

Genetic Evaluation for Functional Traits in Norway

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Abstract

The breeding plan for the Norwegian dairy cattle (NRF) population was designed for a broad breeding goal and low heritability traits. Each year 125 bulls are progeny tested based on 250 to 300 daughters, as a result of 40% test inseminations. Evaluation using data across years have been implemented for several functional traits and the development in average sire solutions estimated. Mastitis and other production diseases were held on a constant level until 1990, then weight in the total merit index was transferred from milk yield. This increased yearly improvement to 9% of a genetic std for both mastitis and other production diseases. Milk yield and non-return rate of heifers improved yearly by 3.9% and 2.2% of a genetic std, respectively. Dystocia and stillbirth improved slightly for direct effect, and worsened slightly for the maternal effect. Milk speed and leakage are counteractive and kept at present level by removal of their weights in the total merit index.

Key words: Dairy cattle; functional traits; selection

1. Introduction

The breeding plan for the Norwegian dairy cattle (NRF) population has been designed to cope with a broad breeding goal and traits of low heritability. Each year, a cohort of 125 bulls are progeny tested based on 250-300 daughters per sire. This requires that 40% of the inseminations are by semen from test bulls. The ranking within cohort has been reliable although only first lactation daughters of test bulls within the cohort have been utilized (Fimland, 1984), and the system have been robust and feasible to run in a mainframe computing environment. However, Norwegian herds are small, hence including daughters of elite bulls and pooling the whole history of cohorts would be beneficial. Furthermore, ranking across cohorts and estimation of selection response is necessary to participate in international comparisons.

The objectives of this paper are: To report preliminary results on new breeding values for seven functional traits; and to investigate the response to the selection pressure applied.

2. Materials and Methods

2.1 Traits

Mastitis (MAST) and Other Diseases (ODIS) were handled as treated - untreated between 15 days prepartum and 120 days postpartum of first lactation. MAST was considered treated with one or more treatments for clinical mastitis, acute or chronic. ODIS was considered treated with one or more treatments for ketosis, milk fever or retained placenta. Both traits were adjusted to a standard deviation of 1 within each year due to large changes in treatment frequency.

Fertility (FERT) was measured on heifers as non-return rate 56 days after first insemination.

Dystocia (DYST) was scored by the farmer at 1st calving as none, some or large calving difficulties or as not observed. The groups were merged into difficulties - no difficulties before analysis. Not observed and twin births were discarded.

Stillbirth (STIB) was defined as dead at birth or within 24 hours at 1st calving. Stillbirth more than 20 days before expected calving was considered an abortion and discarded together with twin births.

Milking speed (MISP) and leakage (LEAK) were judged by the farmer in second month of 1st lactation. The cow would be compared against herdmates on a 3-level scale.

For MAST, ODIS and FERT there were 1.7 million records from 1978 onwards, whereas for DYST, STIB, MISP and LEAK there were 0.7 million from 1989 onwards.

2.2 Models

The traits were analyzed by univariate mixed linear models containing effects according to table 1. Test bulls and elite bulls were used for more than one year. Therefore overlap between generations and between generations and years exists (Svendsen, 1999), and orthogonal estimates of fixed and random effects can be obtained.

Variance structures assumed were:

$$\begin{aligned} \text{herd} \times \text{year} &\supseteq N(\mathbf{0}, \mathbf{I}\rho_{hy}^2), \\ \text{sire of cow} &\supseteq N(\mathbf{0}, \mathbf{A}\rho_s^2), \text{ and} \\ \text{residual} &\supseteq N(\mathbf{0}, \mathbf{I}\rho_e^2); \end{aligned}$$

where $\mathbf{A}$ was the numerator relationship matrix constructed from sire and dam of the sires.

