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Estimation of Genetic Parameters and Environmental Factors on Early Growth Traits for Lori Breed Sheep Using Single Trait Animal Model

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Abstract: The effects of different environmental factors and estimation of genetic parameters on early growth traits for Lori breed sheep including birth weight, weaning weight and body weight at 6 months of age using 19960 records from 35 herds of Lorestan Jahad Agriculture Organization were studied in the cities of Aleshtar, Khorramabad and Poldokhtar from 1995 to 2003. The effect of herd, sex of lambs, dam age and birth year on all traits and birth type had significant effect only on weaning weight. Different single trait animal models estimated the components of direct additive genetic variance, maternal genetic variance and maternal permanent environment variance through restricted maximum likelihood using environmental factors as a fixe effect and different random effects. The results showed that direct additive genetic effect had additionally significant effect on all traits moreover maternal additive genetic and maternal permanent environment effects. Results also revealed that the maternal permanent environment variance for all traits is higher than maternal genetic variance. Also the direct heritability for all traits was higher than maternal heritability. Estimation of the direct heritability from the birth to 6 months of age showed a reducing trend that could arise from high dependence of birth and weaning weight on maternal environment conditions as compared with the age conditions afterward. The genetic assessment of growth traits in Lori breed sheep without inclusion of maternal effect in animal model causes decreased selection accuracy and incorrect genetic assessment of the lambs.

Key words: Lori breed sheep, growth traits, maternal effects, environmental factors

INTRODUCTION

Lori is a fat-tailed and white wool sheep, which accounts for one of the heavy weight breeds in Iran as the dominating breed of Lorestan province. It has a population more than 4.8 million animal units and is considered to have superiority over other breeds in terms of resistance against disease and tolerance of hard environmental conditions. Breeding of this sheep highly depends on the pastures and its environmental conditions (Tavakkolian, 2000).

Nowadays, body weight is one of the major selection traits in sheep population (Szwaczkowski *et al*., 2006). Also studies have shown that in hard environmental conditions profitability of sheep husbandry industry depends on the total weight of the lambs born by each ewe in each year of pregnancy when they stop feeding on milk (Olivier *et al*., 2000). The importance of this characteristic is due to different features of reproduction (such as ovulation number, fecundity, longevity of the lamb, number of lambs born and weaned), maternal potentials, lactation of ewes and growth capacity of the lamb (Vatankhah and Moradi, 2002; Ligda *et al*., 2000).

In order to have a successful breeding plans and relative increase in economic value of traits, we should know responsible environmental and genetic factors and their impact on the function of each trait. In consequence, maternal effects are defined as any influence from dam to progeny, excluding the effects of directly transmitted genes (Nejad Sajjadi *et al*., 2007; Szwaczkowski *et al*., 2006). Due to the important of maternal effects on the growth of lambs many of researchers such as Nejad Sajjadi *et al*. (2007), Nasholm (2004), Hassen *et al*. (2003), Van Vleck *et al*. (2003) and Vatankhah and Moradi (2002) shown that the important of including it in various genetic assay.

Biological mechanisms for explaining of maternal effects include cytoplasm inheritance, nutritional condition during pregnancy and neonatal stages, antibodies, pathogenic factors transfer from dam to progeny and maternal behavior (Vatankhah and Moradi, 2002). In fact the mother other than transmitted half of

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total genes but also reveal part of its genes as maternal effects in the phenotype of lamb (Nejad Sajjadi *et al*., 2007)

The objective of this research was to study the effect of different environmental factors on early growth traits including birth weight, weaning weight, body weight at 6 months of age and estimation of the direct genetic parameters as well as indirect (maternal) genetic effects on this traits and their importance in selection programs of Lori breed sheep.

MATERIALS AND METHODS

The effect of environmental factors and estimation of genetic parameters for early growth traits including birth weight, weaning weight and body weight at 6 months of age were studied by using 19960 records collected from 35 herds from 1995 to 2003 by Lorestan Jahad Agriculture Organization. The environmental factors including dam age, sex of lambs, birth type, birth year and geographical region were studied by using a proper statistical method.

