Estimation of Genetic Parameters for Growth and Body Measurement Traits in Different Ages in Iranian Makuei Sheep

**Abstract**

The present study aimed to estimate heritability, genetic and phenotypic correlations between body weight and body measurement traits in Iranian Makuei sheep. The used data were collected from 1989 to 2012 at Makuei Sheep Breeding Station in Maku (West Azerbaijan province). The data included body weight and five body measurement traits (body length (BL), heart girth (HG), withers height (WH), rump height (RH) and leg circumference (LC)) in 6, 12 and 18 months of age with 400, 900 and 350 records in different time, respectively. The data were analyzed using multi-trait animal model through DFREML software. Results showed that the estimated heritabilities for body weight and body measurement traits in 12 months of age is less than those for 6 and 18 months of age; those comes down from 6 to 12 months of age, then go up to 18 months of age. In six months of age the highest and lowest genetic correlations were between body weight (BW) with WH and LC; respectively, and the highest and lowest phenotypic correlations were between BW with RH and LC; respectively. Genetic and phenotypic correlations between body weight in six months of age and body measurement traits were approximately high but with leg circumference were low. Genetic correlations in 12 months of age were generally higher than phenotypic correlations. Genetic correlations between body weight in 18 months of age and body measurement traits were moderate to high and the highest genetic correlation was found between body weight in 18 months of age and body length. The positive correlation between body weight and body measurements in different ages indicated that selection for body measurements would results body weight improvement.

**Key Words** genetic correlation, heritability, sheep breeding programs.

**Introduction**

Makuei sheep breed is the dominate sheep breed in West Azerbaijan province (Iran) with a population size around 2.7 millions. This breed that is well adapted to cold and highland environments (Safari, 1986), is reared for meat as the main, and wool and milk as the secondary purposes. In order to design an effective selection programs to increase efficiency of sheep production, knowledge of genetic parameters of economical important traits is need (Brown et al. 1973).

Genetic and non-genetic factors have a highly impact on meat yield as a complex polygenic trait (Salako, 2006). To improve meat yield, biometric characters or measurement traits with simple genetic controls have been used as an indirect criterion in many domestic animal species (Salako, 2006). Using measurement criteria, breeders can be able to identify early maturing and late maturing animals with different sizes (Brown et al. 1973). Identifying appropriate animals in earlier growth stage will be worthwhile for selection and prediction of mature ranking. Body measurement traits and indices not only help breeders to evaluate animal
weight but also could be used as functional indicators in animal production (Salako, 2006).

It is important to determine the relationship among two or more measured characters at early time or at later time, since early selection is one of the modern selection programs for higher production in animals (Salako, 2006); also it is important to determine the relationship between body measurement traits at different ages group, as early selection is one of the main methods in animal breeding. Simple correlation analysis is usually preferred by researchers to determine degree and direction of relationship among body measurement traits (Cankaya and Kayaalp, 2007). Janssens and Vandepitte (2004) reported moderate to high heritability for three breeds of adult Belgian sheep. Their estimates of heritability for BL, HG and WH were 0.30, 0.45 and 0.43 in Blue du Main, 0.35, 0.39 and 0.57 in Suffolk, and 0.28, 0.40 and 0.40 in Texel.

Abbasi and Ghafori (2011) reported that heritability estimates for BW, BL, HG, HW, HB and SC in Makuei sheep were 0.22, 0.11, 0.21, 0.17 and 0.32, respectively. These estimates indicate that selection in Makuei sheep would generate moderate genetic progress in body weight and body measurements. Supakorn et al. (2012) reported that heritability estimate for BW, HG and BL were 0.32, 0.52 and 0.54 in sheep population in Thailand. Hamayun Khan et al. (2006) reported a high and significant correlation among height at withers and heart girth and body weight at 4 to 18 months age, and suggested that any of these variables or their combination would provide a good estimate for predicting body weight at early age of Beetal goats.

Mukherjee et al. (1986) and Singh et al. (1987) found that, there is high and significant correlation between body weight and chest girth in brown Bengal does and grey Bengal goats, respectively. Ravimurugan et al. (2013) showed that body weight and the body measurements were significantly correlated with each other in Kilakarsal sheep and body weight had higher association with chest girth than body length or height rump. Information of growth and body measurements recorded at Makuei Sheep Breeding Station provides an opportunity to estimate of genetic parameters and development of appropriate selection index. The aim of present study was to estimate heritability for body weight and body measurement traits at different ages (6, 12 and 18 months age); and genetic and phenotypic correlation between these traits.

