Test day milk yield and composition records are affected by deviations in milking intervals in overly simplified recording schemes.

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Abstract

The main work-load at milk recording is for farmers centered on the work collecting data and milk samples and thereby disturbing milking routine. DHI service providers therefore continuously look for simpler ways to collect information. In Denmark this is via a single sample protocol for herds using 11 test days (TD) per year, and a two samples protocol for herds using 6 TD per year. In both cases milk weight from all milkings are collected. We looked into data to evaluate if we can simplify further. This study used data from 121 Holstein herds in Denmark subscribing to the 6-TD-a-year protocol, and investigated the effects on accuracy of using only a single record per test day, with or without adjustments for milking interval. The adjustment factors used for TD were obtained using a linear regression model of total daily yield of fat or protein at either morning or evening yields of milk, fat and protein combined with regressions on milking interval seen within breed, parity-class and lactation stage classes. One question is if the cows enter the milking point in the same or nearly the same order every time. This study compared the residuals of predicted yields from adjustment models with and without yield and milking interval information from evening milking's. The analysis included Holstein cows in herds dominated by the same breed, and included 292,297 Holstein cow-test-days with both morning and evening records. The morning milking intervals for Holsteins and Jerseys were (mean = 13.22, std. 0.89), ranging from 11.79, to 14.64 h (as percentile 5 to 95). Evening and morning milking order was well, but not perfectly correlated (r = 0.61). Omitting the evening milking information caused an increase in residual standard deviation from 1.04 to 2.32 kg ECM/d in Holsteins. Over the most frequent range of milking intervals and yields this means an increase in ranges of prediction errors for ECM from -1.49 to +1.63 kg/d to a wider range -3.26 to +3.69. The large increase in residuals was expected and that will mainly impact on test day information intended for management purposes such as replacement decisions. So, in effect, the reduced sampling scheme should be expected to lead to unwanted errors in cow replacements, in herds using the low intensity recording practice. In conclusion, the savings in labor and other costs of going to a reduced recording scheme need to weighed against risk and cost of wrongful management decisions.
Keywords: Accuracy loss, Milking interval, Simplified testing protocols

Introduction

The value of milk recording data comes from two sides, one is decision support in herd management, and the other is genetic evaluations breeding purposes. Accurate data recording is the key to obtain better decision support, and next the key to improve genetic evaluations through better phenotyping. Improved phenotyping can be achieved by more frequent recording that effectively will reduce random noise, resulting in higher heritability. On the other hand, reduced recording and sampling protocols will lead to lover accuracy, impacting negatively on cow-level decision support. However, intense recording is a work-load for farmers, so some compromise is needed in balancing costs against accuracy.

Recording schemes were traditionally using an evening and a morning milking, repeated at11 test days per year. Reduced protocols has replaced this, by going to 6 test days per year, or when keeping 11 test days, have yield recorded at both milkings and sampling at only one, alternating between morning and evening. It has been suggested to simplify further to have only one recording and sampling in mornings. The consequences of having such reduced recording protocols need to be investigated with a view to provide advice to herd managers subscribing to DHI services. This aim was undertaken in a study of 2X parlor milking records of Holstein cows in Denmark. Protocols for 3X or AMS were not considered.

In current protocols for herds subscribing to 11 test days with alternating AM/PM recording, daily yield is estimated using a linear regression model using information from the milking with composition and supported by the yield and milking interval from the alternate milking. If the protocol is simplified some or all the information from the alternate (i.e. evening milking is ignored). We simulated that situation using data from herds recording and sampling from both morning and evening, by removing evening information. The consequences were assessed as the increase in residual variance with each step of simplification.

Special attention was given to milking interval because of its well-known relation to yield. However, it has been suggested that within a herd-test-day there will little variation in milking interval because cows like to be milked in a rather constant order and are consistent in other aspects of milking behavior (e.g. Berry et al. 2012; Polikarpus et al 2015; Løvendahl et al. *in press*). This aspect also required further study using commercial herd data.

Materials and Methods

DESIGN and DATA. This study was designed as a cohort study using data from yield recording in commercial Danish dairy herds. Eligible herds had a recording scheme with six recordings per year, and milking evening and the following morning including milk sampling and analysis at both milkings. The "**Full** scheme" was defined as milk yield and analysis at PM+AM, so that a Day yield would be the sum of the two. The next schemes were reduced as follows: **X_AM** (Morning milk+composition, with evening milk yield and milking time); **X_PM** (Evening milk + composition and morning milk + morning milking time); **R_cow_int** (Morning milk + composition, with evening milking time); **R_htd_int** (Morning milk yield + composition, with eveving milking start time for the herd-test-day); **Simple** (Morning milk yield + composition alone). For any of the reduced protocols, yields were extrapolated to daily yields of ECM (see later).

Milk yield was measured using electronic milk meters (EMM, Tru-test Group, Auckland, New Zealand), and milk sampled directly into barcoded sample tubes. Milk samples were assayed for content of fat (fat_b) and protein, and somatic cells at the Eurofins lab using Combifoss 4000/5000/6000 or FT+ systems (Foss Electric, Hillerød, Denmark). Data were stored at the Danish Cattle Database (SEGES, Skejby, Denmark), together with animal ID. From each milking the following was recorded: Herd_ID, Cow_ID, Date and time at start and end of milking, yield in Kg, Fat percentage, Protein percentage, and ECM yield. Cow_ID information included Breed_code, Calving date, and Calving Number (Parity). The cohort included cows of Holstein, Red Dairy Cattle, Jersey, Red Holstein, and Crossbreeds, however only Holstein herds were included in this study. Herd size was grouped in simple categories: <= 50; 51 to 100; 101 to 200; 201 to 400; 400+.

