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Genetic and non-genetic factors affecting reproductive performance in exotic rabbit breeds under Egyptian conditions

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SUMMARY - Data on 2466 parturitions from 300 Bauscat (BAU), 200 New Zealand White (NZW) and 100 Californian (CAL) purebred does were analysed by fixed and mixed model procedures. The data came from two groups one imported from Hungary (473) and one locally-born in Egypt (127). The work was carried out to investigate the effects of group, breed, season of birth and parity on reproductive performance. Reproductive performance of the imported does was better than that of the locally-born does. The CAL breed had significantly higher (P<0.01) litter size at different periods (birth, 21 & 30 days) and lower litter weight at birth than NZW and BAU breeds. Season of birth showed highly significant (P<0.01) effects on preweaning litter size and litter weight. The regression coefficients of litter size at birth, 21 and 30 days on both gestation period and litter weight at birth were highly significant and it was significant for litter weight birth and at 21 days on gestation period. Heritability of litter size at different ages were moderate values. The genetic correlation among each of litter size and litter weight at different ages were positive and high. The phenotypic correlations among all reproductive performance traits were highly positive. The observed trends of the LZ and LW showed the unfavorable climate conditions depressed performance the locally-born does and indicate that these seem to be undergoing the adaptive process during the period of the study. Improvement of (phenotypic) one of these characters means improvement other characters at the same time.

Key words: Commercial rabbits, exotic, non-genetic and heritability.

Introduction

In Egypt, in the early 1980s, the Government attempted to increase meat production by subsidizing large scale, production of imported purebred commercial rabbits. The reproductive performance of exotic breeds of rabbits deteriorates (e.g. low fertility and depressed growth) when introduced into a new adverse environment (DAMODAR & JATKAR 1985; OPOKU & LUKEFAHR 1990). To date, little information is available about the degree of adaptability and genetic properties in commercial rabbit populations reared in tropical and subtropical environments. (LUKEFAHR et al. 1992). To establish an adequate strategy of selection methods under new adverse conditions, it is necessary to evaluate the environmental and genetic factors related to litter performance in exotic breeds.

The objective of the present investigation is to study the changes that occur due to adaptation in imported and locally-born rabbits in litter performance. In addition, the effects of environmental factors such as parity and season, and genetic parameters for reproductive performance, were also evaluated under Egyptian conditions.

Materials and methods

HERD MANAGEMENT

This work was carried out at the San El-Hagar Agricultural Company Farm, San El-Hagar area, Sharkeya Province, Egypt, during a one-year production cycle that started in January 1992. The data set included three commercial rabbit breeds Bauscat (BAU), New Zealand White (NZW) and Californian (CAL). The does and bucks were housed separately in individual galvanized wire batteries. Batteries for does were provided with external nest boxes for delivery and nursing young. Bucks were allocated to the does at random at each mating period and inbreeding was minimized by avoiding closely related matings (full-sib, half-sib and parent-offspring matings). The buck/doe ratio was low (1:6) and this allowed all matings contemporaneously. The animals were reared under similar environmental conditions. They were fed ad libitum on a commercial pelleted rabbit ration. The composition of that ration was 18% crude protein, 3% ether extract, 14% crude fibre, 2% mineral mixture (1% Ca, 0.7% P and 0.3 Na) and 63.0% soluble carbohydrate. The digestible energy was 2600 kcal per kg ration. Constant fresh water was provided from automatic drinkers with nipples. Data were collected at birth (within 12 h after delivery), 21 and 30 days. The weaning age was 30 days. All weights were recorded to the nearest gram. Traits analysed were litter size (LZ) and litter weight (LW) at birth (LZB & LWB), 21 (LZ21 & LW21) and 30 (LZ30 & LW30) days.

Climatological data, from the San El-Hagar Farm, included minimum and maximum air temperatures (°C) and relative humidity (%) at 08.00 and 15.00 h inside the house for the year 1992. December, January and February were Winter months; March, April and May the Spring months; June, July and August the Summer months and September, October and November the Autumn months. Least squares means ± S.E. for seasons are shown in Table 1. The difference between seasons were highly significant.

