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Full Length Research Paper

Estimation of genetic parameters for economic important traits in Moghani Iranian sheep

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Moghani sheep breed is one of the most important meat type breeds among Iranian local sheep. The objective of this contribution was to estimate direct and maternal genetic variance as well as covariance between direct and maternal additive genetic effects. Maternal permanent environmental variance was also estimated. The following traits were studied: Birth weight (BW), average daily gain until three months (ADG3) and average daily gain until 6 months (ADG6). Genetic parameters were estimated for conception rate (CR), number of lambs born per ewe lambing (LS), number of lambs born alive (NLBA), number of alive lambs at weaning (NLAW), litter mean weight per lamb born (LMWLB) and litter mean weight per lamb weaned (LMWLW). Three single trait linear animal models have been employed to estimate genetic parameters for production traits and one mixed model method used to analyze reproduction traits included fixed effects due to year, age of ewe and hormone treatment and also random effects due to animal direct and maternal genetic effects, permanent environmental effects due to repeated lambing by ewes and residual effects. Data were analyzed by restricted maximum likelihood method (REML).

Key words: Birth weight, genetic parameters, Moghani sheep, reproductive traits.

INTRODUCTION

Increasing production efficiency is as much a challenge to producers of livestock as it is in more mechanical forms of industry. Genetic improvement in reproductive and growth traits is a major goal in sheep breeding. Dickerson, (1970) pointed out that efficiency of livestock production is dependent upon reproduction, female production and growth of offspring, and concluded that improvements in reproduction were particularly likely to increase efficiency of sheep production. Development of effective genetic evaluation and improvement programs requires knowledge of the genetic parameters for these economically important traits (Safari et al., 2005). Estimates of genetic parameters for reproductive traits of sheep generally have been low. Gillivan (1996) and Matika et al., (2003) showed that in sheep production, reproductive traits such as fertility, litter size and lamb survival are undoubtedly the most important traits in all systems of sheep production and in all environments. Among reproduction traits, litter size (number of lambs born per ewe lambing) has most often been used as a selection criterion. Body weight and growth traits in sheep are known to be influenced by direct and maternal genetic effects as well as by environmental effects. A number of reports indicate considerable maternal effects for these traits in sheep (Hassen et al., 2003; Vanvaleck et al., 2003; Nasholm, 2004). From mother's perspective, maternal effects on progeny performance results from maternal traits controlled by her genotype and associated environ-mental factor. Therefore, these effects are divided into genetics and environmental components. Estimates of genetic parameters for reproductive traits using animal to plan optimum designs for selection programmers for this breed are scarce. Hence, reliable estimates of genetic parameters are needed to establish an efficient selection program for ewe productivity. However, the goal of this study was to obtain estimates of genetic parameter that are necessary to develop efficient selection strategies for improving the production and

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reproduction in Moghani sheep.

MATERIALS AND METHODS

Data from 1999 to 2009 were extracted from Moghani sheep data base from 1998 to 2008, providing record on ewe and lamb performance for trait included in the breeding programmes. The production traits analyzed in this study were: birth weight (BW), average daily gain from birth until 3 months (ADG3) - weight at 3 months was measured within ±10 days, average daily gain from 3 months until 6 months (ADG6) - weight at 6 months was measured within ±15 days. The reproduction traits analyzed in this study were: Conception rate (CR - with measure of 1 or 0, that is whether the ewe exposed to the ram did or did not lamb), litter size (LS - the number of lambs born per ewe lambing), number of lambs born alive (NLBA - the number of lambs alive at 24 h of age), number of lambs alive at weaning (NLAW), litter mean weight per lamb born (LMWLB - the average weight of lambs at birth from the same parity) and litter mean weight of lambs at weaning (LMWLW - the average weight of lambs at weaning from the same parity). Number of records and means of the traits are given in Table 1.

For production traits, three single trait linear animal models have been employed to estimate genetic parameters.

