56th Annual Meeting of the European Association for Animal Production (EAAP), June 5-8, 2005, Uppsala, Sweden, Commission on Animal Genetics, G4.2 Session 17, sgaede@tierzucht.uni-kiel.de

Estimates of genetic parameters for milkability from automatic milking

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Introduction

Milkability is of interest because of the interrelation to udder health as well as labour efficiency (Pérez-Guzmán, 1984; Göft et al., 1994). Given the results of literature a moderate milk flow may be considered to be optimal in terms of udder health (Köhler, 2002).

The milkability is sufficiently heritable with heritabilities on middle level (Boettcher et al., 1998; Rupp and Boichard, 1999; Luttinen and Juga, 1997; Bahr et al., 1995; Santus and Bagnato 1998; Trede 1987; Duda, 1995; Göft et al., 1994), so that breeding is feasible.

Nowadays some farms offer the possibility of automatic recording of milk yield and thus provide serial data about milkability. An uninterrupted milkability test over the course of lactation is therefore possible.

The objective of the study is the estimation of genetic parameters for three milkability traits (average milk flow rate, maximum milk flow rate and milking time) and the subsequent breeding value estimation regarding serial data out of an automatic milking system. The analyses are carried out both for milkability per milking and for milkability per day.

Materials and methods

Data were automatically recorded from 401 Holstein-Friesian cows milked by an automatic milking system. Totally 320834 records, respectively milkings, with three milkability traits are available.

Milkings with a preceding milking interval which comprises midnight were divided into two milkings, each with the milkability traits of the original milking. So, daily traits of milkability could be calculated. The daily values for milk yield and milking time resulted from adding up the milk yields and the milking times respectively from all single milkings a day. The daily value for maximum milk flow rate corresponds to the highest value for this trait from all single milkings a day. The daily value for average milk flow was attained by weighting the several values a day with the respective milk yield.

Only records between day 8 and day 305 after calving were considered. So data preparation totally resulted in 253886 milkings and 104132 daily observations. Per milking the means are 12.4 kg for milk yield, 2.5 kg/min for average milk flow, 3.8 kg/min for maximum milk flow and 5.7 min for milking time.

Variance components were estimated by REML using the VCE 4 package (Neumaier and Groeneveld, 1998). The data based on milkings was analysed with the following multi-trait animal model:

$$y_{ijklmn} = \mu + LNRCLA_i + DAY_j + MI_k + b_{i1}\,(D/c) + b_{i2}\,(D/c)^2 + b_{i3}\ln(c/D) + b_{i4}\,[\ln(c/D)]^2 + a_l + pe_m + e_{ijklmn}$$

where: y_{ijklmn} =average or maximum milk flow rate (kg/min) or milking time (min), μ= mean, $LNRCLA_i$ = effect of parity class (i=1., ≥2.), DAY_j = effect of day (j=1-1020), MI_k = effect of milking interval length (milking interval is divided into 9 classes: k= < 7 h, 7-8 h, 8-9 h, 9-10 h, 10-11h, 11-12 h, 12-13 h, 13-14 h, ≥ 14 h), a_l = random additive genetic effect (l= 1-1404), pe_m = random permanent environmental effect to account for repeated measures within cow (m = 1-401), e_{ijklmn} = random error. Following Ali and Schaeffer (1987) the stage of lactation is considered as linear, quadratic and logarithmic regression within class of parity. b_{i1} and b_{i2} are regression coefficients on the linear and quadratic effect of the ratio D/c, in which D is the day in lactation and c is a constant, in this case c = 325. b_{i3} and b_{i4} are regression coefficients on the linear and quadratic effect of ln(c/D). The regression coefficients were estimated within two effect stages for parity, i.e. there are two lactation curves.

For the data based on daily values a second model was applied, which did not comprise the effect milking interval, but milk yield was included as a further dependent variable.

The data structure shows that there are totally 401 cows from 127 sires. About 40 % of the sires have three and more daughters and about 20 % of them have five and more female progenies. 72.8 % of the cows have observations only out of the first parity. This is caused by the performance testing of bull dams which is implemented on the dairy research farm Karkendamm. The potential bull dams are tested between day 8 and day 180 after first calving. Pedigree information contain sires and dams two generations back, so totally 1404 animals are in pedigree file.

Breeding values for the milkability traits were estimated by using the PEST software package (Groeneveld, 1990).

Results and discussion

The computed heritabilities based on single milkings are on high level with h^2=0.54, h^2=0.61 and h^2=0.48 for average milk flow, maximum milk flow and milking time. So, selection for a good milkability seems to be promising. A potential explanation for the higher value for the maximum milk flow rate might be the fact that the peak milk flow is predominantly influenced by the inherited teat morphology (length and expansibility of teat canal) (Naumann et al., 1998) whereas average milk flow and milking time underlie higher temporary environmental influences, e.g. milking technique (amongst other things tactile stimulation of the mammary gland). In this study the heritabilities are higher than shown in the literature. This can be explained with standardised environmental conditions existing on the research farm. In addition a direct comparison with literature information is not appropriate because this study is based on serial data from an automatic milking system while results from literature are due to singular recorded milkability information. The genetic correlations are r_g=0.97 between average and maximum milk flow, r_g=-0.90 between average milk flow and milking time and r_g=-0.85 between maximum milk flow and milking time. It can be derived that recording of only one of the three milkability traits in the performance test might be sufficient.

