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GENETIC CONTRIBUTION OF RAM ON LITTER SIZE IN ŠUMAVA SHEEP

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Original scientific paper

SUMMARY

The objective of the present study was to quantify the service sire effect in terms of (co) variance components of born and weaned lambs number and to propose models for the potential inclusion of this effect in the linear equations for breeding value estimation. The database with 21,324 lambings in Šumava sheep from 1992-2013 was used. The basic model equation for the analysis of variance of litter size contained effects of ewe´s age at lambing, contemporary group, permanent environmental effect of ewe and direct additive genetic effect of ewe. Two modifications of the basic model were used for estimation of service sire effect. The proportions of variance for the service sire effect for number of born and weaned lambs were 2.1% and 2.0%, when service sire was not included into relationship matrix; while included into the relationship matrix and dividing effect into genetic contribution and permanent environment effect refer that nongenetic effect seems to be bigger than genetic (0.013 vs. 0.009 for number of born and 0.017 vs. 0.004 for number of weaned). Changes in other variance components were relatively low, except of contemporary group. Model including service sire effect as a simple random effect without genetic relationship matrix inclusion is recommended for genetic evaluation of litter size traits.

Key-words: service sire effect, genetic parameters, reproduction

INTRODUCTION

The contemporary Šumava sheep is the successor of autochthonous landrace of sheep kept in Šumava Mountains in the South Bohemia and plays a crucial role in environmental system of Šumava National Park. Gradual regeneration of this local breed led to rams and ewes selection with similar phenotype to original population (Jandurova et al., 2005). Šumava sheep belongs to breeds of medium body size and general utilization. Single lambs were preferred in the past time, because they needed to walk for long distances at low quality grazing pasture. However, according to increasing economic value of meat relative to wool and the increased importance of lamb and sheep meat and milk production in recent years (Krupova et al., 2013) it mean that improving reproductive traits has high economic significance (Wang and Dickerson, 1991; Wolfova et al., 2011a, 2011b).

Litter size is a complex trait influenced by a paternal, maternal and fetal component (Hamann et al, 2004). Usually breeding schemes in sheep only include the maternal component of litter size as fertility trait. Service sire can influence both fertilization rate and prenatal survival rate.

Until recently, the service sire effect has not been studied in sheep breeds in the Czech Republic (Schmidova et al., 2014; Vostry and Milerski, 2013), and no information on this effect has been available for Šumava sheep. Therefore, the objective of the present study was to quantify the service sire effect in terms of (co) variance components of litter size and number of weaned lambs and to propose models for the potential inclusion of this effect in the linear equations for breeding value estimation.

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MATERIAL AND METHODS

Data

Performance test data from 1992-2013 were provided by the Sheep and Goat Breeders Association of the Czech Republic. The database with records of 29,401 lambings in Šumava sheep contained information on: animal (lambing ewe), herd, date of lambing, parity, ewe age at lambing, interval between successive lambings, service sire, number of born and number of weaned lambs. Sire and dam identification were added from the pedigree database. Four generations of the known ancestors were used for the estimation of genetic parameters. Number of born lambs was recorded on the day of lambing as total number of lambs born. Number of weaned lambs was recorded as number lambs weight at 80-120 days. Only ewes, that had lambed, were in the database (at least one lamb independently if it was alive or dead). The following records were deleted from the database prior to analysis: ewes lambing at younger than 10 months or older than 150 months of age, lambing ewes whose sire had less than 4 daughters with performance. Ewe age at lambing time was categorized into 6 classes divided according to age (10-18 months, 19-30, 31-42, 43-78, 79-102 and 103-150 months of age. Contemporary group (CG) effect was created with ewes lambed within successive 40-day intervals in a given herd and year constituting the CG's (Schmidova et al., 2014). Those CG's with fewer than 7 ewes were excluded from variance component estimation analyses. Also herds using only one ram and rams acting only in one herd-year were excluded.

The database adjusted in this way contained data on 21,324 lambings from 5,984 ewes and 396 rams bred in 35 herds.

Statistical methods

The basic model equation for the analysis of litter size variance was determined based on the single-trait repeatability model (Schmidova et al., 2014):

Model 1: $LS_{ijk} = A_i + CG_j + Ew_k + Epe_k + e_{ijk}$

where LS_{ijk} is the litter size of animal k (number of born or weaned lambs); A_i is the age class at lambing; CG_j is the random effect of contemporary group; Ew_k is the random direct additive genetic effect of ewe k; Epe_k is the random permanent environmental effect of ewe k; e_{ijk} is the random residual.

Two modifications of the Model 1 were used for estimation of service sire effect:

Model 2: $LS_{ijkl} = A_i + CG_j + Ew_k + Epe_k + S_l + e_{ijkl}$

Model 3: $LS_{ijkl} = A_i + CG_j + Ew_k + Epe_k + SG_l + Spe_l + e_{ijkl}$

S_l is the random effect of service sire l (Model 2); SG_l is the random direct additive genetic effect of service $sire_l$ (Model 3); Spe_l is the random permanent environmental effect of service sire l (Model 3).

Variance components were estimated by the Gibbs sampling method using the GIBBS1F90 program (Misztal et al., 2002). After some exploratory analyses one chain of 700,000 samples was used, rejecting the first 80,000 samples and saving every 100 thereafter.

RESULTS AND DISCUSSION

Distributions of number of lambs, means and standard deviations of lambs born and weaned are presented in the Table 1.

