Estimation of Genetic Parameters for Milk Urea and Milk Production Traits of Latvian Brown Cows

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Summary

The objectives of this study were to determine the effects of environmental and physiological factors on milk urea content (MU) and milk production traits and to estimate heritability and repeatability for MU and milk production traits. Milk yield and MU, fat, protein, lactose, somatic cell count (SCS) and freezing point (FP) of milk were collected from the herd control data from August 2008 to August 2009 from dairy herd of the Study and research farm "Vecauce" of the Latvia University of Agriculture. Milk content parameters for total 794 milk samples were analyzed in accredited milk quality laboratory. The investigation data was processed using a program SPSS. Genetic parameters of MU and milk production traits were estimated by REML method using WOMBAT software applying a repeatability animal model. The average MU was 16.55 mg dL^{-1} and milk yield was 20.37 kg per test day. The average fat, protein and lactose contents were 4.60, 3.56 and 4.70%, respectively. The average SCS and FP of milk were 2.40 and minus 0.529°C. Milk productivity traits varied depending on season, lactation number and stage of lactation ($p<0.001$) expected fat content, which is not affected by lactation number. MU and FP varied depending on season and milking systems ($p<0.001$). Estimated heritability for MU (0.072) and FP (0.062) were low and moderate for milk production traits.

Key words

dairy cattle, genetic parameter, milk yield, urea

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Introduction

In Latvia lactation milk yield has increased in recent years reaching 5900 kg in 2010. Therefore ever greater attention has to be paid to ensure balanced feeding of animals. The concentration of MU is a useful measurement for assessing whether the balance between the intake of protein and energy is correct. MU is varied from herd to herd and between cows in the same herd. In different countries measuring of MU content may be used to monitor status of lactating dairy cows and used as a way to monitor the efficiency of protein utilization in dairy herds (Eicher et al., 1999; Godden et al., 2001). Using MU to monitor the efficiency of dietary protein utilization requires the identification of factors other than nutritional ones that may influence MU.

MU might be used as a selection tool, and therefore, information on genetic parameters is needed. In the study by Wood et al. (2003), heritability of milk urea nitrogen (MUN) for the first three lactations ranged between 0.44 to 0.59.

Aim

The objectives of this study were 1) to determine the effects of environmental and physiological factors on MU and milk production traits, 2) to estimate heritability and repeatability for MU and milk production traits.

Material and methods

The data used for this study were 794 monthly records of 86 lactating Latvian brown dairy cows from August 2008 till August 2009 from dairy herd of the Study and research farm "Vecauce" of the Latvia University of Agriculture.

All cows were kept in stall housing systems and milked in two milking systems: the "Side by Side" milking system (SBSM) and automatic milking system (AMS). From the cows in the "Side by Side" milking – system were collected 483 milk samples, and from the AMS were collected 311 milk samples. Animals had ad libitum access to total mixed rations.

Monthly control milk samples were analyzed for protein, fat, lactose, MU, SCS and FP. All of these parameters were analyzed in accredited milk quality laboratory SIA "Piensaimnieku Laboratorija" with FOSS instrument CombiFoss FC. SCS was analyzed as log-transformed SCS. The FP was analyzed folowing ISO 5764/IDF 108:2009 – thermistor cryoscope method.

The cow milk yield and pedigree information used in this study were available from Latvian Agricultural Data Centre.

Data in tables and figures are presented as least square mean ± standard error of means. The investigation data was processed using a program SPSS. Genetic parameters of MU and milk production traits were estimated by REML method using WOMBAT software (Meyer, 2010) applying a repeatability animal model:

$Y_{ijklmn} = \mu + A_i + PE_j + M_k + LS_l + L_m + MS_n + e_{ijklmn}$,

Y_{ijklmn} = ijklmnth observation of MU and production traits;

μ – population means;

A_i – animal random effect;

PE_j – permanent environmental factor;

M_k – fixed effect of k-th month class (k=1, 2,…, 12);

LS_l – fixed effect l-th day in milk (l=1, 2,…, 14);

L_m - fixed effect m-th lactation (m=1, 2, 3);

MS_n - fixed effect n-th milking systems (n=1, 2);

e_{ijklmn} – residual effects.

