Estimation of Genetic Parameters of Test Day Production in Finnish Ayrshire Cows

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Introduction

Dairy cow evaluation applications around the world are mainly based on the use of 305-d production, which is formed using the milk weighings from the first 10 months after calving. Lactation records are described by statistical models that include the most important environmental effects such as herd-year-season, calving month and calving age. In Finland, the major problem in defining the contemporary comparison groups arises from the very small herd sizes which do not allow to group animals further within herd-years, thus preventing from accounting for the seasonal variation within herds. Forming contemporary comparison groups based on season of calvings may also sometimes be inaccurate. An example of such a situation could be when two cows in the same herd calve in March and April. According to the present grouping in Finland these two cows are assigned to different herd years although they actually share same environmental conditions on eight or nine tests. If the evaluation was based on original monthly test day records, the amount of information would increase and the estimation of monthly test day effects within herds could be possible. Test day records would also have the advantage that the extension of records could be avoided, and if the heritabilities of test day records were close to those of lactation records accuracy of evaluations could be increased (Ptak and Schaeffer, 1993).

The objective of this study was to estimate genetic parameters for test day milk yield with a special emphasis on different contemporary comparison groupings and to compare the estimated parameters to those of 305-d production in Finnish Ayrshire.

Material and Methods

The data was provided by Agricultural Data Processing Center and it consisted of 988,701 test day records of 40,696 cows from some 2,900 randomly selected herds from three distinct geographical regions (Kuopio district, Middle Bothnia and Lappland) in Finland. Only the first lactation Ayrshire cows that calved between April 1991 and March 1995 (both inclusive) were extracted for further editing. To maximize the number of observations within herd-years (and herd test months) only the herd-years with three lactations or more and cows with minimum of 8 test days were accepted. After these edits 9,219 cows from 2,301 herd-years remained; the average number of cows within herd-years was 4.0. To keep the number of observations within herd test months as high as possible the first 12 test days of individual cows were included; later test days were rare. The average number of test months per cow was 10.5 and the total number of test day observations was 96,990. If on the test day the daily milk yield was less than 6.0 kg, the cow was, according to milk recording regulations, considered dry. This led to 27,864 herd test months in totally, with an average number of observations of 3.5 per herd test month. The cows were sired by 812 A.I. bulls with an average of 11.3 daughters per bull.

The variance components were estimated by using REML method and AI-REML algorithm (Johnson and Thompson, 1995). The following linear model was assumed to describe the test day milk yield:

$$y_{ijklmnop} = age_i + dcc_j + herd_k + \sum_{1}^{4} b_{q(l)}X_q + CCG_m + pe_{n(o)} + sire_o + e_{ijklmnop}$$

where

$y_{ijklmnop}$	is the test day milk yield
$age_{i,\ i=1,..,7}$	is the fixed effect of calving age class
$dcc_{j,\ j=1,..,5}$	is the fixed effect of days carried calf class
$herd_{k,\ k=1,..,231}$	is the fixed effect of herd
$b_{q(l)}$	are the regression coefficients on the functions of DIM that describe the shape of lactation curves nested within calving month $classes_{l,\ l=1,..,3}$ (X_1 = DIM/c, $X_2 = (DIM/c)^2$, X_3 = ln(c/DIM), $X_4 = (\ln(c/DIM))^2$, DIM is the days in milk for a test day yield, and c = 305)
CCG_m	is the effect of contemporary comparison group
$pe_{n(o)}$	is the effect of permanent environment of a cow within sire
$sire_o$	is the effect of sire and
$e_{ijklmnop}$	is the residual effect.

The classification of calving age and days carried calf effects is given in Table 1.

Variance components for 305-d milk production were estimated from the data of the same 9,219 cows as for test day yield assuming the following linear model:

$$y_{ijklmn} = month_i + age{*}DO_j + herd_k + CCG_l + sire_m + e_{ijklmn}$$

where

y_{ijklmn}	is the 305-d milk yield
$month_{i\ i=1,..,12}$	is the fixed effect of calving month, and
$age{*}DO_{j,\ j=1,..,55}$	is the fixed effect of calving age*days open interaction.

The other terms are as described previously.

The effects of contemporary comparison group, permanent environment, sire and residual were assumed random with zero means, and var(CCG)=$\mathbf{I}\sigma^2_c$, var(pe)=$\mathbf{I}\sigma^2_p$, var(sire)=$\mathbf{A}\sigma^2_s$ and var(e)=$\mathbf{I}\sigma^2_e$, where $\mathbf{I}$ is the identity matrix, $\mathbf{A}$ is the additive relationship matrix among sires, and σ^2_c, σ^2_p, σ^2_s and σ^2_e are variance components for contemporary comparison group, permanent environment, sire and residual effect, respectively. The additive relationship matrix contained the relationships among sires from male pathways only.

In the analyses of test day production three different definitions for contemporary comparison group were used: 1) herd*calving year (HY) 2) herd*year*season of production (HYSOP), with four seasons per year 3) herd*test month (HTM). For 305-d milk yield CCG was defined only as herd*calving year.

Results and Discussion

Solutions for the calving age and days carried calf classes (from analysis with HTM as CCG) are given in Table 1. The differences between calving age classes were distinct, cows that calved for the first time at the age of 23 months had a daily production of nearly 2 kg less compared to cows that were older than 28 months when calving. Pregnancy also had a significant effect on production, after 7 months of pregnancy daily milk yield was reduced by almost 4 kg.

