

## Variance Components and Genetic Parameter Estimates Using Random Regression Models on Test Day Milk Yields of Holstein Friesians

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### Summary

Genetic parameters for test day milk yields of Holstein Friesian cows were estimated by random regression with Legendre polynomials. The analyzes were applied to 5918 first lactation test day milk yields of 612 Holstein Friesian cows calving from 1987 to 1993 in Dalaman, Tahirova, Sarımsaklı and Türkgeldi State Farms. Estimated genetic variances for test day milk yields were larger at extremes of the lactation. Permanent environmental variances mostly decreased in middle part of the lactation. The heritability values for test day milk yields were from 0.26 to 0.57. The genetic correlations between test day milk yields (TD1-TD9) with the last test day milk yield (TD10) were changed from -0.10 to 0.96 and it was high between consecutive test day milk yields, but decreased when the intervals between the test days increased. In random regression models it can be concluded that higher order polynomials were recommended for a sufficient fit of the (co)variance structures over the lactation but a reduction of the orders can also be used for computational simplicity due to small numbers of parameters.

**Keywords:** Legendre polynomial, Variance component, Genetic parameter

## Siyah Alacalarda Şansa Bağlı Regresyon Modelleri Kullanılarak Denetim Günü Süt Veriminin Varyans Bileşenleri ve Genetik Parametrelerinin Tahminlenmesi

### Özet

Bu çalışmada Legendre polinomiyal uygulanan şansa bağlı regresyon modelleri ile Siyah Alaca'ların denetim günü süt verimlerine ait genetik parametreler tahminlenmiştir. Analizler, 1987 ile 1993 yılları arasında Dalaman, Tahirova, Sarımsaklı ve Türkgeldi çiftliklerinde buzağulayan, 612 adet Siyah Alaca ineklerin toplam 5918 adet ilk laktasyon test günü süt verim kaydına uygulanmıştır. Denetim günü süt verimlerinin genetik varyans tahminleri laktasyonun başında ve sonunda büyük bulunmuştur. Kalıcı çevre varyanslarının laktasyonun orta döneminde oldukça düşük olduğu belirlenmiştir. Test günü süt verimlerinin kalıtım dereceleri 0.26 ile 0.57 arasında tahminlenmiştir. Denetim günü süt verimlerinin (TD1-TD9) en son denetim günü süt verimi (TD10) ile olan korelasyonları -0.10 ile 0.96 arasında değişim göstermiştir. Korelasyonlar denetim günleri birbirine yaklaştıkça yüksek, denetim günleri arası mesafe arttıkça düşük tahminlenme eğilimi göstermiştir. Şansa bağlı regresyon modellerinde, kovaryans yapılarını iyi tahminlemeleri nedeniyle yüksek dereceli polinomiyallerin kullanımı önerilmektedir. Bununla birlikte, daha az parametre içermeleri nedeniyle hesaplama kolaylıkları sağlayan küçük dereceli polinomiyaller de kullanılabilir.

**Anahtar sözcükler:** Legendre polinomiyal, Varyans bileşeni, Genetik parametre

### INTRODUCTION

Estimated 305 day lactation yields have been considered in genetic evaluation systems of dairy cows for a long time. Nowadays, the use of 305 day lactation records have replaced by consideration of test day records using test day models as repeatability,

multivariate and random regression models which have been developed to model test day records directly<sup>1,2</sup>. In repeatability model, test day records are considered as repeated observations of same trait but in multivariate model, test day records are considered



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as separate traits, or test day records as repeated observations within lactations and lactations as separate traits.

The quality of test day evaluation is partly depends on the accuracy of (co)variance components<sup>3</sup>. Random regression models have also different approaches for test day models<sup>4,5</sup>. and these models try to fit (co) variance structure of repeated measurements along lactation trajectory<sup>6</sup>. REML approach is used by random regression models for analyzing variance components, because of several advantages over ANOVA methods<sup>7</sup>.

There have been numerous studies about the application of random regression models to the test day records for longitudinal traits such as body weight<sup>8,9</sup>, milk yields<sup>10-16</sup>, somatic cell count<sup>17,18</sup>, body condition score<sup>19-21</sup> and feed intake<sup>22</sup>.

The random regression models have described general shape of lactation curve by fixed regression for all cows and the individual genetic deviation from the fixed regressions<sup>23</sup>. Regression coefficients from random regression models are commonly described by the orthogonal functions (e.g. Legendre polynomials). Coefficients derived from fitting orthogonal functions are very useful for analyzing patterns of genetic variation in the trajectory<sup>24</sup>. Legendre polynomials, a family of the orthogonal functions, are orthogonal and normalized, which results in better converge and more accurate results than the conventional polynomials<sup>25</sup>.

