Analysis of Milk Production Traits of Alpine and Saanen Goat Populations in Croatia and Slovenia

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Summary

A total of 65,204 lactation records that were recorded over the period from 2005 to 2016 in Alpine (ALP) and Saanen (SAN) goat populations in Croatia (CRO) and Slovenia (SVN) were used to determine lactation milk yield (MY), fat content (FC) and protein content (PC). The objective of this study was to estimate the sources of non-genetic variation for milk production traits. Data according to the ICAR standards were obtained from the Central database of the Croatian Agricultural Agency and the Slovenian Central Database for Small Ruminants. The data were analysed by the PROC MIXED procedure in the SAS/STAT software based on the restricted maximum likelihood method (REML). The results showed significant effects of the population, parity, litter size, year and month of kidding and the interactions between them as well as the effect of lactation length on analysed traits. SAN goats from Croatia produced the highest MY (585.09 ± 18.03 kg) among the four goat populations that were included in the study. Slovenian SAN goats produced 511.74 ± 28.92 kg of MY. MY in ALP goats was higher in the Croatian population (499.59 ± 7.88 kg) compared to the Slovenian ALP population (486.38 ± 18.86 kg). Milk yield increased with litter size and was the highest in the fourth parity, thereafter declining slowly.

Key words

Alpine goat, Saanen goat, milk production, lactation milk yield, fat content, protein content

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Introduction

Goats disseminated all over the world because of their great adaptability to a variety of environmental and production system conditions. However, over 80% of the world's goat population is located in Asia and Africa (Morand-Fehr et al., 2004). Goat milk as an excellent food source plays an important role in human nutrition in the area of the Middle East, the acknowledged cradle of modern civilisation (Hatziminaoglou and Boyazoglu, 2004). Dairy goats produce approximately 2% of the total amount of milk produced by livestock species worldwide and according to the FAOSTAT (2016), the world's goat milk production has increased by around 70% between the years 1991 and 2013, pointing to a promising future for this sector.

Today, there are about 22,400 goats in Slovenia that are kept on approximately 4,000 farms in total, which represent about 7% of all livestock farms in Slovenia (Statistical office …, 2017). According to the Annual report of the Croatian Agricultural Agency (CAA, 2017), the number of goats in Croatia was around 65,000 in 2016. The most widely distributed dairy goat breeds in Croatia and in Slovenia are the Alpine and Saanen goat. Both breeds are seasonally fertile and kidding occurs once per year. In Slovenia, the breeding population size of Alpine goats is around 1,461 purebred does, while Slovenian Saanen goats count about 686 purebred does (Register of breeds …, 2016). The Croatian breeding population has significantly decreased in the past decades. Nowadays, the Croatian Alpine goat population counts 3,302 breeding does, while the Saanen breed consists of 476 breeding does (CAA, 2017). On Slovenian goat farms, the main source of income besides milk is goat cheese that is produced on the farm. There are also two by-products known as ricotta and whey. In Croatia, goat milk is mainly used for cheese production in small family dairies in a traditional manner or industrially in large dairies. Although the economics of goat milk production are not on a high level yet, the demand for goat milk and dairy goat products is constantly rising and is currently greater than the supply.

Earlier research has shown that the reproduction and milk production traits of cows, sheep and goats are influenced by a number of factors such as breed, age, lactation stage, season of kidding, parity and management including the method of milking (Al-Saiady, 2006; El-Tarabany and El-Bayoumi, 2015). In several studies investigating factors that affect goat milk production, the effect of parity and litter size has been evident (Mourad, 2001; Carnicella et al., 2008; Memiši, 2011). Additionally, parity affects the milk fat and protein content (Goetsch et al., 2011).

Since the Alpine (ALP) and Saanen (SAN) dairy goat populations have a similar origin and are reared under similar conditions, the objective of this study was to estimate the sources of non-genetic variation for milk production traits in the Alpine (ALP) and Saanen (SAN) dairy goat populations based on Croatian (CRO) and Slovenian (SVN) milk recording data.

