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Original Scientific Article

PRODUCTIVITY OF MILK AND MILK COMPOSITION OF ISTRIAN SHEEP IN CROATIA AND SLOVENIA

Miran Kastelic[1]*, Marija Špehar[2], Zdravko Barać[2]

[1]University of Ljubljana, Biotechnical Faculty, Animal Science Department, Groblje 3, 1230 Domžale, Slovenia, [2]Croatian Agricultural Agency, Ilica 101, 10000 Zagreb, Croatia

*Corresponding author, E-mail:miran.kastelic@bf.uni-lj.si

Summary: The effects of country, flock nested within country, litter size, parity, lambing season, interval between lambing and the first milk recording, and year of lambing on production of Istrian sheep in Slovenia and Croatia was studied in period between 2005 and 2009. Data consisted of 3,347 lactations in Croatia and 1,788 in Slovenia that were collected as a part of separate breeding programs. The Croatian animals produced 124.87 kg total milked milk (TMM) with 7.31 % of fat (FC) and 6.05 % of protein content (PC). Slovenian ewes produced only 79.33 kg TMM with 7.25 % FC and 5.87 % PC. The increase of TMM was 5.40 kg per year (P<0.05). Ewes that lambed between October and the end of January had the highest TMM, fat yield (FY), and protein yield (PY). The productivity did not differ between countries. Flock effect nested within country caused differences (P<0.05) in TMM, FC, and PC. The effect considered genetic, management and climatic conditions (average temperature, above mean sea level (AMSL), and precipitation). Productivity was not affected by the litter size. Higher productivity was observed in ewes reared in the Mediterranean area. The exception was one flock coming from harsher continental conditions. The productivity in such conditions can be improved with earlier lambing, high quality forage before the grazing season and with an extra feeding on pasture after the dry weather begins.

Key words: Istrian sheep; dairy production; Croatia; Slovenia; environmental effects

Introduction

Istrian sheep (Istarska ovca, Istrska pramenka or Istriana) is an autochthonous dairy sheep breed originating from Istrian Peninsula and its hinterland. In the year 2009, estimated population size was between 2,600 and 3,100 animals in Croatia, 1,150 animals in Slovenia, and 920 animals in Italy (1). The population of Istrian sheep was divided after the Second World War to Yugoslav and Italian subpopulations. At the beginning of 1990s, the Yugoslav subpopulation was further split between Croatia and Slovenia. Migration of animals between the two countries has nearly stopped.

Geographic and climatic characteristics are changing very rapidly considering a rather small area. The altitude of breeding ranges from the sea to 1,000 meters above mean sea level (AMSL). The border between Slovenia and Croatia is also geographical. The Croatian part of breeding area consists mostly of the Istrian peninsula, therefore under influence of the sea. The temperature and

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the yearly rainfall levels are changing with the AMSL increase and with the distance from the sea. Pula (AMSL 30 m) on the southern coast of Istria has an average temperature of 14.7°C[1] [v “nogo” na ustreuno stran : The climatic data for period 1990 – 2010 were provided by Croatian Meteorological and Hydrological Service and Slovenian Environment Agency]. The coldest months are January and February with an average temperature of 6.0°C and 6.3°C respectively. Pazin (AMSL 242 m) is located in the middle of Istrian Peninsula with the average temperature of 11.5°C. Slovenian breeding area is placed around Ilirska Bistrica (AMSL 421 m), which is situated outside the Istrian peninsula in the typical Karstic valley. It is not influenced by Mediterranean climate. The average temperature is 9.9° C. The annual sum of precipitation for all three areas reaches the peak in winter months: 828 mm in Pula, 1,065 mm in Pazin and 1,356 mm in Ilirska Bistrica. In Istria, the pasture is available during the winter and especially in early spring period. However, in Ilirska Bistrica and its surrounding mountains, snowing is common and pasture season starts in April. The dry period lasts in Istria (Pula and Pazin) from spring to middle autumn, and from the middle July to the end of August in Slovenia (Ilirska Bistrica). Poor summer vegetation is a consequence of the low summer precipitation and porous Karstic pastureland on limestone bedrock with a very thin layer of soil.

