ABSTRACT: Total milk solids in first lactation were analyzed using random regression models, given that there were repeated measures for cows. Age (d) and days in milk were used as covariates. The additive genetic, permanent environmental and residual variance components, from which heritability was obtained, were estimated. The model containing sixth degree orthogonal Legendre polynomials best fit the data. The lowest heritability estimate was at 123 d (0.19) and the highest at 5 d (0.59). This implies greater genetic influences in early lactation, which should be an indicator of the time to select animals that are potentially the best producers of total milk solids.

Keywords: dairy cattle, total solids, milk production

Introduction

Although milk production is important to supply the internal market in Brazil, in most systems, the productivity per animal is low. The national average production is around 4 kg of milk per animal per day, while productive countries report an average exceeding 15 kg. In Brazil only highly specialized farms can produce at this level, and there are very few.

The composition and quality of milk is linked not only to environmental factors (feeding and management) but also to genetics factors. The knowledge of population genetics is essential to obtain information that will guide producers and technicians in identifying and breeding superior animals. Thus, it will be possible to obtain genetic progress in breeding (Marion et al. (2001)). The objective of this study was to estimate the additive genetic and permanent environmental variance components to obtain heritability for total milk solids in first lactation Holstein dairy cows using random regression models.

Materials and Methods

Data. The data used in this study was provided by the Milk Clinic, Laboratory of the Department of Animal Science (College of Agriculture “Luiz de Queiroz”) of the University of São Paulo (LZT-ESALQ-USP). It consisted of total milk solids from Holstein cows raised in tropical conditions from 36 different Brazilian herds.

The data consisted of 27,665 records of 4,901 first lactation cows that were the daughters of 371 sires and 211 dams. The ages of cows (AOC) ranged from 720 to 1500 d, and there are very few.

Analysis. Since the data consisted of repeated measures on animals within the same lactation, random regression models (RRM) were utilized. With this approach, it was possible to understand the behavior of heritability throughout lactation and choose the best time to practice selection. Analyses to obtain the variance components were performed using an animal RRM in the WOMBAT software (Meyer (2006)). The covariance functions for the random effects of additive genetic and permanent environmental components were estimated using orthogonal Legendre polynomials. The model included the fixed effects of contemporary groups (CG) by considering herd, year and month, and AOC.

Model. Total milk solids were modeled using random regression with the animal model, proposed by Meyer (1998):

\[ y_{ij} = F + \sum_{m=0}^{k_1} \beta_m \phi_m(t_{ij}) + \sum_{m=0}^{k_2} \alpha_m \phi_m(t_{ij}) + \sum_{m=0}^{k_3} \gamma_m \phi_m(t_{ij}) + \epsilon_{ij} \]

where \( y_{ij} \) is the \( i^{th} \) observation of the \( j^{th} \) animal, \( F \) is the set of fixed effects (CG and AOC); \( \beta_m \) is the regression coefficient of the characteristics according to DIM for the population mean; \( \alpha_m \) and \( \gamma_m \) are the random regression coefficients for additive genetic and permanent environmental effect for animal \( i \); \( k_1 \), \( k_2 \) and \( k_3 \) are the degrees of the polynomials; \( t_{ij} \) corresponds to the \( i^{th} \) age of \( j^{th} \) animal; \( \phi_m \) is the \( m^{th} \) Legendre polynomial function to be evaluated for \( t_{ij} \); and \( \epsilon_{ij} \) is the random residual.

Models with Legendre polynomials from third to sixth degree (Leg3, Leg4, Leg5 and Leg6) were tested and used to fit the curves of genetic and permanent environmental effects. A quadratic effect was used for AOC. The criteria to determine the best model were: the likelihood ratio test (LRT), Akaike Information Criterion (AIC), Bayesian Information Criterion of Schwarz (BIC) and -2log (L).

Results and Discussion

Leg6 was found to best fit the data according to AIC, BIC and LRT (Table 1). The lowest heritability for total milk solids estimated by Leg6 was 0.19 at 123 DIM (Figure 1). Similar to the other models, Leg6 estimated a higher heritability at the beginning of lactation, the highest being 0.59 at 5 DIM. Throughout lactation, an average heritability of 0.39 was estimated. This implies greater genetic influences in early lactation, which should be an indicator of the time to select animals that are potentially the best producers of total milk solids. These results are in accordance with López-Romero and Carabaño (2003), who report the beginning and end of lactation as the phases where greater differences between the variance components occur.
Table 1 – Model name, number of parameters and criteria for model selection with different orders of adjustment in the Legendre scale, for additive genetic and permanent environmental effects.

<table>
<thead>
<tr>
<th>Model</th>
<th>Nº Parameters</th>
<th>-2log(L)</th>
<th>AIC</th>
<th>BIC</th>
<th>GL</th>
<th>LRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg3</td>
<td>13</td>
<td>2727.72</td>
<td>2753.72</td>
<td>2860.26</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Leg4</td>
<td>21</td>
<td>2206.00</td>
<td>2248.00</td>
<td>2420.12</td>
<td>8</td>
<td>521.72</td>
</tr>
<tr>
<td>Leg5</td>
<td>31</td>
<td>1911.40</td>
<td>1973.40</td>
<td>2227.46</td>
<td>10</td>
<td>294.6</td>
</tr>
<tr>
<td>Leg6</td>
<td>43</td>
<td>1765.00</td>
<td>1851.00</td>
<td>2203.42</td>
<td>12</td>
<td>146.4</td>
</tr>
</tbody>
</table>

Figure 1: Heritability for total solids in first lactation Holstein cows in the four models studied (Leg1, Leg2, Leg3, Leg4).

For first lactation Holstein cows, Albuquerque et al. (1996) and Poso and Mantysaari (1996a,b) estimated heritability for fat yield from 0.22 to 0.40, values that are similar to the present study when analyzing average total solids. Weber et al. (2005) found a heritability estimate of 0.49 for fat production in milk. This estimate is greater than the average found in this study (0.39), but is lower than the value estimated at the beginning of lactation (0.59). The estimates found in the present study are similar to those found by Paula et al. (2008), who report estimates of heritability of 0.60 for fat and 0.58 for protein contents in milk from Holstein cows managed in the state of Paraná, Brazil.

The average heritability of total solids in milk obtained in this study, when compared with the estimated heritability for milk protein production, showed higher heritability than the ones presented by Paula et al. (2008) and Chauhan & Hayes (1991), whose averages were both 0.25.

Conclusion

The present study’s estimated heritability indicates that additive genetic variance of milk solids accounts for a considerable portion of the phenotypic variance in this population. Early lactation has the greatest genetic influence and it is suggested as the best time for selection in first lactation cows.

Literature Cited