J. Agric. Sci. Mansoura Univ., 33 (7): 4835 - 4848, 2008

GENETIC AND PHENOTYPIC RELATIONSHIPS INVOLVING BODY WEIGHT, DEGREE OF MATURITY AND MEASURES OF GAIN RATE OF BARKI SHEEP WITHOUT HAVING RECOURSE TO FITTING GROWTH CURVES

El-Wakil, Salwa I.*; A.R. Shemeis; A. M. Ahmed* and O.Y. Abdallah****

*** Animal and Poultry Production Division, Desert Research Center, Matareya, Cairo, Egypt.**

****Department of Animal production, Faculty of Agriculture, Ain Shams University, Shoubra Al-Kheima, 11241 Cairo, Egypt**

ABSTRACT

Estimates of genetic and phenotypic parameters for body weight, degree of maturity and measures of gain rate on 910 Barki sheep (530 females and 380 males), progeny of 49 unrelated rams were calculated and used to predict the responses to selection both as a result of direct and indirect selection. Weight at 48 months of age was considered the mature weight as it was the last weight taken and was different significantly ($P< 0.05$) from the preceding weight. The phenotypic and genetic coefficient of the variation in degree of maturity declined with age to zero at maturity. Degree of maturity was more variable than body weight genetically till six months and phenotypically till 14 months when the order was reversed. Heritabilities for degree of maturity were essentially lower than the corresponding heritabilities for body weight. The genetic inter-age correlations for degree of maturity were almost always lower than the corresponding phenotypic correlations. All were positive, so that animals more mature at a given age also tended to be more mature at any later age. High positive correlations were found within the marketing body weight group (W_{10} and W_{12}), the pre-marketing group (W_{04}, W_{06} and W_{08}) and the post-marketing group (W_{24}, W_{36} and W_{48}). The marketing and pre-marketing body weights show essentially high genetic and phenotypic correlations, implying the possibility of selecting heavier animals at marketing by using early information. All measures of average gain rate decline from 4 to 48 months of age. The CV's reached their highest values for average absolute growth rate (AGR_a) and average absolute maturing rate (AMR_a) between 16 and 24 months of age and average relative growth rate (RGR_a) between 36 and 48 months of age. AGR_a, AMR_a and RGR_a were highly genetically correlated with each other whenever they referred to the same period of gain. Their estimates at the first five age intervals were mostly negatively correlated with their estimates from 36 to 48 months of age. Substantial increase in weight at age of selection and less increase in weight at all other ages would result from selection for body weights and degrees of maturity. Selection for AGR_a, AMR_a and RGR_a at early stages (4 to 8 months) would result in increase in body weight and degree of maturity at all subsequent stages. Selection for AGR_a or AMR_a after 12 months of age would have little effect on mature weight. Increase in mature weight would be expected from animals selected for their lower than average RGR_a after the age of 12 months.

Keywords: Barki sheep, body weight, degree of maturity, measures of rate gain, genetic parameters, direct and correlated responses.

INTRODUCTION

Barki sheep which dominate the north western desert of Egypt with a population of c. 470,000 heads (c. 11% of the total Egyptian sheep population), are known to be well-adapted to the desert harsh conditions and scarce vegetation. While basic information on their body conformation are available (Ragab and Ghoneim, 1961) major information regarding the genetics of their body weight growth is still lacking.

According to Fitzhugh, 1976 investigating the relationships involving body weights and their degree of maturity, maturing rate and measures of gain rate would resolve genetic antagonism between rapid, efficient early growth of slaughter progeny and desired small size and lower maintenance costs of parental stock, improve intrinsic efficiency through increased maturation rate, lower age at first breeding in parental stock by decreasing time taken to sexual maturity, and decrease carcass fatness at preferred market weights by increasing time taken to chemical maturity.

Estimates of additive genetic parameters for the above mentioned traits may be obtained with advantage at different stages of growth when the mean growth curve is so irregular that normal type of growth curve could not be meaningfully fitted, or when computational difficulty arises from choice of function and the characteristics of the data set. According to Fitzhugh, 1976 most functions are sensitive to the frequency and regularity of data on both the body weight and age scales. Algorithms involving iteration are sensitive to choice of starting values and may not even converge to a solution. On top of that, no relationship involving earliness of maturity or degree of maturity could be investigated without body weight has been explicitly or implicitly measured at maturity.

The present study was planned to investigate the phenotypic and genetic relationships involving body weight, degree of maturity, maturing rate, time taken to maturity and measures of gain rate to estimate the expected direct and correlated responses to selection for body weights, degrees of maturity and gain rates at different successive stages.

MATERIALS AND METHODS

Source of Data. The data used in the present study were collected over 10 years started in 1963 and ended in 1995 on an experimental north western coast Barki sheep flock belonging to the Desert Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

Management of Animals. As a rule, mating season takes place around July and lambing starts around December each year. Following their birth, lambs were ear-tagged, and kept with their dams to suckle their milk until weaning at 4 months of age. After weaning, lambs were fed a concentrate mixture (50% Cottonseed cake; 18%, Wheat bran; 15%, Yellow maize; 11%, Rice polish; 3%, Molase; 2%, Limestone; 1%, Common salt) amounting 0.5 to 1.0 kg / head / day according to physiological status plus *ad-libitum* amounts of

Berseem hay (*Trifolium alexandrinum*). Fresh water was available for flock, once a day.

Weighing conditions. Body weights were recorded just before morning feeding at bimonthly intervals starting from weaning until 16 months of age, then at yearly intervals thereafter until the animal was removed from the flock. Weight at 48 months of age was considered the mature weight as it was the last weight taken and was different significantly ($P< 0.05$) from the preceding weight.

Data processing. Adjustments for individual body weights to different ages in the original data were carried out by interpolation between the data of two successive ages; growth during the short intervals being assumed to be linear. Animals having normal records were included in the analysis. An animal's record was considered abnormal if:

The animal was removed from the flock before 48 months of age;
The lamb was born as twin;
The sire of the lamb has less than 3 progeny;
The absolute growth rate of the lamb in two successive periods was negative.