Observed differences in climatic conditions between Croatian and Slovenian breeding area were not very important in the past. The larger flocks from Slovenian hinterland moved to the winter transhumance pasture (2) to the seaside of Trieste and Istria. At the beginning of April, the flocks returned home and prolonged good pasture to the middle of July. The exploitation of Mediterranean and continental vegetation was a comparative advantage of flocks from Slovenian territory. This practice was abandoned during the Second World War and since then animals are kept in the stables during the winter period. Under such conditions, early lambings are possible only with hay of high quality and a supplement of concentrates. Late lambings caused shorter lactation and consequently lower production in lactation. Most of Slovenian Istrian sheep flocks remained on less productive agricultural land, opposite to what was observed in Italy, Spain and France.

The aim of this study was to evaluate the effects of country, flock, lambing season, parity, litter size, interval between lambing and first milk recording, and year of lambing on the productivity of Istrian sheep.

Material and methods

Data were collected as part of separate breeding programs in Croatia and Slovenia for the period from 2005 to 2009. Breeding programs were established in the 1990-ties, 20 to 30 years later as in France, Italy or Spain (3). Daily milk yield and milk components were recorded according to the ICAR guidelines (4) using the AT4 method. The total number of recorded lactations was 3,347 in Croatia and 1,788 in Slovenia. The number of lactations per year did not change in the studied period in Slovenia. However, the number of recorded lactations per year increased more than six times (from 195 in 2005 to 1,266 in 2009) in Croatia.

The total milked milk (TMM) was calculated from recorded daily milk yield using test interval method (4). Fat (FY) and protein yields (PY) in the milking period were calculated with remodelled formula for TMM where daily yields of fat and protein were used instead of daily milk yield. Fat (FC) and protein (PC) contents in milking period were calculated from TMM, FY, and PY. The exact weaning date was not recorded. Therefore, the start of the milking period was set 15 days before the first milk record.

Lambing season (S) starts on the 1st October. The season was expressed as continuous variable and calculated as the number of days after October 1st. Data were analysed using the following statistical model:

$$y_{ijk} = \mu + C_i + H_{ij} + b_{11}\left(L_{ijk} - \overline{L}\right) + b_{21}\left(P_{ijk} - \overline{P}\right) + b_{22}\left(P_{ijk} - \overline{P}\right)^2 + b_{31}\left(S_{ijk} - \overline{S}\right) + b_{32}\left(S_{ijk} - \overline{S}\right)^2 + b_{33}\left(S_{ijk} - \overline{S}\right)^3 + b_{41}\left(I_{ijk} - \overline{I}\right) + b_{51}\left(J_{ijk} - \overline{J}\right) + e_{ijk}$$

where y_{ijk} is an observed trait i.e. TMM, FY, PY, FC, PC, and lactose (LC), μ is overall mean, C_i is the effect of the country (Slovenia, Croatia), H_{ij} is the flock effect nested within country, b_{11} is a linear regression coefficient for litter size (L_{ijk}), b_{21} and b_{22}

are linear and quadratic regression coefficients for parity (P_{ijk}), b_{31}, b_{32} and b_{33} are linear, quadratic and cubic regression coefficients for lambing season (S_{ijk}), b_{41} is linear regression coefficient for the effect of interval between lambing and the first recording (I_{ijk}), b_{51} is a linear regression coefficient for year of lambing (J_{ijk}), and e_{ijk} is the residual.

The statistical analysis was done by least square method using GLM (general linear models) procedure of statistical package SAS/STAT (5). The significance of parity effect was tested as composite quadratic, while the season of lambing effect was tested as composite cubic polynomial equation using the option CONTRAST in SAS/STAT (5).

