Proceedings of the 14th International Symposium
Modern Trends in Livestock Production
October 4 – 6, 2023, Belgrade, Serbia

# TREND OF MILK YIELD TRAITS OF BULL MOTHERS OF THE HOLSTEIN-FRIESIAN BREED

**Marina Lazarević[1], Vlada Pantelić[1], Dragan Stanojević[2], Dragan Nikšić[1], Nevena Maksimović[1], Miloš Marinković[1], Ljiljana Samolovac[1]**

[1]Institute for Animal Husbandry, Belgrade-Zemun, 11080 Zemun, Serbia
[2]University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Zemun Serbia
Corresponding author: Marina Lazarević, marinaplazarevic@gmail.com
Invited paper

**Abstract:** The research was conducted on 175 cows of the Holstein-Friesian breed that were selected as bull dams and achieved 400 lactations. Animals are reared on 5 farms of the "Belgrade" Agricultural Corporation. Bull dams are the offspring of 32 bulls calved between 2007 and 2014. The research included the following characteristics of milk yield in standard lactation (305 days): milk yield (kg), milk fat yield (kg), milk fat content (%), protein yield (kg), protein content (%). The variability of traits and the influence of factors (farm, lactation in order, season and year of calving, bull-sire) were evaluated by the method of least squares using the GLM (General Linear Model) procedure in the SAS software package. The average milk yield of bull dams is 9617.11 kg, with 3.44% milk fat and 3.21% protein. The average yield of milk fat and protein is 329.56 kg and 308.65 kg, respectively. The largest positive deviation of milk yield from the general average is 363.64 kg, while the largest negative deviation is -1021.36. The largest negative deviation of milk fat yield and protein yield is -21.74 kg and -36.09 kg, respectively. The largest positive deviation of milk fat yield is 18.35 kg and protein yield is 9.46 kg. The influence of the farm is present in the variability of all the observed traits of milk production except milk yield. Lactation in turn had a statistical effect ($p<0.05$) on all traits included in the research, except for protein content. The influence of the calving season is present in the variability of milk yield and protein yield, while it had no effect on the other traits included in the research. Calving year statistically ($p<0.05$) had a significant effect on the variability of all observed milk yield traits. The sire bull influenced the phenotypic expression of milk yield traits, while his influence on the variability of milk fat and protein content was not significant.The results of the research indicate that the established variability of milk yield traits in the population of the Holstein-Friesian breed provides enough room for their further improvement through selection.

**Key words:** bull dams, milk traits, variability, genetic trend, Holstein-Frisian breed

# Introduction

Milk yield is one of the most important criteria for defining economic profit in dairy cattle breeding. The previous selection of Holstein-Friesian cattle was mainly aimed at improving milk yield characteristics (*Lazarević, 2019*). Genetic improvement is possible by selecting parents with higher breeding values (*Kosgey et al., 2006*) that can make positive genetic contributions to the next generation.

The first step is to identify the potential cows, candidates to become a bull dam. Bull dams represent a group of elite females that are selected based on EBV or GEBV. These cows are mated with elite bulls for the purpose of producing bull calves (*Schefers and Weigel, 2012*). The best cows are selected from the mother herd, which as a rule represent about 1% of the population, primarily in terms of milk and milk fat production, and then also in body structure, udder structure, milking characteristics and reproductive properties. These cows should be at least two standard deviations above the average of the parent population in milk production (*Main Cattle Breeding Program, Holstein-Friesian Breed, 2019*).

When mating between animals is planned, it is necessary to examine the changes in the average breeding value of the population as a result of selection and determine the effectiveness of that breeding program. Estimation of genetic and environmental trends in a population makes it possible to evaluate selection methods (*Mohammaddiyeh and Behmaram, 2023*).

One of the most important indicators of achieved selection success in cattle populations intended for milk production is the genetic trend of milk yield traits (*Beskorovajni, 2014*).

Breeding objectives need to be outlined and regularly updated to address the changes in the consumer environment. Breeders have to plan ahead because genetic choices made today will improve profits only in future generations, and a review of past selection objectives may be of use in determining new selection goals (*Ombura et al., 2007).*

The objectives of this study were to determine the variability and genetic trend of milk traits in the nucleus dairy herd of Holstein-Frisian bull dams by using the linear method of evaluation, and to determine their importance in the selection of cattle.