The heritabilities estimated with data based on daily values (Table 1) are comparable with the values based on single milkings. They are h^2=0.55, h^2=0.55 and h^2=0.39 for average milk flow, maximum milk flow and milking time. The genetic correlations are r_g=0.98 between average and maximum milk flow, r_g=-0.89 between average milk flow and milking time and r_g=-0.86 between maximum milk flow and milking time (Table 1) and thus conform to the genetic correlation coefficients based on single milkings. The heritability for milk yield is h^2=0.25 and the genetic correlation coefficients are r_g=0.51, r_g=0.44 and r_g=-0.23 between the milk yield and average milk flow, maximum milk flow and milking time respectively. So milk flow arises with increasing milk yield. The negative genetic correlation between milk yield and milking time with r_g=-0.23 seems obscure. This negative correlation coefficient means that cows with the disposition for high milk yield show the tendency for less milking time coevally. But the standard error is high (SE=0.16). This must be taken into account during interpretation of the genetic correlation.

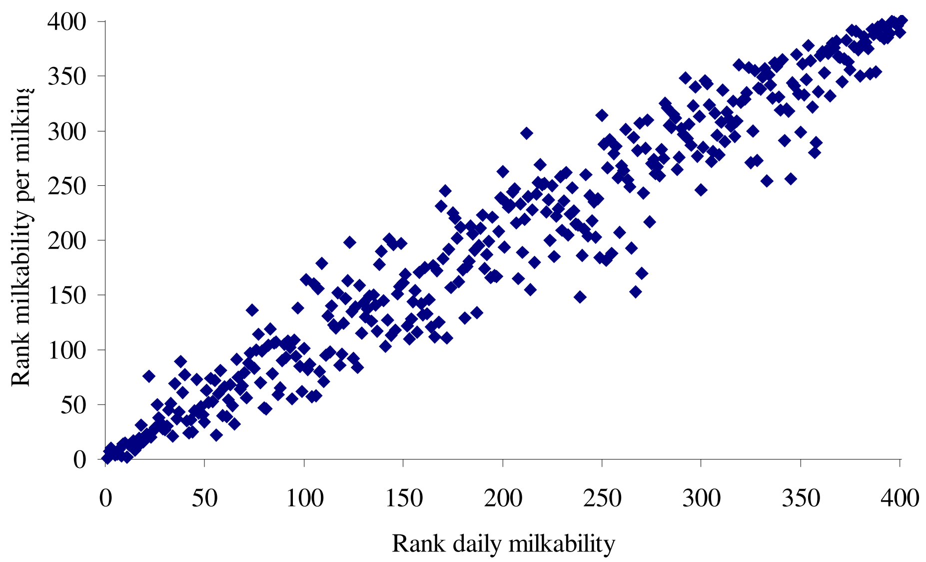
Table 1

Genetic parameters with standard errors (in parentheses) for the three milkability traits and milk yield-based on daily values. (Heritabilities on the diagonal, permanent environmental correlations above and genetic correlations below the diagonal.)

		(1)	(2)	(3)	(4)
(1)	Average milk flow (kg/min)	**0.55** (.08)	0.73 (.07)	-0.48 (.09)	0.20 (.05)
(2)	Maximum milk flow (kg/min)	0.98 (.01)	**0.55** (.07)	-0.42 (.09)	-0.01 (.06)
(3)	Milking time (min)	-0.89 (.05)	-0.86 (.05)	**0.39** (.06)	0.63 (.10)
(4)	Milk yield (kg)	0.51 (.07)	0.44 (.08)	-0.23 (.16)	**0.25** (.04)

The estimated breeding values for the three milkability traits (relative breeding values with mean of 100 and a standard deviation of 12) from the 401 cows vary from 73 to 134 based on single milkings and from 69 to 135 based on daily values respectively. That means that there is enough variability between the animals for successful selection on milkability. The rank correlations (the Spearman correlation coefficients are 0.97, 0.98 and 0.94 for average milk flow, maximum milk flow and milking time respectively) show a general analogy in the rank order of the cows in their breeding values for the milkability traits on the basis of single milkings with the ranking in their breeding values on the basis of daily values (Figure 1). Thus breeding value estimation can be conducted successfully based on daily values instead of single milkings.

Figure 1
Rank of breeding values for average milk flow per milking and per day (401 cows)



Conclusion

The results of the present study show that it is possible to carry out a promising estimation of variance components with subsequent estimation of breeding values based on the automatic recorded serial information for milkability traits.

In detail:

- As fixed effects in the model for statistical evaluation the day of observation, the parity number and the course of the lactation curve within the parity number should be considered.
- There are distinct genetic differences between the cows (high additive genetic variances and heritability coefficients respectively).
- From the three milkability traits the average milk flow can be chosen to describe milkability. This trait is already established as selection trait and shows a high heritability coefficient and high genetic relations to maximum milk flow and milking time.
- The rank correlation between breeding values for the average milk flow per milking and per day is high (0.97). So, as observation unit should be chosen the day according to the established breeding value estimation for milk, protein and fat yield and somatic cell score.
- The genetic correlation coefficient between milk yield and average milk flow is positive. So, further selection for higher milk yield might result in a deterioration of udder health, as a higher milk flow is associated with increased problems in terms of udder health (Boettcher et al.,1998; Grindal and Hillerton, 1991; Lacy-Hulbert and Hillerton, 1995). But in this project it must be accounted for the little sample size.

  Thus in the future the relative breeding value for milkability (average milk flow) should be involved for the selection of the potential bull dams on the test station. At least extreme low and high milk flow respectively should be avoided. Subsequent investigations will focus on the interrelation between udder health and milkability.

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