Estimation of Genetic Parameters for Persistency of Milk Production in Dairy Cattle

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1. Introduction

Persistency of milk production is the ability to maintain milk production at a high level after peak production (Jamrozik *et al.*,1998). With short lactations included in the genetic evaluations, genetic variation in persistency can reduce accuracy of 305-day yield predictions and selection response.

Several measures for persistency are described in literature. Three groups can be distinguished. Parameters from mathematical models describing the lactation curve form the first group of criteria. The Wilmink function is a well-known example of a mathematical model describing the lactation curve. This function is: $y = a + b * t + c * \exp^{(-0{,}05 * t)}$. The parameters are linked to the lactation curve: a to the level of production, b to the production decrease after peak yield, c to the production increase towards peak yield and the factor -0.05 to the moment of peak yield, i.e. around 50 days in lactation. Another, relatively new, way to fit a lactation curve through test day (TD) yields is random regression. This method makes it possible to estimate the shape of the genetic lactation curve for every cow by fitting the curve through the test day yields individually for each lactation, with a simultaneous correction for other fixed and random effects on phenotypic performances.

The second group that can be distinguished are measures of ratios between partial, maximum or other yields.

The third group of criteria contains measures of the variation of TD yields during the lactation.

Genetic improvement of persistency is of economic importance because it might reduce feed costs, diseases and reproduction failures. Dekkers *et al*. (1998) found economic values of 3.8% and 9.4% compared to the economic value of 305-day yield for a calving interval of 12.4 and 13.0 months, respectively.

The aim of this study is to estimate genetic parameters for persistency of milk, fat and protein production for 305-day yield in the first three lactations, using an animal model and using a random regression TD model. Because persistency might be influenced by gestation, the effect of days in gestation on persistency of milk, fat and protein yield will be estimated, using a random regression TD model.

2. Material and methods

Data

Data were 20,156,879 TD records from 2,013,576 Dutch Holstein dairy cows with lactations made between 1993 and 1998. All cows had 75% or more Holstein-Friesian genes. The TD records from first three lactations with milk, fat and protein yield were available.

For all cows, the Wilmink function was fitted using individual TD. Animals with estimated parameters deviating more than 3 standard deviations from the mean were excluded. Using the predicted parameters, 305-day yield (Y_{305}) was computed by summing predicted daily productions from day 1 to 305. Cows should have made their first lactation before 1996 to give them the opportunity to complete a third lactation. After this 69,677 records from 33,832 cows with first lactations were left. Because of computational problems, data were randomly split up by dividing the cows into six data sets (DW 1-6) according to the herd, first lactation was taken and second and third lactations were joined, if available. DW1 was used for all methods in this study and included 5,236 first lactations, 3,555 second lactations and 2,049 third lactations.

Analysis of 305-day yield (method B)

After fitting the Wilmink curve on individual TD yields, the b-parameters were analysed by an animal model. All six data sets were analysed to estimate the standard error of the selected data set. The same model was used for milk, fat and protein

$$b_{ijklm} = hy_i + my_j + \alpha * age_k + \beta * (age_k)^2 + ani_l + e_{ijklm}$$

where b_{ijklm} is the estimated b-parameter from the Wilmink function for each of the yield traits, hy_i is the fixed effect for herd-year of calving (i = 1 to 628), my_j is the fixed effect for month-year of calving (j = 1 to 71), age_k is the covariable of age at calving (days), ani_l is the random effect of animal and e_{ijklm} is the random error term. Genetic correlations of persistency of milk, fat and protein between the first three lactations were estimated by a multiple-trait model containing the first three lactations per trait. The same model was used to estimate heritabilities for 305-day milk, fat and protein yield.

