat and Egyptian Giza White breeds were collected from 849 litters born at the Experimental. Farm of the Faculty of Agriculture at Moshtohor, Zagazig University, Egypt, from October 1975 to September 1983. The traits studied were litter weight at birth and at weaning, preweaning mortality (%) and mean bunny weight at weaning (litter weight at weaning/litter size at weaning). The breeding plan and management of the experimental rabbitry were described by Khalil *et al.* (1987b).

Least-squares Maximum Likelihood method of analysis (Harvey, 1977) were used to analysis the data. Data were sorted according to the sire-daughter (paternal half-sisters) groups and only sires with at least to daughters were included in the analysis. Therefore, the records of 210 daughters (does) of 52 sires were analysed using the following mixed model:

$$Y_{ijklmn} = \mu + S_i + D_{ij} + A_k + B_l + C_m + e_{ijklmn}$$

Where Y_{ijklmn} = Observation on the ijklmnth litter; μ= Overall mean, common element to all observations; Si= random effect of i^{th} sire of doe; D_{ij} = Random effect of j^{th} doe nested within a random effect of ith sire; A_k = Fixed effect of k^{th} parity; B_l = Fixed effect of lth month of kindling; C_m = Fixed effect of m^{th} litter size at birth, and e_{ijklmn} = A random deviation of the n^{th} litter of ij^{th} doe and assumed to be independently randomly distributed $(0, \sigma^2 e)$.

Due to the dependency in the least-squares equations existing when simultaneously using year of kindling, sires and does within sires in the same mixed model of analysis. The data were adjusted for year-of-kindling effects. Estimates of the sire (σ^2S), does within sire (σ^2D:S) and within doe

(σ^2W) components of variance for each year-adjusted litter were derived by equating mean squares to their expectations and solving the resulting set of simultaneous equations. Estimates of repeatability or intraclass correlation (t) were computed for each breed as:

$$t=\frac{\sigma^2{:}S + \sigma^2D{:}S}{\sigma^2{:}S + \sigma^2D{:}S + \sigma^2W}$$

Where $\sigma^2{:}S + \sigma^2D{:}S$ estimates the sum of genetic and permanent environmental variances among does, and σ^2W estimates temporary environmental effects associated with each litter. Approximate standard errors for the repeatability estimates were computed by the LSML76 program of Harvey (1977). The approximate standard errors for repeatability were computed from procedures described by Swiger *et al.* (1964).

RESULTS AND DISCUSSION

Litter weight.

Litter weight at birth in Bouscat and at weaning in both breeds increased significantly ($P<0.01$) as parity advanced (Table 1). This trend agrees with that observed by Khalil (1980). Afifi *et al.* (1982a) found that litter weight at birth and/or at weaning increased from the 1^{st} to 2^{nd} parity and decreased in the 3^{rd}. However, changes in the physiological efficiency of the doe (such as intra-uterine environment, milk production and the ability of the doe to rear her young) which occur with advance of parity may be responsible for the observed differences in litter weight between parities. Holdas and Szendro (1982) found that milk yield of does increased as parity advance. Litters of the1st parity were the lightest whether at birth or at weaning when compared with the litters of other parities (Table 1). Similar results were observed by Khalil (1980), Afifi *et al.* (1982a), Afifi *et al.* (1982b) and Emara (1982) for litter weight at birth and by Khalil (1980) for litter weight at weaning.

The least-squares means (Table 1) showed a general tendency for litter weight at birth to be low at the beginning of the year of production (October-November) and to increase ($P<0.001$) as month of kindling advance (reaching its peak in March) and to decrease ($P<0.001$) slightly at the end of year production (April May). The same pattern was observed for the effect of month ofkindling on the litter weight at weaning, but the peak was recorded for litters born during February. This trend was also reported by Afifi *et al.* (1976a), Khalil (1980) and Emara (1882). Afifi *et al.* (1976a) explained this trend on the basis of the availability and nutritive value of the green fodder and to the differences in ambient temperature during these months.

Table 1. Least-squares means (g) and tests of significance of factors (fixed) affecting litter weight at birth and at weaning in Bouscat and Giza White rabbits.