The data included body weight and five body measurement traits (body length, heart girth, withers height, rump height and leg circumference) in 6, 12 and 18 months of age with 400, 900 and 350 records in different times, respectively. The investigated traits were withers height (WH), rump height (RH), body length (BL), heart girth (HG), leg circumference (LC) and body weight (BW). WH was defined as the distance from the surface of a platform on which the animal stands to the withers. RH was defined as the distance from the surface of a platform to the rump. BL refers to distance between first cervical vertebrae to the base of the tale where it joint the body. HG is a circumferential measure taken around the chest just behind the front legs and withers. The midpoint between hock and pin bone at right rear leg is used to measuring the circumference of rear legs (LC). For HG and LC the measuring tool was tape measure.

**Statistical analyses**

Preliminary data of body weight and body measurement traits were analyzed using generalized linear models (GLM) procedure of SAS to identify non-genetic factors affecting the investigated traits (SAS, 2011). The model for whole traits (body weight and body measurements) were included effects of lambing year, lambing month (January, February, March and April), sex (male and female), birth type (single and twin) and age of dam at lambing (2-7 years old). For whole traits, all the factors were significant (P<0.01), but for BW, BL, HB and LC, age of dam was not significant (p>0.05) in six month age and not significant (P>0.01) for all traits at 12 and 18 month of age, therefore were omitted from final model. Preliminary analyses (not shown) showed that influence of maternal effects can be was negligible and non-significant in six month age (P>0.05) and in 12 and 18 month age (P>0.01) for all variables. As a consequence, maternal effects were not included in the fitted model.

A six-trait animal model combined with REML procedure, which allowed for design matrices observations, was used to estimate variance components, heritability coefficients and correlations among those six traits, simultaneously. DFREML software package Meyer were used for analyzing the data using following model (Meyer, 2000):

\[ y = X\beta + Za + e \]

Where:
- \( y \): vector of observations.
- \( \beta \): vector of fixed effects.
- \( a \): vector of random effects.
- \( e \): vector of random residual effects.
- \( X \) and \( Z \): incidence matrices relating observations to fixed and random effects, respectively.

**MATERIALS AND METHODS**

**Data structure**

The used data were collected from 1989 to 2012 at Makuei Sheep Breeding Station in Maku (West Azerbaijan).
It is assumed that additive genetic effects and residual effects are normally distributed with mean zero and variance $A$ and $I_e$, respectively:

Where:
$A$: additive numerator relationship matrix obtained from pedigree structure.
$I_e$: identity matrix with orders of $N$ (number of records).
$\sigma^2_a$ and $I_e \sigma^2_e$: additive genetic variance and residual variance, respectively.

RESULTS AND DISCUSSION

Descriptive statistics for different traits have been summarized at Table 1. The mean of BW, WH, RH, BL, HG, and LC in Makuie sheep were measured in three ages group as 6, 12, and 18 months of age; data value were 27.08 ± 0.19, 56.73 ± 0.14, 58.80 ± 0.16, 42.87 ± 0.12, 70.41 ± 0.18 and 29.21 ± 0.12 for 6 months; 34.05 ± 0.19, 63.47 ± 0.13, 64.91 ± 0.14, 51.88 ± 0.15, 81.50 ± 0.23 and 36.13 ± 0.11 for 12 months; and 43.35 ± 0.27, 66.04 ± 0.17, 67.17 ± 0.17, 57.18 ± 0.19, 91.27 ± 0.23 and 36.13 ± 0.11 for 18 months of age, respectively. According to estimated values of coefficient of variation (CV %), BW was the most variable traits in three ages group. The reason of greater CV for BW was probably due to more variability in relation to the mean of body weight and effect of outside environment on this trait. Similar to this result, Janssens and Vandepitte (2004) found greater CV for body weight compared to body measurement traits in three breeds of Belgian sheep: Blue du Maine, Suffolk and Texel.

Studied traits in six months of age

Estimation of variance components and heritability for studied traits are shown in Table 2. The estimated heritability estimates were $0.49 \pm 0.17, 0.46 \pm 0.09, 0.48 \pm 0.11, 0.45 \pm 0.08, 0.47 \pm 0.15$ and $0.5 \pm 0.19$ for BW$_6$, WH$_6$, RH$_6$, BL$_6$, HG$_6$ and LC$_6$, respectively. The estimated heritability for BW$_6$ was in agreement with report of Miraei-Ashtiani et al. (2007) in Sangsari breed (0.49). The estimated heritability for BW$_6$ in Iranian sheep ranged from 0.13 in Zandi breed (Mammadi et al. 2011) to 0.49 in Sangsari breed (Miraei-Ashtiani et al. 2007).