Material and methods

Lactation records of Alpine (ALP) and Saanen (SAN) dairy goat populations from two countries, Croatia (CRO) and Slovenia (SVN), 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) of the University of Ljubljana. Milk production traits included in the analysis were lactation milk yield (MY), fat content (FC) and protein content (PC) for the period from 2005 to 2016. The raw data contained 65,204 records. CRO data represented the majority of the records with 48,998 records of the CRO ALP and 5,342 of the CRO SAN population. The number of records was considerably lower in the SVN ALP (7,778) and SVN SAN (3,086) populations. Both goat breeds from both countries were considered as four different populations.

Data were edited before the analysis and records were excluded from the analysis for: parities larger than ten, flocks with less than five animals within the flock, lactation lengths deviating from an interval of 90 to 300 days, and for litter size reported as 0. Additionally, parities from the eighth to the tenth were joined into a common class (parity 8+) due to the small number of records. If the number of kids born was larger than three, the number of kids born was set to three. The season of kidding was defined as a month of kidding. Seasons with less than 30 records

Table 1. Descriptive statistics for the milk production traits

Breed (Country)	Trait	N	Mean	SD	Min	Max
All populations together	MY (kg)	54,179	492.45	216.23	70.00	1595.01
	FC (%)	53,998	3.37	0.58	2.00	6.00
	PC (%)	54,278	3.04	0.29	2.01	5.98
Alpine goat (Croatia)	MY (kg)	39,089	493.35	216.23	70.00	1595.01
	FC (%)	39,004	3.42	0.58	2.00	6.00
	PC (%)	39,173	3.05	0.29	2.01	5.98
Saanen goat (Croatia)	MY (kg)	4,320	556.55	245.41	74.81	1534.55
	FC (%)	4,310	3.30	0.59	2.07	6.00
	PC (%)	4,340	2.98	0.25	2.17	5.03
Alpine goat (Slovenia)	MY (kg)	7,731	468.45	209.24	72.00	1373.00
	FC (%)	7,672	3.21	0.55	2.00	6.00
	PC (%)	7,726	3.05	0.32	2.10	5.80
Saanen goat (Slovenia)	MY (kg)	3,039	450.82	161.57	115.00	1279.00
	FC (%)	3,012	3.28	0.56	2.00	6.00
	PC (%)	3,039	3.02	0.28	2.20	4.70

MY = milk yield, FC = fat content, PC = protein content, N = number, SD = standard deviation, Min = minimum, Max = maximum

were joined to the previous or the next season to improve the data structure. MY was confined to a range from 70 to 1600 kg, while FC and PC could vary between 2 and 6%. The final data set contained 54,294 records of 21,679 does. Descriptive statistics for the milk production traits are presented in Table 1.

The average MY across all breeds was 492.45 kg (SD = 216.23) with an average FC of 3.37% (SD = 0.58) and an average PC of 3.04% (SD = 0.29) (Table 1). There was no strong deviation of any breed in the studied traits with the exception of the average MY in CRO SAN, which was higher (556.55 kg) than in the other three populations.

Statistical analysis

Milk yield was analysed using the following statistical model (eq. 1):

$$y_{ijklmno} = \mu + b_{1i}\left(x_{ijklmno} - \bar{x}\right) + b_{2i}\left(x_{ijklmno} - \bar{x}\right)^2 + B_i + P_j + L_k + Y_l + M_m + YM_{lm} + f_{in} + e_{ijklmno} \quad (1)$$

where $y_{ijklmno}$ is the analysed trait (MY), μ is the intercept, b_{1i} is the linear regression coefficient nested within the population for lactation length, b_{2i} is the quadratic regression coefficient nested within the population for lactation length, B_i is the fixed effect of the population, P_j is the fixed effect of the parity, L_k is the fixed effect of the litter size, Y_l is the fixed effect of the year of kidding, M_n is the fixed effect of the month of kidding, YM_{lm} is the interaction between the year and month of kidding, and f_{in} is the random flock effect nested within the population, while $e_{ijklmno}$ is the residual. Lactation length ($x_{ijklmno}$) was used as covariate and was modelled as a quadratic regression nested within the population. For content traits (FC and PC), the same effects were included in the model. The exception was the effect of the lactation length, which was modelled as a linear regression and was not nested within the population (eq. 2).

$$y_{ijklmno} = \mu + b_1\left(x_{ijklmno} - \bar{x}\right) + b_{2i} + B_i + P_j + L_k + Y_l + M_m + YM_{lm} + f_{in} + e_{ijklmno} \quad (2)$$

Analyses were performed using the proc MIXED procedure in the SAS/STAT statistical package (SAS Inst. Inc., 2009) that is based on the restricted maximum likelihood method (REML). Least squares means of milk production traits were computed for each of the significant fixed effects.

