COBISS: 1.08
Agris category code: L10

THE INFLUENCE OF RAM ON LITTER SIZE IN SUFFOLK SHEEP

Jitka SCHMIDOVÁ [1, 2], Michal MILERSKI [3], Alena SVITÁKOVÁ [4], Alexandra NOVOTNÁ [5], Hana VOSTRÁ-VYDROVÁ [6], Luboš VOSTRÝ [7]

ABSTRACT

The proportion of variance for service ram effects was estimated for number lambs born and weaned. The database with 11,311 lambings in purebred Suffolk was used. The basic model equation for the analysis of variance of litter size contained effects of ewe´s age at lambing, contemporary group of ewes at lambing, ewe´s permanent environmental effect and ewe´s direct additive genetic effect. The other models were extended by contemporary group of ewes during mating (harem), and additive genetic and permanent environmental effect of service ram. Variance components were estimated by the Gibbs sampling method. The proportions of variance for the service ram effect for number of lambs born and weaned were 4.1 % and 2.6 %. The annual genetic trends were 0.4 % of lambs born and 0.2 % of lambs weaned for female fertility. Male contribution on litter size was 0.2 % of lambs born and 0.1 % of lambs weaned. The results demonstrated that service rams in Suffolk sheep have low influence on litter size of their mates.

Key words: sheep, litter size, prolificacy, variance components, genetic parameters, heritability, breeding values

1 INTRODUCTION

In the Czech Republic, there are about 200,000 sheep of which 23,500 ewes and their lambs are included in performance test. Suffolk is the most numerous breed in Czech Republic. In year 2014 it account for about 25.4 % of purebred ewes in performance test (Bucek *et al.*, 2015).

In recent years the importance of lamb and sheep meat and milk production increased relative to wool production. Consequently the economic value of sheep meat and sheep milk increased too (Krupova *et al.*, 2013). As reported by Wang and Dickerson (1991) and Wolfova *et al.* (2011a, 2011b) the improvement of reproductive traits has high economic significance in meat production system.

Traditionally, litter size is considered and evaluated as a trait of female. However, prolificacy is a complex trait (Fig. 1) as described by Schmidova *et al.* (2016) and Shorten *et al.* (2013). It is also influenced by paternal and fetal effects. In studies of Sanchez-Davila *et al.* (2015) and Schmidova *et al.* (2015) genetic evaluations for number of lambs born per ewe were described using model equations that included an effect of service ram.

In view of the foregoing, the objective of the present study was to estimate the proportion of variance for service ram effect and other factors acting during the mating period on subsequent litter size in Suffolk, the meat purpose breed.

1 Institute of Animal Science, Pratelstvi 815, 10401 Praha-Uhrineves, Czech Republic, e-mail: Schmidova.jitka@vuzv.cz
2 Czech University of Life Science Prague, Faculty Agrobiology, Food and Natural Resources, Kamýcka 129, Prague, Czech Republic
3 Same address as 1, e-mail: Milerski.michal@vuzv.cz
4 Same address as 1, e-mail: Svitakova.alena@vuzv.cz
5 Same address as 1, e-mail: Novotna.alexandra@vuzv.cz
6 Same address as 1, e-mail: Vostravydrova.hana@vuzv.cz
7 Same address as 1, e-mail: Vostry.lubos@vuzv.cz