For FERT, DYST and STIB there was a second random effect:

$$\text{sire of calf} \supseteq N(\mathbf{0}, \mathbf{A}\rho_t^2),$$

correlated to sire of cow. The direct and maternal component of these traits can be found from:

$$\begin{aligned} \rho_s^2 &= \frac{1}{4}\rho_m^2 + \frac{1}{16}\rho_d^2 + \frac{1}{4}\rho_{d,m} \\ \rho_t^2 &= \frac{1}{4}\rho_d^2 \\ \rho_{s,t} &= \frac{1}{8}\rho_d^2 + \frac{1}{4}\rho_{d,m}. \end{aligned}$$

BLUP of the breeding values, given the variance ratios in table 2, were obtained utilizing the DMU5 program for iteration on data (Jensen and Madsen, 1996).

2.3. Parameters

REML estimates of the variance components are shown in table 2. They were obtained under the models described by table 1, utilizing the VCE4 program (Neumaier and Groeneveld, 1998).

3. Progress in sire solutions

Import of Holstein semen in the early seventies increased milk yield, but also production diseases under the Norwegian feeding regime (Figure 1). The total merit index weights were therefore adjusted to allow progress for milk yield without unwanted correlated response in the functional traits.

Focus was also turned towards saving production costs other than the scaling effects from increased yield. A milk quota system was introduced in 1982 and made this more profitable. Since 1990, the weight on milk production in the total merit index has been reduced from 30% to 20% to allow genetic progress for health and fertility.

In the period 1976 to 1989 average sire solution weighted by number of daughters improved yearly by .0048 ρ_A for MAST and by .0043 ρ_A for ODIS, while from 1990 to 1997 the yearly improvement in average sire solutions were .090 ρ_A and .088 ρ_A , respectively. Progress for milk yield was affected by this, but has still been .0386 ρ_A per year taken over the whole period.

FERT received 11% increasing to 14% of the weight in the total merit index from 1976 to 1998. The average sire solution improved yearly by .0218 ρ_A .

The milk recording system was revised in 1989 and allowed for increased daughter groups by farmer registration of DYST, MISP and LEAK. DYST and STIB each receive 3 to 4 % weight in the total merit index. The selection criterion has been the sire of cow component, although from 1992 the weight was split with the sire of calf component for STIB. In the period 1976 to 1989 average sire solution for direct effect on DYST and STIB improved yearly by .009 ρ_A and .016 ρ_A ,

respectively. However, for the maternal effect on DYST and STIB there was a yearly worsening by .0009 ρ_A and .0077 ρ_A .

MISP and LEAK are counteractive and have an optimum level. The crucial point is to have a balanced weighting of these traits. From 1997 they both receive zero weight, but extreme bulls are avoided when elite bulls are selected. For the period 1978 to 1997 average sire solutions improved yearly by .0048 ρ_A for MISP and worsened by .0005 ρ_A for LEAK.

4. Conclusions

Simultaneous progress for milk yield, health and fertility was obtained. This was due to sufficient information on low heritability traits and sufficient weighting in the total merit index.

Progress for milk yield was affected, but not to an unacceptable level under the present production regime.

Unfavorable correlated responses in the other functional traits have been avoided.

References

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Table 1. Linear models used in the analysis of: Mastitis (MAST), other diseases (ODIS), fertility (FERT), dystocia (DYST), stillbirth (STIB), milking speed (MISP) and leakage (LEAK)

Effect in model	MAST	ODIS	FERT	DYST	STIB	MISP	LEAK
Year x Month of calving	X	X		X	X	X	X
Month of insemination			X				
Age	X	X	X	X	X	X	X
Sex of calf				X	X		
Stage of lactation						X	X
Herd x Year (random)	X	X	X	X	X	X	X
Sire of cow (random)	X	X	X	X	X	X	X
Sire of calf (random)			X	X	X		

Table 2. Parameters used in the analysis of: Mastitis (MAST), other diseases (ODIS), fertility (FERT), dystocia (DYST), stillbirth (STIB), milking speed (MISP) and leakage (LEAK)

Variance ratios and corr.	MAST	ODIS	FERT	DYST	STIB	MISP	LEAK
Herd x Year	.073	.098	.021	.105	.017	.067	.085
4 x Sire of cow	.032	.024	.012	.026	.015	.191	.108
4 x Sire of calf / embryo			.009	.030	.009		
Corr. sire of cow and calf			.276	.459	.442		
Maternal			.011	.020	.012		
Direct			.009	.030	.009		
Corr. direct and maternal			-.174	-.093	.047		

