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# Genetic and Phenotypic Parameter Estimates of Body Weight at Different Ages and Yearling Fleece Weight in Markhoz Goats

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**ABSTRACT :** The objective of the present study was to estimate genetic parameters for economic traits in Markhoz goats. Data collected from 1993 to 2006 by the Markhoz goat Performance Testing Station in Sanandaj, Iran, were analyzed. The traits recorded as body weight performance at birth (BW), weaning (WW), six month (6MW), nine month (9MW), yearling (YW) and yearling fleece weight (YFW) were investigated. Least square analyses were used for estimation of environmental effects. Genetic parameters were estimated with single and multi trait analysis using restricted maximum likelihood (REML) procedures, under animal models. By ignoring or including maternal additive genetic effects and maternal permanent environmental effects, five different models were fitted for each trait. The effects of sex, type of birth, age of dam and year of birth on the all body weights were significant ($p<0.01$), but had no effects on YFW except year of birth. Age of kids had significant influences on WW and 6MW ($p<0.01$). A log likelihood ratio test was carried out for choosing the most suitable model for each trait. Total heritability estimates for YFW and growth traits varied from 0.16 for YFW and WW to 0.41 for YW. For all traits, maternal heritability was lower than direct heritability, ranging from 0.06 for BW to 0.01 for 6MW and 9MW. The magnitude of $c^2$ was more substantial for BW than the others, and relative importance was reduced from 0.12 for BW to 0.04 for 9MW. The direct additive genetic correlations estimates were positive and varied from 0.21 between BW-YW to 0.96 between WW-6MW. Direct additive genetic correlations between YFW and body weight traits were positive and ranged from 0.14 between BW-YFW to 0.67 between 6MW-YFW. For all traits, the corresponding estimates for phenotypic correlation were positive and lower than genetic correlations. The maternal additive genetic correlations between various traits were varied and ranged from -0.19 between 9MW-YFW to 0.96 between 6MW-9MW. The estimates of the maternal permanent environmental correlations between various traits were positive and ranged from 0.33 between WW-YFW to 0.93 between WW-6MW. Also, the environmental correlations between various traits ranged from 0.01 between BW-YFW and WW-YFW to 0.70 between 9MW-YW. Estimates of genetic parameters for various traits in this study confirm that selection should be applied on WW for genetic improvement in Markhoz goats. (**Key Words :** Markhoz Goat, Body Weight, Mohair, Heritability, Genetic Correlations)

## INTRODUCTION

The beginning of Markhoz goat rising in Kurdistan goes back to 10,000 years ago. The bones of a goat (*capra hirecus*) found at Ganj Dareh in Kermanshah province, shows the earliest secure evidence of goat domestication in Kurdistan (Zeder and Hesse, 2000). Markhoz goats are a multi purpose breed. Mohair and kids sale are main sources of income for producer, whereas milk production from this animal is of secondary importance (Rashidi, 2000). Markhoz goats, is only breed raised for colour mohair production. The colours of these goats are white, sandy brown, saddle brown, grey, black and combination between them with partial dominant effects. These goats adapted to the wide range and forest mountain in harsh region, and produce in the low input-low output system. Predominant feed of animals during winter is tree foliage, which collected from Oak trees (*Quercus, ssp.*) during the summer. The animals are shorn once per year. Today about 25,000 Markhoz goats are raised in Kurdistan province of Iran and produce about 20 ton of mohair annually. The mohair obtained from these animals has important cultural role for making of local clothes in Kurdistan. Although, goats have been traditionally one of the major sources of red meat in Iran (102,000 ton per year), however there are limited published results on the estimates of genetic parameters for growth traits and yearling fleece weight in Markhoz goats. The objective of the present study was to estimate (co)

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**Table 1.** Description of the data set, means, standard deviations (S.D.) and coefficient of variance (CV) for various traits[a]

| | BW | WW | 6MW | 9MW | YW | YFW |
|---|---|---|---|---|---|---|
| Number of records | 2,780 | 2,333 | 2,154 | 1,952 | 1,560 | 1,746 |
| Number of sire | 125 | 121 | 120 | 112 | 105 | 125 |
| Number of dam | 847 | 731 | 693 | 656 | 563 | 669 |
| Number of dam with own records | 613 | 476 | 462 | 434 | 366 | 422 |
| Progeny/dam | 3.3 | 3.2 | 3.1 | 3.0 | 2.8 | 2.6 |
| Mean (kg) | 2.58 | 15.74 | 18.07 | 22.03 | 27.42 | 0.485 |
| S. D. (kg) | 0.44 | 3.43 | 4.44 | 5.11 | 6.36 | 0.211 |
| CV (%) | 17.05 | 21.79 | 24.57 | 23.19 | 23.19 | 43.51 |

[a] BW = Birth weight, WW = Weaning weight, 6MW = Six month weight, 9MW = Nine month weight.
YW = Yearling weight, YFW = Yearling fleece weight.

variance components and genetic parameters for birth weight, weaning weight, weight at six month, weight at nine month, yearling weight and yearling fleece weight in Markhoz goats, by determining the most appropriate animal models to be fitted. In addition, genetic, phenotypic and environmental correlations between various traits were estimated.