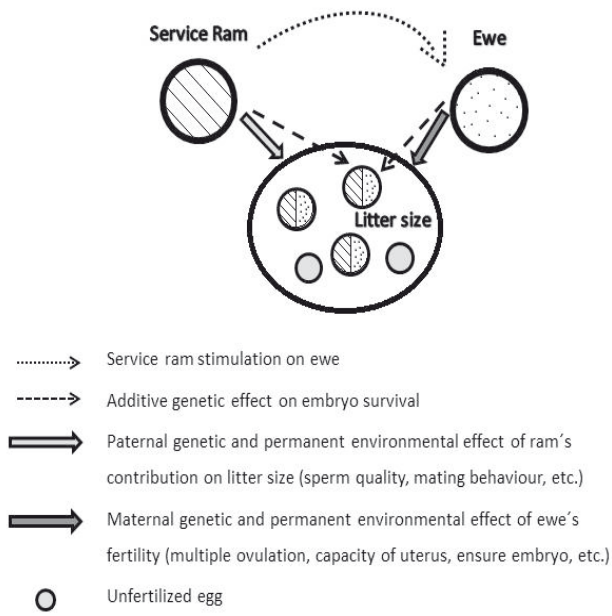

Figure 1: *Effect of service ram and ewe on litter size*

2 MATERIALS AND METHODS

2.1 DATA

Database was provided by the Sheep and Goat Breeders Association of the Czech Republic. It contained data from performance test from year 1996 to 2013. The Association collect information of animals as flock, date of lambing, parity, ewe age at lambing, interval between successive lambings, service ram and litter size. Litter size was recorded on the day of lambing as total number of born lambs (alive or dead). Only ewes that had at least one lamb were included in the database. Only natural matings were included. Four generations of known ancestors from the pedigree database were used for the estimation of genetic parameters.

Crossbred ewes, ewes with an unknown date of birth, ewes that were younger than 10 months or older than 140 months of age at lambing, ewes whose sire had less than four daughters with at least two lambing records each were excluded from the database. Flocks where only one ram was used, and rams used in only one flock-year subclass were excluded from the database prior to analysis. Contemporary groups (CG) were created of ewes that lambed within successive 40-day intervals in the same flock and year (Schmidova *et al.*, 2014). Those CG's with less than 7 ewes were excluded from analyses. Another contemporary group category identified as the harem was created of all ewes mated to one ram during one mating period (Schmidova *et al.*, 2015).

The edited database contained data on 11,311 lambing events from 4,032 ewes and 385 rams. There were 460 contemporary groups of ewes at lambing, 1,104 harems, and 7879 animals in the pedigree file.

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

For estimation of service ram effect were used two extensions of the Model 1:

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 effect of service ram l in model 2 (random); SG_l is the direct additive genetic effect of service ram_l in model 3 (random); Spe_l is the permanent environmental effect of service ram l in model 3 (random).

Variance components were estimated by the Gibbs sampling method (GIBBS1F90, Misztal *et al.*, 2002). After some exploratory analyses one chain of 700,000 samples was generated, rejecting the first 80,000 and saving every 100th sample thereafter. Bayesian measure of adequacy – the deviance information criterion (DIC) (Spiegelhalter *et al.*, 2002) was also evaluated.

Breeding values (BV) for number of born lambs and number of weaned lambs as a ewe trait (female fertility) and as a service ram trait (male fertility) were predicted using BLUPF90 (Misztal *et al.*, 2002). Genetic trends

Table 1: *Distributions of number of lambs*

	Litter size				
	0	1	2	3	4
No. of born lambs per litter	*	4263	6246	784	18
		37.69 %	55.22 %	6.93 %	0.16 %
No. of weaned lambs per litter	844	4583	5397	483	4
	7.46 %	40.52 %	47.71 %	4.27 %	0.04 %

* Only ewes with at least one born lamb were included in the database

Table 2: *Variance components for number of born and number of weaned lambs in Suffolk sheep for different models*

Litter size		σ_P^2	σ_e^2	σ_{Ew}^2	σ_{Ewpe}^2	σ_{CG}^2	σ_S^2	σ_{Spe}^2	σ_{Har}^2	DIC
Born	Model 1	0.350	0.273	0.019	0.006	0.052				18399
	SD		0.004	0.004	0.003	0.006				
	Model 2	0.341	0.271	0.017	0.006	0.031	0.016			18378
	SD		0.004	0.004	0.003	0.005	0.004			
	Model 3	0.342	0.271	0.017	0.005	0.028	0.014	0.005	0.002	18371
	SD		0.005	0.004	0.003	0.005	0.005	0.004	0.001	
Weaned	Model 1	0.467	0.360	0.019	0.010	0.078				21495
	SD		0.006	0.005	0.005	0.008				
	Model 2	0.457	0.359	0.019	0.009	0.061	0.009			21505
	SD		0.006	0.005	0.005	0.009	0.004			
	Model 3	0.455	0.358	0.020	0.008	0.051	0.012	0.003	0.003	21507
	SD		0.006	0.005	0.005	0.008	0.005	0.003	0.002	

σ_P^2 = phenotypic variance; 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_{Har}^2 = harem variance; DIC = Deviance information criterion

were characterized as mean breeding values by year of birth from 1989 to 2011.

