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Impact of parity and litter size on dairy traits in Istrian ewes

Utjecaj redoslijeda laktacije i veličine legla na svojstva mliječnosti istarske ovce

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ABSTRACT

The aim of the study was to determine the influence of parity and litter size on dairy traits in Istrian ewes. The following traits were analysed: lactation milk yield, daily milk yield, fat yield, fat content, protein yield, protein content, lactose yield, and lactose content. Lactation records (n = 6,481) collected on 2,786 ewes were analyzed using a statistical model adjusted for unbalanced data structure accounting for all the available sources of phenotypic variability. Parity had a statistically significant effect on all the investigated traits (P<0.01, P<0.001). Lactation milk yield, daily milk yield, protein yield, and lactose yield peaked in 3rd, fat yield, fat content, and protein content in 4th, and lactose content in 2nd lactation. Litter size had a significant effect on all the investigated traits (P<0.01, P<0.001) except the fat content (P<0.05). Multiple litters led to higher yields of milk and all the examined dry matter components. The results of the study should contribute to better understanding of the phenotypic variability of some economically very important dairy traits in ewes.

Keywords: lactation, litter size, milk, parity, sheep

SAŽETAK

Cilj istraživanja bio je utvrditi utjecaj redoslijeda laktacije i veličine legla na svojstva mliječnosti istarskih ovaca. Analizirana su sljedeća svojstva: ukupna laktacijska količina mlijeka, prosječna dnevna količina mlijeka, prinos masti, sadržaj masti, prinos proteina, sadržaj proteina, prinos laktoze i sadržaj laktoze. Laktacijski zapisi (n = 6481) prikupljeni na ukupno 2786 ovaca su analizirani su pomoću statističkog modela prilagođenog neuravnoteženoj strukturi podataka uvažavajući sve raspoložive izvore fenotipske varijabilnosti. Utvrđen je statistički značajan utjecaj redoslijeda laktacije na sva istraživana svojstva (P<0,01, P<0,001). Ukupna laktacijska količina mlijeka, prosječna dnevna količina mlijeka, prinos masti i prinos laktoze su postigli vrhunac u trećoj, prinos masti, sadržaj masti i sadržaj proteina u četvrtoj, a sadržaj laktoze u drugoj laktaciji. Veličina legla je značajno je utjecala na sva istraživana svojstva (P<0,01, P<0,001) osim na sadržaj masti u mlijeku (P<0,05). Povećanje broja janjadi u leglu je rezultiralo većim prinosom mlijeka i svih istraživanih komponenti suhe tvari. Rezultati istraživanja bi trebali doprinijeti boljem razumijevanju fenotipske varijabilnosti nekih ekonomski vrlo važnih svojstava mliječnosti kod ovaca.

Ključne riječi: laktacija, mlijeko, ovca, redoslijed laktacije, veličina legla

INTRODUCTION

Sheep are generally known as producers of relatively small amounts of milk that is very rich in dry matter (Selvaggi et al., 2014). Dairy orientated sheep farming is the most prevalent in Mediterranean "basin" where variety of traditional cheeses are produced and offered on domestic and foreign market. In addition to its economic importance, dairy sheep farming in marginal rural areas has some other positive implications such as preventing depopulation and maintenance of natural wild pastures (fire fighting role). Croatia, and particularly its coastal area, has a long tradition of sheep farming and production of sheep cheese (Mioč et al., 2007). Breed choice in dairy sheep farming in Mediterranean basin (with prevalence of semi-extensive systems) is very challenging task due to cost-benefit issues. Accounting for the fact that highly productive dairy sheep breeds have relatively small adaptability, many breeders prefer indigenous breeds well known for their resistance and production in harsh conditions (limited forage resources in droughty seasons, hiking on the rocky grounds, etc.). Istrian sheep have lived for centuries in Istrian peninsula in semi-arid climate conditions with long, dry, hot summers, and mild winters. However, the year 1771 is considered as the official beginning of the formation of the breed which started with systematic introduction of rams of several foreign breeds (Gentile di Puglia, Bergamo, Southdown, Merinolandschaf and Merino) that were methodically mated to autochthonous Istrian ewes (Putinja, 2005). Nowadays, the breed counts a total of 1,245 animals that are all under the national breeding program (Mioč et al., 2011). Seasonality of oestrus activity and consequently seasonality of dairy production of Istrian ewes is highly influenced by environmental conditions since the naturally grown pastures represent the most important feeding resource for ewes. Recording of dairy and reproductive traits and BLUP based estimation of breeding values have been routinely conducted for past few years (Croatian Agricultural Agency, 2017). Parity and type of lambing are considered as important sources of phenotypic variability in dairy sheep. However, these effects have not yet been systematically researched in Istrian sheep breed and their true magnitudes are unknown to both scientists and breeders. Therefore, the objective of the study was to examine the impact of these effects in Istrian sheep breed in field conditions. The obtained results should contribute to better understanding of these effects and serve as direct scientific background for making business decisions in dairy sheep facilities.

