RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

4.1 Means of uncorrected records:

Means, standard deviations (SD) and percentages of phenotypic variation (V%) for postweaning body weights and livabilities for New Zealand White (NZW) and Californian (CAL) rabbits are given in Table 9. Means for body weights in both breeds increased with the advancement of age. However, body weights in NZW was slightly higher than in CAL breed (Table 9). These results are in agreement with some of the Egyptian studies (El-Maghawry *et al.*, 1988; El-Maghawry, 1990; Ayyat, .1993; Khalil *et al.*, 1993; Yamani *et al.*, 1994).

Means of body weights for the two breeds used (NZW and CAL) are lower than those reported in most of the Egyptian studies (El- Maghawry *et al.*,1988; El-Maghawry, 1990; Oudah, 1990; El-Desoki, 1991; Abd El-Mooty, 1991; El-Gaafary *et al.*, 1991; Tawfeek and El-Gaafary ,1991; Tawfeek and El-Hindawy *et al.*, 1991; Yamani *et al.*, 1992; El-Sayiad *et al.*, 1993; El-Darawany *et al.*, 1994; El-Gaafary *et al.*, 1994; El-Raffa, 1994; Maria *et al.*, 1994; Yamani, 1994; El-Mahdy and Karousa, 1995; Toson *et al.*, 1995), while they are nearly similar with other few studies (Afifi *et al.*, 1993; Yamani *et al.*, 1994; El-Deghadi, 1996). Means of body weights for NZW and CAL rabbits are also lower than that of rabbits raised in other Mediterranean countries (e.g. Blas *et al.*, 1991; Masoero *et al.*, 1992; Pagano *et al.*, 1992; Panella *et al.*, 1992).

Livability in NZW and CAL are nearly similar (Table 9). Livabilities are higher than those corresponding estimates reported in the Egyptian studies (Tawfeek and El-Gaafary, 1991; El-Gaafary *et al.*, 1992; El-Maghawry, 1993; El-Deghadi, 1996), while they were lower than those of NZW and CAL rabbits raised in other Mediterranean countries (e.g. Morisse *et al.*, 1989).

Table 9. Means, standard deviations (SD) and percentages of phenotypic variation (V%) for post weaning body weights and livabilities in New Zealand White and Californian rabbits.

Trait	New Zealand White				Californian			
	No.	Mean	SD	V%	No.	Mean	SD	V%
Body weight:								
5 weeks	2257	546.6	149.5	25.4	1748	514.1	147.1	26.5
6 weeks	2178	668.6	156.7	21.4	1671	634.2	155.2	22.3
8 weeks	2095	936.4	195.7	17.9	1598	888.0	184.1	17.5
10 weeks	2028	1247.6	252.9	16.9	1549	1187.0	222.8	15.2
12 weeks	1975	1607.6	336.6	17.4	1501	1541.8	288.1	14.6
Livability (%):								
6 weeks	2257	95.6	18.0	18.3	1748	95.6	20.1	20.5
8 weeks	2178	96.2	18.7	19.2	1671	95.6	19.8	20.4
10 weeks	2095	96.8	17.5	17.9	1598	96.6	17.4	17.9
12 weeks	2028	87.5	32.1	35.4	1549	85.9	33.9	38.3

Results of postweaning body weights in the present study and reviewed studies indicate that **NZW** and **CAL** rabbits could be used as an effective meat-type breeds in Egypt. However, means of postweaning growth traits reported here and those reviewed from literature for **NZW** and **CAL** rabbits indicate that rabbits of these two breeds raised in other Mediterranean countries are relatively better than those rabbits raised in Egypt. This is due to **NZW** and **CAL** rabbits were raised in Egypt under stress of bad climatic and management conditions. Genotype-environment interaction could be added as another limitation cause in this respect.

4.2 Variations of uncorrected records:

Estimates of phenotypic variation (V%) for postweaning growth traits in both breeds (**NZW and CAL**) are moderate or relatively high (Table 9). These estimates in **NZW** ranged from 16.9 to 25.4% for body weights and from 17.9 to 35.4% for livabilities, while they ranged from 14.6 to 26.5% and from 17.9 to 38.3% for the corresponding traits in **CAL** rabbits. The estimates in both breeds tended generally to decrease with the advancement of age, *i.e.* variation percentages for body weights at earlier ages were higher than those estimates at older ages. This trend was expected since rabbits at young ages (5 or 6 weeks) are more sensitive to non-genetic maternal effects (in terms of lactation, mothering ability, litter size and weight) which decrease with the advancement of age. Also, it could be due to the consequence of the expression of the combination of non-genetic maternal environment (which decreases with advance of age) and the genetic factors (**Falconer, 1989**). A reverse trend was observed for livabilities in both breeds (Table 9). These high estimates of **V%** at earlier ages lead to conclude that improvement of growth traits in **NZW** and **CAL** rabbits through phenotypic selection is quiet possible. The estimates of V% are in agreement with estimates of **V%** of the Egyptian studies (Khalil *et al.,* 1987b, Afifi *et al.,* 1990; Yamani, 1994; Yamani *et al.*, 1994a; El-Deghadi, 1996 in different breeds of rabbits).

4.3 ANOVA and tests of significance:

Least-square means for postweaning growth traits (body weights and livabilities) in different sub-classes of year-season, parity, sex and litter size at birth are presented in Appendices through 1 to 14. For sire and dam models, **ANOVA** and **F- ratios** estimated by Henderson method along with tests of significance of factors contributing to the variation of different postweaning growth traits in **NZW** and **CAL** rabbits are presented in Tables 10&11. For most growth traits, year-season, parity, sex and litter size at birth affected significantly these traits in both breeds. High values of F-ratios obtained here indicate that the non-genetic environmental effects (year-season), and non-genetic maternal effects (**parity**) are considered as ones of the most important factors affecting postweaning body weights of **NZW** and **CAL** rabbits raised in adverse environment. Also, litter size at birth contributed significantly (**$P<0.01$**) to the variance of all body weights of both breeds and therefore, it was also considered as the most important non-genetic maternal factor influencing postweaning body weights of these two standard breeds. For **NZW** and **CAL** raised in adverse environment in Egypt, El-Maghawry (1990), Hanna (1992) and El-Deghadi (1996) reported that litter size at birth had considerable effect (**$P<0.01$ or $P<0.001$**) on postweaning body weights. Therefore, Khalil *et al.* (1993) stated that deriving some sets of litter-size correction factors for postweaning body weights are recommended for effective selection.

Results given in Table (10) indicate that differences in the majority of the postweaning growth traits due to sire effect were of considerable magnitude for both NZW and CAL rabbits. For NZW and CAL rabbits raised in Egypt, most of the studies reported non-significant sire effect (El-Maghawry, 1990; Abd

Table 10. F-ratios of Sire Model components for postweaning growth traits in New Zealand White and Californian rabbits.

Source	Body weight+										Livability+							
	W5		W6		W8		W10		W12		L6		L8		L10		L12	
	D.F	F	D.F	F	D.F	F	D.F.	F	D.F	F	D.F	F	D.F	F	D.F	F	D.F	F
New Zealand White:																		
Sire	67	2.70***	67	2.33***	67	2.36***	67	4.42***	67	2.75***	67	1.76***	67	1.88***	67	1.39*	67	2.35***
Year-season	9	10.70***	9	12.84***	9	23.34***	9	27.99***	9	31.40***	7	7.38***	8	10.23***	7	10.85***	10	14.79***
Parity	5	3.85***	5	4.10***	5	6.77***	5	11.03***	5	13.47***	5	3.08**	5	1.78ns	4	0.67ns	5	2.30*
Sex	1	1.30ns	1	0.89ns	1	0.13ns	1	0.69ns	1	0.12ns	1	0.34ns	1	0.45ns	1	1.21ns	1	0.002ns
Litter size at birth	8	21.86***	8	21.70***	8	19.92***	8	13.34***	8	9.02***	8	1.55ns	8	0.78ns	8	0.97ns	8	1.80ns
Remainder d.f.	2166		2087		2004		1937		1884		2168		2088		2007		2165	
Remainder mean squares	19209		20476		28343		44761		77841		.03		.03		.03		.03	
Californian:																		
Sire	50	3.96***	50	3.51***	50	3.62***	50	3.24***	50	2.81***	50	1.91***	50	2.14***	50	.94ns	50	2.45***
Year-season	9	3.16***	9	5.24***	9	13.97***	9	23.57***	9	36.84***	6	11.63***	6	6.34***	6	2.07*	6	12.69***
Parity	5	8.31***	5	5.78ns	5	8.61***	5	7.24***	5	5.06***	5	4.39***	5	1.38ns	5	1.89ns	5	4.21***
Sex	1	2.60ns	1	2.85***	1	2.80ns	1	1.59ns	1	0.64ns	1	0.59ns	1	0.04ns	1	.73ns	1	0.17ns
Litter size at birth	8	21.29***	7	21.88800	7	23.98***	7	17.69***	7	13.08***	8	0.64ns	11	0.74ns	8	1.30ns	8	1.38ns
Remainder d.f.	1674		1598		1525		1476		1428		1677		1597		1527		1677	
Remainder mean squares	18579		20056		24256		32763		50972		0.04		0.04		0.03		0.12	

+ W5 = 5-week weight; W6 = 6-week weight; W8 = 8-week weight; W10 = 10-week weight; W12 = 12-week weight; L6 = Livability at 6 weeks; L8 = Livability at 8 weeks; L10 = Livability at 10 weeks; L12 = Livability at 12 weeks.

ns = non-significant; * = P<0.05; ** = P<0.01; *** = P<0.001.