Independent variable	Litter weight at birth						Litter weight at weaning					
	Bouscat (N=502)			Giza White (N=347)			Bouscat (N=425)			Giza White (N=308)		
	No	Mean	S.E.	No	Mean	S.E.	No	Mean	S.E.	No	Mean	S.E.
Parity		**			NS			**			***	
1st	90	269	8.9	65	295	9.2	79	1818	120.8	55	1621	151.6
2nd	87	320	8.8	61	301	9.0	79	1821	119.3	52	1716	148.7
3rd	99	320	8.3	67	306	8.5	79	2038	118.8	60	1755	140.9
4th	88	314	8.4	53	319	9.0	73	2179	116.6	52	1948	142.7
5th	65	308	9.4	35	305	10.9	60	2093	125.2	31	2206	171.0
>6th	73	304	10.0	66	305	10.4	55	2380	140.9	58	2502	161.7
Month of kindling		***			***			***			***	
October-Nov.	79	289	9.2	43	272	10.4	67	1416	127.5	40	1592	161.2
December	58	303	10.3	42	295	10.9	52	2142	140.1	39	2072	168.7
January	88	332	9.0	51	320	9.7	78	2369	120.3	49	2059	151.4
February	82	321	9.0	69	318	8.5	73	2453	122.5	63	2408	139.7
March	61	314	10.0	50	315	9.9	55	2272	134.0	46	2297	155.7
April & May	134	304	7.9	92	311	8.1	100	1677	114.2	71	1321	139.6
Litter size at birth		***			***			***			**	
<3	45	157	11.3	19	161	14.3	34	1656	161.5	16	1555	214.1
4	40	250	11.6	36	254	11.4	30	1771	166.4	29	1615	179.3
5	63	275	9.9	72	278	8.9	50	2043	137.7	63	1967	146.7
6	83	321	9.1	53	320	9.7	74	2031	123.2	50	1953	152.8
7	115	350	8.2	68	338	8.8	98	2078	112.1	62	2132	145.1
8	74	387	9.4	53	371	10.1	70	2591	123.3	44	2138	162.7
>9	82	431	9.3	46	414	10.5	69	2215	127.9	44	2347	160.8

NS= non significant; **= $P<0.01$; ***=$P<0.001$.

The average litter weight at birth and at weaning increased ($P<0.01$ or $P<0.001$) with the increase of litter size at birth (Table 1). The levels of significance for the effects of litter size at birth and month of kindling on litter weight indicate that both factors were most important factors influencing litter weight at birth. Similar results have been reported by Afifi *et al.* (1976a) and Emara (1982).

Preweaning mortality percentages were subjected to arc-sin transformation before being analysed in order to approximate nor mal distribution. The least-squares means were retransformed to the original scale before being illustrated in Table 2.

Preweaning mortality, in Bouscat, increased slightly with the advance of parity while in Giza White no definite trend could be established (Table 2). Rouvier *et al* (1973) and Khalil (1980) observed a general trend indicating that preweaning mortality rate decreased as parity sequence advanced till a definite parity, then increased again in the later subsequent parities. However, it could be suggested that rabbits' mothering and rearing performance has been improved with the advance in age. Contradic tory to the previous reviewed trend, Afifi *et al* (1982a) and Emara (1982) reported that the percent of litter losses during the suckling period increased with advance in parity sequence. The present results (Table 2) indicate that parity effects had negligible or no significant influence on preweaning litter mortality. Similar findings were reported by Khalil (1980) and Emara (1982).

Preweaning mortality generally decreased ($P<0.001$) as month of kindling advanced until March and increased ($P<0.001$) thereafter during April and May (Table 2). The lower litter losses during December to March may be due to the availability and betternutritive value of green fodder, in addition to the milder weather (especially the atmospheric temperature) which prevails during these months. It is also shown that the lowest litter losses occurred for litters born during December, while the highest losses per litter occurred during April and May. Ragab and Wanis (1960) and Nossier (1970) found that the lowest preweaning mortality rate was for rabbits born during January and February. Khalil (1980) found this superiority during November and December, while Emara (1982) during March and April. However, the levels of significance for the factors studied indicate that month of kindling was the only factor with a meaningful effect on pre weaning mortality. Similar results for the same breeds and for other breeds of rabbits were reported by Ragab and Wanis (1960), khalil (1980) and Emara (1982). Rouvier *et al (*1973) and Lukefahr *et al* (1983c) reported that month- or season-of-birth effect has an influence on preweaning mortality rate. Khalil (1980) stated that differences among results of different investigators for the effect of month of kindling on mortality percent may be due to differences in the breed groups used, location, management, feeding systems and climatic conditions.