## MATERIAL AND METHODS

### Data collection and management

Data were collected from the 1993 to 2006 by the Markhoz goat Performance Testing Station in Sanandaj, Iran were analyzed. Measurements were taken on body weight performance at birth (BW), weaning (WW) at about three month of age, six month (6MW), nine month (9MW), yearling (YW) and on fleece weight at yearling age (YFW) of kids. Mohair harvesting has done at 12 months of age and YW was taken after shearing. Kids were weighed and ear-tagged after kidding. Flocks were housed in semi-intensive conditions with dry summer and cold winter. The grazing season generally starts from the April to October on range and pasture during the day and were kept indoors during the night. Does were exposed to the bucks at about 18 months of age in breeding pens. Mating period started during the October to November and kidding time could be occurred from February to March. Kids suckled their mothers twice a day for the three or four months of age. Sires only were selected based on phenotypic value according to mohair yield, body weight and body conformation with no selection of dam. The data sets included full pedigree information, date of birth, sex, type of birth, age of dam and date of recording. Other relevant information were collected and stored in a database. Description of the data is given in Table 1.

### Environmental effect models

Least square analysis was performed using the general linear model (GLM) procedure of SAS software package (SAS Institute, 1989) for investigation of environmental effects. Comparisons of means values were carried out with the Duncan's test at a significant level of 5% (Duncan, 1955). Two statistical models were utilized for investigation of environmental effects:

Statistical models for BW, 9MW, YW and YFW were,

$$y_{ijklo} = \mu+YE_i+S_j+T_k+A_l+e_{ijklo}$$

Statistical models for WW and 6MW were,

$$y_{ijklo} = \mu+YE_i+S_j+T_k+A_l+b(X_{ijklo}-\overline{X})+e_{ijklo}$$

Where $y_{ijklo}$ is the each of records, $\mu$ the overall mean, $YE_i$ the effect of i[th] birth year in 14 class (1993-2006), $S_j$ the effect of j[th] sex in 2 class (male and female), $T_k$ the effect of k[th] type of birth in 3 class (single, twin and triplet), $A_l$ the effect of l[th] age of dam at kidding in 6 class (2-7 years old), b is the linear regression coefficient weight of WW or 6MW on age of kids, $X_{ijklo}$ and $\overline{X}$ are the age and mean of age for WW or 6MW and $e_{ijklo}$ is the random error. Because the age of kids in 9MW, YW, YFW and fixed effects interactions were not significant, their effects not become in these models.

### Genetic parameters statistical models

Genetic parameters were estimated with single and six traits analysis, using restricted maximum likelihood (REML) procedures, under animal models. By ignoring or including of maternal genetic or maternal environmental effects, five different models were fitted for each trait. The models were:

Model 1 $$y = Xb+ Z_1a+e$$

Model 2 $$y = Xb+Z_1a+Z_2m+e \quad Cov(a,m) = 0$$

Model 3 $$y = Xb+Z_1a+Z_2m+e \quad Cov(a,m) = A\sigma_{am}$$

Model 4 $$y = Xb+Z_1a+Z_2m+Z_3c+e \quad Cov(a,m) = 0$$

Model 5 $y = Xb+Z_1a+Z_2m+Z_3c+e$
$Cov(a,m) = A\sigma_{am}$

Where y is the vector of observations on the different traits, b is the vector of fixed effects (sex, type of birth, age of dam and year of birth for BW, WW, 6MW, 9MW, YW and only year of birth for YFW), a is the vector of direct additive genetic effects, m is the vector of maternal additive genetic effects, c is the vector of maternal permanent environmental effects, e is the vector of residual effects and X, $Z_1$, $Z_2$ and $Z_3$ are incidence design matrices relating the fixed effects, direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects, respectively, to vector of y. For WW and 6MW the effect of kid's age was considered as a covariate in the model. For estimation of genetic, environmental and phenotypic correlations between traits, multivariate analysis was carried out with model 4. The DFREML 3.1 software (Meyer, 2000) was used to estimate of genetic parameters. Convergence was considered to be reached when the variance of function values was less than $10^{-8}$. Total heritability was calculated according to the following equation (Willham, 1972):

$$h_T^2 = \frac{\sigma_a^2 + 0.5\sigma_m^2 + 1.5\sigma_{am}}{\sigma_P^2}$$

It is assumed that direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects and residual effects to be normally distributed with mean 0 and variance $A\sigma_a^2$, $A\sigma_m^2$, $I_d\sigma_c^2$ and $I_n\sigma_e^2$, respectively. Also, $\sigma_a^2$, $\sigma_m^2$, $\sigma_c^2$ and $\sigma_e^2$ are direct additive genetic variance, maternal additive genetic variance, maternal permanent environmental variance and residual variance, respectively. A is the additive numerator relationship matrix, $I_d$ and $I_n$ are identity matrices that have order equal to the number of dams and number of records, respectively, and $\sigma_{am}$ denotes the covariance between direct additive genetic and maternal additive genetic effects. In the univariate analysis, log likelihood ratio tests were applied to choose the most appropriate model for each trait (Snyman and Olivier, 1996).

