Biotechnology in Animal Husbandry 36 (4), 407-416 , 2020
Publisher: Institute for Animal Husbandry, Belgrade-Zemun
ISSN 1450-9156
UDC 575.21:636.034'6234
https://doi.org/10.2298/BAH2004407D

PHENOTYPIC CHARACTERISTICS OF LINEAR TRAITS OF UDDER AND ANGULARITY IN HOLSTEIN-FRIESIAN COWS AND THEIR CORRELATION WITH MILK YIELD TRAITS

Radica Djedović[1], Vladan Bogdanović[1], Dragan Stanojević[1], Hasan Ismael[1], Dobrila Janković[2], Snežana Trivunović[2], Ljiljana Samolovac[3], Tamara Stamenić[3]

[1]University of Belgrade, Faculty of Agriculture, Department of Animal Science, Nemanjina 6, 11080 Zemun, Serbia
[2]University of Novi Sad, Faculty of Agriculture, Square Dositej Obradović 8, 21101, Novi Sad, Serbia
3Institute for Animal Husbandry, Auto put 16, 11080 Belgrade-Zemun, Serbia
Corresponding author: Radica Djedovic, genrad@agrif.bg.ac.rs
Original scientific papers

Abstract: Data set including 10860 primiparous Holstein-Friesian breed cows first calved in the period from 2011 to 2015, was used in determining phenotypic variability and correlation between the traits of milk yield and linearly estimated traits of udder and angularity. The average values obtained for type traits (angularity, fore udder attachment, front teats placement, teats length, udder depth and rear udder height) were 6.47; 5.74; 4.96; 5.20; 5.99 and 6.25, respectively.
The values obtained for phenotypic correlations between linear type traits and traits of milk yield ranged from -0.042 (udder depth and milk yield) to 0.335 (fore udder attachment and protein yield). Positive phenotypic correlation (0.293) was recorded also between fore udder attachment and milk yield which is deemed the most important trait of milk yield while the lowest correlation between milk yields was determined in relation to udder depth (-0.033). The results obtained indicate a possibility of applying direct and indirect multiple traits selection which should be conducted within a national progeny-testing programme on Holstein-Friesian bulls by using the method of selection indexes.

Key words: Linear type traits, phenotypic correlations, milk yield traits

Introduction

Modern trends in dairy industry require a permanent work on improving genotypes and phenotypes of cattle. Recently, more and more attention has been

paid to body conformation, body development and type traits of cattle. It has been determined that certain malfunctions in type traits, particulary udder traits, can lead to lower production and bad health state of an animal and therefore to the early culling of the cows from the breeding stock. Visual assessment and recognising the characteristics of cow`s udders are preliminary indicators of milk yield, longevity and reproductive capacity of animal. A linear type estimation as an objective and unbiased method for estimating an animal body development has been used and it represents the basis of modern classification systems as well as the foundation of all systems for describing dairy cows (*Janković, 2017*).

Selection of cows directed exclusively to the traits of milk yield can decrease the values of other traits which relate to a type, conformation, durability and longevity. These traits have a great economic importance, therefore in order to increase productive life of an animal it is essential to direct selection also to the traits of type which are phenotypically and genetically connected with milk yield traits. The application of selection on multiple traits can decrease unwanted cullings and increase lifetime profitability per animal *(Stanojević et al., 2018).*

Studying the correlation between the traits of milk yield and linear type traits and therefore the traits of udder and angularity *Živanović, 2002; Pantelić et al., 2012; Tapki and Güzey, 2013; Bohlouli et al., 2015; Janković, 2017*, determined that their mutual interdependance was relatively weak but also that a dairy character-angularity showed constant positive correlations with milk yield. *Berry et al. (2005)* determined also that all phenotypic correlations between type traits and milk yield traits were weak and positive except for an udder depth and teats length.

The objective of this study was to determine phenotypic variability and correlation between the traits of milk yield and the traits of udder and angularity in primiparous cows, primarily due to the significance that these traits have on final milk production and necessity that these traits be included in the national selection programme of Holstein-Friesian breed bulls and cows.

