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ENVIRONMENTAL AND GENETIC ASPECTS OF LITTER TRAITS IN NEW ZEALAND WHITE AND CALIFORNIAN RABBITS UNDER THE EGYPTIANCONDITIONS.

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ABSTRACT

Records of 1088 New Zealand White and Californian purepred litters produced by 286 does (paternal half-sisters) sired by 61 bucks during two successive years of production (1986/87 and 1987/88), were used in the present study which aimed to quantify the environmental and genetic factors influencing litter size and litter weight at birth, 21 days and at weaning (at five weeks of age) and pre-weaning litter mortality percentage. Genetic parameters were also evaluated.

Year of kindling affected significantly (P<0.05) only litter size in Californian rabbits. Month of kindling influenced all litter traits significantly (P<0.05 or 0.01) in New Zealand White rabbits and the reverse was true in Californian ones. Litter size and litter weight at different ages and pre-weaning litter mortality percentage changed with advancement of parity, but not in a similar or consistent pattern. Parity effect was highly significant (P<0.01) only on litter weight at birth in Californian rabbits.

Effect of sire of the doe was significant on the doe's litter size at weaning in New Zealand White rabbits. Differences among does within sires constituted significant (P<0.01 or 0.05) source of variation in most litter traits studied.

Paternal half-sib heritability estimates of different litter traits were generally low. Repeatability estimates of most litter traits were of moderate values.

Phenotypic correlation coefficients between each of litter size traits and litter weight traits and each of litter size traits and litter weight traits were positive and mostly with high magnitudes in the two breeds. Phenotypic correlation between litter size and pre-weaning litter mortality percentages at birth was positive and of low to moderate magnitude in the two breeds. Most of estimates of genetic correlations between different pairs of litter weight traits were positive and of high magnitude in New Zealand White rabbits. Genetic correlations among litter size and litter weight traits were positive and relatively high. Phenotypic correlation between litter size and litter weight traits were positive and generally high.

INTRODUCTION

Rabbits of New Zealand White and Californian breeds are newly introduced to Egypt. Thus, there is a lack in the information about their genetic potentialities and productive abilities under the Egyptian conditions. Size and weight of the litter are considered as determinant traits of the doe productivity.

The present work was carried out to quantify the genetic and phenotypic variances and covariances in New Zealand White and Californian rabbits under the conditions of Sharkia Governorate, Egypt. Heritability and repeatability values of litter traits in the two breeds, were also estimated.

MATERIALS AND METHODS

Data of this work were collected during two successive production years (1986/87 and 1987/88) on purebred litters of New Zealand White and Californian rabbits produced in the rabbitry of the National Rabbit Project established in the Department of Animal Production, Faculty of Agriculture Zagazig University, Zagazig, Egypt, and financed by the Academy of Scientific Research and Technology of Egypt.

Breeding bucks and does were housed separately in individual universal galvanized wired battery cages equipped with feeders and automatic nipple drinkers and arranged in raws back to back. Permanent wire nest box was provided for each doe. The rabbit battaries were located in a conventional confined windowed rabbitry naturaly ventilated. Side electric fans were used in Summer and the windows were closed during cold and windy days. The average of air temperature inside the rabbitry through the breeding season (from August to the next May) ranged between 15.7 and 26.2°C. Battery cages and nest boxes were cleaned and disinficted regularly. Urine and faeces dropped from cages on the rabbitry floor were cleaned regularly every morning.

Matings were carried out at random between purebred mates within each breed with a restriction of avoiding full-sib, half-sib and parent-offspring matings. Each buck was allowed to produce all its litters during the period of the study from the same breeding does (five does) allocated at random. The dead breeding animals or the culled ones for any reason were substituted with others from the same breed with the same restrictions. The breeding season of each year of production started at August and ended in May.

According to the breeding plan, each doe was transferred to the buck's cage to be mated and returned back to its cage after being bred. Hand mating was exercised by restraining the doe when she refused the buck, to assure copulation. Pregnancy was diagnosed by abdominal palpation ten days post-service and those failed to conceive were immediately returned after palpation to the same mating buck to be remated. All does were bred seven days after parturition by their bucks.

On the 25th day of pregnancy, the nest boxes were supplied with sawdust or wood shavings to provide a comfortable and warm nest for the kindled bunnies. Within 12 hours after kindiling, litters born were examined and weighed. All measurements thereafter were taken in time. Weaning was practiced at five weeks of age

Rabbits were always fed ad-libitium all year round on a commercial pelleted ration composed of 32% barly, 21% wheat bran, 10% soyabean meal (44% CP), 22% hay, 6% barseem straw, 3% corticated cotton seed meal, 3% molasses, 1.3% meat meal (60% CP), 1% limestone, 0.34% table salt, 0.3% minerals and vitamins and 0.06% methionine. Fresh clean water was available all time.

