ANIMAL MODEL FOR THE GENETIC EVALUATION OF FUNCTIONAL TRAITS IN GERMAN FLECKVIEH

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SUMMARY

Animal models for calving ease (scored 1 to 5) and fertility (non-return rate 90) including both, direct/paternal and maternal genetic effects were developed. The fixed effects accounted for were herd*year, season and parity in both models, sex of calf for calving ease and time of first calving and time interval from calving to first insemination for fertility in addition. Some 8.6 mio. calvings and 6.7 mio. first inseminations from German Fleckvieh were evaluated. Solutions were obtained through iterating on data, for calving ease the reduced animal model was applied. Breeding values ranged from -0.42 to +0.43 scores in calving ease and from -10% to +10% for non-return rate 90. The results show, that improvements even in low heritable traits can be made.

INTRODUCTION

Due to the dramatically increasing computer facilities there has been a change from sire to animal models for the genetic evaluation of production traits in most countries over the last decade. More or less sophisticated models were implemented to improve the genetic merit mainly through higher accuracies of breeding values for cows. For functional traits such as fertility and calving ease however, less effort was made according to their relative low economic importance, low heritabilities and difficulties as well in defining the traits as in data recording.

Recently there is a higher interest in the so called 'secondary traits' because of the high production level already achieved in the population and because of the quota system in Germany, which restricts the milk production per farm (AVERDUNK and HAUßMANN, 1985). This led to a discussion for a new breeding goal including functional traits, for which a new breeding value estimation was developed using animal models.

MATERIALS AND METHODS

Data

Since 1979 data for calving ease have been collected in connection with the milk recording scheme in Bavaria. Calving difficulty is scored subjectively in five classes by the farmer with respect to the assistance necessary for delivery. In total some 9.6 mio. observations from about 4 mio. cows were recorded. Twin calvings were excluded from the evaluation, which, together with missing paternity, resulted in a reduction of data by about one mio. observations. From these, 28.3% of the calvings occured without help, in 55.2% one man and in 14.0% two or more men were necessary for delivery, whereas in 2.2% veterinarian assistance was required and in 0.4% of the cases a caeserian was conducted.

Fertility data were recorded via the insemination stations starting in the years 1985/86. The non-return rate 90 days after first insemination (NRR90) was regarded to be the best measurement for both male and female fertility in an animal model. Double inseminations within the first two days were not judged as a return event. The overall NRR90 in German Fleckvieh was 61.7%.

Method

Although linear models are theoretically not justified for categorial traits (GIANOLA and FOULLEY, 1983), several investigations on field data (WELLER et al., 1988; HAGGER and HOFER, 1989) as well as simulation studies (MEIJERING and GIANOLA, 1985) showed that there is only little difference in using linear versus threshold methodology. HOESCHELE (1989) carried out intensive simulation studies for all-or-none traits, which resulted in a nominal superiority of the threshold concept only for extreme categories and high heritabilities. MISZTAL et al. (1989) pointed out, that a threshold model requests a factor of three up to five of CPU-time in comparison to a linear model. As a consequence it was decided to choose the linear approach for calving ease and fertility. The main reason was that calving ease is scored in several classes while the two categories of NRR90 show moderate frequencies. On the other hand the additional runtime costs for routine evaluation are too high compared to the expected additional benefit up to now.

Models

Both, calving ease and fertility are combined traits genetically affected by more than one animal. Therefore for the evaluation of calving ease the direct effect of the calf and the maternal effect of the cow and for fertility the paternal effect of the bull and the maternal effect of the cow respectively, were included in the models. Due to most recent investigations a slightly negative correlation of -0.1 between the direct or paternal and the maternal effects was assumed. Since consecutive calvings or service periods of a cow were taken as repeated measures, a permanent effect was added to the model. The following model was used for the evaluation of calving ease:

$$y_c = h*y + s + sex + c + a_d + a_m + u_p + e$$

where y_c is the calving score (1 to 5), **h*y** the herd*year, **s** the season, **sex** the sex of calf, **c** number of calving, $\mathbf{a_d}$ the direct genetic effect of the calf, $\mathbf{a_m}$ the maternal genetic effect of the cow and $\mathbf{u_p}$ the permanent environment effect of the cow.

The model for fertility was:

$$y_f = h*y + s + l + a + r + a_p + a_m + u_p + e$$

where y_f is the return event (0 or 1), **h*y** the herd*year, s the season, **l** the number of the following lactation, **a** the age of heifers at first insemination, **r** the time interval from calving to first insemination (cows), $\mathbf{a_p}$ the paternal genetic effect of the bull, $\mathbf{a_m}$ the maternal genetic effect of the cow and $\mathbf{u_p}$ the permanent environmental effect of the cow.

