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VARIABILITY OF GENETIC CORRELATIONS OF MILK YIELD AND FERTILITY TRAITS IN SIMMENTAL COWS IN DIFFERENT REGIONS OF SERBIA

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Abstract: The Simmental breed of cattle is mostly reared in the central part of the Republic of Serbia, where it makes up about 80% of all breeds. In areas of more intensive cattle production, populations of cattle with pronounced milk yield are reared. In more extensive, as well as hilly and mountainous areas, somewhat less productive animals are raised. The main goal of this study was to examine the variability of genetic correlations of milk and fertility traits on the farms of individual agricultural producers using modern methods, depending on the breeding area, i.e. the region in which they are bred and reared. This study included 2589 controlled Simmental heifers, with lactations concluded during one year. All first calving heifers were housed and reared on agricultural family farms in the area of Central Serbia. The paper examines genetic correlations between the following traits of milk yield and fertility: duration of lactation, milk yield in standard lactation, milk fat content in standard lactation, milk fat yield in standard lactation, yield of 4% FCM in standard lactation, age at first calving, duration of service period. The results of the study of genetic correlations were obtained using mixed LSMLMW models (*Harvey 1990*). The examined genetic correlations of milk yield and fertility traits in Simmental cows showed pronounced variability depending on the breeding area where the cows are reared.

Key words: genetic correlations, Simmental breed, regions, milk yield, fertility.

Introduction

Genetic correlations are of great importance in indirect selection where changes in one trait are caused through the selection of another trait between which there is a genetic correlation. *Chaunan and Hayes (1991)* have found a moderate to very positive 0.45 ± 0.053 genetic association between milk production and milk fat, between milk fat content and yield 0.56 ± 0.045, between milk yield and milk fat content 0.49 ± 0.050.

Campos et al. (1994), in their study of the genetic parameters of milk yield and reproductive traits of Holstein cows, have found the genetic correlation between milk yield and milk fat of 0.743; between milk yield and fat content 0.235; milk yield and duration of service period of 0.159; between milk yield and calving interval 0.170.

Estimates of genetic correlations for milk yield, milk fat and milk fat content have high interdependence according to *Miščević (1995),* which indicates that information from the first lactation can be used for selection and breeding purposes. The correlation between milk production and milk fat in the first lactation is 0.93; between milk yield and milk fat content -0.32; between milk yield and 4% FCM 0.95; between yield and milk fat content 0.49; between milk fat yield and 4% FCM 0.93 and between milk fat content and 4% FCM yield -0.42.

Marković (1999) states positive values of genetic correlations between milk traits, except for those between milk yield and milk fat content. Genetic correlation parameters range from −0.78 (milk yield and milk fat content) to 0.95 (milk yield and 4% FCM).

Costa et al. (2000), in studies related to genetic analysis of the Holstein Friesian population in the United States and Brazil, have established a value of genetic correlation coefficient between milk and milk fat production of 0.79 in Brazil and 0.62 in the United States.

Gaydarska et al. (2001) investigated phenotypic and genotypic correlations on a sample of 3,254 cows. Analyzes shows a high and positive genetic correlation between milk production and milk fat 0.935 and 0.953. The correlation between milk yield and milk fat percentage is negative -0.155. A slightly positive genetic and phenotypic association are established between the production and the percentage of milk fat of 0.171 and 0.045, respectively.

Oseni et al. (2004), in their study of genetic parameters related to the service period and the duration of pregnancy, present data on the correlation between milk production and the duration of the service period from 0.12 to 0.6.

Studying the heritability and genetic correlations of production traits of Simmental heifers in Serbia, *Pantelić et al. (2011)* find that the genetic correlation between the traits of milk yield and the duration of the service period or age at first calving is extremely weak and weak positive. Thus, the coefficients of correlation between the service period and the traits of milk yield are: duration of lactation 0.239, milk yield 0.089, percentage of milk fat 0.095, quantity of milk fat 0.105, and yield of 4% FCM 0.099. The correlation between the service period and the age at calving is 0.535. Genetic correlation between age at calving and milk traits have the following values: duration of lactation 0.245, milk yield 0.003, percentage of milk fat 0.531, quantity of milk fat 0.082 and production of 4% FCM 0.050.

In the study by *Toghiania (2012)*, genetic correlations between reproductive traits and milk yield range from −0.24 to 0.593. The correlation between milk yield and calving interval is 0.593, which indicates that increased milk production is associated with a longer calving interval. The same author cites a genetic correlation between milk yield and the duration of the service period of 0.355, with higher milk yield being associated with a longer service period.