Consequently, a total of 910 animals (530 females and 380 males) progeny of 49 unrelated sires were included in the analyses.

Expressing growth characteristics. Growth characteristics, defined in Table (1), were determined for each lamb.

Table (1): Symbols, Definitions and Working Algebraic Expressions for Growth Characteristics

Growth characteristic	**Related symbols, definitions and working algebraic expressions**
Amount of mature weight already attained at a given age, t	$W_t = U_t * W_m$; where U_t = proportion of mature weight already attained, W_m = mature weight
Amount of mature weight	W_m
Proportion of mature weight already attained at a given age, t	$U_t = W_t / W_m$
Average absolute growth rate in a given age interval (t_2-t_1)	$AGR_a = (W_{t2}-W_{t1}) / (t_2- t_1)$ $= \Delta W_t/ \Delta t$
Average absolute maturing rate in a given age interval (t_2-t_1)	$AMR_a = (U_{t2}-U_{t1}) / (t_2- t_1)$ $= \Delta U_t/ \Delta t$ $= W^{-1}_m \Delta W_t/ \Delta t$
Average relative growth rate (= relative maturing rate) in a given age interval (t_2-t_1)	$RGR_a = (\ln W_{t2}-\ln W_{t1}) / (t_2- t_1)$ $= \Delta \ln W_t/ \Delta t$ $= (\ln U_{t2}-\ln U_{t1}) / (t_2- t_1)$ $= \Delta \ln U_t / \Delta t$

Estimation of genetic and phenotypic parameters. The genetic and phenotypic parameters of the traits considered were estimated from sire components of variance and covariance using the following mixed model:

$$\mathbf{Y_{ijklm} = \mu + S_i + D_j + A_k + R_l + e_{ijklm}}$$

where:

Y_{ijklm} = the record of the m [th] lamb, progeny of the l [th] ram, born at the k[th] year, at the j[th] age of his dam and having an i[th] sex,
μ = the overall mean,
S_i = the fixed effect of the i[th] sex (i= 1,2),
D_j = the fixed effect of the j[th] age of dam (j=2,3,4,5,6),
A_k = the fixed effect of the k[th] year of birth (k=1 to 10),
R_l = the random effect of the l[th] ram (l= 1,2,…49)
e_{ijklm} = the random error assumed N.I.D. (0, $\sigma^2 e$).

The estimation was carried out using the Mixed Least Squares and Maximum Likelihood Computer Program of Harvey (1990).

Estimation of direct and correlated responses. While the direct response (DR) of a given trait was calculated as:

$$DR = I * h^2 * \sigma_P,$$

the correlated response (CR_Y) of a trait Y, with selection applied on a trait X, was calculated as:

$$CR_Y = I * h_X * h_Y * r_G * \sigma_{P(Y)}$$

where:
I = Intensity of selection on X,
h = Square root of the heritability, with subscript X or Y, according to
r_G = trait,
$\sigma_{P(Y)}$ = Genetic correlation between X and Y; and
Phenotypic standard deviation for the trait Y.

RESULTS AND DISCUSSION

Variation in degree of maturity and body weight. Table (2) shows means, genetic and phenotypic coefficients of variation and heritabilities for degree of maturity at ten ages from 4 months to maturity. For comparison, the corresponding statistics for body weight are also given.

Table (2): Means, Genetic and Phenotypic Coefficients of Variation (CV_G and CV_P) and Heritabilities (h^2) for Degree of Maturity in Body Weight ($U_t = W_t / W_m$) and Body Weight (W_t) at Successive Ages.

Age (mo)	Degree of maturity in body weight				Body weight			
	Mean (%)	CV_G (%)	CV_P (%)	h^2	Mean (kg)	CV_G (%)	CV_P (%)	h^2
04	40.82	15.04	26.68	0.32±0.05	18.80	12.98	22.82	0.32±0.05
06	47.79	14.40	25.80	0.31±0.05	22.01	13.04	23.08	0.32±0.05
08	55.04	11.70	25.01	0.22±0.04	25.35	11.99	22.01	0.30±0.05
10	62.46	11.54	24.39	0.22±0.04	28.77	12.65	21.45	0.35±0.05
12	67.78	11.46	23.49	0.24±0.04	31.22	12.49	21.59	0.34±0.05
14	71.04	10.56	21.52	0.24±0.04	32.72	11.40	21.15	0.29±0.05
16	75.81	9.04	19.68	0.21±0.04	34.92	11.11	20.33	0.30±0.05
24	85.89	5.36	14.64	0.13±0.04	39.56	15.24	26.49	0.33±0.05
36	92.73	7.29	16.14	0.20±0.04	42.71	14.80	26.39	0.31±0.05
Maturity (W_m)	100.00	00.00	00.00	----------	46.06	12.12	25.25	0.23±0.04

The phenotypic and genetic coefficients of variation in degree of maturity declined with age to zero at maturity. Degree of maturity was more variable than body weight genetically till 6 months and phenotypically till 14 months when the order is reversed. Heritability for degree of maturity, while declined from 4 to 10 months remained at about 0.24 from 12 to 14 months of age. Heritabilities for degree of maturity were essentially lower than the corresponding heritabilities for body weight.

The present h^2-value for 4-month body weight (0.32) is not far from other values obtained on the same breed (0.46, Fahmy, 1967; 0.45, Fahmy *et al.*, 1969; 0.42, Aboul-Naga and Afifi, 1982 and 0.39, Abdel Aziz, 2000) or other foreign fat-tail breeds from North Africa (Tunisian Barbary: 0.32, Demali *et al.*, 1994) or Asia (Mehraban Iranian: 0.34, Bathaei and Leroy, 1998). These values are much higher than those obtained on the other fat-tailed Egyptian breeds (Ossimi: 0.11, Aboul-Naga and Afifi, 1982; Rahmani: 0.14, Aboul-Naga and Afifi, 1982, 0.26, Abdel Aziz, 2000). The present values are by far lower than those obtained on the fat-tailed Awassi breed (0.73, Alrawi *et al.*, 1982; 0.82, Chaudhry and Shah, 1985).