Material and Method

A trial conducted included 10860 primiparous cows of Holstein-Friesian breed that were first calved in the territory of Vojvodina Province, Republic of Serbia, in the period from 2011 to 2015. Primiparous cows were being examined by 22 evaluators who have finished a specialist training according to the Instructions for the evaluation of linear type traits and body development in Holstein-Friesian breed cows *(Janković, 2012).* Each dairy farm had on average 10 cows and the cows first calved in the age of 27 months. At the time of estimation the average age of primiparous cows was 30 months while average number of days

realized in lactation on the day of assessment in primiparous cows was 95 with variability of 15 to 210 days.

The available traits were: milk yield (MY), fat content (FC), fat yield (FY), protein content (PC) protein yield (PY), and 6 type traits: angularity (ANG), fore udder attachment (FUA), front teats placement (FTP), teats length (TL), udder depth (UD) and rear udder height (RUH).

Values of standard statistical parameters (arithmetic mean, standard deviation (SD), variation coefficients (CV), variation interval (Min-Max)) for phenotypic expressivity of studied traits were calculated by means of standard statistical procedures using a statistical package (*SAS Institute, 2013*).

Data used for the estimation of phenotypic correlation coefficients of milk yield and type traits were encoded in a PEST software package *(Groeneveld et al., 1990)*, while the estimation of phenotypic variances and covariances was done by means of VCE v6 software package within a programme package (*Groeneveld et al., 2010)* with application of multiple traits model. The values of phenotypic correlations were calculated by means of two mixed models. For type traits a following mixed model was used:

$$Y_{ijklmno} = \mu + F_i + GG_j + YxS_k + AFC_l + O_m + Y_n + YO_o + animal + e_{ijklmno}$$

(model Eq. 1)

Where:

$Y_{ijklmno}$ – is a phenotype expressiveness of tested trait,

μ- population general average

F_i-fixed effect of the size of farm (6 classes, according to the number of first calvings, I (1-5); II (6-10); III (11-15); IV (16-50); V (51-100); VI (>100)));

GGj-fixed effect of genetic group, (interaction of bull`s year of birth (1980-2011) and country of bull`s origin (12), 79 genetic groups in total);

YxSk – fixed effect of interaction of the year and calving season (5 years, every year being divided into 4 seasons: winter, spring, summer, autumn);

AFCl – fixed effect of the age at first calving, (animals`s age expressed in months and allocated into 5 classes: I (19-23); II (24-26); III (27-30); IV (31-33); V (34-44));

Om – fixed effect of the evaluator;

Yn – fixed effect of the year of evaluation, (4 years, from 2012-2015 during which the animals were evaluated);

YOo – fixed effect of the age at evaluation, (animal`s age expressed in months and allocated into 5 classes: I (20-24); II (25-29); III (30-34); IV (35-39); V (40-45));

animal – random effect of an individual for whom the kinship matrix has been created,

eijklmno – random error.

For calculating phenotypic correlations of milk yield traits a following model was used:

$$Yijkl = \mu + Fi + GGj + YxSk + AFCl + animal + eijkl \quad \text{(model Eq. 2)}$$

Where:
Yijkl - phenotypic expression of the investigated trait; eijkl - random error; μ, Fi, GGj, YxSk, AFCl, animal – model variables are defined in the previous model (model Eq. 1).

Results and Discussion

Table 1 shows average values, standard deviations, variation coefficients and range of phenotypic variability of studied traits as well as ideal score for udder traits and angularity in primiparous Holstein-Friesian breed cows.

A pronounced milk production yield presupposes a cow with well developed and broad chest with open ribs and strongly expressed angularity. Such a cow has a harmonious frame which suggests resistance and high milk production yields.

For the angularity in primiparous Holstein Friesian cows a mean score of 6.47 was obtained. A considerably lower mean values of 5.60 and 5.50 for angularity were obtained by *Nemcova et al. (2011)* and *Zavadilova et al. (2009)* in Holstein cows in Czech Republic.

