The estimation of variance components for litter size in two Slovenian sheep breeds

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Abstract

The aim of this study was to estimate variance components for ewe litter size in two autochthonous Slovenian sheep breeds, the Jezersko-Solčava sheep (JS) and the Improved Jezersko-Solčava sheep (JSR). Both breeds are fertile all year round and are mainly bred for lamb production. Litter size records were collected from the farms according to the breeding programs for 17,071 ewes with 79,387 lambings (40,172 - JS, 39,215 - JSR) in the period from 2007 to 2023. A pedigree file with 24,425 animals was created from the Central database for small ruminants in Slovenia. The fixed part of the model was analysed with the SAS statistical package using the MIXED procedure and included the breed effect (JS, JSR), ewe parity (from 2 to 10) and the year-season interaction (1, 2, 3, …, 68), while the lambing interval was included as a linear covariate. The variance components were estimated using the REML method implemented in the VCE-6 program. The random part of the model consisted of the additive genetic effect, the permanent environmental effect and the flock effect. JSR ewes had a significantly higher litter size (1.39 ± 0.01 lambs per litter) compared to JS ewes (1.26 ± 0.01 lambs per litter). Litter size was significantly the lowest in the second parity (1.22 ± 0.01 lambs per litter) and increased until the sixth parity (1.36 ± 0.01 lambs per litter). Thereafter, it gradually decreased until the tenth parity (1.33 ± 0.01 lambs per litter). Litter size increased with increasing lambing interval and was also affected by year-season interaction. The estimated heritability for litter size was 0.06. The effect of permanent environment explained 0.02 variability, while the flock effect explained 0.11 variability in litter size. As expected, the variance components including estimated heritability for litter size were relatively low. Nevertheless, it is expected that they could contribute to more effective selection in the future, and for this reason the estimated variance components will be used in predicting breeding values for ewe litter size from 2024 onwards.

Keywords: parity, lambing period, heritability, permanent environmental effect, flock effect.
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Introduction

Fertility traits are economically very important factors which affects the profitability of lamb production. Apart from lambing interval, the most important fertility trait is ewe's litter size. A higher litter size could increase the profit of farmer through a higher quantity of lamb meat produced per ewe. In Slovenia, the most widespread sheep breeds are two autochthonous breeds - the Jezersko-Solčava sheep (JS) and the Improved Jezersko-Solčava sheep (JSR). Both are bred mainly for lamb production and are fertile all year round. They are distinguished by several phenotypic traits as well as in some production traits such as litter size. Nevertheless, JSR sheep is the result of improving of JS sheep with the Romanov sheep in order to achieve better fertility and this goal was achieved (Cividini *et al.*, 2024a; Cividini *et al.*, 2024b). Still, no study about variance components for litter size in sheep breeding has been made in Slovenia.

The main objective of the study was to determine the main factors affected the litter size and to estimate variance components for litter size in two Slovenian sheep breeds, the Jezersko-Solčava sheep, and the Improved Jezersko-Solčava sheep.

Material and methods

Records were provided by the breeding programs of JS and JSR (Cividini *et al.*, 2024a; Cividini *et al.*, 2024b) for sheep collected from the year 2007 to the year 2023. Data about ewe's breed, flock, lambing date, parity, and litter size were acquired from the Central Database for Small Ruminants in Slovenia. Only ewes with lambing interval between 150 and 550 days were included in the analysis. Ewes with more than 10 parities were excluded. Due to a low number of quadruplets, they were counted to triplets. After the records control, 17,071 ewes with 79,387 lambings (40,172 JS, 39,215 JSR) were included in the analysis. A pedigree file with 24,425 animals was also created from the Central Database for Small Ruminants. The fixed part of the model was analysed with the SAS statistical package using the MIXED procedure (SAS Institute Inc., 2014). The model included breed (JS, JSR), parity (2, 3, 4, 5, 6, 7, 8, 9, 10), and the year-season interaction (1, 2, 3, …, 68), while the lambing interval was included as a linear covariate. The variance components were estimated using the REML method implemented in the VCE-6 program (Groeneveld *et al.*, 2010). The random part of the model consisted of the additive genetic effect, the permanent environmental effect and the flock effect.

Results and discussion

Table 1 shows p-values for fixed effects included in the model for litter size. All effects (breed, parity, year-season interaction and lambing interval) significantly affected litter size ($P<0.001$)

The litter size of JS ewes and JSR ewes is presented in Table 2. JSR ewes had significantly higher litter size (1.39 ± 0.13 lambs per litter) than JS ewes (1.26 ± 0.12 lambs per litter). This was expected because JSR sheep is the result of improving JS sheep with the Romanov sheep in order to achieve better fertility.

