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EFFECT OF FARMING REGION AND CALVING SEASON ON COMPLETE-LACTATION PRODUCTION TRAITS IN SIMMENTAL COWS

Petrović M.D.[1], Rakonjac S.*[1], Bogosavljević-Bošković S.[1], Đoković R.[1], Petrović M.Ž.[1], Bogdanović V.[2], Đedović R.[2]

Abstract: The present research focused on analysing the effect of farming region, calving season and their interaction on complete-lactation milk performance traits (lactation length, milk production, milk fat production, and milk fat content) using the generalised linear model based on the least squares method (the GLM procedure). The research involved 253 cows with a total of 827 lactations in three farming regions (Aranđelovac (74 cows with 263 lactations), Kraljevo (87 cows with 249 lactations) and Toponica (92 cows with 315 lactations)). In all three farming regions, the average lactation length (the overall mean) was 316.98 days, milk production – 4926.82 kg, milk fat production – 194.37 kg, and milk fat content – 3.94%.

Milk and milk fat production and milk fat content showed very significant differences ($P<0.01$) depending on farming region, whereas the difference in lactation length was significant ($P<0.05$). Calving season had a significant effect ($P<0.05$) only on milk fat production, whereas the farming region x calving season interaction significantly affected only the milk fat content. The other milk performance traits were not significantly affected ($P>0.05$) by either calving season or the farming region x calving season interaction. Therefore, the coefficients of determination were low and very significant ($P<0.01$), ranging from 0.15 for complete lactation length to 0.30 for milk fat content.

Keywords: lactation, milk, milk fat, farming region, calving season, coefficient of determination.

Introduction

Production traits of cows generally refer to milk performance traits such as lactation length, production of milk, milk fat and milk protein in complete and standard lactations, milk fat and protein contents in complete and standard lactations, and 4% fat corrected milk production in complete and standard lactations. As milk performance is a quantitative polygenic trait which is only about 25% heritable (0.25 heritability), the proportion of non-genetic factors, regardless of their nature (categorical or continuous), is large. Non-genetic factors have been examined in many

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studies. In the available literature, milk performance traits are generally analysed in terms of the effect of fixed non-genetic factors, including the effect of farm or farming region, season of birth, year of birth, calving season, calving year and lactation number, and their interactions. Among continuous factors, research attention is commonly devoted to the regression effect of age at first conception or calving.

When there are large numbers of relatively small herds or farms in a particular area of land, they are grouped according to a set of criteria into large herds which, along with the land area, form a farming region for the population of animals under study. Apart from the factors characterising each herd i.e. farm, farming region also involves factors such as altitude and soil with its specific floristic composition, which is of particular importance when pasture and mowing are undertaken on natural grasslands. The division into farming regions as the method used in evaluating the effect of non-genetic factors on production, reproduction or functional traits has been used by many researchers, who mostly found significant and very significant effects of this systematic non-genetic factor on milk performance traits. Chladek and Kucera (2000), Petrović D.M. et al. (2009), Petrović M.M. et al. (2009) and Bogdanović et al. (2012) studied the effect of region on milk and milk fat production, and milk fat content in Serbian Spotted and Simmental cows, and observed significant ($P<0.05$) and highly significant ($P<0.01$) variations in milk and milk fat yield due to the effect of farming region.

The systematic effects of season of birth and season of calving result from changes in climate, primarily temperature and precipitation, and their indirect effect on milk production through forage crops and plant condition during the growing season. This is of particular importance in the grazing system. Milk production is also indirectly affected by season through the effect of high and low temperatures. While certain breeds of cows show different degrees of tolerance to low temperatures, many breeds are more or less equally adversely affected by high temperatures (above 27^{o}C). Most authors (Singh et al., 2002, Cilek and Tekin, 2005, Petrović D.M. et al., 2005 and 2006, Lateef et al., 2008, Petrović M.M. et al., 2009, Lazarević et al., 2013, Nikšić et al., 2013) reported significant ($P<0.05$), highly significant ($P<0.01$) and very highly significant ($P<0.001$) effects of season on milk and milk fat production, whereas some authors (Pantelić et al., 2005, Chladek and Kucera, 2000) observed non-significant effects ($P>0.05$) of calving season on production traits in standard and complete lactations.

The objective of this research was to evaluate the effect of farming region and calving season on the phenotypic expression and variability of complete-lactation milk performance traits in Simmental cows under production conditions using the GLM statistical procedure.

