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# THE EFFECT OF GENETIC AND NON-GENETIC FACTORS ON PRODUCTION TRAITS OF SIMMENTAL COWS

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**Abstract:** This study covered 737 controlled first calving Simmental cows with, lactations concluded within one year. All first calving animals were on the farms of individual farmers in the municipalities of Kragujevac and Mladenovac. The research included the influence of bull sires, year and season of calving on milk yield and fertility. Least squares method was used to determine the average duration of lactation of 323.74 days. For a period of 305 days, heifers produced 3701.67 kg of milk, or 3644.58 kg of 4% FCM. The average production of milk fat was 144.26 kg and milk fat content was 3.88%. The interval from calving to first insemination lasted in average 124.19 days, and the animals were first calved at the age of 789.95 days. The bull sires had a highly significant effect ($P<0.01$) on the duration of lactation, milk yield and 4% FCM, milk fat yield and content and age of cows at first calving. The duration of service period was not under significant effect ($P>0.05$) of bull sires. Year of calving had a significant effect ($P<0.01$) on the duration of lactation, production of milk, milk fat and 4% FCM. Milk fat content, service period and age at first calving did not show significant variation due to the impact of different years of calving ($P>0.05$). Season of calving of cows demonstrated highly significant effect ($P<0.01$) on the production of milk and 4% FCM, and significant ($P>0.05$) on the production of milk fat, however it had no effect ($P>0.05$) on the milk fat content, duration of lactation and service period and age at calving.

**Key words**: Simmental breed, milk performance, fertility, bulls, year, season

## Introduction

Milk production is important from the biological aspect as well as from the aspect of production. Together with reproduction it represents the material basis for

maintaining of the species. In order to achieve high milk production and production of milk fat, it is necessary, in addition to strict selection, to provide adequate living conditions, particularly with regard to nutrition, rearing and care.

Simmental cows in the Republic of Serbia are reared in semi-intensive conditions - housing, management and feeding, i.e. on small farms with few animals to farms with a few dozen cows in the more intensive systems of production. Genetic improvement of Simmental cattle in our country is achieved by selection and breeding in pure breed. At one time there were attempts to introduce genes of red Holstein breed to improve milk production traits and milking properties *(Petrović M.M. et al.2009).*

*Kučević et al.(2005)* have analysed milk traits of daughters of same Simmental bull sires, in Germany and Serbia. First calving heifers born and reared in our conditions had 3.796 kg of milk yield and milk fat content of 144.8 kg or 3.81%.

Presenting the results of the application of technology of genetic improvement of Simmental cattle population in Serbia, *Petrović et al.(2006)* have obtained following milk performance results in the study with 2.134 first calving cows. The average milk production was 4.413 kg with 3.88% milk fat contetn or 170 kg milk fat quantity. The yield of 4% FCM was 4.213 kg.

*Pantelić et al.(2008a)* have analysed the phenotypic variability of milk production traits of Simmental first calving cows in Serbia. Using the method of least squares, average values are obtained for the lactation period - 317.94 days, milk yield - 3872.65 kg, milk fat content - 3.87%, the milk fat yield - 149.78 kg and yield of 4% FCM - 3795.82 kg.

*Nikšić et al.(2011)* have investigated the production potential of first calving Simmental cows calved in the period 2007-2010 in the individual sector in Serbia, and found the average milk production level of 4.348 kg of milk with 3.93% milk fat content and milk fat yield of 171.1 kg.

Given the fact that the economic importance of fertility traits in cattle is considerable, it is necessary to know some factors that affect the fertility of cows. Fertility of cows is significantly more influenced by environmental factors because most of the variation of reproductive traits are affected by them. The impact of individual factors on the fertility of cows varies, and also a complex effect of multiple factors is possible. Comprehensive knowledge of the impact of certain reproductive traits can be used to improve cow fertility (*Trifunović et al.2004).*

In his research by *Đurđević (2001),* an average value for the age of the animals at first calving of 831.94 days was determined. Service period between the first calving and second fertilization was in average of 96.81 days.

Analysing the production and reproductive performance of Simmental bull dams in our country, *Pantelić et al.(2005)* have found the average age at first conception of 517.61 days, and the duration of the service period of 108.98 days.