Results and discussion

The present study showed that almost all effects included in the model (Table 2; Figure 1) were significant (p<0.01) with the exception of the month of kidding on the FC. The proportion of phenotypic variation (R^2) explained by fixed effects was similar for MY and FC (33.04% and 33.03%), while a lower proportion was obtained for PC (24.71%). The random effect of the flock accounted for a relatively large part of the phenotypic variance for the milk production traits (Table 2).

Least squares means and standard errors of milk production traits across populations, litter size and parity of the ALP and SVN goat populations from Croatia and Slovenia are shown in Table 3. The results showed higher MY in the populations of ALP (499.59 ± 7.88 kg) and SAN (585.09 ± 18.03 kg) goats from Croatia compared to the Slovenian populations of ALP (486.38 ± 18.86 kg) and SAN goats (511.74 ± 28.92 kg). Goats with a litter size of three kids had a higher MY (548.02 ± 10.76 kg), followed by goats with two kids (517.57 ± 10.14 kg) or only one kid (496.50 ± 10.13 kg). The highest MY was found in the fourth parity (554.84 ± 10.28 kg). Similar results were reported

Table 2. Significance (p-values) of the effects fitted in the model and variance component estimation ± standard error for milk production traits

P-values/Trait	MY (kg)	FC (%)	PC (%)
B_i	0.0010	0.0004	0.0001
P_j	< 0.0001	< 0.0001	< 0.0001
L_k	< 0.0001	< 0.0001	< 0.0001
Y_l	< 0.0001	< 0.0001	< 0.0001
M_m	< 0.0001	0.0203	< 0.0001
YM_{lm}	< 0.0001	< 0.0001	< 0.0001
b_{1i}	< 0.0001		
b_{2i}	< 0.0001		
b_1	< 0.0001	< 0.0001	< 0.0001
R^2 (%)	34.04	33.03	24.71
Variance estimation			
σ^2_{fp}	10841±961	0.13±0.01	0.02±0.002
σ^2_e	21968±133	0.24±0.001	0.07±0.0003

MY – lactation milk yield, FC – fat content, PC – protein content, 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} – linear regression coefficient nested within the population for lactation length, b_{2i} – quadratic regression coefficient nested within the population for lactation length, b_1 – linear regression coefficient for lactation length, R^2 – coefficient of determination, σ^2_{fp} – variance of flock nested within the population, σ^2_e – residual variance

Table 3. Least squares means (LSM) ± standard errors (SE) of milk production traits across fixed effect classes

Effects/Trait	MY (kg)	FC (%)	PC (%)
Population			
CRO ALP	499.59±7.88	3.40±0.02	3.06±0.01
CRO SAN	585.09±18.03	3.30±0.06	3.01±0.03
SVN ALP	486.38±18.86	3.18±0.06	3.04±0.03
SVN SAN	511.74±28.92	3.23±0.09	3.03±0.04
Litter size			
1	496.50±10.13	3.33±0.03	3.05±0.01
2	517.57±10.14	3.28±0.03	3.03±0.01
3	548.02±10.76	3.22±0.04	3.03±0.02
Parity			
1	431.49±10.22	3.31±0.04	3.08±0.01
2	518.07±10.22	3.26±0.04	3.05±0.01
3	546.32±10.25	3.25±0.04	3.03±0.01
4	554.84±10.28	3.26±0.04	3.02±0.01
5	552.22±10.36	3.26±0.04	3.02±0.02
6	539.81±10.49	3.29±0.04	3.03±0.02
7	518.50±10.71	3.27±0.04	3.03±0.02
8	504.34±10.72	3.32±0.04	3.02±0.02