Material and method

The analysis of the phenotypic expression and effects of farming region, calving season and their interaction on milk performance traits in complete lactations involved farms with 2 to 10 cows in three farming regions (Aranđelovac (74 cows with 263 lactations), Kraljevo (88 cows with 249 lactations) and Toponica (92 cows with 315 lactations) with a total of 254 cows and 827 lactations.

The expression and variability of milk performance traits in complete lactations (length of complete lactations (days), milk production (kg), milk fat production (kg) and milk fat content (%)) were evaluated in terms of the effect of the following non-genetic factors:
- *Farming region.* The effect of three locations: Aranđelovac (1), Kraljevo (2) and Toponica (3).
- *Calving season*. In accordance with the calving date i.e. onset of lactation, as indicated in the herd book, cows were grouped into four seasons: spring season (1) (calvings in March, April and May), summer season (2) (calvings in June, July and August), autumn season (3) (calvings in September, October and November) and winter season (4) (calvings in December, January and February).
- *Farming region x calving season interaction* (3 farming regions x 4 calving seasons).

The effect of systematic environmental factors on milk performance traits in complete lactations was analysed by the generalised linear method. This procedure estimates a number of different effects, regardless of their nature i.e. whether they are categorical factors (farming region, lactation, year of birth and season of birth) or continuous factors (age at first calving). To evaluate the effects and test the hypotheses, the generalised linear model relies on the least squares (GLM) procedure. The effect of non-genetic factors on milk performance traits in complete lactations was analysed using the following model:

$$\mathbf{y_{ij} = \mu + F_{Ri} + S_{Cj} + F_R S_{Cij} + e_{ij}},\ \text{where:}$$

y_{ij} – an individual animal of the i-th farming region and j-th calving season,
μ – overall mean of the population at equal proportions of all classes of effects (F_R, S_C),
F_{Ri} – fixed effect of the i-th farming region (1–3),
S_{Cj} - fixed effect of the j-th season of calving (1–4),
$F_R S_{Cij}$ - fixed effect of the interaction between the i-th farming region and j-th season of calving (1–12),
e_{ij} – other undetermined effects.

Further analysis of production traits presents the results of the analysis of variance using the above model, and the coefficients of determination (R^2) for each milk performance trait.

Results and discussion

The results of the analysis of the effect of systematic factors (farming region, calving season and their interactions) on milk production in complete lactations, i.e. least squares means (LSM), standard error of means (SE_{LSM}) and the significance of observed effects are presented in Table 1.

The differences in the production indicators result not only from the effect of genotype, but also from the effect of nutrition, care, housing system and the human factor. The relationship between these factors varies across farms. Hence, there are differences among herds i.e. farms even when animals have similar genetic potential for production. In the present research, it is due to differences in feed quality and management practices that the production of milk and milk fat was very significantly ($P<0.01$) greater in the region of

Toponica, since the same (tie-stall) housing system, the same genotype and similar knowledge of cow farming among producers were used for all three regions.

Table 1. Least squares means, standard errors of means, significance of systematic effects and coefficients of determination for milk performance traits in complete lactations

Systematic effects			Lactation length (days)		Milk production (kg)		Milk fat production (kg)		Milk fat content (%)	
		N	LSM	SE_{LSM}	LSM	SE_{LSM}	LSM	SE_{LSM}	LSM	SE_{LSM}
Farming region (farm)										
Aranđelovac (1)		263	313.13^{b}	1.84	4920.84^{b}	50.68	192.91^{b}	2.13	3.93^{b}	0.005
Kraljevo (2)		249	318.74^{a}	1.91	4746.97^{c}	52.69	189.48^{b}	2.22	3.98^{a}	0.005
Toponica (3)		315	318.74^{a}	1.68	5055.70^{a}	46.35	198.67^{a}	1.95	3.93^{b}	0.005
F_{exp}			*		**		**		**	
Calving season										
Spring (1)		181	318.39	2.24	4942.09	61.71	194.41^{ab}	2.60	3.94	0.006
Summer (2)		233	318.39	1.95	5006.49	53.90	198.46^{a}	2.27	3.95	0.005
Autumn (3)		201	318.12	2.12	4866.40	58.64	192.29^{ab}	2.47	3.95	0.006
Winter (4)		212	312.58	2.04	4816.36	56.28	189.58^{b}	2.37	3.94	0.006
F_{exp}			ns		ns		*		ns	
Farming region x calving season										
1	**1**	59	310.17	3.87	4902.27	106.67	190.02	4.49	3.91^{c}	0.010
1	**2**	72	315.69	3.50	5040.86	96.56	198.40	4.07	3.94^{b}	0.009
1	**3**	63	315.05	3.74	4888.48	103.23	192.51	4.35	3.94^{b}	0.010
1	**4**	69	311.59	3.57	4851.74	98.64	190.70	4.15	3.93^{bc}	0.010
2	**1**	49	323.22	4.24	4746.94	117.05	190.06	4.93	4.00^{a}	0.011
2	**2**	73	316.84	3.47	4779.67	95.90	192.54	4.04	3.99^{a}	0.009
2	**3**	55	318.65	4.00	4629.31	110.48	184.36	4.65	3.98^{a}	0.011
2	**4**	72	316.26	3.50	4831.96	96.56	190.98	4.07	3.95^{b}	0.009
3	**1**	73	321.79	3.47	5177.05	95.90	203.16	4.04	3.92^{bc}	0.009
3	**2**	88	322.64	3.16	5198.93	87.34	204.45	3.68	3.93^{bc}	0.009
3	**3**	83	320.65	3.26	5081.41	89.94	200.01	3.79	3.93^{bc}	0.009
3	**4**	71	309.89	3.52	4765.39	97.24	187.06	4.09	3.94^{b}	0.010
F_{exp}			ns		ns		ns		*	
Coeff. of determ. - R^2			0.15^{ns}		0.21**		0.18**		0.30**	