Model 1

$Y = X\beta + Z_1a + e$

Where, Y is the n × 1 vector of observation; β is the p × 1 vector of fixed effect; a is the q × 1 vector of random direct additive genetic effect; e is the n × 1 vector of random error; X, Z are the n × p, and n × q design matrixes, respectively.

Model 2

$Y = X\beta + Z_1a + Z_2m + e$

Where, m is the q × 1 vector of random maternal additive genetic effects; Z_2 is the n × q design matrix connected observations with maternal additive genetic effects Y, β, a, e, X, Z_1 – as previously mentioned.

Model 3

$Y = X\beta + Z_1a + Z_2m + Z_3c + e$

Where, c is the r × 1 vector of random maternal permanent environmental effects; Z_3 is the n × r design matrix connected observation with maternal permanent environmental effects Y, β, a, m, e, X, Z_1, Z_2 – as previously mentioned.

The first and second moments were assumed to be as follow:

$$E\begin{bmatrix} a \\ m \\ c \\ e \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad \text{and} \quad \text{var}\begin{bmatrix} a \\ m \\ c \\ e \end{bmatrix} = \begin{pmatrix} A\delta^2_a & A\delta_{am} & 0 & 0 \\ A\delta_{am} & A\delta^2_m & 0 & 0 \\ 0 & 0 & I_r\delta^2_{pe} & 0 \\ 0 & 0 & 0 & I_n\delta^2_e \end{pmatrix}$$

Where, A is the q×q additive relationship matrix; I_r and I_n are the identity matrixes; δ^2_a is the direct additive genetic variance; δ^2_m is the maternal additive genetic variance; δ_{am} is the covariance between direct and maternal additive effects; δ^2_{pe} is the maternal permanent environmental effects; δ^2_e is the error variance. Hence, the following genetic parameters have been estimated:

- Direct heritability ($h^2 = \delta^2_a/\delta^2_p$), where, δ^2_a is the phenotypic variance,
- Maternal heritability ($h^2_m = \delta^2_m/\delta^2_p$),
- Covariance between direct and maternal effects as proportion to phenotypic variance ($d_{am} = \delta_{am}/\delta^2_p$),
- Total heritability $h^2_T = (\delta^2_a + 0.5\ \delta^2_m + 1.5\delta_{am})\ /\delta^2_p$ according formula given by Willham (1972).
- Ratio of maternal permanent environmental variance to phenotypic variance (pe^2).

Computing algorithm and comparison criteria

The average information restricted maximum likelihood (AI-REML) algorithm (Johanson and Thompson, 1995) has been employed for estimating the variance components. A value of 10^{-8} was used as the conver-gence criterion for the whole analysis. The computations were preformed using the DFREML package programs of Meyer (2001).

For reproduction traits, mixed model method used to analyze all traits including fixed effects due to year, age of ewe and hormone treatment and also random effects due to animal direct and maternal genetic effects, permanent environmental effects due to repeated lambing by ewes and residual effects. The choice of fixed effects to be considered was made after testing whether the effects were statistically significant with a linear fixed model analyzed with SAS (1996). Covariance components and genetic parameters were estimated using the restricted maximum likelihood method based on derivative-free algorithm, DFREML program of Meyer (2000). A fitting multitrait animal model was fitted as follows:

$Y_i = X_ib_i + Z_ia_i + W_ipe_i + e_i$

Where, Y_i is the vector of observations for trait i; b_i is the vector of fix effects for trait i; a_i is the vector of additive genetic effects for trait i; pe_i is the vector of permanent effects for trait I and e_i is the vector of residual effects for trait i. Incidence matrices X_i, Z_i and W_i relate the observations of the i^{th} trait to the respective fixed effects, additive genetic effects and permanent environmental effects, respectively.

RESULTS

Number of records, animals, sires and means standard deviations of production traits (BW, ADG3, ADG6) are presented in Table 1 and estimates of arithmetic means

Table 1. Means and standard deviations of production traits.

