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# EFFECT OF FIXED AND CONTINUOUS NON-GENETIC FACTORS ON LENGTH OF SERVICE PERIOD IN SIMMENTAL COWS

**M.D. Petrović[1], M.M. Petrović[2], V. Bogdanović[3], S. Bogosavljević-Bošković[1], R. Đedović[3], S. Rakonjac[1]**

[1]Faculty of Agronomy, Cara Dušana 34, 32000, Čačak, Republic of Serbia
[2]Institute for Animal Husbandry, Autoput 16, P. Box 23, 11080, Belgrade-Zemun, Republic of Serbia
[3]Faculty of Agriculture, Nemanjina 6, 11080, Belgrade-Zemun, Republic of Serbia
Corresponding author: milunp@kg.ac.rs
Invited paper

**Abstract**: Cattle reproduction is a highly important field and complex stage of production with large reserves of milk, meat, breeding cattle and by-products. In scientific literature, fertility is generally assessed through age at first conception, gestation length, length of service period, calving interval, and calf birth weight. Determination of the effect of particular non-genetic factors on the above traits is a vital step in cattle breeding and reproduction. Length of service period is largely governed by the effect of non-genetic factors, viz. fixed effects generally including the effect of breeding region, season of birth, calving season, year of birth, calf sex and their interactions, and continuous or regression effects including age at first conception or age at calving. The effect of fixed and continuous non-genetic factors on length of service period was analysed in 245 Simmental cows (907 service period) in three breeding regions, with the effect of season of birth as a fixed factor and cow age at first conception as a continuous factor being highly significant ($P < 0.01$), and that of season of calving being significant ($P < 0.05$). The effect of breeding region, year of birth, parity group or age and calf sex was statistically non-significant ($P>0.05$). Therefore, the coefficient of determination showing the level of variation in service period as explained by the effect of non-genetic factors fitted in the model was low (0.078).

**Key words**: Simmental breed, service period, fixed non-genetic effects, continuous non-genetic effects, coefficient of determination

# Introduction

Cattle reproduction is a very important research field and a highly complex stage of cattle production securing reserves of milk, meat, breeding herds and by-products.

Fertility traits of great importance, which is expressed in the normal course of the production cycle. One of their most important specificity is pronounced variability and low heritability (*Novaković et al., 2011*).

At the current level of development of agricultural production and animal science, the issue of milk and meat production is considered less serious than that of cattle reproduction management. Cattle reproduction physiology is a complex field affected by a range of endogenic and exogenic factors more intensely than any other stage of cattle production. It is noted that there is a cow productivity limit beyond which normal fertility cannot be maintained. In their study on the effect of production levels on length of service period, *Hakana et al. (1995)* reported very significant differences ($P<0.01$) in length of service period between cows with high and low production levels (106.5 and 82.5 days, respectively). *Heushow (1993)* suggests that full economic returns from a herd can be achieved if oestrus occurs within 60 days following parturition in 85% of cows, if 70% of cows conceive after first insemination and if 60% of the conceived cows calve. The insemination index should be 1.6, the percentage of problem cows in a herd should be below 10% and the proportion of cows showing silent oestrus below 15%. Service period should be shorter than 100 days, as stated by the said author.

In their study on cattle fertility, *Trifunović et al. (1990)* provided a classification of the parameter, with the service period of 70 days, 71-90, 91-110 and over 110 days being classified as excellent, very good, satisfactory and unsatisfactory, respectively. Unfortunately, the unsatisfactory service period of over 110 days is quite common in practice, as reported by most authors.

*Schmitz (1996a, 1996b, 1997 and 1998)* report the average service period of 95-97, 89-95 and 93-99 days in Simmental cows with 14%, 14-74% and 75-100% Red and White Holstein (RWH) inheritance, respectively.

*Petrović D.M. et al. (2009)* reported the average service period of 137, 146 and 179 days in 2805 Simmental cows kept in three breeding regions under different housing systems and at different altitudes. Service period was longest in cows housed on privately owned upland mini farms that had no adequate rearing conditions available due to land fragmentation, low financial resources and low level of knowledge regarding animal husbandry practices. In contrast, the other two state-owned farms provided better conditions and, hence, ensured a considerably shorter service period, although longer than optimum (137 and 146 days, respectively).