When estimating the breeding value of Holstein-Friesian cows for milk traits using the method of selection index, *Lazarević (2019)* also states the values of correlations between milk traits and fertility. Genetic correlations of milk traits and fertility are slightly higher than phenotypic correlations. There is a weak negative to almost complete positive correlation between the examined milk traits. The genetic correlation between milk yield and milk fat yield is 0.9768. The content of milk fat is in a negative genetic correlation with the yield of milk fat -0.0055. Genetic and phenotypic correlations of milk and fertility traits are negative and very close to zero except for protein content and service period duration and protein content and calving interval which were positive: 0.1067 and 0.1010 (genetic), 0.0807 and 0, 0765 (phenotypic correlations), respectively.

Material and Methods

The Simmental breed of cattle is mostly reared in the central part of the Republic of Serbia, where it makes up about 80% of all breeds. In areas of more intensive cattle production, populations of cattle with pronounced milk yield are reared. In more extensive, as well as hilly and mountainous areas, somewhat less productive cattle breeds are reared. The parent population of the Simmental cattle breed in central Serbia consists of high quality breeding heads registered in the main cattle registry. According to the data of the Institute of Animal Husbandry, Belgrade Zemun (2019), in 2018, the number of registered heads of the Simmental breed was 163,016, which is 90% of the total number of registered cattle of all other breeds.

This study included 2589 controlled first-calving heifers of the Simmental breed, with lactations concluded during one year. All heifers were located on the farms of individual agricultural producers in Central Serbia. The paper examines the genetic correlations between the following traits of milk yield and fertility:

- 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 4% MKM in standard lactation (kg) -4% FCM
- age at first calving (days) - AFC
- duration of service period (days) -DSP

The results of genetic correlation research were obtained using mixed models of LSMLMW (*Harvey 1990*):

$$Y_{ijklm} = \mu + B_i + R_j + G_k + S_l + e_{ijklm}$$

Yijklm = manifestation of the trait in the *m*th cow, daughter of the *i*th bull-sire, which produced in the *j*th region, and which calved in *k*th year in the *l*th season

μ = general average
B_i = random effect of *i*th bull-sire
R_j = fixed effect of the *j*th region
G_k = fixed effect of the *k*th year of calving
S_l = fixed effect of the *l*th calving season
e_{ijklm} = random error

The first-calving heifers included in this research were reared on family farms, but mainly in different housing and feeding conditions, depending on the breeding area. The cows were kept in barns with a tied system, on long and medium-long beds covered with straw. The diet was based on hay and whole maize plant silage, as well as ready-made mixtures of concentrates, depending on the amount of milk produced. Milk control was performed according to the AT4 method by primary breeding organizations. In the AT4 method, the measurement of the obtained quantity of milk is performed only during the morning or only during the evening milking on the control day (alternative method), where the obtained results must be mathematically corrected to the reference method.

When examining the variability of genetic correlations of production and reproduction traits by regions of Serbia, all first-calving heifers included in this research were classified into 5 breeding regions are as follows:

1. Mačva-Kolubara region (area of the municipalities of Šabac and Valjevo)
2. Braničevo-Podunavlje region (area of the municipality of Požarevac and Smederevo)
3. Šumadija region (area of the municipalities of Kragujevac and Mladenovac)
4. Zaječar region (area of the municipality of Zaječar)
5. South region (area of the municipalities of Pirot, Leskovac, Prokuplje and Niš)

Figure 1. Distribution of first calves by regions

1	2	3	4	5
342	689	737	416	405

Due to the specifics of the terrain, i.e. approximately the same configuration, nutrition, as well as the conditions and methods of keeping, the breeding areas are grouped with each other, except for the Zaječar region, which figures as independent.

Results and Discussion

In addition to examining heritability to determine optimal selection methods and procedures, it is very important to examine the phenotypic and genetic association of traits that are to be improved through selection.

