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A GENETIC ANALYSIS OF BODY WEIGHT TRAITS IN YOUNG BAUSCAT AND GIZA WHITE RABBITS

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ABSTRACT

The effects of various genetic and environmental factors on body-weight traits were studied in 3051 records of Bauscat (B) and Giza White (G) rabbits in the period from October 1976 to September 1983. Sixty-five sires and 289 dams were used for analysis of data of body weight at 6 weeks and bi-weekly up to 12 weeks of age. Year and month of birth exerted a pronounced effect on body weights of rabbits. Sex differences on the other hand were small at all ages studied and no pattern of parity effects was observed. Effects of litter size at birth were significant for 6-week weight but not for weights taken at later post-weaning ages. Body weights at the four ages studied decreased as litter size at weaning increased. Litter-weight effects on body weights decreased significantly as the age of the rabbit advanced. Sire and dam affected significantly most of the body-weight traits studied. The proportion of variance attributable to both sire and dam components for all body weights studied in G rabbits were generally larger than those in B rabbits. Heritabilities from sire and dam components of variance for body weights in B rabbits were substantially lower than the corresponding estimates in G rabbits. Genetic and phenotypic correlations among body weights at all ages studied were positive and of moderate or high magnitude, and tended to decrease in value as the differences between the two ages increased.

INTRODUCTION

THE production of 1 kg of rabbit meat requires only 0·25 of the food energy needed to produce the same amount of lamb or beef and only 0·7 of the food required for the equivalent quantity of pork (Lebas and Matheron, 1982). Several investigators including Blasco, Balsega and Garcia (1983) have reported on size inheritance in rabbit and indicated that body weight is influenced by many different non-genetic factors, e.g. year and month of kindling, parity, litter size, etc.

However, the potential for genetic improvement is dependent largely on the heritability of the trait measured and its relationship with other traits of economic importance. There are few published studies on the genetics of body growth to maturity in rabbits. Some estimates of heritability for body weight for different breeds and at different ages have been reported, e.g. Mostageer, Ghany and Darwish (1970). These and other authors have also reported high positive genetic and phenotypic correlations between rabbit body weights at different ages.

The objective of the present study was to quantify the average genetic, phenotypic and environmental variation and covariation of body weight at different ages.

MATERIAL AND METHODS

Data on rabbits of a French (Bauscat) and an Egyptian (Giza White) breed were collected from 3051 weanlings, the progeny of 65 sires and 289 dams raised at the Experimental Farm of the Faculty of Agriculture at Moshtohor, Zagazig University, Egypt, in the period from October 1976 to September 1983. Individual rabbits were weighed at 6, 8, 10 and 12 weeks of age. Records were not taken after 12 weeks of age because this was regarded as the normal age for marketing broiler rabbits in Egypt (Ghany, Badreldin, Shafie and Hanafi, 1961). The breeding plan and management of the experimental rabbitry were presented by Khalil, Owen and Afifi (1987).

Groups of does to be mated to one buck were chosen at random avoiding half and full sisters. Bucks were allocated at random to groups of does again avoiding half or full-sib mating. Only sires mated with at least two dams were included in the analysis. Data of body weight at 6, 8, 10 and 12 weeks of age were analysed within breed by adopting the following mixed model (model type 4 of Harvey, 1977):

$$Y_{ijklmnpq} = \mu + S_i + D_{ij} + A_k + B_l + LB_m + LW_n + SX_p + b_{1L}(X_{1ijklmnpq} - \bar{X}_1) + b_{2L}(X_{2ijklmnpq} - \bar{X}_2) + e_{ijklmnpq} \quad (1)$$

where:

