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THE PHENOTYPIC VARIABILITY OF PRODUCTION TRAITS IN THE POPULATION OF SIMMENTAL COWS

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Invited paper

Abstract: The breeding objective for the Simmental breed of cattle is to achieve maximum genetic values for economically important traits, in line with the economic effects of genetic improvement, which this breed has achieved in developed countries. The present study included 302 Simmental cows selected as bull dams on the territory of the Republic of Serbia in the course of one year. The impacts of paragenetic factors and lactation on production traits (milk yield and fertility) were examined. Order of lactation influenced highly significant deviations ($P<0.01$) in milk yield, milk fat content, milk fat yield and 4% FCM from the general average, as well as slight variations in the length of gestation and lactation, calving interval and service period, that were not statistically significant ($P>0.05$). Simmental bull dams included in the present study, in the lactation period of 311.45 days, have realized milk yield of 5754.49 kg with 3.98% and 230.24 kg of milk fat and 5755.47 kg of 4% FCM. Average duration of gestation of tested heads was 286.31 days, the service period 110.37 days, and calving interval 398.44 days. Overall comprehension and understanding of a number of paragenetic factors and their interactions on specific production characteristics can have impact on improvement of milk yield and fertility in cows.

Key words: fertility, milk yield, Simmental breed, lactation.

Introduction

Simmental cows in the Republic of Serbia are reared in semi-intensive conditions of housing, care and feeding, or on small farms with a few animals, to farms with dozens of breeding animals in a more intensive system of rearing. Genetic improvement of Simmental cattle in the country is achieved by selection and breeding, in a pure breed. At one time there were attempts to introduce genes of red

Holstein breed to improve milk production traits and milkability (*Petrović, M.M. et al 2009*).

The necessity of continuous improvement of the production of milk, milk fat and milk proteins imposes the need for systematic work on all levels related to the aforementioned production. Their general characteristic is that they are quantitative genetic traits and their degree of phenotypic expression depends on the interaction of genotype and environment in which production takes place. In order to achieve high milk and milk fat yield it is needed, in addition to a strict selection process, to provide adequate production conditions, particularly with regard to nutrition, then rearing and care (*Pantelić 2006*).

By examining the production potential of first calving Simmental cows calved in the period 2007-2010 on individual farms in Serbia, *Nikšić et al. (2011)* found that their average milk production of 4348 kg of milk with milk fat content of 3.93% and milk fat yield of 171.1 kg. With the exception of year 2009, milk yield in first calving heifers continuously increased on average by about 100 kg of milk per animal per year.

Panić and Vidović (2006) have conducted study of the heritability of important milk traits of of Simmental cows on two farms in Vojvodina. First lactation lasted in average a long time - 350 days, as a consequence of late first insemination on these farms. Cows realized in standard lactation average milk production of 4298 kg, with the milk fat yield and content of 170 kg and 3.98%, respectively. Average yield of 4% FCM was 4277 kg.

Reproduction in intensive cattle production is the most important phase because it provides animals for renewal of the herd, milk production and fattening, i.e. meat production.

Croatian Livestock Selection Center (2003) provides some indicators of the reproduction of Simmental cattle population. The average age of registered cows in first lactation was 28 months, and the duration of the service period 120 days.

Bielfeldt et al. (2004) have established the average duration of service period of 92.9 days and of the calving interval 384.5 days. They have also concluded that the year and season of calving have a highly significant effect ($P<0.01$) on the duration of service period and calving interval.

Given the high economic importance of fertility traits in cattle it is necessary to know certain factors affecting fertility in cows. The fertility of cows is much more influenced by environmental factors because most of the variation of reproductive traits are affected by them. When analyzing individual factors, their impact on the fertility of cows is different, and also complex action is possible. More comprehensive knowledge of the impact of certain factors on specific reproductive traits may improve fertility in cows (*Trifunović et al., 2004).*

Petrović M. D. et al. (2005), have analyzed the effect of paragenetic factors on production traits in complete lactations in Simmental cows. The influence of lactation on all production traits was highly significant, $p<0.01$ with the exception of duration complete lactations where the impact was not statistically significant, $p> 0.05$.