Genetic and phenotypic correlations were estimated using multi trait analysis. The fixed effects included in the multi trait animal models were those in single trait analyses. If the values of -2 log likelihood variance in the AI-REML function were below $10^{-8}$, it was assumed convergence had been achieved. The multi trait animal model used to estimate direct additive genetic, maternal additive genetic, maternal permanent environmental, phenotypic and environmental correlations can be represented as follows:

$$y_i = X_ib_i+Z_{1i}a_i+Z_{2i}m_i+Z_{3i}c_i+e_i$$
$$Cov(a,m) = 0$$

Where $y_i$ is the vector of observations for ith trait, $b_i$ is the vector of fixed effects for ith trait, $a_i$ is the vector of direct additive genetic effects for ith trait, $m_i$ is the vector of maternal additive genetic effects for ith trait, $c_i$ is the vector of maternal permanent environmental effects for ith trait, $e_i$

**Table 2.** Effects of environmental factor on body weight at different ages and yearling fleece weight

| Fixed effects | Traits[a] | | | | | |
|---|---|---|---|---|---|---|
| | BW (kg) | WW (kg) | 6MW (kg) | 9MW (kg) | YW (kg) | YFW (gr) |
| Overall means±SE | 2.48±0.04 | 13.78±0.41 | 16.61±0.45 | 21.20±0.46 | 27.03±0.64 | 468.03±18.03 |
| Sex | ** | ** | ** | ** | ** | NS |
| Male | 2.59$^a$±0.04 | 15.02$^a$±0.41 | 17.83$^a$±0.46 | 22.94$^a$±0.47 | 29.79$^a$±0.66 | 463.57±18.44 |
| Female | 2.37$^b$±0.04 | 12.53 $^b$±0.41 | 15.38 $^b$±0.45 | 19.47$^b$±0.47 | 24.26$^b$±0.65 | 472.48±18.32 |
| Type of birth | ** | ** | ** | ** | ** | NS |
| Single | 2.65$^a$±0.01 | 15.44$^a$±0.24 | 17.65$^a$±0.25 | 22.38$^a$±0.17 | 27.82$^a$±0.24 | 477.95±6.19 |
| Twin | 2.53$^b$±0.01 | 13.75$^b$±0.26 | 16.37$^b$±0.26 | 21.07$^b$±0.17 | 26.66$^b$±0.24 | 476.31±6.39 |
| Triplet | 2.27$^c$±0.11 | 12.14$^b$±1.01 | 15.79$^b$±1.18 | 20.16$^b$±1.34 | 26.60$^b$±1.86 | 452.60±52.54 |
| Age of dam | ** | ** | ** | ** | ** | NS |
| 2 | 2.36$^c$±0.04 | 13.31$^c$±0.42 | 16.11$^c$±0.46 | 20.21$^b$±0.48 | 26.15$^c$±0.67 | 455.23±18.79 |
| 3 | 2.48$^b$±0.04 | 14.06$^{ab}$±0.42 | 17.12$^a$±0.47 | 21.26$^a$±0.49 | 27.34$^{ab}$±0.67 | 458.29±18.88 |
| 4 | 2.51$^{ab}$±0.04 | 14.20$^a$±0.42 | 17.05$^a$±0.46 | 21.56$^a$±0.48 | 27.64$^a$±0.67 | 470.45±18.75 |
| 5 | 2.52$^{ab}$±0.04 | 13.67$^{bc}$±0.44 | 16.20$^{bc}$±0.49 | 21.41$^a$±0.51 | 26.60$^{bc}$±0.71 | 466.24±19.79 |
| 6 | 2.55$^a$±0.05 | 13.99$^{ab}$±0.49 | 16.86$^{ab}$±0.54 | 21.60$^a$±0.59 | 27.45$^{ab}$±0.83 | 476.68±22.84 |
| 7 | 2.47$^b$±0.06 | 13.43$^{bc}$±0.57 | 16.27$^{abc}$±0.63 | 21.17$^a$±0.69 | 26.97$^{abc}$±0.99 | 481.27±25.75 |
| Year of birth | ** | ** | ** | ** | ** | ** |
| Regression coefficient on day of birth | - | 0.075**±0.008 | 0.085**±0.009 | NS | NS | NS |

[a] For trait abbreviations see footnote of Table 1.
Means with similar letters in each sub class within a column don't differ from another at p<0.05, ** p<0.01. NS: p>0.05

is the vector of residual effects for ith trait and $X_i$, $Z_{1i}$, $Z_{2i}$ and $Z_{3i}$ are incidence design matrices relating records of the ith trait to fixed effects, direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects, respectively.

