Estimation of Genetic Parameters for Body Measurements and Their Association with Yearling Live Weight in Makuie Sheep Breed

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Abstract: The body measurements data of 2144 lambs from 122 sires and 984 dams recorded during 24 years from 1989 to 2012 at Makuie Sheep Breeding Station (MSBS) were used to estimate the genetic parameters of body measurements in Makuie sheep breed. The used traits in present study were: height at withers (HW), height at rump (HR), body length (BL), heart girth (HG), leg circumference (LC) and yearling weight (YW). The estimations were done by using DFREML software. Direct heritabilities by single trait analysis were estimated 0.20 for HW, 0.24 for HR, 0.10 for BL, 0.14 for HG, 0.02 for LC and 0.36 for YW. Using bivariate analysis, additive genetic correlations were estimated 0.56, 0.58, 0.81, 0.79 and 0.68 between HW, HR, HG, BL and YW, respectively. Six different animal models were fitted for all traits. The log likelihood ratio test (LRT) was used to selection of appropriate model. Based on LRT the direct additive genetic and maternal permanent environmental effects were considered as the main source of variation in the studied traits and hence, modest rates of genetic progress were possible for the studied traits.

Key words: (Co) variance components, Direct and maternal effects, Heritability, Makuie sheep

INTRODUCTION

Makuie sheep breed is a native breed of Azerbaijan province (Iran) and can also be found in Turkey (called as white Karaman). Its total population is estimated 2.7 millions in Iran [1]. It has been adapted to cold and highland environments [2]. Makuie is a medium-sized (ewe= 45-48 kg, ram = 51-53 kg) and fat-tailed sheep breed. The common color of its body is white and black rings are around its eyes, nose and knees [3]. This breed is reared for meat, wool and milk production, but the main purpose of flock holders is lamb and mutton production in an extensive or semi-intensive system. Because of Makuie sheep breed importance in Azerbaijan region economy, in 1986, the Makuie Sheep Breeding Station (MSBS) was established in the city of Maku, Western Azerbaijan, Iran by the Jihad Sazandegi Ministry [2]. The main goals of MSBS were protection and improvement of this sheep breed [2]. Rearing system in MSBS is mostly extensive-migratory on natural pastures in spring and summer, from April to September and semi-intensive in station with fed in barn during autumn and winter, from October to March. Alfalfa, barley, corn silage, concentrates and grass are used to feed the animal in semi-intensive rearing period. Breeding season starts late of summer and early of autumn. Estrus synchronization is done in the flock. Intra vaginal progesterone release devise (CIDR) is used to estrus synchronization. Ewes then are bred either with artificial insemination in the first cycle of estrus or with controlled rams in the second or 3rd cycle of estrus. To increase of the litter size, two programs are applied: flushing (feeding of ewes with high level of energy 2-3 weeks before breeding season); equine chorion gonadotrophin (ECG) injection at CIDR removal. Ewes are kept in the flock for a maximum of 6 parities and rams for 5 breeding season. lambing occurs once in a year and its season starts early of latest month of winter (late of January). Lambs receive creep feeding at two week of age [4].

Meat yield is a complex polygenic trait that is highly affected by non-genetic and genetic factors. Biometric characteristics or linear measurements with simple genetic controls could be used as an indirect criterion in many domestic animal species to help meat yield improvement.
Body measurements beside weight measurements describe more completely an individual or population than the conventional methods of weighing and grading [5].

Using measurement criteria, breeders can be able to identify early maturing and late maturing animals with different sizes [6]. It will be helpful for identifying appropriate animals in earlier growth stage 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 [5]. The body size, same as breed, genetic selection, nutrition and season of birth influences the age of maturing. Lambs with bigger size of body are suitable to maturing in low ages. Breeders can use biometric traits as a criterion in selection programs. Present study was focused on estimation of genetic parameters of body measurements with 6 different models and their correlations with yearling live weight in Makuie sheep breed.

MATERIALS AND METHODS

Data Structure: The body measurements data of 2144 lambs from 122 sires and 984 dams recorded during 24 years from 1989 to 2012 at MSBS was used in present study. The collected data were on: height at withers (HW), height at rump (HR), body length (BL), heart girth (HG), leg circumference (LC) and yearling weight (YW).

HW measures the distance from a platform on which the animal stands to the withers. The measurement is best made with a special measuring stick on two arms one is held vertical and the other at right angles to it sliding firmly up and down to record height. HR is the distance from the surface of a platform to the rump using a measuring stick as described for height at withers. BL refers to the distance from the first cervical vertebrae to the base of the tale where it joins the body. HG is a circumferential measure taken around the chest just behind the front legs and withers. Tape measure was used to measuring HG. LC refers to the circumference of rear legs. The midpoint between hock and pin bone at right rear leg is used to measuring LC. The measuring tool is tape measure.