Stage of lactation was defined by 14 classes for DIM (<30, 31 - 60, … 361– 390, >391).

Lactations were arranged in three groups according to lactation number (1st, 2nd and ≥3rd). Average lactation number was 2.01. Only cows with four and more valid records were included in the analyses.

Results and discussion

The statistical parameters of MU and milk production traits, SCS and FP in milk of observed cows are shown in Table 1.

The average MU in the study (16.55 mg dL^{-1}) was lower than reported in the study of Bijgaart (2003). The MU levels between 15 and 30 mg dL^{-1} are generally considered as optimal if the protein content is from 3.20 to 3.80% (Spohr and Wiesner, 1991). Average daily milk yield, fat, protein and lactose content were 20.37, 4.60, 3.56 and 4.70%, respectively. The Latvian brown cows are characterized by higher fat and protein content and lower milk yield than Holstein breed cows. Parameter of the milk quality - SCS was 2.40 and in our study it is according to the EU qualitative requirements for milk. The mean value of FP, in the study, was minus 0.529˚C, which is consistent with the quality indicator of cows' raw milk in Latvia (–0.520 ˚C). Coefficient of variation for MU (50.1%) and SCS (62.4%) were high; moderate for yield traits (25.2%), fat content (24.7%) and low for protein content (10.3%), lactose content (5.2%) and FP (3.7%) compared with other milk production traits.

The evaluation of effects of test-day, lactation stage, lactation number and milking systems on MU and milk composition are shown in Table 2. In the study MU and all milk production traits variation were significantly influenced by test-day ($p<0.001$) and milking systems ($p<0.05$). Lactation stage significantly influenced all milk production traits, except the MU and FP.

Lactation number did not influence MU, fat content and FP. The various environmental and the cow effect explained the variance in MU and milk productivity traits, as the R^2 (coefficient of determination) of the model was between 0.64 and 0.48. Average MU and milk yield of study to different months presented in Figure 1.

Table 1. Descriptive statistic and coefficient of variation for MU and milk production traits of Latvian brown cows (n=794 milk sample)

Trait	Mean ± SEM[1]	CV[2]	Minimum	Maximum
MU (mg dL^{-1})	16.55 ± 0.29	50.1	1.4	47.5
Milk yield (kg)	20.37 ± 0.23	25.2	5.3	44.4
Fat (%)	4.60 ± 0.04	24.7	1.18	9.74
Protein (%)	3.56 ± 0.02	10.3	1.39	5.22
Lactose (%)	4.70 ± 0.01	5.2	1.55	5.31
SCS[3]	2.40 ± 0.06	62.4	-2.06	9.93
FP (°C)	-0.529 ± 0.001	3.7	-0.729	-0.484

[1] Standard error of the mean; [2] Coefficient of variation; [3] log-transformed SCS.

Table 2. Results for tests of significance of fixed factors on test-day concentrations of MU and milk production traits

Trait	Factor (*p-values*)			
	Month	Lactation stage	Lactation	Milking systems
MU (mg dL^{-1})	<0.001	0.545	0.337	<0.001
Milk yield (kg)	<0.001	<0.001	0.007	<0.001
Fat (%)	<0.001	<0.001	0.217	<0.001
Protein (%)	<0.001	<0.001	<0.001	<0.001
Lactose (%)	<0.001	<0.001	<0.001	<0.001
SCS	<0.018	<0.008	<0.001	0.422
FP (°C)	<0.002	0.699	0.234	<0.001

Table 3. Least square means of test day observations for MU and milk productions trait per lactation