Swalve<sup>26</sup> reported that heritability values from single test day milk record analysis were changed between 0.18-0.36. Misztal et al.<sup>27</sup> have considered milk, fat and protein yields in a multivariate model and found the heritability values of milk yields as 0.44. Rekaya et al.<sup>13</sup> were also found the heritability of milk yields as 0.30, 0.27 and 0.24 for first three lactations from multivariate model, respectively.

Using random regression models, Jamrozik and Schaeffer<sup>11</sup> have estimated heritabilities for daily milk yields between 0.40-0.59. Olori et al.<sup>12</sup> and Rekaya et al.<sup>13</sup> have found these values as 0.22-0.49 and 0.24-0.34, respectively. Estimates obtained by López-Romero et al.<sup>14</sup> were 0.10-0.35 for first lactation milk yields of Spanish Holstein cows. Nearly the similar estimates (0.16-0.39; 0.15-0.31 and 0.10-0.25) were obtained by Druet et al.<sup>15</sup>, Strabel and Misztal<sup>3</sup> and Cobuci et al.<sup>16</sup>, respectively.

During recent years, random regression models have

been also introduced for national genetic evaluation system on milk production traits in most countries. In our country, there is no any study on estimates of genetic parameters for test day milk yields of Turkish Holstein cows using random regression models. Therefore, the aim of the present study was to estimate variance components and genetic parameters for first lactation test day milk yields of Turkish Holstein cows using better fitting random regression models determined in the study of Takma and Akbaş<sup>28</sup>.

## MATERIAL and METHODS

Data comprised of 5918 first lactation test day milk yields of 612 Holstein Friesian cows which were raised in Dalaman, Tahirova, Sarımsaklı and Türkgedi State Farms of Turkey. The cows, produced test day milk yields, were daughters of 92 sires and 130 dams, and calved from 1987 through 1993. Lactation length was restricted to have at least 150 days and maximum 308 days long. Maximum ten test day records (TD1-TD10) were collected at monthly periods.

Takma and Akbaş<sup>28</sup> were compared several models for better fitting. The models were changing two lactational Ali Schaeffer (ARR) and Wilmink (WRR) models and twenty five orthogonal Legendre polynomial models (LRR) with orders from 2 to 6 for both additive genetic and permanent environmental effects. The Legendre polynomial models described as L(6,2), L(6,5), L(6,6) were chosen as better models and L(3,3) was also recommended for simplicity.

In this study, variance components for test day milk yields were estimated using four Legendre polynomial models called L(6,2), L(6,5), L(6,6) and L(3,3). Analysis was carried out using the DXMRR option of the DFREML program<sup>6</sup>. Residual variance was assumed to be constant throughout lactation for reducing the number of parameters to be estimated and the dimension of the likelihood searches.

The general random regression model used in this study is as follows:

$$y_{ijk} = HTD_i + \sum_{m=1}^{k_B} \beta_m X_m(t_{ij}) + \sum_{m=1}^{k_A} \alpha_{jm} \Phi_m(t_{ij}) + \sum_{m=1}^{k_P} p_{jm} \Phi_m(t_{ij}) + e_{ijk}$$

$y_{ijk}$ : is the  $k^{\text{th}}$  test day milk yield of the cow  $j$  obtained at  $i^{\text{th}}$  herd-test day (month)

$HTD_i$ :  $i^{\text{th}}$  herd-test day (in month)

$\beta_m$ :  $m^{\text{th}}$  fixed regression coefficients for cow

$t_{ij}$ :  $i^{\text{th}}$  test day of the cow  $j$

$X_m(t_{ij})$ :  $m^{\text{th}}$  covariate evaluated at and represented by the Ali-Schaeffer function, where  $C=305$ ,  $X_1=1$ ,  $X_2=\text{DIM}/c$ ,  $X_3=(X_2)^2$ ,  $X_4=\ln(c/\text{DIM})$ ,  $X_5=(X_4)^2$

$\alpha_{jm}$ :  $m^{\text{th}}$  additive genetic random regression coefficients for cow  $j$

$\rho_{jm}$ :  $m^{\text{th}}$  permanent environmental random regression coefficients for cow  $j$

$\varphi_m$ :  $m^{\text{th}}$  polynomial evaluated for the age  $t_{ij}$

$k_B$ ,  $k_A$  and  $k_P$  are the order of fitted fixed, random additive and random permanent regression coefficients