# Materials and Methods

The research was carried out on 175 head of the Holstein-Friesian breed, which were selected as bull dams and achieved 400 lactations. Goats were grown on 5 farms of the Agricultural Corporation "Belgrade" (table 1). Bull dams are the offspring of 32 bulls that calved in the period from 2007 to 2014 (table 4). Bulls with a minimum of 5 daughters were included in the survey.

Within each year, four seasons were observed (table 3):

1. winter: includes cows calved in December, January and February;
2. spring: includes cows calved in March, April and May;
3. summer: includes cows calved in June, July and August;
4. autumn: includes cows calved in September, October and November.

Table 2 shows the distribution of concluded lactations by lactation order. Due to the small number of lactations, all lactations after the third were considered as one group.

**Table 1. Distribution of concluded lactations by farms**

| Farm | Number of lactations |
|---|---|
| 1 | 138 |
| 2 | 143 |
| 3 | 103 |
| 4 | 4 |
| 5 | 12 |
| Total | 400 |

**Table 2. Distribution of concluded lactations by parity/lactation order**

| Lactation order | Number of lactations |
|---|---|
| 1 | 175 |
| 2 | 115 |
| 3 | 67 |
| >3 | 43 |
| Total | 400 |

**Table 3. Distribution of concluded lactations by calving season**

| Calving season | | Number of lactations |
|---|---|---|
| 1 | (winter) | 102 |
| 2 | (spring) | 72 |
| 3 | (summer) | 112 |
| 4 | (autumn) | 114 |
| | Total | 400 |

The research included the following milk yield traits in standard lactation (305 days):

- milk yield (kg),
- yield of milk fat (kg),
- milk fat content (%),
- protein yield (kg),
- protein content (%).

Descriptive statistical analysis was performed with the statistical program SAS (SAS Institute Inc. 9.3, 2012). The variability of traits was assessed by the method of least squares using the GLM (General Linear Model) procedure in the SAS software package. The following model was used to analyse the influence of genetic and non-genetic sources of variability:

$$Y_{ijklmn} = \mu + F_i + L_j + S_k + C_l + S_m + e_{ijklmn}$$

where:

- $Y_{ijklmn}$: studied trait,
- $\mu$: population average for given trait,
- $F_i$: fixed effect of i farm (i=1,…,5),
- $L_j$: fixed effect of j lactation order (j=1,2,3,>3),
- $S_k$: fixed effect of k calving season (k=1,2,3,4),
- $C_l$: fixed effect of l calving year (l=1,…,8),
- $S_m$: fixed effect of m sire (m=1,…,32),
- $e_{ijklmn}$: random error with features N (0,σ2).

# Results and Discussion

Table 4 shows the average milk yield per calving year and the general average for all observed traits. The average milk yield of bull dams is 9617.11 kg, with 3.44% milk fat and 3.21% protein. The average yield of milk fat and protein is 329.56 kg and 308.65 kg, respectively.

Observing the milk yield per calving year, significant variability is observed. The lowest milk yield of 8720.50 kg was achieved in the first observed year (2007). After the increase in milk yield in 2008, the milk yield decreased in 2009 and 2011. The increase in milk yield was observed in 2010, then in 2012 and 2013, when the milk yield was the highest (9980.75 kg).

**Table 4. Distribution of concluded lactations and average milk yield in standard lactation (305 days) per calving year**

| Calving year | Number of lactations | Milk yield, kg | Milk fat yield, kg | Milk fat content, % | Protein yield, kg | Protein content, % |
|---|---|---|---|---|---|---|
| 2007 | 2 | 8720.50 | 319.92 | 3.67 | 302.14 | 3.46 |
| 2008 | 7 | 8954.71 | 317.90 | 3.55 | 278.03 | 3.10 |
| 2009 | 16 | 8595.75 | 307.85 | 3.59 | 272.56 | 3.17 |
| 2010 | 30 | 9521.30 | 347.94 | 3.65 | 311.04 | 3.27 |
| 2011 | 61 | 9246.77 | 325.36 | 3.52 | 302.03 | 3.27 |
| 2012 | 98 | 9549.00 | 333.29 | 3.50 | 309.48 | 3.24 |
| 2013 | 123 | 9980.75 | 331.05 | 3.33 | 318.11 | 3.19 |
| 2014 | 63 | 9778.78 | 323.49 | 3.32 | 306.96 | 3.14 |
| Overall mean | 400 | 9617.11 | 329.59 | 3.44 | 308.65 | 3.21 |

Animals selected for bull dams achieved the highest milk fat yield of 347.94 kg in 2010, while the protein yield was the highest in 2013 (318.11 kg).