Data of litter traits were sorted according to sire-daughter (paternal half-sister) groups and only data on litters produced by does with sires having at least two daughters (does) were included in the statistical analysis. Litter traits of this analysis were considered as traits of the doe; therefore, the references to sires in this work means the sires of the does that produced the litters.

Litter traits studied were litter size and litter weight at birth, 21 days and at weaning, in addition to pre-weaning mortality percentage per litter. Records of pre-weaning litter mortality percentages were subjected to arc-sin transformation before being analysed to approximate normal distribution and the means obtained were returned to the original scale before presentation. Therefore, these means were not associated with standard errors and coefficients of variability.

Data of litter traits of this study were analysed by the least-squares and maximum likelihood computer program (Harvey, 1985). A mixed model including sire of the doe that produced the litter and the doe within sire as random effects, as well as, year and month of kindling and parity as fixed effects, were adapted. Sire analysis and estimation of genetic and phenotypic parameters were performed by using results of the same model. Estimates of variance components of sire of the doe ($\sigma^2 s$), doe within sire ($\sigma^2 D{:}S$) and within doe or remaining component and covariance were coputed ($\sigma^2 w$) according to methods of Henderson (1953). Heritability estimates were obtained by the paternal half-sib (half-sister) methods as :$h^2 s = 4\sigma^2 s / (\sigma^2 s + \sigma^2 D{:}S + \sigma^2 w)$. Repeatability estimates were computed as the ratio of the sum sire and doe within sire variance components to the sum of sire, doe within sire and the remainder variance components as: $t = \sigma^2 s + \sigma^2 D{:}S / (\sigma^2 s + \sigma^2 D{:}S + \sigma^2 w)$. Standard errors of heritability and repeatability estimates were calculated according to Swiger et al. (1964). Estimates of genetic, phenotypic and environmental correlation coefficients were obtained by LSML 76 program of Harvey (1985). The approximate standard errors for genetic correlation coefficients were calculated according to Tallis (1959).

RESULTS AND DISCUSSION

Means and variance of uncorrected records:

Means, standard deviations and coefficients of variation for litter size, litter weight and preweaning litter mortality percentage in New Zealand White and Californian rabbits are presented in Table 1. The coefficients of variation for litter size and litter weight in the present study were found to increase as age advanced in the two breeds. Similarly, Lukefahr

(1982), Khalil, Owen and Afifi (19879, El-maghawry, Yamani and Marai (1988) observed higher coefficients of variation at weaning than at birth. The higher coefficients of variation in litter size and litter weight at weaning than at earlier ages may be attributed to differences in litter losses during the suckling period and to differences in post-natal growth of the litter-mates up to weaning caused by differences in their genotypes and in milk production of their dams during the suckling period. The higher variability values in both litter size and weight at weaning than at birth and 21 days would lead to a greater improvement in these traits through selection at weaning than at earlier ages.

Litter mortality percentage up to weaning averaged 35.2 and 39.1% for New Zealand White and Californian rabbits, respectively (Table 1). Differences in preweaning mortality percentage for a particular breed reported by different authors may be due to differences in management, nutrition, climatic conditions, disease, samples and number of records used.

Non-genetic effects:

Litter size at birth in Californian breed varied significantly only with year of kindiling (Tables 2, 3 and 4). Year of kindiling differences in litter traits could be due to year changes associated with climate, management, feeding, care of the does, stockman's skill and disease attack, changes in genetic make-up of the flock in long periods and differences in litter losses that occur during the suckling period. Vrillon et al (1979) reported that year differences in litter size during long periods were partly due to genetic factors and partly due to raising conditions.

All litter traits of the study varied from month of kindling to another, but no consistent trend was observed (Tables 2, 3 and 4). Month of kindling effects were found to be significant on litter size and litter weight at kindling, 21 days after kindling and at weaning ($P<0.01$), as well as, on preweaning litter mortality percentage ($P<0.05$) in New Zealand White rabbits and the reverse was true when considering Californian rabbits. Differences in litter size due to month of kindling may be ascribed in Egyptian conditions to changes in the availability of green fodder and its nutritive value and/or weather conditions especially ambient temperature which are associated with changes in months of the year. Differences in litter losses which occurred in litters kindeled during different months could be added as another cause when considering litter weight at weaning. Month-of-kindling differences in pre-weaning mortality percentage might be due to differences in nutrition, atmospheric temperature and/or disease conditions which usually change from one month to another.