$Y_{ijklmnpq}$ = the observation on the $ijklmnpq$th rabbit;
μ = overall mean, common element to all observations;
S_i = random effect of the ith sire;
D_{ij} = random effect of the jth dam mated to the ith sire;
A_k = fixed effect of kth parity;
B_l = fixed effect of lth month of birth;
LB_m = fixed effect of mth litter size at birth;
LW_n = fixed effect of nth litter size at weaning;
SX_p = fixed effect of pth sex;
b_{1L} and b_{2L} = the linear regression coefficients of the observation of $ijklmnpq$th young on its litter weight at birth and at weaning, respectively (as a covariate);
$\bar{X}$ = the mean of $X_{ijklmnpq}$; and
$e_{ijklmnpq}$ = random deviation of qth member of ijth dam and assumed to be independently randomly distributed $(0,\ \sigma_e^2)$. It includes all the other effects not specified in the model.

It was not possible to examine simultaneously all factors and their interactions, because the equations for estimation would have included a matrix too large to invert (see Tables 3 and 4).

Dependency in the least-squares equations existed when simultaneously fitting year of production together with the sire in the same model of analysis. Accordingly, the data were adjusted for year-of-production effects. The least-squares constants from using a linear model including the year of production as a fixed effect were used to adjust the data. Sire and dam analyses as well as estimation of genetic and phenotypic parameters were performed by fitting the same linear model (equation 1) to the year-adjusted data. Estimates of sire (σ_S^2), dam within sire ($\sigma_{D:S}^2$) and within dam (σ_W^2) components of

TABLE 1

Means (g), standard deviations and coefficients of variation (CV)† of uncorrected individual body weight in Bauscat and Giza White rabbits

Body weight (g) at:	Bauscat				Giza White			
	No.	Mean	s.d.	CV	No.	Mean	s.d.	CV
6 weeks	1259	516·8	158·1	0·2806	793	546·5	138·8	0·2182
8 weeks	942	672·6	190·4	0·2558	648	691·7	183·6	0·2215
10 weeks	764	853·1	228·4	0·2318	503	870·9	228·3	0·2116
12 weeks	663	1033·6	273·1	0·2199	462	1052·2	281·4	0·2069

† Coefficient of variation computed as the residual standard deviation divided by the overall least-squares means of a` given body weight (Harvey, 1977).

variances and covariances were computed according to method III of Henderson (1953). Estimates of heritability and genetic and phenotypic correlations for different body weights and approximate standard errors were obtained by the methods of Tallis (1959), Swiger, Harvey, Everson and Gregory (1964) and Harvey (1977).

RESULTS AND DISCUSSION

Means and variation of uncorrected records

The means, standard deviations and coefficients of variation (CV) of individual body weight in the Bauscat and the Giza White breeds are given in Table 1. CV in body weights of Bauscat rabbits were higher than the corresponding values in Giza White rabbits (Table 1). Also, the CV in rabbit body weights at younger ages were higher than at older ages, i.e. CV decreased with advance of age of the young rabbit. Similarly, Lukefahr (1982) reported higher variation at weaning (28 days) than at marketing at 5 days of age (0·251 at weaning *v.* 0·118 a marketing). The mean body weight at 6, 8 10 and 12 weeks of age in the Bausca rabbits reported here were generally lowe than the estimates reported by most Egyptiar investigators (Emara, 1982). The lower mear weights for both breeds than those reported by other investigators in the literature might possibly be attributed to one or more of the following reasons: (1) rearing rabbits under different climatic, nutritional and managerial conditions, (2) genetic differences in growth potential and in systems of breeding.

Estimation of non-genetic effects

Year of production. Least-squares means of rabbit body weights at all ages studied (Table 2) varied from one year of birth to another ($P < 0{\cdot}001$). Similarly, results of other Egyptian investigators (Emara, 1982) reported that year of birth was a significant source of variation in body weight of purebred and/or crossbred rabbits at different ages. Year-of-production effects on rabbit body weights

TABLE 2

Least-squares means (g), standard errors and tests of significance for the effect of year of birth on body weight at different ages in Bauscat and Giza White rabbits