*Means followed by the same letters in columns are not different (P>0.05) based on the LSD test; F-test: N.S. - P > 0.05, * - P < 0.05, ** - P < 0.01.*

Depending on the amount of milk produced, milk fat content was very significantly (P<0.01) higher in the region of Kraljevo, where the lowest milk performance was recorded. Complete lactations were significantly (P<0.05) shorter in the region of Aranđelovac (313.13 days) than in the other regions, where the average lactation length was 318.74 days. The results of the mixed least squares model using fixed and random effects (LS – Least Squares and BLUP – Best Linear Unbiased Prediction) of non-genetic

factors on milk performance traits in black-and-white (n=1090) and Simmental first-calvers (n=1370) showed very highly significant deviations from the overall mean for all milk performance traits as induced by farming region (Lazarević et al., 2013 and Nikšić et al., 2013).

In the available literature, two explanations are generally provided for the effect of season on the amount of milk produced and milk fat content over a lactation. The first explanation is that green forage fed to cows during summer has a positive effect on milk yield, but not on milk fat content. In the second explanation, season affects milk performance traits through the effect of high temperatures during summer, when feed intake is reduced and milk produced in small amounts, with its fat content decreasing as high temperatures persist. With these considerations in mind, many authors have observed the highest milk performance during winter and spring, and the lowest during the summer and autumn calving seasons. However, the effect of calving season i.e. onset of lactation on milk performance traits, except milk fat production ($P>0.05$), was not significant ($P<0.05$), which was due to the indoor no-pasture farming system generally used during spring and summer. As determined by Barach et al. (2001), cows in Iran that calved in December achieved higher yields of milk and protein than cows that calved in June. The increase in temperature by each C^0 led to a decrease in milk and protein yield by 0.38 kg and 0.01 kg, respectively. The interaction between farming region and calving season had a significant effect ($P>0.05$) only on milk fat content, whereas its effect on the other milk performance traits in complete lactations was non-significant ($P<0.05$).

The coefficients of determination (R^2), which indicate the level of explained variability in milk performance traits as induced by non-genetic factors according to the model presented, were low and very significant ($P>0.01$), except for lactation length, whose R^2 was non-significant ($P<0.05$). The low coefficient of determination is due to the small number of fixed non-genetic factors included in the model, which suggests that complete-lactation production traits were also affected by a multitude of other factors which were not analysed in this study. In this experiment, the coefficients of determination ranged from 0.15 for complete lactation length to 0.30 for milk fat content. When assessing the effects of farm, calving season and lactation number and their interactions on milk performance traits in complete lactations, Petrović D.M. et al. (2005 and 2009) determined similar values for coefficients of determination in the range between 0.100–0.269 for complete lactation length and 0.361–0.232 for milk fat content.

Conclusion

The model used for the analysis of the effect of non-genetic factors on milk performance traits in complete lactations suggests that farming region had a very significant ($P>0.01$) effect on milk and milk fat production and milk fat content, whereas its effect on lactation length was significant ($P>0.05$). Calving season significantly ($P>0.05$) affected only milk fat production, whereas the farming region x calving season interaction had a significant ($P>0.05$) effect only on milk fat content. The coefficients of determination were low and very significant ($P>0.01$), except for lactation length (R^2 non-significant, $P>0.05$).

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