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Genetic Parameters for Direct and Maternal Effects on Growth Traits of Arman Lambs

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Abstract: Data and pedigree information of Arman lambs breed were collected in Abbas-Abad sheep breeding station, Mashhad, Iran by separating direct genetic, maternal genetic and maternal permanent environmental effects during 1997-2008. Genetic parameters of Birth Weight (BW), Weaning Weight (WW) and 6 Months Weight (6 MW) were estimated using mixed animal models of DFREML computer software. For all traits, the fix effects were lamb's sex, birth type, age of dam and birth year and the random effects were direct additive genetic, maternal additive genetic, maternal permanent environment and maternal common environment. Six different models of analysis were fitted into each trait by ignoring or including maternal genetic effects or common environmental effects. Most appropriate model for each trait was determined by likelihood ratio test. The test indicate that models including direct and maternal genetic effect, without covariance between them was the most appropriate model for BW and WW and the model including effects common environmental due to dam was the most appropriate model for 6 MW. Direct heritability values of 0.094, 0.101 and 0.145 were estimates for BW, WW and 6 MW, respectively. Maternal heritability for birth and weaning weights 0.173 and 0.112 was estimated, respectively. The effect of permanent environmental due to dam for 6 months weight was estimated 0.089. The results generally show that considering effect of maternal in animal models are necessary for correct estimating direct heritability of growth trait of lambs.

Key words: Arman lambs, growth traits, direct heritability, maternal effects, animal models, Iran

INTRODUCTION

The Arman sheep was obtained by crossbreeding among 4 breeds of Chios, Suffolk, Ghezel and Baluchi which is a fat tailed and dual purpose (mutton and wool) breed developed for arid regions and well adapted to a wide range of harsh environmental conditions in eastern Iran.

Many factors affect the birth weight and pre-weaning growth of lambs. These factors include direct genetic effects, maternal genetic effects and environmental factors which affect both the lamb and its dam. Hence, to achieve optimum genetic progress in a selection program both the direct and maternal components should be taken into account (Meyer, 1992 ; Miraei-Ashtiani *et al*., 2007).

The objectives of the present study were firstly to determine the most appropriate model for the data set used and secondly to investigate the importance of direct and maternal genetic and maternal permanent environmental effects on mentioned traits of Arman lambs breed in Abbas-Abad Animal Breeding Station, Mashhad, Iran according to the determined model. In mammalian species, growth traits in particular until weaning are not only influenced by the genes of the individual for growth and environment under which it is raised but also by the maternal genetic composition and environment provided by the dam (Ekiz, 2005). In young animals, the milk supply of their dam and the maternal care she provides contribute to their growth (Bradford, 1972; Maniatis and Pollott, 2002). The genotype of the dam therefore affects the phenotype of the young through a sample of half her direct additive genes for growth as well as through her genotype for maternal effects on growth (Miraei-Ashtiani *et al*., 2007).

The dam's genes for these traits affect the environment experienced by the offspring through milk production and mothering ability (Bourdon, 2000).

Generally, in order to decide upon a feasible selection strategy, estimation of the genetic parameters and the correlations between direct and maternal genetic effects is necessary. When growth traits are included in the breeding goal, both direct and maternal genetic effects should be taken into account in order to achieve optimum genetic progress.

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MATERIALS AND METHODS

Data and pedigree information of the Arman sheep used in this study were collected from 1997-2008 by the Animal Breeding Station in Abbas Abad station, Mashhad, Iran. The data sets for BW, WW and 6 MW included 2194, 1692 and 1470 heads with data records 63, 56 and 56 sires and 604, 481 and 447 dams with progeny, respectively. The mean and coefficient of variation for each trait are shown in Table 1.

The mating period began from mid August to late October and lambing was from February until March. All lambs were weighed and ear tagged within 12 h of birth. The identities of newborns and of their parents, date of birth, sex, type of birth and birth weight were recorded. The suckling program of the lambs lasted for 90 days on average. During this program, grass hay and lamb grower feed were given to the lambs. The lambs were weighed after birth and weaning.

