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PHENOTYPIC CORRELATION OF TRAITS OF PRODUCTION AND REPRODUCTION OF SIMMENTAL COWS IN DIFFERENT REGIONS OF SERBIA

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Abstract: The main goal of this research was to examine, using modern methods, the variability of phenotypic correlations of production performances and reproductive properties of Simmental cows reared on the farms of individual agricultural producers, in different breeding areas of the Republic of Serbia. The study of phenotypic correlations of milk performance and fertility properties in different regions of Serbia was carried out on a total of 3.056 primi parous Simmental heifers under control, with lactations completed within one year. The examined animals were reared on different individual farms, and mainly in very different conditions of housing and nutrition, depending on the breeding area. The study of phenotypic correlations included the following milk performance traits: milk yield, milk fat content, milk fat yield, yield of 4% corrected milk; and fertility properties: age at first calving and service period.

The results of the study among other things indicate that although the phenotypic correlations between the fertility and milk performance properties show different degrees of variation, they should be taken into account in the final assessment of the breeding value of the animal, so that the breeding selection programs are more comprehensively designes.

Key words: regions, correlations, milk performance, fertility, Simmental breed

Introduction

Phenotypic correlation of milk performance and fertility properties is very important in a comparative selection for several properties, and even more important for indirect selection in conditions where some properties can not be directly improved. At the same time, opportunities to increase the success of

selection are realized by early selection conclusions and decisions (*Pantelić et al., 2007).* In the mentioned study, age at calving was in negative phenotypic correlation with all production indicators: milk yield -0.023,% milk fat -0.005, milk fat -0.023, and production of 4% FCM -0.023. The mutual phenotypic correlation of age at calving and service period was week positive 0.047. The service period was also in a negative correlation with the milk yield traits, except for the milk fat content 0.001, and the duration of lactation 0.329.

The coefficients of phenotypic correlations between milk performance properties in standard lactation and age at first calving (AFC) and service period (SP) were calculated by *Stojić (1996).* Correlation coefficient values were: milk yield - AFC 0.034; milk yield - SP 0.095; milk fat % - AFC 0.034; milk fat% - SP - 0,032; milk fat, kg - AFC 0.045; milk fat, kg - SP 0.072; yield of 4% FCM - AFC 0.042; yield of 4% FCM - SP 0.085.

Marković (1999) notes the values of phenotypic correlations between milk performance properties. The results of phenotypic correlations ranged from -0.35 between milk yield and milk fat content up to 0.96 between milk yield and 4% FCM.

According to the results obtained by *Parna and Savelli (1998),* the phenotypic correlation between the yield of milk and the yield of milk fat and protein in Black and White cows ranges between 0.826 and 0.890,

Gaydarska et al. (2001) have investigated phenotypic and genotypic correlations on a sample of 3,254 cows. The analyzes shows a high and positive genetic and phenotypic correlation between milk production and milk fat 0.935 and 0.953. The correlation between the milk yield and the milk fat content was negative -0.155 (genetic) and -0.257 (phenotypic). Week positive genetic and phenotypic correlations of 0.171 and 0.045, respectively, between the milk fat yield and content were established.

The highly significant influence of the breeding area ($P<0.01$) on the production of milk and milk fat, milk fat content and yield of 4% FCM is confirmed by *Petrović et al. (2006)* for cows of the first Simmental breed. The authors believe that the results thus obtained indicate the justification of the use of linear methods, i.e. the correction of systematic environmental factors.

In the examination of the phenotypic and genetic correlations of the milk performance properties and the type of bull dams of Holstein Friesian breed, *Pantelić et al. (2012)* have established a negative phenotypic correlation between milk production and milk fat content of -0.28, and highly positive between milk yield and milk fat yield 0.99.

The results of phenotypic correlations in Simmental cows have been established by *Pantelić et al. (2018).* The mutual positive and complete phenotypic correlation between the yield of milk, milk fat and 4% of FCM have been established in all three lactations with the coefficient of correlation ranging from 0.98 to 0.99. Low and mainly positive correlation was established in yield

indicators and milk fat content (0.13, 0.21, 0.32). Low and generally positive phenotypic correlation has been reported in all three lactations for milk performance and fertility indicators. The coefficient of phenotypic correlations ranged from 0.03 between the milk yield and the duration of service period in the first lactation (Tab.1) to 0.24 between the yield of 4% FCM and the age at first calving.