	6-week weight			8-week weight			10-week weight			12-week weight		
	No.	Mean	s.e.	No.	Mean	s.e.	No.	Mean	s.e.	No.	Mean	s.e.
Bauscat												
General mean	1259	517·5	4·5	942	666·8	6·4	764	847·0	8·5	663	1020·7	11·6
Significance of year of birth		***			***			***			**	
1976/77	133	476·0	12·6	59	561·4	22·4	34	688·6	33·9	17	871·5	55·1
1977/78	309	531·6	8·2	259	684·3	10·7	222	839·3	13·3	189	1019·2	16·5
1978/79	122	503·1	13·1	95	668·2	17·6	74	854·3	23·0	65	985·6	28·2
1979/80	74	541·1	16·9	62	675·3	21·8	50	843·2	28·0	46	961·0	33·5
1980/81	185	474·4	10·7	176	592·1	13·0	156	730·1	15·8	139	872·6	19·3
1981/82	243	448·3	9·3	157	634·0	13·7	123	864·1	17·8	115	1056·2	21·2
1982/83	193	647·8	10·4	134	852·1	14·9	105	1109·0	19·3	92	1378·8	23·7
Giza White												
General mean	793	541·9	4·6	653	676·3	6·5	503	863·6	9·0	462	1035·2	11·1
Significance of year of birth		***			***			***			***	
1976/77	67	478·4	14·5	43	516·6	23·4						
1977/78	215	505·9	8·1	173	654·8	11·6	146	796·9	15·2	125	955·0	19·5
1978/79	95	492·4	12·3	77	669·6	17·4	65	857·3	22·8	62	994·8	27·6
1979/80	69	565·3	14·3	63	663·9	19·3	38	750·8	29·9	33	903·2	37·9
1980/81	109	491·3	11·4	102	605·3	15·2	91	740·8	19·3	83	876·1	23·9
1981/82	86	580·9	12·9	78	742·3	17·3	61	917·3	23·6	59	1114·1	28·3
1982/83	152	679·3	9·7	117	881·5	14·2	102	1118·7	18·2	100	1368·2	21·8

could be attributed to the usual annual changes in climatic, managerial, feeding and disease conditions as well as in the stockman's skill in caring for the rabbitry.

TABLE 3

Least-squares means (g), standard errors and tests of significance of factors affecting body weight of Bauscat rabbits at different ages

