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GENETIC AND PHENOTYPIC PARAMETERS FOR WEANING AND PREWEANING BODY WEIGHTS AND GAIN IN BOUSCAT AND GIZA WHITE RABBITS

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Abstract

Data on 1149 young rabbits of the Bouscat and Giza White breeds were analyzed to estimate genetic and phenotypic parameters for individual body weights at birth (WB), 21 days (W21) and at weaning (WW), and preweaning daily gain (PDG). Data represented a total of 15 sires and 69 dams across the two breeds. Body weights and gain at weaning showed higher variation than those at birth. Effects of year of birth on weights and gain were not significant, while litter size and month of birth exerted significant effects on these traits. Individual preweaning weights and gain decreased ($P < 0.001$) as litter size at birth increased, while an increase in litter weight at birth was associated with an increase in weight and gain of the young. Weights and gain tended to increase as parity advanced from the 1st to the 3rd, and to decrease thereafter. Sires of Giza White rabbits did not contribute significantly to the variance of traits studied, while a considerable additive genetic variance (due to sire) in WW and PDG in Bouscat rabbits was observed. A reverse trend was detected for the dam component of variance (i.e. higher variance of milking and maternal abilities in Giza White dams than in Bouscat dams). This offers the possibility for rabbit breeders in Egypt to select sires from Bouscat rabbits and dams from Giza White rabbits for stratified systems of commercial production. High estimates of heritability from the sire component of variance for WW and PDG (0.48 and 0.50, respectively) in Bouscat rabbits were obtained. Heritabilities estimated from littermate components (sire + dam) of variance, ranging from 0.33 to 0.74, indicated the possibility of improving preweaning body weights and gain through littermate selection. Genetic (from littermate components) and phenotypic (from sire and littermate components) correlations between weights and gain at all ages studied were positive, generally of moderate to high magnitude, and tended to decrease in value as the interval between the two ages increased.

Introduction

Preweaning body weight is an economically important trait requiring particular attention in any breeding scheme aiming to improve the overall productivity of rabbits, since it is a reflection of maternal factors, one of which is the doe's milking ability. Several investigators (e.g. Venge, 1963; El-Amin, 1974; Afifi et al., 1985) have reported on size inheritance in rabbits and indicated that preweaning growth is influenced by different non-genetic factors, e.g. month of kindling, parity, litter size and dam's milk supply. The study of such different factors affecting preweaning growth is useful in planning selection and breeding programs to maximize the efficiency of growth during this period.

Information obtained from genetic and phenotypic analyses of preweaning growth in rabbits is scarce (McReynolds, 1974; Lampo and Broeck, 1975; Valderrama de Diaz and Varela-Alvarez, 1975; Niedzwiadek, 1978). Therefore, the objective of the present study was to quantify genetic and phenotypic variation and covariation of preweaning body weights and gain in Bouscat and Giza White breeds.

Materials and Methods

Data on weaning and preweaning body weights and gain of Bouscat and Giza White rabbits were collected from the Experimental Farm of the Faculty of Agriculture at Moshtohor, Zagazig University, Egypt, over a period of two years (from October, 1977, to September, 1979). Genetic and phenotypic analyses of these traits were carried out on 1149 young produced by 15 sires mated to 69 dams (8 and 7 sires and 39 and 30 dams for Bouscat and Giza White breeds, respectively). Only sires mated with at least two dams were included in the analyses.

Groups of does to be mated to one buck of the same breed were chosen at random, avoiding full sisters and half sisters (paternal or maternal). Does that failed to conceive were returned to the same mating buck to be remated, and were returned to the same buck every other day thereafter until a service was observed. Other details of the breeding plan and management of the experimental rabbitry were presented by Khalil et al. (1987a).