Preweaning litter mortality differed as the size of the litter changed, but the differences were not significant (Table 2). Ragab and Wanis (1960), Khalil (1980) and Emara (1982) found a general trend indicating that preweaning mortality percent increased with the increase of litter size at birth. The increase of preweaning mortality with the increase of litter size at birth seems to be a normal trend. This might be due to that high litter

Table 2. Least-squares means (g) and tests of significance of factors (fixed) affecting preweaning morality and mean bunny weight at weaning in Bouscat and Giza White rabbits.

Independent variable	Preweaning mortality				Mean bunny weight at weaning					
	Bouscat		Giza White		Bouscat			Giza White		
	No	Mean	No	Mean	No	Mean	S.E.	No	Mean	S.E.
Parity		NS		NS		**			***	
1st	90	19.1	65	23.5	79	401	19.2	55	373	21.8
2nd	87	19.3	61	24.5	79	445	18.8	52	420	21.2
3rd	99	31.6	67	27.6	79	455	18.7	60	459	19.7
4th	88	32.4	53	15.5	73	484	18.2	52	442	20.1
5th	65	27.5	35	27.3	60	493	20.1	31	520	25.5
>6th	73	31.1	66	16.5	55	538	23.4	58	532	23.7
Month of kindling		***		***		**			**	
October-November	79	36.5	44	34.0	67	401	20.6	40	414	23.6
December	58	18.8	42	13.2	52	475	23.6	39	480	25.1
January	88	19.2	51	13.8	78	528	19.0	49	481	21.8
February	82	20.0	69	13.2	73	506	19.5	63	523	19.5
March	61	21.6	50	12.0	55	495	21.9	46	459	22.6
April and May	134	46.7	92	56.4	100	410	17.7	71	389	19.4
Litter size at birth		NS		NS		***			***	
<3	45	19.2	19	9.3	34	667	27.5	16	601	33.4
4	40	36.5	36	17.5	30	501	28.5	29	525	27.0
5	63	20.9	72	26.0	50	476	22.7	63	469	20.8
6	83	26.4	53	18.8	74	437	19.6	50	415	22.0
7	115	28.2	68	30.0	98	425	17.2	62	423	20.5
8	74	17.0	53	34.9	68	389	19.7	44	387	23.9
>9	82	39.9	47	23.3	71	390	20.3	44	384	23.6

NS= non significant; **= P<0.01; ***=P<0.001.

size at birth is associated with a decrease in the average individual weight per litter at birth (Afifi *et al.*, 1973) and with alower share of the dams milk during the short period of suckling (2.7 to 4.5 minutes/day) where competition for teats is greater and consequently the small rabbits become weak, unfit and moresusceptible to death.

Mean bunny weight at weaning.

The mean bunny weight at weaning increased (P<0.01 orP<0.001) as parity sequence advanced till the 6^{th} (Table 2). However, comparing this trend with that observed previously for litter weight (Table 1) confirms the direct and positive association between litter weight and individual bunny weight measured at weaning. This trend is thought to be due to the improvement in the care and ability of the doe to suckle her young with advance of parity sequence. For both breeds, the highest mean bunny weight at weaning was shown by litters in the 6th parity and the lowest weight was recorded by those of the 1st parity (Table 2). Reversed results were observed by Afifi *et al* (1982b). However, the present findings were expected since does in their 1st parity have just reached sexual maturity and consequently their ability to suckle their young were at the lowest level.

As observed for litter weight, mean bunny weight at weaning increased significantly but at a decreasing rate as month of kindling advanced (reaching its peak in January and February) and to decrease slightly during March, April and May (Table 2). The levels of significance for the non-genetic effects included in the model of analysis (P<0.01), indicate that month of kindling was one of the most important factors influencing mean bunny weight at weaning. Lukefahr (1982) observed that month of service had significant effects (P<0.01) on average bunny weight at 4 weeks of age.