The statistical analysis of data for study of environmental effects of understudied traits was done by general linear model method and the comparison of least squares means using SPSS software and following statistical model.

$$Y_{ijklmn} = \mu + b_i + C_j + H_k + PS_l + R_m + e_{ijklmn}$$

Where:

Y_{ijklmn} = Observation of each trait
μ = Mean of trait
b_i = Ith lamb sex of fixed effect (male and female)
C_j = Jth birth type of fixed effect (single or twin)
H_k = The random animal effect
Ps_l = Lth birth year of fixed effect (1995 to 2003)
R_m = Mth geographical region (Aleshtar, Khorramabad, Poldokhtar) of fixed effect
e_{ijklmn} = Residual random effect

Study of the random effects including direct additive genetic effect, maternal additive genetic effect and maternal permanent environmental effect as well as variance components estimation for the understudied traits were done using DFREML software (Meyer, 1997) and derivative free algorithm restricted maximum likelihood method. In order to study genetic and maternal environment effects on understudied trait, analysis of data was done by fitting six different animal models as follows:

$Y = Xb + Z_1a + e$ Meyer 1
$Y = Xb + Z_1a + Z_3Pe + e$ Meyer 2
$Y = Xb + Z_1a + Z_2m + e \ (cov_{a,m} = 0)$ Meyer 3
$Y = Xb + Z_1a + Z_2m + e \ (cov_{a,m} \neq 0)$ Meyer 4
$Y = Xb + Z_1a + Z_2m + Z_3Pe + e \ (cov_{a,m} = 0)$ Meyer 7
$Y = Xb + Z_1a + Z_2m + Z_3Pe + e \ (cov_{a,m} \neq 0)$ Meyer 8

Where:

Y = Observation vector
b = Fixed effect vector
a = Random direct additive genetic effect vector
m = Random maternal additive genetic effect vector
Pe = Random maternal permanent environment effect vector
e = Residual random effect vector
X, Z_1, Z_2, Z_3 = Incidence matrices relating records to b, a, m and Pe vectors, respectively

In order to determine best model for processing of data under study, the likelihood ratio test method and comparison of significant increase in logL in Meyer 1 to Meyer8 models were used and if -2 logL higher than chi-square distribution with one degree of freedom its use as a criteria for maintaining an effect in the model.

RESULTS AND DISCUSSION

Estimation of environmental factors: The least square means and standard errors for birth weight, weaning weight and body weight at 6 months of age by geographical region, lamb sex, dam age, birth type and birth year as well as criterion of variation (CV) for each trait have been shown in Table 1.

Results show that the effect of geographical region on all traits was significant. The birth weight of the lambs of Aleshtar was the highest and that of the Khorramabad was the lowest. The lambs of Aleshtar had the least weaning weight, however their weights at the end of 6 months of age were higher than other regions which reveals that environmental difference in a small region of area could have a significant effect on economic traits, which arises from the inferior maternal environmental effect in Aleshtar region. However, the lambs of this region due to the compensatory growth at the end of 6 months of age, have shown a higher weaning weight than other regions. Khezdozi *et al*. (2007) shown that a difference between two type of field and alpine Kordi breed sheep for birth weight, weaning weight, body

Table 1: Least square means and standard errors for early growth traits

Sources	Birth weight (kg)	Weaning weight (kg)	Body weight at 6 months of age
Mean (kg)	3.00±0.64	22.50±1.72	29.21±3.24
CV (%)	21.33	7.66	11.10
Region	**	**	**
Aleshtar	3.38+0.67	16.60+0.58	33.00±3.10
Khorramabad	2.35±0.03	22.50±2.64	28.30±4.12
Poldokhtar	2.80±0.04	25.00±2.50	31.55±2.94
Sex	***	**	**
Male	3.40±0.99	22.50±1.61	28.90±3.73
Female	3.10±0.73	22.40±1.62	28.60±3.51
Dam age (years)	**	**	**
2	3.30±0.96	24.00±5.73	29.60±1.19
3	3.50±1.19	22.20±1.85	30.90±5.37
4	3.50±1.01	22.17±1.45	28.40±3.83
5	3.00±0.24	22.40±1.70	28.20±2.76
6	2.80±0.29	22.40±1.54	28.50±2.99
7	2.70±1.54	22.50±0.25	28.90±3.10
8	3.10±0.42	22.50±1.57	28.40±3.03
Birth type	ns	**	ns
Lamb	3.35±0.78	23.00±1.61	28.60±3.57
Twin lambs	3.36±1.04	22.50±1.45	28.50±3.66
Birth year	**	**	**
1995	3.55±0.96	24.00±0.80	29.60±5.73
1996	3.54±1.19	22.28±1.85	30.92±5.38
1997	3.55±1.01	23.17±1.45	28.41±3.84
1998	3.01±0.24	22.24±1.70	28.21±2.76
1999	2.84±0.29	22.45±1.54	28.55±2.99
2000	2.93±0.25	22.57±1.55	29.90±3.17
2001	3.07±0.27	22.55±1.56	28.28±2.68
2002	3.02±0.11	22.30±1.54	27.80±2.88
2003	3.10±0.46	22.86±1.55	29.40±3.84

ns: non significant, **: $p<0.01$, ***: $p<0.001$

weight at the 12 months of age and milk yield of ewes because of distinctive environmental condition in two region.