## RESULT

### Environmental effects

The results from analysis of data for study of environmental effects, means and standard error for different traits are given in Table 2. The least squares means and standard errors for BW, WW, 6MW, 9MW, YW and YFW in Markhoz kids were 2.48±0.04, 13.78±0.41, 16.61±0.45, 21.20±0.46, 27.03±0.64 kg, and 468.03±18.03 gr, respectively. The effects of sex, type of birth and age of dam on the all body weights was significant ($p<0.01$), but did not play an important role on the YFW ($p>0.05$). In our study, male kids had significantly heavier live weight in different ages ($p<0.01$). Female kids had heavier YFW than males, but differences between sexes in YFW were small and not significant ($p>0.05$). The year of birth effect was significant on the all traits ($p<0.01$). Age of kids had significant influences on WW and 6MW ($p<0.01$), but had no effects on 9MW, YW and YFW ($p>0.05$).

### Analysis under different model

The log likelihood values under five different models with the most appropriate model (in bold) determined using log likelihood ratio test are presented in Table 3. The results obtained in this study indicated that the most appropriate model for BW, WW, 6MW and 9MW was model 4, which

**Table 3.** Estimates of (Co) variance components, genetic parameters and log likelihood ratio with best model in bold for various traits with different models

| Traits[a] | Models | $\sigma_a^2$ | $\sigma_m^2$ | $\sigma_c^2$ | $\sigma_{am}^2$ | $\sigma_e^2$ | $\sigma_p^2$ | $h_d^2 \pm$SE | $h_m^2 \pm$SE | $c^2 \pm$SE | $r_{am}$ | $h_T^2$ | Log L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BW | 1 | 0.06 | - | - | - | 0.11 | 0.17 | 0.35±0.04 | - | - | - | 0.35 | 1,164.42 |
| | 2 | 0.03 | 0.03 | - | - | 0.11 | 0.17 | 0.18±0.04 | 0.17±0.03 | - | - | 0.27 | 1,190.35 |
| | 3 | 0.03 | 0.03 | - | -0.004 | 0.11 | 0.17 | 0.18±0.04 | 0.18±0.03 | - | -0.13 | 0.23 | 1,190.54 |
| | 4 | 0.03 | 0.01 | 0.02 | - | 0.10 | 0.17 | 0.19±0.04 | 0.06±0.03 | 0.12±0.04 | - | 0.22 | **1,195.95** |
| | 5 | 0.04 | 0.01 | 0.02 | -0.003 | 0.10 | 0.17 | 0.20±0.04 | 0.06±0.03 | 0.12±0.04 | -0.15 | 0.24 | 1,196.06 |
| WW | 1 | 2.81 | - | - | - | 9.17 | 11.98 | 0.23±0.04 | - | - | - | 0.23 | -4,026.11 |
| | 2 | 1.86 | 0.80 | - | - | 9.23 | 11.89 | 0.16±0.04 | 0.07±0.02 | - | - | 0.19 | -4,021.42 |
| | 3 | 1.74 | 0.70 | - | 0.16 | 9.29 | 11.89 | 0.15±0.04 | 0.06±0.02 | - | 0.15 | 0.20 | -4,021.33 |
| | 4 | 1.79 | 0.18 | 1.02 | - | 8.84 | 11.83 | 0.15±0.04 | 0.02±0.01 | 0.09±0.04 | - | 0.16 | **-4,018.38** |
| | 5 | 1.80 | 0.18 | 0.96 | 0.06 | 8.85 | 11.85 | 0.15±0.04 | 0.02±0.01 | 0.08±0.04 | 0.11 | 0.16 | -4,018.38 |
| 6MW | 1 | 3.20 | - | - | - | 9.61 | 12.81 | 0.25±0.04 | - | - | - | 0.25 | -3,784.80 |
| | 2 | 2.40 | 0.78 | - | - | 9.57 | 12.75 | 0.19±0.05 | 0.06±0.03 | - | - | 0.22 | -3,781.69 |
| | 3 | 2.69 | 1.06 | - | -0.37 | 9.39 | 12.77 | 0.21±0.05 | 0.08±0.03 | - | -0.22 | 0.21 | -3,781.45 |
| | 4 | 2.36 | 0.15 | 1.05 | - | 9.14 | 12.70 | 0.19±0.05 | 0.01±0.02 | 0.08±0.04 | - | 0.19 | **-3,777.72** |
| | 5 | 2.75 | 0.17 | 1.22 | -0.38 | 8.99 | 12.75 | 0.22±0.05 | 0.01±0.02 | 0.09±0.04 | -0.55 | 0.18 | -3,777.39 |
| 9MW | 1 | 6.23 | - | - | - | 11.47 | 17.70 | 0.35±0.04 | - | - | - | 0.35 | -3,706.25 |
| | 2 | 5.88 | 1.18 | - | - | 10.63 | 17.69 | 0.33±0.05 | 0.07±0.02 | - | - | 0.34 | -3,705.79 |
| | 3 | 7.35 | 1.18 | - | -1.36 | 10.62 | 17.79 | 0.41±0.05 | 0.07±0.02 | - | -0.46 | 0.33 | -3,704.25 |
| | 4 | 5.91 | 0.19 | 0.67 | - | 10.91 | 17.68 | 0.33±0.05 | 0.01±0.02 | 0.04±0.05 | - | 0.34 | **-3,702.67** |
| | 5 | 7.35 | 1.03 | 0.20 | -1.35 | 10.55 | 17.78 | 0.41±0.05 | 0.06±0.02 | 0.01±0.05 | -0.49 | 0.31 | -3,704.19 |
| YW | 1 | 10.91 | - | - | - | 15.88 | 26.79 | 0.41±0.05 | - | - | - | 0.41 | **-3,271.67** |
| | 2 | 10.42 | 0.42 | - | - | 15.90 | 26.74 | 0.39±0.06 | 0.02±0.03 | - | - | 0.40 | -3,271.49 |
| | 3 | 11.35 | 0.90 | - | -0.85 | 15.39 | 26.79 | 0.42±0.06 | 0.03±0.03 | - | -0.27 | 0.39 | -3,271.25 |
| | 4 | 10.39 | 0.44 | 0.00 | - | 15.90 | 26.73 | 0.39±0.06 | 0.02±0.03 | 0.00±0.05 | - | 0.40 | -3,271.49 |
| | 5 | 11.33 | 0.92 | 0.00 | -0.86 | 15.40 | 26.79 | 0.42±0.06 | 0.03±0.03 | 0.00±0.05 | -0.27 | 0.39 | -3,271.25 |
| YFW | 1 | 3,902.85 | - | - | - | 20,249.63 | 24,152.48 | 0.16±0.03 | - | - | - | 0.16 | **-9,595.70** |
| | 2 | 3,906.58 | 0.00 | - | - | 20,246.76 | 24,153.34 | 0.16±0.03 | 0.00±0.02 | - | - | 0.16 | -9,595.70 |
| | 3 | 4,890.07 | 87.21 | - | -652.91 | 19,901.55 | 24,225.92 | 0.20±0.03 | 0.00±0.02 | - | -1.00 | 0.16 | -9,595.70 |
| | 4 | 3,901.08 | 0.00 | 13.54 | - | 20,238.39 | 24,153.01 | 0.16±0.03 | 0.00±0.02 | 0.00±0.03 | - | 0.16 | -9,595.70 |
| | 5 | 5,464.99 | 189.44 | 343.17 | -1,017.49 | 19,335.86 | 24,315.97 | 0.22±0.03 | 0.01±0.02 | 0.01±0.03 | -1.00 | 0.17 | -9,595.70 |

