ESTIMATION OF GENETIC PARAMETERS FOR GROWTH TRAITS OF SHEEP POPULATION IN LATVIA

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Abstract
The aim of the present study was to estimate variance and covariance components and genetic parameters for birth, weaning and yearling weights. The data were collected from lambs who born in period from 2007 to 2010 years and located in 58 pure-bred sheep herds in Latvia. Records of 11310 lambs from 160 rams and 4180 ewes for birth and weaning weight and on 3194 lambs from 134 rams and 2058 ewes for yearling weight were used in this study. The total number of individual pedigree was 18932. The fixed effects in the model were sex and type of birth, birth year and month and age of dam, because all growth traits were significantly affected by these fixed effects ($p<0.01$, $p<0.05$). Genetic parameters for growth weights were estimated by Restricted Maximum Likelihood (REML) procedure fitting three animal models including various combinations of maternal and herd effects. Based on the most appropriate fitted model which included additive genetic, maternal additive genetic and herd effect, direct heritability's were estimated to be 0.26 ± 0.01, 0.29 ± 0.63, 0.29 ± 2.63, but maternal heritability's 0.14 ± 0.00, 0.04 ± 0.19, 0.04 ± 0.94, respectively for birth, weaning and yearling weights. The results showed maternal and strong herd influence in this study, therefore inclusion of maternal and herd effects into the model for growth traits is necessary.
Key words: genetic parameters, growth traits, sheep.

Introduction

The total sheep population in Latvia is 83743 heads and Latvian dark-head sheep breed is the main sheep breed with a population of 37773 (Agricultural Data Centre, 2013). This local sheep breed belongs to the mutton-wool type, the sheep are white color with dark head and legs and animals are well adapted to the local conditions. In Latvia, sheep breeding becomes a significant branch of agriculture, because there are favorable conditions created for raising sheep breeding and it is a complementary component of a mixed farming system. Similarly, the high fertility and short generation intervals make it popular among breeders.

Estimated breeding value is a tool for the genetic improvement of animals therefore the aim of genetic evaluation is to provide an accurate estimate of the breeding value of an animal from the given performance and pedigree information. The performance of an animal is affected by several genetic and environmental factors. The most important environmental factors are sex, type of birth, birth year and age of dam. The significant influences of environmental factors on body weight at the various ages can be explained in part by differences in years, male and female endocrine system, limited uterine space and inadequate availability of nutrients during pregnancy, competition for milk between the twins, maternal effects and maternal ability of dam in different ages (Mohammadi et al., 2010b). Various environmental factors have been studied in several investigations (Hussain, 2006; Thiruvenkadan et al., 2008; Tariq et al., 2010; Mokhtari and Rashidi, 2010; Savar-Sofla et al., 2011).

Direct genetic effects, maternal genetic effects and environmental factors are random factors which affect both the lamb and its dam. Growth traits, in particular until weaning is not only influenced by genes of the individual for growth and environmental under which it raised but also by the maternal genetic composition and environment provided by the dam (Lewis and Beatson, 1999). Dam's genes for growth traits affect the environment experienced by the offspring through milk production and mothering ability (Lotfi Farokhad et al., 2010). Numerous studies have shown that both direct and maternal genetic influences are of importance for lamb growth (Bahreini Behzadi et al., 2007; Mohammadi et al., 2010a; El-Awady et al., 2011; Savar-Sofla et al., 2011; Ghafouri-Kesbi and Baneh, 2012). Hence, to achieve optimum genetic progress in a selection program both the direct and maternal components should be taken into account (Meyer, 1992).

Knowledge of genetic parameters for weight traits is needed to determine optimal breeding strategies to increase the efficiency of sheep production in Latvia. The aim of this study were to estimate the variances and covariance's for direct genetic effect, maternal genetic effect and herd effect on lamb weights and to determine the most appropriate model of analysis for three growth traits of Latvian dark-head lambs.

Materials and Methods

Pedigree and performance data of the Latvian dark-head lambs used in this study were obtained from the state agency 'Agricultural Data Centre' which is responsible for the data processing of the sheep recording results. Lambs were born during the period from 2007 until 2011 and located in 58 pure-bred sheep herds. Three traits were considered: birth weight, weaning weight (weight at 70 days of age) and yearling weight. Characteristics of data structure are summarized in Table 1. Data set used for analyses consisted of 11310 records for birth and weaning weights and 3194 records for yearling weight. Recording data collected from lambs located in 58 herds (in average 195 lambs in one herd). The lambs were the progeny of 160 rams and 4180 ewes for birth and weaning weights and 134 rams and 2058 ewes for yearling weight. The pedigree links were considered for all animals with performance records. Total numbers of individuals in the pedigree were 18932 and all the pedigree information was utilized in the estimation of genetic parameters using animal model. Means of birth, weaning and yearling weighs were 4.0 kg, 21.7 kg and 47.6 kg, respectively.