Material and methods

Simmental breed is the breed most present in Serbia, where the total number of cattle population is about 908,990 animals, of which about 525,000 cows and heifers. In the breed structure of cattle in Serbia, it is estimated that the Simmental breed makes up about 80%, the group of Black and White Holstein-Friesian cattle around 10%, while the primitive breeds and cross-breeds account for about 10% of the total number of cattle. Active population of Simmental cattle in the Republic of Serbia comprise only animals that are included in the main animal recording/registration system (about 90,000 head or 17%). The breeding objective for the Simmental breed of cattle is to achieve maximum genetic values for economically important traits in line with the economic effects of genetic improvement, which this breed has achieved in developed countries *(Pantelić et al. 2011).*

This study included 302 Simmental cows selected as bull dams on the territory of the Republic of Serbia in the course of one year. Selection of cows into the herd of bull dams was performed after completion of the first, and based on the subsequent lactations.

The study included the following properties of milk throughout the lactation:

- Duration of lactation, days
- Milk yield, kg
- Milk fat content,%
- Milk fat yield, kg
- Yield of 4% FCM, kg

Correction of milk yield at 4% FCM was performed using the Gaines-Davidson's formula:

$4\% FCM = 0.4 M + 15 F$

Where:

M - milk yield

F - milk fat yield

The following reproductive traits were investigated:

- Duration of pregnancy (days)
- Duration of service period (days)
- Duration of the interval between calving (days)

The impact of paragenetic factors and order of lactation on production traits (milk yield and fertility) was examined. Analysis of the impact of paragenetic factors on milk production traits and fertility was carried out by the method of least squares, using a fixed model:

$Y_{ml} = \mu + L_l + e_{ml}$

Where:

Y_{ml} = Expression of the studied trait of cow *m*, which produced in lactation *l*

μ = general average

L_l = fixed effect of *l* order of lactation

e_{ml}= random error

Results and Discussion

Study of the duration of lactation has practical importance because it is through this trait that the utilization efficiency of dairy cows in milk production can be estimated. Duration of lactation is related to the duration of the service period. Earlier drying due to lower milk production leads to the problems in regard to the body condition and at calving. Poor diet does not shorten the lactation but decreases the yield of milk and adversely affects the reproduction. Prolonged lactation indicates that the cows are not inseminated in optimal time, or are dried on time.

Table 1. General average (μ), deviation from the general average (ĉ), least square mean values (lsm) and their errors (S) and significance of studied effects on duration of lactation, days

Effects	**N**	**ĉ**	**Sc**	**lsm**	**Slsm**
General average					
μ	975	311.45	2.24		
Lactations ^{ns}		f_{tab}**= 11,019**		df_1**=6**	df_2**=949**
I	292	-3.66	4.96	307.79	3.01
II	230	-2.31	3.43	309.14	1.74
III	170	-3.49	2.15	307.96	1.54
IV	116	-0.04	1.57	311.41	2.64
V	81	-0.67	2.36	310.77	4.11
VI	48	1.74	3.80	313.19	5.72
≥VII	38	8.42	5.81	319.86	7.84
ns – P>0.05		*** – P<0.05**		**** – P<0.01**	

Table 2. General average (μ), deviation from the general average (ĉ), least square mean values (lsm) and their errors (S) and significance of studied effects on milk yield in complete lactation, kg

Effects	N	ĉ	Sc	lsm	Slsm
General average					
μ	975	5754.49	109.80		
Lactations **		f_{tab}= 17,808		df_1=6	df_2=949
I	292	-927.92	242.56	4826.57	147.48
II	230	-232.67	167.83	5521.82	84.94
III	170	139.15	105.13	5893.64	75.25
IV	116	274.07	76.77	6028.56	129.10
V	81	321.71	115.33	6076.21	200.90
VI	48	301.18	185.86	6055.68	279.63
≥VII	38	124.48	284.25	5878.97	383.58
ns – P>0.05		*** – P<0.05**		**** – P<0.01**	

Based on the results presented in Table 1 it can be concluded that the average duration of lactation period was 311.45 days. Minimum duration of the lactation period was 307.79 days and maximum of 319.86 days.

Similar results were obtained in the research by *Perišić (1998),* and higher and significantly higher values were obtained by *Petrović (2000), Perišić et al. (2002), Panić and Vidović (2006).*

From Tables 2, 3, 4 and 5, it can be concluded that the lactation influenced the incidence of highly significant deviations (P<0.01) in milk yield, milk fat content, milk fat yield and 4% FCM from the general average.

