

Genetic Evaluation with a Multiple Lactation Test Day Model for SCS

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Abstract

A multiple lactation model for test day data was applied to predict genetic merit for somatic cell scores of German Holsteins. This method has been implemented as official evaluation procedure in 1996. Application of this computationally demanding procedure has proven that a test day evaluation is feasible, even with large scale national datasets. Associations were desirable for EBV of SCS with EBV for some udder conformation traits and longevity evaluations, but undesirable for EBV for protein yield. Starting in August 1997 genetic evaluations for SCS will also be included in the total merit index for German Holsteins.

1. Introduction

The introduction of penalty systems for high somatic cell counts (SCC) in the bulk milk has given an incentive for dairy cattle breeders to measure individual cows regularly on somatic cell counts. An additional incentive for measurement of SCC is the fact that SCC is genetically correlated to clinical and subclinical mastitis (Shook, 1989, Schutz, 1994, Philipsson et al., 1995). Therefore, genetic evaluation for somatic cell score (SCS), which is a \log_2 transformed measurement of the SCC of milk samples, has been introduced for genetic selection against mastitis susceptibility in many national dairy cattle breeding schemes during the past years.

However, the trait SCS has some statistically undesirable features, which are not accounted for by regular genetic evaluation procedures using lactation measures as trait in the genetic evaluation procedure. The common herd-year-season classification only accounts for environmental effects like parity, age of cow, and month of calving but there are some important short-term environmental effects that have a significant effect

on SCS. Typical short-term environmental effects on this trait are age of the sample, calibration of measurement equipment, infection pressure in the herd, milking practices, etc. (Figure 1). Use of a herd-test-day effect instead of a herd-year-season classification accounts for these short-term effects and leads to a higher heritability (Reents et al., 1995a).

Studies on genetic parameters for SCS indicate, that SCS from first lactation is genetically a different trait from second and later lactations. Additionally, mastitis incidence increases with parity of cows, and therefore SCS from later lactations should be included in the genetic evaluation procedure, ideally as genetically different traits.

A problem specific to Germany is the quite different management level in some historical data with respect to the region of production (Figure 2).

Aim of the present study is to describe the genetic evaluation procedure for SCS in Germany which considers the specific items of the trait SCS and to show some results from practical application of this method.

2. Materials and methods

2.1. Data

Data consisted of test day records for SCC on Holstein cows from data records processing centres in Germany from 1990 to December 1996 which were used for the official evaluation in February 1997.

Table 1 displays number of records and number of herd-test-date levels. Following edits on

- age of calving in months (20 to 40, 30 to 56, and 44 to 75, for lactations 1 to 3, respectively),
- day in milk of the sample between 4 and 365,
- interval between consecutive tests from 7 to 90 days

61,453,932 records on 4,046,096 cows remained in the dataset. Pedigree was completed for cows with identification of sire, dam and maternal grandsire from the national pedigree file maintained at VIT. Pedigrees for bulls with daughter records or granddaughter records were completed for several generations. Unknown parents were assigned to phantom parent groups, grouped by birth year of offspring (5 year per interval) and selection path. A total of 6,164,201 animals were considered in the relationship matrix.

2.2. Models

For genetic evaluation of test-day observations, a multiple trait test day model with repeated observations within each lactation was used. Table 2 displays genetic parameters, which were estimated using Gibbs sampling procedures on subsets of the analysed datasets. Material and methods are described in a paper by Reents et al. 1995a. Variance components were estimated applying the same methodology using a dataset of 26,216 German Holstein cows with 362,478 test day records from lactations 1 to 3.