Item	Trait		
	BW (kg)	ADG3 (g)	ADG6 (g)
Number of records	4741	4341	4146
Number of animals	6752	6752	6070
Number of sires	227	200	202
Number of dams	1314	1238	1256
Mean	4.58	0.196	0.156
Standard deviation	0.78	0.08	0.5

Table 2. Estimates of arithmetic means (± S.D), coefficient of variation (CV), direct (h^2) and maternal heritability, direct-maternal genetic correlation (r_{am}), fraction of variance due to permanent environmental (pe^2) and repeatability (r).

Trait	Mean ± SD	CV	h^2 (±SE)	m^2 (±SE)	r_{am}	Pe^2	r
LS	1.4 ± 0.51	15.39	0.08 ± 0.01	0.038 ± 0.01	0.33	0.25 ± 0.05	0.1
CR	0.7 ± 0.25	15.42	0.03 ± 0.01	---	---	---	0.12
NLBA	1.1 ± 0.3	17.72	0.11 ± 0.01	0.05 ± 0.01	0.89	0.03 ± 0.01	0.12
NLAW	1.02 ± 0.36	15.96	0.05 ± 0.02	0.01 ± 0.001	0.27	---	0.09
LMWLB	4.85 ± 0.78	15.68	0.1 ± 0.02	0.03 ± 0.02	0.31	0.03 ± 0.01	0.19
LMWLW	22.86 ± 5.14	19.96	0.09 ± 0.01	0.05 ± 0.01	0.1	---	0.15

(±S.D), coefficient of variation (CV), direct (h^2) and maternal heritability, direct-maternal genetic correlation (ram), fraction of variance due to permanent environmental (pe^2) and repeatability (r) of reproduction traits are shown in Table 2. Figures 1 to 3 present the estimates of genetic parameters for each of the four traits obtained via the models. Estimates of direct and maternal heritabilities, direct-maternal genetic correlation and fraction of variance due to permanent environmental effect of the ewe and ewe-mate, as well as phenotypic variances for reproduction traits are shown in Table 2.

DISCUSSION

Production traits

Mean birth weights ranged from 3.8 to 5.36 kg, ADG3 ranged from 145 to 247 g, ADG6 ranged from 77 to 237 g. In particular, use of model 1 resulted in high estimates of additive genetic variance and direct heritability were 0.33 (±0.01), 0.42 (±0.02), and 0.49 (±0.01) for BW, ADG3, ADG6, respectively. Inclusion of maternal effects (models 2 and 3) resulted in much smaller estimates of h^2. One of the most popular criteria of goodness of model fit is residual variance estimate. In each case, the smalllest ones were obtained for a model with direct and maternal additive genetic effect. For BW, the additive heritability estimates were influenced by the statistical model. In the case of model 2 and 3, h^2_a was the smallest; after eliminating maternal genetic effects, the value increased. For each trait, there was a negative covariance between direct and maternal genetic effects. In contrast to genetic variance, the maternal permanent environmental variance for birth weight, ADG3 and ADG6 were zero or close to zero. The maternal heritability of BW ranged from 0.05 to 0.18. This result is consistent with the results of Nasholm and Danell, (1996) and Larsgard and Olessen, (1998) showed that additive genetic effect on body weight was larger than the maternal genetic effect on birth weight. Larsgard and Olessen, (1998) reported surprisingly high heritability for BW. In this study, maternal heritability was too low unlike in any other literature. Safari et al., (2005) showed that the amount of direct and maternal heritability's of BW in dual-purpose breeds, were of the same size. The literature was conflicting regarding the relative magnitude of the direct and maternal heritability for birth weight; some studies reporting maternal heritabilities higher than direct heritability (Nasholm and Danell, 1996; Maria et al., 1993; VAnwyk et al., 1993; Tosh and Kemp, 1994), while others present results showing the opposite (Al Shorepy and Notter, 1998; Neser et al., 2001). Direct heritabilities estimates of ADG3 and ADG6 were obtained as 0.25 and 0.16, respectively. The direct heritability of ADG3 and ADG6 in this study was similar to the esti-mates reported for other sheep breeds (Nasholm, 2004; Maria et al., 1993). On the other hand, estimates of direct heritability obtained for ADG3 and ADG6 in this study was lower than those reported by Abboud (1989) and Kumar and Reheja, (1993). This change, in the contribution of the direct and maternal genetic effects with increasing age