Phenotypic and genetic correlations in six months of age are presented in Table 3. Results showed that phenotypic and genetic correlations ranged from 0.11 to 0.88 and 0.1 to 0.87, respectively. The maximum and minimum genetic correlations were between BW$_6$ with WH$_6$ (0.53) and BW$_6$ with LC$_6$ (0.17), respectively. Maximum and minimum phenotypic correlations were between BW$_6$ with RH$_6$ (0.57) and BW$_6$ with LC$_6$ (0.18), respectively.

Phenotypic and genetic correlations between RH$_6$ with BL$_6$ and HG$_6$ were medium and with LC$_6$ were very low. Phenotypic and genetic correlations between HG$_6$ and other traits were medium but with LC$_6$ were lower and LC$_6$ had relatively lower correlation with other traits; so the highest genetic and phenotypic correlations were between RH$_6$ and WH$_6$ (0.87 and 0.88, respectively); also the lowest genetic and phenotypic correlations were between RH$_6$ and LC$_6$ (0.10 and 0.11, respectively) in six months age. Sahin et al. (2007) reported the moderate and significant correlation value between BW$_6$ and HG (0.56) in Merino lambs. Rare researches have been published about estimation of genetic parameters at six months age in sheep; therefore it’s hard to compare the results with others.

Studied traits in 12 months of age

Estimation of variance components and heritability coefficients for studied traits in 12 months of age are shown in Table 4. Heritability estimates were $0.34 \pm 0.05, 0.23 \pm 0.05, 0.25 \pm 0.04, 0.20 \pm 0.04, 0.29 \pm 0.06$ and $0.07 \pm 0.04$ for BW$_{12}$, WH$_{12}$, RH$_{12}$, BL$_{12}$, HG$_{12}$ and LC$_{12}$, respectively. The estimated value of heritability for BW$_{12}$ (0.34) was lower than those have been reported by Snyman et al. (1995) in Afrino breed (0.58) and by Bathaei and Leroy (1998) in Mehraban breed (0.44). On the other hand, our estimation is higher than those results have been reported by Bahreini-Behzadi et al. (2007) in Kermani breed (0.14) and by Miraei-Ashtiani et al. (2007) in Sangsari breed (0.10). Heritability estimates for BL$_{12}$, HG and WH are lower than results of Janssens and Vandepitte (2004) for three breeds of adult Belgian sheep.

In current study, heritability estimates at 12 months age were lower than six months age; it could be because of poor nutrition and low quality of pasture on sheep breeding station which can cause a big environmental variance.

Phenotypic and genetic correlations at 12 months of age are reported in Table 5. Results showed that genetic correlations were generally higher than phenotypic correlations. The estimated genetic correlations ranged from 0.35 to 0.99, while corresponding values for phenotypic correlations were ranged from 0.28 to 0.92. These results were in agreement with reports for Belgian blue du Maine, Suffolk, Texel sheep (Janssens and Vandepitte, 2004).

Genetic and phenotypic correlations between BW$_{12}$ and body measurement traits were very high and moderate, respectively. The highest genetic and phenotypic correlation were between HG$_{12}$ and BW$_{12}$ (0.95 and 0.63). The high and significant correlations between BW$_{12}$ with HG and RH show these two traits or their combination can be good estimation for live body weight in 12 months age in Makuie sheep.
Studied traits in 18 months of age

Estimation of variance components and heritability coefficients for studied traits in 18 month of age are shown in Table 6. Heritability estimates were 0.65 ± 0.19, 0.37 ± 0.08, 0.48 ± 0.12, 0.32 ± 0.10, 0.73 ± 0.21 and 0.44 ± 0.11 for BW, WH, RH, BL, HG and LC, respectively.

Table 1: Descriptive statistics for body weight at year of age (BW), withers height (WH), rump height (RH), body length (BL), heart girth (HG) and leg circumference (LC) for different traits

<table>
<thead>
<tr>
<th>Item</th>
<th>BW</th>
<th>WH</th>
<th>RH</th>
<th>BL</th>
<th>HG</th>
<th>LC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of records</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>No. of sire</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>No. of dam</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Mean</td>
<td>27.08 (kg)</td>
<td>56.73 (cm)</td>
<td>58.80 (cm)</td>
<td>42.87 (cm)</td>
<td>70.41 (cm)</td>
<td>29.21 (cm)</td>
</tr>
<tr>
<td>SE</td>
<td>0.19</td>
<td>0.14</td>
<td>0.16</td>
<td>0.12</td>
<td>0.18</td>
<td>0.12</td>
</tr>
<tr>
<td>CV (%)</td>
<td>14.32</td>
<td>4.97</td>
<td>5.43</td>
<td>5.88</td>
<td>5.30</td>
<td>8.18</td>
</tr>
</tbody>
</table>