Table 11. F-ratios of Dam Model components for postweaning growth traits in New Zealand White and Californian rabbits.

Source	Body weight+										Livability+							
	W5		W6		W8		W10		W12		L6		L8		L10		L12	
	D.F	F	D.F	F	D.F	F	D.F	F	D.F	F	D.F	F	D.F	F	D.F	F	D.F	F
New Zealand White:																		
Dam	149	3.64***	149	3.58***	149	3.07***	149	3.05***	148	3.04***	149	1.62***	149	2.54***	149	1.01ns		
Year-season	8	13.64***	8	15.68***	8	28.47***	8	36.93***	10	39.58***	8	7.62***	8	5.56***	8	7.17***		
Parity	5	2.79**	5	3.97**	5	6.34***	5	10.44***	5	14.52***	5	1.91ns	5	3.09**	5	1.88ns		
Sex	1	0.44ns	1	0.25ns	1	0.11ns	1	0.51ns	1	0.03ns	1	0.64ns	1	0.57ns	1	2.24ns		
Litter size at birth	7	18.83***	7	16.45***	7	13.39***	7	7.69***	6	7.43***	8	1.86ns	8	1.15ns	8	2.02*		
Remainder d.f.	1970		1899		1822		1760		1706		1969		1863		1828			
Remainder mean squares	16647		17427		24699		41363		67523			0.3		0.03		0.03		
Californian:																		
Dam	123	2.88***	122	3.07***	121	3.17***	121	2.97***	121	2.99***	122	1.15ns	122	1.63***	121	1.44***	121	1.92***
Year-season	9	4.28***	9	6.25***	9	14.44***	9	23.59***	9	36.76***	8	12.16***	8	10.29***	8	2.88***	8	1.96*
Parity	5	6.46***	5	5.85***	5	10.94***	5	9.95***	5	8.92***	5	2.98**	5	0.72ns	5	3.62***	5	1.22ns
Sex	1	3.43ns	1	2.88ns	1	4.23*	1	2.14ns	1	1.51ns	1	0.75ns	1	0.003ns	1	0.32ns	1	0.33ns
Litter size at birth	8	15.03***	8	16.29***	8	19.18***	8	15.81***	8	11.52***	8	0.76ns	8	0.343ns	8	1.19ns	8	1.55ns
Remainder d.f.	1603		1525		1453		1404		1356		1602		1525		1453		1404	
Remainder mean squares	17758		18676		22618		30652		46910			0.04		0.04		0.03		0.03

+ Traits as defined in table 10.

ns = non-significant; *=P<0.05; **=P<0.01; ***=P<0.001.

‡ Negative estimate of dam component of variance set to zero.

El-Raouf, 1993; Khalil *et al.*, 1993). However, El-Deghadi (1996) reported significant differences due to sire effects for postweaning growth traits. On the other hand and for other breeds of rabbits, most of the Egyptian studies (e.g. Khalil *et al.*, 1987b) reported significant sire effects on postweaning growth traits. Khalil *et al.* (1986) reported that the apparent differences in variance components due to sire may be attributed to differences in: (1) genetic constitution of the breeds and intensive selection if practiced, (2) data structure, (3) methods of estimation, (4) numbers of rabbits used in estimation, (5) the models of analysis applied to data, (6) level of inbreeding and (7) coefficients of relationship among animals in the population (A^{-1} matrix).

Findings presented in Table (11) showed that differences due to dams for most postweaning growth traits in NZW and CAL rabbits were significant. These results indicate that maternal additive genetic effects on these traits were of considerable importance. For NZW and CAL rabbits raised in Egypt, all the available studies indicate that dam effects on postweaning growth traits were significant at different ages (El-Maghawry, 1990; Khalil and Khalil, 1991; Abd El-Raouf, 1993). Khalil *et al.* (1987b) came to the same notation for Bouscat and Giza White rabbits.

4.4 Random Components of variance:

4.4.1 Sire Model:

The variance components estimated using Henderson's method and Restricted Maximum Likelihood procedure (REML) along with these percentages of variation attributed to the sire (σ^2_s) and remainder (σ^2_e) for postweaning growth traits in NZW and CAL rabbits are presented in Table (12). These estimates indicate that sire variance components in both breeds using Henderson or REML methods were moderate for body weights, while

Table 12. Variance components estimated by the Sire Model using Henderson's method and REML for postweaning growth traits in New Zealand White and Californian rabbits.

Trait	Henderson's method							REML				
	Sire			Remainder			σ^2_e/σ^2_s	Sire		Remainder		σ^2_e/σ^2_s
	df	σ^2_s	v%[+]	df	σ^2_e	v%[+]		σ^2_s	v%[+]	σ^2_e	v%[+]	
(i) New Zealand White:												
Body weight:												
5 weeks	67	1090.5	5.3	2166	19209.8	94.6	17.6	1721.2	8.2	19386.5	91.8	11.3
6 weeks	67	946.9	4.4	2087	20476.8	95.6	21.6	1246.2	5.7	20659.2	94.3	16.6
8 weeks	67	1389.4	4.7	2004	28343.2	95.3	20.4	1788.6	5.9	28558.9	94.1	15.9
10 weeks	67	5696.0	11.3	1937	44761.0	88.7	7.9	10126.9	17.9	46266.4	82.0	4.6
12 weeks	67	5196.2	6.3	1884	77841.2	93.7	14.9	7058.1	8.3	78474.9	91.8	11.1
Livability:												
6 weeks	67	0.001	3.1	2168	0.031	96.9	31.0	0.100	0.3	0.032	99.7	0.3
8 weeks	67	0.001	2.9	2088	0.034	97.1	34.0	0.001	2.9	0.034	97.1	34.0
10 weeks	67	0.400	1.3	2007	0.030	98.7	0.1	0.100	0.3	0.030	99.7	0.3
12 weeks	67	0.383	0.1	1938	0.026	99.9	0.1	0.155	0.1	0.026	99.9	0.2
(ii) Californian:												
Body weight:												
5 weeks	50	1802.5	8.8	1674	18579.4	91.2	10.3	2664.3	12.5	18676.1	87.6	7.0
6 weeks	50	1717.4	7.9	1598	20056.6	92.1	11.7	2583.1	11.4	20174.6	88.7	7.8
8 weeks	50	2270.2	8.6	1525	24256.8	91.4	10.7	3910.7	13.8	24428.5	86.2	6.2
10 weeks	50	2698.8	7.6	1476	32763.6	92.4	12.1	3954.2	10.7	33053.2	89.3	8.4
12 weeks	50	3507.5	6.4	1428	50972.3	93.6	14.5	3682.0	6.7	51649.3	93.3	14.0
Livability:												
6 weeks	50	0.001	2.5	1677	0.039	97.5	39.0	0.001	2.5	0.039	97.5	39.0
8 weeks	50	0.002	5.0	1597	0.038	95.0	19.0	0.002	5.0	0.038	95.0	19.0
10 weeks	50	a										
12 weeks	50	0.300	0.9	1478	0.030	99.0	0.1	0.001	3.2	0.030	96.8	30.0

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

[+] Percentages of variance components relative to the total phenotypic variance.

they were low for livability traits. For NZW and CAL raised in Egypt, reviewed percentages of variation obtained using Henderson method (El-Maghawry, 1990; Abd El-Raouf, 1993; Khalil *et al.*, 1993) or REML method (Hassan, 1995) were low or moderate.

For comparison of σ^2_s in both breeds (*i.e.* NZW and CAL), estimates for most postweaning growth traits obtained for CAL were generally somewhat larger than those estimates obtained for NZW rabbits. This may be due to that NZW breed have been exposed to more intensive selection for growth than that practiced in CAL breed. These results are in agreement with results of El-Maghawry (1990), Khalil *et al.* (1993) and El-Deghadi (1996).

For Henderson's method, percentages of sire variance components in NZW rabbits ranged from 4.4 to 11.3% for body weights and from 0.1 to 3.1% for livabilities (Table 12). The corresponding estimates in CAL rabbits ranged from 6.4 to 8.8% for body weights *vs* 1.0 to 5.0% for livabilities. El-Deghadi (1996) reported that percentages of variation due to sire effect in NZW rabbits for postweaning body weights ranged from 2.2 to 7.3% *vs.* 3.9 to 7.0% for livabilities. Most of the Egyptian studies used Henderson's method reported low or moderate estimates of sire variance components for postweaning growth traits in NZW and CAL rabbits. These estimates ranged from 0.0 to 16.2% in NZW rabbits, while they ranged from 0.0 to 5.9% in CAL (El-Maghawry, 1990; Abd El-Raouf, 1993; Khalil *et al.*, 1993; El-Deghadi, 1996). Little studies had been reported on the variance components obtained by Henderson's method for livability. El-Deghadi (1996) reported that sire variance components for livability in NZW rabbits ranged from 3.9 to 7.0%, while the corresponding estimates in CAL rabbits ranged from 1.7 to 3.2%.