Instead of the usual herdclass*year*season comparison used in dairy trait evaluation in Germany herd*year classes were introduced to correct for the herd effect as close as possible. The reasons were, that the farmer's subjective scoring and available persons for assistance in delivery differ very strongly among herds and would influence such sensitive traits enormously, whereas a meaningful criterion for the assignement of herdclasses is difficult to define. In evaluation of fertility the inseminator is closely confounded with the herd so that a separate effect of the inseminator was neglected.

Computations
For the evaluation of calving ease, the reduced animal model of QUAAS and POLLACK (1980) for beef cattle was used. In contrast to dairy traits where only little advantage is obtained by the technique of absorbing nonparents with the cost of increasing the complexity of the equations, a notable reduction of the dimension was achieved. Most male calves are not utilized for breeding purposes. Thus, their breeding value is of no interest but would nearly double the size of the equation system. Solutions were calculated by iterating on the data without explicitly forming the mixed model equations as suggested by SCHAEFFER and KENNEDY (1986) and MISZTAL and GIANOLA (1987) using second order Jacobi. This stragety was the best fit to the available computer resources with a maximum of 210 MB CPU-storage to solve nearly 12 mio. equations. High efficency of input/output was reached by reading binary files into buffers.

RESULTS

In preliminary studies with reduced data sets (1.8 mio. observations), LSQ-analyses were carried out to check the influence of interactions between herd, year and season in the model. All factors of the models above were included as well, except for animal effects.

Table 1: Comparison of interactions between herd, year and season

model		MSE abs.	MSE rel.	effects (n)	obs./ cell
I.	h+y+s	0.3704	100.00	11083	163.0
II.	h*s+y	0.3684	99.46	41237	43.8
III.	h*y+s	0.3520	95.03	117000	15.4
IV.	h*y+y*s	0.3519	95.01	117000	15.4
V.	h*y*s	0.3384	91.36	372000	4.8

Complexity varied from pure crossclassification to triple interaction h*y*s. MSE was taken as a criterion with lower MSE indicating higher uniformity within the comparison unit. Decreases relative to crossclassification (model I) were found for h*y interaction and accounting for h*y*s additionally. However the best fitting model (V) has an average cell size of less than 5 which is too low for suitable numbers of comparisons in evaluation of lowly heritable traits. As a compromise model III seems to be justified.

Time requirements for the solution of the calving ease equation system with 8.5 mio. observations and 11.9 mio equations (551.000 h*y) were 17 min CPU per iteration (55% I/O) on an IBM 3090 mainframe. Convergence was reached after 77 iterations.

In relation to a mean of 1.91 and a standard deviation of 0.74 in the raw data, the following fixed effects were estimated for calving ease. Sex difference was 0.18 classes indicating bigger problems in male calves. The effect for first calvings was 0.19 classes above average, with easier births expected with increasing calving number. Estimates for season were 0.019 for winter, -0.002 for spring, -0.018 for summer and 0.001 for autumn respectively. The herd*year subclasses showed a deviation of 0.38 scoring points about the mean.

In fertility for heifers a 9% higher NRR90 was estimated in comparison to cows, whereas nearly no difference was found between later service periods. Very low and very high ages at first calving influenced the trait negatively with NRR90 up to 3% lower. A strong decrease of NRR90 was estimated for shorter time intervals from calving to first insemination with 18% lower NRR90 in the extreme interval between 20 and 30 days after calving. Differences between herd*years had a coefficient of variation of 17% from the average NRR90.

The estimated breeding values for calving ease ranged from -0.35 to 0.36 scoring points for direct effects and from -0.42 to 0.43 for maternal genetic effects. For fertility, the range of the paternal breeding values was from -8% to 8% NRR90 and for the maternal breeding values from -10% to 10% NRR90 respectively.

DISCUSSION

The implementation of animal models provide the base for a consequent selection on functional traits with lower heritability. Especially through accounting for the relationship among all animals and the simultaneous evaluation of direct and maternal genetic effects and accounting for their genetic correlation leads to reliable estimates with higher accuracies. This was confirmed by comparisons between the breeding values and the raw measurements (calving difficulty rate, NRR90) for bulls which resulted in correlations of 0.6 to 0.8 and showed the improvement achieved through correction of fixed effects as well.

However, the trait definition for calving ease is critical, as the differences between the scores do not reflect the grade in calving difficulty. As a possible approach in direction of the threshold concept it might be useful to assume an underlying variable and to calculate the mean for each calving score on that scale. These values could then be used in genetic evaluation.

Another point is, that it is not quite clear wether first and later calvings or service periods respectively can be seen as the same trait. Evaluations were conducted with separate data sets and correlations of 0.7 to 0.8 were found between breeding values of first and later calvings which might be a hint to use a multitrait model which is not feasible up to now. In addition, models without permanent effects were calculated, resulting in correlation of the breeding values of 0.99.

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