a: for trait abbreviations see footnote of Table1 $\sigma_a^2$: direct additive genetic variance; $\sigma_m^2$: maternal additive genetic variance; $\sigma_c^2$: maternal permanent environmental variance; $\sigma_{am}$: direct-maternal genetic covariance; $\sigma_e^2$: residual variance; $\sigma_p^2$: phenotypic variance; $h_d^2$: direct heritability; $h_m^2$: maternal heritability; $c^2$: ratio of maternal permanent environmental effect; $r_{am}$: direct-maternal genetic correlation; Log L: log likelihood; SE: standard error.

included direct additive genetic effects, maternal additive genetic effects as well as maternal permanent environmental effects. Also, the most appropriate model for YW and YFW was model 1, which included only direct additive genetic effects. According to results obtained from single traits analysis, model 4 was used for estimation of correlations between various traits, which included direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects, respectively.

### Heritability estimates

Heritability estimates from the all models for various traits are shown in Table 3. Total heritability estimates for body weight in different ages are low to moderate, and varied from 0.16 for WW and YFW to 0.41 for YW. Also, for all traits, maternal heritability was lower than direct heritability and ranged from the 0.06 for BW to 0.01 for 6MW and 9MW. For maternally influenced traits, maternal permanent environmental variance as a proportion of phenotypic variance was higher than estimates of maternal heritabilities. The magnitude of $c^2$ values were 0.12 for BW, 0.09 for WW, 0.08 for 6MW and 0.04 for 9MW. The $c^2$ was still a significant source of variation in post weaning body weights, but its relative importance was reduced from BW to 9MW.

### Correlation estimates

Multivariate analysis results obtained for estimates of direct additive genetic correlations, maternal additive genetic correlations, maternal permanent environmental correlations, phenotypic and environmental correlations between body weight at different ages and yearling fleece weight are given in Table 4. The low to high direct additive genetic correlations were found between body weight performances at different ages in our study. The range varied from 0.21 between BW-YW to 0.96 between WW-6MW. These estimates were positive and increased between all other body weight traits from the birth to post weaning weight. Direct additive genetic correlations between YFW with body weight traits were quite variable and ranging from 0.14 between BW-YFW to 0.67 between 6MW-YFW.

