

Research Regarding Heritability and Repeatability Coefficients of some Milk Production Traits from Farms in Moldavian Region

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Abstract

Aim of this study was estimation of two genetic parameters: heritability and repeatability, for five milk production traits. Data used in current paper consisted from phenotypic information from 998 cows with 1897 yield records. The traits which were considered for 305 days of lactation included milk, fat and protein yields and percentages of milk fat and protein. Data were statistically analyzed through the S.A.V.C. (Statistical Analyze of Variance and Covariance) software. The estimated heritabilities for studied traits were 0.24 to 0.38 for milk yield (MY), 0.27 to 0.41 for fat yield (FY), 0.61 to 0.87 for percentage of fat (F%), 0.25 to 0.39 for protein yield (PY) and 0.59 to 0.78 for percentage of protein (P%). Repeatability estimates for studied traits ranged from 0.27 to 0.34 for MY, from 0.30 to 0.41 for FY, from 0.67 to 0.86 for F%, from 0.28 to 0.39 for PY and from 0.62 to 0.77 for P%. Results from this paper are in line with values reported from other authors. Also, Fisher results indicate significant differences between studied farms.

Keywords: heritability, repeatability, yield traits, genetic parameters, Holstein cow

1. Introduction

Milk is valued as natural and traditional food because it has high nutritional value providing a substantial amount of vitamins and minerals and has an antitoxic role. Because of that milk production represents a criterion in breeding programs for dairy or mixed breeds [1, 2].

Usually dairy cattle breeding programs have been based on selecting traits that are related to the milk production and its quality and also, on traits such as conformation, longevity and udder health. Planning an efficient breeding program in dairy cattle requires knowledge of phenotypic characteristics and genetic parameters. Two of

these genetic parameters are heritability and repeatability. The heritability represents additive genetic value from total phenotypic value [3-5]. In general, the heritability coefficient is higher for milk quality traits (percentage of milk fat and percentage of milk protein) and lowers to medium for those that indicate milk yield (milk, fat or protein). This parameter allows to determine the way of improvement of a special trait by selection, or by breeding, or both. Repeatability is a genetic parameter that explains how a production trait or parameter measured, keeps value in following measurements in the future [6, 7].

In animal breeding data are frequently seen problems with missing observations. Because of that the genetic estimates that are expected has some differences. This also, are caused because of differences found in population, estimation method or because errors caused by anthropic factor. Many authors from different countries have

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studied and published results regarding genetic parameters of milk production traits from dairy cattle [8-11, 1, 2].

Purpose of this paper was the estimation of genetic parameters such as heritability and repeatability, for five quantitative traits from six farms in Moldavian region, each with a different number of cows.

2. Materials and methods

Total number on studied animals was 998 cows from 30 bulls of Holstein-Friesian breed. Yield records were taken from six farms from Moldavian region. Final data included 1897 completed lactation records of parities 1 to 8 on Holstein cows from 2011 through 2017 (table 1).

Final information included herd of each studied cow, animal identification, calving and dry dates, days in milk, yields for normal lactations, total number of registered monthly samples of milk. To avoid possible errors from registered data were excluded cows with mastitis or problems with udder health, those missing dry or calving dates, those with less than 7 registered controls or missing more than 2 consecutive controls. Also, lactations were truncated at 305 day after calving between 5 and 305 days according to the icar guidelines [12]. Milk (MY) fat (FY) and protein (PY) yields and percentage of milk fat (FP) and

protein (PP) was considered as traits analyzed in this paper.

For statistically analysis and estimation of genetic parameters S.A.V.C. (Statistical Analyze of Variance and Covariance) software was used.

The basic multi-trait repeatability model was [13]:

$$J_{ijkl} = \mu + F_i + L_j + A_k + e_{ijkl}$$

where: J_{ijkl} = performance “l” for animal “k” in “j” lactation from farm “i”, μ = overall mean common to all observations, F_i = fixed effect of “i” farm, L_j = fix effect of “j” lactation, A_k =random genetic additive effect of “k” animal, e_{ijkl} = random effect of residual.