Litter size and litter weight at different ages up to weaning changed with advancement of parity, but not similarly either at different ages for any breed or for the two breeds at a particular age (Tables 2 and 3). The least squares means for the effect of parity on litter size and litter weight presented in Tables 2 and 3, show that the lowest performance was generally recorded by litters of the first parity when compared with those of other parities. This trend is thought to be due to that does in their first parity have just reached sexual maturity and consequently their ovulation rate, efficiency of providing their young with nourishment and intra-uterine environment during the pre-natal development and the ability of the doe to produce milk, to care and suckle her young during the suckling period are at the loweset level. Preweaning litter mortality percentage varied with parity in the two breeds but without similar pattern (Table 4). It decreased up to seventh parity in New Zealand White rabbits and did not show any definite trend in Californian rabbits. Many reviewed studies showed a general trend indicating that preweaning litter mortality percentage decreases as parity advanced till reaching its bottom level at certain parity and increases thereafter (Rouvier, Poujardieu and Vrillon 1973; Khalil, Afifi and Emara., 1988; Abdella et al., 1990. The decrease in preweaning litter mortality percentage seems to be due to the improvement in the ability of the does to care and suckle their young with advancement of parity (Khalil, 1980), while the latter increase in parities might be due to senility. Parity affects significantly (P<0.01) litter weight at birth in Californian rabbits. These findings may indicate that parity effects were, in general, of no or minor importance in influencing litter traits under consideration. The inclusion of month of kindling in the model of the analysis besides parity and the partial confounding between the effects of parity and those of month of kindling may be responsible for the non-significant parity-effects.

Random effects:

Effects of sire of the doe (Table 5) were significant (P<0.05) only on litter size at weaning in New Zealand White rabbits. However sire of the doe effects, when prove to be important, improvement in litter traits could be achieved through selection of the sires based on their daughter s performance.

Differences among does within sires constituted significant (P<0.01 or 0.05) source of variation in most of traits of this work, except litter size and litter weight at weaning in Californian rabbits and preweaning litter mortality percentage in the two breeds (Table 5). The significant doe effects on litter traits may be due to doe differences in ovulation rate and pre-implantation viability, as well as, differences in the maternal effects determined by the number of mature, fertilized, established ova and the environment that the doe provides her litter and the genes she transmits to her offspring in addition to differences in milk production during the suckling period (Randi and Scossiroli, 1980). The non-significant doe effects on litter traits may possibly be due to masking of the full genetic expression of doe by systems of feeding and management practices, the negative covariance that may exist between litters in the adjacent years because of imbalances in body reserves of the does from one year to another and kindling or rearing of does in litters different in size or weight. The differences in the phenotypic correlations between growth rate of the does and their reproductive traits reported by Rollins et al. (1963), could be added in this respect.

Does within sire component of variance was higher than sire component of variance for most litter traits studied. These findings support those of Rouvier, Poujardien and vrillon (1973) and Garcia et al. (1982) who showed that the doe contributes strongly to the phenotypic value of her litter traits not because of the genes she transmits only but due to her maternal environment she provides. The estimates of doe within sire component of variance of litter size and litter weight were higher at weaning than at kindling in New Zealand White rabbits, while the reverse was true of Californian rabbits (Table 5). This may reflect the importance of the post-natal maternal ability in the variance of litter traits at weaning in New Zealand White rabbits and may indicate the presence of genotype-environment interaction. Improvement of litter traits up to weaning as traits of the does (dams of the litter) could be achieved through selection of the does based on their own performance or their dams performance and selection of sires of the does based on their daughters performance.

Heritability:

estimates of paternal half-sib heritability (h^2) of different litter traits in New Zealand White and Californian rabbits of the study are presented in Table 6. These estimates are generally low. The only two exceptions are those of litter weight at 21 days and at weaning in Californian rabbits which showed moderate values associated with relatively sizeable standard errors. Heritability estimates of pre-weaning litter mortality percentage were with negative sign for New Zealand White. Small or negative estimates of heritability might be attributed to sampling variation (McCarteny, 1962), sampling error (Thompson and Moor, 1963); small number of progeny per sire i.e. of paternal half-sibs (Gill and Jensen, 1968), large maternal effects (Garcia, et al., 1982), small sampling size per generation (Narayan, Rawet and Saxena, 1985) or non-randomness in the distribution of daughters within sire groups (Khalil and Soliman, 1989). The high standard errors of more than half for the obtained heritability estimates in this work may suggest that further investigations should be carried out on flocks of large size in order to get more reliable heritability estimates. Most of the reviewed estimates of heritability for litter size and litter weight at birth were of low or moderate magnitude (Randi and Scossiroli, 1980; Lahiri and Mahajan, 1982; Kadry and Afifi, 1984; Khalil, Owen and Afifi, 1987).