	6-week weight			8-week weight			10-week weight			12-week weight		
	No.	Mean	s.e.	No.	Mean	s.e.	No.	Mean	s.e.	No.	Mean	s.e.
Sex												
Male	604	531·4	8·0	449	695·6	13·9	359	864·3	22·8	308	1035·5	29·9
Female	649	528·1	8·0	493	686·2	13·8	403	861·7	22·7	354	1014·1	29·7
Significance of month of birth		***			***			***			***	
October and November	190	490·8	13·0	129	663·4	22·4	105	899·8	33·1	96	1009·8	44·1
December	233	545·1	13·3	187	663·6	24·6	146	808·3	37·6	136	1052·9	49·5
January	282	550·5	11·2	230	721·4	19·1	199	901·8	28·9	176	1109·6	38·2
February	190	543·0	11·4	150	707·0	18·9	127	918·6	29·2	106	1068·1	38·8
April and May	247	515·3	12·6	173	639·8	20·9	131	758·8	32·0	102	885·4	43·2
Significance of parity no.					**			***			***	
1	290	518·5	14·4	224	630·7	24·6	183	791·7	39·5	162	935·5	58·4
2	216	543·4	12·6	162	674·8	21·9	131	901·5	33·9	116	1111·7	48·2
3	216	532·7	12·2	147	666·8	21·6	112	818·6	32·5	95	970·0	45·7
4	205	517·1	11·3	154	724·4	20·2	133	892·1	31·1	121	1071·6	43·2
5	168	532·6	12·1	140	730·2	20·6	115	917·8	32·3	98	1076·5	44·3
≥6	158	534·4	17·0	115	718·4	28·5	88	556·3	43·9	70	983·5	61·1
Significance of litter size at birth		***										
≤4	143	586·5	17·1	114	723·0	30·3	101	885·3	45·7	90	948·0	63·1
5	149	529·7	14·4	112	703·8	25·4	92	846·9	36·7	76	971·8	50·1
6	217	527·5	12·2	168	692·4	20·4	145	822·0	31·4	132	969·4	42·2
7	289	523·6	11·5	223	688·0	20·3	174	883·4	31·2	154	1084·5	42·0
8	222	526·9	13·4	170	702·9	23·6	141	905·7	35·3	125	1080·8	47·9
≥9	233	484·4	15·2	155	635·1	26·8	109	834·7	40·4	85	1094·3	54·9
Significance of litter size at weaning		***			***			***			***	
≤3	164	714·2	15·7	130	902·2	27·2	113	1046·4	41·3	98	1243·8	57·8
4	156	609·4	12·8	122	788·9	21·8	97	996·6	33·1	81	1135·2	44·2
5	252	544·6	11·7	188	698·3	20·2	145	915·0	30·9	124	1063·5	41·6
6	250	510·8	12·3	194	665·0	21·4	150	839·9	32·3	141	1015·6	44·2
7	256	452·7	12·8	198	603·3	23·0	166	732·3	35·1	146	877·9	46·6
≥8	175	346·9	15·8	110	487·7	29·0	91	647·9	41·7	72	812·9	58·8
Regression on:												
birth litter weight, linear		−0·213**	0·079		−0·415**	0·147		−0·308	0·222		−0·901**	0·311
weaning litter weight, linear		0·146***	0·010		0·141***	0·017		0·101***	0·026		0·101**	0·035

Sex. Results given in Table 3 showed a slight general trend for males of Bauscat rabbits to be heavier than females at different ages. On the other hand, the reverse was

TABLE 4

Least-squares means (g), standard errors and tests of significance of factors affecting body weight of Giza White rabbits at different ages

	6-week weight			8-week weight			10-week weight			12-week weight		
	No.	Mean	s.e.	No.	Mean	s.e.	No.	Mean	s.e.	No.	Mean	s.e.
Sex												
Male	411	513·1	8·0	327	656·1	16·9	275	814·9	21·6	248	984·9	32·1
Female	399	513·9	8·0	324	662·0	16·8	278	818·8	21·5	254	991·7	31·9
Significance of month of birth		***			***			***			***	
October and November	102	481·2	14·3	86	581·9	26·4	79	741·4	34·4	69	949·7	49·7
December	146	530·3	16·7	118	707·4	33·3	101	999·0	45·5	94	1166·7	66·6
January	182	530·8	12·2	161	671·0	22·9	135	771·8	31·8	129	975·3	46·5
February	114	540·6	13·5	96	760·4	25·9	82	930·4	33·6	78	1088·4	48·9
March	106	505·1	13·9	85	649·0	26·1	67	802·8	35·7	63	972·1	50·1
April and May	160	492·9	13·4	105	584·8	25·7	89	655·9	34·6	69	778·1	48·8
Significance of parity no.					*							
1	175	541·2	22·8	139	715·3	41·7	123	787·0	58·1	116	994·2	79·1
2	128	520·5	17·8	93	646·6	33·0	75	774·6	45·0	72	942·3	61·5
3	145	519·1	13·6	119	668·9	24·9	95	807·3	32·9	87	1037·5	47·5
4	141	493·3	11·8	117	637·5	22·9	100	837·6	29·9	90	970·8	42·4
5	74	483·5	18·9	63	617·6	34·7	53	830·2	47·3	44	999·5	66·7
≥6	147	523·4	25·4	120	668·7	45·3	107	864·6	61·8	93	985·8	85·8
Significance of litter size at birth		***										
≤4	89	531·0	18·1	67	684·3	33·8	59	829·8	46·4	52	996·5	63·5
5	171	505·8	13·9	139	664·4	25·9	115	825·8	34·3	106	996·1	48·5
6	145	491·7	12·6	125	643·4	23·9	108	764·0	31·3	98	934·6	45·6
7	199	502·3	12·1	160	700·2	23·3	130	875·4	31·2	118	1035·1	44·7
8	113	549·3	14·1	99	652·7	25·5	86	809·1	35·3	77	984·6	48·6
≥9	93	500·8	18·0	61	609·5	34·5	55	797·2	47·4	51	983·3	66·2
Significance of litter size at weaning		***			***			***			***	
≤3	124	726·4	20·1	99	808·5	35·3	88	1079·5	49·1	79	1192·1	69·2
4	125	610·6	14·0	98	719·7	27·2	85	941·3	36·0	81	1101·8	49·9
5	260	560·1	12·6	213	695·1	24·3	173	884·7	32·8	158	1061·7	45·9
6	115	511·6	12·7	89	654·2	24·2	78	823·3	32·1	69	1030·2	47·3
7	117	396·7	16·0	101	587·4	28·8	84	689·0	38·0	74	847·3	52·5
≥8	69	275·6	26·1	51	489·6	46·9	45	483·7	65·7	41	697·0	89·5
Regression on:												
birth litter weight, linear		−0·183*	0·082		−0·106	0·138		−0·199	0·194		−0·358	0·260
weaning litter weight, linear		0·159***	0·013		0·076***	0·022		0·117***	0·030		0·107**	0·044