For 6-month body weight, the present h^2-value (0.32) is below those reported by Mousa, (1989) on Ossimi (0.57) or Rahmani (0.54), by Bathaei and Leroy (1998) on Mehraban Iranian fat-tailed sheep (0.43) and by Chopra and Acharya (1971) on Bikaneri sheep (0.70), while higher than that calculated by Sharma *et al.*, 1999) on Nali Indian sheep (0.17).

The present h^2-value for 8-months weight (0.30) is not far from what obtained by Ercanbrack and Price (1977) on Targhee breed (0.35) while higher than their values obtained on Rambouillet (0.26) and Columbia (0.21) and lower than that calculated by Johari (1972) on Polwarth sheep (0.68).

For 10-months of age, the present h^2-value (0.35) is comparable to that reported on Columbia sheep (0.38, Ercanbrack and Price, 1977), but higher than those obtained on Romney Marsh (0.16, Radomska and Klewiec, 1976), Polish Mountain (0.17, Tecza *et al.*, 1974), Rambouillet and Columbia respectively, 0.32 and 0.38, Ercanbrack and Price, 1977) and lower than those calculated for Polwarth sheep (0.64, Johari, 1972) and Targhee sheep (0.54, Ercanbrack and Price, 1977).

The h^2-value given in this work for 12-month body weight (0.34) is comparable to that already obtained on the same breed (0.41, Fahmy *et al.*, 1969), and on the Mehraban Iranian fat-tailed breed (0.44, Bathaei and Leroy, 1998). These values are much higher than those obtained on other the fat-tailed Egyptian breeds (Ossimi: 0.17, Rahmani: 0.03, Aboul-Naga and Afifi, 1982). The present value is lower than that calculated for Awassi (0.53, Alrawi *et al.*, 1982).

For 24-month body weight, the present h^2-value (0.33) is lower than that obtained on Mehraban Iranian fat-tailed (0.45, Bathaei and Leroy, 1998).

Inter-age correlations for degree of maturity. The genetic inter-age correlations for degree of maturity were almost always lower than the corresponding phenotypic correlations (Table 3). All were positive, so that animals more mature at a given age also tended to be more mature at any later age.

Table (3): Genetic (above diagonal) and Phenotypic (below diagonal) Correlations among Degrees of Maturity ($U_t = W_t / W_m$) at Successive Ages.

	U_{04}	U_{06}	U_{08}	U_{10}	U_{12}	U_{14}	U_{16}	U_{24}	U_{36}
U_{04}	-----	0.94	0.76	0.56	0.38	0.28	0.23	0.14	0.06
U_{06}	0.87	-----	0.98	0.83	0.65	0.52	0.48	0.19	0.25
U_{08}	0.75	0.80	-----	0.91	0.82	0.66	0.59	-0.09	0.26
U_{10}	0.67	0.72	0.92	-----	0.96	0.86	0.75	-0.11	0.52
U_{12}	0.57	0.61	0.84	0.93	-----	0.93	0.86	-0.05	0.60
U_{14}	0.52	0.53	0.76	0.84	0.90	-----	0.98	0.14	0.75
U_{16}	0.47	0.46	0.72	0.78	0.82	0.91	-----	0.19	0.73
U_{24}	0.36	0.29	0.48	0.50	0.53	0.62	0.69	-----	0.36
U_{36}	0.30	0.29	0.47	0.52	0.55	0.60	0.65	0.70	-----

Inter-age correlations for body weight. These correlations are shown in Table (4). The variation in marketing body weight at 10 months of age expressed itself to a large extent in marketing body weight at 12 months (r_G=0.97; r_P=0.93). This is in agreement with a previous report by Ercanbrack and Price (1972) on Rambouillet (r_G=0.99; r_P=0.93), Targhee (r_G=0.88, r_P=0.89) and Columbia sheep (r_G=0.97; r_P=0.89).

The present study showed very high positive correlations among the body weights at 4, 6 and 8 months of age (r_G ranged from 0.76 to 0.94 and r_P from 0.80 to 0.92), such that they can interchangeably characterized the early growth potential. The 4-month weight showed a high relationship with the 6-month weight (r_G=0.90; r_P=0.89). This confirms previous works on Awassi sheep (r_G=0.65; r_P=0.83, Juma *et al.*, 1969; r_P=0.90, Alrawi *et al.*, 1982) and Mehraban Iranian fat-tailed sheep (r_G=0.95, r_P=0.83, Bathaei and Leroy, 1998).

Table (4): Genetic (above diagonal) and Phenotypic (below diagonal) Correlations among the Body Weights (W_t) at Successive Ages.

	W_{04}	W_{06}	W_{08}	W_{10}	W_{12}	W_{14}	W_{16}	W_{24}	W_{36}	W_m
W_{04}	----	0.90	0.76	0.59	0.43	0.34	0.30	0.38	0.27	0.33
W_{06}	0.89	----	0.94	0.84	0.71	0.57	0.50	0.30	0.35	0.35
W_{08}	0.80	0.92	----	0.94	0.88	0.75	0.70	0.40	0.51	0.51
W_{10}	0.71	0.84	0.93	----	0.97	0.89	0.82	0.42	0.65	0.56
W_{12}	0.62	0.75	0.85	0.93	----	0.94	0.88	0.46	0.70	0.60
W_{14}	0.56	0.68	0.79	0.86	0.92	----	0.98	0.59	0.84	0.63
W_{16}	0.52	0.63	0.74	0.80	0.85	0.93	----	0.67	0.90	0.67
W_{24}	0.43	0.48	0.54	0.57	0.61	0.70	0.76	----	0.79	0.86
W_{36}	0.36	0.42	0.49	0.54	0.59	0.67	0.73	0.86	----	0.78
W_m	0.35	0.42	0.49	0.52	0.57	0.62	0.65	0.80	0.76	----

The body weights at 24, 36 and 48 months of age can interchangeably characterize the late growth potential as they were found to be highly intercorrelated genetically (r_G ranged from 0.78 to 0.86) and phenotypically (r_P ranged from 0.76 to 0.86).