MATERIALS AND METHODS

Lactation records of Istrian ewes collected between April 2010 and November 2015 were provided by the central database of the Croatian Agricultural Agency. Recording of phenotypic traits was conducted by regular alternate scheme of milk recording (AT4 and BT4 method) according to the ICAR rules (International Committee for Animal Recording, 2011). Lactation records used in the study were calculated from test-day records for all ewes that had at least three milk controls within lactation. First control was conducted between 5th and 30th day after weaning and after that every 30 (from 28 to 34) days until the end of lactation (i.e. when daily milk secretion fell below 0.2 kg). After data editing, a total of 6,481 lactation records, obtained from 2,786 ewes were used in descriptive and inferential statistical analysis. The following traits were analysed: lactation milk yield (LMY), daily milk yield (DMY), fat yield and content (FY and FC), protein yield and content (PY and PC), and lactose yield and content (LY and LC). Type of birth, parity, season (month-year of lambing i.e. start of lactation), recording scheme, length of suckling period (LSP), and length of milking period (LMP) were considered as the sources of phenotypic variability and were fitted in the statistical model used in inferential statistical analysis. In order to improve frequency distribution of the examined effects, few adjacent classes of analysed fixed effects were joined together. October lambings were set to November lambings, multiple litters were set to unique class (regardless of the number of lambs born alive) and parities after the 7th parity were set to 7+. The following model was used in the analysis:

$$y_{ijklm} = \mu + b_1(s_{ijklm} - \bar{s}) + b_2(m_{ijklm} - \bar{m}) + P_i + BT_j + SE_k + RS_l + e_{ijklm}$$

Parity (P_i, i = 1, ..., 7), litter size (BT_j, j=singles, twins), lambing season (SE_k, k = 1....25), and recording scheme (RS_l, l = AT, B4) were fitted as class fixed effects. Lengths of Suckling (s) and Milking (m) periods were fitted as covariates (linear regressions). Although it may seem at first sight that one of these covariates is redundant in the model, it was determined the both of them were needed. All calculations in descriptive and inferential statistical analysis were performed within statistical package SAS (SAS Institute Inc., 2009). The following procedures were used: TABULATE, FREQ, GLM, TEMPLATE, and SGRENDER.

RESULTS AND DISCUSSION

Cross classifications performed during the preliminary statistical analysis implied the impacts of parity and litter size on all the examined traits (Tables 1 and 2). The determined lengths of suckling and milking period increased with the parity and the number of lambs born alive. The exceptions were the same lengths of milking period from parity four to parity six and shorter milking length in parity 7+ compared to the previous one. Total milk yield and daily milk yield in milking phase of lactation period reached their peaks in the third parity and thereafter gradually decreased. The biggest gap in the LMY (25 kg) and DMY (0.18 kg) was determined between the third and last parity. Yields of the dry matter components followed the same pattern of the change, i.e. gradually declined after the third parity. During the milking phase of lactation period, ewes with multiple litters produced higher amounts of milk (21 kg), fat (1.62 kg), protein (1.15 kg), and lactose (0.89 kg). FC and PC increased after the third parity while the opposite was determined for LC. Ewes with multiple litters produced fattier milk, but scarcer in protein and lactose. However, these differences were negligible.