In the research of the variability of age at calving and service period of first calving Simmental *Pantelić et al.(2008b)* have established the average service period of 115.19 days and age at first calving of 795.53 days. Year and season of calving have demonstrated highly statistically significant effect ($P<0.01$) on age at first calving and duration of service period.

*Pantelić et al.(2013)* list some of the indicators of milk production and fertility of Simmental cattle population: the duration of lactation - 311.45 days, milk yield - 5754.49 kg, milk fat percentage - 3.98% and milk fat quantity -230.24 kg, and 5755.47 kg – yield of 4 % FCM. The average duration of gestation of studied animals is 286.31 days, 110.37 days of service period, and calving interval of 398.44 days.

## Material and methods

The present study covered 737 controlled first calving Simmental cows with lactations concluded within one year. All first calving cows were on the farms of individual farmers in the municipalities of Kragujevac and Mladenovac. The total number of bull sires included in the study was 33.

In order to more precisely determine the effects of different non-genetic factors, all first calving cows included in this study were classified into four groups according to the season, and three groups according to year of calving.

Months of calving of cows, i.e. beginning of lactation, were divided into four seasons, namely:

- I - winter (December, January, February)
- II - spring (March, April, May)
- III - summer (June, July, August)
- IV - autumn (September, October, November)

The following properties/traits were included in the study:

1. Milk performance:

- Duration of lactation (days)- DL
- Milk yield in standard lactation (kg)- MY
- Milk fat content in standard lactation (%)- MFC
- Milk fat yield in standard lactation (kg)- MFY
- Yield of 4% FCM in standard lactation (kg)- 4%FCM

2. Fertility:

- Age at first calving (days)-AFC
- Duration of service period (days)-DSP

The reduction of lactation to the standard lactation of 305 days was carried out according to the coefficients by *Nenadović, 1974*. Correction of milk yield to

4% FCM was performed using the Gaines-Davidson formula as follows: 4% FCM = 0.4 M + 15 F

where: M – milk yield, kg

F – milk fat yield, kg

The method of least squares LSMLMW *(Harvey 1990)* was used in the analysis of the collected data. This method allows optimal assessment of the impact of many of the studied traits (bull sires, year and season of calving). Mixed model for assessing the phenotypic variability of milk yield and fertility traits in standard lactation for the entire sample was set according to the following equation:

$$Y_{iklm} = \mu + B_i + G_k + S_l + b_1(x_1 - \overline{X}_1) + b_2(x_2 - \overline{X}_2) + e_{iklm}$$

$Y_{ijklm}$ = expression of milk trait of cow *m*, daughter of bull sire *i*, which produced milk in region *j*, and calved in year *k,* in season *l*

$\mu$ = general average

$B_i$ = random effect of *i* bull sire

$G_k$ = fixed effect of *k* calving year

$S_l$ = fixed effect of *l* calving season

$b_1$ = linear regression effect of duration of service period

$b_2$ = linear regression effect of age at calving

$e_{ijklm}$ = random error

# Results and discussion

The overall average, Least squares mean values, the variability of production indicators by year and season, and F-test of examined impacts are presented in Tables 1, 2, 3, 4, and 5.

**Table 1. General average (μ) and standard errors (SE) for milk and fertility traits in standard lactation and F-test of studied factors (n=737)**

| Traits | μ | SE | F – test of studied factors | | |
|---|---|---|---|---|---|
| | | | Bull | Year | Season |
| | | | $df_1=32$ $df_2=699$ | $df_1=2$ $df_2=699$ | $df_1=3$ $df_2=699$ |
| **DL, days** | 323.74 | 9.45 | 3.682** | 31.876** | $1.675^{ns}$ |
| **MY, kg** | 3701.67 | 277.96 | 2.930** | 7.594** | 4.637** |
| **MFC, %** | 3.88 | 0.10 | 9.245** | $1.018^{ns}$ | $1.701^{ns}$ |
| **MFY, kg** | 144.26 | 13.17 | 3.840** | 6.738** | 3.779* |
| **4%FCM, kg** | 3644.58 | 305.69 | 3.432** | 7.136** | 4.141** |
| **DSP, days** | 124.19 | 10.32 | $0.728^{ns}$ | $1.982^{ns}$ | $0.552^{ns}$ |
| **AFC, days** | 789.95 | 48.58 | 3.609** | $0.645^{ns}$ | $2.498^{ns}$ |

The Least squares method was used to determine the average duration of lactation of 323.74 days. For a period of 305 days first calving cows produced 3701.67 kg of milk, i.e. adjusted to 4% FCM - 3644.58 kg. The average production of milk fat was 144.26 kg and milk fat content 3.88%. The interval from calving to first insemination lasted in average 124.19 days, and the animals were first calved at the age of 789.95 days.