The General Linear Model (GLM) procedure of SAS statistical package (SAS, 2003) was used to test the significance of the fixed effects of sex (male and female) and the type of birth (single, twins, triplets and quads), birth year (3 levels: 2007 and 2008, 2009, 2010), birth month (4 levels: January, February, March, April-December) and age of dam (4 levels:1 and 2, 3, 4, 5 years old and older).

Variance and covariance components and genetic parameters were estimated by Restricted Maximum Likelihood using VCE-6 software package (Groeneveld et al., 2010). Three different single-trait animal models were fitted for each trait by ignoring or including maternal genetic effect and herd effect (Table 2).

Model 1 was a model with direct additive genetic effect as the only random effect. Model 2 included an additive maternal genetic effect fitted as second random effect, ignoring direct – maternal genetic covariance. Model 3 included direct additive genetic, maternal additive genetic and herd effect, ignoring direct – maternal genetic covariance. A log likelihood ratio test was used to choose the most suitable random effects model for each growth trait.

Results and Discussion

All traits were significantly affected by sex and type of birth, birth year and month and age of dam ($p<0.01$, $p<0.05$). As it is expected, male lambs and single born lambs were heavier (+0.16, + 0.94 and + 15.28 kg for male lambs and + 0.71, + 3.48 and + 1.07 kg for single born lambs, respectively for birth, weaning and yearling weights) than lambs born as female and lambs born from larger litters (Table 3). The difference between the two sexes increased with age of lamb, probably because of increasing differences in the endocrine system between males and females. The differences of traits related to type

Table 1

Characteristics of the data structure

Character	Birth weight	Weaning weight	Yearling weight
Number of lamb records	11310	11310	3194
Number of rams	160	160	134
Number of ewes	4180	4180	2058
Ratio of rams and lambs	70.7	70.7	23.8
Ratio of ewes and lambs	2.7	2.7	1.6
Ration of rams and ewes	26.1	26.1	15.4
Mean (kg)	4.0 ± 0.01	21.7 ± 0.05	47.6 ± 0.14
Standard deviation (kg)	0.71	5.41	7.91

Table 2

Description of animal models fitted

Model [1)]			(Co)Variance components estimated [2)]
1	$y = Xb + Z_1a + e$		σ^2_a, σ^2_e
2	$y = Xb + Z_1a + Z_2m + e$	Cov (a, m) = 0	σ^2_a, σ^2_m, σ^2_e
3	$y = Xb + Z_1a + Z_2m + Z_3h + e$	Cov (a, m) = 0	σ^2_a, σ^2_m , σ^2_h, σ^2_e

[1)] y: vector of records on the different traits; b, a, m, h and e: vectors of fixed direct additive genetic, maternal additive genetic, herd and the residual effects; X, Z1, Z2 and Z3: corresponding design matrices associating the fixed, direct additive genetic, maternal additive genetic and herd effects.

[2)] σ^2_a: direct additive genetic variance, σ^2_m: maternal additive genetic variance, σ^2_h: herd variance, σ^2_e: residual variance.