Material and methods

This study covered 3,056 controlled primi parous Simmental females, with lactations completed within one year. All the primi parous cows were located on the farms of individual agricultural producers in the territory of the Republic of Serbia. The paper examines phenotypic correlations between the following milk performance and fertility propertiess:

- 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
- age at first calving (days) -AFC
- duration of service period (days) –DSP

The results of the study of phenotypic correlations were obtained using mixed models LSMLMW *(Harvey 1990):*

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

Y_{ijklm} = the manifestation of the trait of *m* cow, the daughter of the *i* bull sire, producing in the *j* region, which calved in *k* year and *l* season

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

The standard error of phenotypic correlations was calculated using the following formula:

$$SGr_p = \sqrt{\frac{1 - r_p^{\ 2}}{n - 2}}$$

The symbols have the following meanings:
SGrp-standard error of phenotypic correlations
rp-phenotypic correlations
n-total number of descendants/offspring

The examined animals were reared on different individual farms, and mainly in very different housing and nutrition conditions, depending on the breeding area. The cows were mainly kept in stables in a tied system, on long and medium long boxes with straw. The diet was based on hay and alfalfa haylage, whole maize silage and mainly ready concentrates. Productivity control was carried out according to the principles of the AT4 control of productivity by breeding organizations, which included measuring of the amount of milk daily/once a day, only during the morning or only during the evening milking on the control day (alternative method), but the results must be mathematically corrected to the reference method.

In order to investigate the variability of phenotypic correlations of production performance and reproductive properties across the regions of Serbia, all primi parous cows included in this research were classified into 6 breeding areas. Breeding regions were as follows:

1. Mačva-Kolubara (area of municipalities of Šabac and Valjevo)
2. Braničevo-Podunavlje (area of municipalities Požarevac and Smederevo)
3. Šumadija (municipality of Mladenovac and Kragujevac)
4. Raška-Rasina (area of Kraljevo and Kruševac municipalities)
5. Zlatibor-Moravica (area of municipalities of Užice and Čačak)
6. Zaječar (area of Zaječar municipality)

Because of the specificity of the terrain, i.e. approximately the same configuration, nutrition, as well as the housing conditions, the breeding areas are grouped together, except for the Zaječar region, which is considered as an independent one.

Figure 1. Distribution of the primi parous cows by regions

1	2	3	4	5	6
342	689	737	653	219	416

Results and discussion

In addition to examining heritability to determine optimal methods and selection procedures, it is very important to examine the phenotypic association of properties that are to be promoted through selection. The strength of the correlation of the examined properties is based on the interpretation of Pearson's linear

correlation coefficient: ≥0.70 strong connection, 0.30 - 0.69 mean connection, <0.30 weak connection, around 0.0 no linear connection (does not exclude the presence of a nonlinear form of correlation).

The coefficients of the phenotypic correlation of milk performance properties, the duration of service period and the age at calving in different regions of Serbia are shown in Tables 1 and 2.

Table 1. Coefficients of phenotypic correlations (r_p) and their errors (Sr_p) between the milk performance and fertility properties in standard lactation in regions 1, 2 and 3.

	REGION 1		REGION 2		REGION 3	
Traits	r_p	Sr_p	r_p	Sr_p	r_p	Sr_p
DL, days						
MY, kg	-0.073	-0.004	-0.046	-0.002	-0.139	-0.005
MFC, %	0.190	0.010	0.082	0.003	0.097	0.004
MFY, kg	-0.026	-0.001	-0.020	-0.001	-0.107	-0.004
4% FCM, kg	-0.046	-0.002	-0.031	-0.001	-0.120	-0.004
DSP, days	0.229	0.012	0.232	0.009	0.197	0.007
ACF, days	0.075	0.004	0.006	0.000	0.004	0.000
MY, kg						
MFC, %	-0.234	-0.013	-0.050	-0.002	0.140	0.005
MFY, kg	0.968	0.052	0.949	0.036	0.976	0.036
4% FCM, kg	0.989	0.053	0.981	0.037	0.991	0.037
DSP, days	-0.170	-0.009	0.066	0.003	-0.012	0.000
ACF, days	0.074	0.004	0.097	0.004	-0.016	-0.001
MFC, %						
MFY, kg	0.016	0.001	0.267	0.010	0.350	0.013
4% FCM, kg	-0.088	-0.005	0.142	0.006	0.269	0.010
DSP, days	0.132	0.007	-0.078	-0.003	0.022	0.001
ACF, days	0.089	0.005	-0.027	-0.001	0.055	0.002
MFY, kg						
4% FCM, kg	0.994	0.054	0.992	0.038	0.996	0.037
DSP, days	-0.139	-0.008	0.038	0.001	-0.007	0.000
ACF, days	0.098	0.005	0.085	0.003	-0.003	0.000
4%FCM, kg						
DSP, days	-0.153	-0.008	0.050	0.002	-0.009	0.000
ACF, days	0.089	0.005	0.091	0.003	-0.008	0.000
DSP, days						
ACF, days	0.076	0.004	0.066	0.003	-0.007	0.000