The heritability coefficient was calculated as additive genetic variance divided by phenotypic or total variance:

$$h^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_p^2 + \sigma_e^2}$$

For repeatability coefficient were used the ratio of the between-individual component to the total phenotypic variance measures:

$$r = \frac{\sigma_a^2 + \sigma_{pe}^2}{\sigma_a^2 + \sigma_p^2 + \sigma_e^2}$$

where: σ_a^2 , σ_{pe}^2 , σ_e^2 represents additive genetic variance, permanent environment variances and residual variance respectively.

Table 1. Number of lactations in each farm from 1 to 4+ lactation

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
Lactation 1	112	248	73	15	68	161
Lactation 2	85	186	28	-	52	138
Lactation 3	71	125	28	-	23	91
Lactation 4+	100	124	98	-	29	42
Total number	368	683	227	15	172	432

3. Results and discussion

The estimated heritability and repeatability coefficients for each trait from data using REML method are shown in table 2.

Estimates of heritability were medium for quantity milk traits (milk, fat and protein yields) and high for quality traits (percentage of milk fat and protein). Heritability ranged from 0.24 to 0.38 for MY, from 0.27 to 0.41 for FY, from 0.61 to 0.87 for FP, from 0.25 to 0.39 for PY and from 0.59 to 0.78 for PP. Also, higher value was observed at farm with lowest number of registered lactations.

So, the minimum limit where observed for each trait in farm 3 with 227 lactations and the maximum limit were in farm 4 with 15 lactations. Estimates of repeatability for milk yields were medium with one exception, at farm 2 for fat yield the value is 0.41 which corresponds to a highly repeatable trait. Also, highly repeatable traits are whose responding for quality of milk (percentage of milk fat and protein). Obtained value ranged from 0.27 to 0.34 for MY, from 0.30 to 0.41 for FY, from 0.67 to 0.86 for FP, from 0.28 to 0.39 for PY and from 0.62 to 0.77 for PP. As shows studies of Negruțiu (1969) numbers of records

affects the value of repeatability coefficient because with more records the obtained value for this parameter will be more constant during its productive live [7].

For this parameter the highest value was obtained in farm 6 with 432 registered lactations and the

lowest limit was for farm 3 with 227 recorded lactations.

For cows from farm 4 the repeatability coefficient was not estimated because edited data set included cows with only first lactation.

Table 2. Heritability and repeatability coefficients for five milk production traits

Farm	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Fat content (%)	Protein content (%)
Heritability (h²)					
Farm 1	0.27	0.31	0.28	0.76	0.65
Farm 2	0.30	0.34	0.32	0.78	0.73
Farm 3	0.24	0.27	0.25	0.61	0.59
Farm 4	0.38	0.41	0.39	0.87	0.78
Farm 5	0.27	0.30	0.29	0.63	0.61
Farm 6	0.33	0.38	0.35	0.79	0.72
Repeatability (r)					
Farm 1	0.30	0.35	0.31	0.86	0.68
Farm 2	0.32	0.36	0.33	0.79	0.71
Farm 3	0.27	0.30	0.28	0.67	0.62
Farm 4	-	-	-	-	-
Farm 5	0.30	0.35	0.31	0.71	0.63
Farm 6	0.34	0.41	0.39	0.82	0.77

Results for Fisher test shows distinctive differences between farms from this study. This indicate that between farms exist many sources of variances which demonstrate the existing

variability and only with analysis of variance can be established which source of variance is essential and which are random (table 3).

Table 3. Results from Fisher test

Trait	Fisher value	Comparison	Differences
Milk yield (kg)	206.56	F 0.1% ¹ < Fisher value	*** ²
Fat yield (kg)	58.42		***
Protein yield (kg)	27.28		***
Fat content (%)	143.28		***
Protein content (%)	9.99		***

¹Distribution values for F5%= 2.21; F1%= 3.02; F0.1% = 4.10 [14]

² ***= distinctive differences between farms

Comparing with other authors (table 4) we found that Ghaderi-Zefrehei (2014), based on multi-trait random regression animal model obtained the value of 0.32 for milk and fat yields and 0.33 for protein yield [15].