Very similar results for milk traits were obtained by *Pantelić et al.(2008a), Kučević et al.(2005)*, and higher values are reported by *Nikšić et al.(2011), Petrović et al.(2006)* and *Pantelić et al.(2013).* Regarding the results of reproductive traits, they are very similar to those obtained in the research by *Pantelić et al.(2008, 2013),* and slightly higher than the results of *Đurđević (2001).*

The bull sires had a highly significant effect (P<0.01) on the duration of lactation, milk yield and yield of 4% FCM, on milk fat yield and content and age of cows at first calving. The bull sires did not show a significant effect (P>0.05) on the duration of the service period.

*Stojic (1996)* has examined the correction factors of milk production traits and their contribution to the evaluation of breeding value of bulls and cows. In this study, the bull sires have influenced highly significantly (P<0.01) the properties of milk yield, milk fat and 4% FCM in the first standard lactation, but no significant effect (P>0.05) is observed on the duration of lactation and milk fat content. The influence of bull-sires on age at first calving is highly significant (P<0.01), but no significant effect (P> 0.05) on the service period is manifested.

Studying the variability of estimated linear type and milk traits of first calving Black and White cows *Živanović (2002)* have found a highly significant effect (P<0.01) of bulls-sires on milk production, the quantity of milk fat, milk fat content and yield of 4% FCM. On the duration of lactation bulls-fathers did not show a significant effect (P>0.05).

**Table 2. Least square means (lsm) and standard errors (Slsm) for milk and fertility traits in standard lactation by calving years**

| Traits | μ | SE | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|---|---|
| | | | lsm | Slsm | lsm | Slsm | lsm | Slsm |
| **DL, days** | 323.74 | 9.45 | 368.89 | 14.27 | 309.39 | 8.70 | 292.94 | 9.04 |
| **MY, kg** | 3701.67 | 277.96 | 2976.03 | 454.38 | 4178.82 | 248.67 | 3950.16 | 262.32 |
| **MFC, %** | 3.88 | 0.10 | 3.84 | 0.12 | 3.89 | 0.10 | 3.92 | 0.10 |
| **MFY, kg** | 144.26 | 13.17 | 115.37 | 19.62 | 162.81 | 12.17 | 154.60 | 12.63 |
| **4%FCM, kg** | 3644.58 | 305.69 | 2921.07 | 472.50 | 4113.64 | 279.20 | 3899.03 | 291.48 |
| **DSP, days** | 124.19 | 10.32 | 165.31 | 30.47 | 104.74 | 2.88 | 102.51 | 7.26 |
| **AFC, days** | 789.95 | 48.58 | 783.92 | 73.85 | 784.78 | 44.62 | 801.14 | 46.45 |

Year of calving had a significant effect (P<0.01) on the duration of lactation, production of milk, milk fat and 4% FCM. Milk fat content, service period and age at first calving did not show significant variation due to the impact of different years of calving (P>0.05).

**Table 3. Deviation of least square (ĉ) and deviation errors (Sĉ ) for milk and fertility traits in standard lactation by calving years**

| Traits | μ | SE | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|---|---|
| | | | ĉ | Sĉ | ĉ | Sĉ | ĉ | Sĉ |
| **DL, days** | 323.74 | 9.45 | 45.15 | 7.72 | -14.35 | 3.98 | -30.80 | 4.22 |
| **MY, kg** | 3701.67 | 277.96 | -725.64 | 259.47 | 477.15 | 133.88 | 248.49 | 141.71 |
| **MFC, %** | 3.88 | 0.10 | -0.04 | 0.05 | 0.01 | 0.03 | 0.03 | 0.03 |
| **MFY, kg** | 144.26 | 13.17 | -28.89 | 10.50 | 18.55 | 5.42 | 10.34 | 5.74 |
| **4%FCM, kg** | 3644.58 | 305.69 | -723.51 | 260.08 | 469.06 | 134.19 | 254.45 | 142.04 |
| **DSP, days** | 124.19 | 10.32 | 41.13 | 20.69 | -19.45 | 10.68 | -21.68 | 11.30 |
| **AFC, days** | 789.95 | 48.58 | -6.03 | 40.15 | -5.17 | 20.72 | 11.19 | 21.93 |