Data of individual body weight at birth (WB), 21-days (W21) and at weaning at 35 days (WW) and preweaning daily gain (PDG) were analyzed within breed using Harvey's (1987) mixed model computer program. The following mixed model was adopted:

$$Y_{ijklmnp} = \mu + S_i + D_{ij} + A_k + B_l + C_m + D_n + b_L (X_{ijklmnp} - X) + b_Q (X_{ijklmnp} - X)^2 + e_{ijklmnp},$$

where $Y_{ijklmnp}$ denotes observation of the ijklmnpth rabbit, μ = overall mean, S_i = random effect of the i^{th} sire, B_{ij} = random effect of the j^{th} dam nested within random effect of the i^{th} sire, A_k = fixed effect of the k^{th} year of kindling, B_l = fixed effect of the l^{th} month of kindling, C_m = fixed effect of the m^{th} parity, D_n = fixed effect of the

n^{th} litter size at birth, b_L&b_Q =linear and quadratic partial regression coefficients of the ijklmnpth young on its litter weight at birth, $\bar{X}$ =mean of $X_{ijklmnp}$, and $e_{ijklmnp}$ =random deviation of the p^{th} young of the ij^{th} dam, assumed to be independently randomly distributed $(0,\sigma^2_e)$. The limited number of records or their absence in some subclasses did not permit the inclusion of all possible interactions. Henderson's method 3 was utilized to estimate the genetic and phenotypic variance and covariance components for the different traits. Accordingly, estimates of sire (σ^2_s), dams within sire $(\sigma^2_{D:S})$ and remainder (σ^2_e) components of variance and covariance were obtained. Estimates of heritability and genetic and phenotypic correlations for different body weights and gain were obtained by computing techniques described by the LSMLMW program of Harvey (1987). Heritability was estimated by the expression $4\sigma^2_s/(\sigma^2_s+\sigma^2_{D:S}+\sigma^2_e)$ and $2(\sigma^2_s+\sigma^2_{D:S})/(\sigma^2_s+\sigma^2_{D:S}+\sigma^2_e)$ for components of paternal half-sibs and littermates (full-sibs), respectively. Standard errors for heritability estimates were computed according to the method described by Swiger et al. (1964).

Results and Discussion

Means and Variation

Least-squares means, standard errors and coefficients of variation (CV) of individual body weights and preweaning daily gain for Bouscat and Giza White breeds are given in Table 1. Means of WB and/or WW and PDG for Bouscat and Giza White breeds reported here were generally within the range of estimates reported by most Egyptian investigators (El-Khishin et al., 1951; Ragab et al., 1952; Ragab and Wanis, 1960; Ghany et al., 1961; Mostageer et al., 1970; Afifi et al., 1985 and 1987). Differences between the estimates of preweaning body weights and gain reported herein and those reported by other Egyptian workers for the same and/or different breeds of rabbits could 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, (3) different statistical models used.

Body weights (in both breeds) at a later stage of the preweaning period (i.e. W21 and WW) showed higher CV's than WB, i.e. CV increased with advance in age. Similarly, Afifi et al. (1985) reported higher CV's for preweaning weights at 21 days (23%)than at birth (15%). Similiar findings were reported in other studies (e.g. Lukefahr, 1983a). The higher CV's are likely due to variation in maternal effects on offspring (lactation). May and Simpson (1985) reported that kits up to 12 days of age remained solely dependent on their mothers' milk and, therefore, until they were weaned, the mother's milk provided the main supply of nutrients. The great variation in losses of kits that occurred during the suckling period could be added as another source of variation in this respect.

Year of Birth

The effect of year was non-significant for all traits studied (Table 2). A non-significant effect for year of birth was reported by Afifi et al.(1987) while a significant effect on WB and/or W21 and WW was reported by other investigators (e.g. Ragab and Wanis, 1960; McReynolds, 1974; Afifi et al., 1982). Khalil et al.(1987b) reported that year-of-birth effects on body weights could be attributed to the usual annual changes in climatic, managerial feeding and disease conditions as well as in the stockman's progressive skills in caring for the rabbitry.