Table 3. General average (μ), deviation from the general average (ĉ), least square mean values (lsm) and their errors (S) and significance of studied effects on milk fat content in complete lactation, %

Effects	N	ĉ	Sc	lsm	Slsm
General average					
μ	975	3.987	0.016		
Lactations **		f_{tab}= 6,660		df_1=6	df_2=949
I	292	-0.213	0.035	3.774	0.021
II	230	-0.134	0.024	3.854	0.012
III	170	-0.076	0.015	3.911	0.011
IV	116	-0.019	0.011	3.968	0.019
V	81	0.061	0.017	4.048	0.029
VI	48	0.140	0.027	4.128	0.040
≥VII	38	0.241	0.041	4.229	0.056
ns – P>0.05		*** – P<0.05**		**** – P<0.01**	

Milk production is characterized by a regular trend of increase in the subsequent lactations, so that the minimum milk yield is in the first lactation, where the deviation from the general average was - 927.92 kg, and the maximum in the fifth with a deviation from the general average of 321.71 kg. Highly significant effect (P<0.01) of lactation on milk yield has also been established by *Trifunovic et al. (2002).*

The situation is identical with the milk fat content, since the trend of increase is present starting from the first lactation, 3.77% to 4.23% in the seventh lactation.

The lactation highly significantly (P<0.01) influenced the variability of milk fat yield. The first lactation had the greatest negative deviation from the average of -49.31 kg, and therefore the lowest yield 180.94 kg. Milk fat yield gradually increased to 250.86 kg in the sixth lactation which is marked with the highest positive deviation 20.62 kg. Approximately similar results were obtained in the research by *Trifunović et al. (2002), Petrović M.D et al. (2005),* who found highly significant effect of lactation on milk fat yield.

For the purpose of more efficient comparison of milk production, 4% fat - corrected milk is often used. The effect of lactation was highly significant (P<0.01) on the yield of 4% FCM. The minimum yield was in realized in the first lactation 4644.66 kg with a deviation from the general average of -1,110.81 kg. The yield gradually increased until the sixth lactation, which was 6185.25 kg with maximum deviation of 429.79 kg.

Table 4. General average (μ), deviation from the general average (ĉ), least square mean values (lsm) and their errors (S) and significance of studied effects on milk fat yield in complete lactation, kg

Effects	**N**	**ĉ**	**Sc**	**lsm**	**Slsm**
General average					
μ	975	230.24	4.56		
Lactations **		f_{tab}***= 16,715***		df_1***=6***	df_2***=949***
I	292	-49.31	10.07	180.94	6.12
II	230	-17.53	6.97	212.72	3.53
III	170	0.54	4.36	230.78	3.12
IV	116	9.56	3.19	239.81	5.36
V	81	16.47	4.79	246.71	8.34
VI	48	20.62	7.71	250.86	11.60
≥VII	38	19.65	11.80	249.89	15.92
ns – P>0.05		*** – P<0.05**		**** – P<0.01**	

Table 5. General average (μ), deviation from the general average (ĉ), least square mean values (lsm) and their errors (S) and significance of studied effects on yield of 4%FCM in complete lactation, kg

Effects	N	ĉ	Sc	lsm	Slsm
General average					
μ	975	5755.47	111.71		
Lactations **		f_{tab}= 17,236		df_1=6	df_2=949
I	292	-1110.81	246.78	4644.66	150.05
II	230	-355.98	170.75	5399.49	86.42
III	170	63.74	106.96	5819.21	76.56
IV	116	253.07	78.10	6008.54	131.35
V	81	375.68	117.34	6131.15	204.39
VI	48	429.79	189.09	6185.25	284.50
≥VII	38	344.51	289.19	6099.97	390.26
ns – P>0.05		*** – P<0.05**		**** – P<0.01**	

Based on results presented in the paper, it can be concluded concluded that Simmental cows included in the present study, significantly increased milk and milk fat yield to the age of approxinately 7 years, i.e. during the first five lactations. After the 7. Year of age or after the fifth lactation milk yield stagnated, and subsequently started to decline significantly to reach approximately the level of the first calving heifers at the age of 15 or 16 years.

Knowledge of the impact of external factors on the milk properties and fertility is very important with respect to their importance in achieving breeding goals and good economic results.