MEASUREMENTS AND STATISTICAL METHODS

The records analysed used comprised 2466 complete normal parturitions from 600 does sired by 108 bucks and recorded during the year 1992. The purebred rabbits included in the present study represented two stages of acclimatization of rabbits under to subtropical conditions. The 473 does imported directly Budapest, Hungary represented the first stage and the 127 locally-born does represented the second stage. During the first 6 months after import, there were no locally-born rabbits in production, and after 6 months no further importation took place. The imported does were not included in the statistical analysis during the first 6 months of importing (by confounding between season at delivery of imported and locally-born does). The sires used were similar for both imported and locally-born does.

The method of least-squares means was carried out by using the General Linear Model from SAS program (1989). The data were statistically analysed according to the following models:

Model 1 for litter size (LZ)

$$Y_{ijklm} = \mu + B_i + G_j + P_k + S_l + b_1(x_1)_{ijklm} + b_2(x_2)_{ijklm} + e_{ijklm}$$

where: Y_{ijklm}= litter size at birth, 21 or 30 days; μ= overall mean; B_i= effect due to ith breed, i= 1,..3 (1= BAU, 2= NZW 3= CAL); G_j= effect due to the jth group, j= 1 and 2 (1= imported rabbits 2= locally-born rabbits); P_k= effect due to kth parity k=1,..≥7; S_l= effect due to the lth season at delivery, l= 1,..4 (1= Winter 2= Spring 3= Summer 4= Autumn); b_1&b_2= the partial regression coefficients of Y_{ijklm} (dependent variable) on gestation period (x_1) and litter weight at birth (x_2) and e_{ijklm}= residual random effect.

Model 2 for litter weight (LW)

$$Y_{ijklmo} = \mu + B_i + G_j + P_k + S_l + Z_m + b_1(x_1)_{ijklmo} + e_{ijklmo}.$$

where: Y_{ijklmo}= litter weight at birth, 21 or 30 days; μ, B_i, G_j, P_k, S_l, b_1 and e_{ijklmo} as defined in model 1 and Z_m= effect due to mth litter size at birth m=1,..≥10.

In preliminary analyses, the two-and three-way interactions were observed to be statistically nonsignificant, so these interactions were not included in the final models.

Variance components were estimated by reanalysis date by using the least-squares and maximum likelihood computer program (HARVEY, 1990). A mixed model (Model type 5 of HARVEY, 1990) including sire within breed and doe nested sire within breed as random effects, as well as, fixed effects as defined in model 1 were adapted. The variance components {Sires ($\sigma^2 s$), does within sires ($\sigma^2 d$) and residual ($\sigma^2 e$)} were obtained by equating the mean squares for random effects to their expected values (HENDERSON, 1953). Heritability (h^2), genetic (r_G) and phenotypic (r_P) correlations by paternal half-sib were computed by using the formulas as described by HARVEY, (1990).

Results

Least squares means ± S.E. and the analyses of variance of LZ and LW at different periods are presented in Tables 2 and 3, respectively.

The imported does were significantly higher than the locally-born does in the LZB, 21 and 30 days and LW at the same time.

The effect of breed was highly significant for LZB, 21 and 30 days and LW at the same time. The CAL breed was significantly higher than NZW and BAU in LZ at different periods but it was significantly lower than NZW and BAU in LW at the same periods. Differences between NZW and BAU were not significant in all traits studied.

Season of birth significantly ($P<0.001$) affected LZ and LW at birth, 21 and 30 days. The highest of LZB during winter, but LZ at 21 & 30 and LWB, 21 & 30 days were highest during spring.

Parity of doe significantly ($P<0.001$) affected LZ and LW at birth, 21 and 30 days. The first parity recorded the highest LZB. There were no significant differences in LZB between parities from second to fifth. Each of LZ at 21 and 30 days were increased as parity increased. LWB, 21 and 30 days increased by parity.