Results

The average AMSL for six farms in Slovenia was 557.4 m and only 210.6 m for 32 farms in Croatia (Table 1). The average number of parities was 3.23 for Slovenian and 3.78 for Croatian ewes. The average litter size was 1.19 in Slovenia and 1.09 in Croatia. Ewes in Croatia lambed on average 104 days (middle of January) after the 1st October. Slovenian ewes lambed more than one month later. The lambing season is more variable in Croatia than in Slovenia (SD: 37.76 days vs. 19.14 days). The average interval between lambing and the first milk recording was 78 days in Croatia and 86 days in Slovenia.

Table 1: Mean and standard deviation (SD) for AMSL, parity (P), litter size (LS), lambing season (S), interval between lambing and first milk recording (I) and for TMM, FY, PY, FC, PC and lactose (LC) for Croatia and Slovenia

	AMSL	P	LS	S	I	TMM	FY	PY	FC	PC	LC
Croatia											
Mean	210.6	3.78	1.09	103.91	77.79	124.87	8.91	7.46	7.31	6.05	4.30
SD	162.3	2.13	0.29	37.76	29.01	81.42	5.52	4.69	1.17	0.53	0.34
Slovenia											
Mean	557.4	3.23	1.19	140.88	85.67	79.33	5.66	4.63	7.25	5.87	4.41
SD	132.5	1.94	0.43	19.14	34.55	48.61	3.28	2.81	0.94	0.52	0.29

Croatian ewes were more productive than the Slovenian ones. The later produced only 79.33 ± 48.61 kg milk compared to 124.87 ± 81.42 kg in Croatia. Large standard deviations were observed in both populations. FC and PC were slightly lower (7.25, 5.87) in Slovenia than in Croatia (7.31, 6.05). LC was higher (4.41 vs. 4.30) in Slovenia than in Croatia. FY and PY were higher in Croatian compared to Slovenian values due to larger milk yield and higher percentage of milk contents.

The productivity of flocks is presented on Map 1. Flocks are divided in four classes based on the average TMM per flock: up to 50 kg, 50.01 to 100 kg, 100.01 to 150 kg and more than 150 kg. Only two flocks (one in Slovenia and one in Croatia) milked less than 50 kg TMM, causing a large standard deviation in milk production. Four other Slovenian flocks produced between 50.01 and 100 kg TMM and one more than 150.01 kg. Nine Croatian flocks produced between 50.01 and 100 kg milk, ten between 100.01 and 150 kg and four flocks produced more than 150 kg TMM.

Map 1: Location of Istrian sheep flocks. Flocks are divided into four classes according to TMM: up to 50 kg (●), 50.01 to 100 kg (■), 100.01 to 150 kg (♦) and more than 150 kg (*)

Table 2: Coefficient of determination (R2) and p-values for model and effects of country (C), flock nested within country (H), litter size (L), parity (P), lambing season (S), interval between lambing and the first milk recording (I), and year of lambing (J)

	TMM	FY	PY	FC	PC	LC
Model	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
R^2	0.575	0.549	0.559	0.288	0.264	0.234
C	0.4348	0.7667	0.7967	0.5171	<0.0001	<0.0001
H	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
L	0.4792	0.8548	0.2703	0.1946	0.0350	0.0002
D	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
J	<0.0001	<0.0001	<0.0001	0.1458	0.0012	0.0373
P*	<0.0001	<0.0001	<0.0001	0.9865	0.4566	<0.0001
S**	<0.0001	<0.0001	<0.0001	<0.0001	0.0453	<0.0001

*composite linear and quadratic term; ** composite linear, quadratic and cubic term

Table 3: Linear regression coefficients and standard deviations for litter size (L), interval between lambing and the first milk recording (I), and year of lambing (J)

	L (b_{11})	I (b_{41})	J (b_{51})
TMM	1.45±2.05	-0.84±0.03	5.40±0.59
FY	0.03±0.15	-0.054±0.002	0.33±0.04
PY	0.14±0.12	-0.048±0.002	0.29±0.04
FC	-0.05±0.04	0.008±0.001	-0.016±0.011
PC	0.04±0.02	0.0046±0.0003	-0.018±0.006
LC	-0.05±0.01	-0.0025±0.0002	-0.0072±0.0035

As seen on Map 1, flocks with productivity between 50.01 and 100.00 kg TMM are spread over the whole territory. More productive flocks with TMM over 100 kg are mostly located on the southern part of the peninsula.