Estimated heritabilities for Holstein cows in Japan using the animal model with repeated record obtained by Suzuki M. and Van Vleck D. (1994) were 0.30 for milk and fat yield and 0.26 for protein yield. Also values for repeatability coefficients were 0.54 for milk yield and 0.52 for fat and protein yields [16].

Another research on heritability parameter published by Amini et al. (2011) where was used repeatability model obtained the 0.21 value for milk yield and 0.15 value for fat yield. The repeatability estimates for milk yield was 0.46 and 0.35 for fat yield [17]. Ravazi et al. (2007) published a research regarding genetic parameters for Holstein cows from Markazi province for milk production traits. The obtained values for heritability coefficient were 0.16 for milk yield, 0.15 for fat yield, 0.20 for milk fat percentage, 0.13 for protein yield and 0.11 for milk protein percentage. And for repeatability coefficient

values were 0.44 for milk yield, 0.35 for fat yield, 0.31 for milk fat percentage, 0.39 for protein yield and 0.20 for milk protein percentage [18].

Comparing values for heritability coefficient from this research with the results obtained by Zaabza et al. in 2016 they are higher. The obtained results for heritability coefficient for Tunisian Holstein dairy cattle based on REML method were 0.21 for milk yield, 0.16 for fat and protein yields [11].

In a study, Roman et al. (2000) reported that heritability for milk yield was 0.26, for fat yield was 0.31, for protein yield was 0.17 and percentage of milk was protein 0.53 which are between the limits presented in current paper, but the value for percentage of milk fat (0.53) is higher than percentage of milk fat from current paper research [19].

Heritabilities for milk yield, fat yield, protein yield, percentage of milk fat and percentages of milk protein were 0.29, 0.26, 0.25, 0.25 and 0.35 respectively. And for repeatability coefficient the values were 0.43 for milk yield, 0.34 for fat yield and 0.39 for protein yield [8].

In their research, Paura L. et al. (2002) the repeatability coefficients were 0.84 for milk yield, 0.49 for percentage of milk fat and 0.71 for percentage of milk protein [20].

Tyriseva A.M. et al. (2003) using a multi-trait animal model and REML methodology reported a repeatability of 0.41 for milk yield, 0.44 for percentage of milk fat and 0.61 for percentage of milk protein. Comparing with results from current research values are lower [21].

Table 4. Estimated values of heritability and repeatability for milk production traits from previous studies

Source	Milk yield (kg)		Fat yield (kg)		Fat content (%)		Protein yield (kg)		Protein content (%)	
	h ²	R	h ²	R	h ²	R	h ²	R	h ²	R
Ravazi et al., 2007	0.16	0.44	0.15	0.35	0.20	0.31	0.13	0.39	0.11	0.20
Ghaderi-Zefrehei et al., 2014	0.32	--	0.32	--	--	--	0.33	--	--	--
Roman et al., 2000	0.26	--	0.31	--	0.53	--	0.17	--	0.53	--
Suzuki et al., 1994	0.30	0.54	0.30	0.52	--	--	0.26	0.52	--	--
Amini et al., 2011	0.21	0.46	0.15	0.35	--	--	--	--	--	--
Turiseva A.M. et al., 2003	--	0.41	--	--	--	0.44	--	--	--	0.61
Paura L. et al., 2002	--	0.84	--	--	--	0.49	--	--	--	0.71
Zaabza et al., 2016	0.21	--	0.16	--	--	--	0.16	--	--	--
Jamrozik et al., 1997	0.48	--	0.47	--	--	--	0.52	--	--	--
Alijani et al., 2012	0.29	0.43	0.26	0.34	0.25	--	0.25	0.39	0.35	--

4. Conclusions

In conclusion the obtained results for genetic parameters: heritability and repeatability for studied farms are in line with values reported from other authors. Also, high values were obtained for percentages of milk fat and protein for both parameters. And for those referring to the quantity of milk value were medium heritable and repeatable. This indicates that for studied cows for these traits it is efficient to apply only selection method.

Differences for obtained values for studied populations in future researches are expected as a result of differences in populations (number on registered records), in estimation method and mathematical models applied.

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