Table 1. Coefficients of genetic correlations (r_p) and their errors (S_{rp}) between milk and fertility traits in standard lactation in regions 1, 2 and 3

Traits	REGION 1		REGION 2		REGION 3	
	r_p	Sr_p	r_p	Sr_p	r_p	Sr_p
DL, days						
MY, kg	-0.594	0.277	-0.469	0.206	-0.325	0.245
MFC, %	0.792	0.171	0.820	0.171	0.357	0.197
MFY, kg	-0.459	0.358	-0.324	0.231	-0.122	0.240
4%FCM, kg	-0.529	0.315	-0.387	0.221	-0.195	0.243
DSP, days	0.655	0.257	0.543	0.224	0.376	0.243
AFC, days	0.700	0.331	0.073	0.285	0.352	0.225
MY, kg						
MFC, %	-0.976	0.117	-0.292	0.279	-0.500	0.187
MFY, kg	0.989	0.023	0.982	0.011	0.956	0.021
4%FCM, kg	0.997	0.006	0.994	0.004	0.982	0.009
DSP, days	-0.937	0.199	-0.084	0.291	-0.416	0.393
AFC, days	-0.838	0.270	0.266	0.276	-0.124	0.255
MFC, %						
MFY, kg	-0.933	0.177	-0.109	0.292	0.731	0.118
4%FCM, kg	-0.958	0.142	-0.186	0.285	0.656	0.144
DSP, days	0.343	0.769	0.386	0.326	0.030	0.747
AFC, days	0.976	0.210	0.227	0.334	0.108	0.218
MFY, kg						
4%FCM, kg	0.997	0.006	0.997	0.002	0.995	0.003
DSP, days	-0.863	0.291	-0.009	0.298	0.176	0.244
AFC, days	-0.750	0.348	0.314	0.276	-0.058	0.242
4%FCM, kg						
DSP, days	-0.903	0.240	-0.041	0.295	-0.041	0.295
AFC, days	-0.797	0.304	0.295	0.275	-0.082	0.246
DSP, days						
AFC, days	0.159	0.328	0.286	0.326	0.203	0.240

Table 2. Coefficients of genetic correlations (r_p) and their errors (S_{rp}) between milk and fertility traits in standard lactation in regions 4 and 5

Traits	REGION 4		REGION 5	
	r_p	Sr_p	r_p	Sr_p
DL, days				
MY, kg	0.058	0.477	-0.417	0.267
MFC, %	-0.144	0.415	0.245	0.296
MFY, kg	-0.007	0.465	-0.374	0.272
4%FCM, kg	0.018	0.471	-0.393	0.270
DSP, days	0.239	0.281	0.244	0.236
AFC, days	0.286	0.939	-0.296	0.305
MY, kg				
MFC, %	0.194	0.323	-0.231	0.251
MFY, kg	0.924	0.050	0.981	0.010
4%FCM, kg	0.970	0.020	0.993	0.004
DSP, days	0.316	1.382	-0.396	0.952
AFC, days	0.302	0.801	-0.439	0.235
MFC, %				
MFY, kg	0.552	0.237	-0.038	0.257
4%FCM, kg	0.423	0.278	-0.118	0.255
DSP, days	0.221	0.236	0.430	1.031
AFC, days	-0.673	0.842	-0.096	0.273
MFY, kg				
4%FCM, kg	0.989	0.007	0.997	0.002
DSP, days	-0.322	1.290	-0.315	0.894
AFC, days	0.030	0.747	-0.466	0.229
4%FCM, kg				
DSP, days	-0.050	1.098	-0.350	0.918
AFC, days	0.136	0.768	-0.457	0.231
DSP, days				
AFC, days	0.194	0.323	-0.487	1.067

Coefficients of genetic correlation of milk traits, as well as individual reproductive traits - duration of service period and age at calving in different regions of Serbia, are shown in Tables 1 and 2.

Genetic correlations can be positive, when change in the additive effect of a gene in one trait causes a one-way change in the additive effect in another trait. Negative genetic correlation means opposite in the direction of changes in additive effects in two traits. The increase of the additive effect in one is accompanied by the decrease of the mentioned effect in the other trait and vice versa. The strength of the correlation of the examined traits was classified based on the interpretation of Pearson's linear correlation coefficient: ≥0.70 strong correlation, 0.30 - 0.69

mean correlation, <0.30 weak correlation, about 0.0 no linear correlation (does not exclude the existence of a nonlinear form of correlation) (www.mfub.bg.ac.rs/dotAsset/66835.pdf).

Obtained results of genetic correlations between milk yield and milk fat yield (region 1: 0.989, region 2: 0.982, region 3: 0.956, region 4: 0.924, region 5: 0.981), i.e. between milk yield and yield of 4% FCM (region 1: 0.997) , region 2: 0.994, region 3: 0.982, region 4: 0.970, region 5: 0.993) indicate the presence of a strong and complete association between these two traits. The correlation between milk yield and milk fat content had a pronounced variability ranging from -0.976 in the Mačva Kolubara region to 0.194 in the Zaječar region.