Results of Table 1 shows that the effect of lamb sex, dam age and birth year on all traits are significant that correspond with many of study so Khezdozi *et al.* (2007), Dashti *et al.* (2007), Tibbo (2006), Al-Saigh and Al-Khouzai (1991), Buvanendran *et al.* (1992) and Naikar *et al.* (1990) have proven that the weight of male lambs at time of birth, weaning and older ages is significantly higher than the female lambs, which is compatible with the results of this study and may be attributed to the physiological differences of two sex.

Kulkarni and Deshpande (1991), Al-Saigh and Al-Khouzai (1991), Buvanendran *et al.* (1992) and Oltoff and Boylan (1991) have reported the birth and weaning weight of lambs born by the 2 years old ewes to be significantly less than the lambs born by ewes of other age groups (3 to 7 years old) that correspond to result of this study can be caused by higher body condition in older ewes.

Makarechian *et al.* (1977) have point out in their studies that the lambs born by the 4 and 6 years old ewes would have more birth and weaning weight as compared with the lambs born by the 2 years old ewes which is due to the sufficient feeding. At the same time there is decreasing effect of dam age on growing traits after weaning time due to less dependence of lambs to dams at the older ages which conforms the results of this study.

Results of Table 1 show that the effect of the birth type is significant only for weaning weight. The number of lambs per ewe in parturition has an impact on birth weight and growth of lambs before the end of suckling period and the rate of growth of singles at this stage is quicker than twin lambs (Khezdozi *et al.*, 2007; Al-Saigh and Al-Khouzai, 1991; Dimsoski *et al.*, 1999; Bourfia and Touchberry, 1993) that opposite with results of this study.

Generally, with the increase in litter size and due to the competition between the embryos to receive nutrients from dam, birth weight of lambs decreases, however the lack of significant difference between the birth weight of the single and twin lambs in this study may arise from the high capacity of this breed and provision of suitable maternal environmental effect at the time of pregnancy.

As increase in litter size and due to the competition for the satisfaction of needs through milk consumption, weaning weight in twin lambs decreases as compared with singles according to Shelton *et al.* (1991) and Vaez Torshizi *et al.* (1992) and conform the results of this study.

The results show that there is no significant difference in the body weight at 6 months of age between single and twin lambs which may be attributed to the independence of lambs on the maternal environmental effects in older ages and compensatory growth of the twin lambs.

As shown by Tibbo (2006) and Yazdi *et al.* (1998) the effect of birth year on early growth traits is significant which correspond the results of this study and may be caused by difference in raining, humidity and temperature which effect the quantity and quality of the pastures and this is predictable in breeding of Lori sheep because of it dependency to the condition of pastures.

Estimation of genetic factors: Variance components and genetic parameters of studied traits in this research have been estimated with six different animal models and by using the likelihood ratio test, the model which showed a significantly increase in the likelihood logarithm was used as the most suitable model for the estimation of the variance components. Elements of this model include direct additive genetic variance, maternal additive genetic variance and maternal permanent environment variance, which were derived by using the Meyer 7 model (Table 2).

Table 2: Estimation of variance components and genetic parameters for early growth traits

Traits	Birth weight (kg)	Weaning weight (kg)	Body weight at 6 months of age
σ^2_a	0.609	2.499	4.657
σ^2_m	0.228	0.782	1.170
σ^2_{Pe}	0.407	1.830	2.650
σ^2_e	0.004	1.970	5.035
σ^2_P	1.248	7.081	13.512
h^2_a	0.488	0.353	0.345
h^2_m	0.183	0.110	0.087
h^2_{Pe}	0.326	0.258	0.196

σ^2_a = Direct additive genetic variance, σ^2_m = Maternal genetic variance, σ^2_{Pe} = Maternal permanent environmental variance, σ^2_e = Residual variance, σ^2_P = Phenotype variance, $h^2_a = \sigma^2_a / \sigma^2_P$, $h^2_m = \sigma^2_m / \sigma^2_P$, $h^2_{Pe} = \sigma^2_{Pe} / \sigma^2_P$

The birth weight is the first growth index and it's phenotypic expression in progeny is influenced by the ability of the dam to provide a suitable environment in the form of better nourishment. Thus the dam contributes to the performance of the progeny in two ways: Firstly, through her direct genetic effects passed to the progeny and secondly, through her ability to provide a suitable environment. The ability of dam is partly genetic and partly environmental (Mrode, 1996). Thus, the genotype of lamb and maternal ability has the highest effect on the birth weight (Bourdon, 1997). The birth weight has a high correlation to other weight related traits, so that the lambs had heavier birth weight would have a higher weight in the subsequent stages of growth as compared to the lambs with lower birth weight.