In REML method, percentages of variance components due to sire in NZW rabbits ranged from 5.7 to 17.9% for body weights and from 0.1 to 2.9% for livabilities (Table 12). The corresponding percentages in CAL ranged from

6.7 to 13.8% for body weights and from 0.01 to 5.0% for livabilities. However, reviewed estimates of sire variance components in NZW were moderate and ranged from 4.0 to 13.5% for livability traits (Lukefahr, 1992; El-Raffa, 1994; Hassan, 1995; El-Deghadi, 1996).

For postweaning growth traits, sire variance components estimated by Henderson's method were smaller than those obtained by REML method (Table 12). This may be due to the inclusion of the relationship coefficient matrix (A^{-1}) in estimation of variance components by REML method. Similarly, Teepker and Swalve (1988), Cameron (1988), Raheja (1992) and Xu *et al.* (1994) reported that sire variance components estimated using Henderson's method were smaller than those obtained by REML procedure, *i.e.* σ^2_e obtained by Henderson were higher than those estimated by REML. Also, Xu *et al.* (1994) reported that estimates of predicted error variance **(PEV)** obtained from REML were lower than those obtained from Henderson's method.

Considering the ratio of σ^2_e/σ^2_s in Henderson's method and REML, all ratios for body weights in NZW and CAL rabbits indicated that REML method had lower ratios than Henderson's method (Table 12). Thus, more precise estimates were obtained from REML since it considers the relationships among sires (A^{-1}). These results indicate also that Henderson's method gave underestimates of sire variance components because it ignores relationship among sires. This leads to an increase in sire variance and a decrease in error variance, *i.e.* analysis under sire mixed models **(MME)** which account for relationships among sires (REML) should therefore give more accurate genetic variance components than Henderson's method. Similar conclusion was reported by Van der Werf and de Boer (1990). Also, Shebl *et al.* (1997) with three lines of rabbits came to the same conclusion. For livability traits in both breeds, a reversible trend was observed (Table 12), *i.e.* an increase in error variance and a decrease in sire variance. No literature available to interpret this contradicted notation. This may be due to scaler effect.

4.4.2 Dam Model:

The estimates of variance components and percentages of variation attributable to the dam effect (σ^2_D) and remainder (σ^2_e) using Henderson's method and REML for postweaning growth traits and livabilities in NZW and CAL rabbits are presented in Table 13.

For comparison of σ^2_D in both breeds, estimates for body weights obtained in NZW rabbits were generally somewhat larger than those estimates obtained for CAL rabbits. A reverse trend was observed for livabilities where CAL rabbits recorded the highest estimates of σ^2_D in most cases. High variation in maternity of lactation in NZW rabbits may be responsible for such high estimates of σ^2_D for body weights in this breed, while stress of high size of litter may be the cause of low σ^2_D for livabilities. Since CAL rabbits were originated from NZW rabbits and an intensive selection program was practiced in the establishment of CAL, therefore, a reduction in σ^2_D could be attained for growth traits in this breed comparable with NZW breed.

Estimates of σ^2_D for body weight at weaning or 6 weeks of age for both methods of estimation in NZW rabbits are somewhat larger than those at subsequent ages (Table 13). The reverse was observed for CAL rabbits. This large component of σ^2_D at weaning in NZW rabbits may be due to variation in additive maternal and non-additive maternal (in terms of lactation, litter size, litter weight, young survival,.....etc.) and possibly due to additive by additive interactions (Khalil *et al.,* 1993).

For postweaning body weights and livabilities, σ^2_D estimated using Henderson's method were smaller than those obtained using REML method

Table 13. Variance components estimated by the Dam Model using Henderson's method and REML for postweaning growth traits in New Zealand White and Californian rabbits.

Trait	Henderson's method							REML method				
	Dam			Remainder			σ^2_e/σ^2_d	Dam		Remainder		σ^2_e/σ^2_d
	df	σ^2_d	%[+]	df	σ^2_e	%[+]		σ^2_d	%[+]	σ^2_e	%[+]	
(i) New Zealand White:												
Body weight:												
5 weeks	149	3252.4	16.3	1970	16647.0	83.7	5.1	5046.4	23.1	16772.2	76.9	3.3
6 weeks	149	3444.7	16.5	1899	17426.9	83.5	5.1	5181.8	22.8	17581.2	77.2	3.4
8 weeks	149	4064.1	14.1	1822	24698.7	85.9	6.1	5914.8	19.1	25097.1	80.9	4.2
10 weeks	149	6984.5	14.5	1760	41362.8	85.6	5.9	9928.6	19.1	42134.3	80.9	4.2
12 weeks	148	11570.0	14.6	1706	67523.5	85.4	5.8	15044.7	17.9	69040.3	82.1	4.6
Livability:												
6 weeks	149	0.001	3.3	1969	0.029	96.7	29.0	0.0004	1.3	0.030	98.7	75.0
8 weeks	149	0.004	11.8	1863	0.030	88.2	7.5	0.005	13.9	0.031	86.1	6.2
10 weeks	149	0.000	0.0	1828	0.029	99.9	58.0	a	0.1	0.029	99.9	
12 weeks	149	a						a				
(ii) Californian:												
Body weight:												
5 weeks	123	2539.4	12.5	1603	17757.7	87.5	6.7	2905.4	13.9	18050.9	86.1	6.2
6 weeks	122	3052.4	14.0	1525	18676.0	85.9	6.1	4774.8	20.1	19036.8	79.9	3.9
8 weeks	121	4030.3	15.1	1453	22618.5	84.9	5.6	6074.7	20.8	23182.5	79.2	3.8
10 weeks	121	5132.7	14.3	1404	30652.2	85.7	5.9	7046.5	18.3	31385.6	81.7	4.5
12 weeks	121	8201.5	14.9	1356	46909.8	85.1	5.7	10942.4	18.5	48203.1	81.5	4.4
Livability:												
6 weeks	122	0.000	1.0	1602	0.039	98.9	48.8	0.000	0.1	0.039	99.9	0.0
8 weeks	122	0.002	5.0	1525	0.038	95.0	19.0	0.001	2.6	0.038	97.4	38.0
10 weeks	121	0.001	3.3	1453	0.029	96.7	29.0	0.001	3.3	0.029	96.7	29.0
12 weeks	121	0.002	6.7	1404	0.028	93.3	14.0	0.002	6.5	0.029	93.5	14.5

[a] Negative estimate of dam component of variance set to zero.

[+]Percentages of variance component relative to the total phenotypic variance.

(Table 13). However, reviewed estimates of additive genetic variance estimated by Henderson and REML methods showed that the contribution of dam to the variance of postweaning growth traits in different breeds of rabbits are relatively high (Khalil and Khalil, 1991; Moura *et al.,* 1991a & b; Lukefahr; 1992; Abd El-Raouf, 1993; Khalil *et al.,*1993; El-Raffa,1994; Cifre *et al.,*1994; Hassan, 1995). These results are expected since they are a reflection of variation in maternal and mothering and milking abilities.

For Henderson's method, percentages of dam variance components in NZW rabbits ranged from 14.1 to 16.5 % for body weights and 0.04 to 11.8% for livability traits (Table 13). Similarly, the corresponding estimates in CAL rabbits ranged from 12.5 to 15.1% for body weights and from 1.0 to 6.7% for livabilities. By applying Henderson's method, most of the reviewed Egyptian studies indicate that σ^2_D for postweaning growth traits were of considerable magnitude since they ranged from 6.2 to 27.4% in different breeds of rabbits (Khalil *et al.,* 1987b; El-Maghawry, 1990; Khalil and Khalil, 1991; Abd El-Raouf, 1993; Khalil *et al.,* 1993). For σ^2_D of livability traits in rabbits raised in Egypt, no reviewed studies were available for comparison with the present estimates.

Dam variance components estimated by REML for postweaning body weights in NZW were moderate and ranged from 17.9 to 23.1%, while they were of small magnitude for livability traits and ranged from 1.3 to 13.9% (Table 13). Similarly, the corresponding estimates in CAL ranged from 13.9 to 20.8% for body weights and from 0.1 to 6.5% for livability. The available reviewed estimates of σ^2_D using REML for postweaning body weights were moderate or high and they ranged from 26.4 to 35.4% (Lukefahr, 1992; Cifre *et al.,* 1994; El-Raffa, 1994; Hassan, 1995).

Considering the ratio of σ^2_e/σ^2_D in Henderson's method and REML, all ratios for postweaning growth traits in NZW and CAL rabbits indicated that

REML method had lower ratios than Henderson's method. Considering the relationships among dams (A^{-1}) in REML caused an increase in dam variance and a decrease in error variance. Therefore, analysis of postweaning growth traits using dam mixed model which includes the relationships among dams will give more accurate genetic variance in dam component when using REML method than when using Henderson method.