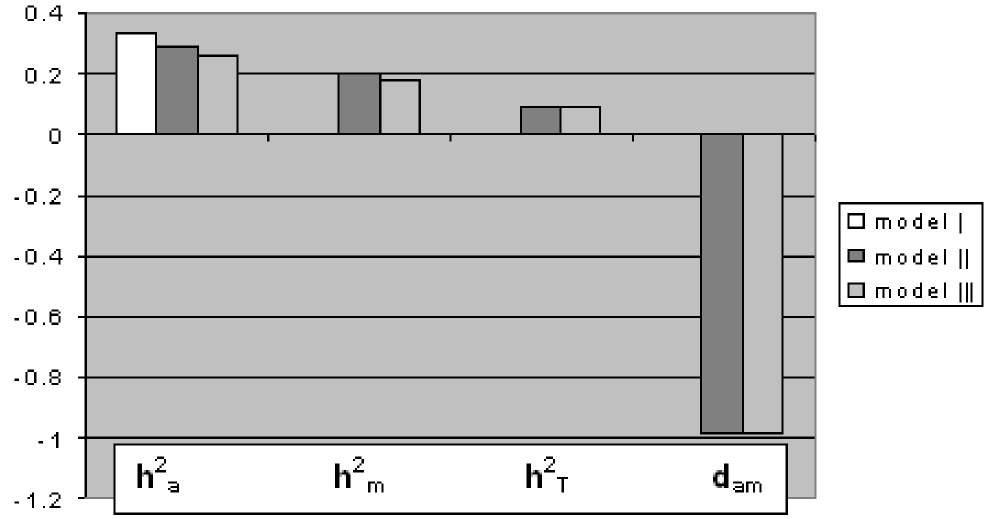

Figure 1. Genetic parameters for BW (body weight).

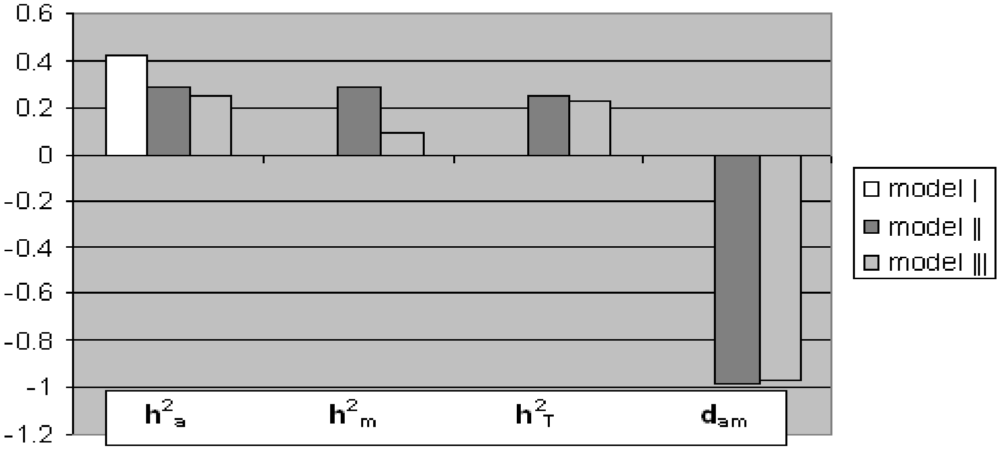

Figure 2. Genetic parameters for ADG3 (average daily gain until three months).