The coefficient of determination and p-values are shown in Table 2. The TMM, FY, PY, and FC were not affected by the country but by the effect of flock nested within the country (P<0.0001). For PC and LC, the effects of country and flock nested within the country were statistically significant (P<0.0001). The litter size effect influenced only PC and LC. The interval between lambing and the first milk recording had a statistically significant (P<0.0001) effect on all studied traits. The year of lambing significantly influenced (P<0.05) all traits with an exception of FC. The polynomial regression of the third degree, which describes the lambing season effect, was statistically significant for all traits (P<0.05), while the impact of parity affected TMM, FY, PY, and LC (P<0.0001).

The litter size caused 0.04 increase of PC and a 0.05 reduction of LC per liveborn lamb (Table 3). The prolonged interval from lambing to the first milk record contributed to 0.84 kg decrease of TMM, 0.054 kg of FY, and 0.048 kg of PY per day. The FC and PC increased 0.008% and 0.0045% respectively, if milk recording started one day later. The delay of one day decreased LC by 0.0025.

Total production of ewes increased during the studied period: TMM by 5.40, FY by 0.33, and PY by 0.29 kg per year. At the same time, FC, PC, LC decreased on average 0.018, 0.016, and 0.0072 % per year.

Estimated regression coefficients were used for the calculation of predicted yields and contents of milk (Figure 1). The largest TMM, FY, and PY were produced between the second and the forth lactation. The production of older ewes was rapidly reduced. The decrease of FY and PY during lactation was a consequence of reduced