In the phase of the preliminary analysis, the available sources of phenotypic variability were examined in detail in order to construct a reliable model for the inferential statistical analysis (Figure 1). By being aware that lactation yields as well as contents of dry matter components in milk (fat, protein and lactose) heavily depend on the stage of lactation, the intention was to "capture", and take into account this important source of phenotypic variability. In the lactation test-day statistical models you "capture" this source of variability by the covariate "days in milk", but in the whole-lactation models where phenotypic records are centred into one point, you

Table 1. Fermentation characteristics of the alfalfa silages in g/kg dry matter

			LSP (days)		LMP (days)		LMY (kg)		DMY (kg)	
		n	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd
P	1	1,143	47	23.69	124	30.15	130.23	57.34	1.05	0.39
	2	1,263	49	22.34	130	30.36	145.15	77.32	1.11	0.49
	3	1,058	52	24.48	133	29.40	152.47	86.46	1.13	0.53
	4	885	53	24.78	135	30.56	151.48	88.82	1.10	0.53
	5	696	54	23.30	135	29.47	143.95	81.85	1.05	0.49
	6	537	55	24.78	135	29.44	136.63	78.30	1	0.47
	7	899	56	22.86	133	28.29	127.87	65.47	0.95	0.40
LS	1	6,131	52	23.79	131	29.83	140.21	75.72	1.06	0.47
	2	350	53	25.27	133	32.12	161.21	96.23	1.18	0.54
$\bar{X}$		6,481	52	23.87	131.62	29	141.35	77.11	1.06	0.48

P - parity, LS - litter size, LSP - length of suckling period, LMP - length of milking period, LMY - lactation milk yield , DMY - daily milk yield.

Table 2. Determined lactation yields and contents (%) of fat, protein, and lactose cross tabulated by parity and litter size

			FY (kg)		PY (kg)		LY (kg)		FC (%)		PC (%)		LC (%)	
		n	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd
P	1	1,143	9.19	4.27	7.65	3.41	5.63	2.60	7.09	1.24	5.88	0.47	4.30	0.30
	2	1,263	9.91	5.26	8.47	4.49	6.33	3.56	6.91	1.23	5.86	0.43	4.32	0.29
	3	1,058	10.41	5.46	8.96	4.99	6.63	3.98	7.02	1.23	5.91	0.46	4.30	0.33
	4	885	10.59	5.89	8.93	5.17	6.53	4.04	7.14	1.25	5.93	0.45	4.26	0.36
	5	696	10.35	5.91	8.53	4.80	6.18	3.65	7.27	1.22	5.97	0.46	4.26	0.30
	6	537	9.72	5.49	8.10	4.55	5.89	3.56	7.23	1.19	5.98	0.48	4.26	0.33
	7	899	9.16	4.76	7.58	3.79	5.46	2.94	7.24	1.17	5.97	0.46	4.23	0.33
LS	1	6,131	9.80	5.18	8.26	4.41	6.06	3.45	7.1	1.23	5.92	0.46	4.28	0.31
	2	350	11.42	6.64	9.41	5.64	6.95	4.35	7.13	1.19	5.85	0.47	4.27	0.40
$\bar{X}$		6,481	9.88	5.28	8.32	4.49	6.11	3.51	7.1	1.23	5.92	0.46	4.28	0.32

P - parity, LS - litter size, FY - fat yield, PY - protein yield, LY - lactose yield, FC – fat content, PC - protein content, LC – lactose content.

usually have nothing to account for except the length of days in milk. This is insufficiently informative covariate by itself, primarily because it only provides information about length of milking period and tells nothing about the phase of lactation. For example, lactation spanning from 10 to 100 and that from 60 to 150 days after lambing (both lasting 90 days) are not the same thing. However, by having information about the length of suckling period (which actually corresponds with the start of milking period) his very valuable information can be captured and used by the statistical model for better estimation of the effects of the interest. Before including this effect in the model, in order to avoid problems with multicollinearity, correlation between these two covariates (lengths of milking period and length of suckling period) were tested. The correlation was very week and insignificant (r = -0.095) providing an “alibi” (from statistician’s point of view) to include this covariate in the model.

The results of the inferential statistical analysis are presented in the tables 3 and 4. The least square means (LSM) obtained from the statistical model adjusted for unbalanced experimental design showed great consistency with previously discussed raw means. Parity and litter size were found to have a significant effect on practically all the examined traits. It has been found a statistically significant effect (P<0.001, P<0.01) of the parity on all the analysed traits. LMY DMY, PY and LY had peeks in third, FY, FC, and PC in fourth, and LC in second lactation.

The estimated differences in total lactation production between parity with maximum and minimum production for LMY, FY, PY, and LY were 21.6 kg, 1.1 kg, 1.25 kg, and 0.98 kg, respectively. It has been determined a statistically significant effect of litter size on all the investigated traits (P<0.001, P<0.01) except the FC (P>0.05). Multiple litters led to higher yields of milk and dry matter components, and to lower contents of dry matter components in produced milk. The estimated differences in lactation production between ewes with single and multiple litters for LMY, FY, PY, and LY 17.1, 1.3, 0.91, and 0.68 kg, respectively. By taking into account these results, it can be stated that parity and litter size notably affect productivity of dairy sheep. Comparisons of these results with reports of the previously conducted studies concerning similar issues showed to be very ungrateful, primarily due to very heterogeneous: 1) “genotypes” (i.e.