Table 1. Phenotypic variability of linear type traits and traits of milk yield (n=10860)

Trait	Abbreviation	Ideal score	Mean	SD	Cv (%)	min	max
Angularity (points)	ANG	9	6.47	1.40	21.64	1	9
Fore udder attachment (points)	FUA	9	5.74	1.46	25.44	1	9
Front Teats Placement (points)	FTP	5	4.96	1.14	22.98	1	9
Teats length (points)	TL	5	5.20	1.12	21.54	1	9
Udder depth (points)	UD	5	5.99	1.22	20.37	1	9
Rear udder height (points)	RUH	9	6.25	1.33	21.28	1	9
Milk (kg)	MY		6672	1740	26.07	1811	14395
Con. Fat (%)	FC		3.81	0.45	11.81	2.04	5.96
Fat (kg)	FY		252.83	67.66	26.76	59.00	612.00
Con.Protein (%)	PC		3.21	0.21	6.54	2.02	5.09
Protein (kg)	PY		213.86	56.94	26.62	51.00	472.00

Tapki and Guzey (2013) also obtained low mean score of 5.18 for angularity in Turkish primiparous Holstein cows. A lower mean score of 5.60, for angularity in Holstein cows in Australia, was obtained by *Haile-Mariam et al. (2014)*, while *Kern et al. (2014)* obtained similar mean score of 6.35 for the trait of angularity in population of Holstein cows in Brazil. Mean score for angularity which is closest to one calculated in this research was determined in Holstein cows in Brazil being 6.44 *(Campos et al., 2012)*, while the mean values of over 6.0 for this trait were obtained by *Otwinowska-Mindur et al. (2016)* in Polish Holstein-Friesian population (6.12), then *by Bohlouli et al. (2015)* in Holstein cows in Iran (6.24), by *Janković et al. (2016)* in primiparous Holstein-Friesian cows in Vojvodina province (6.33) and by *Almeida et al. (2017)* in Holstein cows in Brazil (6.30). In relation to a mean value reported herein a higher value of 6.67 for angularity was obtained by *Dadpasand et al. (2012)* in Holstein population in Iran while *Van der Laak et al. (2016)* obtained a significantly lower value of 4.83 in tested sample of Holstein-Friesian cows in Holland.

An absolute variability of angularity expressed in standard deviations ranged from 1.05 in the research of *Tapki and Guzey (2013)* to 1.57 in the research of *Bohlouli et al. (2015)*. A calculated standard deviation of 1.40 for angularity in primiparous Holstein-Friesian cows in Vojvodina province is closest to a standard deviation of 1.36 reported in the research of *Van der Laak et al. (2016)*, while a relative variability of angularity expressed by variation coefficent was 21.64 % what is similar to variation coefficient of 22.23% obtained by *Zavadilova and Štipkova (2012).*

Although a mean value of 6.47 obtained for angularity in primiparous Holstein-Friesian cows in Vojvodina province is closer to a mean value (5) than to an ideal score (9) for Holstein Friesian breed, it was higher than majority of mean values calculated in the above mentioned studies. The importance of dairy character and its improvement in dairy cattle conformation is reflected also in the fact, that besides the effect on milk production *(Brotherstone, 1994; Bohlouli et al., 2015)* and productive lifetime of dairy cows *(Weigel et al., 1998)*, there is also a correlation between angularity and fertility traits *(Pryce et al., 2000; Makgahlela et al., 2009; Almeida et al., 2017)*. The research by *Berry et al. (2005)*, showed that milk production affects also a functional longevity of cows in commercial herds and that higher yielding cows exhibit better ability to remain longer in productive herds.

A particular importance in dairy cows conformation is given to udder traits which, according to the *WHFF (2016)* recommendations make 40% of total evaluation of type traits. *Nemcova et al. (2011)* obtained similar mean values of evaluation in Holstein population in Czech Republic (from 4.90 for front teat position to 5.80 for udder depth), while *Campos et al. (2012)*, in Holstein population in Brazil, obtained higher mean scores for almost all udder traits (from 5.22 for front teat position to 6.36 for teat lenght), except for udder depth (4.85) and rear udder height (5.77). *Tapki and Guzey (2013)*, in their research on Turkish