Ewe's litter size by parity is shown in Figure 1. Litter size was significantly the lowest in ewes at the second parity (1.22 ± 0.01 lambs per litter) and increased until the sixth parity (1.36 ± 0.01 lambs per litter). Thereafter, it gradually decreased until the tenth parity (1.33 ± 0.01 lambs per litter).

Estimated variance components for litter size are presented in Table 3. Estimated heritability was 6%, while permanent environmental effect explained 2% of the variability. The flock effect explained 11% of variability in litter size, while 81% of phenotypic variance remained in the residual. Habtegiorgis *et al.* (2023) estimated genetic parameters for some growth and fertility traits in Dawuro sheep in Ethiopia. The estimate of direct heritability for litter size was 0.10, which is higher in comparison with the present study (0.06). The estimate for permanent environmental effect was 0.31, which is quite high compared to the present study (0.02). In the study of Hamman *et al.* (2004), permanent environment also explained a higher proportion of phenotypic variance (0.05) while estimated heritability (0.04) was slightly lower than in our study. However, Schmidova *et al.* (2014) estimated variance components for litter size in

Table 1. p-values of included effects in the statistical model for ewe's litter size.

	Effects			
	Breed	**Parity**	**Year-season interaction**	**Lambing interval**
Litter size	<0.0001	<0.0001	<0.0001	<0.0001

Table 2. Litter size (LSM ± SE) by the sheep breed.

	Breed (LSM ± SE)	
	Jezersko-Solčava sheep	**Improved Jezersko-Solčava sheep**
Litter size	1.26 ± 0.12	1.39 ± 0.13

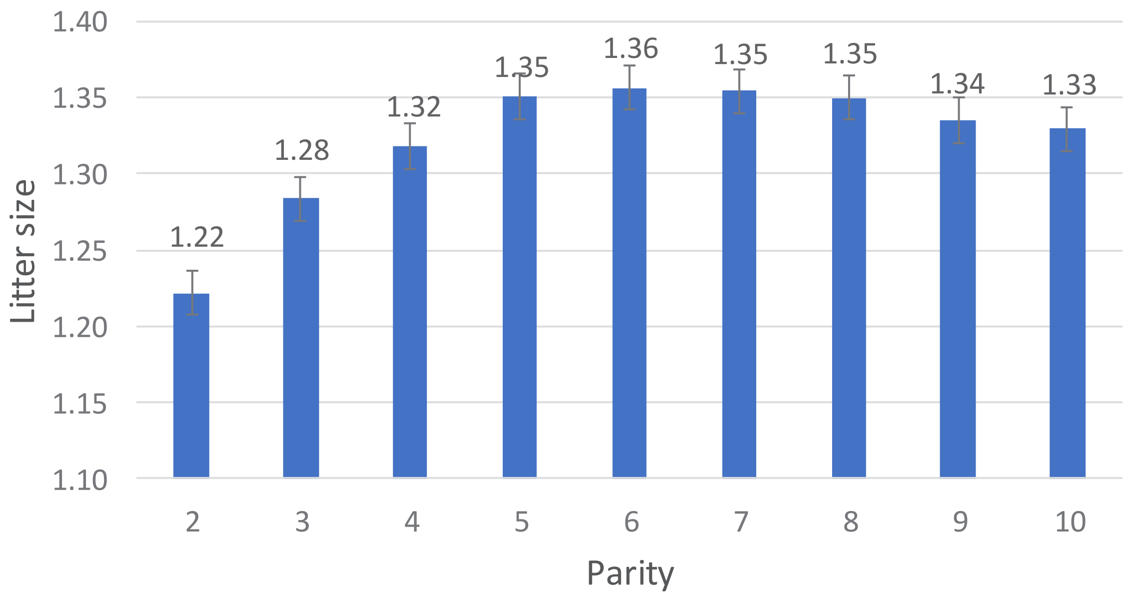

Figure 1. Ewe's litter size by parity.

Table 3. Estimated variance components ratios for litter size of ewes in two Slovenian sheep breeds.

	Variance components (ratios)			
	Additive genetic effect	**Permanent environment**	**Flock**	**Residual**
Litter size	0.06	0.02	0.11	0.81

seven sheep breeds and found that the heritability estimate in Šumava sheep and Romney sheep was 0.06 while the estimate for permanent environmental effect was 0.02 which is the same as in our study.

Conclusions

The variance components including estimated heritability for litter size were relatively low what was expected. Still, it is expected that they could contribute to more effective selection in the future, and for this reason, the estimated variance components will be used in predicting breeding values for ewe litter size from 2024 onwards.

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