Month of Birth

F ratios given in Table 2 show that month of birth was one of the most important non-genetic factors influencing preweaning body weights and gain. They also indicate that the magnitude of these effects increased as age of the rabbit advanced. Most Egyptian studies have shown that month-of-birth effects were of some importance in influencing $(P<0.01)$ preweaning body weights of rabbits (e.g. Ragab and Wanis, 1960; Afifi et al., 1985, 1987). Rabbits born during February and March had the highest $(P<0.01)$ preweaning weights and gains while those born during October and November had the lowest (Tables 3,4). A similar trend has been observed by most Egyptian investigators (Ragab and Wanis, 1960; Afifi et al., 1985, 1987). These observations could be explained on the basis of the amount and nutritive value of available greens and of temperature effects during these months. During October and November, green fodder for pregnant and suckling does is not available in adequate quantity and is of lesser nutritive value, while during February and March, fodder becomes more abundant and of higher nutritive value, and weather conditions become milder (optimum temperature for rabbit production is 22°C, May and Simpson, 1975). These conditions can exert their effects on the weights and gains of kits during the suckling period through the amount of milk produced by the suckling dam and during the later preweaning period from 21 days to weaning through the quantity and quality of directly ingested food, the appetite and food utilization of the young.

Parity

Preweaning body weights and gains increased with advance of parity from the 1st to the 3rd and decreased thereafter (Tables 3,4). A similar trend was observed in other Egyptian studies (Afifi et al., 1982, 1985, 1987). McReynolds (1974) observed an increase in 21-day weight with advance of parity. However, the pattern of change $(P<0.05$ or $P<0.01)$ observed in birth weight due to parity effects may be due to changes in the physiological efficiency of the dam, especially those associated with nourishment and intra-uterine environment provided during pregnancy which occur with advance of parity (Afifi et al., 1987). Significant changes $(P<0.01)$ in WW and PDG of Giza White rabbits due to parity effect are mostly a reflection of maternal ability, especially those associated

Table 1. Least-squares means (g), standard errors (SE) and coefficients of variation (CV%) of preweaning weights and daily gain in Bouscat and Giza White rabbits.*

Trait	Bouscat			Giza White		
	N	Mean ± SE	CV%**	N	Mean ± SE	CV%**
WB	617	58 ± 0.7	13.5	532	58 ± 0.7	10.8
W21	526	222 ± 7.4	20.6	431	205 ± 7.0	20.4
WW	463	434 ± 19.3	18.8	351	408 ± 16.9	19.1
PDG	463	11 ± 0.5	21.3	351	10 ± 0.5	22.0

* Differences between two breeds for all traits were not significant ($p > 0.05$).

** Coefficients of variation computed as the remainder standard deviation divided by the overall least-squares means of a given trait (Harvey, 1987).

Table 2. F-ratios of least-squares analysis of variance for preweaning weights and gain of Bouscat and Giza White rabbits.

Source of variation	WB				W21				WW				PDG			
	Bouscat		Giza White		Bouscat		Giza White		Bouscat		Giza White		Bouscat		Giza White	
	d.f.	F	d.f.	F	d.f.	F	d.f.	F	d.f.	F	d.f.	F	d.f.	F	d.f.	F
Sire^a	7	0.4	6	1.5	7	1.2	6	0.6	7	3.0**	6	0.6	7	3.1**	6	0.6
Dams:sire	30	3.3***	23	1.9**	30	4.4***	23	5.9***	30	4.4***	23	4.4***	30	4.4***	23	4.4***
Year of birth	1	0.0	1	0.3	1	0.0	1	0.0	1	0.8	1	0.0	1	0.8	1	0.0
Month of birth	5	5.0***	5	3.4**	5	21.2***	5	17.1***	5	30.7***	5	22.5***	5	31.6***	5	22.5***
Parity	5	2.6*	5	2.9**	5	1.2	5	1.1	5	1.0	5	5.1***	5	1.0	5	5.1***
Birth litter size	5	55.7***	5	44.4***	5	29.6***	5	7.9***	5	20.7***	5	11.8***	5	17.5***	5	10.2***
Regression on:																
Birth litter wt., linear	1	117.3***	1	152.4***	1	0.2	1	0.2	1	1.8	1	0.9	1	5.9**	1	0.1
Birth litter wt., quadratic	1	0.2	1	7.5**	1	25.7***	1	2.6*	1	12.7***	1	4.0*	1	13.6***	1	5.1*
Remainder d.f.	560		483		469		382		406		302		406		302	
Remainder mean square		61		39		2083		1759		6647		6081		5.2		4.9

^{a}Sire effect tested against dams within sire and other effects tested against remainder mean squares.

* = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$.

with sustained ability of the dam to suckle her young until weaning. Holdas and Szendro (1982) and McNitt and Lukefahr (1990) have also confirmed that milk yield of dams increased as parity advanced. However, Lukefahr et al. (1983b) found no relationship between age of doe and lactation level. Khalil et al.(1987a,b) reported that mothering ability improves with advance of parity up to the 6th, then remains constant for a period and decreases thereafter due to aging.

Birth Litter Size

Preweaning body weights and gains decreased ($P<0.01$) with increase in litter size at birth (Tables 3,4). The F ratios presented in Table 2 reveal that the magnitude of the birth-litter size effect on preweaning body weights decreased as age of the rabbit increased. These trends were evident in different Egyptian (El-Khishin et al., 1951; Ragab and Wanis, 1960; Afifi et al., 1973, 1985, 1987) and foreign (Venge, 1963; Valderrama de Diaz and Varela-Alvarez, 1975) studies with different rabbit breeds. Also, results of Mgheni et al.(1982) and Lukefahr et al. (1984) revealed a general pattern indicating that individual or average body weight at weaning was lower in large-sized litters than in small- and intermediate-sized litters. This inverse relationship can be attributed to the fact that each dam 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, resulting in lighter weights and less gains (Afifi et al., 1985; Khalil et al., 1987b). The relationships observed in the present and reviewed studies between body weights and litter size may be useful in selection programs directed towards improving preweaning growth in rabbits.

Birth Litter Weight

Estimates of linear and quadratic regression coefficients given in Table 5 reveal that increase in litter weight at birth was generally associated with increase in subsequent body weights of the young. Such an association gradually decreases as age of the young increases. These results, coupled with those of the effect of litter size at birth on body weight and gain (Table 2), confirm that litter weight, as a maternal character, is decreasingly associated with the rabbit's body weight as age increases, until finally non-maternal environmental influences become the main determining factor in this respect.

From linear and quadratic regression coefficients given in Table 5, prediction equations for preweaning body weight and gain (adjusted for other effects in the model) in Bouscat and Giza White rabbits were calculated. Therefore, a prediction curve based on the regression of preweaning body weights and gain (adjusted for other effects in the model) could be plotted to indicate the changes that would be expected in such traits with increasing litter weight at birth.

Table 3. Least-squares means (grams) and standard errors (SE) of factors affecting body weight at birth and 21 days of age.

Independent Variable	WB				W21			
	Bouscat		Giza White		Bouscat		Giza White	
	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE
Year of birth								
1977/78	420	59 ± 1.5	361	59 ± 1.3	357	225 ± 11	303	207 ± 17
1978/79	197	59 ± 1.6	171	58 ± 1.7	169	224 ± 12	128	206 ± 19
Month of birth								
Oct.-Nov.	131	55 ± 2.4	96	53 ± 1.7	108	144 ± 17	87	143 ± 16
December	43	54 ± 2.3	45	55 ± 2.2	39	209 ± 16	36	206 ± 19
January	70	60 ± 1.7	79	60 ± 1.4	65	217 ± 12	67	196 ± 14
February	109	63 ± 1.5	87	57 ± 1.3	99	269 ± 11	76	241 ± 14
March	53	56 ± 2.3	54	62 ± 1.7	43	259 ± 16	51	217 ± 16
April-May	211	63 ± 2.4	171	62 ± 1.7	172	249 ± 17	114	238 ± 16
Parity								
1st	55	60 ± 4.9	56	60 ± 3.3	47	212 ± 35	47	215 ± 27
2nd	99	64 ± 3.2	76	64 ± 2.2	82	224 ± 22	64	223 ± 19
3rd	118	67 ± 1.7	111	65 ± 1.5	99	230 ± 12	82	225 ± 14
4th	153	56 ± 1.7	122	57 ± 1.3	131	215 ± 12	107	192 ± 13
5th	111	52 ± 3.1	89	52 ± 2.2	97	215 ± 22	70	196 ± 20
≥6th	81	53 ± 4.8	79	50 ± 3.3	70	212 ± 34	61	188 ± 27
Birth litter size								
≤4	52	83 ± 2.5	47	80 ± 2.2	48	292 ± 16	42	263 ± 20
5	83	69 ± 1.8	65	58 ± 1.6	71	245 ± 12	53	236 ± 15
6	90	64 ± 1.7	89	62 ± 1.3	76	258 ± 12	80	195 ± 13
7	144	54 ± 1.6	119	53 ± 1.2	121	246 ± 11	101	222 ± 13
8	104	46 ± 1.7	72	48 ± 1.5	96	184 ± 12	59	164 ± 15
≥9	144	35 ± 2.0	140	40 ± 1.5	114	123 ± 13	96	159 ± 15

Table 4. Least-squares means (grams) and standard errors (SE) of factors affecting weaning weight and preweaning daily gain.

