ESTIMATION OF GENETIC PARAMETERS FOR MILKING SPEED FOR HOLSTEIN CATTLE IN CROATIA

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Summary

Milking speed has a growing importance from a dairy management standpoint. Cows with slow milking speed require more labour, while cows with fast milking speed could be in greater risk for udder diseases. Selection is therefore aimed for achieving an optimal milking speed. The aim of this paper was to estimate genetic parameters for milking speed using test-day records of Holstein cattle in Croatia. Data included 51,266 test-day records for 15,588 first calving cows taken from the central database of the Croatian Agricultural Agency. Pedigree file consisted of 32,021 animals. In order to improve the normality, logarithmic transformation for milking speed was used. Variance components where estimated using REML method as implemented in the VCE-6 program. Statistical model included calving season, milking time, and milk class as fixed effects, while age at first calving and days in milk were fitted as covariates. Random effects were: direct additive genetic effect, herd-test-day, and permanent environmental effect. The estimated heritability for milking speed was 0.12±0.01. Permanent environmental effect explained 19% of phenotypic variation, while herd-test-day explained another 17% of variability. The proportion of unexplained phenotypic variance was 52%. Results provide genetic parameters for the application of genetic evaluation for milking speed in Croatian Holstein breed.

Key words: milking speed, Holstein breed, test-day records, genetic parameters

INTRODUCTION

Milking speed or milking flow rate belongs to the group of functional traits together with the calving ease, fertility, health, and feed efficiency, which hold an increasing importance in dairy cattle (Groen et al., 1997). It is defined as the cow's capacity to give completely and in short time milk produced in the udder gland (Dodenhoff et al. 1999; Ordloff, 2001). In the breeding programs, milking speed is trait of interest due to relationship with udder health and labour efficiency (Göft et al., 1994). Slow milked cows are undesirable for the farmers because of increased labour time and consequently higher costs of milk production. Higher milking speed is associated with the higher risk of mastitis (Boettcher et al., 1998; Mijić et al., 2004; Zwald et al., 2005). Therefore, a moderate milk speed considered to be optimal in terms of udder health. According to the Ashraf (2007), an optimal milking speed for high-producing herds should be at least four kg/min. Milking speed could be improved through selection (Boettcher et al., 1998) since it is sufficiently heritable trait which makes breeding reasonable. According to the literature, estimated heritability for milking speed ranged from 0.14 (Sewalem et al., 2011) up to 0.40 (Dodenhoff and Emmerling, 2008) and its genetic correlation with milk production was around 0.40 (Naumann et al., 1998; Santus and Bagato, 2000).

In Croatia, milking speed has been recorded since 2008. Recording is conducted by supervisors of Croatian Agricultural Agency according to the ICAR rules (ICAR, 2011). It is performed on two consecutive test-days (2nd and 3rd test-day during the 1st parity) using stop-watch on family farms or Lactocorders on big enterprises. In order to include milking speed in the genetic evaluation of the Croatian Holstein population, variance components should be estimated. The objective of this study was to develop an animal model for estimation of genetic parameters of milking speed in Croatian Holstein breed.

MATERIALS AND METHODS

Test-day records from regular milk recording (AT4 and BT4 method) and pedigree information were included in the analysis. Data were provided from the central database of the CroatianAgricultural Agency for the period from December 2007 to April 2013. Records were edited according to ICAR guidelines (ICAR, 2011). Holstein

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cows with records in the first parity between five and 180 days in milk were included in the analysis. Additionally, records were deleted for cows: 1) without birth, calving or test date, 2) with unknown parity, region or herd, and 3) unexpected age at the first calving (younger than 18 months or older than 40 months) or test day. Calving season was defined as year-season interaction. Four seasons within year were used as follows: spring (from March to May), summer (from June to August), autumn (from September to November), and winter (from December to February), respectively. Furthermore, ten milk classes were formed based on daily milk yield production (low to 5 kg, 5 to 10 kg, ..., 45 to 50 kg). After editing, 51,266 test-day records for 15,588 first calving cows were used for further analysis. In preliminary study, the normality of trait was tested and logarithmic transformation for milking speed (logMS) was performed. The average logMS and daily milk yield were 4.11 and 26 kg/day (Tab1). Similar averages were reported for Hungarian Holstein breed (Ashraf, 2007).

Tab.1. Descriptive statistics for production data								
Variable	Unit	Ν	Mean	SD	Minimum	Maximum		
Milking speed	kg / min	51,266	2.31	0.85	0.50	8.00		
LogMS	log	51,266	4.11	0.54	2.00	6.00		
Milk yield	kg	51,266	26.1	6.9	3.0	50.0		
Age	months	51,266	26.6	6.9	18	40		
Stage of lactation	days	51,266	93.52	48.28	5	180		

Remaining data preparation was related to the construction of pedigree data that contains information about genetic relationship among animals (Tab2). The total number of animals included into pedigree was 32,021. There were 89% non-base animals among all animals in pedigree. More than half animals (54%) have both parents known.

Tab.2. Pedigree structure							
Item	Number of records	Item	Number of records				
Total number of animals	32,021	Non-base animals	28,491				
Animals with records	15,588	Both parents known	17,192				
Base animals	3,530	Only Dam known	966				
		Only Sire known	10,333				

The following model[1] present the best fit for logMS:

$$y_{ijklmn} = \mu + b_1 \left(x_{ijklmn} - \bar{x} \right) + b_2 \left(x_{ijklmn} - \bar{x} \right)^2 + b_3 \left(t_{ijklmn} - \bar{t} \right) + S_i + T_j + M_k + c_l + a_m + p_n + e_{ijklmn}$$
[1]

Effects of calving season (S_i), milking time (T_j), and milk class (M_j) were considered as fixed class effects. Age at first calving (x_{ijklmn}) and stage of lactation (t_{ijklmn}) were treated as covariables. Age was fitted in the model as quadratic regression, while stage of lactation was modeled as linear regression. Common herd-test day environment (c_k), direct additive genetic effect (a_l), and permanent environment (p_m) were included in the model as random effects.