The statistical model for analysis of test-day records, which is an extension of the model of Ptak and Schaeffer (1993) was:

$$y_{ijkmn} = \text{HTD}_{im} + A_{jm} + P_{jm} + \text{RAS}_{km} + b_{km1}(D/c) + b_{km2}(D/c)^2 + b_{km3}\ln(c/D) + b_{km4}[\ln(c/D)]^2 + e_{ijkmn}$$

where

y_{ijkmn}	is the n^{th} test day observation of the j^{th} cow in parity m
HTD_{im}	is a fixed herd-test-date effect
A_{jm}	is an animal additive genetic effect (random)
P_{jm}	is a within lactation permanent environmental effect to account for common environmental effects associated with all test-day records of the j^{th} cow in parity m (random)
RAS_{km}	is a region-age-season subclass mean effect in parity m
b_{km1} and b_{km2}	are regression coefficients on the linear and quadratic effects of D/c , where D is days in milk and $c=381$
b_{km3} and b_{km4}	are regression coefficients on the linear and quadratic effects of $\ln(c/D)$
e_{ijkmn}	is a random residual effect. Regression coefficients were estimated within 135 region-parity-age of calving-season groups. Contemporary groups for second and third lactation records from a specific herd-test-date were combined into a common herd-test-day class to increase the size of subcells. Higher level of SCS in 3rd lactation is then accounted for by regression coefficients, which are defined by parity.

The multi-lactation test day model provides separate EBVs for SCS in the first three lactations. The three EBVs were combined into an overall EBV for SCS by index weights of .26, .37, .37 for EBV for SCS in lactations 1, 2, and 3. EBVs are published as relative breeding values. For SCS, focus would be mostly on avoiding bulls with high EBV for SCS, which would be undesirable. Therefore, use of a scale with relative breeding values should be reversed to indicate undesirable bulls with values below 100. This index is called **RZS**, which stands for **R**elative **E**BV (EBV=**Z**uchtwert) **S**omatic Cell Score. Like all

relative breeding values in Germany this figure is standardized to a mean of 100 and a standard deviation of 12 points (for bulls with 100% reliability). The base is defined by all AI bulls born 8-10 years ago.

Computing strategies used for iterative solution of large scale test day animal models were described in detail by Reents et al. (1995b). Use of a high performance UNIX workstation with 2 GB of random access memory (HP-9000 with a K420 processor) allowed a time per round of iteration of less than five minutes when putting all data records in core for iteration on data. Demand for RAM was about 1.6 GB for the described dataset. With limited RAM a feature for iteration on data from disk using specific IO routines (fread) can be used. Then time per round of iteration increases by a factor of 4. Convergence was reached after about 150 rounds of iteration.

3. Results and discussion

Genetic evaluations for SCS have been well adopted by the German dairy cattle breeding industry. One main reason for this is, that the consequent use of a herd-test-day classification and also the definition of lactation curves by region of production allowed an unbiased evaluation across regions even if there are quite different phenotypic levels of SCS (Figure 2).

In the newly created net merit index, which will likely be implemented in August 1997, the SCS evaluations have an economic weight of 14% (56% for milk production, 4% reproduction, 6% longevity, 20% type traits). Pilot runs for genetic evaluation of length of productive life with a software package of Egger-Danner and Sölkner (1994) have been done at VIT (Reinhardt and Pasman, 1996). Genetic evaluations for longevity, even with the use of censored data, do have low reliabilities when the first crop of daughters of a bull finishes first lactation. Therefore some linear type traits and SCS evaluations, which can be obtained with a decent reliability during first lactation, can be used as traits for indirect selection on increased longevity. Table 3 displays genetic

associations between EBVs for RZS and protein yield, some type traits and longevity. Although these correlations should not be interpreted as genetic correlations, they indicate that there is a genetically undesirable association of SCS with production. Selection for udder health could be enhanced by the use of RZS proofs along with some udder conformation traits.

The proof correlation of .4 between EBV longevity and RZS indicates, that there is also a favourable association between SCS evaluations and longevity.

References

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Table 1. Number of test-day records and levels of herd-test-date effects for 4,046,096 cows.

	Lactation			Total
	1	2	3	
Number of test day records	27,385,453	20,018,898	14,049,581	61,453,932
Number of herd-test-date levels*	3,123,137	3,088,270	3,088,270	

* Same no. of levels for lactation 3 as lactation 2 because herd-test-date classes were combined for lactation 2 and 3.

Table 2. Genetic parameters for SCS of lactations 1 to 3.