The two sets of regression analyses for LZB, 21 and 30 days made with fixed effects (groups of does, breed, season of delivery and parity). The regression coefficients of LZB, 21 and 30 days on gestation period and LWB were highly significant (Table 2). The regression coefficients of LWB and 21 on gestation period were significant (P<0.001 and 0.05, respectively), but regression coefficients of LW at 30 days on gestation period was not significant. LZB significantly (P<0.001) affected LWB, 21 and 30 days (Table 3).

The Heritability (h^2), genetic and phenotypic correlation (r_G & r_P) for and between preweaning litter traits at different ages are given in Table 4. The h^2 for LZ and LW were moderate. The r_G among each of litter size and litter weight at different ages were positive and high. The r_P between LZ and LW at different periods were highly positive.

Discussion

The results show the effects of group (imported and locally-born does), breed, season of delivery and parity on reproductive performance.

The imported does showed reproductive performance superior to the locally-born does, having a higher LZ and LW at different periods. These results indicating that the locally-born does were affected negatively by Egyptian conditions more than their dams.

A high variability is also found among the genetic types studied (CAL, BAU and NZW), supported by statistical significances in LZ and LW at different ages studied. Does CAL showed a LZ at different ages superior to the NZW and BAU. However, both types of does (NZW and BAU) showed a LW at different ages studied than the CAL does, noted by Mach (1986), TAG-EL-DIN & ALI (1989) and OUDAH (1990).

Season of delivery showed highly significant effects (P≤0.001) on all traits studied. The highest LZ and LW at the ages studied were noticed during spring (except for LZB during winter). The difference in this characters among different seasons may be attributed to the temporal variation in climatic conditions. The differences among seasons were highly significant (P<0.001) for temperature and relative humidity (Table 1). The results agree with the findings reported by LUI et al. (1980) and RANDI (1982) for LZ.

Parity had a significant effect on LZ and LW at the ages studied, but it showed no definite trend in both of LZ and LW at the ages studied. These results agree with the finding reported by KAWINSKA et al. (1979) and NIEDZWIADEK et al. (1983) reported that the effect of parity on LZB did not show any consistent trend.

The highly significant of regression coefficient values of LZ at different periods on gestation length clarified the association between small LZB and increased length of gestation, noted by ADAMS (1972) and PARTRIDGE et al. (1981) were confirmed in the present experiment. The highly significant of regression coefficient values of LW at different periods on LZB clarified the LW at different periods increased with the increase of LZB, these results agreed with those reported by ATTILA BALLAY et al. (1988).

The paternal half-sib h^2 for LZ at different age suggests that improvement could be realized by selection. Similar, results were reported by PATRAS (1985) and KHALIL et al. (1986). The low h^2 of LW at different ages indicates that the relative importance of additive genetic factors is low and most improvement of these traits of imported herd could be realized by improvement of environment and management of the litter after birth, because the period from birth to weaning is most sensitive to environment and management change. The low or moderate h^2 values in the present study for preweaning litter weight traits noted by KHALIL et al. (1987) and AFIFI et al. (1992). The r_G between LZ and LW at the same ages were positive, with small standard error. These results indicate that doe producing high levels of LZ tend to give higher LW. High genetic correlation among LZ and LW indicate the synergistic control of the same additive gene and environmental deviations, influence traits above. Therefore, selection of LZ would also improve the LW. The highly positive r_p between LZ and LW at different periods agreed closely with those reported by KHALIL et al. (1986) and AFIFI et al. (1992) from NZW and CAL rabbits.

Conclusions

In conclusion, the observed trends of the LZ and LW showed the unfavorable climate conditions depressed performance the locally-born does and indicate that these seem to be undergoing the adaptive process during the period of the study under Egyptian conditions. Moderate and low h^2 indicated comparatively large influences of environmental effects on these traits. The r_p between preweaning litter traits were moderately positive. Improvement of (phenotypic) one of these characters means improvement other characters at the same time.

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Table 1. Least squares means ± S.E. of air temperature and relative humidity according to different seasons.

