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Full Length Research Paper

Heritability and genetic correlation of production and reproduction traits of Simmental cows

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Improvement of production capacity of cattle in terms of increasing the production of milk, milk fat and number of calves, greatly depends on phenotype and genotype variability, heritability and correlation between desirable traits, as well as on the production level of the cattle population. Heritability, as a value expressing and measuring average additive gene effect, is one of the major characteristic of quantitative traits from the point of view of creating genetically high-value cattle populations. Knowledge of the heritability is necessary in the estimation of the beeeding value of cattle and has significant impact on the selection of breeding method. Genetic correlations are very important in indirect selection where changes in one trait are induced through selection of other traits between which a genetic correlation exists. Genetic correlations can be determined in all cases where heritability coefficient can be calculated. This research included 3.461 first calving Simmental cows under control, with lactation concluded within one year. All first-calvers were reared on individual farms in the territory of Republic of Serbia. In this study, heritability and genetic correlations between the the following milk and fertility traits were investigated: 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)- AC and duration of service period (days)- DSP.

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

INTRODUCTION

Knowledge of genetic and phenotypic parameters is of great importance in the evaluation of the additive genetic value of milk traits in cattle population. Evaluation of the additive variance component depends, first of all, on additive gene effect of studied traits, method and implementation of the model of their evaluation, size of the sample and effect of other factors on expression of production and reproduction traits.

Costa et al. (2000) reported on genetic analysis of the Holstein-Friesian population in USA and in Brazil, and established value of the heritability coefficient for the production of milk and milk fat to be 0.25 and 0.22, respectively, in Brazil, and 0.34 and 0.35 in USA. Genetic analysis of the milk yield and reproduction properties of Simmental cows was reported by Durdević (2001). In this study, service period and calving interval was under the weak influence of additive genes (0.051 and 0.060), and heritability coefficients for milk yield and yield of milk fat in standard lactation were 0.350 and 0.369, respectively.

Petrović et al. (2001), established in their research low values of heritability coefficient for age at first conception (0.132), age at calving (0.127) and duration of service period. In the study of the variability of linear type scores and milk yield of first calving of black and white cows,

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Abbreviations: **DL**, Duration of lactation (days); **MY**, milk yield in standard lactation (kg); **MFC**, milk fat content in standard lactation (%); **MFY,** milk fat yield in standard lactation (kg); 4%**FCM**, yield of 4% FCM in standard lactation (kg); **AC**, age at first calving (days); **DSP,** duration of service period (days).

Živanović (2002) established low heritability values for the following traits: duration of lactation (0.014), milk yield in standard lactation (0.120), content of milk fat (0.147), yield of milk fat (0.157) and yield of 4% FCM (0.142).

Konig et al. (2005) investigated the evaluation of variance components of productive and reproductive traits. The following heritability coefficient values were obtained: milk production (0.35), protein yield (0.34), production of milk fat (0.38) and duration of service period (0.03). Assessment of genetic parameters for the production of milk, milk fat and protein by using »test-day« model was applied by Silvestre et al. (2005). Heritability coefficients for milk traits of Simmental cows were also reported by Panić and Vidović (2006): duration of lactation (0.017), production of milk (0.227), content of milk fat (0.037) and production of milk fat (0.21).

If the heritability of certain traits is high, there is strong correlation between genotype and phenotype, which facilitates selection procedures based on animal phenotype. If the heritability coefficient is low, then selection according to phenotype will be uncertain. With application of intensive selection, the genetic variability is reduced, thus decreasing the heritability. Genetic correlations are very important in intermediary or indirect selection, where changes of one trait is caused by selection of other trait in which there is a genetic correlation.

Campos et al. (1994), studying the genetic parameters of milk performance and reproductive traits of Holstein cows, established that the genetic correlation between the milk yield and yield of milk fat was 0.743, between milk yield and milk fat content was 0.235, milk yield and duration of service period was 0.159 and milk yield and calving interval was 0.170. Positive values of genetic correlations between milk traits, with the exception of those between milk yield and milk fat content, were also noted by Marković (1999). Parameters of genetic correlation vary in the range of -0.78 (milk yield and milk fat content) to 0.95 (milk yield and 4%FCM).