$e_{ijk}$ : Random residual effect

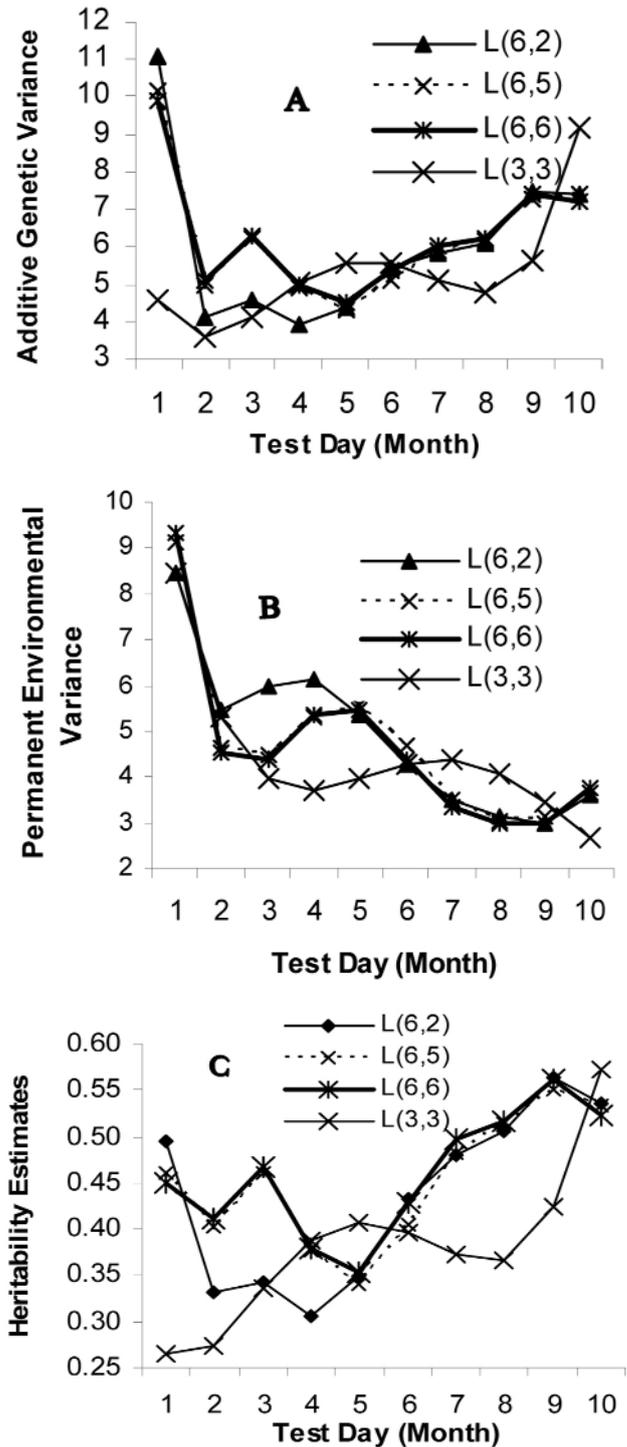
## RESULTS

Variance components for test day milk yields estimated from the model L(6,2), L(6,5), L(6,6) and L(3,3) were displayed in *Figure 1*. The genetic variance estimates for milk yield in different test days ranged between 3.58 and 11.05 (*Figure 1A*).

Furthermore, the estimates of genetic variances for milk yields from L(6,5) and L(6,6) models were similar. These estimates were also close to estimates from L(6,2) model (*Figure 1A*). The genetic variances for milk yields were generally larger at the first and last part of the lactation (*Figure 1A*) except the model L(3,3) in which genetic variance was small at the beginning of lactation and increased afterwards.

The estimates of permanent environmental variances for test day milk yields from L(6,2), L(6,5), L(6,6) and L(3,3) models were changed between 2.66 and 9.34 and their tendencies were presented in *Figure 1B*. This figure shows that estimates of permanent environmental variances were higher at early part of lactation and decreased in the rest of the lactation (*Figure 1B*). In model L(3,3), permanent environmental variance was sharply decreased at the beginning but not changed in the middle and decreased during last two test days.

Heritability estimates for test day milk yields were given in *Figure 1C*. Heritabilities were altered from 0.26 to 0.57 and the changes were consistent with the changes in genetic variances (*Figure 1A*). In addition, heritabilities from L(6,2), L(6,5) and L(6,6) models were lower at the middle part of the lactation than the values at the beginning and the last part of the lactation. Genetic variances and heritabilities were especially lower at TD2, TD3 and TD4 from the L(6,2) model. However, pattern of heritability from L(3,3) model were quite different and heritabilities were generally increased from first to last test days.