Models for Analysis of Data: Variance and covariance components were estimated based on animal model with restricted maximum likelihood (REML) approach using a derivate-free (DF) algorithm [7]. The year of birth, sex, birth type and age of dam had 24, 2, 3 and 6 levels, respectively and were considered as a fixed effect. The statistically significant tests (P<0.05) were done using general linear model with GLM procedure in the SAS [8] software. Six different univariate models were fitted for each trait. They were different in the concept of random effect and their correlations. Maternal genetic or permanent environmental effects were taken into account by including them in appropriate models [9]. The linear forms of six models were:

Model I: \( Y_{ijkl} = \mu + YB_i + LS_j + AE_k + HT_l + AN_m + e_{ijkl} \)

Model II: \( Y_{ijkl} = \mu + YB_i + LS_j + AE_k + HT_l + AN_m + PE_n + e_{ijkl} \)

Model III: \( Y_{ijkl} = \mu + YB_i + LS_j + AE_k + HT_l + AN_m + M_n + e_{ijkl} \) (\( r_m=0 \))

Model IV: \( Y_{ijkl} = \mu + YB_i + LS_j + AE_k + HT_l + AN_m + M_n + e_{ijkl} \) (\( r_m \neq 0 \))

Model V: \( Y_{ijkl} = \mu + YB_i + LS_j + AE_k + HT_l + AN_m + M_n + PE_n + e_{ijkl} \) (\( r_m=0 \))

Model VI: \( Y_{ijkl} = \mu + YB_i + LS_j + AE_k + HT_l + AN_m + M_n + PE_n + e_{ijkl} \) (\( r_m \neq 0 \))

where \( Y_{ijkl} \), each observation on underlying trait belongs to its appropriate group; \( \mu \), overall mean of population; \( YB_i \), fixed effect of year \( i \); \( SX_j \), fixed effect of sex \( j \); \( Bt_k \), fixed effect of birth type \( k \); \( AD_l \), fixed effect of age of dam \( l \); \( AN_m \), individual additive genetic effect of animal \( m \); \( PE_n \), random effect of permanent maternal environment in \( n \) levels (\( n= \) number of maternal levels for each trait); \( M_n \), maternal genetic effect; \( E_{ijkm} \), residual random effect of observation \( ijk \)….

Depending on fitted model, phenotypic variance \( \sigma^2\), direct additive genetic variance \( \sigma^2_a \), maternal genetic variance \( \sigma^2_m \), permanent environmental variance \( \sigma^2_{PE} \), residual variance \( \sigma^2_e \), direct heritability \( h^2_a = \frac{\sigma^2_a}{\sigma^2} \) and maternal heritability \( h^2_m = \frac{\sigma^2_m}{\sigma^2} \) were estimated. Genetic covariance between direct additive and maternal effects \( \sigma_{am} \) and correlation between direct and maternal additive effects \( r_{am} \) and maternal permanent environmental variance into total phenotypic variance \( \sigma^2 \) were estimated accordingly. In model (VI), phenotypic variance \( \sigma^2 \) partitioned to additive genetic variance \( \sigma^2_a \), maternal
additive genetic variance \((\sigma^2_a)\), a part of total phenotypic variance of animals (lamb) that defined by maternal additive genetic; \(\sigma_{am}\), covariance between animal effects, permanent environmental variance \((\sigma^2_p)\) a part of total phenotypic variance of animal (lamb) that defined by maternal permanent environment such as uterus environment, amount of milk production by mother else and error variance \((\sigma^2_e)\).

Estimates of variance and covariance components and genetic parameters for HW, HR, BL, HG and LC at 12 months age and yearling weight and likelihood values for each analysis under the six different models are summarized in Table 3. For choosing the best model, likelihood ratio test (LRT) was applied. Based on LRT, the model with highest value of log-likelihood (alternative model) was compared with models that had low values of log-likelihood (null models). LRT supposed to be distributed as chi-square, then its degrees of freedom was differentiation between number of parameters of alternative model and null models. Statistical significance for models set at 5% probability level.

### RESULTS AND DISCUSSION

**Descriptive Statistics:** Number of data, mean of traits, standard deviations and coefficient of variance according to sex of animals are presented in Table 1. By considering the values of HW and HR, it is observed that HR is higher by 1.45 cm than HW that it could be proposed as an advantage of Makuie sheep due to its raising condition and its breed characteristics. This finding is in accordance with the results for the Turkish Karayaka sheep breed [10].

The low CVs observed for body measurements in Makuie sheep breed have been also reported by other researchers [5, 11-13]. The reason for this condition maybe due to small differences among animals in population, minor change of body measurements by environmental qualification and other unknown factors.