*Pichler (2004)* reports the service period of 90-95 days for the Simmental breed as a breeding programme target in the Czech Republic.

Research conducted by *Pantelić et al. (2005)* on the effect of non-genetic factors on reproductive traits of Simmental bull dams resulted in the overall least squares mean for length of service period of 108.98 days.

The same author, *Pantelić et al. (2008),* using the method of least squares, have established very significant effect of region on the service period, which amounted to 115. 19 days. Studying the production and reproduction traits of Simmental and Holstein Friesian cows of the Semberia, *Budimir et al.(2011*) point out that the service period after the first three lactations in Simmental cows was 163.97, 136.85 i 126.43 days.

## Material and Methods

Effect of non-genetic environmental factors on length of service period was evaluated in 245 Simmental cows with a total of 907 service period housed on privately-owned mini farms under tie-stall system in the Municipality of Čačak (n=67 cows and n=297 service period), Zlatibor (n=123 cows and n=439 service period) and Rudno region (n=51 cows and n=171 service period). The Municipality of Čačak is a lowland, whereas Zlatibor and Rudno regions are upland areas.
The effect of the following systematic factors on service period length was evaluated:

- ***Breeding region (farm).*** Three locations employing a tie-stall housing system were covered by the study, two in the upland region (II – mini dairy farms on Mt. Zlatibor and III – on Rudno highlands) and one in the lowlands (I – mini farms in the Municipality of Čačak).
- ***Parity groups.*** To reduce variability induced by the decrease in the number of cows across parity groups, the effect of five groups of parity (group I (1st parity), group II (2nd parity), group III (3rd parity), group IV (4th parity), group V (5th and above)) rather than the effect of each individual parity, was evaluated.
- ***Calving season i.e. the onset of lactation.*** The effect of four seasons, including I – spring season (March, April, May), II – summer season (June, July, August), III – autumn season (September, October, November) and IV – winter season (December, January, February) was analysed.
- ***Season of birth.*** Effects of four seasons, viz. I-spring season (March, April, May), II-summer season (June, July, August), III-autumn season (September, October, November), and IV-winter season (December, January, February) were evaluated.
- ***Year of birth.*** Ten years of birth i.e. cows born during 1998-2007 were covered by the experiment.
- *Calf sex:* I-male calves, II – female calves.

- ***Year of birth x season of birth interaction*** (10 years of birth (1998-2007) x 4 seasons of birth).
- ***Age at first conception.***

The analysis of the effect of the above systematic environmental factors was conducted using a general linear model enabling a simultaneous analysis of a number of different effects, irrespective of their being categorical or continuous ones. The general linear model involved the use of the least squares method for the evaluation of the effects and testing of the hypotheses, according to the following model:

$$\mathbf{y}_{ijklmn} = \mu + \mathbf{R}_i + \mathbf{P}_j + \mathbf{Sc}_k + \mathbf{Sb}_l + \mathbf{Yb}_m + \mathbf{S}_n + \mathbf{YbSb}_{ml} + \mathbf{b}_1(\mathbf{x}_1 - \bar{x}_1) + \mathbf{e}_{ijklmn},$$ where

$\mathbf{y}_{ijklmn}$ - individual cow of the i-th rearing area, j-th parity group, k-th season of calving, l-th season of birth, m-th year of birth and n-th sex of calf),
$\mu$ - overall population mean under identical distribution of all classes of effects (R, P, Sc, Sb, Yb, S, YbSb),
$\mathbf{R}_i$ - fixed effect of the i-th rearing area (1-3),
$\mathbf{P}_j$ - fixed effect of the j-th parity group (1-5),
$\mathbf{Sc}_k$- fixed effect of the k-th season of calving (1-4),
$\mathbf{Sb}_l$ – fixed effect of l- th season of birth, (1-4),
$\mathbf{Yb}_m$ – fixed effect of m-th year of birth (1-10),
$\mathbf{S}_n$ -fixed effect of the n-th sex of calf (1-2),
$\mathbf{YbSb}_{ml}$ – fixed effect of the m-th year of birth x l-th season of birth (1-40),
$\mathbf{b}_1$ - linear regression coefficient of the effect of age at first conception and
$\mathbf{e}_{ijklmn}$ - other non-determined effects

Further analysis of service period shows results of the analysis of variance using the above model, i.e. significance of factors, as well as the coefficient of determination ($R^2$), denoting the remainder and the model variance divided by 100, respectively.