Table 6. General avera, least square mean values and their errors, and significance of the effect of lactation on reproductive traits

	Durat. of gestation		Service period		Calving interval	
Lactation	**LSM**	**Slsm**	**LSM**	**Slsm**	**LSM**	**Slsm**
Gen.average	286.31		110.37		398.44	
1.	284.39	0.54	112.38	4.68	398.17	4.50
2.	285.88	0.62	109.94	5.23	396.13	5.05
3.	285.93	0.61	98.65	5.94	385.91	5.96
4.	286.73	0.83	106.31	7.21	392.84	7.04
5.	285.93	0.96	111.82	7.97	397.66	8.01
6.	284.99	1.15	110.15	10.55	397.35	10.30
≥7.	285.65	1.32	113.52	11.86	400.34	11.82
F-test	$f_{tab}=1.251^{ns}$		$f_{tab}=0.935^{ns}$		$f_{tab}=0.774^{ns}$	

N.S – P >0.05; * - P < 0.05; * * - P< 0.01

Problems with fertility have become one of the most expensive factors in dairy cattle production. Selection for maternal fertility is becoming increasingly important, and requires its greater involvement in the total breeding merit/breeding value. If there are serious problems in reproduction, in addition to direct effects on milk and milk fat production, difficulties occur in the normal implementation of the herd renewal, which reflects on the cost of production (*Pantelić et al. 2009*).

The general average of least square mean values of duration of gestation corrected for the impact of lactation was 286.31 days.

Environmental factors, i.e. lactation had no significant effect on this trait ($P>0.05$). This can be explained by the fact that the duration of gestation is a biological constant characteristic of the particular species on which external factors have limited effect.

Average service period in studied Simmental cows was 110.37 days. Lactation had no effect ($P>0.05$) on the duration of service period (Table 6). This is also confirmed by research results of *Stojić et al. (1993)*. *Pantelić et al. (2008)* have established, by the method of least squares, average service period of 115.19 days and age at first calving of 795.53 days of first calving Simmental cows kept on individual farms.

Most of the research related to the duration of the service period have indicated that its optimal duration should be up to 90 days, during which time a full involution of the genital organs is completed, and they are ready for the next conception, on the other hand, it is also the best time period from the economic point of view with regard to the natural course of lactation of cows.

Calving interval is the best indicator of cow fertility. Its duration is directly related to the duration of the service period and duration of gestation. Calving period lasted on average of 398.44 days. Lactation caused slight variations in calving period, which were not statistically significant ($P>0.05$).

Conclusion

Since the fastest genetic improvement through selection and improvement of production performance is through sire-son line, selection of bull dams and sires should be given the utmost attention.

Knowledge of the impact of external factors on the properties of milk and fertility is very important with respect to their importance in achieving of breeding goals and good economic results.

Selection for maternal fertility is becoming increasingly important, and requires its greater involvement in the evaluation of total merit/breeding value. If there are serious problems in reproduction, in addition to direct effects on milk and

milk fat production, difficulties arise in the normal implementation of the renewal of the herd, which reflects on the cost of production.

In order to achieve high milk and milk fat yield, satisfactory fertility, in addition to strict selection, it is necessary to provide adequate rearing conditions, especially in regard to nutrition, housing and care.

Acknowledgement

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Fenotipska varijabilnost proizvodnih osobina u populaciji krava simentalske rase

V. Pantelić, D. Ružić-Muslić, M.M. Petrović, D. Nikšić, D. Ostojić-Andrić, S. Aleksić, M. Lazarević

Rezime

Odgajivački cilj za simentalsku rasu goveda je postizanje maksimalnih genetskih vrednosti za ekonomski važne osobine, a u skladu sa ekonomskim efektima genetskog poboljšanja, koju je ova rasa postigla u razvijenim zemljama sveta.
Ovim istraživanjem su obuhvaćene 302 krave simentalske rase odabrane u kategoriju bikovskih majki na području Republike Srbije u toku jedne godine. Ispitani su uticaji paragenetskih faktora i reda laktacije na proizvodne osobine (mlečnost i plodnost). Red laktacije uticao je na pojavu visoko značajnih odstupanja od opšteg proseka ($P<0,01$) u prinosu mleka, sadržaju i prinosu mlečne masti i 4% MKM, kao i na neznatna variranja dužine bremenitosti i laktacije, međutelidbenog intervala i servis perioda, koja nisu bila statistički značajna ($P>0,05$).
Bikovske majke simentalske rase obuhvaćene ovim ispitivanjima za laktaciju u trajanju od 311,45 dana, ostvarile su proizvodnju mleka od 5.754,49kg, sa 3,98% i 230,24kg mlečne masti, odnosno 5.755,47kg 4% MKM. Prosečno trajanje bremenitosti ispitivanih grla iznosilo je 286,31 dana, servis perioda 110,37 dana, i međutelidbenog intervala 398,44 dana.

Celokupnim sagledavanjem i poznavanjem većeg broja paragenetskih faktora, kao i njihovih međusobnih interakcija na određene proizvodne osobine može se uticati na poboljšanje mlečnosti i plodnosti krava.

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