Repeatability:

Repeatability estimates of most preweaning litter traits of the study were of moderate values. The only traits that showed low repeatability values were pre-weaning litter mortality percentage in New Zealand White and Californian rabbits and litter size at 21 days and at weaning in the latter breed (Table 6). Low repeatability estimates were reported in the Egyptian literature for litter size and litter weight at birth and at weaning as well as pre-weaning litter mortality (Khalil and Afifi,1986; Khalil, afifi and Emara, 1988). Also reports on the non-Egyptian work indicated low or moderate repeatability for litter size and litter weight at birth (Rouvier et al., 1973; Suh et al., 1978, Lukefahr et al., 1983 & 1984; Lahiri, 1984).

Repeatability estimates for litter size and litter weight at birth in the two breeds were of moderate magnitude (0.15-0.23) and showed, in general, higher values than at 21 days or at weaning (Table 6). These findings may indicate that culling of does for litter size and litter weight based on single record would be more efficient in improving these traits when done at birth than at later ages.

Correlations:

Phenotypic correlation coefficients between litter size traits and also those between litter weight traits in both New Zealand and Californian rabbits were positive and mostly of high magnitudes, but tended to decrease as the time interval between the correlated traits increased (Table 7). The estimate of the phenotypic correlation between litter size and litter weight at a certain age (birth, 21 days or weaning) was always positive and strong. It ranged between 0.82 and 0.89 and 0.75 and 0.80 in New Zealand White and Californian rabbits, respectively. Also the phenotypic correlation between litter size and litter weight in each of the two breeds, when the two traits were measured at different ages, were positive but were somewhat lower than when measured at a particular age (Table 7). The phenotypic correlation between litter size at birth and pre-weaning litter mortality percentage was positive and of moderate magnitude in the two breeds (0.22 and 0.16 in New Zaland and Californian rabbits, respectively). The non-strong phenotypic correlation between litter size at birth and pre-weaning mortality per litter could be due to that pre-weaning mortality is greatly influenced by environmental effects.

Estimates of genetic correlations between different pairs of litter size traits in the two breeds were positive and high. Most estimates exceeded unity (Table 7). Also, the genetic correlations between litter weight at birth and each of 21-day and weaning litter weights in New Zealand White rabbits and between 21-day and weaning litter weights in Californian rabbits were positive and high. These findings indicate that the genes affecting litter size and litter weight at birth may have effects on the corresponding traits at later ages. Estimates of genetic correlations among litter size and litter weight traits (Table 7) were positive and relatively high (except between litter size at birth and each of 21-day and weaning litter weight and also between 21-day litter size and 21-day litter weight in Californian rabbits).

Estimates of the genetic and phenotypic correlations obtained in this study may reveal that selection for litter size at birth would possibly improve litter size and litter weight at weaning.

Environmental correlations between litter size and litter weight traits were positive and generally high (Table 7). These

Table 1 Means, standard deviations (S.D) and coefficients of variation (C.V.%) of uncorrected litter traits in New Zealand White and Californian rabbits.

Traits	New Zealand White			Californian		
	No.	Means±S.D*	C.V.%	No.	Means±S.D.	C.V.%*
Litter size at:						
Birth	727	7.3± 2.4	30.1	361	7.6± 2.4	27.7
21-day	651	5.6± 2.2	35.9	327	5.3± 2.0	35.4
Weaning	643	5.2± 2.2	37.4	326	4.9± 2.0	39.4
Litter weight (g) at:						
Birth	727	419.3± 136.9	28.3	361	432.7± 119.7	24.8
21-day	651	1708.2± 576.1	30.6	327	1632.2± 517.1	29.0
Weaning	643	3454.8±1334.3	37.7	326	3146.5±1212.6	36.5
Preweaning litter mortality(%)**	727	35.2		361	39.1	

* Coefficient of variation computed as the residual standard deviation divided by the overall least-squares means of given litter traits according to Harvey (1985).

