

Estimates of (co)variance components for direct and maternal effects on birth weight of Karayaka lambs

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Accepted: 29 October 2012 / Published online: 7 December 2012
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Abstract The purpose of this study was to estimate the genetic parameters for birth weight of Karayaka lambs by separating direct genetic, maternal genetic, and maternal permanent environmental effects. Records of 1013 Karayaka lambs born between 2005 and 2010 were analyzed. Six different animal models were examined, all including direct additive genetic variance and various combinations of genetic and environmental maternal effects. The most appropriate model was chosen based on log-likelihood ratio tests. Since model 1 had the smallest likelihood value, it was chosen as the best model in this study. Depending on the model, direct heritability varied from 0.37 to 0.55 and maternal heritability ranged from 0.08 to 0.20 for birth weight.

Keywords Maternal heritability · Direct heritability · Best model · Log-likelihood · Animal model

Introduction

Karayaka sheep is one of the major indigenous sheep breeds of Black Sea Region in Turkey. This sheep breed numbering about 1,300,000 is highly adapted to the harsh environment of this region. Being a non-fat tailed sheep in a harsh environment makes the Karayaka sheep more interesting. The breed is mainly kept for its high meat quality. Sheep

meat production depends to large extend on the birth weight of lambs. Birth weight is also an important factor affecting growth and development during the postpartum period. It is the easiest and most reliable measure of growth during the post-natal period. Many factors affect the birth weight. This trait has been reported to be associated with the age at first lambing (Kabuga and Akowuah 1991). 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; Ekiz et al. 2004). Environmental factors are also known to be important in growth and the trait is under polygenic control.

There are no reports on maternal effects and correlations between additive direct and additive maternal effects calculated by restricted maximum likelihood algorithms for the birth weight of Karayaka lambs. The aim of this study was to estimate genetic parameters for birth weight of Karayaka lambs by fitting six animal models attempting to separate direct genetic, maternal genetic, and maternal permanent environmental effects. In addition, the genetic correlations between additive direct and additive maternal effects were estimated.

Material and methods

The study was carried out at the experimental farm of the Gaziosmanpasa University, Tokat, Turkey (40° 31'N, 36° 53'E and 650 m above the sea level). Data were collected from an experimental nucleus flock of Karayaka sheep at college farm of Gaziosmanpasa University between the years of 2005 and 2010. The birth weight data for this study was obtained from 1,013 lambs (520 males and 493 females) held in Gaziosmanpasa University Agricultural

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Research Farm. The lamb weights were taken at birth with a 50 g sensitivity scale.

Minitab Version 12.1 (1998) was used for preliminary data analyses with general linear model. In each of the linear mixed-models considered in the analyses were the fixed effects of year, the sex of lamb, and birth type. Dam age was fitted as a linear covariable.

Estimates of genetic parameters and variance components were obtained by restricted maximum likelihood fitting six different animal models (Table 1) and utilizing all pedigree information using the program ASREML (Gilmour et al. 1998). The model included the random effects of animal, sire, and dam. Six different animal models were used to estimate the parameters as presented in Table 1.

Where,

σ_a^2 , direct additive genetic variance; σ_m^2 , maternal additive genetic variance; σ_{am}^2 , the covariance between direct and maternal genetic effects; σ_c^2 , the variance of the permanent environmental effect of the dam; σ_p^2 , phenotypic variance; h_d^2 , direct heritability; m^2 , maternal heritability; c^2 , the permanent environmental variance due to the dam as a proportion of phenotypic variance; c_{am} , genetic variance between direct and maternal effects as a proportion of the total variance; r_{am} genetic correlation between direct and maternal effects. Total heritability (h_d^2) was calculated with the help of the following equation (Willham 1980):

$$h_T^2 = (\sigma_a^2 + 0.5\sigma_m^2 + 1.5\sigma_{am}) / \sigma_p^2$$

The best model for the data set was selected based on the likelihood ratio test, comparing differences between $-2 \log L$ to a critical value from a chi square distribution (Saatci et al. 1999).

Results and discussion

The genetic parameters and variance components for models 1–6 are summarized in Table 2. Model 1, fitting animal as the only random effect, yielded substantially higher estimates for direct additive genetic variance and heritability than models 2, 3, and 5. Models which were ignoring additive maternal effects (models 1 and 2) had produced

higher direct heritability than model 3 which was included additive maternal effects.

In model 1, where maternal genetic effects were ignored, direct heritability was 0.48, while the inclusion of maternal genetic effects in models 3 and 5 reduced the direct heritability. When the maternal genetic effects and genetic and/or environmental were included in the model, direct additive genetic variance ranged from 0.10 to 0.16. Depending on the model used, the maternal effects divided into environmental and genetic components.

Model 5, removing the covariance between direct additive and maternal effects, tended also to generate greater estimates of maternal heritability. Model 1 (maternal effect ignored) determined the highest direct heritability (h_d^2) and direct additive genetic variance (σ_a^2) compared to model 2. In model 2 (maternal environmental effect included), a decrease has been observed in both σ_a^2 and h_d^2 compared to model 1 but not to the other models. Model 4 (the variance of the permanent environmental effect of the dam ignored) produced the highest direct heritability (h_d^2) and direct additive genetic variance (σ_a^2). Including additive maternal effect with no maternal environmental effects in model 3 resulted in smaller σ_a^2 and h_d^2 compared to those estimated in models 1 and 2. But, including additive maternal effect with no maternal environmental effects in model 4 resulted in higher σ_a^2 and h_d^2 compared to those estimated in models 1 and 2.