Upon awareness of the genetic and environmental components, which affect a trait, suitable decisions can be made in breeding management and methods. Results of the Table 2 show that the direct additive genetic variance for birth weight is relatively high, thus confirming the high potential of this breed in response to the selection for this traits and whereas Lori breed is considered as a heavy weight breed, the high potential of this breed for high direct additive genetic effect for birth weight is predictable.

Despite the relatively high direct additive genetic variance, the maternal additive genetic variance and maternal permanent environmental effect of the birth weight is significant and the portion of the maternal additive genetic variance and maternal permanent environmental variance in the total phenotype variance for the birth weight is relatively higher than the weaning weight and body weight at 6 months of age, which shows that ignoring these effects in genetic assessment of the lambs will cause biases and inaccuracy of estimation.

The results reported on the effect of maternal factors on the growth traits are much varied. The present study shows that both additive genetic and maternal permanent environment effect had a considerable part of the phenotype variance of the understudied traits. Safari *et al.* (2005) by using the six different animal models on Turkish merino sheep have reported that in addition to the direct additive genetic effect, both of maternal additive genetic and maternal environment effect have a significant effect on the birth and weaning weights. The effect of these factors decreased for the weight related traits after weaning time, although it has been significant effect. Moreover, the significant effects of maternal additive genetic variance have been reported in the many studies such as Vaez Torshizi *et al.* (1996) and Yazdi *et al.* (1998).

On the other hand, selection for increased birth weight ignoring of the potential of the ewe would be accompanied by the hard delivery. However the number and structure of date to be used may influence the results of the estimation and suitable model (Hanford *et al.*, 2003). The genetic parameters and the heritability is different by herd condition, number of records, the number of fixed or random effects as well as the type of the software (Sadeghi and Yazdanshenace, 2007). However, estimation of genetic parameters in this research was in the range of other study.

The weaning weight is one of the most important economic trait in sheep, which is influenced by the birth weight and the growth rate of the lamb before the end of suckling period. Results of the Table 2 show that the portion of the maternal genetic variance and maternal permanent environment variance in the phenotypic variance (h^2_{Pe} and h^2_m) for weaning weight decreases as compared to the birth weight and this portion decreases once again in body weight at 6 months of age due to the decreased dependence of the lambs on the environment conditions of the ewes in the after weaning times. Nejad Sajjadi *et al.* (2007) has pointed to the reduction of the maternal effects on growth traits of the Kermari lambs with the increase of age. Sadeghi and Yazdanshenace (2007) shown that the decreasing trend of direct heritability from 6 to 12 months of age in Sanjabi breed sheep that similar to results of this study. Wilson and Reale (2006) show that mean standardized variance components decreased with age, consistent with compensatory growth. Phenotypic convergence among adult sheep occurs through decreasing environmental and maternal genetic variation. Maternal genetic effects are thus reduced with age.

The results show that there is a significant trend in heritability that result from declining maternal and environmental components rather than from changing additive variation and correspond with study of Wilson and Reale (2006).

CONCLUSIONS

Studies have shown that ignoring of maternal effects in animal model for estimation of variance components will cause decrease in direct genetic variance components and add in maternal genetic components (Elfadili *et al.*, 2000), therefore, if in the traits that influenced by the maternal ability, the only random animal effect in the model was mentioned, the variance component resulting from other random effects would be insert in the direct additive genetic variance component and will cause up estimate of direct heritability (Nejad Sajjadi *et al.*, 2007). The likelihood ratio test shows that insert of maternal effect in the model for estimation of the variance components is better than condition that only random animal effect inserts in the model. Therefore, maternal effects are considered as a major source of variety in the growth traits. In the present study the maternal genetic heritability of birth weight, weaning weight and body weight at 6 months of age are as much as 0.375, 0.312 and 0.252 times of direct genetic heritability, respectively, which reveal the reduction of the role of maternal effects for growth traits with grow up animals and the highest rate is related to the birth weight which shows the very high maternal effects on the birth weight.

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