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Original Paper

Non-genetic factors affecting somatic cell count in milk of dairy goat populations in Croatia and Slovenia

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Somatic cell count (SCC) is a useful indicator of intramammary infection of cow's udders and a standard of quality and hygiene of cow's milk in many countries. The main non-inflammatory factors influencing SCC in goat milk are intrinsic depending directly on the animal and extrinsic where some of them are routinely recorded along milk recording. The objective of this study was to determine the sources of non-genetic variation for SCC in Alpine (ALP) and Saanen (SAN) dairy goat populations based on Croatian (CRO) and Slovenian (SVN) milk recording data. For that purpose, test day records (327,404 in total) were used. They were collected over the period from 2005 to 2017 in Alpine (ALP) and Saanen (SAN) goat populations in Croatia (CRO) and Slovenia (SVN). The majority of records (310,371) represent CRO data, while SVN data included 17,033 records. Data have been obtained from the Central database of Croatian Agricultural Agency and Slovenian Central Database for Small Ruminants, which are collected according to the ICAR standards. Data were analysed using MIXED procedure in SAS/STAT, based on the REML method. Results showed significant effect of the population, parity, litter size, year and month of kidding and interaction between them as well as the effect of the stage of lactation nested within the population on the SCC in milk of studied goat populations.

Keywords: Alpine goat, Croatia, dairy goat, logSCC, Saanen goat, Slovenia, somatic cell count

1 Introduction

Alpine and Saanen goats are widely used populations among dairy breeds in both countries. The breeds are well adapted to the environment, since they originate from similar conditions in the Switzerland. They are seasonally fertile and kiddings occurred once per year, in the springtime. According to the Annual report of Croatian Agricultural Agency (CAA, 2016) around 4.500 animals of Alpine goat (CRO ALP) and around 700 animals of Saanen goat (CRO SAN) have been encompassed by the breeding work. In Slovenia (2017), there were around 1.100 animals of Slovenian Alpine goat (SVN ALP) and around 700 animals of Slovenian Saanen goat (SVN SAN) (Savšek et al., 2018). Milk recording is performed according to ICAR guidelines (ICAR, 2018) using regular alternate AT4 scheme (morning/evening system) in both countries. The milk of all mammals contains different types of somatic cells (SC), which are blood-borne SC and epithelial one. Somatic cells are present in healthy mammary glands, but regarding mammary inflammation, there is an increased influx of blood leukocytes. The presence of leukocytes in milk results in increased somatic cell count (SCC) values. On the other hand, the non-infectious factors can influence on the SCC as well. Epithelial cells in milk result from desquamation of the epithelium of alveoli and ducts of the mammary gland that is mainly physiological, due to regeneration of the normal epithelia. Besides the presence of SC, there are also cytoplasmic particles in the milk that originated from the distal alveolar mammary secretory cells. These formations are very abundant when milk secretion is apocrine, as in the case of goats, and very few or virtually absent, when the discharge is merocrine, as in cattle (Jimenez-Granado et al., 2014).

SCC is a useful indicator of intramammary infection of cow's udders and a standard of quality and hygiene of cow's milk in many countries. However, three characteristics distinguish goat milk from sheep or cow milk: higher values of SCC, cytoplasmic particles and polymorphonuclear neutrophils. In the absence

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of mastitis, SCC in goat milk varies between 270 × 10^3 and 2,000 × 10^3 SC/ml what confirmed that SCC in goat milk is not highly correlated to intramammary infection (Jimenez-Granado et al., 2014). The main non-inflammatory factors influencing SCC in goat milk are intrinsic – depending directly on the animal (fraction of milking, time between milking, milking frequency, daily variations, stage of lactation, number of lactation, prolificacy, breed, production level, heat) and extrinsic (type of milking, feed, stress, seasonality, farming system, facilities) (Jimenez-Granado et al., 2014). Some of them are routinely recorded along milk recording (Jimenez-Granado et al., 2014).

The objective of this study was to determine the sources of non-genetic variation for SCC in Alpine (ALP) and Saanen (SAN) dairy goat populations based on Croatian (CRO) and Slovenian (SVN) milk recording data.

2 Materials and methods

Test day records of Alpine (ALP) and Saanen (SAN) dairy goat populations from two countries, Croatia (CRO) and Slovenia (SVN) collected in the period from 2005 to 2017, were used for the joint analysis. Croatian data were taken from the Central database of the Croatian Agricultural Agency, while Slovenian data were provided by the Central Database for Small Ruminants, which is maintained by the Department of Animal Science, Biotechnical Faculty, University of Ljubljana. Test-day records were included in the analysis while SCC was the analysed trait. These records were collected in accordance to the ICAR guidelines (ICAR, 2018) using regular alternate AT4 scheme (morning/evening system), while goats were machine milked twice a day. The raw data contained 497,372 test-day records. CRO data represented the majority of the records containing 329,022 records of the CRO ALP and 35,576 of the CRO SAN population. The number of test-day records was considerably lower in the SVN ALP (91,468) and SVN SAN (37,306) populations. The reason was that in Croatia the costs of the SCC analysis is covered by the state, while in Slovenia breeders need to pay analysis by themselves. In the further analysis, goat breeds from both countries were considered as four different populations.