Variability of duration of lactation ranged from 292.94 days in the third year to 368.89 days in the first year. However, the highest milk production per cow was recorded in the second year – 4.178.82 kg, with a deviation from the general average of 477.15 kg. In the first year, lactation had the longest duration, but milk production was the lowest 2.976.03 kg, with a deviation of -725.64 kg. Similar oscillations were identified for the production of 4% FCM.

In this example, the impact of the year on the performance traits of cows is obvious, which is primarily related to the quantity and quality of feed in the diet of cattle.

Year of calving caused significant variation of milk fat yield, so the highest production was realized in the second (deviation 18.55 kg), and the lowest in the first year (deviation -28.89 kg).

Service period and age at calving did not have a significant variation due to the impact of factor of calving year.

Season of calving of cows demonstrated highly significant effect (P<0.01) on the production of milk and 4% FCM, significant (P>0.05) on the production of milk fat and the milk fat content, but it had no effect on the duration of lactation and service period, and age at calving (P>0.05).

In this region, grazing and summer diet of cows, the use of pastures and free ranges showed positive effect on milk production which was the highest in the summer season (June, July, August) - 3807.75 kg with a deviation of 106.08 kg.

Lack of quality hay and silage, which usually occurs in late March, influenced that in the second season (March, April, May) the lowest quantity of milk with 3606.78 kg was produced with a deviation of -94.89 kg. The calving season caused significant deviations in the quantity of milk fat, which was the highest in the third season - 148.06 kg, and the lowest in the second - 140.58 kg.

*Pantelić et al.(2008b)* have found a statistically significant effect (P<0.01) of the calving year and season on age at first calving and duration of service period.

**Table 4. Least square means (lsm) and standard errors (Slsm) for milk and fertility traits in standard lactation by calving seasons**

| Traits | μ | SE | I (n=148) | | II (n=191) | | III (n=213) | | IV (n=185) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | lsm | Slsm | lsm | Slsm | lsm | Slsm | lsm | Slsm |
| **DL, days** | 323.74 | 9.45 | 326.19 | 9.48 | 322.94 | 9.53 | 322.02 | 9.53 | 323.81 | 9.51 |
| **MY, kg** | 3701.67 | 277.96 | 3670.32 | 279.08 | 3606.78 | 281.29 | 3807.75 | 281.01 | 3721.83 | 280.34 |
| **MFC, %** | 3.88 | 0.10 | 3.90 | 0.10 | 3.89 | 0.10 | 3.88 | 0.10 | 3.87 | 0.10 |
| **MFY, kg** | 144.26 | 13.17 | 143.71 | 13.21 | 140.58 | 13.28 | 148.06 | 13.27 | 144.70 | 13.25 |
| **4%FCM, kg** | 3644.58 | 305.69 | 3623.72 | 306.72 | 3551.40 | 308.74 | 3743.98 | 308.48 | 3659.21 | 307.87 |
| **DSP, days** | 124.19 | 10.32 | 126.46 | 10.51 | 123.21 | 10.88 | 121.15 | 10.83 | 125.93 | 10.72 |
| **AFC, days** | 789.95 | 48.58 | 799.43 | 48.73 | 779.30 | 49.04 | 782.46 | 49.00 | 798.61 | 48.90 |