Holstein population, obtained lower mean score for all udder traits (from 4.37 for rear teat position to 5.89 for rear udder height), as well as *Bohlouli et al. (2015)*, who in population of Holstein primiparous cows in Iran obtained considerably lower average score for all udder traits (from 3.58 for front teat position to 5.67 for rear teat position), except for teat length (5.20) which is identical to the value obtained in this research. *Janković et al. (2016)* obtained lower average values in primiparous Holstein-Friesian cows in Vojvodina province for all udder traits (from 4.91 for front teat position to 5.97 for rear udder height), likewise *Van der Laak et al. (2016)*, who obtained lower average values for all udder traits (from 5.05 for fore-udder attachment to 5.49 for rear udder height), except for a teat lenght (4.71), in Holstein-Friesian population of Holland. *Otwinowska-Mindur et al. (2016)*, in Holstein-Friesian population in Poland, obtained lower mean values for rear udder height (5.43), udder depth (5.50) and front teat position (5.66); while higher values were obtained for fore-udder attachment (6.16), front teat position (5.26) and teat length (5.39) compared to mean values obtained in this research. *Almeida et al. (2017)* obtained higher average values in Brazilian Holstein population for fore-udder attachment (6.0), rear udder attachment (6.40), and front teat position (6.20). They also obtained lower average values for front teat position (4.50) and udder depth (4.80). In the research on udder linear traits in primiparous Holstein-Friesian cows, mean values obtained for front teat position and teat length are approaching mean values in primiparous Holstein Friesian cows (5), which are at the same time the ideal values for these traits according to ICAR and WHFF nomenclature. When fore-udder attachment trait is in question the average value is also more approaching mean value (5) than ideal one according to ICAR and WHFF nomenclature and it seems necessary to improve it further primarily through bull-sire selection.

The coefficients of phenotypic correlations between studied linear type traits (udder traits and angularity) and milk yield traits in primiparous cows are shown in Table 2.

Table 2. Estimation of value of phenotypic correlations between investigated traits in first calving cows

Traits	MY	FC	FY	PC	PY	ANG	FUA	FTP	TL	UD	RUH
		-0.324	0.974	-0.142	0.961	0.310	0.321	0.101	0.241	-0.042	0.022
		-	-0.019	0.524	-0.192	0.223	0.032	0.574	-0.174	0.183	0.144
			-	-0.051	0.981	0.244	0.271	0.274	0.176	0.034	0.061
				-	0.055	0.062	0.224	0.194	0.052	-0.081	0.194
					-	0.280	0.335	0.141	0.234	-0.074	0.051
						-	0.768	0.584	0.041	0.252	0.364
							-	0.554	-0.045	0.447	0.414
								-	0.279	0.071	0.161
									-	0.059	0.087
										-	0.417
											-

The values obtained for correlations ranged from -0.042 (between udder depth and milk yield) to 0.335 (between fore udder attachment and protein yield). Phenotypic correlations between milk yield as the most important trait of milk production capacity in our national programme and studied type traits such as angularity, fore udder attachment, front teats placement, teats length, udder depth and rear udder height) were 0.310; 0.321; 0.101; 0.241; -0.042 and 0.022, respectively.

Similarly to the results obtained in this paper a number of studies shows that there is a positive and negative phenotypic correlation between milk yield traits and linear type traits in dairy cows. According to *Pantelić et al. (2012)* phenotypic correlations between milk yield and udder traits ranged in the interval from -0.11 (rear udder height) to +0.1 (front teats placement).

The phenotypic correlations between type traits and milk yield according to *Tapki and Güzey (2013)* ranged from -0.31 (udder depth and milk yield) to 0.29 (angularity and milk yield); -0.23 (udder depth and fat yield) to 0.26 (angularity and fat yield) for fat yield and -0.29 (udder depth and protein yield) to 0.25 (angularity and protein yield) for protein yield.

Brotherstone (1994) determined that all phenotypic correlations between type traits and milk yield traits were low, while moderate correlations were obtained between milk yield, milk fat and protein and angularity (0.43), as well as between milk yield and udder depth (-0.44). Also, *Bohlouli et al. (2015)* in their study on correlations between type traits and milk yield determined positive correlations in all type traits which ranged in the interval from very weak (0.02) for front teats placement to weak (0.26) for angularity. All mentioned studies indicate that by application of selection on type traits and by an appropriate improvement of the structure of dairy cow`s udder a simultaneous effect can be obtained both on the increase of milk yield and of milk content.