3 RESULTS AND DISCUSSION

The average number of born lambs per litter was 1.70 (± 0.60) and the average number of weaned lambs was 1.49 (± 0.70). The Table 1 presents distributions of both litter size traits.

Variance components and genetic parameter estimations for number of born and weaned lambs are presented in Table 2 and 3. The basic model (Model 1) shows in general low coefficient of heritability and repeatability.

As it was showed earlier by Sanchez-Davila *et al.* (2015) rams differed by from one to two offspring in average litter size of their mates. Significant differences among service rams in litter size per mate and also conceptus survival through gestation were observed by Holler *et al.* (2014). The service ram effect on litter size was found also by Hagger (2002), where it was from 0.7 % to 2.9 % of phenotypic variance with difference among breeds. In Šumava sheep (Schmidova *et al.*, 2015), the variance attributable to service ram ranged from 0.9 % to 2.1 % of phenotypic variance; whereas in high prolific Romanov sheep (Schmidova *et al.*, 2016) the proportion of variance attributable to the service sire effect ranged from 0.046 to 0.10.

As pointed out by David *et al.* (2007), even if ewe

Table 3: *Variance component proportions of phenotypic variance for number of born and number of weaned lambs in Suffolk sheep for different models*

Litter size		h^2	r_{rep}^2	Ew_{pe}^2	e^2	CG^2	S^2	S_{pe}^2	Har^2
Born	Model 1	0.054	0.071	0.017	0.781	0.148			
	Model 2	0.049	0.067	0.017	0.797	0.090	0.047		
	Model 3	0.051	0.067	0.016	0.792	0.081	0.041	0.014	0.006
Weaned	Model 1	0.042	0.063	0.022	0.771	0.166			
	Model 2	0.041	0.062	0.021	0.784	0.133	0.020		
	Model 3	0.045	0.062	0.017	0.786	0.112	0.026	0.007	0.006

$h^2 = (\sigma_{Ew}^2 / \sigma_P^2)$ = 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 and ram sources of variation seem small, the range of estimated BV between extreme animals can be substantial.

Using the proportion of residual variance as the criterion for the comparison of models in our study, both models that included the service ram effects were slightly better than model 1. Including the service ram effects into the model decreased DIC in our study for estimation of variance components for number of born but not for number of weaned lambs.

Spearman´s correlations among maternal breeding values for number of born lambs estimated by these models ranged from 0.991 to 0.998; Pearson´s correlations ranged from 0.989 to 0.997. Both types of correlations among maternal breeding values for number of lambs weaned ranged from 0.992 to 0.998. Spearman´s correlations between paternal breeding values (model 3) and random sire-effect (model 2) were 0.079 and 0.028 for number of lambs born and weaned, respectively. The annual genetic trends were 0.4 % of lambs born and 0.2 % of lambs weaned for female fertility. There were only slight differences among models (data not shown). In male contribution on litter size it was 0.2 % of lambs born and 0.1 % of lambs weaned (model 3).

4 CONCLUSIONS

Traditionally, litter size is considered and evaluated as a ewe trait. However, prolificacy is a complex trait. Results from the present study indicate that service rams in Suffolk sheep also have a clearly detectable influence on number of born and weaned lambs. No antagonistic dependence between additive genetic service ram (paternal) component and the additive genetic ewe (maternal) component was found. Genetic parameter estimates indicate that selection based on breeding values for the service ram effect could be an additional selection criterion to improve litter size in Suffolk sheep.

5 ACKNOWLEDGEMENT

The study was supported by the Ministry of Agriculture of the Czech Republic (Project No. QJ1510139 and Project No. QJ1310184).