Prior to the statistical analysis, some of the test-day records were excluded or modified. The following was excluded: records collected after sixth parity, records collected before 5th and after 305th days in milk, and records where SCC was unknown value. All multiple litters were considered as the same class (2+). The season of kidding was defined as a month of kidding. Seasons with less than 30 records were joined to the previous or the next season to improve the data structure. After pruning of the original data set, a total of 327,404 records obtained from 23,923 does were used in the statistical analysis. In the preliminary study, the normality of SCC was tested and logarithmic transformation for SCC (logSCC) was performed. Descriptive statistics for the analysed traits are presented in Table 1.

Table 1 Descriptive statistics for the milk production traits

Breed (Country)	Trait	N	Mean	*SD*	Min	Max
All populations together	DMY (kg)	327,404	2.34	1.06	0.30	6.00
	SCC (log)	327,404	9.13	1.96	1.00	15.00
	DIM (days)	327,404	148.88	69.93	5.00	305.00
ALP (Croatia)	DMY (kg)	279,286	2.32	1.05	0.30	6.00
	SCC (log)	279,286	9.14	1.96	3.00	15.00
	DIM (days)	279,286	150.00	69.94	5.00	305.00
SAN (Croatia)	DMY (kg)	31,085	2.66	1.13	0.31	5.99
	SCC (log)	31,085	9.14	1.97	3.00	14.87
	DIM (days)	31,085	148.47	68.68	5.00	305.00
ALP (Slovenia)	DMY (kg)	8,720	1.98	1.05	0.30	6.00
	SCC (log)	8,720	9.43	1.96	1.00	13.65
	DIM (days)	8,720	127.47	61.47	5.00	288.00
SAN (Slovenia)	DMY (kg)	8,313	1.97	0.85	0.30	6.00
	SCC (log)	8,313	8.51	1.81	1.00	13.29
	DIM (days)	8,313	135.30	76.99	5.00	305.00

DMY – daily milk yield, SCC – somatic cell count, DIM – days in milk, ALP – Alpine goat, SAN – Saanen goat, N – number, *SD* – standard deviation, Min – minimum, Max – maximum

The average logSCC was 9.13 and daily milk yield 2.34 kg.day^{-1} (Table 1) for all populations. There was no strong deviation of any population for the logSCC. The average lactation length (days in milk) was 148.88 days.

The following model present the best fit for logSCC and is shown in scalar notation (1):

$$y_{ijklmno} = \mu + B_i + \sum_{p=1}^{4} b_{pi} t_p + P_j + L_k + Y_l + M_m + YM_{lm} + e_{ijklmno} \quad (1)$$

Effects of population (B_i), parity (P_j), litter size (L_k), year of kidding (Y_l), month of kidding (M_m), and interaction between the year and month of kidding (YM_{lm}) were considered as fixed class effects. Days in milk ($t_{ijklmno}$) was fitted as a covariate and modelled using the Ali-Schaeffer lactation curve (Ali and Schaeffer, 1987) nested within the population. A transformation of the days in milk (Eq. 2) was done with the constant of 305 as follows:

$$t_1 = \frac{t_{ijklmno}}{305},\ t_2 = \left(\frac{t_{ijklmno}}{305}\right)^2, \quad (2)$$

$$t_3 = \ln\left(\frac{305}{t_{ijklmno}}\right),\ t_4 = \left(\ln\left(\frac{305}{t_{ijklmno}}\right)\right)^2$$

Flock effect nested within the population (f_{in}) was included in the model as a random effect. Analyses were performed using the proc MIXED procedure in the SAS/STAT statistical package (SAS Inst. Inc., 2011) that is based on the restricted maximum likelihood method (REML). Least squares means of logSCC were computed for each of the significant fixed effects.

3 Results and discussion

The present study showed that all effects included in the model were significant (P <0.001). The random effect of the flock accounted for a relatively large part of the phenotypic variance for the SCC (Table 2).

The effect of the breed significantly affected SCC in milk. The lowest logSCC was found in the milk of SVN ALP goat (8.81 ±0.19) and the highest logSCC in the milk of CRO SAN goat (9.48 ±0.05) (Table 3). Rupp et al. (2011) found expected lower values of logSCC in the milk of first kidding does of Alpine (5.09 ±1.36) and Saanen (5.32 ±1.19) goats. Jimenez-Granado et al. (2014) explained breed variability with the difference in the health status, milk yield and the management used.