**Fixed Effects:** Data structure resulted by incorporating fixed effects on body measurement traits are presented in Table 2. The studied environmental factors showed significant effect on body measurement traits in Makuie sheep breed.

Sex of animal was found to have non-significant to significant \((P<0.01)\) effect on body measurement traits. For HW, HR and BL traits, the males were bigger by 2cm, 2.21 and 1 cm, respectively than females. However, females were superior to males for LC trait. Male and female didn’t have significant difference in HG trait. These results are approximately similar to the reports for Zulu sheep breed [14]. Significant influences of sex factor on growth may be due to physiological characteristics and endocrinial system, type and measure of hormone secretion especially sexual hormones [15].

Significant effect of birth type on body measurement traits has been reported in other breeds such as Muzaffarnagri sheep [16]. The limited uterine space during pregnancy, nutrition of dam especially during last pregnancy and competition for milk sucking between multiple births lambs during birth to weaning, maybe lead to the significant effect of birth type on body measurement traits and yearling weight. Significant influences of birth year on studied traits can be explained by differences in management, food availability, disease, climatic condition (such as rate of rainfall, humidity and temperature that had effect on quality and quantity of pasture forage) and raising system in different years. The results for age of dam on BL, HG and LC traits were non-significant. Its effect on HW and HR was significant \((P<0.05)\).
Heritability and (Co) Variance Components: Most suitable models are showed as bold shape in Table 3. Among estimated $h^2_s$ for each of HW, HR, BL and LC traits based on 6 different models, there wasn’t notable difference. This could be reason of selecting model I as the best model for mentioned traits. This means that we didn’t need to introduce maternal random effects. These results were in accordance with the reports for body measurements traits in Muzzafarnegri sheep breed at 12 months of age [16]. Permanent environmental maternal effect in model (Model 2) explained 2% to 16% of total phenotypic variance for body measurement traits and yearling weight and it was significant for HG and YW traits.

Direct heritability Estimates using model I was 0.20, 0.24, 0.10, 0.14, 0.02 and 0.36 for HW, HR, BL, HG, LC and YW respectively.

Although, negative $r_{AM}$ is impossible from biological perspective [17], introducing a non-zero covariance between direct and maternal genetic in model (model IV and VI) was yielded a negative correlation between these effects. Based on previous studies the probable reasons for negative $r_{AM}$ are poor environmental conditions (such as udder problems, non-sufficient nutrition and experimental conditions) [9].

Recent studies have shown that the data structure plays the main role in the producing of negative correlation between direct and maternal genetic. As low progeny records per dam in data structure produce negative $r_{AM}$ [17], whereas high number of progeny records per dam produce positive $r_{AM}$.

Model 3, which included only direct and maternal additive effects, was yielded maternal effects contributing 0.00% to 29% for body measurement traits and yearling weight. But, presence of maternal genetic was non-significant in affecting of total phenotypic variance.

From a developmentally perspective, some negative correlations provide checks and balances between direct and maternal effects for growth traits whereas this condition could undermine species from becoming extreme in view of producing more and more milk [18].

Correlation: Characteristic of data structure are summarized in Table 4. Additive correlations were generally higher than phenotypic correlations. Expected correlations among body measurements were moderate to high and positive. The additive correlations were estimated in the range of 0.25 to 0.99. Phenotypic correlations were estimated in the range of 0.32 to 0.90. These results are nearly similar to the reports for Belgian

| Trait | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|-------|---------|---------|---------|---------|---------|---------|
| HW    | 0.20    | 0.18    | 0.19    | 0.20    | 0.18    | 0.20    |
| HR    | 0.24    | 0.21    | 0.20    | 0.20    | 0.20    | 0.20    |
| BL    | 0.10    | 0.08    | 0.10    | 0.10    | 0.07    | 0.07    |
| HG    | 0.14    | 0.11    | 0.14    | 0.20    | 0.10    | 0.10    |
| LC    | 0.02    | 0.009   | 0.02    | 0.02    | 0.009   | 0.02    |
| YW    | 0.36    | 0.31    | 0.20    | 0.20    | 0.20    | 0.20    |
| HR    | 0.99    | 0.53    | 0.45    | 0.41    | 0.41    | 0.46    |
| BL    | 0.76    | 0.77    | 0.44    | 0.36    | 0.41    | 0.41    |
| HG    | 0.47    | 0.46    | 0.82    | 0.38    | 0.47    | 0.47    |
| LC    | 0.88    | 0.83    | 0.97    | 0.25    | 0.32    | 0.32    |
| YW    | 0.55    | 0.57    | 0.77    | 0.78    | 0.73    | 0.73    |

Phenotypic and additive correlations are respectively reported above and below the main diagonal; HW, Height at wither; HR, height at rump; BL, body length; HG, heart girth; LC, leg circumference; YW, yearling weight.
blue du Main, Suffolk and Texel sheep [19] and Yankasa lambs [20]. Genetic (phenotypic) Correlations between body measurements and yearling weight were estimated moderate to high. The highest genetic (phenotypic) correlation was estimated between heart girth and yearling body live weight.