Costa et al. (2000) reported on the genetic analysis of Holestein-Friesian population in USA and Brazil, and established the value of the coefficient of the genetic correlation between milk production and production of milk fat of 0.79 in Brazil and 0.62 in USA. Gaydarska et al. (2001) reported high and positive genetic correlation between milk production and production of milk fat of 0.953. Correlation between milk yield and percentage of milk fat was negative (-0.155). Slightly positive genetic correlation of 0.171 was established between production and percentage of milk fat. Oseni et al. (2004), in their research of genetic parameters related to service period and duration of pregnancy, reported correlation between production of milk and duration of service period of 0.12 to 0.6.

Simmental breed is a dominant breed in Serbia. It is characterized by certain variability, especially with regards to production and reproduction traits. By applying selection and other methods, substantial effort has been made in increasing the production of milk and milk fat, but the genetic potentials of this breed have still not been utilized. The breeding goal for Simmental cattle is to reach maximum genetic values for economically important traits, and in concordance with the results of genetic improvement which this breed has already achieved in developed world countries.

The objective of this research was to obtain production conditions and relevant data on heritability coefficient and genotype correlations between milk and fertility traits.

MATERIALS AND METHODS

This study included 3.461 first calving Simmental cows under control, with lactations concluded within one year. All first-calvers were reared on individual farms in the territory of the Republic of Serbia. Facilities used for rearing of first calving cows were of semi closed and closed type. Lactating cows were kept in tie housing system on beds of medium length. Nutrition of cows was made up of summer and winter diet. The basis of winter diet were conserved feeds, silage and hay, supplemented with adequate amount of concentrated feeds. Summer diet started with introduction of green mass in daily ration, combined with concentrate mixture. The results of the study of heritability and genetic correlations between production and reproduction traits were obtained by using mixed model:

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

Where, Y_{ijklm} = expression of the trait in *m* cow, daughter of bull-sire *i*, which was produced in *j* region, and calved in year *k* and *l* seasons; μ = general average; B_i = random effect of *i* bull sire; R_j = fixed effect of *j* region; G_k = fixed effect of *k* calving year;l S_l = fixed effect of *l* calving season; e_{ijklm} = random error;

For the investigated milk yield and fertility traits, basic variation-statistical parameters were calculated: arithmetic mean ($\overline{X}$), standard deviation (SD), variation coefficient (CV), standard error of the mean ($S\overline{X}$), and variation interval (Min-Max).

RESULTS

Heritability values and errors for milk traits and fertility in Simmental cows are presented in Table 1. Heritability coefficient for lactation duration was 0.083 with heritability error of 0.035. Low heritability value was also established for percentage of milk fat (0.093) with error of 0.037. Production of milk had medium value of heritability coefficient of 0.487 (error 0.111) as well as production of 4% FCM of 0.474 (heritability error 0.109) and milk fat quantity of 0.455 (error 0.105). Low heritability values of fertility traits were confirmed in this study. Established degree of heritability for duration of service period was 0.105 with error of 0.040. Slightly lower heritability coeficient was calculated for age at first calving (0.093), with standard error of 0.037.

Genetic correlations can be positive, in which case changes of additive gene effect in one trait lead to change in the same direction of additive effect in the

Table 1. Heritability (h^2) and heritability errors (Sh^2) for milk and fertility traits in standard lactation.

Trait	h^2	Sh^2
Duration of lactation	0.083	0.035
Milk yield (kg)	0.487	0.111
Milk fat content (%)	0.093	0.037
Milk fat yield (kg)	0.455	0.105
Yield of 4% FCM (kg)	0.474	0.109
Service period (days)	0.105	0.040
Age at calving (days)	0.093	0.037

other trait. Negative genetic correlation indicates changes of additive effects in opposite directions in two traits. Increase of additive effect in one is accompanied by decrease of same effect in the other, and vice versa.