For all traits, the corresponding estimates for phenotypic correlation were positive and lower than direct additive genetic correlations.

The maternal additive genetic correlations between all body weight traits were positive and ranged from 0.02 for BW-6MW to 0.96 for 6MW-9MW. The maternal additive genetic correlations between BW-YFW and WW-YFW were positive, but between some of traits such as 6MW-YFW, 9MW-YFW and YW-YFW were negative and values obtained in this research were -0.18, -0.19 and -0.16, respectively (Table 4).

The permanent environmental correlations between all various traits are positive, moderate to high, and ranged from 0.33 between WW-YFW to 0.93 WW-6MW.

The environmental correlations estimates between various traits in this study were positive and varied from 0.01 for BW-YFW to 0.70 for 9MW-YW.

## DISCUSSION

The results obtained in this research indicated that the overall least squares means for kid weight at different ages were similar with the results reported by Horst et al. (1993) and Gunes et al. (2002) in Turkish Angora goats, Nicoll (1985) in New Zealand Angora goats, Gifford et al. (1990) in Australian Angora goats, Koratkar et al. (1990) in Indian Angora goats and Said et al. (1990) in Iraq Angora goats. The least square mean for yearling greasy fleece weight was lower than those reported for Angora goat by Yalcin et al.

**Table 4.** Correlations estimates between growth traits and yearling fleece weight [a]

| Trait 1-trait 2 | $r_p$ | $r_d$ | $r_m$ | $r_c$ | $r_e$ |
|---|---|---|---|---|---|
| BW-WW | 0.33 | 0.47 | 0.43 | 0.58 | 0.23 |
| BW-6MW | 0.29 | 0.48 | 0.02 | 0.74 | 0.17 |
| BW-9MW | 0.24 | 0.26 | 0.30 | 0.73 | 0.25 |
| BW-YW | 0.12 | 0.21 | 0.17 | 0.90 | 0.22 |
| BW-YFW | 0.05 | 0.14 | 0.05 | 0.57 | 0.01 |
| WW-6MW | 0.79 | 0.96 | 0.72 | 0.93 | 0.61 |
| WW-9MW | 0.69 | 0.81 | 0.80 | 0.84 | 0.57 |
| WW-YW | 0.54 | 0.61 | 0.45 | 0.85 | 0.48 |
| WW-YFW | 0.23 | 0.65 | 0.43 | 0.33 | 0.02 |
| 6MW-9MW | 0.79 | 0.90 | 0.96 | 0.91 | 0.68 |
| 6MW-YW | 0.62 | 0.74 | 0.87 | 0.92 | 0.50 |
| 6MW-YFW | 0.28 | 0.67 | -0.18 | 0.48 | 0.10 |
| 9MW-YW | 0.79 | 0.91 | 0.89 | 0.81 | 0.70 |
| 9MW-YFW | 0.30 | 0.64 | -0.19 | 0.79 | 0.16 |
| YW-YFW | 0.23 | 0.61 | -0.16 | 0.42 | 0.10 |

$r_p$: phenotypic correlations between traits 1and 2; $r_d$: direct genetic correlation between trait 1 and trait 2; $r_m$: maternal additive genetic correlation between trait1 and trait 2; $r_c$: maternal permanent environmental correlations between traits 1and trait 2; $r_e$: environmental correlations between traits 1and trait 2; [a] For traits abbreviations see footnote of Table 1.

(1989), Gunes et al. (2002) and Taddeo et al. (1998). Although values obtained in this research was similar with results reported by Rashidi et al. (2006) who have studied this population and is in accordance with that of 431 gr obtained by Koratkar et al. (1990) in Indian Angora goats. The first clips for fleece weight in Markhoz goats were taken at 12 month of age. This period of shearing were not suitable for collecting of records, because many animals tendency to shed their fiber during September.

The effects of sex, type of birth, age of dam, year of birth and age of kid, have been shown to be important sources of variation for all traits. These results obtained from this research are in agreement with other results reported by Nicoll (1985), Horst et al. (1993) and Wenzhong et al. (2005). Although the results reported by these workers indicated that the age of dam and type of birth effects would be expected to be of lesser important at post weaning traits (Nicoll, 1985; Gifford et al., 1990; Wenzhong et al., 2005).

The significant influences of environmental factors on growth traits in this study can be explained by differences between male and female in endocrine system (Sex effects), limited uterine space during pregnancy for single and multi birth kids, nutrition of dam specially during last pregnancy, competitions for milk suckling between the twins and triplet kids during birth to weaning (Type of birth effects), differences in maternal effects, nursing and maternal behavior of dam in different ages (Age of dam effects), differences in management, food availability, diseases, condition of climate and raising systems in different years (Year of birth effects), increase milk consumptions of kids with older ages or earlier born (Age of kids effects).