Seasons	Air temperature (°C)		Relative humidity (%) at	
	Minimum	Maximum	8 hour	15 hour
Overall mean	21.3	25.7	89.9	63.4
Winter	17.7±0.18a	20.3±0.26a	98.2±0.73a	80.5±0.94a
Spring	19.5±0.18b	24.0±0.26b	72.1±0.73b	47.7±0.93b
Summer	24.7±0.18c	30.8±0.26c	92.1±0.73c	59.1±0.93c
Autumn	23.2±0.18d	27.6±0.26d	97.2±0.73d	66.4±0.94d

- Within each classification, mean bearing different letters, differed significantly at (P<0.001).

Table 2. Least squares means ± S.E. and levels of significance of LZB, 21 and 30 days.

Classification	LZ at								
	Birth			21 days			30 days		
	No.	Mean±SE	F.value	No.	Mean±SE	F. value	No.	Means±SE	F. value
Overall	2466	7.17		2100	6.07		1970	5.93	
Group of does			13.84 ***			8.27 **			11.42 ***
Imported	2096	7.20±0.04 a		1833	6.08±0.05 a		1745	5.93±0.05 a	
locally	370	6.82±0.10 b		267	6.00±0.13 b		235	5.90±0.14 b	
Breed			5.58 **			15.71 ***			12.18 ***
NZW	850	7.17±0.07 a		729	6.09±0.08 a		709	5.91±0.09 a	
BUA	1340	7.16±0.06 a		1144	5.98±0.08 a		1057	5.87±0.08 a	
CAL	276	7.19±0.10 b		227	6.43±0.12 b		214	6.31±0.13 b	
Season of kindling			8.83 ***			15.39 ***			10.97 ***
1	700	7.50±0.09 a		503	5.67±0.12 a		473	5.40±0.13 a	
2	669	7.30±0.11 a		632	6.62±0.13 b		610	6.43±0.14 b	
3	529	6.65±0.08 b		484	5.70±0.10 a		456	5.67±0.10 b	
4	568	7.09±0.07 b		481	6.14±0.08 b		441	6.07±0.08 b	
Parity			11.31 ***			3.64 **			4.58 ***
1	635	7.56±0.07 a		506	6.00±0.09 a		489	5.76±0.09 a	
2	481	7.06±0.08 b		433	6.01±0.09 a		417	5.98±0.10 ab	
3	416	7.00±0.09 b		378	6.22±0.10 a		355	6.17±0.11 cb	
4	311	7.07±0.11 b		279	6.39±0.13 b		256	6.33±0.14 c	
5	258	7.04±0.12 b		228	6.57±0.15 b		222	6.51±0.15 c	
6	208	6.79±0.13 bc		171	6.51±0.16 b		152	6.46±0.17 c	
≥7	157	6.56±0.14 c		105	6.64±0.18 b		89	6.50±0.19 c	
Regressions									
b_1 Gestation period	-0.20±0.0225		79.94 ***	-0.11±0.027		15.56 ***	-0.12±0.029		17.90 ***
b_2 LWB	0.01±0.0002		3142.46 ***	0.01±0.0003		1547.38 ***	0.01±0.0003		1420.12 ***
R^2		59			47			47	
CV%		20			26			26	

- Within each classification, mean bearing different letters, differed significantly.
** P<0.01 *** P<0.001

Table 3. Least squares means ± S.E. and levels of significance of LWB, 21 and 30 days.