The genetic correlation between milk production and the duration of the service period by regions was in the following range: region 1: -0.937, region 2: -0.084, region 3: -0.416, region 4: 0.316, region 5: -0.396. The correlation coefficients between the service period and milk fat content were moderately strong and positive and ranged from 0.030 in the Šumadija region to 0.430 in the South region.

The coefficient of genetic correlations between age at calving with milk production had the following values: Mačva Kolubara region -0.838, Podunavlje Braničevo region 0.266, Šumadija region -0.124, Zaječar region 0.302 and South region -0.439. The mutual genetic correlation between age at calving and milk fat content showed a significant degree of variability, which ranged from -0.673 (Zaječar region) to 0.976 (Mačva Kolubara region).

Analyzing the genetic correlations of milk and fertility traits according to different regions of Serbia shown in Tables 1 and 2, we can conclude the following differences and specificities:

1. In the Mačva-Kolubara region, the correlations between the service period and age at calving, on the one hand, and milk yield, on the other, were negative and high, ranging from -0.937 to -0.838. A negative correlation between fertility and milk fat yield has also been established.

2. In the Braničevo-Podunavlje region, the correlation between the duration of the service period and the production of milk, milk fat and 4% FCM, the coefficients of genetic correlations were negative: -0.084, -0.009 and -0.041, respectively.

3. The genetic correlation between age at calving and milk yield, percentage of milk fat, quantity of milk fat, 4% FCM in the Šumadija region was negative and had the following values: -0.124, 0.108, -0.058 and -0.082, respectively.

4. In the Zaječar region, milk yield had a positive genetic correlation with reproductive traits: service period - 0.316 and age at first calving - 0.302. The correlation between milk yield and milk fat content, and 4% FCM, was positive and strong and quite high: 0.924 and 0.970, respectively.

5. The percentage of milk fat in the South region showed a negative correlation with milk yield -0.231, yield of 4% FCM -0.118, calving age -0.096 and a positive correlation with the duration of the service period 0.430 and the duration of lactation and 0.245. The genetic correlation of service period and age at calving was negative -0.487.

If we compare the obtained results with the studies of other authors, it can be concluded that the positive values of the coefficients of genetic correlations between milk yield and service period were established by *Campos et al. (1994), Petrović et al. (1998), Oseni et al. (2004), Pantelić et al. (2011)* and *Toghiania (2012)*. The positive correlation between milk yield and age at calving is stated by *Petrović et al. (1998),* who also find a positive relationship between the duration of the service period and the age at calving, on the one hand, and the yield of milk fat, on the other. A positive genetic correlation between milk yield and milk fat content, and 4% FCM, is stated by a number of authors in their studies: *Chaunan and Hayes (1991), Campos et al. (1994), Miščević (1995), Marković M. (1999), Costa et al. (2000), Gaydarska et al. (2001)* and *Lazarević (2019).*

Conclusion

The main goal of breeding and selection work is to create new generations that will surpass the previous ones in terms of their production results and show greater production effects in the production of milk and meat. For these reasons, it is necessary, in the selection work, to know the breeding value of parental pairs, as well as the degree of heredity and genetic correlation of important traits to the offspring.

Estimates of genetic correlations for milk yield, milk fat yield and milk fat content have high interdependence, which indicates that information from the first lactation can be used for selection and breeding purposes. The examined genetic correlations of milk and fertility traits in Simmental cows showed pronounced variability depending on the breeding region.

Determining the degree of correlation between two or more traits largely depends on their manifestation. Knowing the genetic and phenotypic correlations between fertility traits and milk yield can help define the breeding goal.

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Varijabilnost genetskih korelacija osobina mlečnosti i plodnosti kod krava simentalske rase u različitim regionima Srbije