The effects of non genetic factors indicated that performance records for body weight at different ages should be corrected for effects of sex, type of birth, age of dam, year of birth and age of kids at WW, 6MW and 9MW, but for yearling greasy fleece weight only correction for effect of year is needed.

Log likelihood ratio test indicated that model 4 is the most appropriate model for estimation of genetic parameters for BW, WW, 6MW and 9MW in this research. For these traits, fitting a maternal additive genetic effect as well as maternal permanent environmental effect resulted in a significant increase in log likelihood ratio ($p<0.01$). Also, no significant improvement in log likelihood ratio ($p>0.05$) was observed by fitting a covariance between direct and maternal additive genetic effects for these traits. According to results reported by Snyman and Olivier (1996) the maternal additive genetic effect caused a significant increase in Log L over model 1, but covariance between direct and maternal additive genetics effects not increase of Log L in 9MW trait. The results obtained from this study indicate that permanent environmental effects have important sources of variation in BW, WW, 6MW and 9MW. As the data set collected over 14 years period, and a lot of the dams had some progeny in the herd, therefore, possible to determine accurately, if a significant maternal permanent environmental effect was included in model (Snyman and Olivier, 1996). Neither maternal additive genetic effects, nor maternal permanent environmental effects were significantly improved log likelihood ratio ($p>0.05$) for YW and YFW traits, therefore, model 1 was considered the most appropriate for these traits. Gerstmayr et al. (1992) and Taddeo et al. (1998) reported similar results for maternal genetic effects on YFW in Angora goats. Published results in literature showed that the maternal effects had a negligible influence on traits collected at 12 month of age in sheep and goats (Snyman and Olivier, 1996; Rashidi et al., 2006).

The direct heritability estimate (0.19) of BW in the present study is medium and are in agreement with that of 0.18 reported by AL-Shorepy et al. (2002) in Emirati goats, higher than those 0.00 reported by Yalcin et al. (1989) and 0.02 Gerstmayr et al. (1995) in Turkish Angora goats, but lower than that of 0.50 by Bosso et al. (2007) in Dwarf goats. The value of the maternal heritability estimate for BW (0.06) in the present study was lower than results with those of 0.10 reported by Gerstmayr et al. (1995) and 0.18 by AL-Shorepy et al. (2002).

Estimate of direct heritability for WW (0.15) obtained in this research was within the range of results reported from the 0.02 by Yalcin et al. (1989), to 0.43 by Bosso et al. (2007) and correspond with those of 0.17 reported by Yalcin (1982), 0.10 by Nicoll et al. (1989), lower than those of 0.34 by AL-Shorepy et al. (2002) and 0.28 by Nicoll (1985), but higher than that of 0.04 reported by Gerstmayr et al. (1989). Also, the results obtained for maternal heritability of WW (0.02) in the present study was low and are in agreement with those of 0.02 reported by Gerstmayr et al. (1989), 0.00 by AL-Shorepy et al. (2002) but lower than that of 0.10 reported by Gerstmayr et al. (1992).

The direct heritability estimates of 0.19 for 6MW was in agreement with that of 0.22 reported by Rashidi et al. (2006) in Markhoz goats. Also, the direct heritability estimated in present research (0.33) for 9MW is in similar with that of 0.29 reported by Snyman and Olivier (1996) in the South Aferican Angora goats. Although, the results obtained for maternal heritability of 9WW (0.01) in the present study was lower with that of 0.09 reported by Snyman and Olivier (1996) in the South Aferican Angora goats.

Estimate of direct heritability for YW (0.41) obtained in this study are within the range of those reported by other workers in literature. These results is in accordance with that of 0.50 obtained by Shelton and Basset (1970) and higher than those 0.13 reported by Gifford et al. (1991), 0.30 by Bosso et al. (2007) and 0.24 by Yalcin (1982).

The range of results reported for body weight traits, reflecting of the limited nature of data in different breeds of goats and using different statistically methods for estimated of heritability. Also, estimates of direct heritability depended on the statistical models in each trait, and ignoring of maternal additive genetic effects and maternal permanent environmental effects leads to over estimate of direct heritability, especially for pre weaning traits in goats. In addition the results obtained in the present study indicated the trend of increasing direct heritability and decreasing maternal heritability with age of kids. The heritability estimates for body weight tended to increase with age. The increase in heritability with age is probably explained by no maternal protection and maternal ability of dam on growth in the post weaning traits of kids.

The moderate heritability estimates for 9MW and YW may be due to good management raising, high nutritional level in station and suggest that this environment is favorable for expression of genetic potentials. Although heritability estimates of YW are moderate in all models employed (as shown in Table 3), phenotypically (0.54-0.79) and genetically (0.61-0.91) correlation estimates between YW with WW, 6MW and 9MW are high. Therefore, mass selection conducted before yearling age could be expected to be more effective and suitable than at one year of age due to decreasing production cost.