Independent Variable	WW				PDG			
	Bouscat		Giza White		Bouscat		Giza White	
	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE
Year of birth								
1977/78	323	456 ± 38	245	406 ± 31	323	11.3 ± 1.1	245	9.9 ± 0.9
1978/79	140	417 ± 34	106	410 ± 36	140	10.2 ± 1.0	106	10.0 ± 1.0
Month of birth								
Oct.-Nov.	95	307 ± 40	69	304 ± 30	95	7.1 ± 1.1	69	7.1 ± 0.8
December	30	373 ± 40	31	414 ± 39	30	9.0 ± 1.1	31	10.3 ± 1.1
January	59	472 ± 33	57	411 ± 26	59	11.8 ± 0.9	57	10.0 ± 0.7
February	94	512 ± 31	63	497 ± 26	94	12.8 ± 0.9	63	12.5 ± 0.7
March	41	530 ± 39	46	430 ± 30	41	13.6 ± 1.1	46	10.6 ± 0.8
April-May	144	425 ± 41	85	389 ± 29	144	10.4 ± 1.1	85	9.3 ± 0.8
Parity								
1st	41	401 ± 71	40	365 ± 53	41	10.6 ± 2.0	40	8.5 ± 1.5
2nd	69	460 ± 49	53	348 ± 37	69	11.4 ± 1.4	53	8.6 ± 1.0
3rd	89	464 ± 33	60	451 ± 28	89	11.0 ± 0.9	60	11.1 ± 0.7
4th	110	406 ± 34	89	409 ± 25	110	10.0 ± 0.9	89	10.0 ± 0.7
5th	90	408 ± 49	60	459 ± 38	90	10.1 ± 1.4	60	11.6 ± 1.1
≥6th	64	398 ± 69	49	413 ± 52	64	9.7 ± 1.9	49	10.3 ± 1.4
Birth litter size								
≤4	45	531 ± 38	36	566 ± 40	45	12.9 ± 1.1	36	13.9 ± 1.1
5	66	447 ± 33	46	477 ± 29	66	10.8 ± 0.9	46	11.6 ± 0.8
6	64	503 ± 33	66	393 ± 26	64	12.5 ± 0.9	66	9.5 ± 0.7
7	106	479 ± 32	82	437 ± 24	106	12.1 ± 0.9	82	11.0 ± 0.7
8	87	371 ± 32	45	317 ± 30	87	9.2 ± 0.9	45	7.7 ± 0.8
≥9	95	286 ± 35	76	256 ± 30	95	7.1 ± 1.0	76	6.1 ± 0.8

Table 5. Linear and quadratic regression coefficients and prediction equation of preweaning body weights and daily gain (g) on litter weight at birth (g).

Trait	Regression on litter weight at birth:		
	Linear (gm/gm)	Quadratic (gm/gm^2)	Prediction equation*
WB			
Bouscat	0.1078 ± 0.0080	-0.00002 ± 0.00004	$WB = 58.9 + 0.1078(LWB-\bar{X}) - 0.00002(LWB-\bar{X})^2$
Giza White	0.1136 ± 0.0092	-0.00010 ± 0.00004	$WB = 58.0 + 0.1136(LWB-X) - 0.00010(LWB-X)^2$
W21			
Bouscat	0.0222 ± 0.0509	0.00135 ± 0.00026	$W21 = 222 + 0.0222(LWB-\bar{X}) + 0.00135(LWB-\bar{X})^2$
Giza White	0.0282 ± 0.0725	0.00049 ± 0.00030	$W21 = 205 + 0.0282(LWB-X) + 0.00049(LWB-X)^2$
WW			
Bouscat	0.1282 ± 0.0957	0.00181 ± 0.00051	$WW = 434 + 0.1282(LWB-\bar{X}) + 0.00181(LWB-\bar{X})^2$
Giza White	0.1540 ± 0.1604	0.00147 ± 0.00074	$WW = 408 + 0.1540(LWB-X) + 0.00147(LWB-X)^2$
PDG			
Bouscat	0.0065 ± 0.0027	0.00005 ± 0.00001	$PDG = 10.7 + 0.0065(LWB-\bar{X}) + 0.00005(LWB-\bar{X})^2$
Giza White	0.0014 ± 0.0045	0.00005 ± 0.00002	$PDG = 10.0 + 0.0014(LWB-X) + 0.00005(LWB-X)^2$