The content of milk fat (3.67%) and protein (3.46%) was the highest in 2007, when the lowest milk yield was achieved.

In the research of *Lazarevic et al., (2018)* 575 standard lactations of Holstein-Friesian cows selected as bull dams and their progeny were observed. On average they produced 9239.84 ± 1607.64 kg of milk, with a milk fat content of 3.44 ± 0.20 and protein content of 3.21 ± 0.12.

Kawahara et al., (2006) for the population of the Holstein-Friesian breed in Japan reported average values of milk yield, milk fat, dry matter without fat, protein and content of fat, matter without fat, and protein of 7899 kg, 301 kg, 689 kg , 253 kg, 3.83 %, 8.74 % and 3.18 %, respectively.

*Stanojević et al. (2013)* state that in the Holstein-Friesian breed, the average milk yield in the first three standard lactations is 8179 kg of milk with 3.46% milk fat and 280.38 kg of milk fat.

In a study by *Campos et al. (2015)* the mean and standard deviation for milk yield, milk fat and protein for standard lactation Holstein cows in Brazil were 8415.22 ± 1910.17 kg, 276.89 ± 66.63 kg and 253.56 ± 57.21 kg, respectively.

*Pantelić et al. (2010)* conducted research on 292 Simmental cows selected as bull dams in the territory of the Republic of Serbia. The average milk yield of individual animals selected for bull dams is 5754.49 kg, with 3.98% milk fat and 230.24 kg milk fat. Bull dams of Holstein Friesian breed achieved an average milk production of 10,245.98 kg, with a variation interval ranging from 6,514 kg to 13,251 kg. The average milk fat production was 361.95 kg, and the milk fat content was 3.53% (*Pantelić et al., 2012*).

In the Israeli Holstein population, average milk yield in standard lactation was 10.281 kg with 3.23% milk fat and protein content of 3.04% (*Weller and Ezra, 2004).*

Table 5 shows the deviation of milk yield traits from the general average observed by year of calving.

**Table 5. Deviation of milk yield traits from the general average observed by year of calving (standard lactation, 305 days)**

| Calving year | Milk yield, kg | Milk fat yield, kg | Milk fat content, % | Protein yield, kg | Protein content, % |
|---|---|---|---|---|---|
| 2007 | -896.61 | -9.67 | 0.23 | -6.51 | 0.25 |
| 2008 | -662.40 | -11.69 | 0.11 | -30.62 | -0.11 |
| 2009 | -1021.36 | -21.74 | 0.15 | -36.09 | -0.04 |
| 2010 | -95.81 | 18.35 | 0.21 | 2.38 | 0.06 |
| 2011 | -370.34 | -4.23 | 0.08 | -6.62 | 0.06 |
| 2012 | -68.11 | 3.70 | 0.06 | 0.83 | 0.03 |
| 2013 | 363.64 | 1.46 | -0.11 | 9.46 | -0.02 |
| 2014 | 161.67 | -6.10 | -0.12 | -1.69 | -0.07 |

The largest positive deviation of milk yield from the general average was recorded in 2013 (363.64 kg), while in 2009 the largest negative deviation was recorded (-1021.36). A negative deviation of milk yield from the general average was recorded from 2007 to 2012. In the last two years of the observed period, there is a positive deviation from the general average.

Deviation of milk fat content is in contrast with deviation of milk yield, which is the result of negative genetic correlation of these two traits. In the period from 2007 to 2012, there was a positive deviation from the general average, and a negative deviation in the last two years of the observed period.

The biggest negative deviation of milk fat yield and protein yield was in 2009 (-21.74 kg, respectively -36.09 kg). The largest positive deviation of milk fat yield was in 2010 (18.35 kg) and protein yield was in 2013 (9.46 kg).