The magnitude of maternal permanent environmental variance as a proportion of phenotypic variance ($c^2$) was substantial for BW than the others, but its relative importance was reduced from 0.12 for BW to 0.04 for 9MW. Although no published data for $c^2$ in Angora goats are available. The uterine environmental effects, multiple birth influences on milk yield, feeding level at late gestations and maternal behavior of the dam had been important factors for maternal permanent environmental effects of dam on progeny, especially for pre weaning traits in kids. The magnitude of maternal permanent environmental effects of dam on progeny is increased, with increase of the number of progeny per dam during kid production in different years (Table 1).

Direct heritability estimate of greasy yearling fleece weight (0.16) obtained in this study are low but within the range of those reported in the previous research. The result obtained for YFW is in agreement with that of 0.19 reported by Snyman and Olivier (1996), 0.19 by Allain and Rogute (2003), 0.14 by Shelton and Snowder (1983), 0.13 by Yalcin (1982), 0.18 by Rashidi (2006), lower than those of 0.40 by Nicoll (1985), 0.25 by Nicoll et al. (1989), 0.45 by Gifford et al. (1991), 0.26 by Taddeo et al. (1998), 0.40 by Shelton and Basset (1970), but higher than those 0.04 estimated by Yalcin et al. (1989) and 0.06 by Gerstmayr et al. (1992).

Heritability values obtained in this study indicated that genetic improvement could be successful and increase in the yearling fleece weight by mass selection within breed, but that genetic response to selection would be smaller.

The positive and high estimates of direct additive genetic correlations between body weights in different ages were found. The results were varied from 0.21 between BW-YW to 0.96 between WW-6MW. Signs and sizes of genetic correlation estimates between body weight traits were similar to those reported by Nicoll et al. (1989) for WW-YW.

The direct additive genetic correlations between body weights in different ages and yearling fleece weight observed in this study were positive and varied from low to high. These results were similar with those of 0.67 reported by Snyman and Olivier (1996) in South African Angora goats for 9MW and greasy fleece weight, 0.53 reported by Nicoll et al. (1989), in New Zeland Angora goats for WW-YW, but results obtained in this study higher than those of -0.29 and -0.24 reported by Nicoll et al. (1989) for WW-YFW and YW-YFW, respectively. Also the results obtained in this study for YW-YFW (0.61) was higher than those estimated 0.17 by Yalcin (1982) and -0.26 by Shelton and Basset (1970) in Texas Angora goats. These results indicated that the same set of genes influences these performances of body weight and yearling fleece weight in this breed. Therefore, selection for any of the body weight traits in different ages could be increase in the other correlated traits.

The positive maternal additive genetic correlations have been observed between all body weight traits and ranged from 0.02 between BW-6MW to 0.96 between 6MW-9MW. These results indicating that selection for any of these traits on maternal potentials would result in a marginal increasing in other traits in live weight. Also, negative maternal genetic correlations were observed between live weight and yearling fleece weight in the later age, but positive and low maternal genetic correlations (0.05) of BW-YFW and medium maternal genetic correlations of WW-YFW (0.43) indicated the maternal effects influences on the early weights and development of follicles from the pre-natal period and maturation of follicles after birth to weaning.

The maternal permanent environmental correlations between various traits in this study were positive and varied from 0.33 for WW-YFW to 0.93 for WW-6MW. Probably, under such management and environmental conditions a good maternal environment had positive effects on kids from birth to yearling age.

The phenotypic correlation estimated for various traits in our research were positive. These results are in agreement with those of 0.63 and 0.54 reported by Nicoll et al. (1989) for WW-YW and YW-YFW, 0.39 by Gifford et al. (1991) for YW-YFW, but higher than those of 0.19 by

Yalcin (1982), for YW-YFW, and 0.10 by Shelton and Basset (1970) in Angora goats. The positive phenotypic correlations estimates between various traits from birth to yearling showed the presence of desirable association between these traits.

The estimated environmental correlations between traits were positive, low and medium and ranged from 0.01 between BW-YFW to 0.7 between 9MW-YW. These results indicated the improvement of environment for each traits could improve others traits in the later ages.

## CONCLUSION

In general the results indicated that adjustment for effects of sex, type of birth, age of dam, year of birth and age of kids need to be accounted for estimation of genetic parameters and prediction of breeding value for body weight at different ages in Markhoz goats. The log likelihood ratio test indicated that direct and maternal additive genetic as well as maternal permanent environmental effects should be added to model for BW, WW, 6MW and 9MW traits. From these results it appears that the yearling fleece weight and body weight at different ages traits in Markhoz goats are low to moderately heritable. The magnitude of heritability estimates for post weaning traits in this study indicated that these traits would response to mass selection. These results demonstrate that the selection within breed is a successful breeding strategy for improve of body weight at different ages. Also, very high genetic correlations between WW and other body weight performances indicated that selection on the basis of WW would result in increase in performance at later ages.

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