Table 3

Least square means and standard errors for all traits

Factors	Classes	Birth weight, kg	Weaning weight, kg	Yearling weight, kg
Sex	male	$4.00^{a} \pm 0.01$	$22.29^{a} \pm 0.08$	$62.72^{a} \pm 0.66$
	female	$3.84^{a} \pm 0.01$	$21.35^{a} \pm 0.07$	$47.44^{a} \pm 0.19$
Birth type	1	$4.29^{a} \pm 0.01$	$23.83^{a} \pm 0.09$	$55.47^{a} \pm 0.45$
	2	$3.89^{a} \pm 0.01$	$21.29^{a} \pm 0.05$	$54.40^{a,b} \pm 0.33$
	3 end more	$3.58^{a} \pm 0.02$	$20.35^{a} \pm 0.15$	$55.36^{b} \pm 0.52$
Birth year	2007/2008	$3.86^{a1,a2} \pm 0.01$	$25.16^{a1,a2} \pm 0.09$	$57.30^{a1,a2} \pm 0.40$
	2009	$3.94^{a1} \pm 0.01$	$20.25^{a1} \pm 0.09$	$54.31^{a1,b} \pm 0.40$
	2010	$3.97^{a2} \pm 0.01$	$20.06^{a2} \pm 0.09$	$53.63^{a2,b} \pm 0.41$
Birth month	1.	$3.92^{a1,a2} \pm 0.01$	$21.84^{a1,b} \pm 0.09$	$54.75^{a1} \pm 0.40$
	2.	$3.87^{a1,a3,b} \pm 0.02$	$20.97^{a1,a2} \pm 0.11$	$53.70^{a1,a2} \pm 0.45$
	3.	$3.97^{a2,a3,a4} \pm 0.01$	$22.91^{a1,a2} \pm 0.10$	$56.58^{a1,a2} \pm 0.42$
	4.	$3.92^{a4,b} \pm 0.01$	$21.58^{a2,b} \pm 0.10$	$55.29^{a2} \pm 0.42$
Lambing age of dam	1.	$3.75^{a1,a2,a3} \pm 0.01$	$21.25^{a} \pm 0.10$	$52.98^{a1,a2,a3} \pm 0.44$
	2.	$3.91^{a1,a4,a5} \pm 0.01$	$21.88^{a} \pm 0.10$	$54.02^{a1} \pm 0.45$
	3.	$4.03^{a2,a4} \pm 0.02$	$22.56^{a} \pm 0.11$	$54.61^{a2} \pm 0.47$
	4.	$4.04^{a3,a5} \pm 0.01$	$22.23^{a} \pm 0.09$	$54.32^{a3} \pm 0.43$

Within each factor, mean values with the same superscript letters are significantly different at $p<0.01$ (^{a}) or $p<0.05$ (^{b}). The figure (1, 2, 3, 4, 5) at the superscript letters are indicates to compared factor mean values.

Table 4

Estimates of variance components and genetic parameters for body weights using single-trait analysis

Trait	Model	σ^2_a	σ^2_m	σ^2_h	σ^2_e	$h_a^2 \pm$ S.E.	$h_m^2 \pm$ S.E.	-2logL
Birth weight	1	0.296	-	-	0.156	0.66 ± 0.01	-	19869.62
	2	0.221	0.071	-	0.149	0.50 ± 0.01	0.16 ± 0.01	19618.11
	3	0.131	0.069	0.109	0.189	0.26 ± 0.01	0.14 ± 0.00	19233.25
Weaning weight	1	12.888	-	-	7.452	0.63 ± 0.58	-	17236.86
	2	11.480	1.466	-	7.201	0.57 ± 0.61	0.07 ± 0.20	17174.69
	3	7.509	1.065	8.802	8.848	0.29 ± 0.63	0.04 ± 0.19	16532.70
Yearling weight	1	35.876	-	-	10.607	0.77 ± 2.31	-	14121.85
	2	34.388	3.137	-	8.900	0.74 ± 2.35	0.07 ± 1.06	14112.98
	3	17.837	2.372	25.009	16.463	0.29 ± 2.63	0.04 ± 0.94	13853.07

σ^2_a: direct additive genetic variance, σ^2_m; maternal additive genetic variance, σ^2_h: herd variance, σ^2_e: residual variance, h_a^2: direct heritability, h_m^2: maternal heritability, -2logL: Log likelihood values

of birth might be because of limited uterine space and competition in milk suckling.

As well as, lambs born in March (3.97, 22.91 and 56.58 kg, respectively for birth, weaning and yearling weights) were heavier than lambs born in other period. Variation in birth weight across years indicated that the feeding, management and environmental conditions affect the ewes during pregnancy (Hussain, 2006). The ewes those conceived during September to November months had lambing during January and February, favorable environmental conditions with good availability of the fodder during the gestation period, which might have been contributed to higher body weight at birth (Thiruvenkadan et al., 2008).

Also lambs born from adult ewes had higher weights than those born to younger ewes (difference + 0.29, + 1.31 and + 1.63 kg, respectively for birth, weaning and yearling weights). The significant effect of dam's age could be due to differences in maternal behavior, uterus space and milk production of ewes in different ages.