** Means of the preweaning litter mortality are the retransformed estimates from the Arc-sin scale and consequently are not associated with either standared deviations or coefficient of variability.

Proceedings 5th World Rabbit Congress, 25-30 July 1992, Corvallis – USA, 335-351

Table 2 Least-squares means, standard errors (S.E.) and test of significance of factors (fixed) affecting litter size at birth, 21 day and at weaning in New Zealand White (NZW) and Californian (CA) rabbits.

Indpendent variables	Litter size at Birth				Litter size at 21-day				Litter size at Weaning			
	NZW		CA		NZW		CA		NZW		CA	
	No	$\bar{X}\pm$S.E	No	$\bar{X}\pm$S.E	No	$\bar{X}\pm$S.E	No	$\bar{X}\pm$S.E	No	$\bar{X}\pm$S.E	No	$\bar{X}\pm$S.E
General mean	727	7.6±0.2	361	8.2±0.3	651	5.5±0.2	327	5.2±0.2	643	5.1±0.2	326	4.8±0.2
		NS		**		NS		NS		NS		NS
Year of kindling		(1.48)		(4.42)		(0.0002)		(0.13)		(0.20)		(0.16)
1985/1986	304	8.2±0.4	112	8.8±0.4	271	5.3±0.4	98	5.0±0.4	266	4.7±0.4	98	4.6±0.4
1986/1987	423	6.9±0.4	249	7.6±0.4	380	5.7±0.4	229	5.5±0.4	377	5.4±0.4	228	5.1±0.4
		**		NS		**		NS		**		NS
Month of kindling		(4.52)		(0.74)		(3.43)		(1.24)		(2.53)		(0.78)
Septemper	101	7.6±0.4	41	8.5±0.5	89	5.5±0.4	39	5.4±0.5	87	5.2±0.4	39	4.9±0.4
October	92	7.8±0.4	43	7.9±0.5	85	6.0±0.3	43	5.0±0.4	85	5.5±0.3	43	4.8±0.4
November	69	7.1±0.4	36	7.7±0.5	60	5.2±0.4	32	5.1±0.4	60	4.9±0.3	32	4.6±0.4
December	76	8.0±0.3	30	8.7±0.5	72	5.8±0.3	26	5.7±0.5	71	5.2±0.3	26	5.3±0.5
January	70	8.0±0.3	46	8.5±0.4	66	5.6±0.3	39	5.4±0.4	64	5.0±0.3	38	5.1±0.4
February	73	8.1±0.3	28	8.2±0.5	65	6.1±0.3	25	5.0±0.5	65	5.3±0.3	25	4.5±0.5
March	97	6.9±0.3	51	8.1±0.4	80	5.2±0.3	46	5.6±0.4	79	4.8±0.3	46	5.3±0.4
April	103	7.9±0.3	56	8.7±0.4	94	5.9±0.3	52	5.6±0.3	92	5.6±0.3	52	4.6±0.3
May-June	46	6.5±0.4	30	7.7±0.5	40	4.4±0.4	25	4.3±0.5	40	4.0±0.5	25	4.3±0.5
		NS		NS		NS		NS		NS		NS
Parity		(0.89)		(1.49)		(0.81)		(0.67)		(1.31)		(0.65)
1st	181	7.8±0.4	105	7.2±0.5	168	5.2±0.4	102	5.0±0.4	166	4.7±0.4	102	4.5±0.4
2nd	164	7.2±0.3	85	7.3±0.4	148	5.6±0.3	75	5.2±0.3	146	5.1±0.3	75	4.7±0.3
3rd	142	7.6±0.3	66	8.3±0.4	132	5.8±0.3	59	5.4±0.4	130	5.3±0.3	58	5.1±0.3
4th	104	7.8±0.3	46	8.5±0.4	88	5.7±0.3	42	5.4±0.4	87	5.4±0.3	42	5.2±0.4
5th	62	7.8±0.4	28	8.2±0.5	54	5.5±0.4	26	5.3±0.5	53	5.0±0.4	26	4.6±0.4
6th	29	8.1±0.5	16	8.1±0.7	24	5.8±0.5	14	4.6±0.6	24	5.4±0.5	14	4.4±0.6
>7th	45	7.0±0.6	15	9.9±0.8	37	5.2±0.6	9	5.8±0.8	37	4.5±0.6	9	5.4±0.8
Residual												
d.F.	531		241		455		207		447		206	
M.S.	4.9		4.5		4.1		3.5		3.8		3.7	

( ) Figures between brackets represent F-values.
NS not significant.
** P<0.01.