For comparison of paternal *vs* maternal additive genetic variance (Tables 12&13), it is clear that maternal additive effects could be considered as the most source of variation in postweaning growth traits in rabbits. This confirms the evidence that additive and non-additive maternal effects are still present up to later ages (Khalil *et al.,* 1987b&1993). In this respect, estimates of σ^2_D using Henderson's method reached 14.6 and 14.9% at 12 weeks of age for NZW and CAL rabbits, respectively, while they reached 17.9 and 18.5% at the same age using REML method. Consequently, marketing of broiler rabbits, economically, could be determined at the age in which maternal effects are becoming small or insignificant.

4.5 <u>Sire heritabilities:</u>

Sire heritabilities (h^2_s) estimated by the sire model using Henderson and REML methods for postweaning body weights and livabilities in NZW and CAL rabbits are shown in Table 14. For all body weights in both breeds at different ages, estimates of h^2_S were moderate or relatively high, indicating that sire additive variance is of considerable importance and consequently postweaning growth traits of NZW and CAL rabbits could be improved by selection of sires based on performance of their progenies. These favorable estimates of h^2_S for postweaning growth traits of NZW and CAL rabbits raised in adverse environment are similar to those obtained by the other Egyptian studies (e.g. Afifi *et al.*, 1992; Khalil *et al.*, 1993; El-Deghadi, 1996). This will

Table 14. Sire heritabilities (h^2_s±SE) estimated by the Sire Model using Henderson's method and REML for postweaning growth traits in New Zealand White and Californian rabbits.

	Henderson's method	REML method
(i) New Zealand White:		
Body weight:		
5 weeks	0.215± 0.054	0.326± 0.106
6 weeks	0.177± 0.050	0.228± 0.076
8 weeks	0.187± 0.052	0.236± 0.078
10 weeks	0.452± 0.087	0.718± 0.208
12 weeks	0.250± 0.062	0.330± 0.107
Livability:		
6 weeks	0.099± 0.037	0.011±0.004
8 weeks	0.117± 0.041	0.112±0.039
10 weeks	0.054± 0.032	0.012±0.004
12 weeks	0.006± 0.026	0.002±0.002
(ii) Californian		
Body weight:		
5 weeks	0.354± 0.083	0.499±0.179
6 weeks	0.315± 0.079	0.454±0.165
8 weeks	0.342± 0.084	0.552±0.195
10 weeks	0.304± 0.079	0.427±0.157
12 weeks	0.258± 0.072	0.266±0.102
Livability:		
6 weeks	0.115±10.045	0.055±0.022
8 weeks	0.150± 0.052	0.177±0.069
10 weeks	a	a
12 weeks	0.043± 0.036	0.069±0.028

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

be an encouraging factor to improve growth performance of these standard breeds raised in hot climate through selection of sires. On the other hand, most of the studies carried out on these two breeds in moderate environment showed that h^2_S for postweaning growth traits were low or somewhat moderate (e.g. Panella *et al.*,1992; Ferraz *et al.*,1991&1992). The confliction in most estimates of sire heritabilities obtained in this study and the corresponding estimates reported in the literature may be attributed to: (1) differences in breeds of rabbits reared under particular environmental conditions, (2) estimation methods used, (3) data structure and number of records used, (4) models of analysis applied, and (5) availability of relationship coefficient matrix (A^{-1}) among sires.

4.5.1 Genetic constitution of breeds:

In both methods of estimation (*i.e.* Henderson and REML), sire heritabilities in CAL rabbits are generally higher than those in NZW (Table 14). For both methods of estimation, estimates of h^2_S for body weights ranged from 0.117 to 0.718 in NZW rabbits, while they ranged from 0.258 to 0.552 in CAL rabbits (Table 14). A reversible trend was observed for livability traits where CAL rabbits recorded somewhat higher estimates of h^2_S than those recorded in NZW. The estimates ranged from 0.002 to 0.117 in NZW *vs.* 0.043 to 0.177 in CAL. However, El-Amin (1974) found that sire heritabilities for body weight at 8 weeks of age in NZW (0.72) was greater than in CAL (0.57). Also, El-Deghadi (1996) stated that estimates of h^2_S for all growth traits in NZW rabbits are higher than the corresponding estimates in CAL.

4.5.2 Henderson's method *vs* REML method:

Results given in Table 14 revealed that heritabilities estimated by the sire model using Henderson's method were somewhat lower than those obtained using REML method. For the same two breeds, this notation is in agreement with those reported by Ferraz *et al.* (1991) and El-Deghadi (1996). Relatively higher estimates of h^2_S obtained by REML may be due to that the coefficients matrix of relationship among sires was taken into account. Lawlor (1984) reported that heritabilities estimated by the sire model using REML procedure relatively increased when relationships among sires were utilized. Using REML under Animal Model, Dong (1987) suggested that heritability estimates would be larger if more relationships were considered. Dong *et al.* (1988) found that estimates of heritability when using REML with an Animal Model were considerably smaller if relationships among sires were considered only as compared with model including complete relationship. For most traits in both breeds, the small differences between heritabilities yielded from Henderson and REML procedures have been also observed in many other studies (e.g. Colleau *et al.*,1989; Schutz *et al.*,1990; Ferraz *et al.*,1991; Ahlborn and Demfle, 1992). Cameron (1988) reported that the heritabilities estimated by Henderson's method were smaller than those estimated by REML obtained from sire model and REML obtained from animal model. Gama *et al.* (1991) reported that heritabilities estimated from Henderson method were higher than those estimated by REML procedure. The same authors explained these discrepancies to the differences in the two data sets used in both methods. Swalve *et al.* (1992) found that the estimates of heritability tend to be higher in Hederson's method relative to REML. On the other hand, See *et al.* (1993) from field data set found that the heritabilities estimated by REML procedure were slightly larger than those found in studies of field data in which daughter-dam regression (Strang and King, 1970) or ANOVA (Strang and Smith, 1979) procedures were used.

Using Henderson's method, h^2_S ranged from 0.177 to 0.452 for body weights and from 0.006 to 0.117 for livability traits in NZW rabbits, while the corresponding estimates in CAL rabbits ranged from 0.258 to 0.354 and from 0.049 to 0.150 (Table 14). Most of the reviewed h^2_S estimated by the sire model using Henderson's method for postweaning growth traits in NZW and CAL rabbits raised in Egypt were low or somewhat moderate (El-Maghawry, 1990; Khalil *et al.*, 1993; El-Deghadi, 1996). These reviewed estimates ranged from 0.04 to 0.25 in NZW for body weights whereas the corresponding estimates in CAL rabbits ranged from 0.08 to 0.24 (El-Maghawry, 1990; El-Deghadi, 1996). For other breeds like Bouscat and Giza White rabbits, Mostageer *et al.* (1970) and Khalil *et al.* (1987b) reported moderate or high estimates of h^2_S using Henderson's method. In most studies of the European and American countries, h^2_S estimated by the sire model using Henderson's method for postweaning body weights in NZW and CAL rabbits were low or relatively moderate (e.g. Chevalet, 1976; Merkushin, 1979; Randi and Scossiroli, 1980; Carragel *et al.*, 1980; Moura *et al.*, 1991b; Ferraz *et al.*, 1991). These results showed that sire heritabilities obtained by Henderson's method for body weights in non-Egyptian studies are similar to those obtained in the Egyptian studies.

As in Henderson's method, heritabilities estimated by the sire model using REML method for most body weights in NZW and CAL rabbits were somewhat moderate or relatively high, while low estimates were obtained for livability traits (Table 14). In NZW rabbits, the estimates of h^2_S ranged from 0.228 to 0.718 for body weights and from 0.002 to 0.112 for livability traits, whereas the corresponding estimates in CAL ranged from 0.266 to 0.499 and from 0.069 to 0.177. The reviewed estimates for sire heritabilities using REML method in NZW and CAL rabbits are contradicted since they ranged from 0.03 to 0.86 for body weights and from 0.02 to 0.14 for livability (Ferraz *et al.*, 1991&1992; El-Raffa, 1994; Hassan, 1995; El-Deghadi, 1996).

4.5.3 Data structure and available number of progeny used:

Estimates of heritability in NZW and CAL rabbits of the present study can greatly influenced by the structure of data. For the same two breeds (*i.e.* NZW and CAL), the extremely small differences in sire heritabilities estimated by Henderson's method and REML were also observed in other studies (e.g. Ferraz *et al.*,1991 in USA; El-Deghadi, 1996 in Egypt). The explanation may be due to that a comparatively balanced design and an efficient data structure was used. These systematic matings generated a homogenous number of progeny per sire and a sufficient number of sires which lead to provide connections between cells. With balanced data, Corbeil and Searle (1976), Anderson *et al.* (1984) and Reverter *et al.* (1994) noted that REML procedure produces estimators similar estimates to those obtained by the ANOVA methods. Benyshek (1981) and McCarter *et al.* (1987) found that the estimates of heritability from designed experiments were higher than those estimates from field data.