## Results and Discussion

The effect of systematic environmental factors on service period was analysed by calculating the least squares means (LSM) and standard errors of the means ($SE_{LSM}$). The results of the analysis are given in Table 1.

**Table 1. Least squares means, standard errors of the means and significance of the effect of systematic factors and age at first conception on service period *(SP)***

| Systematic effects | Service period - SP (days) | | |
|---|---|---|---|
| | N | LSM | $SE_{LSM}$ |
| *Total* | *907* | *104.44* | *2.132* |
| Farm | | | |
| I | 297 | 104.03 | 3.423 |
| II | 439 | 103.50 | 3.025 |
| III | 171 | 107.55 | 5.703 |
| $F_{exp}$ | | $0.218^{ns}$ | |
| Parity groups | | | |
| I (1) | - | - | - |
| II (2) | 248 | 111.98 | 4.481 |
| III (3) | 248 | 101.49 | 4.006 |
| IV (4) | 248 | 100.22 | 3.786 |
| V (5 and remain.) | 163 | 103.86 | 4.864 |
| $F_{exp}$ | | $1.783^{ns}$ | |
| Calving season | | | |
| I | 250 | 97.84 | 3.162 |
| II | 223 | 106.90 | 4.543 |
| III | 186 | 101.81 | 4.417 |
| IV | 248 | 110.84 | 4.776 |
| $F_{exp}$ | | 2.676* | |
| Season of birth | | | |
| I | 251 | 102.10 | 3.902 |
| II | 256 | 98.89 | 3.821 |
| III | 160 | 107.22 | 4.708 |
| IV | 240 | 110.94 | 4.656 |
| $F_{exp}$ | | $8.332^{**}$ | |
| Calf sex | | | |
| I | 448 | 102.62 | 2.786 |
| II | 459 | 106.20 | 3.220 |
| $F_{exp}$ | | $1.376^{ns}$ | |
| Year of birth | | | |
| $F_{exp}$ | | $1.237^{ns}$ | |
| Year of birth x season of birth | | | |
| $F_{exp}$ | | $1.434^{ns}$ | |
| Age at first conception | | | |
| $F_{exp}$ | | $7.196^{**}$ | |
| Coefficient of determination – $R^2$ | | $0,078^{**}$ | |

*N.S. - $P > 0.05$; * - $P < 0.05$; ** - $P < 0.01$; *** - $P < 0.001$;*

An average length of service period was considerably longer than that ensuring the production of one calf per year, set as a goal of milk and meat production in cattle breeding. The prolonged service period indicates the unfavourable effect of fixed non-genetic factors.

The effect of farm on length of service period was non-significant (P>0.05), suggesting similar rearing conditions and technology. A non-significant effect of breeding region on length of service period was observed by *Đurđević (2001),* whereas significant and very highly significant effects were reported in a considerably larger number of studies (*Skalicki et al., 1991; Pantelić et al., 2005; Petrović D.M. et al., 2009)*.

Similarly to breeding region, the effects of parity group, calf sex, year of birth and the year of birth x season of birth interaction had no significant effect on fertility rate (P>0.05).The effect of parity order on service period was found to be either non-significant (P>0.05), as reported by *Đurđević (2001), Pantelić et al. (2005)* and *Petrović D.M.i sar. (2009),* or significant (P<0.05), very significant (P<0.01) and very highly significant (P<0.001) in the studies by *Caput et al. (1991), Perišić (1998)* and *Petrović D.M. (2000).* When analysing the effect of birth type, calf sex and birth type x calf sex interaction on reproductive traits in Simmental cows, *Petrović D.M. (2000) and Petrović D.M. et al. (2009)* found no significant effect of calf sex on length of service period.

The effects of season of birth, season of calving and onset of lactation as non-genetic factors on length of service period are reflected through different climate and diet conditions throughout the year, and have been the subject of a substantial number of studies.