The average individual bunny weight at weaning decreased (P<0.001) with the increase of litter size at birth (Table 2). The same trend was reported by Afifi *et al* (1973). Coupling these findings with the findings obtained for litter weight at birth and weaning (Table 1), it could be concluded that larger litter size at birth is related to heavier litter weight at birth and at weaning but with lighter average weaning weight per bunny in the litter.

Components of variance

The sire of doe affected all the preweaning litter traits studied, with the except of preweaning mortality in Bouscat breed (Table 3). This significant sire effect indicate that sire-of-doe effects must be seriously considered when undertaking studies on litter traits in rabbits. Accordingly, improvement in litter traits of rabbits could be made by selection of sires of does based on their own performances for litter traits.

Differences in litter traits due to doe effect were not significant except for litter weight at birth (P<0.01) in Bouscat breed and litter weight at weaning (P<0.01) in Giza White (Table 3). The system of feeding and management practices might have masked the full expression of doe differences as well as a negative covariance might have been existed between litters in adjacent years because of imbalances in body reserves of the doe from one year to another. Another explanation could be that does of the present study were not kindled or reared in litters having the same size or weight. This confirms the fact that the dam effects result in a negative maternal environmental influence on the daughter's litter size and litter weight which may vary from one doe to another (Garcia *et al.*, 1982a & b).

The percentages of variances attributable to the sire component for all litter traits of Giza White breed are larger than the corresponding variances in Bouscat (Table 3). This indicate the presence of moderate or high additive

Table 3. Variance component estimates (e2) and percentages of variation (V%) due to random effects for litter traits in Bouscat and Giza White rabbits.

	Variance component								
	Sire			Doe/sire			Error		
Litter trait	d.f.	$\sigma^2 S$	V%	d.f.	$\sigma^2 S{:}D$	V%	d.f.	$\sigma^2 W$	V%
Bouscat									
Litter weight at birth	24	130.04	3.6*	99	371.76	10.2***	356	3151.13	86.2
Litter weight at weaning	23	20299.61	4.4**	92	a	0.0	293	439013.46	95.6
Preweaning mortality (%)	24	a	0.0	99	a	0.0	356	854.89	100.0
Bunny weight at weaning	23	612.03	4.7**	92	a	0.0	293	12312.02	95.3
Giza White									
Litter weight at birth	26	296.59	9.5**	59	144.35	4.6	245	2680.81	85.9
Litter weight at weaning	24	128149.90	20.0***	56	79714.40	12.5**	211	431924.55	67.5
Preweaning mortality (%)	26	48.27	7.5*	59	18.20	2.8	245	579.51	89.7
Bunny weight at weaning	24	2229.50	14.1***	56	a	0.0	205	3594.34	85.9

a Negative estimate of sire or doe components of variance set to zero.

genetic variance in Giza White. Therefore, the great variability due to sires shows the possibility for the rabbit breeders in Egypt to improve litter traits of this breed through selection. As for the sire, the percentages of variation due to doe effects on litter traits of Giza White rabbits were larger than the corresponding percentages in Bouscat. This indicates a higher variance of maternal and milking abilities from birth to weaning in the Giza White than in the Bouscat.

The smaller percentages of variation due to doe effect than to the sire effect, reflects a larger environmental component of variance associated with the doe during kindling and raising a litter to weaning. Genetic and environmental differences in pre- and post-natal maternal influences can be added as another cause in this respect. Rouvier *et al* (1973) and Garcia *et al* (1982a & b) showed that in litter traits of rabbits, the dam contributes strongly to the phenotypic value of her product not because of her gene transmission ability but due to her maternal environmental effects on them. The absence of positive doe variance components for some litter traits and the small values observed for others lessens the confidence in the estimates of variance for these traits (Table 3). This may be due to small numbers of sires or non-randomness in the distribution of the small numbers of does within sire group. However, the negative or low estimate of variance due to doe effects may suggest that selecting does from dams with better litter traits would not assure genetic response unless corrections were made for maternal environment.