observed for Giza White rabbits (Table 4). In this respect, the results of many investigators working on different breeds of rabbits at various ages, showed that female rabbits were heavier than males at different stages of life (El-Amin, 1974; Carregal, 1980) while the contrary was observed by some others (Mostageer *et al.*, 1970). The trends in sex differences in body weight in this study were small and not statistically significant and consequently can be ignored (Tables 3 and 4).

Parity. Body weights of Bauscat and Giza White rabbits varied considerably from parity to parity, but no consistent pattern was observed (Tables 3 and 4). Emara (1982) and Blasco *et al.* (1983) reported that rabbits born in the first and later litters were lighter than those born in intermediate litters. Nossier (1970) and McReynolds (1974) observed an increase in weight of rabbits, in general, with advance of parity. These changes with parity are mostly a reflexion of the efficiency of the dam as a mother (especially those associated with the sustained ability of the dam to suckle her young until weaning). Mothering ability increases with advance of parity until a certain age, then remains constant for a period and decreases thereafter due to ageing (Emara, 1982). Holdas and Szendro (1982) have also confirmed that milk yield of does increased as parity advanced. The parity effect constituted a significant source of variation in rabbit's body weight at the different ages, with the exception of 6-week weight in both breeds and 10- and 12-week weights in the Giza White, i.e. parity effects on body weight decreased with age. Similar findings were reported by Emara (1982).

Month of birth. Least-squares means given in Tables 3 and 4 revealed, in general, that body weights of both the Bauscat and Giza White rabbits increased from the months of October, November and December (the beginning of the year of production) to January, February and March and decreased thereafter during April and May (the end of the year of production). These observations could be explained on the basis of the amount and nutritive value of the available greens and of temperature during these months. These conditions can exert their effects on the weaning weight of the rabbit through the amount of milk produced by the suckling doe and at later ages through the quantity and quality of the directly ingested food, the appetite of the animal and food utilization during the post-weaning months. A similar trend was observed by most of the Egyptian investigators (Emara, 1982).

Month of birth was one of the most important non-genetic factors influencing body weights of the rabbits from 6 weeks and up to 12 weeks of age ($P < 0{\cdot}01$), but the magnitude of these effects decreased, in general, as age of the rabbit advanced (Tables 2 and 3). Most of the Egyptian studies showed that month-of-birth effects were of some importance in influencing ($P < 0{\cdot}01$) body weight of the rabbits at different ages (Emara, 1982). Reports on non-Egyptian studies such as Blasco *et al.* (1983) also suggested significant month- or season-of-birth effects on rabbit body weights at different ages.