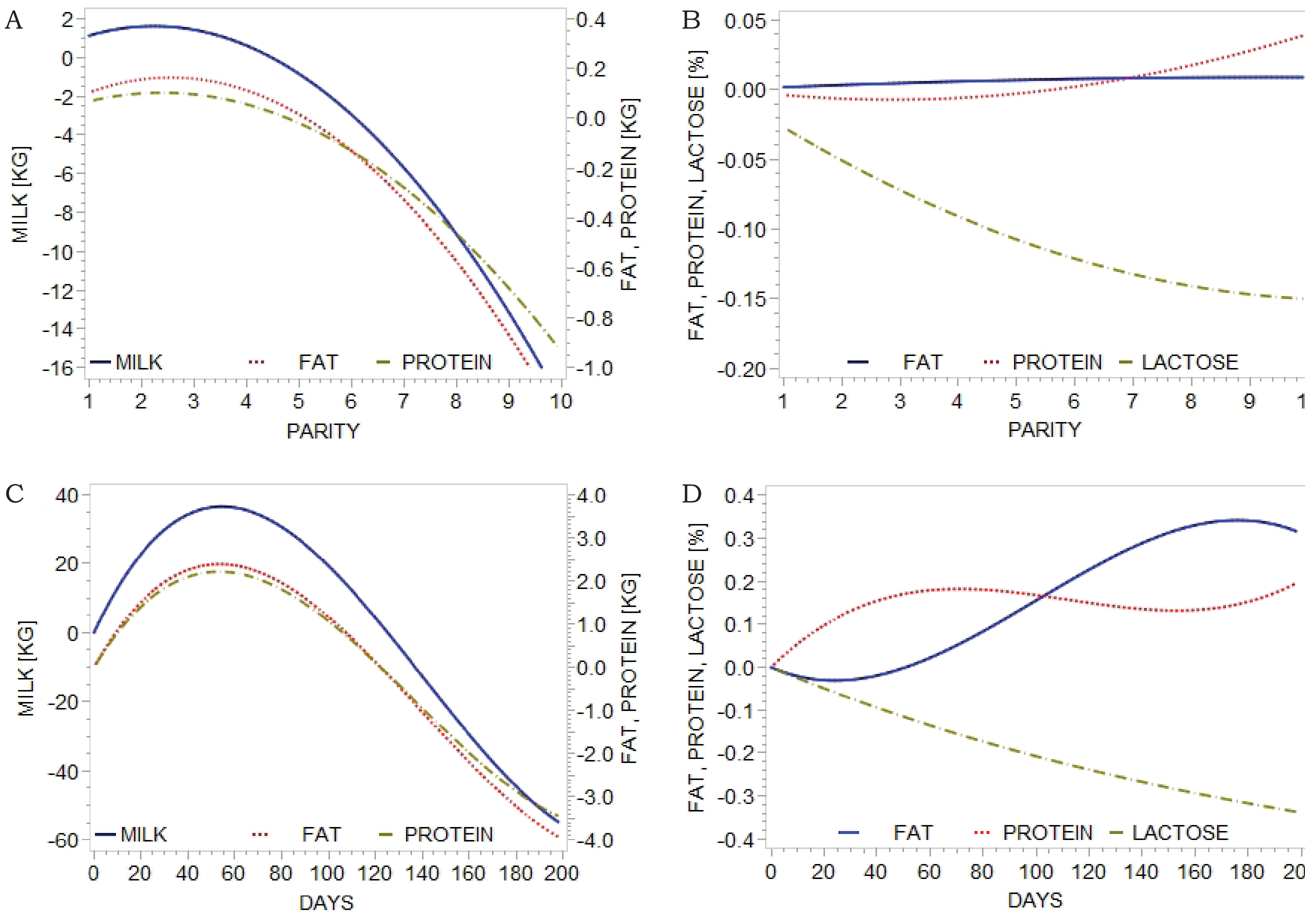

Figure 1: Predicted values of TMM, FY, and PY (A), FC, PC, and LC (B) between the first and tenth lactation, and predicted TMM, FY, and PY (C) and FC, PC, and LC (D) according to the season of lambing

TMM because there was a slight increase of FC and PC in older ewes. The LC decreased towards higher lactations.

The highest TMM, FY, and PY were observed in ewes that lambed 60 days after the beginning of lambing season, i.e. at the end of November and the beginning of December. Ewes that lambed until the end of January still retained satisfying TMM, FY, and PY. Lambings after that period were characterised with lower quantity of produced milk, with higher FC and PC, and lower LC.

Discussion

The production of Istrian sheep is comparable with the production of widespread Mediterranean breeds which have been selected for a longer period: Spanish Churra that produced between 89 (3) and 140 kg (6) or Italian Sarda with 168 (7), 186 (8) to 238 kg milk per lactation (3). However, Istrian sheep has lower TMM compared to the highly productive breeds like East Frisian sheep that produced 429 kg (9), Assaf, 431.6 kg (10) and 334 kg (11) or Awassi, 506 kg (11). The production conditions and average productivity per ewe differed between Slovenia and Croatia. However, the difference is caused mainly by flock within the country. Both effects, country and flock within the country, are related to the direct climate factors like heat stress (6) and indirect climate factors such as availability of feed on pasture. The flock management with high quality supplement feed will certainly improve productivity of housed animals before the beginning of grazing season or in dry period on pasture. Productivity of the best Slovenian flock on high AMSL was as good compared to the best flocks in Croatia and vice versa.