Effects of these environmental factors has been reported significantly in breeds like Moghani (Savar-Sofla et al., 2011), Mengali (Tariq et al., 2010), Kermani (Mokhtari and Rashidi, 2010), Mecheri (Thiruvenkadan et al., 2008), Thalli (Hussain, 2006).

The estimates of direct heritability (h_a^2) for traits studied were in the range from 0.26 to 0.66 for birth weight, from 0.29 to 0.63 for weaning weight and from 0.29 to 0.77 for yearling weight (Table 4). Model 1, which ignored maternal and herd effects, resulted in larger estimates for direct additive genetic variance (σ^2_a) and direct heritability (h_a^2) compared with other models. It is agreement with M.R. Bahreini Behzadi et al. (2007) who reported high heritability's for birth (0.62 ± 0.07) and weaning weights (0.59 ± 0.08) in Kermani sheep using model with direct additive genetic effect as the only random effect. K. Meyer (1992) showed that models not accounting for maternal genetic effects could results in substantially higher estimates of additive direst genetic variance and, therefore, higher estimates of h_a^2. If maternal effects are present, but not considered, the estimate of additive genetic variance will include at least part of the maternal variance.

With Models 2 and 3, the addition of maternal additive genetic and herd effects, reduced the estimates of both σ^2_a and h_a^2, compared with Model 1. Therefore, estimates of direct heritability will decrease when maternal and herd effects are included. Model 3, which included a herd effect, showed smaller estimates of σ^2_a and h_a^2, than did Models 1 and 2. The herd effect was determined to be more important than maternal genetic effect for all traits of the Latvian dark-head lambs. It was determined that on the basis of the log likelihood ratio test results, Model 3 was the most appropriate model for all traits.

Heritability is one important component used to predict genetic progress from selection to improve a trait. Using the most appropriate model, direct heritability's of birth, weaning and yearling weights were estimated 0.26 ± 0.01, 0.29 ± 0.63 and 0.29 ± 2.63, respectively. This heritability's are in the range of those presented by I. Komlosi (2008) for weaning weight in Texel sheep, M.R. Bahreini Behzadi et al. (2007) in Kermani for weaning weight, F. Ghafouri-Kesbi and H. Baneh (2012) in Makooei for birth and weaning weights. The estimates were higher than those reported by M.M. Tariq et al. (2010) in Mengali for weaning weight, P. Akhtar et al. (2008) in Hissardale for yearling weight, S. Savar-Sofla et al. (2011) in Moghani for birth and weaning weights, M.R. Bahreini Behzadi et al. (2007) in Kermani for birth and yearling weights, K. Mohammadi, A. Aghaei et al. (2010a) in Arabi for birth and weaning weights. Estimates of the present study were lower than those of M.M. Tariq et al. (2010) in Mengali for birth weight, H.G. El-Awady et al. (2011) in Egyptian Rahmani for birth weight. The large standard errors associated with the heritability estimates for yearling weight are possible the results of the smaller sample size used in this study.

For all traits, estimates of maternal heritability were lower than the estimates of direct heritability. Using the most appropriate model, maternal heritability's of birth, weaning and yearling weights were estimated 0.14 ± 0.00, 0.04 ± 0.19 and 0.04 ± 0.94, respectively. Maternal heritability decreased with age, because maternal effects in mammals are substantial in young animals, but diminish with age (Robison, 1981). This heritability's are in the range of those presented by K. Mohammadi, A. Aghaei et al. (2010a) for birth weight in Arabi, S. Savar-Sofla et al. (2011) in Moghani for birth weight, F. Ghafouri-Kesbi and H. Baneh (2012) in Makooei for weaning weight. Estimates of the present study were lower than those of M.R. Bahreini Behzadi et al. (2007) in Kermani for birth, weaning and yearling weights, K. Mohammadi, A. Aghaei et al. (2010a) in Arabi for weaning weight, S. Savar-Sofla et al. (2011) in Moghani for weaning weight, H.G. El-Awady et al. (2011) in Egyptian Rahmani for birth weight.

Conclusions

Heritability of growth traits ranged from moderate (0.26 to 0.29 for Model 3) to high (0.50 to 0.74 for Model 2 and 0.63 to 0.77 for Model 1) based on different models. The results of the present study showed that the addition of maternal and herd effects to the model resulted in a decrease in the estimates for direct heritability for all growth traits of the Latvian dark-head lambs. The results showed a strong herd influence possible due to different situation in Latvia because of quite small herds and rams are used only in one herd. Therefore, maternal and herd effects are significant sources of variation of growth traits and ignoring these effects in the model would cause overestimation of direct heritability and inaccurate genetic evaluation of lambs.