Negative and low estimates of h^2_S obtained here for livability traits using Henderson's or REML methods may be due to that maternal variation and non-additive effects were large and that could mask any additive genetic variance. Small estimates of most sire heritabilities obtained for livability traits could be attributed to: (1) the small sample size of progeny per generation (Ferraz *et al.*, 1992; Khalil *et al.*, 1993; El-Deghadi, 1996), (2) the small number of progeny per sire (El-Maghawry, 1990; Ferraz *et al.*, 1991&1992; Khalil *et al.*, 1993), (3) the non-randomness in the distribution of progeny within sire groups (Khalil *et al.*, 1993; El-Deghadi, 1996), and (4) the sampling error (Khalil *et al.*, 1986).

4.6 Dam heritabilities:

Heritabilities estimated by the dam model (h^2_d) using Henderson and REML methods for body weights and livabilities in NZW and CAL rabbits are shown in Table 15. These estimates seem to be higher than those obtained by El-Maghawry (1990), Ferraz *et al.* (1992) and Khalil *et al.* (1993), while they were lower than those obtained by Khalil *et al.* (1987a) in Giza White rabbits.

4.6.1 Genetic constitution of breeds:

Estimates of h^2_D given in Table 15 indicate that h^2_D for body weights in NZW rabbits are higher than those estimates in CAL rabbits. For both methods of estimation (*i.e.* Henderson and REML), h^2_D for body weights ranged from 0.565 to 0.925 for NZW rabbits, while they ranged from 0.500 to 0.830 for CAL (Table 15). A reversible trend was generally observed for livability traits whereas h^2_s recorded by CAL rabbits were somewhat higher than those recorded by NZW. These results are in agreement with Khalil *et al.* (1993) for NZW and CAL rabbits. In fact, CAL breed is originated from NZW breed (as dam breed) and consequently a reduction in maternal variation was obtained. Also, high lactation ability during suckling period in addition to a large litter size in NZW breed relative to CAL may be the causes of such high non-additive maternal variation in NZW breed (Ozimba and Lukefahr, 1991) and consequently estimates of h^2_D were higher. In such situation, there is obviously a large effect of maternal genotype and/or maternal environment on the rabbit's growth during postweaning period (Khalil *et al.*, 1987b; Khalil *et al.*, 1993). Such evidence of maternal effect may probably be due to correlation of rabbit's growth with litter condition (Randi and Scossiroli, 1980). Here, litter is an example of specific maternal environment that persisted almost through the rabbit's production life (Khalil *et al.*, 1993). Accordingly, variation within litter sizes of the dam could biasing non-additive genetic variance up-ward. Similar to the present study, most estimates of h^2_D obtained by the Egyptian studies (Mostageer *et al.*, 1970; Khalil *et al.*, 1987b; El-Maghawry, 1990; Khalil and Khalil 1991) and by the non-Egyptian ones (e.g. Randi and Scossiroli, 1980;

Table 15. Dam heritabilities (h^2_d±SE) estimated by the Dam Model using Henderson's method and REML for postweaning growth traits in New Zealand White and Californian rabbits.

	Henderson's method	REML method
(i) New Zealand White:		
Body weight:		
5 weeks	0.654±0.089	0.925±0.171
6 weeks	0.660±0.090	0.910±0.170
8 weeks	0.565±0.085	0.762±0.149
10 weeks	0.578±0.087	0.763±0.149
12 weeks	0.585±0.088	0.716±0.143
Livability:		
6 weeks	0.176±0.052	0.053±0.013
8 weeks	0.428±0.074	0.569±0.118
10 weeks	0.002±0.038	0.004±0.030
12 weeks	a	
(ii) California		
Body weight:		
5 weeks	0.500±0.086	0.554±0.127
6 weeks	0.562±0.093	0.802±0.171
8 weeks	0.605±0.097	0.830±0.177
10 weeks	0.574±0.096	0.733±0.161
12 weeks	0.595±0.099	0.740±0.162
Livability:		
6 weeks	0.043±0.044	0.004±0.009
8 weeks	0.189±0.060	0.122±0.032
10 weeks	0.140±0.057	0.089±0.023
12 weeks	0.288±0.073	0.230±0.058

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

Blasco *et al.*, 1982) appear to be higher than the corresponding estimates of h^2_S reported in the same literature, *i.e.* contribution of maternal effects and dominance variance was large. However, h^2_D includes all variances of the maternal additive genetic, the covariance between direct and maternal additive effects, and both variances of the maternal dominance and maternal environmental effects. All these components are not included in h^2_S. Several authors have reported difficulties with estimation of h^2_D, stemming from bias due to maternal effects and possibly to dominance effects, sometimes coupled with large sampling errors and non-randomness in the distribution of dams within sire groups (Mostageer *et al.*, 1970; Randi and Scossiroli, 1980; Khalil *et al.*, 1987b). Bias and/or sampling errors were responsible for such biasness in h^2_D (Khalil *et al.*, 1986). Bias may be mainly due to maternal and dominance effects while sampling errors were due to the small number of dams used in the analysis. The presence of partial confounding due to distribution of data over two effects (*i.e.* certain dams were used in one season of kindling) will lead to such bias.

4.6.2 Henderson's method *vs* REML procedure:

Results given in Table 15 revealed that h^2_d estimated by the dam model using Henderson's method were somewhat lower than those estimates obtained by REML method. This may be due to that REML accounts for the relationships coefficient matrix among dams. Cameron (1988) reported that the heritabilities estimated from Henderson's method were smaller than those estimated by REML obtained from dam model and REML obtained from animal model. Gama *et al.* (1991) reported that heritabilities estimated by Henderson method were higher than those estimated by REML procedure. The same authors explained these discrepancies to the differences in the two data sets used in both methods. Swalve *et al.* (1992) found that the estimates of heritability tend to be higher in Hederson's method relative to REML. On the other hand, See *et al.* (1993) from field data set found that heritabilities estimated by REML procedure were slightly larger than those found in studies of field data in which daughter-dam regression (Strang and King, 1970) or ANOVA (Strang and Smith, 1979) procedures were used.

Using Henderson's method, h^2_D for body weights ranged from 0.565 to 0.660 in NZW rabbits and from 0.50 to 0.605 in CAL. For livability, the estimates ranged from 0.002 to 0.428 in NZW and from 0.043 to 0.288 in CAL rabbits. Heritabilities obtained by Henderson's method here are higher than the corresponding estimates reported by El-Maghawry (1990), Ferraz *et al.* (1992) and Khalil *et al.* (1993) for NZW and CAL rabbits.

Using REML, dam heritabilities for postweaning growth traits in NZW rabbits ranged from 0.716 to 0.925 for body weights and from 0.004 to 0.569 for livabilities (Table 15). The corresponding estimates in CAL rabbits ranged from 0.554 to 0.830 for body weights and from 0.004 to 0.230 for livability traits.

4.6.3 Sire *vs* dam heritabilities:

Majority of the heritabilities obtained indicate that dam heritabilities for postweaning body weights and livabilities were greater than sire heritabilities (Tables 14&15). The variance component due to dam includes all of the additive maternal genetic variance, the covariance between direct and maternal additive effects, and both the maternal dominance and maternal environmental variances. Many studies have reported that estimation of heritability may have some difficulties from biasness due to maternal and possibly to dam effects, sometimes coupled with large sampling errors (Darwish *et al.*, 1970; Mostageer *et al.*, 1970; Randi and Scossiroli, 1980; Khalil *et al.*, 1987b; Ferraz *et al.*, 1991; Khalil *et al.*, 1993; El-Maghawry, 1993; El-Deghadi, 1996). Gutierrez *et al.,* (1994) concluded that the sire model (cheaper procedure) to be used as an estimating procedure for genetic parameters may be preferred in data characterized by small number of individuals, little pedigree information and highly disequlibrated distribution of effects.

4.7 Sire Transmitting Abilities (STA):

For the Animal Model, the number of iterations and equations attained in evaluation of body weights and livabilities in NZW and CAL sires are presented in Table 16. When using the Animal Model for NZW sires, the average number of equations and iterations recorded for body weights were 566 equations and 226 iterations, while livability traits recorded 558 equations and 319 iterations. The corresponding figures recorded by CAL sires were 405 and 566 for body weights, while they were 402 and 237 for livability. For most cases, these results indicate that CAL sires recorded lower number of iterations and equations compared with NZW sires. Therefore, data of CAL sires required less iterations to reach adequate convergence criteria. Biair and Pollak (1984), Wiggans and Misztal (1987), and Ducrocq *et al.* (1990) reported that number of rounds of iterations required to reach adequate convergence criteria may not be before 100 or more iterations.

For sires with available records, sire transmitting abilities (STA) for postweaning body weights and livabilities were predicted using a Sire Model (SM) and an Animal Model (AM). In both methods, the relationship coefficients matrix (A^{-1}) among sires were considered in estimation. For all sires and the top 10% of sires, the minimum and maximum estimates of STA in addition to their ranges are presented in Table 17. In the animal model, a simultaneous evaluation of dams and sires in which the genetic merit of all relatives plus the animal's own performance will be obtained, *i.e.* animal's genetic merit will be attained (Westell and Van Vleck, 1987; Meyer, 1989;

Table 16. Number of iterations and equations obtained in evaluation of body weights and livabilities using an Animal Model.