In the first region, a positive correlation was established between the age at first calving and milk performance traits, and the coefficient of correlation ranged

from 0.074 with milk yield to 0.098 with the milk fat yield. So the correlation was positive and quite weak. Strong and positive phenotypic correlation in this region was determined between the milk yield and milk fat yield 0.968 and 4% FCM 0.989. Service period was in week negative phenotypic correlation with milk yield -0.170 and quantity of milk fat -0.139.

As a general characteristic of all regions, a complete and very strong correlation between milk yield and milk fat yield, and 4% FCM (0.970 and more) was established. Also noticeable is the markedly negative correlation between milk yield and milk fat content, which was weakly positive in Šumadija (0.140), Zaječar (0.153) and Zlatibor-Moravica (0.083) regions.

The phenotypic correlation between the service period and the milk yield varied from the negative ones in Mačva-Kolubara (-0,170), Šumadija (-0,012), Raška-Rasina (-0,047), Zlatibor-Moravica (-0,137) and Zaječar (-0,103) regions to weakly positive in Braničevo-Podunavlje (0.066) region.

The correlation coefficient between age at calving and milk yield, milk fat and 4% FCM ranged from positive values in region 1 (0.044, 0.098, 0.089) to negative values in region 6 (-0.067, -0.089, -0.081). The negative coefficient of phenotypic correlations of these properties was also found in regions 3, 4, 5, 6, and positive in regions 1 and 2.

The presence of information on phenotypic and genetic correlations between milk performance and fertility properties can have multiple relevance in cow selection because it provides the ability to select animals for multiple traits at the same time. This is especially the case with the application of modern methods of mathematical statistics in the assessment of the additive genetic value of bulls and cows. In addition, an early selection of parents based on the first lactation is possible, which significantly shortens the period for the introduction of bulls into the breeding.

A negative phenotypic correlation between milk yield and milk fat content, and a positive between the yield of milk and the quantityof milk fat, and 4% of FCM, have been established in a number of studies: *Moore et al. (1991), Parna and Saveli (1998), Marković (1999), Pantelić et al. (2018).* Negative phenotypic correlations between the age at calving and milk yield are reported by *Pantelić et al. (2007).* Contrary to them, *Moore et al. (1991)* and *Stojić (1996),* provide data on the positive values of the coefficient of phenotypic correlation of these properties. Studying the genetic variability of the persistence of lactation of Simmental cows *Đurđević et al. (2002)* conclude that the examination of the effects of known environmental factors is justified because knowledge of their behaviour can contribute to more objective assessment of random effects.

Table 2. Coefficients of phenotypic correlations (r_p) and their errors (Sr_p) between the milk performance and fertility properties in standard lactation in regions 4, 5 and 6.