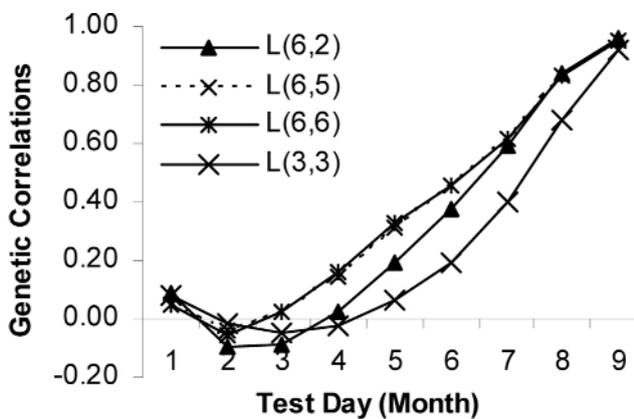


**Fig 1.** Changes in additive genetic (A), permanent environmental variances (B) and heritabilities (C) for test day milk yields during lactation from L(6,2), L(6,5), L(6,6) and L(3,3) models

**Şekil 1.** L(6,2), L(6,5), L(6,6) ve L(3,3) modellerinde eklemeli genetik (A), kalıcı çevre varyansı (B) ve kalıtım derecesi tahminlerinin değişimi (C)

Although numerous genetic correlations between 10 test day milk yields from 4 models were available, genetic correlations between several test days (TD1-

TD9) and the last one (TD10) are considered in this study and illustrated in *Figure 2*. The genetic correlations from all models have almost the same range and tendency. The genetic correlations from L(6,6) and L(6,5) were nearly same. The genetic correlations from L(3,3) during middle and late parts of lactation were the lowest among models. Furthermore, the genetic correlations tended to increase as test days were closer to TD10. The genetic correlations were negative between TD2 or TD3 and TD10 from L(6,2) and between TD2 and TD10 from L(6,5) and L(6,6) models (*Figure 2*). The L(3,3) had also negative correlations of milk yields at TD2, TD3 or TD4 with TD10.



**Fig 2.** Genetic correlations of TD1-TD9 with TD10 for L(6,2), L(6,5), L(6,6) and L(3,3) models

**Şekil 2.** L(6,2), L(6,5), L(6,6) ve L(3,3) modellerinde TD1-TD9 ile TD10 arası genetik korelasyonlar

## DISCUSSION

In this study, genetic parameters for test day milk yields were estimated and compared using several random regression models as L(6,2), L(6,5), L(6,6) and L(3,3) which were chosen as better fitting or simple models during the first step of this series study by Takma and Akbaş<sup>28</sup>.

The genetic variance estimates were lower than the values from previous some works<sup>11-14</sup>. On the other hand, the genetic variances were higher when compared to estimates of<sup>7,15,29</sup>. Similar genetic variance estimates were presented by Kettunen et al.<sup>10</sup>.

The genetic variances for test day milk yields were larger at the first and last part of the lactation. On the contrary, Pool et al.<sup>30</sup> and Rekaya et al.<sup>13</sup> have found lower genetic variances at extremes of the lactation when they fitted random regression models. More-

over, the genetic variances obtained in this study were similar to the results obtained by Kettunen et al.<sup>10</sup>; Jamrozik and Schaeffer<sup>11</sup> and Olori et al.<sup>12</sup>. Genetic variances were higher at early lactation and lower for rest of the lactation when compared to variances of Cobuci et al.<sup>16</sup>.

The estimates of permanent environmental variances for test day milk yields were higher at early lactation and lower for the rest of the lactation. Permanent environmental variances were generally lower in the late lactation when compared to results from the studies<sup>10,12-16</sup> and higher as compared to findings from the studies<sup>7,11</sup>.

Estimates of heritabilities were lower at the middle part of lactation that was opposite to the patterns reported by Rekaya et al.<sup>13</sup> and Kettunen et al.<sup>31</sup>. High heritabilities for test day milk yields at extreme parts of lactation may partly be explained by low environmental variance and high genetic variance. Heritabilities estimated in this study were similar to those reported by Olori et al.<sup>12</sup>, but higher than those studies<sup>4,13-16,31</sup> and lower than reported by Jamrozik and Schaeffer<sup>11</sup>.

Estimated genetic correlations between test day milk yields with the last test day milk yield were increased while test days became closer as reported by the studies<sup>7,13,16</sup>. Some negative genetic correlations at early part of lactation might be concluded that selection for increased milk yields at early test days will negatively or slightly positively affect milk yields of late part of lactation.

The general results show that L(6,2), L(6,5), L(6,6) and L(3,3) models have similar pattern for additive genetic and environmental variances during lactation and also genetic correlations between TD1-TD9 with TD10. But, heritability estimates from L(3,3) model were apparently differ when compared to L(6,2), L(6,5) and L(6,6).

Heritability estimates were moderate to high, varying from 0.26 to 0.57 for test day milk yields of Turkish Holsteins. It can be concluded that higher order of the functions caused high genetic variances and heritability at extreme parts of the lactation. In random regression models, a reduction of the orders can be recommended because of computational simplicity as a result of small numbers of parameters, even if higher order polynomials were necessary for a sufficient fit of the (co)variance structures over the lactation.

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