The largest positive deviation of the protein content was in 2007 (0.25%), contrary to this result, the largest negative deviation from the general average was recorded already the following year (-0.11%).

The production year has its own special characteristics, which are manifested through climatic factors, available food, farm management, economic conditions that affected the entire business, so the phenotypic manifestation of milk yield characteristics had oscillations during the observed period. These results were also contributed to by the uneven number of concluded lactations by observed age.

As stated by *Beskorovajni (2014),* in the population of the improved Black and White breed, the largest positive deviation of milk yield compared to the general average was achieved in 2009 (1590.10 kg). Contrary to this result, the largest negative deviation was recorded in the year 2000 (-1590.60 kg) and the differences in the amount of milk yield, milk fat, 4% MCM and milk fat content per calving year were statistically highly significant

Table 6 shows the influence of factors (farm, lactation order, season and year of calving, bull-sire) on the variability of observed milk yield characteristics in standard lactation.

The influence of the farm is present in the variability of all the observed traits of milk production except milk yield. Lactation in turn had a statistical effect ($p<0.05$) on all traits included in the research, except for protein content. As the average milk yield increases from the first to the following lactations, it is necessary to include this factor in the models for evaluating breeding value (*Beskorovajni, 2014).*

The calving season, that is, the differences between individual seasons, can have a significant impact on milk production. The difference between individual seasons is reflected in specific climatic conditions and differences in the way cows are fed and housed (*Pantelić et al., 2014*). The influence of the calving season is present in the variability of milk yield and protein yield, while it had no effect on the other traits included in the research.

Calving year statistically ($p<0.05$) had a significant effect on the variability of all observed milk yield traits. The sire bull influenced the phenotypic expression of milk yield traits, while his influence on the variability of milk fat and protein content was not significant.

**Table 6. Effect of factors on the variability of milk yield characteristics in standard lactation (305 days), F-test**

| Factor | F- test (standard lactation) | | | | | |
|---|---|---|---|---|---|---|
| | $d.f._1$ | Milk yield, kg | Milk fat yield, kg | Milk fat content, % | Protein yield, kg | Protein content, % |
| Farm | 4 | $2.44^{ns}$ | $4.56^{*}$ | $3.14^{*}$ | $3.61^{*}$ | $9.12^{*}$ |
| Lactation order | 3 | $13.40^{*}$ | $11.76^{*}$ | $2.71^{*}$ | $13.47^{*}$ | $0.48^{ns}$ |
| Calving season | 3 | $4.26^{*}$ | $2.63^{ns}$ | $2.62^{ns}$ | $4.48^{*}$ | $0.62^{ns}$ |
| Calving year | 7 | $6.39^{*}$ | $2.44^{*}$ | $23.47^{*}$ | $5.48^{*}$ | $12.68^{*}$ |
| Bull-sire | 31 | $2.21^{*}$ | $2.26^{*}$ | $1.01^{ns}$ | $2.24^{*}$ | $0.79^{ns}$ |

$p>0.05^{ns}$, $p<0.05^{*}$

In the research of *Lazarević et al. (2018)* the impact of bull-sire, year of birth, lactation order, farm, year and calving season was present at different levels of statistical significance on yield traits, while the genetic group had no influence on any of the milk traits. Bull-sire, year of birth, lactation order and calving season did not influence the variability of milk fat and protein content.

According to *Lazarević (2019)* the influence of lactation order, farm, year and calving season is present at a very high level of statistical significance ($p<0.001$) in the variability of all observed milk yield traits. The sire had a highly significant influence ($p<0.001$) on all milk yield traits both in the whole and in standard lactation, except for the protein content in standard lactation where the statistical significance of this factor is lower ($p<0.01$).

# Conclusion

The results of the research indicate that the established variability of milk yield traits in the population of the Holstein-Friesian breed provides enough room for their further improvement through selection. At evaluated years, many fluctuations were observed in the genetic trend of traits. It seems there was not a strict plan for breeding and genetic improvement of milk traits. Therefore, to improve the breeding status of the population animals should be selected based on their breeding values.

**Acknowledgment**
Research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, on the basis of the Agreement on the realization and financing of scientific research work of SRO No. 451-03-47/2023-01/200022.