In spite of larger TMM of Croatian ewes, the FC and PC were surpassingly higher in Croatia (7.31, 6.05) than in Slovenia (7.25, 5.84). A higher FC and PC of less productive ewes is common within the same breed (8), but also among breeds with different production levels (7, 9, 12). Higher PC and lower LC were observed in ewes with twins. Although, the ewes with twins produced more TMM, FY, and PY with higher PC, the differences were not statistically significant. The effect of litter size on milk production is not clear in literature. Some studies reported significant increase of milk production due to larger litter (13, 14). However, studies with non-significant effect of litter size were also found (15, 16). The PC and LC in our study were influenced by litter size. Our results are mostly different from the results of Peeters (17), who reports significantly higher FY and PY in milk of ewes with larger litter size. Longer period between lambing to first milk recording decreased the productivity due to shorter milking period, and increased FC and PC. During the studied period, TMM, FY, and PY were increased. The negative trend for PC and LC was observed in reported period. The increase of milk yield from the first to the third or fourth lactation was found in many researches (14, 18, 19). The increased FC and PC at higher parities was found in the literature (18). However, an increase of FC and PC was negligible and not significant in the present study. FY and PY were related only with TMM.

Late lambings after the end of January caused low TMM, increased FC and PC, and decreased LC. Although the increases of FC and PC in ewes that lambed late in season (after January) were statistically significant, lower TMM caused a decrease of FY and PY. Slovenian ewes were reared in the area with late vegetation. Therefore, late lambings with low productivity are common for Slovenian flocks. The productivity of Istrian sheep in Slovenia could be improved by earlier lambings and feeding with high quality forage before the grazing season and with an extra feeding on pasture after dry weather begins.

Conclusions

Productivity of Istrian sheep was studied for the period between 2005 and 2009 in Croatia and Slovenia. Milk production increased during the studied period. Litter size did not influence TMM, FY, and PY. The most productive ewes lambed between October and January. Ewes reared in Croatia were more productive compared to Slovenian ones. This is mostly the consequence of flock productivity and not the country effect. Most of the Slovenian flocks produced less than 100 kg TMM. However, the most productive flock in Slovenia had similar production to the best Croatian flocks with the productivity over 150 kg TMM. The Slovenian producers did not adapt their management to harsher climate in Slovenian hinterland, and pasture season is too short for high production. In the past, grazing season of Slovenian flocks was prolonged with transhumance pasture in Mediterranean conditions, which is nowadays not possible anymore. The productivity of Istrian sheep in Slovenia could be increased with earlier lambings and feeding with high quality forage before the grazing season starts and with an extra feeding on pasture after the dry weather begins.

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VPLIV GEOGRAFSKE LEGE NA PROIZVODNOST IN SESTAVO MLEKA ISTRSKE PRAMENKE

M. Kastelic, M. Špehar, Z. Barać

Povzetek: Proizvodnost istrske pramenke na Hrvaškem in v Sloveniji smo proučevali v obdobju med leti 2005 in 2009. Skupna količina namolzenega mleka na Hrvaškem s 7,31 % maščobe in 6,05 % beljakovin je znašala 124,87 kg. Slovenske ovce so dale 79,33 kg mleka s 7,25 % maščob in 5,87 % beljakovin. Količina namolzenega mleka je naraščala za 5,40 kg letno ($P<0,05$). Proizvodnost se med državama statistično značilno ni razlikovala. Učinek tropa, vgnezdenega znotraj države izvora živali, je povzročil razlike v količini in sestavi prirejenega mleka. Ta učinek vključuje tako genetske vplive kot vpliv menedžmenta črede in klimatske vplive. Ti so predvsem povprečna temperatura, nadmorska višina in letna količina padavin. Velikost gnezda ni vplivala na proizvodnost. Ovce, ki so jagnjile med oktobrom in koncem januarja, so dale večjo količino mleka z večjim odstotkom maščob in beljakovin. Menedžement črede in živali je bolje prilagojen klimatskim razmeram na Hrvaškem kot tršim pogojem reje v slovenskem zaledju.

Ključne besede: istrska pramenka; mlečna proizvodnja; Hrvaška; Slovenja; okoljski vplivi