The marketing (W_{10}, W_{12}) and pre-marketing (W_{04}, W_{06}, W_{08}) stages show from moderate to high genetic correlations (r_G ranging from 0.43 to

0.94) and from fairly high to high phenotypic correlations (r_P ranging from 0.62 to 0.93). This result implies the possibility of selecting heavier animals at marketing by using early information. The present work showed full agreement with previous reports concerning the magnitude of many individual correlations [4-month weight with 12-month weight: (r_G=0.43 and r_P=0.62, Table 4; r_G=0.78 for Barki, Fahmy, 1967; r_P=0.75 for Awassi, Juma *et al.*, 1969); 6-month weight with 10-month weight: r_G=0.84 and r_P=0.84, Table 4; r_G=0.89 and r_P=0.82 for Rambouillet; r_G=0.71 and r_P=0.83 for Targhee and r_G=0.90 and r_P=0.84 for Columbia, Ercanbrack and Price, 1972; 6-month weight with 12-month weight: r_G=0.71 and r_P=0.75, Table 4; r_G=0.53 and r_P=0.66 for Mehraban Iranian fat-tailed sheep, Bathaei and Leroy, 1998; 8-month weight with 10-month and 12-month weights: r_G=0.94, r_P=0.93 and r_G=0.88 and r_P=0.85, respectively, Table 4; r_G=0.88, r_P=0.86 and r_G=0.85, r_P=0.75, respectively for Rambouillet; r_G=0.63, r_P=0.88 and r_G=0.48, r_P=0.75, respectively for Targhee and r_G=0.88, r_P=0.88 and r_G=0.76, r_P=0.74, respectively for Columbia sheep, Ercanbrack and Price, 1972].

The marketing and post-marketing stages show fairly high genetic correlations (r_G ranging from 0.42 to 0.70) and phenotypic correlations (r_P ranging from 0.52 to 0.61). This indicates that any change in body weights at the marketing stage would lead to a concomitant change in the post-marketing body weights including the mature body weight.

Genetic improvement of pre-marketing body weights is expected to result in increase in 24-month weight (r_G ranging from 0.30 to 0.40, r_P ranging from 0.43 to 0.54); 36-month weight (r_G ranging from 0.27 to 0.51, r_P ranging from 0.36 to 0.49) and 48-month weight (r_G ranging from 0.33 to 0.51, r_P ranging from 0.35 to 0.49). Thus, early selection for body weight would lead to a significant change in the growth curve after attaining more than 85% maturity.

Correlations of degree of maturity with body weight. The correlations between degree of maturity and body weight at the same age were positive, indicating that genetically heavier animals at any given age tended to be more mature (Table 5). However, as the age interval between degree of maturity and body weight increased, the correlation declined and even become negative if the interval was long enough. Almost all correlations were negative between degree of maturity and mature body weight.

The implications of these results are that (i) animals more mature at any age tended to be lighter at maturity; (ii) animals heavy at maturity tended to be relatively less mature in body weight at earlier age, and (iii) animals selected for increased weight at a fixed age will show increased average degree of maturity, and to less extent at adjacent ages.

The genetic flexibility in the shape of the degree of maturity-age curve depends partially on degree of independence of degree of maturity from mature weight. For the ten-ages considered the genetic regression coefficients of ln degree of maturity on ln mature weight ranged from –0.26 to –0.64, and the related residual genetic coefficients of variation in ln degree of maturity at constant age, holding mature ln weight constant, ranged from -21 to –167 % (Table 6).

Table (5): Genetic (G) and Phenotypic (P) Correlations between Degree of Maturity ($U_t = W_t / W_m$) and Body Weights (W_t) at Successive Ages.

Degree of Maturity		Body weight at:									
		W_{04}	W_{06}	W_{08}	W_{10}	W_{12}	W_{14}	W_{16}	W_{24}	W_{36}	W_m
U_{04}	G	0.65	0.47	0.24	0.05	-0.09	-0.17	-0.23	-0.25	-0.30	-0.44
	P	0.52	0.36	0.21	0.09	-0.02	-0.08	-0.14	-0.27	-0.29	-0.52
U_{06}	G	0.63	0.61	0.12	0.27	0.14	0.04	-0.03	-0.24	-0.20	-0.41
	P	0.47	0.49	0.34	0.23	0.11	0.02	-0.05	-0.24	-0.23	-0.46
U_{08}	G	0.46	0.59	0.54	0.41	0.36	0.23	0.13	-0.33	-0.18	-0.38
	P	0.35	0.38	0.40	0.29	0.19	0.10	0.03	-0.23	-0.21	-0.51
U_{10}	G	0.32	0.53	0.55	0.57	0.56	0.49	0.34	-0.28	0.06	-0.28
	P	0.25	0.29	0.32	0.35	0.26	0.16	0.08	-0.22	-0.18	-0.51
U_{12}	G	0.13	0.36	0.45	0.51	0.57	0.53	0.40	-0.28	0.08	-0.28
	P	0.18	0.23	0.27	0.31	0.35	0.24	0.15	-0.18	-0.13	-0.47
U_{14}	G	-0.06	0.14	0.25	0.37	0.44	0.51	0.42	-0.28	0.10	-0.36
	P	0.13	0.17	0.22	0.26	0.29	0.35	0.25	-0.10	-0.07	-0.46
U_{16}	G	-0.11	0.11	0.22	0.31	0.41	0.52	0.46	-0.24	0.11	-0.36
	P	0.07	0.11	0.15	0.18	0.19	0.25	0.30	-0.08	-0.05	-0.48
U_{24}	G	0.18	0.12	0.09	0.07	0.11	0.28	0.32	0.57	0.35	0.12
	P	0.09	0.07	0.07	0.07	0.07	0.14	0.19	0.30	0.16	-0.32
U_{36}	G	-0.01	0.14	0.21	0.39	0.46	0.59	0.54	0.09	0.54	-0.06
	P	-0.00	-0.01	0.02	0.04	0.05	0.09	0.12	0.07	0.34	-0.36

Table (6): Genetic Regression Coefficients of ln Degree of Maturity (ln U) on ln Mature weight (ln W_m).