	Heritability	Repeatability	Genetic correlation		Corr. Between PE-effects	
			Lact. 2	Lact. 3	Lact. 2	Lact. 3
Lactation 1	0.08	0.46	0.9	0.85	0.35	0.28
Lactation 2	0.13	0.47		0.97		0.45
Lactation 3	0.14	0.48				

Table 3. Correlations of EBV for RZS with protein yield, some type traits (2045 bulls with a reliability of the RZS proof of > 0,6), and longevity.

Trait	Correlation to RZS	Interpretation
Protein yield	-0,1	undesirable
EBV-Udder	0,2	desirable
Fore-Udder-Attachment	0,3	desirable
Rear-Udder-Height	0,1	desirable
Suspensory Ligament	0,1	desirable
Udder Depth	0,3	desirable
Length of productive life*	0,4	desirable

* 319 bulls were found in the pilot run for longevity with a reliability of \$ 70%.

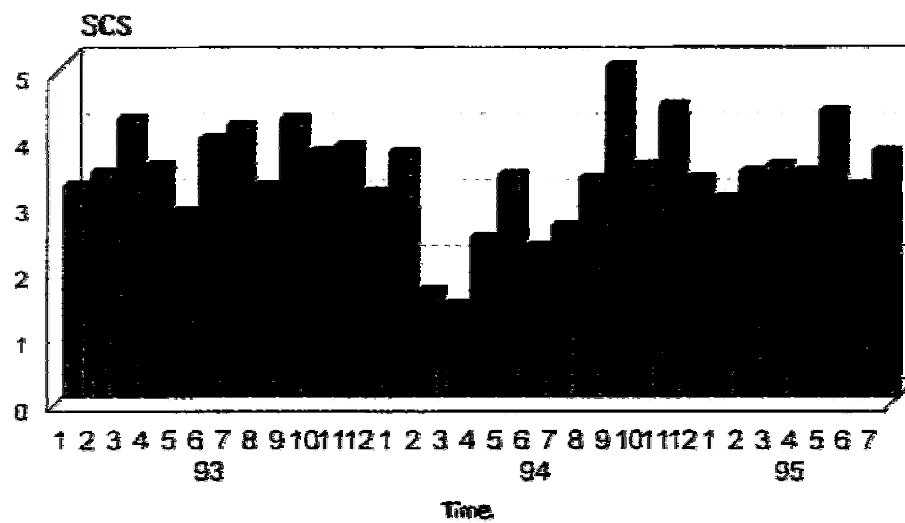


Figure 1. Herd-test-day effects of SCS for a herd.

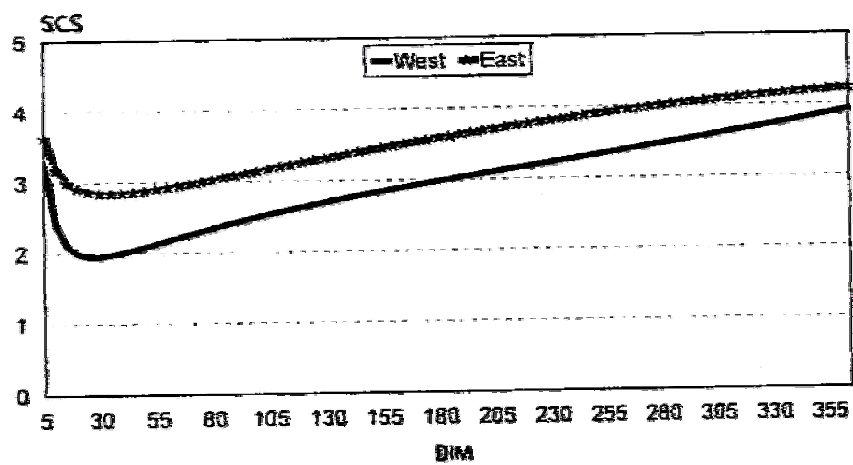


Figure 2. Lactation curves for first lactation Holstein cows, calving between Sep. and Dec., with an age of 29 to 31 months from two regions in Germany.