Repeatability

Repeatability estimates for litter weight at birth and at weaning in both Bouscat and Giza White (Table 4) agree closely with the corresponding estimates of 0.09+0.13 and 0.22+0.14 reported by Lukefahr *et al* (1984). Estimates of Giza White together with the estimates obtained by Lukefahr *et al* (1984), Lahiri (1984) and Khalil *et al.* (1988 & 1989) indicate that repeatabilities for litter weight at weaning were higher than the corresponding estimates at birth. This is because litter weight at birth was highly influenced by litter size at birth (Table 1) and since litter size is of low repeatability (Khalil and Mansour, 1987; Khalil *et al.*, 1988&1989; Afifi *et al*, 1989), low repeatability estimates for litter weight at birth were to be expected. However, Rouvier *et al* (1973) reported repeatability estimates for litter weight at 21 and 56 days of age to be 0.126 and 0.117 for New Zealand White and 0.237 and 0.211 for Fauve de Bourgogne rabbits, respectively. Also, Lukefahr *et al* (1983b) with New Zealand White, Californian and their crosses reported repeatabilities of 0.33+0.07 and 0.07+0.08 for litter weight at birth and weaning, respectively.

Repeatability estimate for preweaning mortality in Giza White rabbits (0.10+0.050) is within the range of estimates reported in the literature (Khalil and Mansour, 1987; Khalil *et al.*, 1988; Afifi *et al.*, 1989). Rouvier *et al* (1973) reported repeatability estimates of 0.158 and 0.197 for mortality rate from birth to 21 or 56 days of age in New Zealand White and 0.145 and 0.105 for Fauve de Bourgogne rabbits, respectively. Concerning preweaning survival rate of the litter, repeatability estimates of 0.22+0.08 and 0.18+0.14 were reported also by Lukefahr *et al* (1983a) and Lukefahr *et al* (1984), respectively.

Table 4. Repeatability estimates (t) of litter traits in Bouscat and Giza White rabbits.

Litter trait	Bouscat			Giza White		
	No	t	S.E.	No	t	S.E.
Litter weight at birth	496	0.14	0.045	347	0.14	0.054
Litter weight at weaning	425	0.04	0.039	302	0.32	0.071
Preweaning mortality	496	a		347	0.10	0.050
Mean bunny weight at weaning	425	0.05	0.040	302	0.14	0.059

a Negative estimate of sire and doe components of variance set to zero.

Repeatability estimates for mean bunny weight at weaning in both Bouscat and Giza White are lower than the corresponding estimate of 0.41+0.13 reported by Lukefahr *et al* (1984). Also, Rouvier *et al* (1973) reported repeatability estimates of 0.191 and 0.183 for individual bunny weight at 21 and 56 days of age for New Zealand White and 0.208 and 0.379 for Fauve de Bourgogne rabbits, respectively. However, the low estimates of repeatabil ity in both breed of the present study may be due to that mean bunny weight at weaning was greatly affected ($P<0.001$) by litter size either at birth or at weaning (Khalil *et al.,* 1987a), and since litter size at the two ages is of low repeatability (Khalil and Mansour, 1987; Khalil *et al.,* 1988; Afifi *et al.,* 1989; Khalil *et al.,* 1989), low repeatability estimates for mean bunny weight at weaning were to be expected. Low or slightly moderate estimates ranging from 0.12+0.14 to 0.39+0.19 were also reported by Garcia *et al* (1982 a&b) for New Zealand White and Californian rabbits.

The present results indicate that doe litter traits were of low repeatability with the exception of litter weight at weaning in Giza White rabbits, i.e. more litters are to be considered before selecting an animal for these traits. Therefore, culling of does based on a single production record would not be advised and consequently assessment of several records are required before selecting does for litter traits. It is recommended for commercial rabbit producers that doe culling could be feasibly practised on litter interval to increase litter productivity per year (Lukefahr *et al,* 1984), on litter weight at 21 days (peak of lactation, Lukefahr *et al,* 1983b) to improve overall herd milking level, and on mean bunny weight at weaning to attain high growth potential of the young (Lukefahr, 1982). Moreover, number of bunnies weaned per litter should be a practical trait on which culling strategies of does of similar genetic background could be followed, to improve mean herd productivity (Lukefahr *et al,* 1983a). The present results data did not suggest, in general, that culling of does for litter traits based on a single production record, as commonly practised in commercial rabbitry operations, would be efficient from a genetic standpoint.

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