Trait	Lactation		
	1 (n=439)	2 (n=168)	3 (n=187)
MU (mg dL^{-1})	16.95±0.32	17.66±0.46	16.97±0.44
Milk yield (kg)	20.93±0.26 [a]	22.13±0.39 [b]	20.47±0.36 [a]
Fat (%)	4.69±0.06	4.52±0.09	4.67±0.08
Protein (%)	3.48±0.02 [a]	3.64±0.03 [b]	3.67±0.03 [b]
Lactose (%)	4.77±0.01 [a]	4.64±0.02 [b]	4.62±0.03 [b]
SCS	1.91±0.08 [a]	2.60±0.12 [b]	3.36±0.12 [c]
FP (°C)	-0.530±0.001	-0.526±0.002	-0.530±0.002

[a, b, c] = P<0.05

The average daily milk yield was higher in August 2008 (22.8 kg) and June 2009 (22.9 kg) than in other months. Significant lower milk yield was in autumn and winter season (p<0.05). MU in milk was in range from 9.9 till 25.7 mg dL^{-1}. The MU had the highest content in September, January and July (least square means 25.32, 25.67 and 24.45. mg dL^{-1}, respectively) and lower content in August, October and March (least square means 10.22, 11.51 and 9.94 mg dL^{-1}, respectively). There were significant differences between test-days, which indicate the problem in herd management. Several other researchers have investigated high MU during the summer (Godden et al., 2001; Rajala-Schultz and Saville, 2003) only in herds with low milk productivity level. Important changes in MU are affected by a combination of temperature, humidity, feeding and cows physiological factors (Carlsson et al., 1995; Ferguson et al., 1997).

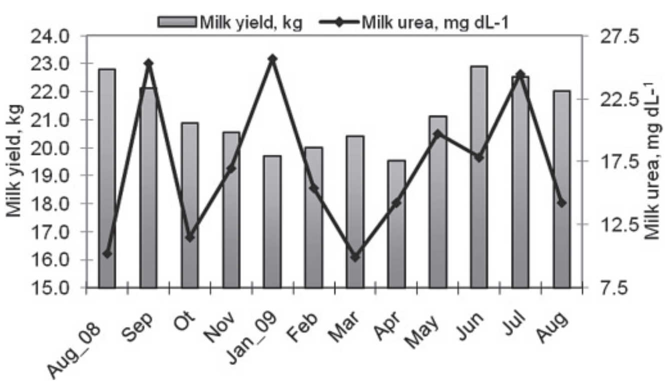

Figure 1. Least squares means of MU concentration and milk yield

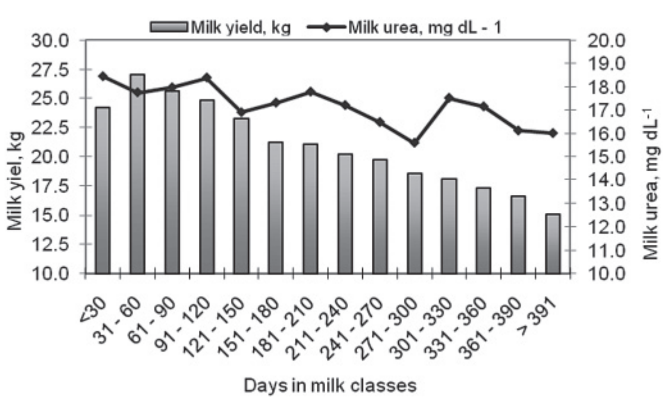

Figure 2. Least squares means of MU concentration and milk yield by days in milk classes

MU and milk yield variations during lactation are shown in Figure 2. In our study significantly higher milk yield were estimated for lactation stage from 31 till 60 and 61 till 90 days, 27.1 kg and 25.6 kg, respectively. During lactation MU between classes of lactation days varied insignificantly and was from 18.4 mg dL^{-1} in first 30 days of lactation to 15.6 mg dL^{-1} in the third phase of lactation (days 271 till 300). In our research MU during lactation was variable, with higher level for cows that were at the initial period of lactation (up to 150th day), still these variations of MU correspond to suggested MU (15- 30 mg dL^{-1}). According to researches of other authors, in first 60 days in milk (DIM) MU is the lowest, while from 60th to 150th lactation day it is the highest (Godden et al., 2001). According to another author's the highest MU in milk was observed between 60 and 180 DIM (Eicher et al., 1999; Johnson and Young, 2003).

