Genetic Association of Test-day Milk Urea Concentration with Milk Yield in Primiparous Holstein Friesian Cows

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Abstract

The aim of this study was to estimate genetic parameters of milk urea concentration (MUC) and the relationships with milk yield (MY) in the first lactation of Holstein Friesian cows. Data consisted of 952 test day records of MY and MUC on 52 first lactation Holstein Friesian cows calving from 2015 and 2016 at Agricultural Research and Development Station (ARDS) Simnic-Craiova, Romania. Random regression models were used to estimate genetic parameters and associations between traits. The coefficient of variation for MUC in the first parity was 38.34%. Average daily heritability of MUC was 0.20. In the first parity, genetic correlation between MUC and MY was positive and increased with days in milk from 0.18 to 0.38. This result confirms that MUC, used for management purposes, may slightly increase due to selection for milk production trait.

Keywords: genetic correlation, genetic parameter, heritability, milk urea.

1. Introduction

Milk urea is a common tool used for evaluation on diet composition and feeding disorders [1]. Urea is synthesized primarily in the liver and originates from ammonia, which comes from protein degradation in the rumen or from deamination of amino acids in excess of requirements [2]. Urea molecules dissolve in body fluids, so milk urea nitrogen (MUN) is correlated with blood urea nitrogen (BUN) and urinary nitrogen excretion [3]. High milk urea concentration (MUC) indicates inefficient protein conversion with higher feeding cost.

Urea is the major contributor to the non-protein nitrogen (NPN) fraction of milk and represents 5 to 6% of the total nitrogen in milk. The phenotypic variability of MUC is high, and the coefficient of variation is over 30% [4]. The variability of MUC is due to genetic factors, but also on other factors, such as nutrition, year and month when the milk samples were collected, stage of lactation, age at calving and level of milk production [4, 5]. The heritability of MUC ranges from 0.13 to 0.59 [4, 6, 7]. Hence, the level of MUC depends, to some extent on the individual genetic potential [7]. The possibility of using MUC as a predictor trait for indirect selection is of great importance [6]. Some economically important traits are difficult to measure. The use of correlated traits may be beneficial for the selection process. The possible use of MUC in the selection process requires knowledge of its relation with the traits such as milk yield trait. Hence, the aim of this study was to estimate genetic parameters of MUC and the relationship with milk yield (MY) in the first lactation of Holstein Friesian cows.

2. Materials and methods

The data used in this study were MU test-day concentrations measured during milk recording by mid-infrared spectrometry. Data consisted of 952 test-day records of milk yield (MY) and Milk Urea concentrations (MUC) on 52 first lactation Holstein Friesian cows.
calving from 2015 and 2016 at Agricultural Researches and Development Station (ARDS) Simnic-Craiova, Romania. Milk urea concentrations were used in contrast with milk urea nitrogen (MUN) value because the dairy farmers receive urea information expressed as MUC (mg/dl of milk). Moreover, MU and MUN express basically the same traits. The conversion equations are:

- MU (mg/dl) = MUN (mg/dl) x 2.14
- MUN (mg/dl) = MU (mg/dl) x 0.47

Only records from 5 to 305 days in milk (DIM) in the first parity were subject to analysis. Detailed descriptions of the data are given in Table 1.

We evaluated indicators of heritability as well as the genetic correlation between the urea content and milk yield. Estimation of parameters was performed with the use of Random regression models [8, 9]. Legendre polynomials were used because they are orthogonal, normalized and resulted in a better convergence, with more accurate results, as compared to conventional polynomials. Daily heritability was defined as the ratio of genetic variance to the sum of genetic, permanent environmental a residual variances at a given DIM.

### Table 1. Characteristics of the data set used for the estimation of (Co) variance components

<table>
<thead>
<tr>
<th>Trait</th>
<th>First lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average test-day MUC* (mg/dl)</td>
<td>24.36</td>
</tr>
<tr>
<td>Coefficient of variation for MUC (%)</td>
<td>38.34</td>
</tr>
<tr>
<td>Average test-day milk (kg)</td>
<td>21.01</td>
</tr>
<tr>
<td>Number of test-day records</td>
<td>952</td>
</tr>
<tr>
<td>Number of annual with records</td>
<td>52</td>
</tr>
<tr>
<td>Average number of test-day records per cow</td>
<td>18,3</td>
</tr>
</tbody>
</table>

* MUC = milk urea concentration
** SD = standard deviation

**Figure 1.** Daily genetic, permanent environmental, and residual variances for milk urea concentration (MUC) over days in milk (DIM) in the first parity

### 3. Results and discussion

**Descriptive statistics**

The average test-day MUC was 24.36 mg/dl ± 9.34 mg/dl in the first lactation (Table 1). The coefficient of variation was 38.36 \%. Several authors have reported average MUC in the same range [4, 7], but with higher coefficient of variation from 40.1 \% [11], to 42 \% [4], or lower coefficient of variation from 15 to 33 \% [10, 11,
The variation found in this study could be explained by different feeding system across DIM, namely, the supplementation of grass-based feeding during the summer months or the type of forage used during the winter season (maize silage and beet pulp).

The average MUC at calving was close to 24.0 mg/dl of milk; it then increased to 28.8 mg/dl at 45 DIM and rose slightly to 29 mg/dl at 85 DIM. The average MUC at 105 DIM decreased to 25.91 mg/dl; it then decreased slightly to 24.25 mg/dl until 225 DIM. The average MUC at 245 DIM increased to 29.32 mg/dl and then decreased slightly to 25.0 mg/dl at 305 DIM. This pattern of change in MUC was observed when MUC data were summarized on a 20-d interval basis.

**Variances Components and Heritabilities**

Genetic and environmental variances were estimated over DIM during the whole 305 days period in the first parity. The pattern of variances for MUC throughout the first lactation is presented in Figure 1. The mean daily permanent environmental variance was lower than genetic variance. Genetic variances in the first lactation were flattened in the central port of lactation, with higher values in the first 2 month after calving, and increased in the last 2 months of lactation. Higher estimates of permanent environmental variation were observed at the beginning of the first parity. The mean daily MUC heritability was 0.20 for the first lactation. The heritabilities of daily MUC are presented in Figure 2. The highest values of daily heritabilities were estimated at the end of lactation due to an increase in genetic variance in the end of lactation. Some authors reported similar pattern [7], but other authors reported a curvilinear pattern, with a rapid increase until 35 DIM followed by a "U" shape with a minimum at mid-lactation [13]. The mean heritability estimated for milk yield trait ranged from 0.16 to 0.38 for first lactation.

Genetic correlations

Daily genetic correlation between MUC and milk yield was positive and increased with days in milk from 0.18 to 0.38. This moderate positive correlation between MUC and milk yield indicates that higher MUC can be observed in cows with higher milk production. In most previous studies, a positive correlation between MUN and milk yield was found and only [14] did not confirm this rule.

**4. Conclusions**

The estimated heritability of milk urea concentration (MUC) in the milk of Holstein Friesian cows from ARDS Simnic-Craiova in the first parity was moderate. Genetic correlation between MUC within first lactation with milk yield was low. The positive genetic correlation...
with milk yield confirms that MUC may slightly increase due to selection for production traits. Further studies are needed in order to assess the genetic correlation with udder hearts and fertility traits which are low heritable but economically important traits.

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References