Reference	New Zealand White		Californian	
	No. of iterations	No. of equations	No. of iterations	No. of equations
Body weight:				
5 weeks	441	572	125	410
6 weeks	184	567	453	403
8 weeks	229	565	1043	405
10 weeks	196	564	1002	404
12 weeks	79	564	207	401
Livability:				
6 weeks	208	565	146	404
8 weeks	406	561	138	404
10 weeks	289	557	a	a
12 weeks	262	557	428	399

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

Boldman and Freeman, 1990). Often, individuals with records or without records can be evaluated quite accurately through performance of their relative's information in case of BLUP estimated by the animal model (Freeman, 1988).

4.7.1 Transmitting abilities for sires (animals with records):

For sires with records in both models of evaluation (*i.e.* Sire Model and Animal Model), CAL sires generally recorded higher ranges in estimates of STA for body weights and livabilities than those ranges recorded for NZW sires (Table 17). Using the Sire Model, the ranges in NZW *vs* CAL sires were 8.8 *vs* 59.3 grams, 11.1 *vs* 87.2 grams, 31.4 *vs* 127.9 grams, 309.3 *vs* 114.3 grams and 53.4 *vs* 79.5 grams for body weights at 5, 6, 8, 10 and 12 weeks of age, respectively. Similarly, the corresponding ranges using the Animal Model were 80.5 *vs* 216.1 grams, 55.7 *vs* 181.4 grams, 67.2 *vs* 213.5 grams, 209.9 *vs* 207.6 grams and 330 *vs* 232.7 grams in the same order. For livabilities in both models (sire model and animal model), the same trend was observed where estimates of STA for livabilities averaged 3.3% in NZW *vs* 7.5% in CAL sires. Using an Animal Model, STA estimated by Hassan (1995) ranged from -78 to 90 grams for weaning weight (4 weeks) and from -8.9 to 10.7% for livability in NZW rabbits raised in Egypt. Using the sire and animal models, El-Deghadi (1996) recorded higher ranges in estimates of STA for postweaning body weights and livabilities in NZW sires relative to CAL sires. For the sire model, she added that the ranges in NZW *vs* CAL sires were 138.9 *vs* 98.9 grams, 137.7 *vs* 90.3 grams, 78.8 *vs* 72.0 grams and 136.2 *vs* 307.9 grams for body weights at 5, 8, 10 and 12 weeks of age, respectively. When she used an Animal Model, the ranges in STA in NZW sires were also larger than in CAL sires. For livability in her study, NZW sires recorded also higher ranges in STA compared with CAL sires, where the estimates averaged 23.3% for NZW *vs* 5.9% for CAL when

Table 17.Minimum and maximum estimates of transmitting abilities (STA) for sires with records estimated by Sire Model (SM) and Animal Model (AM) for postweaning growth traits in New Zealand White and Californian rabbits.

Trait	Sire Model				Animal Model (with records)			
	All sires			Top 10% ofsires	All sires			Top 10% of sires
	Minimum	Maximum	Range	Range	Minimum	Maximum	Range	Range
(i) New Zealand White:								
Body weight (grams):								
5 weeks	-66.1	44.8	110.9	8.8	-39.3	41.2	80.5	25.5
6 weeks	-42.3	35.7	77.9	11.1	-27.0	28.7	55.7	14.7
8 weeks	-71.5	55.8	127.3	31.4	-31.9	35.2	67.2	15.5
10 weeks	-193.3	366.7	560.0	309.3	-70.4	139.5	209.9	91.2
12 weeks	-176.4	114.7	291.1	53.4	-123.5	206.5	330.0	150.4
Livability(%):								
6 weeks	-0.8	0.7	1.6	0.4	-0.5	0.5	1.0	0.3
8 weeks	-8.8	2.9	11.7	1.7	-5.8	2.2	7.9	1.3
10 weeks	-1.0	0.7	1.7	0.3	-0.9	0.8	1.8	0.2
12 weeks	-0.2	0.1	0.3	0.1	-0.2	0.2	0.4	0.1
(ii) Californian:								
Body weight (grams):								
5 weeks	-102.1	103.4	205.5	59.3	-110.5	105.6	216.1	70.3
6 weeks	-88.5	120.5	209.0	87.2	-84.1	97.3	181.4	64.1
8 weeks	-101.1	166.4	267.5	127.9	-105.6	107.8	213.5	80.3
10 weeks	-85.6	153.4	239.1	114.3	-106.0	101.5	207.6	70.9
12 weeks	-89.7	109.5	199.2	79.5	-126.7	106.1	232.7	61.6
Livability(%):								
6 weeks	-3.2	2.3	5.5	1.4	-2.4	1.4	3.8	0.6
8 weeks	-10.1	3.7	13.8	1.6	-9.2	3.3	12.6	1.3
10 weeks	a				a			
12 weeks	-3.2	1.9	5.1	1.2	-2.7	1.5	4.1	0.8

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

Number of sires used for evaluation were 68 and 51 for NZW and CAL, respectively.

using the Sire Model and they averaged 24.1% for NZW *vs* 6.1% for CAL when using the Animal Model. Using a Sire Model, Shebl *et al.* (1997) with data of three lines of rabbits raised in Germany (N line originated from New Zealand White, Z line originated from mating various local German strains, and G line was developed from Giant breed), ranges in STA of postweaning body weights at 8, 12 and 16 weeks of age in G line were the largest, followed by N line and Z line. In this study, the ranges in STA in N, Z and G lines, respectively were 267, 253 and 473 grams for 8-week weight, 341, 280 and 488 grams for 12-week weight, and 304, 99 and 542 grams for 16-week weight.

The ranges in STA for most body weights and livabilities were slightly higher when using the Sire Model than those ranges when using the Animal Model (Table 17), *i.e.* both methods (sire model or animal model) have the same trend in the evaluation of sires for postweaning body weights and livabilities of NZW and CAL rabbits raised in Egypt. Relatively lower estimates of STA obtained by the Animal Model for most traits compared to the Sire Model may be due to the inclusion of common litter effect in the Animal Model and consequently a correction for this effect was considered in the Animal Model while it was not considered in the Sire Model. This trend was also reported by El-Deghadi (1996) who stated that ranges in STA for body weights at 5, 6, 8, 10 and 12 weeks of age in NZW were 138.9, 251.8, 137.7, 78.8 and 136.2 grams when using a Sire Model *vs* 143.3, 165.3, 106.2, 72.8 and 118.2 grams when using an Animal Model. For livability in her study, NZW sires recorded also higher ranges in STA compared with CAL sires. The estimates averaged 23.3% for NZW *vs* 5.9% for CAL when using the Sire Model and they averaged 24.1% for NZW *vs* 6.1% for CAL when using the Animal Model. Among all sires in three lines of rabbits, Shebl *et al.* (1997) concluded that the largest ranges in STA for postweaning growth traits (body weights and gains at

8, 12 and 16 weeks) were obtained by BLUP with A^{-1}, while the lowest ranges were observed by BLUP without A^{-1}.

In general, evaluations using an animal model are more accurate relative to other methods because: (1) It considered the genetic merit of all relatives (Wiggans *et al.,* 1988; Lukefahr, 1992), (2) It has minimum predicted error variance (PEV) with unbiased estimates (Van der Werf *et al.,*1994), (3) It considered the effects of common and/or permanent environments (Ferraz *et al.,* 1991&1992; Baselga *et al.,* 1992), (4) It used the information from all known relationships among animals to predict the genetic merit of each animal (Sorensen and Kennedy, 1986; Wiggans and Misztal, 1987; Van Raden and Wiggans, 1991), (5) Solutions of equations are made by iteration which is much more economically in computation than using inversion of matrix (John *et al.,* 1984), (6) Estimations for the breeding values could be obtained not only for sires and dams and base animals, but also for young animals with progeny records on the basis of their genetic relationships (Wilson and Wilhan, 1988) and (7) In Animal Models, coefficients for each animal can be calculated from the available pedigree information using the method described by Quaas (1976).

When considering the top ten percent of sires in both methods of sire evaluation, the ranges in STA are seem to be of the trend similar to the case in which all sires were considered (Table 17). El-Deghadi (1996) reported that the ranges between minimum and maximum estimates of STA for the top 10% of sires were also smaller than that when considering all the sires list. Using a Sire Model and considering the top 10% of sires (top 30 to 40 sires out of 359 sires) in three lines of rabbits (G, N and Z), Shebl *et al.* (1997) noticed that the differences between maximum and minimum estimates in STA of postweaning growth traits were smaller than that when considering all the sires list. The ranges in STA of this study for the top 10% of sires in N, Z and G lines, respectively were 117, 83 and 174 grams for 8-week weight, 143, 113 and 209 grams for 12-week weight and 106, 43 and 182 grams for 16-week weight.

For body weights and livabilities and using the two methods of sire evaluation, the range in STA of the top 10% of CAL sires were generally somewhat higher than those ranges of the top 10% of the NZW sires (Table 17). Thus, using 10% of the CAL sires will be effective in improvement of postweaning body weights and livabilities through sire selection.