Dependent variable (ln U)	Genetic regression coefficient of Ln U on ln W_m	Residual genetic coefficient of variation (%)
ln U_{04}	-0.64	-20.59
ln U_{06}	-0.56	-23.20
ln U_{08}	-0.52	-26.45
ln U_{10}	-0.51	-31.27
ln U_{12}	-0.45	-37.18
ln U_{14}	-0.41	-42.35
ln U_{16}	-0.41	-48.12
ln U_{24}	-0.26	-77.39
ln U_{36}	-0.32	-166.78

The amount of the genetic variation in degree of maturity that was independent of mature weight ranged from 58 to 95 % (Table 7). Thus, among animals of similar mature weight, there remained considerable genetic variation in degree of maturity.

Variation in average gain rate. All measures of average gain rate declined from 4 to 48 months of age whereas body weight and degree of maturity increased (Table 8) The genetic coefficient of variations for all measures were lower than the corresponding phenotypic coefficients. The coefficients of variations reached their highest values for the three measures of gain rate between 36 and 48 months of age.

Table (7): Genetic Covariation (%) of Degrees of Maturity with Mature Weight at Various Ages.

Dependent variable (U)	Genetic covariation of U with mature weight as % of total genetic variation in (U)	Remaining genetic variation in (U) at the same mature weight (%)
U_{04}	42.11	57.89
U_{06}	35.60	64.40
U_{08}	32.83	67.17
U_{10}	19.98	80.02
U_{12}	19.83	80.17
U_{14}	27.90	72.10
U_{16}	31.03	68.97
U_{24}	12.98	87.02
U_{36}	04.82	95.18

Table (8): Means, Genetic and Phenotypic Coefficients of Variation (CV_G and CV_P) and Heritabilities (h^2) for Average Absolute Growth Rate (AGR_a), Average Absolute Maturing Rate (AMR_a) and Average Relative Growth Rate (RGR_a) for Successive Age Intervals.

Age	Mean gain rates per day			CV_G (%)			CV_P (%)			h^2		
Interval (mo)	AGR_a (g)	AMR_a (%)	RGR_a (%)	AGR_a	AMR_a	RGR_a	AGR_a	AMR_a	RGR_a	AGR_a	AMR_a	RGR_a
04 to 08	53.76	0.10	0.24	21.23	22.91	26.73	46.11	50.00	45.83	0.21± 0.06	0.21± 0.06	0.34± 0.07
08 to 12	49.43	0.09	0.17	28.26	31.72	29.19	49.81	55.56	52.94	0.32± 0.07	0.33± 0.07	0.30± 0.07
12 to 16	42.81	0.08	0.13	20.84	27.53	28.07	57.37	62.50	61.54	0.13± 0.06	0.19± 0.06	0.21± 0.06
16 to 24	29.98	0.05	0.07	48.24	53.76	44.54	90.36	100.00	85.71	0.29± 0.07	0.29± 0.07	0.27± 0.07
24 to 36	9.11	0.01	0.02	48.75	67.08	67.16	70.58	100.00	100.00	0.48± 0.07	0.45± 0.07	0.45± 0.07
36 to 48	8.76	0.01	0.02	83.62	136.53	70.71	118.61	200.00	100.00	0.50± 0.07	0.47± 0.07	0.50± 0.07

Inter-age correlations for the same measure of average gain rate. Positive correlations associated absolute growth rate (AGR_a) from 4 to 8 months with AGR_a from 8 to 16 and from 24 to 36 months, and associated AGR_a from 12 to 16 months with AGR_a from 24 months till maturity (Table 9). AGR_a from 16 to 24 months were negatively correlated with AGR_a from 24 months to maturity. Other correlations involving AGR_a were negligible.

Animals that matured faster than average from 4 to 8 months tended to continue to mature faster than average rate till 16 months of age. Animals that matured faster than average from 12 to 16 months tended to mature faster than average during the interval of 24 to 36 months of age.

Table (9): Genetic Correlations between the Same Average of Gain Rates in Different Age Intervals.

Age interval	Age interval				
	08 to 12 mo	12 to 16 mo	16 to 24 mo	24 to 36 mo	36 to 48 mo
04 to 08 mo	0.45[a]	0.39	-0.11	0.16	0.04
	0.37[b]	0.31	-0.29	0.01	-0.06
	0.40[c]	0.33	-0.29	0.08	0.08
08 to 12 mo		0.01	0.22	-0.06	-0.11
		-0.11	-0.05	-0.22	-0.10
		-0.08	-0.00	-0.12	-0.07
12 to 16 mo			-0.06	0.42	-0.10
			-0.19	0.42	-0.23
			-0.09	0.51	-0.18
16 to 24 mo				-0.33	-0.37
				-0.42	-0.53
				-0.41	-0.36
24 to 36 mo					0.15
					0.03
					0.13

[a] = Between Average Absolute Growth Rates (AGR_a) in two different age intervals.
[b] = Between Average Absolute Maturing Rate (AMR_a) in two different age intervals.
[c] = Between Average Relative Growth Rate (RGR_a) in two different age intervals.

Correlations of different measures of average gain rate. All three measures of average gain rate were highly genetically correlated with each other whenever (Table 10) they referred to the same period of gain. The average were 0.90, 0.95, 0.92, 0.98, 0.95 and 0.97 for, respectively, the intervals between 4 to 8 mo, 8 to 12 mo, 12 to 16 mo, 16 to 24 mo, 24 to 36 mo and 36 to 48 mo; with an overall average of 0.95.

All measures of average gain rate at the first four age intervals were negatively correlated with all measures of average gain rate from 36 to 48 months of age.

Expected direct and correlated responses to selection. Expected responses to selection for body weights and degrees of maturity (Table 11) indicated substantial increase in weight at age of selection but a slightly less increase in weight at all other ages, including maturity. The same trend was found with selection for degree of maturity. Selection for weight at maturity would decrease degree of maturity at early age. Expected responses in degree of maturity for early age (U_4 and U_{12}) result more from increase in weight at 4 and 12 months than from decrease in maturity weight. This expectation follows essentially from the negative genetic relationships between mature weight and maturing rate.