Table 1. Distribution of the number of lambs in litter, total number of records, mean and standard deviation (SD) of litter size

	Litter size					Total number of records	Mean	SD
	0	1	2	3	4			
No. at lambing	*	14,867	6,261	193	3	21,324	1.31	0.48
		69.72%	29.36%	0.91%	0.01%			
No. at weaning	1,908	14,400	4917	98	1	21,324	1.15	0.56
	8.95%	67.53%	23.06%	0.46%	0.00%			

* Only ewes, that had lambed, were in the database (at least one lamb independently if it was alive or dead)

Table 2 documents variance components and genetic parameter estimations for both litter size traits, as computed from repeatability models. The basic model (Model 1) shows low heritability and repeatability estimates. Similar heritability and repeatability for litter size in Šumava sheep was reported in Schmidova et al. (2014), the study also showed these values as the lowest ones in comparison of seven breeds.

Table 2. Variance components and genetic parameters for number of born and number of weaned lambs in Šumava sheep for different models

	σ_e^2	σ_P^2	σ_{Ew}^2	σ_{Ewpe}^2	σ_{CG}^2	σ_S^2	σ_{Spe}^2
Born							
model1	0.187	0.226	0.014	0.004	0.022		
model2	0.186	0.225	0.013	0.005	0.017	0.005	
model3t	0.186	0.225	0.013	0.005	0.016	0.002	0.003
Weaned							
model1	0.257	0.315	0.014	0.002	0.049		
model2	0.255	0.313	0.013	0.003	0.034	0.006	
model3t	0.255	0.313	0.014	0.003	0.036	0.001	0.005
	h^2(SE)	r_{rep}^2	Ew_{pe}^2	e^2	CG^2	S^2(SE)	S_{pe}^2
Born							
model1	0.061(0.007)	0.080	0.019	0.825	0.096		
model2	0.057(0.008)	0.078	0.021	0.827	0.075	0.021(0.007)	
model3t	0.058(0.008)	0.078	0.020	0.826	0.073	0.009(0.005)	0.013
Weaned							
model1	0.045(0.006)	0.053	0.007	0.815	0.133		
model2	0.042(0.007)	0.051	0.008	0.813	0.116	0.020(0.005)	
model3t	0.043(0.005)	0.052	0.008	0.812	0.115	0.004(0.004)	0.017

σ_e^2 = residual variance; σ_{Ew}^2 = additive genetic variance of ewe´s (maternal) performance; σ_{Ewpe}^2 = ewe´s (maternal) permanent environmental variance; σ_S^2 = additive genetic variance of sire´s (paternal) performance; σ_{Spe}^2 = sire´s (paternal) permanent environmental variance; σ_{CG}^2 = contemporary group variance; σ_P^2= phenotypic variance; $h^2 = (\sigma_{Ew}^2/\ \sigma_P^2)$ = maternal heritability; $r_{rep}^2 = ((\sigma_{Ew}^2 + \sigma_{Ewpe}^2)/\ \sigma_P^2)$ = maternal repeatability; $Ew_{pe}^2 = (\sigma_{Ewpe}^2/\ \sigma_P^2)$ = permanent environmental variance as a proportion of phenotypic variance; $e^2 = (\sigma_e^2/\ \sigma_P^2)$ =residual variance as a proportion of phenotypic variance; $CG^2 = (\sigma_{CG}^2/\ \sigma_P^2)$ = variance of contemporary group as a proportion of phenotypic variance; $S^2=(\sigma_S^2/\ \sigma_P^2)$ = paternal heritability; $S_{pe}^2 = (\sigma_{Spe}^2/\ \sigma_P^2)$ = paternal permanent environmental variance as a proportion of phenotypic variance

The proportions of variance for the service sire effect for number of lambs born and weaned were 2.1% and 2.0%, when service sire was not included into relationship matrix (Model 2). While included into the relationship matrix dividing effect into genetic contribution and permanent environment effect (Model 3) refer that nongenetic effect seems to be bigger than genetic (0.013 vs. 0.009 for number of born and 0.017 vs. 0.004 for number of weaned). Changes in other variance components were relatively low, except of contemporary group. This is probably due to low number of rams in one flock.

Hagger (2002) found out a small influence of service sire effect on litter size in four breeds (0.7%-2.9%). Also the proportion of variance for service sire effect for litter size traits in pigs was in range from 2 to 3% (Wolf and Wolfova, 2012). Mohammadi et al. (2012) found out service sire effects to be important only for litter weight traits.

Nevertheless, it is well known that rams with health problems or deficiencies in sperm production can be the reason for insufficient litter sizes in a flock. Serious reproduction problems can arise if rams show sperm deficiencies or suffer from handicaps in locomotion, e.g. foot rot during time of joining. Also less severe disorders of rams could affect litter size (Hagger, 2002). The social relationships that an animal has with others of the same species can affect many aspects of the reproductive process too (Rosa and Bryant, 2002). Rams with high scores for sexual behaviour can improve flock fertility during breeding (Perkins et al., 1992).

CONCLUSION

Litter traits are generally considered as ewe traits. The results show that the service sires in Šumava sheep have a small, but nevertheless a clearly detectable influence on the litter size under the management systems practised. Model including service sire effect as a simple random effect without inclusion of the genetic relationship matrix is recommended for genetic evaluation of litter size traits.

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