Genetic correlation between milk and fertility traits and their errors are presented in Table 2. The obtained results for genetic correlations between production of milk and milk fat (0.989), and between yield of milk and yield of 4% FCM (0.996) indicated the presence of strong and full/complete correlation between these two traits. The correlation between production of milk and milk fat content was negative as expected (-0.125).

Genetic correlation between milk traits and duration of service period, that is, age at first calving, was extremely weak and slightly positive. Correlation coefficients between service period and milk traits were: duration of lactation (0.239), milk yield (0.089), percentage of milk fat (0.095), quantity of milk fat (0.105), yield of 4% FCM (0.099). Correlation between service period and age at calving was 0.535.

Genetic correlation of age at calving and milk traits had the following values: duration of lactation of 0.245, milk production of 0.003, percentage of milk fat of 0.5310, quantity of milk fat of 0.082 and production of 4% FCM (0.050). So, it can be concluded that milk and fertility traits were in positive genetic correlation with coefficients ranging from extremely weak to medium strong.

Increase of the production and quality of milk, as well as the intensity of the fertility, are main pre-conditions of modern cattle production. On the basis of the obtained results presented in Table 3, it can be concluded that the average duration of lactation was 311.72 days, milk yield was 3.885.96 kg, content of milk fat was 3.88%, yield of milk fat was 150.63 kg and yield of 4% FCM was 3.813.84 kg.

Average duration of service period was 110.79 days, with standard deviation of 53.81 days. Variability of the service period was rather high and ranged from minimum of 40 to maximum of 361 days. Average age of cows at first calving was 778.73 days with coefficient of variation of 11.13.

DISCUSSION

Heritability as a value that express and measure average additive gene effect, is one of the major characteristics of quantitative traits from the point of view of creation of genetically highly valuable cattle populations. Knowledge of the heritability is necessary in the assessment of breeding value of cattle and it influences considerably the selection of breeding method.

By comparing the obtained heritability values for milk production, quantity of milk fat and yield of 4% FCM with the results obtained by other authors, it can be noticed that they were slightly higher as compared to the results reported by Costa et al. (2000), Konig et al. (2005) and Panić and Vidović (2006), and significantly higher than the results established by Živanović (2002) and Silvestre et al. (2005). The obtained heritability values were relatively high which can be explained to some extent through small variation within the group of daughters of one bull-sire, and great variability between groups of bulls. Approximately, same heritability coefficient values for milk fat content were reported by Panić and Vidović (2006).

Significantly, lower heritability coefficients were presented by the authors for Holstein-Friesian breed. Lower heritability value for milk production and production of milk fat in Holstein-Friesian cows as compared to Simmental breed indicated that log-term and intensive selection decreased the hereditary differences and genetic variability between members of the population, and at the same time the heritability.

The obtained results on heritability of duration of service period were higher as compared to results presented in the research by Đurđević (2001) and Konig et al. (2005). Approximately same results were reported by Petrović et al. (2001). Heritability of age at first calving was somewhat lower than the results obtained by Đurđević (2001) and Petrović et al. (2001).

Due to significant impact of paragenetic factors on variability of reproduction parameters, heritability coefficients for fertility traits are low, which makes the breeding efforts, that is, work on genetic improvement of these traits, and of total cattle production, very difficult. Based on the obtained results and research carried out by other authors, it can be concluded that reproduction traits are under weak influence of additive gene effect and are low hereditary properties, however, still indicate the importance of inclusion of age at calving and duration of service period in estimation of breeding value.

Economcial efficiency and success in livestock production most often depend on several traits. Therefore, it is neccesary to carry out simultaneous selection for multiple traits. Simultaneous selection for multiple traits depends on genetic correlations which signify the correlation between additive gene effect having impact on expression of two traits.

Positive values of the coefficient of genetic correlation

Table 2. Coefficients of genetic correlations (r_g) and their errors (Sr_g) between milk and fertility traits in standard lactation.