Classification	LW at Birth No.	Birth Mean±SE	Birth F. value	21 days No.	21 days Mean±SE	21 days F. value	30 days No.	30 days Mean±SE	30 days F. value
Overall	2466	393.9		2069	1802.5		1987	3617.1	
Group of does			*** 16.87			** 9.06			** 7.14
Imported	2096	395.4±2.3 a		1808	1818.2±20.4 a		1752	3649.4± 50.1 a	
locally	370	385.6±6.1 b		261	1693.4±43.6 b		235	3376.2±104.8 b	
Breed			*** 8.72			0.82			0.71
NZW	850	396.1±4.3 a		729	1809.3±29.2 a		713	3631.3±70.1 a	
BAU	1340	396.2±3.9 a		1117	1804.5±28.2 a		1060	3614.1±69.1 a	
CAL	276	376.0±5.9 b		223	1769.9±40.1 b		214	3585.0±94.1 b	
Season of kindling			*** 31.29			*** 38.73			*** 37.02
1	700	406.9±5.5 a		485	1654.2±40.7 a		481	2994.9± 98.6 a	
2	669	426.9±6.4 b		628	1913.2±42.5 b		610	3814.1±101.3 b	
3	529	342.8±5.0 c		483	1498.5±31.7 c		458	3283.3± 74.9 c	
4	568	386.8±4.3 d		473	1588.9±28.9 a		438	2956.3± 68.3 a	
Parity			*** 16.84			*** 20.83			*** 17.59
1	635	383.0±4.6 a		486	1375.8±30.1 a		497	2644.7± 72.0 a	
2	481	418.6±5.0 b		427	1645.3±32.1 b		417	3258.5± 75.3 b	
3	416	411.0±5.3 b		375	1637.8±34.1 b		356	3212.8± 80.3 b	
4	311	359.2±6.3 a		281	1622.9±42.2 b		257	3213.0±101.4 b	
5	258	370.1±7.1 a		225	1705.8±47.6 b		222	3266.8±111.3 b	
6	208	398.3±7.6 a		170	1844.2±49.6 c		151	3511.7±118.1 c	
≥7	157	420.1±8.1 b		105	1914.1±56.2 c		87	3727.6±135.7 c	
LZB			*** 359.86			*** 41.72			*** 51.17
1	29	100.5±16.0 a		13	885.4±132.7 a		9	1897.5±351.6 a	
2	74	144.9±10.2 a		53	1143.4± 67.9 a		46	2132.4±160.7 a	
3	100	218.4± 9.0 b		73	1310.7± 59.6 b		64	2566.9±140.5 ba	
4	141	258.7± 7.6 c		112	1511.3± 48.9 c		110	2844.6±110.4 b	
5	208	319.9± 6.4 d		168	1655.1± 41.0 d		161	3306.3± 93.9 c	
6	299	369.9± 5.6 e		257	1766.6± 35.4 e		247	3618.2± 82.0 d	
7	365	401.5± 5.2 f		305	1850.9± 33.5 f		301	3947.3± 76.4 e	
8	457	439.7± 4.9 g		401	1878.3± 31.4 f		389	4032.9± 72.3 e	
9	344	468.4± 5.4 h		297	1913.5± 34.2 f		290	4028.3± 78.3 e	
≥10	449	523.3± 4.9 i		390	1985.1± 31.4 f		370	4277.1± 73.0 f	
Regressions									
b_1 Gestation period	3.52±1.32		** 7.15	17.03±8.39		* 4.12	-14.6±19.6		0.56
R^2		60			28			31	
CV%		21			26			29	

- Within each classification, mean bearing different letters, differed significantly.
** P<0.01 *** P<0.001

Table 4. Heritability (diagonal), genetic (r_G) (above diagonal) and phenotypic correlations (r_p) (below diagonal) between litter traits.

Traits	Traits					
	1	2	3	4	5	6
Litter size at						
1. Birth	**0.20** (0.04)	0.36 (0.13)	0.20 (0.10)	0.57 (0.12)	0.30 (0.14)	-0.07 (0.06)
2. 21 days	0.64	**0.29** (0.04)	0.87 (0.04)	0.19 (0.08)	0.72 (0.12)	0.87 (0.06)
3. 30 days	0.61	0.94	**0.21** (0.03)	-0.19 (0.10)	0.63 (0.14)	0.89 (0.09)
Litter weight at						
4. birth	0.73***	0.67***	0.64***	**0.16** (0.04)	0.65 (0.20)	0.58 (0.20)
5. 21 days	0.33**	0.61***	0.58***	0.51***	**0.17** (0.04)	0.56 (0.18)
6. 30 days	0.38**	0.67***	0.73***	0.51***	0.61***	**0.14** (0.04)

-Standard error (SE) are within parentheses on the *2nd* line of each row.
- (*** P<0.001 or ** P<0.01).