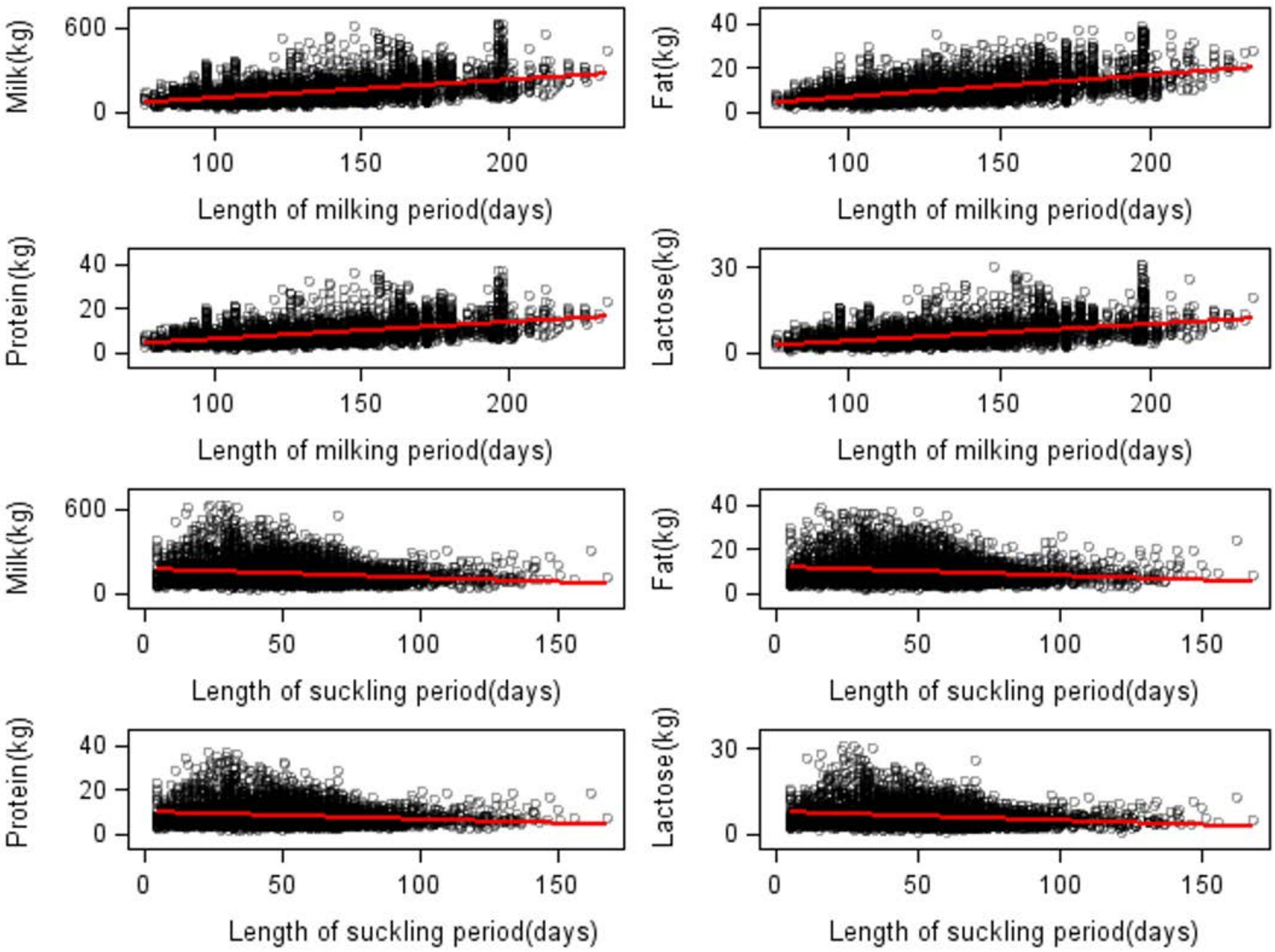

Figure 1. Scatterplots and estimated regression lines of lactation yields on length of milking period (upper 4) and suckling period (lower 4)

breeds), 2) management strategies (nutrition, time of weaning, duration milking period, etc.), and 3) approaches in experimental design and statistical analysis. Yet, it could be stated with high dose of certainty that obtained results go in line with numerous previous reports where the effect of parity on yield traits was confirmed (e.g. Hatziminaoglou et al., 1990; Avondo and Lutri, 2004; Barać et al., 2012; Komprej et al., 2012; Koncagül et al., 2012; Vrdoljak et al., 2012; Sezenler et al., 2016). However, reported yield peeks and magnitudes of the change in yield traits between parities are inconsistent among the studies which hampers very precise generalisation of the examined effect.