Table (10): Genetic Correlations between Average Gain Rates in Different Age Intervals.

Age Interval	Age interval					
	04 to 08 mo	08 to 12 mo	12 to 16 mo	16 to 24 mo	24 to 36 mo	36 to 48 mo
04 to 08 mo	0.87[a]	0.32	0.17	-0.11	0.06	-0.09
	0.89[b]	0.27	0.09	-0.16	0.01	-0.06
	0.93[c]	0.27	0.20	-0.38	-0.04	-0.07
08 to 12 mo	0.32	0.94	-0.17	0.10	-0.22	-0.17
	0.42	0.94	-0.23	0.12	-0.22	-0.19
	0.42	0.97	-0.17	-0.03	-0.21	-0.14
12 to 16 mo	0.38	-0.05	0.90	0.00	0.45	-0.23
	0.51	0.08	0.90	0.02	0.38	-0.25
	0.36	-0.04	0.95	-0.20	0.37	-0.27
16 to 24 mo	-0.37	0.05	-0.28	0.98	-0.47	-0.49
	-0.28	0.06	-0.21	0.98	-0.52	-0.41
	-0.26	-0.04	-0.11	0.99	-0.48	-0.46
24 to 36 mo	0.02	-0.14	0.25	-0.32	0.94	0.05
	0.15	-0.02	0.38	-0.25	0.93	0.04
	0.11	-0.13	0.55	-0.37	0.98	0.01
36 to 48 mo	-0.04	-0.12	-0.21	-0.44	0.07	0.96
	0.13	-0.02	-0.11	-0.33	0.19	0.97
	0.08	-0.03	-0.15	-0.43	0.15	0.99

[a] =Between average absolute growth rate (AGR_a) and average absolute maturing rate (AMR_a).
[b] =Between (AGR_a) and average relative growth rate (RGR_a).
[c] =Between (AMR_a) and (RGR_a).

Table (11): Expected Direct and Correlated Responses Per Generation to Selection for Body Weights (W_t) and Degrees of Maturity ($U_t = W_t / W_m$) at Successive Ages.

Selection Criterion	Responses, % of initial means for traits								
	W_{04}	W_{12}	W_{24}	W_{36}	W_{48}	U_{04}	U_{12}	U_{24}	U_{36}
W_{04}	7.37	3.15	3.89	2.93	2.57	5.58	0.82	-2.12	-0.04
W_{12}	3.33	7.23	4.74	6.56	4.40	-0.78	3.76	0.33	1.92
W_{24}	3.35	3.86	8.77	6.93	6.08	-2.12	-1.85	1.76	0.38
W_{36}	2.54	5.36	6.96	8.29	5.44	-2.49	0.52	1.05	2.19
W_{48}	2.33	3.76	6.37	5.68	5.81	-3.20	-1.54	0.30	-0.21
U_{04}	4.77	-0.63	-2.11	-2.46	-3.03	8.48	2.43	0.43	0.26
U_{12}	0.80	3.46	-2.09	0.58	-1.65	2.76	5.59	-0.14	2.13
U_{24}	0.85	0.49	3.18	1.88	0.51	0.78	-0.22	1.96	0.95
U_{36}	-0.05	2.57	0.63	3.58	-0.33	0.43	3.10	0.86	3.29
Initial means	18.80	31.22	39.56	42.71	46.06	42.43	70.15	86.59	93.62

Expected responses to selection for AGR_a, AMR_a or RGR_a (Table 12) at early stages (4 to 8 months) indicated increase in body weight and degree of maturity at 12, 36 and 48 months and decrease in degree of maturity at 24 months. Selection for AGR_a or AMR_a after 12 months would decrease body weight and degree of maturity at the subsequent ages.

As anticipated, increase in mature weight would be expected from animals selected for their lower than average RGR_a after the age of 12 months.

The favoured genotypes for AGR_a, AMR_a or RGR_a (Table 13) in the 4 to 8 months interval are expected to have increased rates of gain in the subsequent intervals till 36 months of age. The same is expected for those selected for their rates in the 12 to 16 months interval.

Table (12): Expected Direct and Correlated Responses Per Generation to Selection for Body Weights (W_t) and Degrees of Maturity ($U_t = W_t / W_m$) with Average Gain Rates.

Selection criterion	Responses, % initial means for traits								
	W_{04} (kg)	W_{12} (kg)	W_{24} (kg)	W_{36} (kg)	W_{48} (kg)	U_{04} (%)	U_{12} (%)	U_{24} (%)	U_{36} (%)
Gain rates per day in 04 to 08 mo interval:									
AGR_a, g	0.40	4.91	-3.33	4.32	4.34	-4.24	0.49	-6.76	0.10
AMR_a, %	-0.82	2.99	0.62	1.32	1.48	-2.95	1.36	-0.48	0.02
RGR_a, %	-3.18	2.66	0.63	1.72	2.64	-6.49	-0.11	-1.37	-0.51
Gain rates per day in 12 to 16 mo interval:									
AGR_a, g	-0.99	-0.45	0.48	1.17	1.17	-2.49	-1.64	-0.36	0.17
AMR_a, %	-2.03	-1.96	-1.65	-1.10	-0.92	-1.58	-1.32	-0.46	0.12
RGR_a, %	-2.64	-2.96	-1.64	-0.98	-0.72	-2.49	-2.56	-0.59	-0.01
Gain rates per day in 24 to 36 mo interval:									
AGR_a, g	-1.35	2.37	-1.04	3.11	3.25	-4.74	-0.40	-3.33	0.07
AMR_a, %	-1.98	1.03	-2.92	1.19	1.36	-3.62	-0.01	-3.40	0.09
RGR_a, %	-2.37	0.79	-3.19	0.83	1.25	-3.92	-0.18	-3.53	-0.13
Gain rates per day in 36 to 48 mo interval:									
AGR_a, g	-3.09	-1.10	-2.25	-1.74	1.14	-4.19	-2.55	-2.68	-2.13
AMR_a, %	-3.49	-2.32	-3.80	-3.59	-0.54	-3.03	-2.32	-2.64	-2.31
RGR_a, %	-4.02	-2.59	-4.25	-3.98	-0.79	-3.35	-2.31	-2.76	-2.41
Initial means	18.80	31.22	39.56	42.71	46.06	42.43	70.15	86.59	93.62

AGR_a = Average absolute growth rate, AMR_a= Average absolute maturing rate, RGR_a = Average relative growth rate.