Analysis of test day yield (method RR)

The same random regression model was used for trait h in lactation n:

$$y_{hijklmntp} = htd_{hni} + my_{hnk} + \alpha * age_{hnl} + week_{hnp} + \sum pe_{hnjm} * z_{tm} + \sum a_{hnjm} * z_{tm} + e_{hijklmntp}$$

where $y_{hijklmntp}$ is record l on cow j made on day t at herd-test day i, htd_{hni} is the fixed effect of herd-test day (i = 1 to 3521), my_{hnk} is the fixed effect of month-year (k = 1 to 71), age_{hnl} is the covariable of age at calving, $week_{hnp}$ is the fixed effect of week in lactation (p = 1 to 44), pe_{hnjm} is the random regression coefficients for permanent environmental effect (PE) for cow j, a_{hnjm} is the random regression genetic coefficients for cow j, $e_{hijklmnpt}$ is the random error term for each observation and z_{tm} is the Wilmink function.

Persistency of production was defined as the difference in production between day 60 and 280 of the lactation (Jamrozik et al., 1998). Heritability of persistency was calculated as:

$$h^2 = \frac{\sigma_a^2(60) + \sigma_a^2(280) - 2 * \sigma_a(60) * \sigma_a(280)}{\left[\sigma_a^2(60) + \sigma_a^2(280) - 2 * \sigma_a(60) * \sigma_a(280)\right] + \left[\sigma_{pe}^2(60) + \sigma_{pe}^2(280) - 2 * \sigma_{pe}(60) * \sigma_{pe}(280)\right] + \left[\sigma_e^2(60) + \sigma_e^2(280)\right]}$$

where σ_a^2 is additive genetic variance, σ_{pe}^2 is permanent environmental variance, σ_e^2 is error variance and σ_t^2 = total variance of persistency of yield. Genetic correlations of persistency between lactations and between persistency and level of production within lactations were calculated by correlating estimated breeding values (EBV) of 45 sires with ≥ 20 daughters with a first lactation. Genetic correlations were adjusted for the reliabilities of the EBV (Calo *et al*., 1973).

Analysis of TD yield including days in gestation in the model (method RR-G)

Days in gestation were included as a fixed effect in the same model as for method RR. This means that every TD yield was corrected or days in gestation if the cow was pregnant. Days in gestation were calculated using days open and days in lactation. If the number of days in lactation were smaller than days open, days in gestation were considered missing.

3. Results and Discussion

Heritabilities of persistency in first lactation, calculated with method B, RR and RR-G for DW1, are in Table 1. Heritabilities of persistency of milk, fat and protein yield are the same for all methods. The heritabilities for milk, fat and protein yield, calculated as a reference, are lower using method RR than using method B.

Heritabilities of persistency of milk, fat and protein increase with increasing lactation number (Table 2). Total variance of persistency of milk, fat and protein yield is much higher in the second and third lactation compared to the first lactation. This means that there is more variation in the difference in production between peak yield and yield at the end of the lactation. Reason for this might be the higher peak production in second and third lactation.

Average genetic correlations between persistency of milk, fat and protein between the first three lactations are in Table 3. Jamrozik *et al.* (1998) found genetic correlations of 0.37, 0.31 and 0.60 for persistency of milk, 0.35, 0.27 and 0.56 for persistency of fat and 0.36, 0.30 and 0.58 for persistency of protein between lactation 1 and 2, 1 and 3 and 2 and 3 respectively for Canadian Holstein cows. Results from this study indicate the same order of genetic correlations between lactation 1 and 2 and between lactation 1 and 3, whereas the genetic correlations between lactation 2 and 3 are much higher than found by Jamrozik *et al.* (1998). Both studies indicate that persistency of milk, fat and protein is not the same trait in different lactations. Possible explanation for this effect might be that the growth of heifers is interacting with the capacity to produce milk at a high level after peak production.