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Rezime

Simentalska rasa goveda najviše se gaji u centralnom delu Republike Srbije gde čini oko 80% svih rasa. U područjima intenzivnije govedarske proizvodnje gaje se populacije goveda naglašene mlečnosti. U ekstenzivnijim, kao i brdsko-planinskim područjima, gaje se nešto manje produktivna grla. Osnovni cilj ovih istraživanja bio je da se na imanjima individualnih poljoprivrednih proizvođača primenom savremenih metoda ispita varijabilnost genetskih korelacija proizvodnih i reproduktivnih osobina u zavisnosti od odgajivačkog područja odnosno regiona, u kojima se grla i odgajaju.
Ovim istraživanjem je obuhvaćeno 2.589 kontrolisanih prvotelki simentalske rase, sa laktacijama zaključenim u toku jedne godine. Sve prvotelke su se nalazile na imanjima individualnih poljoprivrednih proizvođača na području Centralne Srbije. U radu su ispitane genetske korelacije između sledećih osobina mlečnosti i plodnosti: trajanje laktacije, prinos mleka u standardnoj laktaciji, sadržaj mlečne masti u standardnoj laktaciji, prinos mlečne masti u standardnoj laktaciji, prinos 4% MKM u standardnoj laktaciji, uzrast pri prvom telenju, trajanje servis perioda. Rezultati istraživanja genetskih korelacija dobijeni su korišćenjem mešovitih modela LSMLMW (Harvey 1990). Ispitivane genetske korelacije osobina mlečnosti i plodnosti kod krava simentalske rase, pokazale su izraženu varijabilnost u zavisnosti od odgajivačkog područja gde se grla odgajaju.

Ključne reči: genetske korelacije, simentalska rasa, regioni, mlečnost, plodnost.

References

CAMPOS M.S., WILCOX C.J., BECERRIL C.M., DIZ A. (1994): Genetic Parameters for Yield and Reproductive Traits of Holstein and Jersey Cattle in Florida. Journal of Dairy Science 77, 867-873.

CHAUNAN V.P.S., HAYES J.F. (1991): Genetic Parameters for First Lactation Production and Composition Traits for Holsteins Using Multivariate Restricted Maximum Likelihood. Journal of Dairy Science 74, 2, 603-610.
COSTA N.R., BLAKE W.R., POLLAK J.E., OLTENACU A.P., QUAS L.R., SEARLE R.S. (2000): Genetic Analysis of Holstein Cattle Populations in Brasil and The United States. Journal of Dairy Science 83, 12, 2963-2974.
GAYDARSKA V., KRUSTEV K., SIMEONOVA S., IVANOV M. (2001): Influence of environmental and genetic factors on the milk yield and phenotypic and genotypic parameters of milk production in Black-and-White dairy cows in Bulgaria. Biotechnology in Animal Husbandry 17, 1-2, 11-15.
HARVEY W.R. (1990): Mixed model Least Squares and maximum Likelihood Computer Program. User, s Guiede for LSML MW and MIX MDL.
INSTITUT ZA STOČARSTVO BEOGRAD-ZEMUN (2019): Stručni izveštaj i rezultati obavljenih poslova kontrole mera za sprovođenje odgajivačkog programa u 2018. Godini.
LAZAREVIĆ M. (2019): Procena priplodne vrednosti krava holštajn-frizijske rase za osobine mlečnosti primenom metode selekcijskog indeksa. Doktorska disertacija. Poljoprivredni fakultet, Beograd Zemun.
MARKOVIĆ M. (1999): Mješoviti modeli-BLUP i ANIMAL model u procjeni oplemenjivačke vrednosti bikova holštajn-frizijske rase. Doktorska disertacija. Poljoprivredni fakultet, Novi Sad.
MIŠČEVIĆ B. (1995): Komponente varijansi i genetski trend osobina mlečnosti tokom prve i kasnijih laktacija krava simentalske rase. Doktorska disertacija. Poljoprivredni fakultet, Novi Sad.
OSENI S., TSURUTA S., MISZTAL I., REKAYA R. (2004): Genetic parameters for days open and pregnancy rates in US Holsteins using different editing criteria. Journal of Dairy Science 87, 12, 4327-4333.
PANTELIĆ V., SRETENOVIĆ LJ., OSTOJIĆ ANDRIĆ D., TRIVUNOVIĆ S., PETROVIĆ M.M., ALEKSIĆ S., RUŽIĆ-MUSLIĆ D. (2011): Heritability and genetic correlation of production and reproduction traits of Simmental cows. African Journal of Biotechnology, 10, 36, 7117-7121.
PETROVIĆ M.M, LAZAREVIĆ R., LAZAREVIĆ LJ., MIŠČEVIĆ B., ALEKSIĆ S., NIKITOVIĆ N. (1998)**:** Naslednost i povezanost reproduktivnih osobina i mlečnosti crno belih goveda. Biotehnologija u stočarstvu, 14, 15-20.
TOGHIANI S. (2012): Genetic relationships between production traits and reproductive performance in Holstein dairy cows. Archiv fur Tierzucht, 55, 5, 458-468.
WWW.MFUB.BG.AC.RS/DOTASSET/66835.PDF

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