Table 2: Variance components for body weight (BW₆), withers height (WH₆), rump height (RH₆), body length (BL₆), heart girth (HG₆) and leg circumference (LC₆) in six months age

<table>
<thead>
<tr>
<th>Traits</th>
<th>BW₆</th>
<th>WH₆</th>
<th>RH₆</th>
<th>BL₆</th>
<th>HG₆</th>
<th>LC₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>σ²a</td>
<td>5.65</td>
<td>2.85</td>
<td>3.71</td>
<td>2.16</td>
<td>6.35</td>
<td>2.72</td>
</tr>
<tr>
<td>σ²e</td>
<td>5.81</td>
<td>3.35</td>
<td>3.78</td>
<td>2.64</td>
<td>7.18</td>
<td>2.75</td>
</tr>
<tr>
<td>σ²p</td>
<td>11.46</td>
<td>6.20</td>
<td>7.50</td>
<td>4.80</td>
<td>13.53</td>
<td>5.47</td>
</tr>
<tr>
<td>h²±SE</td>
<td>0.49±0.17</td>
<td>0.46±0.09</td>
<td>0.48±0.11</td>
<td>0.45±0.08</td>
<td>0.47±0.15</td>
<td>0.5±0.19</td>
</tr>
</tbody>
</table>

σ²a: additive genetic variance; σ²e: residual variance; σ²p: phenotypic variance and h²±SE: heritability estimates and standard error.

Table 3: Phenotypic and genetic correlations among body weight (BW₆) with withers height (WH₆), rump height (RH₆), body length (BL₆), heart girth (HG₆) and leg circumference (LC₆) in six months age

<table>
<thead>
<tr>
<th>Traits</th>
<th>BW₆</th>
<th>WH₆</th>
<th>RH₆</th>
<th>BL₆</th>
<th>HG₆</th>
<th>LC₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW₆</td>
<td>-</td>
<td>0.54</td>
<td>0.57</td>
<td>0.50</td>
<td>0.52</td>
<td>0.18</td>
</tr>
<tr>
<td>WH₆</td>
<td>0.53</td>
<td>-</td>
<td>0.88</td>
<td>0.43</td>
<td>0.52</td>
<td>0.30</td>
</tr>
<tr>
<td>RH₆</td>
<td>0.57</td>
<td>0.87</td>
<td>-</td>
<td>0.39</td>
<td>0.42</td>
<td>0.11</td>
</tr>
<tr>
<td>BL₆</td>
<td>0.49</td>
<td>0.42</td>
<td>0.38</td>
<td>-</td>
<td>0.45</td>
<td>0.26</td>
</tr>
<tr>
<td>HG₆</td>
<td>0.50</td>
<td>0.51</td>
<td>0.41</td>
<td>0.44</td>
<td>-</td>
<td>0.29</td>
</tr>
<tr>
<td>LC₆</td>
<td>0.17</td>
<td>0.16</td>
<td>0.10</td>
<td>0.26</td>
<td>0.28</td>
<td>-</td>
</tr>
</tbody>
</table>

Phenotypic and genetic correlations in 18 months of age are reported in Table 3. The genetic correlations were estimated in the range of –0.08 to 0.97. Phenotypic correlations were estimated in the range of 0.10 to 0.95. Genetic correlations between BW₁₈ and body measurements traits were moderate to high and the highest genetic correlation was between BW₁₈ and BL.
Phenotypic correlations between BW subscripts 18 and body measurements traits were medium to low. These results are in agreement with reports of Mukherjee et al. (1986) and Singh et al. (1987) in brown Bengal does and grey Bengal goats, respectively.

The estimated heritability of body weight and body measurement traits in different ages showed that the values at 12 months age are less than those at 6 and 18 months age; it comes down from 6 to 12 months age, then goes up to 18 months of age. These results happened because of greater value of environmental variance at 12 months of age.

Mavrogenis et al. (1980) and Yazdi et al. (1997) reported that heritability estimates for body weight and body measurement traits increase by increasing of age, which are in disagreement with results of current study.

**CONCLUSION**

Body weight and body measurement are important traits in meat animals. The analyses of data on body measurement traits provide quantitative measure of body size and shape that are desirable, as they will enable genetic parameters for these traits to be estimated and also permit inclusion in bre-
eading programs. Estimation of heritability indicated that improvement in body measurements and body weight of Makuei sheep are possible through selection procedures. The positive correlation between body weight and body measurements traits in different ages indicated that selection for body measurements can lead to improve in body weight. Finally, further research need to be conducted to investigate the relationship between body weight and body measurement traits in current and other sheep breeds in different regions and ages.

**ACKNOWLEDGEMENT**

Authors are grateful to support of Razi University and Makuei Sheep Breeding Station staff for providing the working facilities.

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