*Where LWB = observed litter weight at birth and $\bar{X}$ = mean of litter weight at birth.

Table 6. Variance component estimates (σ^2) and proportions of variation (V%) attributable to the sire and littermate component and heritability estimates (h^2) for preweaning weights and gain in Bouscat and Giza White rabbits.

Trait	Sire		Dams:sire		Remainder		$h^2_s \pm SE$	$h^2_{s-o} \pm SE$
	σ^2_s	V%	$\sigma^2_{D:S}$	V%	σ^2_e	V%		
Bouscat								
WB	a	0.0	11.8	16.2	61.0	83.8	a	0.33 ± 0.09
W21	5.5	0.2	695.3	25.0	2083.4	74.8	0.01 ± 0.04	0.50 ± 0.12
WW	1260.0	12.0	2622.0	24.9	6647.0	63.1	0.48 ± 0.24	0.73 ± 0.14
PDG	1.0	12.5	2.0	24.6	5.2	62.9	0.50 ± 0.25	0.74 ± 0.14
Giza White								
WB	0.6	1.3	2.7	6.5	38.7	92.1	0.05 ± 0.06	0.16 ± 0.07
W21	a	0.0	872.0	33.1	1759.0	66.9	a	0.66 ± 0.15
WW	a	0.0	2656.0	30.4	6081.0	69.6	a	0.61 ± 0.15
PDG	a	0.0	2.1	30.6	4.9	69.4	a	0.61 ± 0.15

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

Components of Variance and Heritability Estimates

Effects of sire on preweaning body weights and gain were not significant, with the exception of WW and PDG traits in Bouscat rabbits (Table 2). Results of McReynolds (1974), Lampo and Broeck (1975) and Blasco et al. (1983) indicated that differences in preweaning body weight and/or gain due to sire effect were not significant while others (Bogdan, 1970; Valderrama de Diaz and Varela-Alvarez, 1975; Niedzwiadek, 1978; Khalil et al., 1987b) reported a significant effect. It is clear that there was some evidence of additive genetic variance in WW and PDG traits in Bouscat rabbits (estimates of V% given in Table 6 are 12.0 and 12.5, respectively).

A significant dam effect ($P<0.01$ or $P<0.001$) on preweaning body weights and gain was observed (Table 2). Similarly, there were dam effects ($P<0.01$) on preweaning body weights in many reviewed studies (Mostageer et al., 1970; El-Amin, 1974; McReynolds, 1974; Mgheni et al., 1982; Blasco et al., 1983; Khalil et al., 1987b) involving different rabbit breeds. However, the expected influence of dams on their offspring weights was due not only to genes transmitted (i.e. additive genetic effect) but also to large maternal environmental effects in the pre-and post-natal period (i.e. due to differences in intra-uterine environment and in milking and mothering ability of dams). Mgheni et al.(1982) reported that, although maternal effects decreased in relative importance after birth, they were still present at weaning and could complicate any conclusions drawn in heritability estimation, particularly in selection experiments for preweaning growth in rabbits.

The proportion of variance attributable to sire and dams within sire components for all traits studied are given in Table 6. Such proportions of variance attributable to Giza White dams were, in general, somewhat higher than the corresponding estimates attributable to Bouscat dams, i.e. there was a higher variance of milking and maternal abilities in Giza White dams than in Bouscat dams. A reverse trend was observed for the sire component Therefore, selection of sires from Bouscat rabbits and dams from Giza White could be effective in a stratificatior system for commercial production. The presence ol negative sire variance components for some weights anc gain (WB in Bouscat rabbits and W21, WW and PDG ir Giza White) and the small values observed for other suggest unreliable estimates of sire component of varianc for these traits due to limited sire numbers (Table 6). Thi may be due to the small numbers of sires o non-randomness in distribution of the small numbers c dams within sire groups. Mgheni et al. (1982) reporte that large maternal effects during the preweaning period i rabbits may have masked direct genetic expression of th young.