Table 1. Heritabilities of persistency for the first lactation estimated with method B, RR and RR-G for DW1

Method	B	RR	RR-G
Persistency of milk	0.145	0.151	0.159
Persistency of fat	0.098	0.105	0.107
Persistency of protein	0.066	0.075	0.075
Milk	0.342	0.268	0.269
Fat	0.263	0.164	0.159
Protein	0.195	0.149	0.149

Table 2. Average heritabilities of persistency of milk, fat and protein of six data sets (DW 1 to 6) of lactation 1, 2 and 3 estimated with method B (L1, 2 and 3 = first, second and third lactation)

	L1	L2	L3
Milk	0.13	0.20	0.18
Fat	0.08	0.18	0.18
Protein	0.08	0.17	0.14

Table 3. Average genetic correlations of persistency of milk, fat and protein of DW 1 to 6 between the first three lactations estimated with method B (L1, 2 and 3 = first, second and third lactation) and for DW1 estimated with method RR between lactation 1 and 2

Method	RR	B	B	B
	ρ_a (L1 – L2)	ρ_a (L1 – L2)	ρ_a (L1 – L3)	ρ_a (L2 – L3)
Milk	0.53	0.61	0.60	0.94
Fat	0.52	0.55	0.55	0.94
Protein	0.45	0.46	0.34	0.91

The genetic correlation estimated by Jamrozik *et al.* (1998) between level of production and persistency of production were –0.10, 0.01 and –0.00 for milk, -0.06, 0.15 and 0.14 for fat and 0.13, 0.27 and 0.22 for protein for the first, second and third lactation respectively. Genetic correlations between yield and persistency in this study were only estimated for the first and the second lactation. These were 0.25 and 0.53 for milk, 0.14 and -

0.60 for fat and –0.51 and –0.50 for protein for the first and second lactation respectively. These values are not adjusted for the effect of selection in the second lactation. Genetic correlations between yield and persistency indicate that there is no relationship between level of production and persistency of production. Genetic correlations found in this study indicate different genetic correlations between level of production and persistency of production, especially for the second lactation. However, genetic correlations in this study were based on only 45 sires without the effect of selection between lactations.

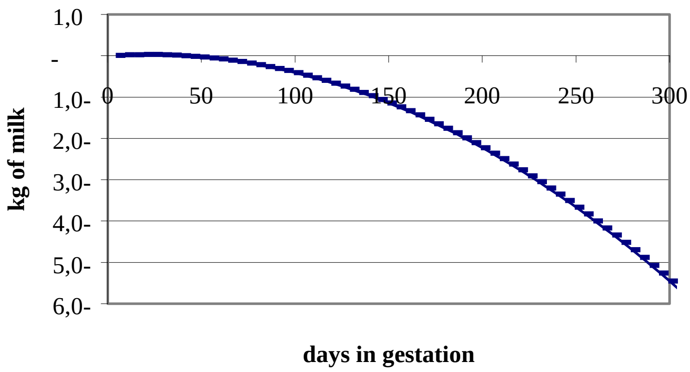

Figure 1. Estimated effect of days in gestation on daily milk yield.

The estimated effect of days in gestation on daily milk yield is in Figure 1. Including days in gestation in the model to estimate persistency of yield gives differences in 305-day production of 180 kg of milk, 7.2 kg of fat and 7.6 kg of protein between cows getting pregnant at day 85 or day 305 of the lactation. Although the estimated effect of days in gestation on daily milk yield, differences in estimated heritabilities with method RR-G and method RR for persistency of milk, fat and protein yield in first lactation are small (Table 1).

4. Conclusion

Heritabilities of persistency with the methods B, RR and RR-G are similar around 0.10 for lactation 1 and about 0.18 for higher lactations. Genetic correlations between lactation 1 and lactation 2 and 3 are almost identical and in the range 0.40 to 0.60. Genetic correlations between lactation 2 and 3 are > 0.90. Persistency of yield traits in lactation 1 is a different trait compared to persistency of yield traits in lactation 2 and 3. Correction for days in gestation at TD level does not affect genetic parameters for persistency.

5. References

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