Table (13): Expected Direct and Correlated Responses to Selection for Average Gain Rates.

Selection criterion	Responses, % of initial means for gain rates in											
	04 to 08 mo interval			12 to 16 mo interval			24 to 36 mo interval			36 to 48 mo interval		
	AGRa	AMRa	RGRa	AGRa	AMRa	RGRa	AGRa	AMRa	RGRa	AGRa	AMRa	RGRa
Average gain rates per day in 04 to 08 mo interval:												
AGRa, g	9.78	9.00	12.50	3.76	2.50	1.54	3.51	2.00	0.25	1.37	-06.00	-02.00
AMRa, %	8.43	10.00	12.50	3.60	3.75	2.31	0.04	0.40	-1.50	-1.71	-04.00	-02.00
RGRa, %	10.98	10.00	15.58	6.31	6.25	5.39	4.17	4.00	3.00	6.39	7.00	3.50
Average gain rates per day in 12 to 16 mo interval:												
AGRa, g	2.98	3.00	4.17	7.57	8.75	7.69	7.46	10.00	10.00	-3.08	-10.00	-05.00
AMRa, %	1.62	3.00	4.17	8.29	12.50	15.38	5.49	10.00	10.00	-7.65	-10.00	-10.00
RGRa, %	0.91	2.00	4.17	8.53	12.50	15.38	8.45	20.00	15.00	-4.11	-09.00	-05.00
Average gain rates per day in 24 to 36 mo interval:												
AGRa, g	2.31	0.30	2.92	6.05	5.00	7.69	33.70	40.00	45.00	8.68	5.00	2.00
AMRa, %	0.86	0.20	2.08	6.33	7.50	15.38	30.63	50.00	45.00	4.00	3.00	0.35
RGRa, %	0.11	-0.60	0.07	5.37	7.50	7.69	30.63	40.00	45.00	10.84	10.00	5.00
Average gain rates per day in 36 to 48 mo interval:												
AGRa, g	0.52	-0.70	2.50	-1.47	-3.75	-2.31	5.16	3.00	10.00	58.90	90.00	50.00
AMRa, %	-1.30	-0.90	1.67	-3.29	-3.75	-3.08	1.65	1.00	5.00	54.91	90.00	50.00
RGRa, %	-0.87	-1.00	1.67	-3.69	-5.00	-3.85	1.43	0.30	5.00	57.19	100.00	50.00
Initial means	53.76	0.10	0.24	42.81	0.08	0.13	9.11	0.01	0.02	8.76	0.01	0.02

REFERENCES

Abdel Aziz, M. (2000). Heritability, genetic and phenotypic correlations of preweaning growth traits of Rahmany and Barki lambs. Alexandria J. Agric. Res., 45: 13-21.

Aboul-Naga, A. M. and E. A. Afifi (1982). Genetic and phenotypic parameters of lamb performance traits in Ossimi, Rahmani and Barki local sheep. 6th Int. Conf. Anim. Poult. Prod., Zagazig, 1: 272-284.

Alrawi, A. A., F. S. Badawi, S. I. Said and M. S. Farag (1982). Genetic and phenotypic parameters estimates for growth traits in Awassi sheep. Indian J. Anim. Sci., 52: 897-900.

Bathaei, S. S. and P. L. Leroy (1998). Genetic and phenotypic aspects of the growth curve characteristics in Mehraban Iranian fat-tailed sheep. Small Ruminant Research, 29: 261-269.

Chaudhry, M. Z. and S. K. Shah (1985). Heritability and correlation of birth weight, weaning weight and 12 months weight in Lohi, Awassi, Hissardale and Kachhi sheep. Pakistan Vet. J., 5: 67-71 (Anim. Breed. Abstr.,1986,54,abst. 2958).

Chopra, S. C. and R. M. Acharya (1971). Genetic and phenotypic parameters of body weights in Bikaneri sheep (Magra strain). Anim. Prod., 13: 343-347.

Demali, M., R. Aloulou and M. B. Sassi (1994). Adjustment factors and genetic and phenotypic parameters for growth traits of Barbarine lambs in Tunisia. Small Ruminant Research., 13: 41-47.

Ercanbrack, S. K. and D. A. Price (1972). Selecting for weight and rate of gain in non-inbred lambs. J. Anim. Sci., 39:713-725.

Ercanbrack, S. K. and D. A. Price (1977). Selecting for weight and rate of gain in inbred lambs. J. Anim. Sci., 44: 532-541.

Fahmy, M. H. (1967). Genetic and environmental factors affecting sheep production under desert conditions. Ph.D. Thesis, Faculty of agriculture, Ain Shams Univ., Egypt.

Fahmy, M. H., E. S. E. Galal, Y. S. Ghanem and S. S. Khishin (1969). Genetic parameters of Barki sheep raised under semi-arid conditions. Anim. Prod., 11: 361-367.

Fitzhugh, H., A. Jr. (1976). Analysis of growth curves and strategies for altering their shape. J. Anim. Sci. 42: 1036-1051

Fitzhugh, H., A. Jr. and St. C. S. Taylor (1971). Genetic analysis of degree of maturity. J. Anim. Sci. 33: 717-725.

Harvey, W. R. (1990). LSMLMW Mixed Least Squares and Maximum Likelihood Computer Program PC-2 Version. Dairy Sci. Department, the OH State Univ., Columbus, OH.

Johari, D. C. (1972). Body weight from birth to one year in Polwarth sheep. Indian J. Heredity, 4: 38-40.