Litter size at birth. Differences in litter size at birth did not show any recognizable pattern for most body weights studied (Tables 3 and 4). This inconsistent trend may be partly attributed to differences in post-weaning mortality that occurred in rabbits of different sizes of litters at birth. Results of the studies in the literature e.g. Mgheni, Christensen and Kyomo (1982) reveal a general pattern indicating that body weight of rabbits at weaning and/or up to later ages was lower for those in large-sized litters than for those of small- and intermediate-sized litters, i.e. rabbit body weights decreased with the increase of litter size at birth. However, Emara (1982) attributed the decrease of body weight with the increase of litter size at birth to the fact that each doe has a limited capacity for providing her young with nourishment during pre- and post-natal growth until weaning and accordingly the share of each young decreases and results in light weights. The continuation of the same trend of the effect of litter size on body weight up to 12 weeks of age might be due to the fact that the maternal effects do not disappear rapidly after weaning and to the high positive association that exists between body weights at weaning and successive ages, i.e. part-whole relationship.

Litter size at weaning. Rabbit body weights at the four ages studied decreased ($P < 0{\cdot}01$ or $P < 0{\cdot}001$) as litter size at weaning increased (Tables 3 and 4). Rabbits weaned in litters of four or less had the heaviest body weights at all ages studied and those weaned in litters of nine or more had the lightest. Similar trends were reported by Emara (1982) on body weight of various breed groups of rabbits at different ages. The decrease in the mean weight of young at weaning with increase in litter size is a result of the low individual share of the dam's milk during the pre-weaning period. The effect of litter size at weaning as a maternal factor was carried over, at a decreasing rate, up to 12 weeks of age.

Litter weight. Estimates of linear regression (Tables 3 and 4) reveal that the increase in litter weight at birth was associated with a decrease in body weight of the young. This may be due to the positive correlation (as shown by Khalil *et al.*, 1987) between the two covariates. The association of litter weight at weaning with the body weights of individual rabbits gradually decreases as the age of the young advanced (Tables 3 and 4). These findings, coupled with those of the effect of litter size on rabbit body weight, confirm the belief that the litter weight, as a maternal character is decreasingly associ body weight of individual ra increases, until finally the environmental influences b determining factor in this respect.

Components of variance and estimates

The sire of the offspring aff weight at each stage, with the e 6-week and 10-week weights of (rabbits (Table 5). Valderrama de Varela-Alvarez (1975), amongst ot also concluded that sire effects body weight at different ages we significant. On the contrary, the McReynolds (1974) indicated that d in body weight due to sire effect significant. In the present study it that there was a considerable additive variance in this stock for body weight.

There was a dam effect on body (Table 5) ($P < 0{\cdot}001$). Similarly ther dam effects ($P < 0{\cdot}01$) on body wei different ages reported by McReynolds for New Zealand White rabbits and Amin (1974) for the same breed to with Californian rabbits. However, expected influence of the dams on offsprings' weights is due not only to transmitted by the dams to their offspring also by the large maternal environm

TABLE 5

Variance component estimates (σ^2) and proportions of variation (V) due to random effects for body weights in Bauscat and Giza White rabbits