Table 3 Least-squares means, standard errors (S.E.) and test of significance of factors (fixed) affecting litter weight at birth, 21-day and at weaning in New Zealand White (NZW) and Californian (CA) rabbits.

Indpendent variables	Litter weight at birth				at 21-day				at weaning			
	NZW		CA		NZW		CA		NZW		CA	
	No	X±S.E.	No	X±S.E.	No	X±S.E.	No	X±S.E.	No	X±S.E.	No	X±S.E.
General mean	727	433.5± 9.5	361	483.6±11.8	651	1767.4± 39.8	327	1584.1± 56.2	643	3435.3± 88.9	326	3200.5±139.3
		NS		NS		NS		NS		NS		NS
Year of kindling		(1.64)		(1.19)		(0.84)		(0.36)		(0.18)		(0.12)
1985/1986	304	471.5±31.4	112	531.5±46.1	271	1896.8±147.3	98	1455.1±225.5	266	3296.4±338.2	98	3016.5±249.1
1986/1987	423	395.4±30.9	249	435.6±44.9	380	1638.1±145.4	229	1713.1±220.3	377	5574.2±333.6	228	3384.5±536.5
		**		NS		**		NS		**		NS
Month of kindling		(6.03)		(0.96)		(3.33)		(1.17)		(2.86)		(1.44)
Septemper	101	422.6±28.0	41	521.4±41.8	89	1731.6±132.9	39	1690.3±199.9	87	3598.3±304.9	39	2663.0±487.1
October	92	476.6±22.9	43	516.2±35.1	85	1957.4±108.4	43	1585.2±167.6	85	3860.1±248.5	43	3478.1±408.4
November	69	407.9±21.3	36	475.2±27.9	60	1712.7±100.0	32	1588.7±132.4	60	3138.8±229.4	32	2791.8±323.1
December	76	472.2±19.1	30	523.8±26.4	72	1820.8± 87.0	26	1962.2±126.5	71	3638.4±199.4	26	3503.3±308.5
January	70	466.4±18.8	46	499.4±20.6	66	1742.3± 84.9	39	1564.9±102.3	64	3202.6±195.6	38	3064.9±251.8
February	73	475.8±18.2	28	474.5±26.4	65	1979.2± 84.9	25	1643.4±124.9	65	3699.3±193.9	25	3354.6±304.6
March	97	386.5±18.2	51	457.7±24.2	80	1734.3± 86.1	46	1648.9±118.1	79	3456.4±197.1	46	3404.7±288.3
April	103	449.2±21.8	56	469.9±29.8	94	1810.0±102.3	52	1586.5±146.3	92	3586.0±235.1	52	2842.9±356.6
May-June	46	352.9±22.0	30	411.0±43.3	40	1638.1±145.4	25	1256.9±208.2	40	2737.4±343.5	25	2701.3±507.0
		NS		**		NS		NS		NS		NS
Parity		(1.97)		(2.14)		(0.87)		(0.97)		(1.64)		(0.94)
1st	181	379.4±35.1	105	377.2±50.6	168	1555.7±167.4	102	1481.1±248.5	166	3134.1±384.8	102	2678.5±604.9
2nd	164	410.3±25.1	85	426.5±33.1	148	1677.6±119.5	75	1604.7±163.0	146	3362.3±274.6	75	3070.0±397.2
3rd	142	446.3±18.0	66	487.8±22.7	132	1775.6± 82.0	59	1588.6±111.4	130	3503.9±187.9	58	3309.2±272.6
4th	104	453.5±16.7	46	514.5±20.1	88	1796.5± 77.6	42	1657.1± 93.4	87	3583.6±177.4	42	3467.3±228.3
5th	62	456.6±20.9	28	517.9±27.1	54	1785.5± 98.0	26	1719.6±126.4	53	3428.9±225.1	26	3240.2±308.4
6th	29	464.5±30.8	16	491.4±39.4	24	1948.8±145.5	14	1494.7±187.9	24	3940.9±333.9	14	3011.9±457.8
>7th	45	423.4±46.7	15	569.8±62.9	37	1832.1±226.0	9	1593.0±334.2	37	3093.0±518.9	9	3626.5±813.2
Residual:												
d.F		531		241		455		207		447		206
M.S		14082.4		11501.5		273869.1		223390.5		1437375.1		1321825.4

( ) Figures between brackets represent F-values.
NS not significant.
** P<0.01.

Table 4 Least-square means and test of significance of factors affecting preweaning litter mortality+ percentage in New Zealand White and Californian rabbits.