Juma, K. H., M. Faraj, J. Eliya and K. Al-Aubaidy (1969). Studies on growth in Awassi sheep. Indian J. Anim. Sci., 39: 503-510.

Mousa, E. F. A. (1989). Phenotypic and genetic variation in lambs growth. M. Sc. Thesis, Faculty of Agriculture, Assuit Univ., Egypt.

Radomska, M. J. and J. Klewiec (1976). Comparative analysis of certain Romney Marsh pedigree flocks. 3. Selection indices. Prace-i-Materialy-Zootechniczne.11: 17-23 (Anim. Breed. Abst., 1977, 45 abst. 7090).

Ragab M.T. and K.E. Ghoneim, (1961). Wool characteristics of the Barki sheep. J. Anim. Prod. U.A.R., 1:23-35.

Sharma, P. R., B. K. Beniwal, V. K. Singh, D. Gopal and G. Dass (1999). Growth of Nali sheep in arid zone of Rajasthan. Indian J. Anim. Sci., 69: 1065-1066.

Tecza, S., H. Duniec and W. Nawara (1974). Selection indices for Polish Mountain rams and ewes. Roczniki Nauk Rolniczych, B. 95: 23-30 (Anim. Breed. Abst., 1975, 43 abst. 3451).

العلاقات الوراثية و المظهرية بين وزن الجسم ودرجة النضج ومقاييس معدلات الزيادة للأغنام البرقى بدون اللجوء إلى مواءمة دوال النمو

سلوى إبراهيم الوكيل * ، أحمد راغب شميس ** ، على أحمد مصطفى * و عمر يسرى عبد الله **

*** شعبة الإنتاج الحيوانى والدواجن، مركز بحوث الصحراء ، المطرية، القاهرة.**

**** قسم الإنتاج الحيوانى، كلية الزراعة، جامعة عين شمس، شبرا الخيمة، ١١٢٤١ القاهرة، مصر.**

تم تقدير المعالم الوراثية والمظهرية لأوزان الجسم ودرجات النضج ومعدلات النمو من عمر ٤ شهور إلى ٤٨ شهر لعدد ٩١٠ من الأغنام البرقى (٥٣٠ أنثى، ٣٨٠ ذكر) من نسل ٤٩ كبش. استخدمت هذه المعالم للتنبؤ بالاستجابة للانتخاب سواء كانت هذه الاستجابة مباشرة أم غير مباشرة. وقد حدد الوزن عند عمر ٤٨ شهر ليكون الوزن الناضج حيث أنه آخر وزن سجل للحيوان واختلف معنويا (احتمال أقل من ٠,٠٥) عن الوزن السابق له. وقد أظهرت النتائج المتحصل عليها أن معاملات الاختلاف المظهرية والوراثية لصفة درجة النضج تراجعت مع تقدم الحيوان فى العمر حتى وصلت إلى الصفر عند تمام النضج. وقد كانت درجة النضج أكثر تباينا من وزن الجسم نفسه، وذلك وراثيا حتى عمر ٦ شهور ومظهريا حتى عمر ١٤ شهرا، وقد انعكس الوضع بعد ذلك. وقد كانت المكافآت الوراثية المقدرة لدرجة النضج أقل من تلك المقدرة لوزن الجسم بشكل عام. وأن الارتباطات الوراثية داخل المرحلة العمرية الواحدة كانت أقل من نظيراتها المظهرية وكانت جميعها موجبة، حيث أن الحيوانات الأكثر نضجا عند عمر معين تميل أيضا لأن تكون أكثر نضجا عند أى عمر آخر. وقد سجلت معاملات ارتباط عالية داخل مجموعة الأوزان عند التسويق (الوزنان عند١٠ و١٢ شهر) ومجموعة الأوزان قبل التسويق (الأوزان عند ٤ و٦ و ٨ شهور) وفى المجموعة التالية على التسويق (الأوزان عند ٢٤ و ٣٦ و ٤٨ شهر). وقد أوضحت الدراسة كذلك أن الارتباطات الوراثية والمظهرية بين الأوزان عند التسويق وعند المراحل المبكرة من عمر الحيوان كانت عالية، وهو ما يشير إلى إمكانية انتخاب الحيوانات الأعلى وزنا باستخدام المعلومات المبكرة. وقد تراجعت كل مقاييس معدل الزيادة المتوسطة خلال أعمار الدراسة وقد وصلت معاملات الاختلاف أعلى مستوياتها بالنسبة لسرعة النمو المطلقة المتوسطة (AGR_a) وسرعة النضج المطلقة المتوسطة (AMR_a) بين عمرى ١٦ و٢٤ شهرا، و بالنسبة لسرعة النمو النسبي المطلقة المتوسطة (RGR_a) بين عمرى ٣٦ و ٤٨ شهرا. كما أوضحت الدراسة أن سرعات الزيادة الثلاثة كانت مرتبطة ارتباطا وراثيا عاليا فيما بينها عندما يتعلق الأمر بنفس الفترة الزمنية، وقد كانت تقديراتها خلال المراحل العمرية الخمسة الأولى على ارتباط سالب مع تقديراتها خلال الفترة ما بين ٣٦ و ٤٨ شهرا من العمر. وقد أظهرت الدراسة أنه من المتوقع حدوث زيادات عالية فى الوزن عند عمر الانتخاب وزيادات أقل فى الوزن عند الأعمار الأخرى نتيجة للانتخاب لوزن الجسم ودرجة النضج، وأن الانتخاب لمعدلات الزيادة المطلقة المتوسطة فى المراحل العمرية المبكرة (من ٤- ٨ شهور) يتوقع أن تؤدى إلى زيادة فى وزن الجسم وفى درجة النضج عند المراحل التالية. أما الانتخاب لسرعات الزيادة المتوسطة المطلقة فى النمو وفى النضج بعد عمر ١٢ شهر فيتوقع أن يؤدى إلى تأثير طفيف فى وزن النضج. وقد وضح أن الزيادة فى الوزن الناضج يتوقع أن تحدث فى الحيوانات المنتخبة ضد معدل الزيادة النسبية والمطلقة المقدرة بعد عمر ١٢ شهر.