	REGION 4		REGION 5		REGION 6	
Traits	r_p	Sr_p	r_p	Sr_p	r_p	Sr_p
DL, days						
MY, kg	-0.079	-0.003	-0.030	-0.002	-0.144	-0.007
MFC, %	0.010	0.000	0.010	0.001	-0.025	-0.001
MFY, kg	-0.071	-0.003	-0.028	-0.002	-0.142	-0.007
4% FCM, kg	-0.075	-0.003	-0.029	-0.002	-0.144	-0.007
DSP, days	0.429	0.017	0.385	0.026	0.412	0.020
ACF, days	0.062	0.002	-0.149	-0.010	0.082	0.004
MY, kg						
MFC, %	-0.031	-0.001	0.083	0.006	0.153	0.008
MFY, kg	0.907	0.035	0.980	0.066	0.967	0.047
4% FCM, kg	0.964	0.038	0.993	0.067	0.988	0.048
DSP, days	-0.047	-0.002	-0.137	-0.009	-0.103	-0.005
ACF, days	-0.034	-0.001	-0.017	-0.001	-0.067	-0.003
MFC, %						
MFY, kg	0.383	0.015	0.278	0.019	0.394	0.019
4% FCM, kg	0.229	0.009	0.201	0.014	0.302	0.015
DSP, days	-0.008	0.000	-0.010	-0.001	-0.110	-0.005
ACF, days	0.030	0.001	-0.026	-0.002	-0.117	-0.006
MFY, kg						
4% FCM, kg	0.986	0.039	0.997	0.067	0.995	0.049
DSP, days	-0.045	-0.002	-0.133	-0.009	-0.123	-0.006
ACF, days	-0.013	-0.001	-0.021	-0.001	-0.089	-0.004
4%FCM, kg						
DSP, days	-0.047	-0.002	-0.135	-0.009	-0.116	-0.006
ACF, days	-0.022	-0.001	-0.019	-0.001	-0.081	-0.004
DSP, days						
ACF, days	0.101	0.004	-0.143	-0.010	0.108	0.005

Determination of the degree of correlation of two or more properties depends to a large extent on their manifestation. Knowing genetic and phenotypic correlations between fertility and milk performance properties can help define a breeding goal.

Phenotypic correlations are determined both by genetic and external factors. If the environmental conditions in animals were identical, then the

phenotypic value of the correlations would be equal to the genetic one. However, as there are no identical conditions in practical cattle-breeding, the values between these correlations are also different. If the external environment conditions are more stable, i.e. less variable, the degree of correlation between the phenotypes of the animals will be higher *(Petrović and Pantelić, 2015; Petrović et al. 2018.).*

Conclusion

Phenotypic correlation of properties in cattle breeding refers to the existence of a common positive or negative covariance, which arises as a result of the action of genetic and environmental factors.

The presence of information on phenotypic and genetic correlations between milk performance and fertility properties can have multiple relevance in cow selection because it provides the ability to select animals for multiple traits at the same time.

This is especially the case with the application of modern methods of mathematical statistics in the assessment of the additive genetic value of bulls and cows. In addition, an early selection of parents based on the first lactation is possible, which significantly shortens the period for the introduction of bulls into the breeding.

The effect of the breeding area includes many factors that complement one another, and the most important factor is the nutrition factor as well as the applied management. Although the phenotypic correlation between fertility and milk performance traits shows different degrees of variation in different regions of Serbia, they should be taken into account in the final assessment of the breeding value of the animal, in order to make the selection programs more comprehensively designed.

Ispoljenost fenotipskih korelacija proizvodnih i reproduktivnih osobina krava simentalske rase u različitim regionima Srbije

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Rezime

Osnovni cilj ovih istraživanja bio je da se na imanjima individualnih poljoprivrednih proizvođača primenom savremenih metoda ispita varijabilnost

fenotipskih korelacija proizvodnih osobina u zavisnosti od odgajivačkog područja Republike Srbije, u kojima se grla i odgajaju. Ispitivanje fenotipskih korelacija osobina mlečnosti i plodnosti u različitim regionima Srbije, izvršeno je na ukupno 3.056 kontrolisane prvotelke simentalske rase, sa laktacijama zaključenim u toku jedne godine. Ispitivana grla su gajena na različitim individualnim gazdinstvima, ali se može reći uglavnom u veoma različitim uslovima držanja i ishrane, u zavisnosti og odgajivačkog područja. Ispitivanje fenotipskih korelacija obuhvatilo je sledeće osobine mlečnosti: prinos mleka, sadržaj mlečne masti, prinos mlečne masti, prinos 4% mast korigovanog mleka; zatim osobine plodnosti: uzrast pri prvom telenju i servis period. Rezultati istraživanja između ostalog ukazuju da iako fenotipske korelacije između osobina plodnosti i mlečnosti pokazuje različite stepene variranja, treba ih uzeti u obzir kod konačne ocene priplodne vrednosti grla, kako bi se selekcijski programi što potpunije formirali.

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

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