Independent variables	Breeds			
	New Zealand White		Californian	
	No.	Means	No.	Means
General mean	727	26.65	361	54.90
Year of kindling:		NS (2.90)		NS (0.38)
1985/1986	304	12.07	112	56.04
1986/1987	423	44.50	249	35.93
Month of kindling:		* (2.18)		NS (1.25)
September	101	19.12	41	44.08
October	92	11.94	43	27.35
November	69	17.98	36	53.92
December	76	16.52	30	46.22
January	70	34.25	46	44.93
February	73	25.24	28	48.13
March	97	41.18	51	37.28
April	103	30.13	56	52.46
May-June	46	49.77	30	59.73
Parity:		NS (0.78)		NS (0.30)
1st	181	46.08	105	40.82
2nd	164	42.39	85	44.36
3rd	142	29.50	66	45.09
4th	104	28.66	46	40.07
5th	62	24.19	28	43.09
6th	29	17.41	16	46.51
>7th	45	6.54	15	61.49
Residual:				
d.F.		531		241
M.S.		638.7		532.6

\+ Preweaning mortality percentages were obtained by the retransformation from Arc-sin to original scale and consequently were not associated with standard errors.

( ) Figures between brackets represent F-values.

NS not significant.

* P<0.05.

Table 5 Variance components estimates and percentage of variance (V%) due to random effects for litter traits in New Zealand White and Californian rabbits.

Litter traits	New Zealand White									Californian								
	Sire			Doe/sire			Remainder			Sire			Doe/sire			Remainder		
	d.F.	S	V%	d.F.	D:S	V%	d.F.	W	V%	d.F.	S	V%	d.F.	D:S	V%	d.F.	W	V[illegible]
Litter size at:																		
Birth	35	0.11	1.9	145	0.77**	1.3	531	4.87	96.8	24	0.16	2.9	80	0.81**	14.9	241	4.47	8[illegible]
21-day	35	0.08	1.8	145	0.69**	1.4	455	4.07	96.8	24	0.05	1.2	80	0.46*	11.4	207	3.54	8[illegible]
Weaning	35	0.12*	2.7	145	0.53**	11.9	447	3.79	85.4	24	0.07	1.8	80	0.08	2.1	206	3.67	9[illegible]
Litter weight at:																		
Birth	35	410.22	2.4	145	2516.94**	1.5	531	14082.36	96.1	24	83.77	2.2	80	674.87**	17.7	232	522.77	8[illegible]
21-day	35	4916.99	1.5	145	38499.35**	12.1	455	273869.12	86.4	24	15102.84	6.4	80	20028.06*	8.5	198	199647.11	8[illegible]
Weaning	35	14864.20	0.9	145	230283.38**	13.7	447	1437375.12	85.4	24	99887.06	7.8	80	88966.92	7.0	197	1083107.41	8[illegible]
Preweaning litter mortality%	35	a	0.0	145	22.81	3.4	531	638.66	96.6	24	12.55	2.3	80	5.03	0.9	241	532.57	9[illegible]

a Negative variance component estimates set to zero.

* P<0.05, ** P<0.01

Table 6 Estimates of heritability (h^2) and repeatability (t) for preweaning litter traits in New Zealand White and Californian rabbits.

Litter traits	h ±S.E.				T±S.E.			
	No.	NZW	No.	CA	No.	NZW	No.	CA
Litter size at:								
Birth	727	0.08±0.06	361	0.11±0.13	727	0.15±0.04	361	0.18±0.05
21-day	651	0.07±0.08	327	0.05±0.12	651	0.16±0.04	327	0.13±0.06
Weaning	643	0.11±0.09	326	0.07±0.13	643	0.15±0.04	326	0.04±0.05
Litter weight at:								
Birth	727	0.10±0.07	361	0.09±0.13	727	0.23±0.04	361	0.20±0.06
21-day	651	0.07±0.08	327	0.23±0.18	651	0.20±0.02	327	0.15±0.06
Weaning	643	0.05±0.08	326	0.28±0.20	643	0.15±0.04	326	0.14±0.06
Preweaning litter:								
Mortality%	727	a	361	0.09±0.11	727	0.04±0.03	361	0.03±0.05

a Negative estimate of sire component of variance set to zero.