Service period was statistically significantly (P<0.05) affected by calving season. Spring calving cows had a significantly shorter service period (97.84 days). A significant effect of calving season on service period was reported by *Đurđević (2001)* whereas a non-significant effect (P>0.05) of calving season on fertility rate was observed by *Perišić (1998), Petrović D.M. (2000) and Petrović D.M. et al. (2009).*
Length of service period was affected by season of birth. Spring- and summer-born cows had a highly significantly (P<0.01) shorter service period compared to winter- and autumn-born cows. In their study on the effect of fixed non-genetic factors on fertility traits in Simmental cows, *Petrović D.M. et al. (2009)* found fertility rate to be very highly significantly affected by the season of birth x year of birth interaction.
The regression analysis used suggested that the effect of age at first conception on service period was statistically highly significant (P<0. 01). *Perišić (1998)* and *Petrović D.M. (2009)* confirmed the highly significant (P<0.01) effect of age at first conception as the fixed factor on service period, whereas *Petrović D.M. (2000)* reported non-significant regression effects (P>0.05).

Given the non-significant effects (P>0.05) of breeding region, year of birth, parity group i.e. age, and calf sex on fertility rate, the coefficient of determination ($R^2$), showing the level of variation in service period as explained by the effect of non-genetic factors fitted in the model, was moderately low - 0.078 i.e. 7.8%. The low value for the coefficient of determination clearly suggests that service period was also affected by a range of genetic and non-genetic factors not included in the model. A somewhat lower coefficient of determination for service period (0.036 i.e. 3.6 % and 0.050 i.e. 5.0%) was reported by *Petrović D. M. (2000 and 2009)* in his study on the effect of systematic factors on reproductive traits.

## Conclusion

The effect of fixed and continuous non-genetic factors on length of service period was analysed in 245 Simmental cows (907 calving interval) in three breeding regions, with the effect of season of birth as a fixed factor and cow age at first conception as a continuous factor being highly significant ($P < 0.01$), and that of season of service period significant ($P < 0.05$).

The effect of breeding region, year of birth, parity group or age and calf sex was statistically non-significant ($P > 0.05$). Therefore, the coefficient of determination showing the level of variation in service period as explained by the effect of non-genetic factors fitted in the model was low (0.078 i.e. 7.8 %).

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## Uticaj fiksnih i kontinuiranih negenetskih faktora na trajanje servis perioda kod krava simentalske rase

*M.D. Petrović, M.M. Petrović, V. Bogdanović, S. Bogosavljević-Bošković, R. Đedović, S. Rakonjac*

## Rezime

Reprodukcija goveda predstavlja veoma značajnu oblast i vrlo složenu fazu proizvodnje u kojoj se nalaze velike rezerve mleka, mesa, priplodnih grla i sporednih proizvoda.

U literaturi plodnost se najčešće posmatra preko uzrasta pri prvoj oplodnji, trajanja bremenitosti, servis perioda, intervala između telenja i mase teladi pri rođenju.

Determinisanje uticaja pojedinih sistematskih faktora na pomenute osobine od velike je važnosti u procesu odgajivanja i reprodukcije goveda.

Dužina servis perioda definisana je najvećim delom dejstvom paragenetskih faktora, od kojih kao fiksni uticaji najčešće se pominju uticaj odgajivačkog područja, sezone rođenja i telenja, godine rođenja, pola teladi i njihove interakcije, a od kontinuelnih ili regresijskih uzrast krava pri prvoj oplodnji ili telenju.

Analiza uticaja fiksnih i kontinuiranih negenetskih faktora na dužinu odnosno trajanje servis perioda izvršena je kod 245 krava simentalske rase (907 servis perioda) raspoređenih na tri odgajivačka područja pri čemu je uticaj sezone rođenja kao fiksnog i uzrasta krava pri prvoj oplodnji kao kontinuiranog faktora bio visoko značajan ($P<0.01$) dok je uticaj sezone telenja na dužinu servis perioda bio značajan ($P<0.05$). Uticaj odgajivačkog područja, godine rođenja, grupe partusa odnosno starosti kao i pola teladi nije bio statistički značajan ($P>0.05$), pa je shodno tome i koeficijenat determinacije, koji ukazuje na nivo objašnjenosti variranja servis perioda dejstvom negenetskih faktora obuhvaćenih primenjenim modelom nizak i iznosi svega 0.078.

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