The values of phenotypic correlations obtained in this paper are mainly lower compared to mentioned studies. These differences can be a consequence of different models applied for their estimation as well as of different systems of linear estimation of dairy cows, but also of the differences in the size of population, size of studied sample, number of evaluators and their competence as well as of the intensity of previously applied selection on studied traits.

Conclusion

The values obtained for phenotypic correlations between type traits and milk yield traits showed that higher milk yields, milk fat and protein were obtained by cows that have more pronounced angularity as well as by those that have a good connection of fore and rear udder.These results also indicate a possibility of improving the traits of milk yield and type traits by application of selection on

multiple traits primarily by using the method of selection indices within national selection and breeding programmes. Milk yield traits and type traits should be included in optimal relationship in national selection programme in line with the aim of improvement in order to obtain a maximal selection effect.

In the future the success of bull and cow testing on the traits of interest shall be significantly improved by means of genomic selection because it will be known in advance whether the potential breeding animals inherited favourable gene patterns of their parents before they start to be exploited in the breeding stock.

Fenotipske karakteristike linearnih osobina vimena i uglatosti holštajn frizijskih krava i njihova povezanost sa osobinama mlečnosti

Radica Djedović, Vladan Bogdanović, Dragan Stanojević, Hasan Ismael, Dobrila Janković, Snežana Trivunović, Ljiljana Samolovac, Tamara Stamenić

Rezime

Za utvrđivanje fenotipske varijabilnosti i povezanosti između osobina mlečnosti i linearno procenjenih osobina vimena i uglatosti korišćena je evidencija o 10860 prvotelki holštajn frizijske rase, koje su se prvi put telile u periodu od 2011. do 2015. godine. Prosečne vrednosti analiziranih osobina tipa: (uglatost, veza prednjeg vimena, položaj prednjih sisa, dužina sisa, dubina vimena i visina zadnjeg vimena) iznosile su: 6,47; 5,74; 4,96; 5,20; 5,99 i 6,25 respektivno. Fenotipske korelacije izmedu ispitivanih linearnih osobina tipa i osobina mlečnosti imale su vrednosti od -0,042 (dubina vimena i prinos mleka) do 0,335 (veza prednjeg vimena i prinos proteina). Pozitivna fenotipska korelacija (0,293) zabeležena je i izmedju veze prednjeg vimena i prinosa mleka kao najvažnije osobine mlečnosti, dok je najniža korelacija između prinosa mleka utvrdjena u odnosu na dubinu vimena (-0,033). Dobijeni rezultati ukazuju na mogućnost primene direktne i indirektne selekcije na više osobina koju je neophodno sprovoditi u okviru nacionalnog programa progenog testiranja bikova holštajn frizijke rase koristeći metod selekcijskih indeksa.

Ključne reči: linearne osobine tipa, fenotipske korelacije, osobine mlečnosti

Acknowledgments

Research was supported by Ministry of education, science and technological development of the Republic of Serbia under the contract No. 451-03-68/2020-14/200116.

References

ALMEIDA T. P., KERN E. L., SANTOS DALTRO D. , NETO J. B., MCMANUS C., NETO A. T., COBUCI J. A. (2017): Genetic associations between reproductive and linear-type traits of Holstein cows in Brazil. Revista Brasileira di Zootecnia, 46, 2, 91-98.

BERRY D. P., HARRIS B. L., WINKELMAN A. M., MONTGOMERIE W. (2005): Phenotypic Associations Between Traits Other than Production and Longevity in New Zealand Dairy Cattle. Journal of Dairy Science, 88, 2962–2974.

BOHLOULI M., ALIJANI S., VARPOSHTI M. R. (2015): Genetic relationships among linear type traits and milk production traits of Holstein dairy cattle. Annals of Animal Science, 15, 4, 903–917.

BROTHERSTONE S. (1994): Genetic and phenotypic correlations between linear type traits and production traits in Holstein-Fresian dairy cattle. Animal Production, 59, 183-187.

CAMPOS R. V., COBUCI J. A., COSTA C. N., NETO J. B. (2012): Genetic parameters for type traits in Holstein cows in Brazil. Revista Brasileira di Zootecnia, 41, 10, 2150-2161.