The General Linear Model (GLM) procedure of SAS (2003) was used to determine whether any of the effects has an influence on the traits ($p<0.05$). Those having an effect ($p<0.05$) were fitted in the subsequent models to estimate the genetic parameters. Fixed effects fitted were birth type (single, twin and triplet), lamb's sex (male, female), dam's age (2-7 years old) and lambing year (1997-2008). Estimation of variance and covariance components was obtained by Restricted Maximum Likelihood (REML) using a Derivative-Free (DF) algorithm (Meyer, 1992), fitting an animal model. Maternal genetic or permanent environmental effects were taken into account by including appropriate random effects in the model (Miraei-Ashtiani *et al*., 2007).

Univariate analysis for each trait was performed considering 6 different animal models to assess the importance of different effects. Maternal genetic or permanent environmental effects were taken into account by including them in appropriate models, as described by Meyer (1992).

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

Model 2: $y = Xb + Z_1a + Z_3c + e$

Model 3: $y = Xb + Z_1a + Z_2m + e \quad Cov(a, m) = 0$

Model 4: $y = Xb + Z_1a + Z_2m + e \quad Cov(a, m) = A\sigma_{am}$

Model 5: $y = Xb + Z_1a + Z_2m + Z_3c + e \quad Cov(a, m) = 0$

Model 6: $y = Xb + Z_1a + Z_2m + Z_3c + e \quad Cov(a, m) = A\sigma_{am}$

Where, y is a vector of records on the different traits, b, a, m, c and e are vectors of fixed effects, direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects and the residual effects, respectively. X, Z_1, Z_2 and Z_3 are corresponding design matrices associating the fixed effects, direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects to vector of y. 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 $A\sigma^2_a$, $A\sigma^2_m$, $Id\sigma^2_c$ and $In\sigma^2_e$, respectively. That σ^2_a, σ^2_m, σ^2_c and σ^2_e are direct additive genetic variance, maternal additive genetic variance, maternal permanent environmental variance and residual variance, respectively. A is the additive numerator relationship matrix, Id and In are identity matrices that have order equal to the number of dams and number of records, respectively and σ_{am} denotes the covariance between direct additive genetic and maternal additive genetic effects. In univariate analysis, log likelihood ratio tests were applied to choose the most appropriate model for each trait (Miraei-Ashtiani *et al*., 2007).

Table 1: Basic statistical information about the examined traits of Arman sheep

Statistical information	BW[a]	WW[a]	6MW[a]
No. of animals with records	2194.0	1692.0	1470.0
No. of sires	63.000	56.000	56.000
Average number of progeny per sires	34.820	30.210	26.250
No. of dams	604.00	481.00	447.00
No. of dams with own record as well	446.00	316.00	274.00
Average number of progeny per dam	3.6300	3.5100	3.2800
Mean (kg)	4.0200	21.650	32.540
Standard deviation (kg)	0.8539	5.5275	6.7821
Coefficient of variation (%)	17.930	20.770	16.900

[a]BW: Birth Weight, WW: Weaning Weight and 6 MW: 6 Months Weight

RESULTS AND DISCUSSION

The overall least squares means for BW, WW and 6MW were 4.02, 21.65 and 32.54, respectively. In general, male lambs were always heavier than female ones, single born lambs were heavier than lambs born as twin and triplet, lmbs born from young ewes had lower weights than those born to adult dams and birth year had a significant effect on all body weight traits in this study. Mentioned effects have been reported significantly in breeds like Horro (Abegaz *et al*., 2005), Kermani (Rashidi *et al*., 2008) and Zandi (Mohammadi *et al*., 2010). Depending on the model fitted, phenotypic variance (σ^2_p), direct additive genetic variance (σ^2_a), maternal genetic variance (σ^2_m), permanent environmental variance (σ^2_{pe}), residual variance (σ^2_e), direct heritability (h^2_d), maternal heritability (h^2_m), genetic covariance between direct additive and maternal effects (σ_{am}) and correlation between direct and maternal additive effects (r_{dm}) were estimated, accordingly in Table 2. The most appropriate model BW and WW was Model 3 which included direct and maternal additive genetic

Table 2: Estimates of (Co) variance components, genetic parameters and log likelihood ratio with best model in bold for BW, WW and 6 MW with different models