Litter size significantly affected SCC in milk, with the lowest logSCC (9.11 ±0.06) in the milk of does with single kid and the highest logSCC (9.22 ±0.06) in the milk of does with twins or more kids (Table 3). Jimenez-Granado et al. (2014) explained the difference with worse health status of the udder in mothers who breastfeed two kids compared to those who only nurse one.

Table 2 Significance (P-values) of the effects fitted in the model and variance component estimation for somatic cells count (SCC)

Trait	P-values
B_i	<0.001
P_j	<0.001
L_k	<0.001
Y_l	<0.001
M_m	<0.001
YM_{lm}	<0.001
b_{1i}	<0.001
b_{2i}	<0.001
b_{3i}	<0.001
b_{4i}	<0.001
Variance estimation	
σ^2_{fp}	0.4542 ±0.039
σ^2_e	3.2481 ±0.008

B_i – population, P_j – parity, L_k – litter size, Y_l – year of kidding, M_m – month of kidding, YM_{lm} – interaction between year and month of kidding, b_{1i}, b_{2i}, b_{3i}, and b_{4i},– parameters of lactation curve nested within the population, σ^2_{fp} – variance of flock nested within the population, σ^2_e– residual variance

Parity significantly affected SCC in milk, with the lowest logSCC (8.59 ±0.07) in the milk of does from the first parity and the highest logSCC (9.64 ±0.07) in the milk of does from the sixth parity (Table 3). The influence of the parity on the SCC seems to depend on the health status of the udder, what could be attributed to a longer

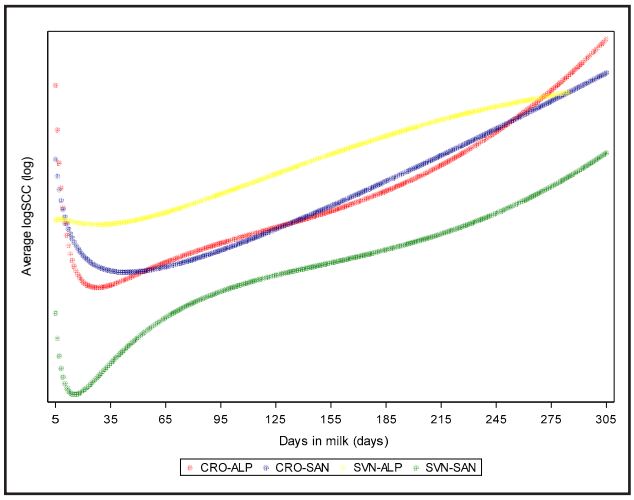

Figure 1 Least squares means for SCC across days in milk
CRO ALP – Croatian Alpine goat, CRO SAN – Croatian Saanen goat, SVN ALP – Slovenian Alpine goat, SVN SAN – Slovenian Saanen goat

exposure of the older animals to pathogens compared to younger one (Jimenez-Granado et al., 2014).

Table 3 Least squares means (LSM) ± standard errors (SE) of logSCC across fixed effect classes

Trait	logSCC (LSM ±SE)
Population	
CRO ALP	9.47 ±0.10
CRO SAN	9.48 ±0.05
SVN ALP	8.81 ±0.19
SVN SAN	8.89 ±0.14
Litter size	
1	9.11 ±0.06
2	9.22 ±0.06
Parity	
1	8.59 ±0.07
2	8.86 ±0.07
3	9.11 ±0.07
4	9.30 ±0.07
5	9.50 ±0.07
6	9.64 ±0.07

CRO ALP – Croatian Alpine goat, CRO SAN – Croatian Saanen goat, SVN ALP – Slovenian Alpine goat, SVN SAN – Slovenian Saanen goat

Days in milk were modelled using Ali-Schaeffer lactation curve nested within the population (Figure 1). The highest logSCC across days in milk was found in the milk of SVN ALP goat followed by the CRO ALP and SAN goat. The lowest logSCC across days in milk was found in milk of SVN SAN goat (Figure 1). Several authors reviewed in Jimenez-Granado et al. (2014) have explained the increase in SCC during the lactation due to a dilution effect and decreasing milk production according to days in milk. Consequently, SCC was higher at the end of lactation.

4 Conclusions

This study for the first time compared SCC in the milk of Slovenian goat breeds with those of goat breeds from a neighboring country. Analysis of variance showed the significant effect of population, parity, litter size, year of kidding, month of kidding and the interaction between year and month of kidding on the SCC in milk what was in accordance to the literature investigated goats breeds in several countries. Taking all above into consideration it is necessary to study in details factors contributing to elevations in SCC, since subclinical mastitis is not detected visually and requires an indirect method, such as the SCC, to detect goat udder health.

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