While trying to explain a significant effect of parity on dairy yield traits, authors usually emphasise increased development of rumen in later lactations which is usually directly accompanied with higher food intake and consequently higher milk production. The results pertaining to the effect of litter size are in line with numerous reports on this issue (Snowder and Glimp, 1991; Hassan, 1995; Özder et al., 2004; Pollott and Gootwine, 2004; Fuerst-Waltl et al., 2005; Reiad et al., 2010; Sezenler et al., 2016; Abecia and Palacios, 2017). By taking into account quantity and quality of data, complexity of the performed statistical analysis and high degree of equivalence with previous reports on these issues, it can be concluded that the obtained results nicely reflect "true effects" of parity and litter size of dairy traits in dairy sheep populations. The results should serve as trustworthy guidelines for making business decisions in diary sheep orientated facilities.

Table 3. The effects of parity and litter size on lactation yields of milk, fat, protein, and lactose

		FY (kg)			PY (kg)			LY (kg)			FC (%)		
		LSM	s.e.	Sig.	LSM	s.e.	Sig.	LSM	s.e.	Sig.	LSM	s.e.	Sig.
P	1	144.2	2.6		10.39	0.17		8.43	0.15		6.18	0.12	
	2	152	2.5		10.61	0.17		8.81	0.14		6.56	0.11	
	3	154.1	2.6		10.75	0.17		8.97	0.15		6.63	0.12	
	4	151.3	2.7	***	10.78	0.18	***	8.83	0.16	***	6.45	0.12	***
	5	144.8	2.9		10.59	0.20		8.48	0.17		6.14	0.13	
	6	138.7	3.2		10.03	0.22		8.11	0.19		5.91	0.15	
	7	132.5	2.7		9.67	0.18		7.72	0.16		5.60	0.12	
LS	1	136.8	1.1	***	9.75	0.07	***	8.02	0.06	***	5.87	0.05	***
	2	153.9	3.5		11.05	0.23		8.93	0.20		6.55	0.16	

P - parity, LS - litter size, FY - fat yield, PY - protein yield, LY - lactose yield, FC – fat content, PC - protein content, LC – lactose content.

Table 4. The effect of parity and litter size on daily milk yield and contents (%) of fat, protein, and lactose

		DMY (kg)			FC (%)			PC (%)			LC (%)		
		LSM	s.e.	Sig.	LSM	s.e.	Sig.	LSM	s.e.	Sig.	LSM	s.e.	Sig.
P	1	1.10	0.02		7.12	0.05		5.85	0.02		4.27	0.01	
	2	1.15	0.02		6.92	0.05		5.80	0.02		4.28	0.01	
	3	1.16	0.02		7.03	0.05		5.84	0.02		4.26	0.01	
	4	1.13	0.02	***	7.14	0.05	***	5.85	0.02	**	4.23	0.01	***
	5	1.08	0.02		7.23	0.06		5.88	0.02		4.22	0.01	
	6	1.04	0.02		7.19	0.06		5.88	0.02		4.22	0.02	
	7	1	0.02		7.21	0.05		5.88	0.02		4.20	0.01	
LS	1	1.03	0.01	***	7.13	0.02	NS	5.90	0.01	***	4.26	0.01	*
	2	1.15	0.02		7.11	0.07		5.80	0.02		4.22	0.02	

P - parity, LS - litter size, DYM – daily milk yield, FC - fat content, PC - protein content, LC - lactose content, *P<0.05, **P<0.05, ***P<0.001, NS – non significant.

CONCLUSIONS

Comprehensive statistical analysis applied on numerous "field data" obtained in routine milking controls in Croatia revealed magnitude of the examined effects in semi-intensive dairy orientated sheep facilities. The results could be beneficial in making business decisions not only in the flocks of Istrian sheep, but also in flocks of other breeds with similar genetic potential for milk production.

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