**CONCLUSION**

There is a substantial variability among the individuals in Makuie sheep breed population. The estimated genetic parameters using 6 different models could be proposed as an ethnic characteristic. The high additive genetic correlations among the body measurements indicated the importance of this effect in the similarity of traits. High correlation between body measurements and YW suggested that genetic progress in the body measurement traits and live weight traits is possible at a same time.

**REFERENCES**

1. Abbasi, M.A. and F. Ghafouri-Kesbi, 2011. Genetic co (variance) components for body weight and body measurements in Makuoei sheep. Asian- Aust. J. Anim. Sci., 24: 739-743.
2. Safari, E., 1986, Report for identification of Makuie ecotype, published by agriculture ministry of Iran.
3. Saadatnoori, M. and S. Siahmansoor, 1986. Principles of sheep industry. Third edition, Armagan Publication.
4. Jafari, S., A. Hashemi, G. Manafiazer, R. Darvishzadeh, S. Razzagzadeh and M. Farhadian, 2012, Genetic analysis of growth traits in Iranian Makuie sheep breed. Ital. J. Anim. Sci., 11: e18: 98-102.
5. Salako, A.E., 2006, Application of Morphological Indices in the Assessment of Type and Function in Sheep. Int. J. Morphol, 24(1): 13-18.
6. Brown, J.E., C.J. Brown and W.T. Butts, 1973. Evaluating relationships among immature measures of size, shape and performance of beef bulls. J. Anim. Sci., 36: 1010-1020.
7. Meyer, K., 1989. Restricted maximum likelihood to estimate variance components for animal models with several random effects using a derivative-free algorithm. Genet. Sel. Evol., 21: 317-340.
8. SAS 2005. ‘SAS/STAT software, version 6 of the SAS system.’ (SAS Institute Inc.: Cary, NC)
9. Meyer, K., 1992, Variance components due to direct and maternal effects for growth traits of Australian beef cattle. Livest. Prod. Sci., 31: 179-204.
10. Cam, M.A., M. Olfaz and E. Soydan, 2010. Body measurements reflect body weights and carcass yield in Karayaka sheep. Asian. J. Anim. Vet. Adv., 5(2): 120-127.
11. Alfolyan, R.A., I.A. Adeyinka and C.A.M. Lakpini, 2006. The estimation of live wight from body measurement in Yankasa sheep. Czech. J. Anim. Sci., 51: 343-348.
12. Ermias, E. and J.E.O, Rege, 2003. Characteristic of live animal allometric measurements associated with body fat in fat-tailed sheep. Livest. Prod. Sci., 81: 271-281.
13. Fourie, P.J., F.W.C. Neser, J.J. Oliver and C. Van der Westhuize, 2002. Relationship between production performance, visual appraisal and body measurements of young Dorper rams. South. Afr. J. Anim. Sci., 32(4): 256-262.
14. Kunene, N., E.A. Nesamvuni and A.F. Fossey, 2007. Characterization of Zulu (Nguni) sheep using linear body measurement and some environmental factors affecting these measurements. South. Afr. J. Anim. Sci., 37: 11-20.
15. Aghaali-Gamasae, V., S.H. Hafezia, A. Ahmadi, H. Baneh, A. Farhadi and A. Mohamadi, 2010. Estimation of genetic parameters for body weight at different ages in Mehraban sheep. Afr. J. Biotechnol, 9(32): 5218-5223.
16. Mandal, A., G. Dass, P.K. Rout and R. Roy, 2010. Genetic parameters for direct and maternal effects on post-weaning body measurements of Muzzaffarnagari sheep in India. Trop. Anim. Health. Prod., 43(3): 675-83.
17. Matiatis, N. and G.E. Pollot, 2003. The impact of data structure on genetic (co) variance components of early growth in sheep, estimated using an animal model with natural effects. J. Anim. Sci., 81: 101-108.
18. Cundiff, Larry, V., 1972. The role of maternal effects in animal breeding: VIII Comparative aspect of maternal effects. J. Anim. Sci., 35: 1335-1337.
19. Janssens, S. and W. Vandepitte, 2004. Genetic parameters for body measurements and type traits in Belgian Bleu du Maine, Suffolk and Texel sheep. Small. Rumin. Res., 54: 13-24.
20. Yakubu, A., 2010, Path coefficient and path analysis of body weight and biometric traits in Yankasa lambs. Slovak. J. Anim. Sci., 43: 17-25.