Trait	r_g	Sr_g
DL (days)		
MY (kg)	-0.121	0.244
MFC (%)	0.099	0.307
MFY (kg)	-0.1	0.246
4% FCM (kg)	-0.109	0.245
DSP (days)	0.239	0.281
AC (days)	0.245	0.302
MY (kg)		
MFC (%)	-0.125	0.237
MFY (kg)	0.989	0.005
4% FCM (kg)	0.996	0.002
DSP (days)	0.089	0.232
AC (days)	0.003	0.239
MFC (%)		
MFY (kg)	0.022	0.24
4% FCM (kg)	-0.038	0.239
DSP (days)	0.095	0.292
AC (days)	0.531	0.267
MFY (kg)		
4% FCM (kg)	0.998	0.001
DSP (days)	0.105	0.232
AC (days)	0.082	0.24
4%FCM (kg)		
DSP (days)	0.099	0.232
AC (days)	0.050	0.239
DSP, days		
AC (days)	0.535	0.252

DL, Duration of lactation (days); MY, milk yield in standard lactation (kg); MFC, milk fat content in standard lactation (%); MFY, milk fat yield in standard lactation (kg); 4%FCM, yield of 4% FCM in standard lactation (kg); AC, age at first calving (days); DSP, duration of service period (days).

between milk yield and duration of service period were established by Campos et al. (1994), Stojić (1996), Petrović et al. (1998) and Oseni et al. (2004). Positive correlation between milk yield and age at calving was reported by Petrović et al. (1998), who also established positive correlation between duration of service period and age at calving on one side and production of milk fat on the other hand. Negative correlation coefficients between production of milk and production of milk fat in standard lactation and age at calving were reported by Stojić (1996).

Negative correlation between production of milk and percentage of milk fat, and positive correlation between milk yield and quantity of milk fat and 4% FCM, respectively, were shown by several authors (Campos et al., 1994; Marković, 1999; Costa et al., 2000; Gaydarska et al., 2001).

The main objective of breeding-selection work is to create new generations which will surpass previous generations in the production performances and express higher production effects in the production of milk and meat. Therefore, the knowledge of the breeding value of the parent is necessary in selection work, as well as heritability and correlations between major traits and their transmission on the progeny (Pantelić, 2006). Evaluation of genetic correlations for milk yield, yield of milk fat and content of milk fat had high mutual dependence which indicates that information of the first lactation can be used in selection and breeding.

Conclusion

Milk traits are expressed under complex influence of the hereditary basis and numerous factors of the environment. Level of heritability represents the variation ratio created by the effect of genotype and total variance which includes all influences. Because of the important effect of paragenetic factors on variability of reproduction parameters, heritability coefficients for fertility are low which makes it difficult to work on breeding, that is, genetic improvement of these traits, and therefore whole cattle production. Fertility traits in general, have low hereditary character, but, nevertheless, heritability values can differ depending on the applied methods and models for their assessment, sample size as well as the structure of data used for calculation of the heritability coefficient.

Genetic correlations have great importance in intermediate or indirect selection where changes of one trait are induced through selection for other trait between which there is a genetic correlation. Genetic correlations can be established in cases where heritability coefficient can be calculated. Values of genetic correlations between production and reproduction traits have multiple significance in selection of cows, because they offer possibility for selection of multiple traits simultaneously. This is especially important with the application of modern methods of mathematical statistics in evaluation of additive gene value of bulls and cows. In addition, early selection of parents based on the first lactation is possible, which significantly shortens the period necessary for introduction of bulls into breeding

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Table 3. Mean values and variability of milk yield and fertility traits in standard lactation.

Trait	$\overline{X}$	SD	CV	$S_{\overline{X}}$	Minimum	Maximum
DL (days)	311.72	28.50	9.14	0.48	241	586
MY (kg)	3885.96	609.63	15.69	10.36	1586	7686
MFC (%)	3.88	0.17	4.44	0.00	2.85	4.87
MFY (kg)	150.63	24.37	16.18	0.41	56.80	316.86
4% FCM (kg)	3813.84	604.37	17.46	9.79	1492	7376
DSP (days)	110.79	53.81	48.57	0.91	40	361
AC (days)	778.73	86.66	11.13	1.47	620	1079

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