References

1. Agricultural Data Centre (2013) Animal register, Available at: http://www.ldc.gov.lv/lv/statistika/registrs/, 20 February 2013.
2. Akhtar P., Ali S., Hussain A., Mirza A., Mustafa M.I., Suktan J.I. (2008) Heritability estimates of post-weaning performance traits in Hissardale sheep in Pakistan. *Turkish Journal of Veterinary and Animal Sciences*, 32(4), pp. 275-279.
3. Bahreini Behzadi M.R., Shahroudi F.E., Van Vleck L.D. (2007) Estimates of genetic parameters for growth traits in Kermani sheep. *Journal of Animal Breeding and Genetics*, 124(5), pp. 296-301.

4. El-Awady H.G., Oudah E.Z.M., Shalaby N.A., El-Arian M.N., Metawi H.R. (2011) Genetic improvement study on pre-weaning body weighr of Egyptian Rahmani lambs under a pure breeding production system. *Options Méditerranéennes*, A (100), pp. 311-316.
5. Ghafouri-Kesbi F., Baneh H. (2012) Genetic parameters for direct and maternal effects on growth traits of sheep. *Archiv Tierzucht*, 55(6), pp. 603-611.
6. Groeneveld E., Kovač M., Mielenz N. (2010) *VCE-6 User's guide and reference manual, version 6.0.* Mariensee, Germany, 125 p.
7. Hussain A. (2006) *Genetic evaluation of Thalli sheep in Pakistan*. Ph.D. Thesis. University of Agriculture, Pakistan, 130 p.
8. Komlosi I. (2008) Genetic parameters for growth traits of the Hungarian Merino and meat sheep breeds in Hungary. *Applied Ecology and Environmental Research*, 6(4), pp. 77-84.
9. Lewis R.M., Beatson P.R. (1999) Choosing maternal-effect models to estimate (co)variances for lives and fleece weight in New Zealand Coopworth sheep. *Livestock Production Science*, 58, pp. 137-150.
10. Lotfi Farokhad M., Beigi Nassiri M.T., Roshanfekr H., Fayazi J., Mamouei M. (2010) Genetic parameters for direct and maternal effects on growth traits of Arman lambs. *Research Journal of Biological Sciences*, 5(1), pp. 71-74.
11. Meyer K. (1992) Variance components due to direct and maternal effects for growth traits of Australian beef cattle. *Livestock Production Science*, 31, pp. 179-204.
12. Mohammadi K., Aghaei A., Bojarpour M., Mirzadeh Kh., Motaghinia Gh. (2010a) Investigation of maternal effects on early growth traits in Arabi lambs, using single-traits animal model. *Journal of Animal and Veterinary Advances*, 9(12), pp. 1712-1716.
13. Mohammadi K., Beygi Nassiri M.T., Fayazi J., Roshanfekr H. (2010b) Investigation of Environmental Factors Influence on Pre-Weaning Growth Traits in Zandi Lambs. *Journal of Animal and Veterinary Advances*, 9(6), pp. 1011-1014.
14. Mokhtari M.S., Rashidi A. (2010) Genetic trends estimation for body weights of Kermani sheep at different ages using multivariate animal models. *Small Ruminant Research*, 88(1), pp. 23-26.
15. Robison O.W. (1981) The influence of maternal effects on the efficiency of selection: a review. *Livestock Production Science*, 8, pp. 121-137.
16. SAS (2003) *User's Guide Statistics. Version 9.1.* SAS Institute Inc., Cary, NC, USA, pp. 201.
17. Savar-Sofla S., Nejati-Javaremi A., Ali Abbasi M. (2011) Investigation on direct and maternal effects on growth traits and the Kleiber ratio in Moghani sheep. *World Applied Sciences Journal*, 14(9), pp. 1313-1319.
18. Tariq M.M., Bajwa M.A., Abbas F., Waheed A., Bokhari F.A., Rafiq M. (2010) Heritability of pre-weaning growth performance traits in Mengali sheep in (Balochistan) Pakistan. *International Journal of Biodiversity and Conservation*, 2(10), pp. 284-288.
19. Thiruvenkadan A.K., Chinnamani K., Muralidharan J., Karunanithi K. (2008) Effect of non-genetic factors on birth weight of Mecheri sheep of India. *Livestock Research for Rural Development*, 20(6), 96 p.