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. Journal of Animal Science, 28, 4, 476-484.

DADPASAND M., ZAMIRI M. J., ATASHI H., AKHLAGHI A. (2012): Genetic relationship of conformation traits with average somatic cell score at 150 and 305 days in milk in Holstein cows of Iran. Journal of Dairy Science, 95, 7340–7345.

GROENEVELD E., KOVAC M., MIELENZ N. (2010): VCE6 User's Guide and Reference Manual. Mariensee, Institute of Farm Animal Genetics, FLI.

GROENEVELD E., KOVAČ M., WANG T. (1990): PEST, a general purpose BLUP package for multivariate prediction and estimation. In: 4th World Congress on Genetics Applied to Livestock Production, Skotland, Edinburgh, Jun 1990, vol. 13: 488-49.

HAILE-MARIAM M., GONZALEZ-RECIO O., PRYCE J. E. (2014): Prediction of liveweight of cows from type traits and its relationship with production and fitness traits. Journal of Dairy Science, 97, 3173–3189.

JANKOVIĆ D., ĐEDOVIĆ R., TRIVUNOVIĆ S., IVANOVIĆ D., ŠTRBAC LJ., KUČEVIĆ D., STANOJEVIĆ D., RADINOVIĆ M. (2016): Variability and effects of farms, classifiers and lactation stage on linear type traits scores of primiparous Holstein-Friesian cows. Proceedings of the International Symposium on Animal Science, November, 24-25th, Belgrade, Serbia, 150-158.

JANKOVIĆ D. (2017): Breeding values estimation of Holstein Friesian bulls for type traits. PhD thesis. University of Belgrade. Faculty of Agriculture. Belgrade-Zemun, Serbia.
KERN E. L., COBUCI J. A., COSTA C. N., PIMENTEL C. M. (2014): Factor analysis of linear type traits and their relation with longevity in brazilian holstein cattle. Asian-Australasian Journal of Animal Science, 27, 784-790.
KHAN M. A. AND KHAN M. S. (2016): Genetic and phenotypic correlations between linear type traits and milk yield in Sahiwal cows. Pakistan Journal of Agricultural Science, 53, 2, 483-489.
NĚMCOVÁ E., ŠTÍPKOVÁ M., ZAVADILOVÁ L. (2011): Genetic parameters for linear type traits in Czech Holstein cattle. Czech Journal of Animal Science, 56, 4, 157–162.
OTWINOWSKA-MINDUR A., PTAK E., JAGUSIAK W. (2016): Genetic relationship between lactation persistency and conformation traits in Polish Holstein-Friesian cow population. Czech Journal of Animal Science, 61, 2, 75–81.
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.
SAS Institute Inc., SAS 9.1.3 Help and Documentation, Cary, NC: SAS Institute Inc., 2013.
STANOJEVIĆ D., DJEDOVIĆ R., BOGDANOVIĆ V., RAGUŽ N., KUČEVIĆ D., POPOVAC M., STOJIĆ P., SAMOLOVAC LJ. (2018): Genetic trend of functional productive life in the population of black and white cattle in Serbia. Genetika, 50, 863-883.
TAPKI I., GUZEY Y. Z. (2013): Genetic and Phenotypic Correlations between Linear Type Traits and Milk Production Yields of Turkish Holstein Dairy Cows. Greener Journal of Agricultural Sciences, 3, 11, 755-761.
VAN DER LAAK M., VAN PELT M. L., DE JONG G., MULDER H. A. (2016): Genotype by environment interaction for production, somatic cell score, workability, and conformation traits in Dutch Holstein Friesian cows between farms with or without grazing. Journal of Dairy Science, 99, 4496–4503.
WORLD HOLSTEIN FRIESIAN FOUNDATION - WHFF (2016): Type characteristics weighting per country; available from: https://www.whff.info
ZAVADILOVA L., ŠTIPKOVA M., NEMCOVA E., BOUŠKA J., MATEJIČKOV J. (2009): Analysis of the phenotypic relationships between type traits and functional survival in Czech Fleckvieh cows. Czech Journal of Animal Science, 54, 12, 521–531.

Received 10 November 2020; accepted for publication 8 December 2020