Among all sires used, numbers and percentages of sire transmitting abilities with positive estimates when using a Sire Model and an Animal Model for postweaning body weights and livabilities in NZW and CAL rabbits are given in Table 18. In both breeds, estimates of STA ranged from 47.1 to 52.9% for body weights and from 48.5 to 60.8% for livability when using the Sire Model. The estimates with positive signs for body weights and livabilities When using the Animal Model ranged from 42.6 to 60.8% and 39.7 to 56.9%, respectively. Across the two methods of sire evaluation, the largest average of percentages of STA with positive signs were recorded by the Animal Model for all traits studied. Similar to this trend, El-Deghadi (1996) with NZW and CAL rabbits reported that the largest average of percentage of positive estimates of STA for postweaning growth traits and livabilities were recorded by the Animal Model relative to the Sire Model. In both breeds of her study, positive estimates of STA ranged from 38.5 to 55.9% for body weights and from 35.9 to 55.9% for livability when using the Sire Model *vs* 50.6 to 61.0% and from 51.3 to 66.1% when using the Animal Model.

The percentage of sires which are common (SC%) between the Sire Model and the Animal Model and the percentage of sires remaining in the same position (SR%) are shown in Table 19. These results show that the percentages of the common sires among the two models of evaluation were 100% for all traits. The percentages of sires remaining in the same position (*i.e.* sires don't

Table 18. Numbers and percentages of sire transmitting abilities with positive signs estimated using a Sire Model (SM) and an Animal Model (AM) for postweaning growth traits in New Zealand White and Californian rabbits.

Trait	New Zealand White				Californian			
	Sire Model		Animal Model		Sire Model		Animal Model	
	No. of sires	%	No. of sires	%	No. of sires	%	No. of sires	%
Body weight:								
5 weeks	33	48.5	39	57.4	25	49.0	31	60.8
6 weeks	32	47.1	36	52.9	27	52.9	31	60.8
8 weeks	32	47.1	33	48.5	25	49.0	32	62.7
10 weeks	31	45.6	33	48.5	24	47.1	29	56.9
12 weeks	36	52.9	29	42.6	24	47.1	28	54.9
Livability:								
6 weeks	37	54.4	31	45.6	29	56.9	26	51.0
8 weeks	37	54.4	32	47.1	31	60.8	29	56.9
10 weeks	42	61.8	30	44.1	a			
12 weeks	33	48.5	27	39.7	26	51.0	25	49.0

a Estimates of STA were not obtained due to that negative estimate of sire component of variance was obtained.

Table 19. Percentages of sires common (SC%) and sires remaining in the same position (SR%) in the two methods of sire evaluation for postweaning growth traits in New Zealand White and Californian rabbits.

Trait	Body weight					Livability			
	5 weeks	6 weeks	8 weeks	10 weeks	12 weeks	6 weeks	8 weeks	10 weeks	12 weeks
(i) New Zealand White:									
SC%	100	100	100	100	100	100	100	100	100
SR%	0	1	4	3	3	1	4	6	4
(ii) Californian									
SC%	100	100	100	100	100	100	100	a	100
SR%	4	4	0	2	2	2	6	a	0

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

change their rank) ranged from 0 to 6% for postweaning body weights and livabilities in both NZW and CAL rabbits. This lead to state that the overall ranking of sires changed much between both methods of sire evaluation. For the two methods of sire evaluation, a similar trend was reported by Shebl *et al.* (1997) for postweaning body weights and livabilities in three lines of rabbits where they found that percentages of sires remaining in the same position ranged from 7 to 23 % for N line, from 0 to 13 % for Z line and from 3 to 28% for G line.

4.7.2 <u>Transmitting Abilities for dams of sires (animals without records):</u>

The dams of sires transmitting abilities (animals without records) for postweaning body weights and livabilities in NZW and CAL rabbits were obtained using the procedure of Animal Model only. The minimum and maximum estimates of transmitting abilities and their ranges for dams of sires in NZW and CAL rabbits are given in Table 20. In NZW rabbits, the ranges of the dams of sires transmitting abilities for body weights were 45.5, 35.9, 48.3, 134.1 and 219.4 grams at 5, 6, 8, 10 and 12 weeks of age, respectively. The corresponding ranges for body weights in CAL rabbits were 98.8, 100.7, 98.5, 74.3 and 89.4 grams at 5, 6, 8, 10 and 12 weeks of age. The ranges for livability traits were 0.7, 5.5 and 0.2% in NZW *vs* 2.3, 6.0 and 3.4% in CAL.

4.8 <u>Dam Transmitting Abilities (DTA):</u>

For the Animal Model, the number of iterations and equations attained in evaluation of postweaning body weights and livabilities in NZW and CAL dams are presented in Table 21. When using the Animal Model for NZW dams, the average number of equations and iterations recorded for body weights were 532 equations and 1022 iterations, while livability traits recorded 600 equations and 146 iterations. The corresponding figures recorded by CAL dams were 475

Table 20. Minimum and maximum estimates of transmitting abilities for dams of sires (animals without records) obtained by the animal model (AM) for postweaning body weights and livabilities in New Zealand White and Californian rabbits.

Trait	New Zealand White			Californian		
	Minimum	Maximum	Range	Minimum	Maximum	Range
Body weight (grams):						
5 weeks	-19.9	25.7	45.5	-26.1	72.7	98.8
6 weeks	-14.1	21.9	35.9	-30.4	70.3	100.7
8 weeks	-22.8	25.5	48.3	-31.7	66.8	98.6
10 weeks	-71.2	62.9	134.1	-17.0	57.2	74.3
12 weeks	-75.4	143.9	219.4	-26.7	62.7	89.4
Livability (%):						
6 weeks	-0.3	0.4	0.7	-1.5	0.8	2.3
8 weeks	-2.7	2.8	5.5	-4.2	1.8	6.0
10 weeks	-0.5	0.6	1.1	a	a	a
12 weeks	-0.1	0.1	0.2	-1.6	1.8	3.4

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

Table 21. Number of iterations and equations obtained in evaluation of postweaning body weights and livabilities using the Animal Model in New Zealand white and Californian rabbits.

	New Zealand White		Californian	
ference	No. of iterations	No. of equations	No. of iterations	No. of equations
Body weight:				
5 weeks	1374	519	120	478
6 weeks	505	517	117	476
8 weeks	1593	515	169	474
10 weeks	1519	514	101	479
12 weeks	119	596	202	471
Livability:				
6 weeks	192	604	1358	477
8 weeks	122	596	112	474
10 weeks	125	600	117	472
12 weeks	a	a	157	471

[a] Negative estimate of dam component of variance set to zero.

and 163 for body weights, while they were 473 and 436 for livability traits. In most cases, CAL dams recorded lower number of iterations and equations compared with NZW dams. Thus, data of dams of CAL progeny required less iterations to reach adequate convergence criteria. Biair and Pollak (1984), Wiggans and Misztal (1987), Ducrocq *et al.* (1990) and Wiggans and Van Vleck (1990) reported that number of rounds of iterations required to reach adequate convergence criteria may not be before 100 or more iterations.

For dams with available records, dam transmitting abilities (DTA) for postweaning body weights and livabilities were predicted using a Dam Model (DM) and an Animal Model (AM). In both models, the relationships among dams (A^{-1} matrix) were considered in estimation. For all dams and the top 30% of dams, the minimum and maximum estimates of DTA in addition to their ranges are presented in Table 22.

4.8.1 Transmitting abilities for dams (animals with records):

For dams with records in Dam Model of the genetic evaluation, NZW dams generally recorded higher ranges in estimates of DTA for body weights and livabilities than those ranges recorded for CAL dams (Table 22). In animal model, estimates of DTA were of reversible trend in favour of CAL breed. Using the Dam Model, the ranges in NZW *vs* CAL dams were 307.9 *vs* 197.2 grams, 333.4 *vs* 276.6 grams, 324.3 *vs* 248.7 grams, 478.7 *vs* 284.6 grams and 446.2 *vs* 320.3 grams for body weights at 5, 6, 8, 10 and 12 weeks of age, respectively. On the contrary, the corresponding ranges in NZW *vs* CAL using the Animal Model were 137.8 *vs* 197.2 grams, 131.5 *vs* 154.7 grams, 143.6 *vs* 167.7 grams, 214.5 *vs* 172.4 grams and 241.1 *vs* 186.2 grams in the same order. For livabilities in both models (dam model and animal model), the same trend was observed where estimates of DTA for livabilities in NZW averaged 12.3% *vs* 8.5% in CAL. With an Animal Model, DTA estimated by Hassan (1995)

Table 22. Minimum and maximum estimates of transmitting abilities (DTA) for dams with records estimated by the Dam Model (DM) and the Animal Model (AM) for postweaning body weights and livabilities in New Zealand White and Californian rabbits.