**Table 5. Deviation of least squares (ĉ) and deviation errors (Sĉ ) for milk and fertility traits in standard lactation by calving seasons**

| Traits | μ | SE | I (n=148) | | II (n=191) | | III (n=213) | | IV (n=185) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ĉ | Sĉ | ĉ | Sĉ | ĉ | Sĉ | ĉ | Sĉ |
| **DL, days** | 323.74 | 9.45 | 2.45 | 1.26 | -0.80 | 1.08 | -1.72 | 1.01 | 0.07 | 1.06 |
| **MY, kg** | 3701.67 | 277.96 | -31.35 | 42.31 | -94.89 | 36.23 | 106.08 | 33.99 | 20.16 | 35.63 |
| **MFC, %** | 3.88 | 0.10 | 0.02 | 0.01 | 0.00 | 0.01 | -0.01 | 0.01 | -0.01 | 0.01 |
| **MFY, kg** | 144.26 | 13.17 | -0.55 | 1.71 | -3.68 | 1.47 | 3.80 | 1.38 | 0.44 | 1.44 |
| **4%FCM, kg** | 3644.58 | 305.69 | -20.86 | 42.41 | -93.17 | 36.31 | 99.40 | 34.07 | 14.63 | 35.71 |
| **DSP, days** | 124.19 | 10.32 | 2.27 | 3.37 | -0.98 | 2.89 | -3.04 | 2.71 | 1.74 | 2.84 |
| **AFC, days** | 789.95 | 48.58 | 9.48 | 6.55 | -10.65 | 5.61 | -7.49 | 5.26 | 8.66 | 5.51 |

Milk production in Serbia is still mainly realized on relatively small farms, often with less than 10 cows, but it is not negligible in terms of the total quantity

of milk that is produced, nor in terms of the number of people engaged in this production. In terms of social transition, milk production, even for farmers with fewer cows is an important source of livelihood.

## Conclusion

Knowledge of the impact of external factors on milk and fertility traits is very important in view of their importance in achieving breeding goals and good economic results.

The basis for selection work is the knowledge of the quality of bull sires used for insemination, and the mode of transmission of important traits to offspring. The bull-sires exhibited a highly significant effect ($P<0.01$) on all production traits, except for service period.

The impact of the year on the production traits is manifested mainly through the production and preparation of food, as well as its use in the diet of cattle during a year. Climatic factors have a very significant impact on the production of food, which is reflected in its quality and nutritional value that directly affects the quality of the diet of cows, and therefore the production and reproduction traits.

Season of calving of cows and differences between the seasons of the year can have a significant impact on the production of milk and meat. Differences between the seasons is reflected in the specific climatic conditions and the differences in diet, housing and care of animals.

## Uticaj genetskih i negenetskih faktora na proizvodne osobine krava simentalske rase

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## Rezime

Ovim istraživanjem je obuhvaćeno 737 kontrolisanih prvotelki simentalske rase, sa laktacijama zaključenim u toku jedne godine. Sve prvotelke su se nalazile na imanjima individualnih poljoprivrednih proizvođača. Istraživanja su obuhvatila uticaj bikova očeva, godine i sezone telenja na osobine mlečnosti i plodnosti. Metodom najmanjih kvadrata ustanovljeno je prosečno trajanje laktacije od 323,74 dana. Za vremenski period od 305 dana prvotelke su proizvele 3.701,67 kg mleka, odnosno, korigovano na 4%MKM 3.644,58 kg. Prosečna proizvodnja

mlečne masti iznosila je 144,26 kg a sadržaj mlečne masti 3,88%. Interval od telenja do prve inseminacije trajao je u proseku 124,19 dana, a grla su se prvi put telila u uzrastu od 789,95 dana.

Bikovi-očevi su imali visoko signifikantan uticaj (P<0,01) na trajanje laktacije, prinos mleka i 4%MKM, proizvodnju i sadržaj mlečne masti i uzrast krava pri prvom telenju. Na dužinu servis perioda bikovi-očevi nisu ispoljili značajnije dejstvo (P>0,05).

Godina telenja imala je visoko značajan uticaj (P<0,01) na trajanje laktacije, proizvodnju mleka, mlečne masti i 4%MKM. Sadržaj mlečne masti, trajanje servis perioda i uzrast pri prvom telenju nisu pokazali značajnija variranja usled uticaja različitih godina telenja (P>0,05). Sezona telenja krava je visoko značajno uticala (P<0,01) na proizvodnju mleka i 4%MKM, značajno (P>0,05) na proizvodnju mlečne masti, a na sadržaj mlečne masti, trajanje laktacije i servis perioda, uzrast pri telenju nije imala značajnijeg uticaja (P>0,05).

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