Table 7 Estimates of phenotypic (above diagonal), genetic (below diagonal) and envornimantal (in brackets above diagonal) correlations among preweaning litter traits based on paternal half-sibs

Litter traits	Litter size at: Birth	Litter size at: 21-day	Litter size at: Weaning	Litter weight at: Birth	Litter weight at: 21-day	Litter weight at: Weaning	Preweaning mortality (%)
				New Zealand White			
Litter size at:							
Birth		0.66(0.61)	0.58(0.51)	0.85(0.84)	0.45(0.40)	0.40(0.33)	0.22(a)
21-day	1.14±0.49		0.91(0.89)	0.65(0.64)	0.82(0.82)	0.76(0.74)	-0.39(a)
Weaning	1.37±0.42	1.15±0.16		0.59(0.56)	0.79(0.80)	0.89(0.89)	-0.55(a)
Litter weight at:							
Birth	0.93±0.12	0.84±0.29	0.80±0.26		0.55(0.53)	0.48(0.47)	0.07(a)
21-day	1.30±0.74	0.89±0.25	0.68±0.37	0.89±0.46		0.80(0.84)	-0.45(a)
Weaning	1.74±0.74	1.23±0.51	1.08±0.30	0.63±0.61	0.04±1.43		-0.60(a)
Preweaning litter mortality %	a	a	a	a	a	a	
				Californian			
Litter size at:							
Birth		0.56(0.50)	0.45(0.42)	0.83(0.84)	0.21(0.40)	0.23(0.35)	0.16(a)
21-day	1.20±0.77		0.89(0.87)	0.55 (a)	0.75(0.84)	0.69(0.73)	-0.36(a)
Weaning	0.73±0.85	1.22±0.43		0.49 (a)	0.73(0.76)	0.88(0.90)	-0.55(a)
Litter weight at:							
Birth	1.90±0.69	a	a		0.35 (a)	0.36 (a)	-0.31(-0.27)
21-day	-1.33±0.84	-0.88±0.49	0.07±0.13	a		0.81(0.76)	0.54(a)
Weaning	-0.37±0.53	1.23±0.40	0.77±0.30	a	0.77±0.29		-0.63(a)
Preweaning litter mortality %	0.34±0.76	a	a	0.82±1.43	a		

\+ Environmental correlations are shown in brackets.

a Undetermined genetic correlations due to negative estimates of sire component of variance.

correlations were similar to their corresponding phenotypic correlations in sign and nearly had the same size. This observation may emphasize the presence of large environmental doe effects on her litter.

In conclusion selection could be carried out for litter size and weight at weaning. The significant sources of variation in the traits studied are month of kinling in New Zealand White rabbits as non-genetic factor and doe within sires as a genetic factor. Phenotypic and genetic correlations between different pairs of litter weights and litter size and litter weight traits were positive and relatively high.

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ENVIRONMENTAL AND GENETIC ASPECTS OF LITTER TRAITS IN NEW ZEALAND WHITE AND CALIFORNIAN RABBITS UNDER THE EGYPTIAN CONDITIONS.

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SUMMARY AND CONCLUSION

Records of 1088 NZW and and Californian purebred litters produced by 268 does (paternal half-sisters) sired by 61 bucks during two sccessive years of production (1986/87 and 1987/88); were used in the present study.

The present work aimed to quantify the environmental and genetic factors influencing litter size and litter weight at birth, 21 days and at weaning (at five weeks of age) and pre-weaning litter mortality percentage. Genetic parameters were also evaluated.

The results obtained may be summaraized in the following :

1- Years of kindling affected significantly (P<0.05) only litter size in Californian rabbits.
2- Month of kindling influenced all litter traits significantly (p<0.05 & 0.01) in NZW rabbits and the converse was true in the Californian.
3- Litter size and litter weight at different ages and pre-weaning litter mortality percentage changed with advancement of parity, but not in a similar or consistent pattern.
4- Parity effect was significant (P<0.01) only on litter weight at birth in Californian rabbits.
5- Effect of sire of the doe was significant on the doe's litter size at weaning in NZW rabbits. Differences among does within sires constituted significant (P<0.5 or 0.01) source of variation in most litter traits studied.
6- Paternal half-sib heritability estimates of different litter traits were generally low. Repeatability estimates of most litter traits were of moderate values.
7- Phenotypic correlation coefficients between each of litter size traits and litter weight traits and each of litter size traits and litter weight traits were positive and mostly with high magnitudes in the two breeds.
8- Phenotypic correlation between litter size and preweaning litter mortality percentages at birth was positive and of low to moderate magnitude in the two breeds.
9- Genetic correlation among litter size and litter weight traits were positive and relatively high.
10- Most of estimates of genetic correlations between different pairs of litter weight traits were positive and of high magnitude in NZW rabbits.