6 REFERENCES

Bucek, P., Kvapilík, J., Kölbl, M., Milerski, M., Pinďák, A., Mareš, V., Kondrád, R., Roubalová, M., Škaryd, V., Dianová, M., Krupová, Z., Krupa, E., Michaličková, M. (2015). *Ročenka chovu ovcí a koz v České Republice za rok 2014*. Českomoravská společnost chovatelů, a.s. Praha.

David, I., Bodin, L., Lagriffoul, G., Leymarie, C., Manfredi, E., & Robert-Granie, C. (2007). Genetic analysis of male and female fertility after artificial insemination in sheep: Comparison of single-trait and joint models. *Journal of Dairy Science*, *90*(8), 3917–3923.

Hagger, C. (2002). Multitrait and repeatability estimates of random effects on litter size in sheep. *Animal Science*, *74*, 209–216.

Holler, T. L., Dean, M., Taylor, T., Poole, D. H., Thonney, M. L., Thomas, D. L., Pate, J. L., Whitley, N., Dailey, R. A., & Inskeep E. K. (2014). Effects of service sire on prenatal mortality and prolificacy in ewes. *Journal of Animal Science*, *92*(7), 3108–3115.

Krupova, Z., Krupa, E., & Wolfova, M. (2013). Impact of economic parameters on economic values in dairy sheep. *Czech Journal of Animal Science*, *58*, 21–30.

Misztal, I., Tsuruta, S., Strabel, T., Auvray, B., Druet, T., & Lee, D. H. (2002). BLUPF90 and related programs (BGF90). In: *Proceedings of the 7th World Congress on Genetics Applied to Livestock Production*, Montpellier, France, August 19–23, 2002 [CD-ROM] (communication 28-07). Castanet-Tolosan: INRA.

Sánchez-Dávila, F., Bernal-Barragán, H., Padilla-Rivas, G., Bosque-González, A. S., Vázquez-Armijo, J. F., & Ledezma-Torres, R. A. (2015). Environmental factors and ram influence litter size, birth, and weaning weight in Saint Croix hair sheep under semi-arid conditions in Mexico. *Tropical Animal Health and Production*, *47*(5), 825–831.

Schmidova, J., Milerski, M., Svitakova, A., Vostry, L., & Novotna, A. (2014). Estimation of genetic parameters for litter size in Charollais, Romney, Merinolandschaf, Romanov, Suffolk, Šumava and Texel breeds of sheep. *Small Ruminant Research*, *119*, 33–38.

Schmidova, J., Milerski, M., Svitakova, A., & Vostry, L. (2015). Genetic contribution of ram on litter size in šumava sheep. *Poljoprivreda/Agriculture*, *21*(1), 159–162.

Schmidova, J., Milerski, M., Svitakova, A., & Vostry, L. (2016). Effects of service ram on litter size in Romanov sheep. *Small Ruminant Research* (in press). http://dx.doi.org/10.1016/j.smallrumres.2016.05.018.

Shorten, P. R., O'Connell, A. R., Demmers, K. J., Edwards, S. J., Cullen, N. G., & Juengel, J. L. (2013). Effect of age, weight, and sire on embryo and fetal survival in sheep. *Journal of Animal Science, 91*(10), 4641–4653.

Spiegelhalter, D. J., Best, N. G., Carlin, B. P., & van der Linde, A. (2002). Bayesian measures of model complexity and fit. *Journal of the Royal Statistical Society, Series B, 64*(4), 583–639.

Wang, C. T., & Dickerson, G. E. (1991). Simulated effects of reproductive performance on life-cycle efficiency of lamb and wool production at three lambing intervals. *Journal of Animal Science*, *69*, 4338–4347.

Wolfova, M., Wolf, J., & Milerski, M. (2011a). Economic weights of production and functional traits for Merinolandschaf, Romney, Romanov and Sumavska sheep in the Czech Republic. *Small Ruminant Research*, *99*, 25–33.

Wolfova, M., Wolf, J., & Milerski, M. (2011b). Calculating economic weights for sheep sire breeds used in different breeding systems. *Journal of Animal Science*, *89*, 1698–1711.