Trait	Dam Model				Animal Model (with records)			
	All dams			Top 30% of dams	All dams			Top 30% of dams
	Minimum	Maximum	Range	Range	Minimum	Maximum	Range	Range
(i) New Zealand White:								
Body weight (grams):								
5 weeks	-152.3	155.6	307.9	142.4	-61.7	76.1	137.8	63.6
6 weeks	-155.4	178.0	333.4	167.8	-52.5	78.9	131.5	66.8
8 weeks	-145.2	179.1	324.3	158.4	-60.2	83.5	143.6	67.2
10 weeks	-221.3	257.4	478.7	231.7	-112.1	102.4	214.5	81.2
12 weeks	-245.8	200.4	446.2	166.4	-116.4	124.7	241.1	104.1
Livability (%):								
6 weeks	-3.1	1.6	4.7	1.2	-3.3	1.7	5.0	1.2
8 weeks	-35.9	7.3	40.2	4.4	-13.9	8.9	22.7	6.5
10 weeks	-0.2	0.2	0.4	0.1	-0.3	0.3	0.6	0.2
12 weeks	a							
(ii) Californian:								
Body weight (grams):								
5 weeks	-92.4	104.8	197.2	65.5	-92.4	104.8	197.2	85.5
6 weeks	-113.9	162.8	276.6	144.4	-79.8	74.9	154.7	64.9
8 weeks	-134.0	144.7	278.7	123.3	-90.2	77.5	167.7	64.7
10 weeks	-154.1	130.5	284.6	104.3	-92.6	79.8	172.4	65.6
12 weeks	-184.3	136.0	320.3	94.9	-92.1	94.0	186.2	74.6
Livability (%):								
6 weeks	-0.2	0.2	0.4	0.1	-9.4	11.5	20.9	11.4
8 weeks	-8.2	3.4	11.6	2.2	-6.9	6.5	13.4	5.5
10 weeks	-6.1	1.9	8.0	1.1	-6.9	5.7	12.6	5.0
12 weeks	-13.2	3.0	16.1	2.0	-10.2	5.0	15.2	4.2

a Negative estimates of dam component of variance set to zero.

b Number of dams used for evaluation were 150 and 124 for NZW and CAL rabbits, respectively.

ranged from -95.5 to 4 grams for weaning body weight (4 weeks) and from 13.6% to 14.4% for livability in NZW rabbits raised in Egypt.

The ranges in DTA for all body weights when using the Dam Model were higher than those ranges when using the Animal Model (Table 22), *i.e.* the Animal Model have somewhat different trend relative to the Dam Model in the evaluation of dams for postweaning growth traits of NZW and CAL rabbits raised in Egypt. Relatively lower estimates of DTA obtained by the Animal Model for all body weights compared to the Dam Model may be due to the inclusion of common litter effect in the animal model and consequently a correction for this effect was considered in the animal model while it was not considered in the dam model.

For both methods of dam evaluation, the ranges in DTA when considering the top 30% of dams are seem to be of the same trend for the case of all dams considered (Table 22). Using the two models of dam evaluation for postweaning body weights and livabilities, the range in DTA of the top 30% of the NZW dams were generally somewhat higher than those ranges of the top 30% of the CAL dams. Consequently, using 30% of the NZW dams will be effective in dam selection for improvement of postweaning growth traits in this breed.

Among all dams used, numbers and percentages of transmitting abilities with positive estimates when using a Dam Model and an Animal Model for postweaning body weights and livabilities in NZW and CAL rabbits are shown in Table 23. In both breeds, estimates of DTA ranged from 41.3 to 52.5% for body weights and from 56.7 to 74.4% for livability when using the Dam Model. When using the Animal Model, the corresponding percentages of positive DTA ranged from 42.3 to 52.7% for body weights and from 50.0 to 74.% for livabilities. For NZW dams, Hassan (1995) reported that 46.5% of the dams had positive DTA for weaning weight in NZW rabbits when using the Animal

Table 23. Percentages of dam transmitting abilities with positive signs (DTA) estimated using a Dam Model (DM) and an Animal Model (AM) for postweaning body weights and livabilities in New Zealand White and Californian rabbits.

Trait	New Zealand White				Californian			
	Dam Model		Animal Model		Dam Model		Animal Model	
	No. of dams	%	No. of dams	%	No. of dams	%	No. of dams	%
Body weight:								
5 weeks	63	42.0	67	44.7	61	49.2	61	49.2
6 weeks	62	41.3	65	43.3	58	47.2	52	42.3
8 weeks	63	42.0	79	52.7	57	46.7	60	49.2
10 weeks	64	42.7	78	52.0	61	50.0	66	54.1
12 weeks	67	45.0	69	46.3	64	52.5	63	51.6
Livability:								
6 weeks	85	56.7	75	50.0	74	60.2	72	58.5
8 weeks	112	74.7	111	74.0	86	69.9	86	69.9
10 weeks	98	65.3	98	65.3	76	62.3	74	60.7
12 weeks	a				73	59.3	74	60.2

+Negative estimate of dam component of variance set to zero and consequently no estimation of DTA were obtained.

Model. He added that 46.51% of the dams had positive transmitting abilities for livability at weaning. Relatively high numbers and percentages of DTA with positive estimates obtained by the Animal Model for most traits compared to the Dam Model may be due to the inclusion of common litter effect in the Animal Model and consequently, a correction for this effect was considered in the Animal Model, while it was not considered in the Dam Model.

The percentage of dams which are common (DC%) between the dam model and the animal model and the percentage of dams remaining in the same position (DR%) are shown in Table 24. These results show that the percentages of the common dams in the two models of evaluation were 100% for all traits. The percentages of dams remaining in the same position (*i.e.* dams don't change their rank) ranged from 0 to 7% for postweaning body weights and livabilities in both NZW and CAL rabbits. This lead to state that the overall ranking of dams changed much between both methods of dam evaluation.

4.8.2 Transmitting Abilities for animals without records:

(i) Transmitting abilities for Sires of dams:

The sires of dams transmitting abilities (animals without records) for postweaning body weights and livabilities in NZW and CAL rabbits were obtained using the procedure of Animal Model only. The minimum and maximum estimates of transmitting abilities and their ranges for the sires of dams in NZW and CAL rabbits are given in Table 25. The ranges of the sires of dams transmitting abilities (animals without records) for body weights in NZW *vs* CAL rabbits were 89.9 *vs* 69.0 grams, 105.4 *vs* 86.0 grams, 103.3 *vs* 95.4 grams, 119.5 *vs* 101.8 grams and 145.3 *vs* 95.9 grams at 5, 6, 8, 10 and 12 weeks of age, respectively. The ranges for livabilities were 3, 7.3 and 0.3% in NZW at 6, 8 and 10 weeks of age, respectively, while they were 4.6, 17.1, 25.4 and 15.9% at 6, 8, 10 and 12 weeks of age in CAL, respectively.

Table 24. Percentages of dams common (CD%) and dams remaining in the same position (RD%) in the two methods of dam evaluation for postweaning body weights and livabilities in New Zealand White and Californian rabbits.

Trait	Body weight					Livability			
	5 weeks	6 weeks	8 weeks	10 weeks	12 weeks	6 weeks	8 weeks	10 weeks	12 weeks
(i) New Zealand White:									
DC%	100	100	100	100	100	100	100	100	a
DR%	1	1	1	0	1	3	4	6	a
(ii) Californian									
DC%	100	100	100	100	100	100	100	100	100
DR%	2	4	2	1	2	5	7	1	1

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

(ii) Transmitting Abilities for Dams of dams:

For dams without records (*i.e.* dams of dams), transmitting abilities for postweaning body weights and livabilities were obtained only in NZW rabbits and they are given in Table 25. The ranges in estimates of dams of dams (animals without records) transmitting abilities for body weights in NZW rabbits were 54.0, 59.6, 71.9, 66.9 and 86.6 grams at 5, 6, 8, 10 and 12 weeks of age, respectively, while they were 0.9, 1.8 and 0.1%. for livabilities at 6, 8 and 10 weeks of age.

Table 25. Minimum and maximum estimates of transmitting abilities for sires of dams and dams of dams (animals without records) obtained by the Animal Model (AM) for postweaning body weights and livabilities in New Zealand White and Californian rabbits.

	Sires of dams			Dams of dams		
	Minimum	Maximum	Range	Minimum	Maximum	Range
(i) New Zealand White:						
Body weight (grams):						
5 weeks	-48.8	41.1	89.9	-16.7	38.1	54.8
6 weeks	-55.7	49.7	105.4	-16.3	43.3	59.6
8 weeks	-47.0	55.9	103.3	-24.9	47.0	71.9
10 weeks	-59.9	59.5	119.5	-20.0	46.6	66.9
12 weeks	-83.9	61.3	145.3	-18.0	70.6	88.6
Livability (%):						
6 weeks	-2.1	0.9	3.0	0.1	0.9	0.9
8 weeks	-2.5	4.8	7.3	-1.2	0.6	1.8
10 weeks	-2.0	0.1	0.3	-0.1	0.1	0.1
12 weeks	a	a	a	a	a	a
(i) Californian:						
Body weight (grams):						
5 weeks	-40.6	28.3	69.0			
6 weeks	-48.2	37.9	86.1			
8 weeks	-51.0	44.3	95.4			
10 weeks	-46.7	55.2	101.8			
12 weeks	-93.1	56.8	95.9			
Livability (%):						
6 weeks	-18.7	22.9	41.6			
8 weeks	-04.7	12.3	17.1			
10 weeks	-13.5	11.9	25.4			
12 weeks	-07.4	8.5	15.9			

[a] Negative estimate of dam component of variance set to zero.