# References

BESKOROVAJNI R. (2014): Genetski trend osobina mlečnosti praćenih u progenom testu bikova crno-bele i holštajn frizijske rase. Doktorska disertacija. Univerzitet u Beogradu, Poljoprivredni fakultet.

CAMPOS R.V., COBUCI J.A., KERN E.L., COSTA C.N., MCMANUS C.M. (2015): Genetic parameters for linear type traits and milk, fat, and protein production in Holstein cows in Brazil. Asian Australas. J. Anim. Sci., 28, 4, 476-484.

GLAVNI ODGAJIVAČKI PROGRAM U GOVEDARSTVU, HOLŠTAJN-FRIZIJSKA RASA (2019): Glavna odgajivačka organizacija, Institut za stočarstvo, Beograd-Zemun

KAWAHARA T., GOTOH Y., YAMAGUCHI S., SUZUKI M. (2006): Variance Component Estimates with Dominance Models for Milk Production in Holsteins of Japan using Method R. Asian-Australasian J. Animal Sci., 19, 6, 769-774.

KOSGEY L. S., BAKER R. L., UDO H. M. J., VAN ARENDOK J. A. M. (2006): Success and failures of small ruminant breeding programmes in the tropics: a review. Small Ruminant Research, 61, 13-28.

LAZAREVIĆ M. (2019): Procena priplodne vrednosti krava holštajn-frizijske rase za osobine mlečnosti primenom metode selekcijskog indeksa. Doktorska disertacija. Univerzitet u Beogradu, Poljoprivredni fakultet.

LAZAREVIĆ M., STANOJEVIĆ D., BOGDANOVIĆ V., PANTELIĆ V., MAKSIMOVIĆ N., MARINKOVIĆ M., MIĆIĆ N. (2018): Variability and heritability of milk traits of Holstein-Frisian bull dams and their progeny. Genetika, 50, 1, 243-251.

MOHAMMADDIYEH M. E. T. K., BEHMARAM R. (2023): Genetic progress evaluation of growth traits in Moghani sheep. Biotechnology in Animal Husbandry 39, 1, 15-32.

OMBURA J., WAKHUNGU J.W., MOSI R.O., AMIMO J.O. (2007): An assessment of the efficiency of the dairy bull dam selection methodology in Kenya. Livestock Research for Rural Develop, 19 (1).

PANTELIĆ V., ALEKSIĆ S., STOJIĆ P., ĐURĐREVIĆ R., SAMOLOVAC L., JANKOVIĆ D., NIKŠIĆ D. (2010): The effect of breeding region and year on milk traits of Simmental bull dams. Biotechnology in Animal Husbandry, 26, 5-6, 287-295.

PANTELIĆ V., NIKŠIĆ D., OSTOJIĆ-ANDRIĆ D., NOVAKOVIĆ Ž., RUŽIĆ-MUSLIĆ D., MAKSIMOVIĆ N., LAZAREVIĆ M. (2012): Phenotypic and genetic correlations of milk and type traits of Holstein-Friesian bull dams. Biotechnology in Animal Husbandry, 28, 1, 1-10.

PANTELIĆ V., PETROVIĆ M.M., OSTOJIĆ-ANDRIĆ D., RUŽIĆ-MUSLIĆ D., NIKŠIĆ D., NOVAKOVIĆ Ž., LAZAREVIĆ M. (2014): The effect of genetic and non-genetic factors on production traits of Simmental cows. Biotechnology in Animal Husbandry, 30, 2, 251-260.

SCHEFERS, J. M. AND K.A. WEIGEL (2012): Genomic selection in dairy cattle: Integration of DNA testing into breeding programs. Animal Frontiers, 2, 1, 4-9.

STANOJEVIĆ D., ĐEDOVIĆ R., PERIŠIĆ P., BESKOROVAJNI R., POPOVAC M. (2013): Fenotipska i genetska povezanost osobina mlečnosti u prve tri uzastopne laktacije crno-belih krava. Zbornik radova sa XXVII savetovanja agronoma, veterinara, tehnologa i agroekonomista, 19, 3-4, 17-24.

WELLER, J.I, E. EZRA (2004): Genetic Analysis of the Israeli Holstein Dairy Cattle population for production and nonproduction traits with a multitrait animal model. J. Dairy Sci., 87, 5, 1519-1527.