MY – lactation milk yield, FC – fat content, PC – protein content, CRO ALP – Croatian Alpine goat, CRO SAN – Croatian Saanen goat, SVN ALP – Slovenian Alpine goat, SVN SAN – Slovenian Saanen goat

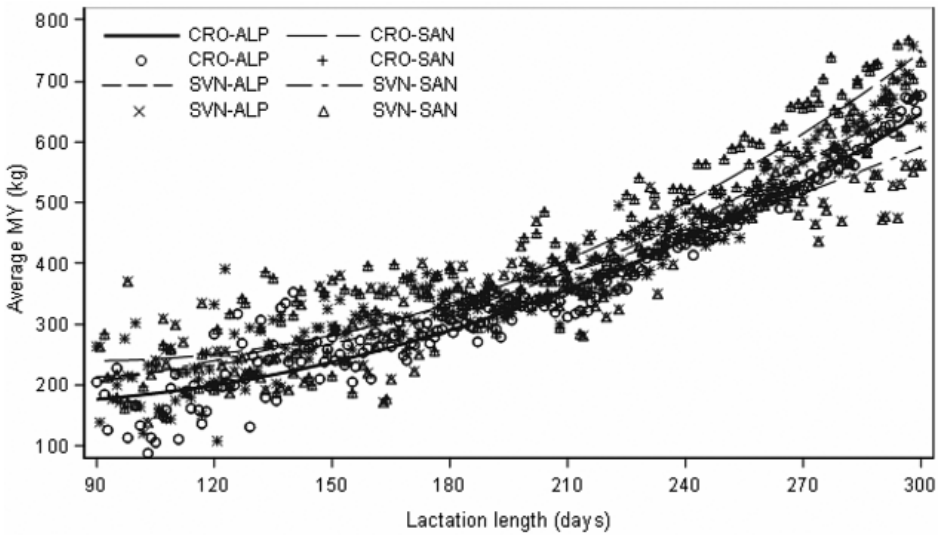

Figure 1.
Least squares means for milk production traits across lactation length (CRO ALP – Croatian Alpine goat, CRO SAN – Croatian Saanen goat, SVN ALP – Slovenian Alpine goat, SVN SAN – Slovenian Saanen goat, MY – lactation milk yield)

by Zeng at al. (2008), Mourad et al. (2001) and Carnicella et al. (2008) who found the highest milk yields in goats in the third and fourth parities. Similarly, Goetsh et al. (2011) reported that milk production increased till the third and the fourth parity, while it slowly decreased in later parities. Contrary to this, Crepaldi et al. (1999) found the highest milk yield and prolificacy in Alpine goats in the fourth and fifth lactation. Considering all four populations, the highest FC and PC was found in the milk of the Alpine goat population from Croatia (3.40 ± 0.02 % and 3.06 ± 0.01 %, respectively).

Lactation length was modelled as a quadratic regression nested within the population (Figure 1). The highest production rate across lactation length was found in the CRO ALP goats followed by the SVN ALP and CRO SAN populations. The lowest MY was observed in the SVN SAN population. For shorter lactations, larger dispersion was observed compared to longer ones.

Conclusion

This study is the first to compare milk production traits of Slovenian goat breeds with those of goat breeds from a neighbouring country. The origin of the goat populations in Slovenia and Croatia is quite similar since in both countries local goat populations were improved with imported Alpine or Saanen goats. Despite the similar genetic background, it seems that environmental conditions play an important role.

Analysis of variance showed the significant effect of population, parity, litter size, year of kidding, month of kidding (with the exception on fat content) and the interaction between year and month of kidding on milk production traits. Considering the country of origin, the Croatian goat breeds had higher lactation milk yields compared to the Slovenian ones, which was expected due to the better environmental conditions for dairy goat flocks in Croatia. Considering the breed, the SAN breed had higher milk yields compared to the ALP breed in both countries, which was also expected as the Saanen breed is known to have the highest milk yield among dairy goat breeds. Milk yield increased from the first to the fourth parity and with increasing litter size.

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