The single trait model [2] was used and presented with following matrix notation:

$$y = Xb + Z_a a + Z_c c + Z_p p + e$$
^[2]

where **y** is vector of phenotypic observations, **b** is a vector of fixed effects, **a** is a vector of random additive genetic effects, **c** is a vector of random common herd-test day environment effects, **p** is a vector of random permanent environment effects and **e** is vector of random residual effects. Incidence matrices relating observations to fixed (X), animal (**Z**_a), common herd - test day environment (**Z**_c) and permanent environment effects(**Z**_p). The variance structure of random effects was: Var[**c**]=**I**_c σ_c^2 , Var[**a**]= $A\sigma_a^2$, where **A** is additive genetic relationship matrix, Var[**p**]= $I_p\sigma_p^2$, Var[**e**]= $I_e\sigma_e^2$, where **I** is identity matrix, Var[**y**]= $Z_aAZ_a'\sigma_a^2 + Z_cZ_c'\sigma_c^2 + Z_pZ_p'\sigma_p^2 + I_e\sigma_e^2$.

The GLM procedure (SAS Inst. Inc., 2009) based on Least Square Method was used to define the fixed part of model. Covariance components were estimated by Residual Maximum Likelihood (REML) method as implemented in the VCE-6 program package (Kovač et al., 2008).

RESULTS AND DISCUSSION

The proportion of variation (\mathbb{R}^2) accounted for the fixed part of the model for milking speed was 23%. All fixed effects included in the model were significant (P<0.05). Age at first calving modelled as quadratic regression had significant effect (P<0.05) on average logMS (Fig1a). The highest proportion of calvings were at the age from 23 to 28 months with the average logMS between 4.1 and 4.2. The average logMS decreased when cows became older at first calving. The proportion of cows that calved between 32 and 40 months was low, as well. An increased trend of logMS by age at calving was observed in the studies of Wiliams et al. (1984) and Meyer and Burnside (1987) for Holstein cows.



Fig1a and Fig1b. Average logMS and proportion of records by age at first calving and stage of lactation

The stage of lactation accounted for variation (P<0.05) of logMS. As shown in Fig1b, logMS increased towards the end of lactation, implying that a linear regression could sufficiently fit the logMS at the phenotypic level. Relationship between stage of lactation and milking speed was modelled by quadratic regression in Canadian Holstein cows (Williams et al., 1984; Meyer and Burnside, 1987), while Dodenhoff et al (1999) used Ali-Schaeffer lactation curve (Ali and Schaeffer, 1987) with four regression coefficients in german Holstein, Fleckvieh, and Braunvieh breed.

Calving season modeled as year-season interaction had significant effect (P<0.05) on logMS (Fig2a). In the first two years, cows that calved in winter had higher estimated logMS than cows which calved during other seasons. LogMS had an increasing trend from the winter calving season of 2009 toward the end of observed period. The largest value had cows that calved during autumn calving season in 2011. Meyer and Burnside (1987) fit calving season as interaction with herd effect which accounted considerable proportion of variation in Canadian Holstein cows.



Fig2a and Fig2b. Average logMS by calving season and milking class

Milking speed is positively correlated with milk yield indicating that high-producing cows have a higher milking speed than low producing cows (Batra and McAllister, 1984). Differences in milking speed (P<0.05) were also observed in this study (Fig2b) and milking speed increased with daily milk production.

Estimated heritability was 0.12 for milking speed for Croatian Holstein breed (Fig 3). The heritability estimated in this work confirms the estimate of 0.14 reported by Sewalem et al. (2011) for Canadian Holstein. In Slovenian Holstein, estimated heritability ranged from 0.03 using univariate model to 0.25 based on multi-trait model (Potočnik et al., 2006) based on subjective score. Rensing and Ruten (2005) reported estimated heritability of 0.28 for German Holstein, while mean heritability for Hungarian Holstein was 0.20 (Ashraf, 2007). Heritability for German Fleckvieh ranged from 0.21 to 0.40 as reported by Dodenhoff and Emmerling (2009) using records measured by milk-recording devices. Difference between heritabilities is coming from different systems of milking speed evaluation.



Fig3. Estimated ratios for milking speed

The variance ratio for permanent environment effect (p^2) was 19% (Fig3). The estimate was lower compared to the study of Ashraf (2007) where the same effect explained variance ratio of 52% using fixed multivariate animal model for Hungarian Holstein. Common herd-test day (c^2) effect accounted for another 17%.

CONCLUSIONS

The development of a single trait test day model for milking speed was studied. The best fit model was determinated with following fixed effects with classes: calving season, milking time, and milk classes. Age at first calving and stage of lactation were fitted as covariates. Random effects were: direct additive genetic effect, common herd-test day environment and permanent environment. Results show that milk speed is medium heritable trait, which is in order with biological assumptions and results of other studies. Results presented in this study indicate that single trait test day model can be applied for genetic evaluation of milking speed for Holstein cattle in Croatia. In the future, with more data collected model should be additionally tested and improved. Based on relatedness between milking speed and milk production traits and milking speed and udder health traits future work will be based on correlation these traits.

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