Including the covariance between the direct additive and direct maternal effects in model 4 gave rise to the highest σ_a^2 and h_d^2 . In model 5, additive maternal effects were included but σ_{am}^2 was excluded. In this case, model 5 produced lower σ_a^2 and h_d^2 than model 4.

In model 6, in which both environmental and genetic maternal effects were taken into account, 19.4 % of the total variance was attributed to the maternal genetic effects and 0.04 % to the permanent environment of the dam. It is clear that the relative values of direct heritability and maternal heritability were greatly influenced by the model used in the analysis. When the permanent environment of the dam was ignored (model 4), the total variance was attributed to the maternal genetic variance, resulting in overestimation of the maternal heritability compared to model 3. Ekiz et al. (2004) reported that estimates for direct heritability from 0.09 to

Table 1 Used animal models in the analyses

	σ_a^2	σ_m^2	σ_{am}^2	σ_c^2	σ_e^2	σ_p^2	h^2	m^2	r_{am}	c_{am}	c^2
Model 1	✓				✓	✓	✓				
Model 2	✓			✓	✓	✓	✓				✓
Model 3	✓	✓			✓	✓	✓	✓			
Model 4	✓	✓	✓		✓	✓	✓	✓	✓	✓	
Model 5	✓	✓		✓	✓	✓	✓	✓			✓
Model 6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 2 Estimates of (co)variance component and genetic parameters of birth weight

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
σ_a^2	0.143	0.124	0.108	0.167	0.120	0.152
σ_m^2			0.026	0.059	0.006	0.052
σ_{am}^2				−0.046		−0.037
σ_c^2		0.021			0.017	0.0005
σ_e^2	0.151	0.147	0.157	0.122	0.149	0.131
σ_p^2	0.295	0.293	0.291	0.302	0.293	0.299
h_d^2	0.48	0.42	0.37	0.55	0.40	0.54
SE	0.075	0.088	0.098	0.125	0.104	0.175
m^2			0.089	0.195	0.205	0.194
SE			0.0481	0.096	0.085	0.149
c_{am}				−0.152		−0.772
SE				0.123		0.480
r_{am}				−0.462		−0.459
SE				0.244		0.241
c^2		0.074			0.060	0.0004
SE		0.041			0.074	0.0824
h_T^2	0.48	0.42	0.41	0.42	0.41	0.41
−2 LogL	134.637	136.426	136.232	136.743	136.431	136.740

0.32, maternal heritability from 0.10 to 0.27, r_{am} from −0.47 to −0.55, c_{am} from −0.05 to −0.10, and c^2 from 0.18 to 0.19 for merino lambs, respectively.

The genetic correlation between direct and maternal genetic effects was −0.45 and the covariance between them was estimated as −0.77. The estimates reported by Ligda et al. (2000) for Chios lambs using a similar model was −0.08 for genetic covariance between direct and maternal effects. Similarly, Rashidi et al. (2008) reported that estimates for maternal heritability, r_{am} , c_{am} , and c^2 were 0.23–0.24, 0.11–0.13, 2.00–2.40, and 0.00–0.17, respectively, for Kermani lambs using similar models. The maternal heritability was ranged from 0.08 to 0.20. On the other hand, Ligda et al. (2000) estimated higher maternal heritability (0.33) in Chios lambs and also a negative genetic correlation between direct and maternal genetic effects.

The genetic correlations estimated by Ligda et al. (2000) for Chios, Abegaz et al. (2002) for Horro lambs were negative and ranged from −0.44 to −0.63 while Nasholm and Danell (1994) Swedish Finewool, Naser et al. (2001) for Dorper lambs positive estimates. Cundiff (1972) stated that the negative covariance between maternal and direct genetic effects, explained from an evolutionary point of view, prevents species from becoming increasingly larger. The findings of present study were not in agreement with Nasholm and Danell (1994) and Nasholm and Danell (1996). On the other hand, several authors reported that a possible existence of a negative environmental covariance between offspring and dam could result in a biased estimation of genetic correlation between direct and maternal effects (Meyer 1992; Ligda et al. 2000).

Detected σ_a^2 and h_d^2 (0.54) in model6 was the same as in model4 but it was higher than those in the other models.

The likelihood values under six different models with the most appropriate model components determined using log likelihood ratio tests are given in Table 2. Model1 with only the additive direct effect was chosen as the best model based −2 logL value. According to the principles of ASREML program, −2 logL smallest value of the model should be preferred as the best model (Van Vleck et al. 1993; Lee and Taper 2002; Ulutas et al. 2002). This result is in contrast with the findings of Ligda et al. (2000) who reported that model6 was the best model which included both maternal and permanent environmental effect due to dam. The absence of maternal genetic effect may be due to a small size of the dataset. In another study, Mohammadi et al. (2010) found that the best model was model3 in which direct and maternal additive genetic effects were included.

Conclusion

The estimates of genetic parameters reported for the Karayaka lambs are in general agreement with those reported in the literature. This study was showed that the addition of only maternal effect to model resulted in a decrease in estimates of direct heritability for birth weight of Karayaka lambs. In conclusion, maternal effect on birth weight in different ages of Karayaka sheep were significant and should be taken into consideration in any selection program for this breed.

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