Traits	Models	σ^2_a	σ^2_m	σ^2_c	σ_{am}	σ^2_e	σ^2_p	h^2_d	h^2_m	c^2	r_{am}	Log L
BW	Model 1	0.070	-	-	-	0.4520	0.5220	0.134	-	-	-	-1184.77
	Model 2	0.061	-	0.024	-	0.4370	0.5220	0.118	-	0.046	-	-1183.51
	Model 3	0.050	0.090	-	-	0.3820	0.5220	0.094	0.173	-	-	-1179.62
	Model 4	0.043	0.075	-	0.037	0.3670	0.5220	0.082	0.144	-	0.67	-1183.58
	Model 5	0.046	0.072	0.024	-	0.3800	0.5220	0.088	0.138	0.047	-	-1180.39
	Model 6	0.047	0.070	0.019	0.051	0.3370	0.5240	0.091	0.133	0.037	0.89	-1181.79
WW	Model 1	3.041	-	-	-	17.371	20.412	0.149	-	-	-	-3396.21
	Model 2	2.700	-	2.290	-	15.270	20.266	0.133	-	0.113	-	-3394.66
	Model 3	2.050	2.278	-	-	15.976	20.304	0.101	0.112	-	-	-3392.77
	Model 4	1.972	2.582	-	1.962	13.819	20.336	0.097	0.127	-	0.87	-3394.82
	Model 5	2.148	2.432	2.006	-	13.681	20.268	0.106	0.120	0.099	-	-3395.66
	Model 6	2.022	2.717	1.696	2.131	11.868	20.434	0.099	0.133	0.083	0.91	-3394.04
6 MW	Model 1	4.924	-	-	-	25.477	30.401	0.162	-	-	-	-3242.44
	Model 2	4.397	-	2.698	-	23.224	30.320	0.145	-	0.089	-	-3239.59
	Model 3	4.280	2.337	-	-	23.737	30.335	0.141	0.077	-	-	-3740.95
	Model 4	4.101	1.974	-	2.389	21.918	30.382	0.135	0.065	-	0.84	-3741.43
	Model 5	3.851	1.607	2.114	-	22.750	30.322	0.127	0.053	0.069	-	-3241.59
	Model 6	4.035	1.651	1.358	2.090	21.437	30.572	0.132	0.048	0.054	0.81	-3240.52

σ^2_a: Direct additive genetic variance, σ^2_m: maternal additive genetic variance, σ^2_c: maternal permanent environmental variance, σ_{am}: direct maternal genetic covariance, σ^2_e: residual variance, σ^2_p: phenotypic variance; h^2_d: direct heritability; h^2_m: maternal heritability; c^2: ratio of maternal permanent environmental effect, r_{am}: direct maternal genetic correlation; log L: log Likelihood

effects but the most appropriate model for 6MW was model 2 which included direct additive genetic effect and maternal permanent environmental effect. Direct heritability estimates for BW, WW and 6 MW were 0.094, 0.101 and 0.145, respectively. The direct heritability estimate (0.094) for BW in present study was lower than that reported by Mohammadi *et al*. (2010) but higher than that reported by Rashidi *et al*. (2008). The estimation of direct heritability for WW (0.101) was within the range of those published in the literature which varied from 0.09 (Maniatis and Pollott, 2002) to 0.35 (Lavvaf and Noshary, 2008). As well as, the direct heritability estimate (0.145) for 6 MW in present study was lower than that reported by Abegaz *et al*. (2005), Miraei-Ashtiani *et al*. (2007) and Rashidi *et al*. (2008).

Estimates of maternal heritability from Model 3 for BW and WW were 0.173 and 0.112, respectively. Maternal heritability estimates for BW was in agreement with the findings of Maria *et al*. (1993). The results show a decreasing trend in maternal effects from birth to later ages. The effect of permanent environmental due to dam for 6 MW was estimated 0.089 that was similar to those reported by Mokhtari *et al*. (2008). These results will mean that ignoring maternal effects in a selection model will bias upwards the estimates of direct heritability.

CONCLUSION

The findings of the present study show that environmental factors were significant sources of variation for body weight and average daily gain from birth to weaning. Therefore, effects of environmental factors need to be accounted for estimate the Best Linear Unbiased Predicted value (BLUP) of Arman lambs. As well as, ignoring maternal effects in the model caused overestimation of direct heritability. Maternal effects are significant sources of variation for growth traits and ignoring maternal effects in the model would cause inaccurate genetic evaluation of lambs.

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