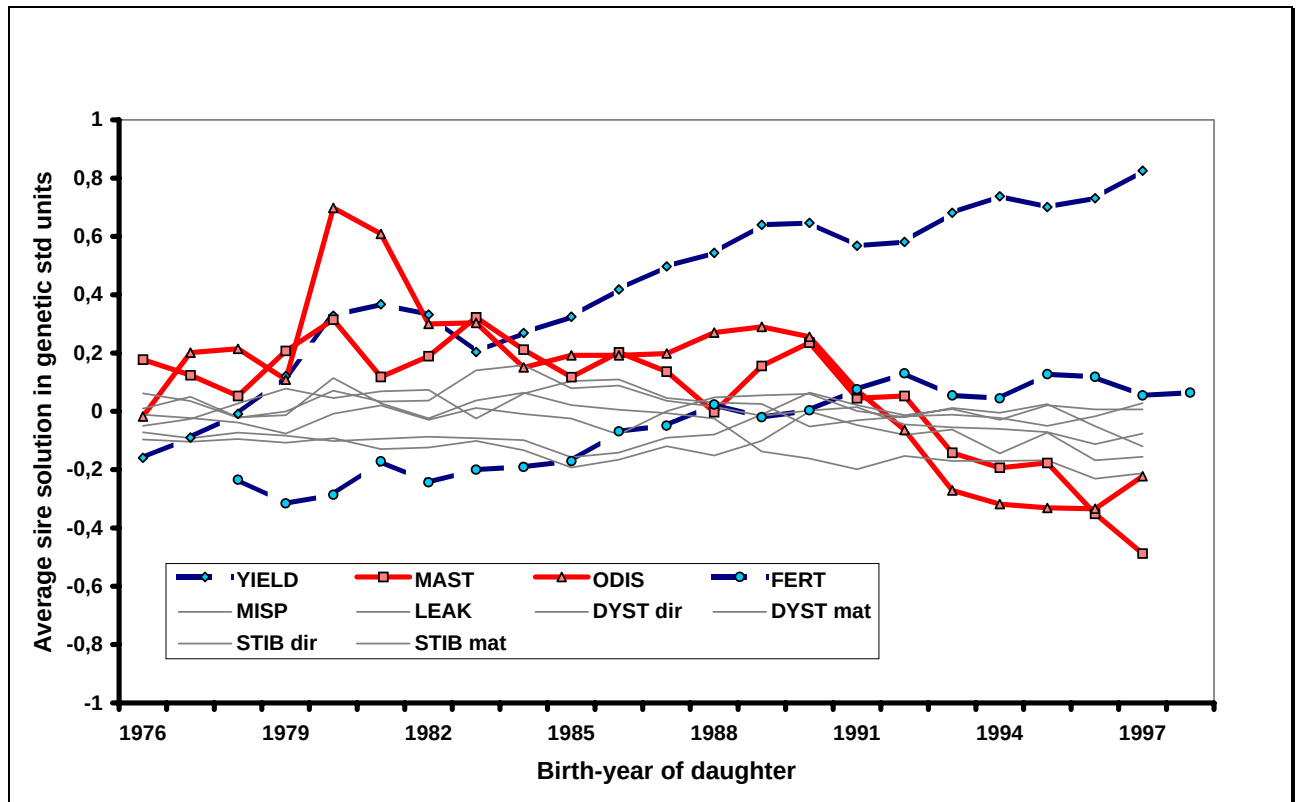


Figure 1. Average sire solution weighted by number of daughters from 1976 to 1998 for milk yield (YIELD), mastitis (MAST), other diseases (ODIST), fertility (FERT), milk speed (MISP), leakage (LEAK), dystocia (DYST, direct and maternal) and stillbirth (STIB, direct and maternal). Positive values are advantageous for YIELD and FERT, and negative values for the other traits. Traits with small progress or stabilizing selection are shown in light gray.