The highest MU was observed in 2nd lactation (17.66 mg dL^{-1}). Differences between average MU in 1st, 2nd and 3rd and later lactations were not significant (Table 3).

In other authors' researches about lactation influence on changes of MU diverse opinions arise. Some studies found the small statistically significant differences in MU between lactation with highest MU in later lactations (Godden et al., 2001). Broderick and Clayton (1997) indicate that lactation number has small effect on MU changes, whereas Johnson and Young (2003) point out that the highest MU was for 1st lactation cows, while the lowest was for 3rd and older lactation cows.

Milk yield, protein and lactose content differed significantly for cows in various lactations (p<0.05). The highest test day milk yield was observed for 2nd lactation cows 22.1 kg.

Least square means of milk urea and production traits of observed cows in both milking systems differ significant (Table 4).

The highest average MU (18.97 mg dL^{-1}) and milk yield (22.35 kg) was found for the AMS. The average fat and protein content were significantly higher in the AMS (4.68 and 3.67%).

Heritability and repeatability of the MU and milk production traits are presented in Table 5. Heritability for MU and FP were 0.072 and 0.062, which were lower than that for milk pro-

Table 4. Least square means of different milking systems on MU and milk productions traits

Trait	SBSM[1] (n=483)	AMS[2] (n=311)
MU (mg dL^{-1})	15.41 ± 0.30[a]	18.97 ± 0.36[b]
Milk yield (kg)	20.00 ± 0.25[a]	22.35 ± 0.30[b]
Fat (%)	4.57 ± 0.05	4.68 ± 0.07
Protein (%)	3.52 ± 0.02[a]	3.67 ± 0.03[b]
Lactose (%)	4.72 ± 0.01[a]	4.63 ± 0.02[b]
SCS	2.58 ± 0.08	2.67 ± 0.09
FP (°C)	-0.521 ± 0.001[a]	-0.535 ± 0.002[b]

[1] "Side by Side" milking system; [2] Automatic milking system; [a, b] = P<0.05

Table 5. Heritability (h^2) and repeatability (r) for MU and milk production traits

Trait	h^2 ± SE	r ± SE
MU (mg dL^{-1})	0.072 ± 0.002	0.134 ± 0.001
Milk yield (kg)	0.271 ± 0.032	0.432 ± 0.012
Fat (%)	0.159 ± 0.009	0.225 ± 0.004
Protein (%)	0.318 ± 0.014	0.467 ± 0.011
Lactose (%)	0.281 ± 0.078	0.413 ± 0.008
SCS[3]	0.132 ± 0.023	0.232 ± 0.006
FP (°C)	0.062 ± 0.003	0.092 ± 0.002

ductivity traits and SCS. So low heritability means that differences in MU was due to environmental factors and cows feed level. Stoop et al. (2007) concluded that heritability estimates for MU was 0.14.

The estimated heritability for milk production traits was moderate for protein content (0.318), milk yield (0.271), and lactose content (0.281); and low for SCS (0.132). Generally the estimates heritability for production traits are similar to previous investigations in Latvian Brown cows population (Sarma, 2010).

Similar tendency were for the repeatability. Repeatability was higher for production traits and lower for MU and FP. The higher repeatability than heritability of the productivity traits suggests the strong nonadditive genetic effect on traits.

Conclusions

MU varied depending on season, parity and lactation stage. Significant effects (p<0.001) on MU and milk production traits were found for season and milking system. Therefore, the effects of environmental variables must be taken into linear model to provide the best estimates of genetic parameters for selection purposes. Heritability of MU was low. This suggests that it is possible that MU is influenced by herd practice and there is low possibility to do selection for MU.

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