The effect of calving month on test day milk yield was studied by estimating lactation curves separately for different calving month classes. A justification for such a procedure is that phenotypic lactation curves differ for cows that calve in the spring from cows that calve in the fall. It can be argued that cows whose production peak during the time when the cows are let to pasture are unfavoured by this change of feeding regime. The lactation curves by calving month classes (Figure 1) showed a similar tendency as the 'raw' phenotypic lactation curves. For cows that calve in late spring or in the beginning of summer the curve peaks lower and stays lower during lactation compared to cows calving in winter. Also, cows that calve in late summer or in early fall peak lower than the winter calvers but for them the lactation curve is more persistent.

Table 2 lists the variances due to CCG, permanent environment, sire and residual, as well as the total variation (σ_T^2), and the estimates of heritability and repeatability with different definitions of CCG. Heritabilities were calculated 'within herds', i.e., excluding the variation due to CCG from the denominator. As expected, seasonal variation within herds was least accounted for when the model contained HY as CCG leading to largest residual variation. HY explained only 5% of the variation whereas HYSOP and HTM accounted for approximately 15% of the variation. Residual variation was smallest with HTM as CCG resulting in highest heritability and repeatability estimate. Also in other studies concerning test day records fitting HTM has given higher heritability estimates than HYS because of smaller unexplained variation and increased additive component (Meyer et al. 1989; Rekaya et al. 1995; Swalve 1995). The heritability estimates for test day milk yield were generally low and distinctly lower than that for 305-d production (Table 2). Swalve (1995) reported also higher heritability estimate for 305-d milk yield than for test day yield with repeatability animal model, but the heritabilities were somewhat higher than the ones from these data. As for individual test days, heritabilities in the mid-lactation have been higher than in the beginning or in the end of lactation but lower than for 305-d records (Meyer et al. 1989; Pander et al. 1992; Swalve 1995).

If a selection index for cumulative yields over entire lactation was constructed using the obtained heritability and repeatability estimates, the squared accuracy of such an index would be higher than h^2 for 305-d production. This suggests that even with lower heritability test day yields could increase accuracy in EBV in comparison to 305-d production due to tenfold amount of observations per cow. If the test day records are to be used in the national evaluation HTM seems to best describe the seasonal variation within herds. HTM in the model would also provide solutions for different test months in the herds, which could be used to help dairy producers in their management decisions. However, before any decisions concerning potential model can be made, it has yet to be determined the amount of possible bias in EBV because of the small number of observations in HTM.

References

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Table 1. Solutions for the effects of calving age and days carried calf (from HTM-model)

	Number of tests	Solution
Calving age (mo.)		
missing	189	0.0
≤23	7,208	-2.4
>23 - ≤24	15,753	-1.7
>24 - ≤25	22,615	-1.5
>25 - ≤26	16,865	-1.3
>26 - ≤28	19,591	-1.1
>28 - ≤30	9,031	-0.5
>30	5,516	-0.3
Days carried calf (mo.)		
<4	71,121	0.0
≥4 - <5	8,073	-0.4
≥5 - <6	7,519	-0.9
≥6 - <7	6,389	-2.0
≥7	3,666	-3.9

Table 2. Estimates of variance components, heritability and repeatability for test day milk yield with different definitions of contemporary comparison group and for 305-d production

	σ_c^2	σ_p^2	σ_s^2	σ_e^2	σ_T^2	h^2	r
Test day yield							
HY	0.67	5.95	0.63	6.28	13.53	0.19	0.51
HYSOP	2.05	6.28	0.63	4.90	13.86	0.21	0.58
HTM	1.80	6.39	0.66	4.59	13.44	0.23	0.61
305-d production							
HY	65,725	-	53,086	620,051	738,862	0.32	-

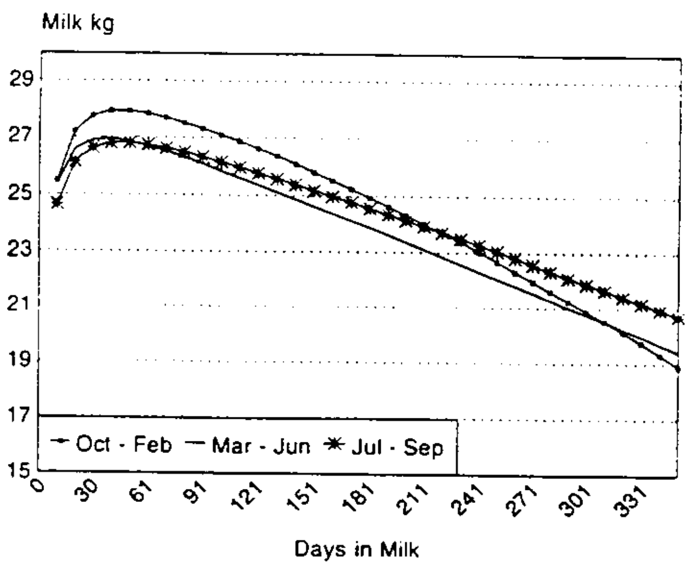

Figure 1. The lactation curves by calving month.