Heritability estimated within breed from the sire (h^2 and littermate (h^2_{s-o}) components are shown in Table Estimates of heritability (h^2_s and h^2_{s-o}) for body weigh and gain in Bouscat rabbits are, in general, substantial higher than the corresponding estimates in Giza Whi rabbits. In practice, these high estimates of h^2_s indicate t possibility for rabbit breeders in Egypt to improve W and PDG of Bouscat rabbits through selection, wh estimates of h^2_{s-o} indicate that improvement of preweani growth in both breeds would be possible throu littermates and/or family selection. Estimates of h^2_s body weights and gain obtained in the present study are agreement with findings of other studies (Mostageer et a 1970; Zotova and Bogdanov, 1972; El-Amin, 19 McReynolds, 1974; Lampo and Broeck, 1975; Blasco al., 1983), while they are lower than estimates reported by others (Bogdan, 1970; Varela-Alvarez et al., 1974). The estimates of h^2_{s-o} for preweaning body weights and gain increased with advance in age (Table 6). Similar estimates were obtained by Mostageer et al. (1970). These results confirm that maternal effects on body weight and gain tend to be very high at birth, decreasing thereafter gradually during the preweaning period and up to later ages.

Genetic and phenotypic correlations

The genetic and phenotypic correlations (i.e. r_s & r_{s-o}) between different body weights and gain for both breeds showed that all of these relationships were positive (Table 7). Also, these estimates tended to decrease in value as the interval between the two ages increased. Similar findings were reported by other investigators (e.g., Valderrama de Diaz and Varela-Alvarez, 1975; Blasco et al., 1983). Estimates of genetic correlations (r_s and r_{s-o}) between body weights and gain in Bouscat rabbits were higher than the phenotypic correlations while the reverse was observed for Giza White rabbits (Table 7). Findings of Valderrama de Diaz and Varela-Alvarez (1975) with Criollo rabbits and Niedzwiadek (1978) with New Zealand White rabbits similarly reported higher estimates of genetic than phenotypic correlation.

Table 7. Genetic (r_G) and phenotypic (r_P) correlations for preweaning body weights and gain in Bouscat and Giza White rabbits.

Traits correlated	Sire		Littermate	
	r_G	r_P	r_G	r_P
Bouscat:				
WB & W21	a	0.37	0.41	0.37
WB & WW	a	0.31	0.34	0.31
WB & PDG	a	0.24	0.30	0.24
W21 & WW	0.67	0.77	0.82	0.77
W21 & PDG	0.69	0.76	0.81	0.76
WW & PDG	1.01	0.99	0.99	0.99
Giza White:				
WB & W21	a	0.22	0.29	0.22
WB & WW	a	0.18	0.24	0.18
WB & PDG	a	0.12	0.21	0.12
W21 & WW	a	0.70	0.65	0.70
W21 & PDG	a	0.69	0.64	0.69
WW & PDG	a	0.93	0.79	0.93

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

Estimates of genetic correlations based on paternal half-sibs (r_s) between PDG and WW in Bouscat rabbits were high in magnitude (Table 7) and indicated that selection at earlier ages may be effective to improve weaning weight in Bouscat rabbits. Also, estimates of correlations based on littermates (r_{s-o}) for both breeds were positive and of moderate or high magnitude. These results may be due to their part/whole relationship. However, these estimates agree quite well with those reported by other investigators (Mostageer et al., 1970; Valderrama de Diaz and Varela-Alvarez, 1975; Khalil et al., 1987b). From estimates of correlations (r_{s-o}) together with heritability estimates (Table 6), it can be concluded that individual weight at 21 days of age (age at peak lactation) can be used to improve weaning weight at 35 days of age through indirect selection, i.e. through selection for littermate performance of body weight and gain at birth and/or 21 days of age.

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