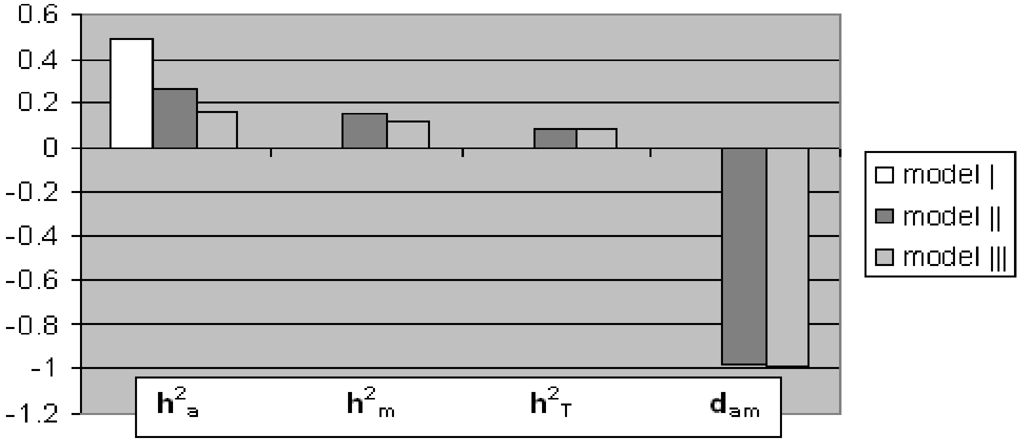

Figure 3. Genetic parameters for ADG6 (average daily gain until six months).

agrees well agrees well with the result presented in Nasholm and Danell, (1996), Larsgard and Olessen, (1998) and Safari et al., (2005). In addition to these reports, there were several articles presenting the effects of genetic parameters of direct and maternal on lamb weights at about two months age (Al Shorepy and Notter, 1998; Neser et al., 2001; Fossceco, 1995; Matika et al., 2003; Janssen et al., 2000) and estimates vary considerably in magnitude between studies. The study confirmed that genetic evaluation should be based on a model including maternal effects for two reasons.

(i) The maternal genetic variances for the traits studies are relatively large.
(ii) A negative covariance between direct and maternal genetic effects indicates different rankings of individuals when the maternal contribution is omitted in the evaluation procedure.

Reproduction traits

Heritability estimate for direct genetic effect of LS and CR are 0.08 and 0.03, respectively. The low estimate may be due to the importance of random environmental effects on variability of the observations and the categorical expression of the trait (Fogarty, 1995; Falconer, 1989). Because the heritability estimate was quite low, improvement of CR by selection would be difficult even though CR has a great economical importance. The estimated heritability for NLBA was 0.11, which is similar to some literature (Vatankhah et al., 2007). The heritability estimate for NLAW (0.06) was lower than estimate for NLBA, probably because the loss of lambs from birth to weaning was related more to environmental effects and genotypes of lambs than to the genotype of the ewes. The heritability estimates for NLBA and NLAW were lower than the average of those in the literature (Fogarty, 1995; Safari et al., 2005). The heritability estimate of LMWLB was 0.1 and 0.03 for direct and maternal genetic effects, respectively. Rosati et al., (2002) reported that the direct and maternal heritabilities for this trait were 0.13 and 0.01, respectively. The estimates of heritability of LMWLW were 0.09 and 0.05 for direct and maternal effects, respectively. In a preliminary animal model, permanent environmental effects were associated with large ratio of variance to total variance. Rosati et al., (2002) reported that the direct and maternal heritabilities for this trait were 0.15 and 0.06, respectively. However, heritability estimates for the different breeds were not significantly different, and in general, these results are in agreement with those presented in literature (Bromely et al., 2001; Hagger, 2000). The repeatability estimates of all traits were higher than heritability estimates. These estimates showed that all traits were influenced by non-additive genetic effects and permanent environmental effects and to improve these traits one should improve environmental effects in first step. Estimates of genetic variances and heritability are necessary for genetic evaluation of sheep and for choosing the best selection schemes. Economic weights for traits can be determined to build advantageous overall selection index.

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