	Variance components							
	Paternal half-sibs			Maternal half-sibs			Error	
Body weights	d.f.	σ^2_S	V	d.f.	$\sigma^2_{D:S}$	V	σ^2_W	V
Bauscat								
6-week weight	31	1107·81	0·114***	121	1938·02	0·200***	6666·14	0·686
8-week weight	30	767·40	0·050*	107	3757·83	0·245***	10789·65	0·705
10-week weight	30	1325·56	0·060*	94	5165·63	0·234***	15548·08	0·706
12-week weight	28	687·51	0·022	90	5400·22	0·175***	24808·93	0·803
Giza White								
6-week weight	23	1263·03	0·162***	75	1849·86	0·238***	4674·58	0·600
8-week weight	20	836·26	0·073**	65	2614·84	0·229***	7951·26	0·698
10-week weight	20	1858·38	0·099**	60	4570·17	0·242***	12426·63	0·659
12-week weight	20	2293·64	0·092**	60	5680·97	0·227***	16998·05	0·681

effects in the pre- and post-natal period. Mgheni *et al.* (1982) reported that, although maternal effects decreased in relative importance after weaning, they were still present at sexual maturity and could complicate any conclusions drawn, particularly in selection experiments for pre-weaning growth in rabbits.

Heritability estimated within breed from the sire (paternal half-sibs) and dam within sire (maternal half-sibs) components are shown in Table 6. Estimates of heritability from sire component of variance for body weight in Bauscat rabbits are, in general, substantially lower than the corresponding estimates in Giza White rabbits (Table 6). The differences in the estimates of the two breeds could be due to reduction in the sire genetic variability within Bauscat rabbits through previous selection in this breed. In practice, these high estimates indicate the possibility for rabbit breeders in Egypt to improve body weights of Giza White rabbits through selection. Moreover, estimates of heritability based on the maternal component (h_D^2) were higher in Giza White rabbits than in Bauscat and this indicates a lower variance of milking and maternal abilities in the former.

Estimates of heritability for body weight traits in Giza White rabbits were higher than those previously reported by the Egyptian investigators (Mostageer *et al.*, 1970) on the same breed at the same ages. Reasons for the higher estimates may be the differences in: (i) the method of analyses and estimation, (ii) the available number of observations, (iii) the statistical models used for correction of the non-genetic factors, and (iv) sampling error. Studies in countries other than Egypt such as those of Valderrama de Diaz and Varela-Alvarez (1975) and Randi and Scossiroli (1980) showed that estimates of heritability for body weight at different ages appear to be higher than the corresponding estimates for the two breeds of the present study.

TABLE 6

Estimates of heritability for body weights at different ages in Bauscat and Giza White rabbits

Body weights	Sire h^2	Sire s.e.	Dam : Sire h^2	Dam : Sire s.e.
Bauscat				
6-week weight	0·46	0·127	0·80	0·116
8-week weight	0·20	0·087	0·98	0·140
10-week weight	0·24	0·106	0·94	0·155
12-week weight	0·09	0·081	0·70	0·158
Giza White				
6-week weight	0·65	0·190	0·95	0·154
8-week weight	0·29	0·135	0·92	0·175
10-week weight	0·39	0·169	0·97	0·193
12-week weight	0·37	0·171	0·91	0·202

The estimates of h_S^2 for body weight show some marked effects of age (Table 6). In particular, 6-week weight has a moderate or high value compared with the lower estimates obtained for post-weaning weights. In this respect, the average of the reviewed estimates for h_S^2 for body weight at different ages were generally higher at younger ages (2 months and under) than at older ages (Mostageer *et al.*, 1970; Niedzwiadek, 1978). However, this pattern needs more study in rabbits to confirm it. Bogdan (1970) reported that h_S^2 for rabbit body weight was highest for weight at birth and declined to the lowest values at 6 months of age. In the present study, there was obviously a large effect of maternal genotype and/or maternal environment on an animal's performance during earlier or post-weaning periods of growth. Similarly, weight characteristics in New Zealand White rabbits from weaning and up to 77 and 84 days of age give evidence of this maternal effect, probably due to correlation of growth with litter conditions (Randi and Scossiroli, 1980). At the same time, parity and litter size were examples of specific maternal environmental effects that persisted almost through the animal's production life. Accordingly, variation within litter sizes of dam could have masked any additive genetic variance, i.e. biasing non-additive genetic variance upward. However, findings of the present and reviewed studies showed that selection for rabbit body weights at earlier post-weaning ages on adjusted field records may be a useful and practical method for improving early rabbit growth.

Estimates of heritability from the dam component revealed larger heritabilities than those from the sire component (Table 6). Also, these estimates indicate that all body weights studied were subject to a large maternal influence. The dam component of variance included all of the maternal additive genetic variance, the covariance between direct and maternal additive effects and both the maternal dominance and maternal environmental variances. These were not included in the sire component of variance and four times their contributions would lead to differences between paternal and maternal estimates of heritability. A suggestion of possible maternal effects upon body weight of rabbits would agree with other reports such as those of Mgheni *et al.* (1982).

Phenotypic correlation. The phenotypic correlations between body weights at the four ages studied were practically identical in the two data sets and positive at all ages (Table 7). In practice, these positive and generally high phenotypic correlations among body weights at different ages give considerable advantage in management decisions. Most of the estin literature (Blasco *et al.*, 1983) the phenotypic correlations be body weights at different ages \ and generally high.

Genetic correlation. The genetic (r_S and r_D) between different b for both breeds showed that a relationships were positive, corresponding phenotypic estimates exception of the negative genetic (r_S) between 10- and 12-week weigh White rabbits (Table 7). Sampling be the cause of this unexpected es negative genetic correlation (r_S) White rabbits. Genetic correlations rabbit body weights at the four ages tended to decrease in value as the di between the two ages increased. findings were reported by other inve such as Valderrama de Diaz and Alvarez (1975).

TABLE 7

Estimates† of genetic correlations with standard errors (below diagonal) and phenotypic correlations (above diagonal) among different body weights in Bauscat and Giza White rabbits

Body weights	6-week weight		8-week weight		10-week weight		12-week weight
Bauscat							
6-week weight			0·76		0·63		0·54
8-week weight					0·81		0·71
S	1·16	0·068					
D	0·72	0·068					
10-week weight							0·84
S	0·96	0·077	1·15	0·168			
D	0·57	0·107	0·81	0·057			
12-week weight							
S	1·04	0·245	1·34	0·640	1·24	0·204	
D	0·49	0·142	0·70	0·097	0·76	0·077	
Giza White							
6-week weight			0·69		0·59		0·55
8-week weight					0·74		0·64
S	1·17	0·079					
D	0·62	0·117					
10-week weight							0·63
S	1·23	0·107	0·99	0·045			
D	0·31	0·195	0·69	0·106			
12-week weight							
S	0·91	0·104	1·25	0·127	−0·50	0·253	
D	0·34	0·195	0·46	0·163	0·69	0·131	

† S = paternal half-sibs and D = maternal half-sibs.

Estimates in Table 7 show that the estimates of genetic correlations (r_S) between rabbit body weights at all ages studied were higher than the phenotypic correlations. Similar results have been reported by investigators working on New Zealand White rabbits e.g. Niedzwiadek (1978). From these estimates together with heritability estimates (Table 6) it could be safely concluded that rabbit body weights at earlier ages could be used for selection and improvement of body weight at later ages, i.e. indirect selection for body weights at later ages. However, it should be noted that estimates of the genetic correlations (r_S) among different body weights reported by most investigators are lower than those obtained in the present study.

The estimates of the genetic correlations (r_D) among body weights of both present breeds at the four ages studied were generally positively moderate or relatively large (Table 7). These estimates represent similarity among non-littermates (maternal half-sibs) caused by additive maternal, non-additive maternal and non-genetic maternal effects. However, the downward bias in the estimates of r_D while r_S showed upward bias, may arise from two circumstances. Firstly, it may be sampling error. Secondly, the bias can also be caused by selection (rabbits surviving to the latest weight at 12 weeks of age). Therefore, estimates of r_D between body weights at the four ages studied in both present breeds were lower than those estimates reported by Nossier (1970) on Bauscat and Baladi Red rabbits and by Randi and Scossiroli (1980) on New Zealand White rabbits.

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