DATA FILTERS. Herd-test-day-sessions should have at least 21 recorded cows. Qualified data were from 121 Holstein herds, having 3359 herd-test-days, and included 33,374 cows, giving 292,297 sets of afternoon / morning milkings.

CALCULATED VARIABLES. Using the composition, yield was expressed as Energy Corrected Milk (ECM), per milking. The intervals between afternoon and morning milkings (Milking_interval) were obtained by subtracting the two starting times. To facilitate correlation calculations, variables were also expressed as afternoon and morning traits. Milking order was obtained from sorted starting time for each milking, and was further standardized to start at zero on the first cow and end at 1.0 for the last cow in that session.

MODELS AND ESTIMATES. Linear mixed models were used to analyze data using SAS software was SAS (PROC MIXED or HPMIXED; SAS Institute Inc). Milking order and milking time were analyzed as correlated traits between evening and morning (Pearson correlation). The "Extrapolation models" were made as model 1 (below, full model example morning records) and then with reduced versions by omitting information from preceding milkings.

ECM_Day_Kg = Intercept + DIM_group + Parity_Group*DIM_group
+ *b* AM_fat_kg*(Parity_Group*DIM_group)
+ *c* AM_milk_kg*(Parity_Group*DIM_group)
+ *f* AM_prot_kg*(Parity_Group*DIM_group)
+ *g* AM_M_int*(Parity_Group*DIM_group)
+ *d* PM_milk_kg*(Parity_Group*DIM_group)
+ *residual*.

Where DIM_group, Parity_group and their interactions are factors, and *b, c, d, f* and *g* are regression coefficients, for overall effects (index 1) or as interactions with the factor (index 2). The reduced model omitted AM_milking interval and PM_milk_kg information.

An analysis of variance was used to estimate variance components for the full recorded ECM yield, and the various extrapolated records. To facilitate computation only first parity data were used. The extrapolated records from model 1 were obtained as predicted values, and used as input to a repeatability model:

*Y_pred = Intercept + a*Wilm(DIM) + b*DIM) + Herd_test_day + Cow_id(herd) + residual*

Where *a* and *b* are regression coefficients belonging to a Wilmink style lactation curve; Test-Day and Cow_ID are random effects, with variance components σ^2_{TD} and σ^2_{COW}.; and the residual has variance σ^2_e. Variance components were also expressed as repeatability

$$t = \sigma^2_{COW} / (\sigma^2_{COW} + \sigma^2_{TD} + \sigma^2_e),$$

and as relative herd-test-day variability:

$$c^2 = \sigma^2_{TD} / (\sigma^2_{COW} + \sigma^2_{TD} + \sigma^2_e).$$

Results and Discussion

MILKING INTERVAL AND MILKING ORDER AND YIELD

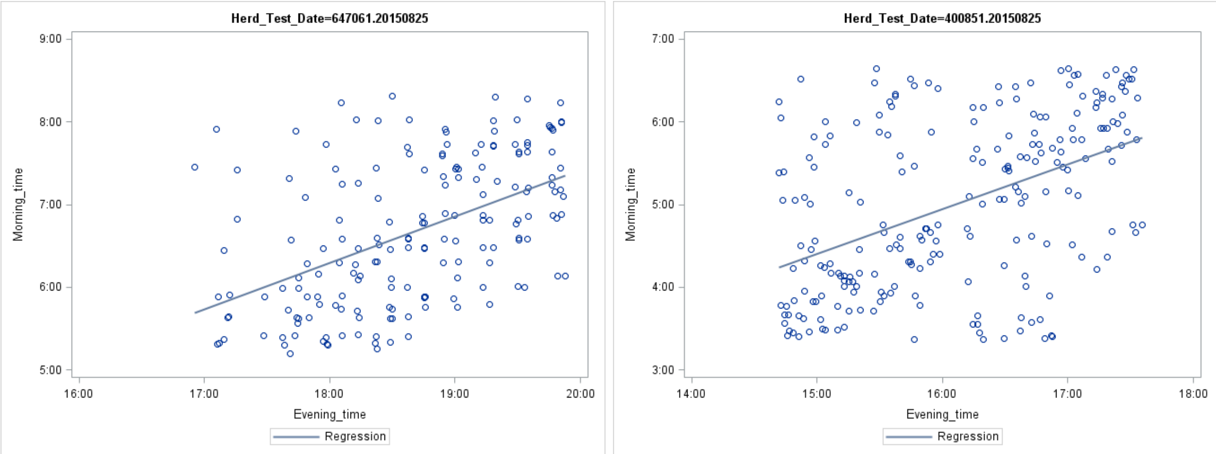

Figure 1a, 1b. Scatter plot of milking time in the morning against milking time at the previous evening for individual cows in two herds at actual test days.

The milking order in the morning was correlated to order at the previous evening, but not very strongly (Examples in Figures 1a, 1b), (r = 0.61; P < 0.001). Similarly, milking time was correlated between morning and evening (r = 0.63; P < 0.001). A spread over 2 – 3 h was observed in many herds. Previous studies have shown that milking order is also somewhat correlated over longer time intervals, with repeatability estimates between 0.3 and 0.5 (Own data not shown) and potentially having a genetic background (Berry et al., 2012). Morning ECM was weakly correlated to the interval preceding the milking (r = 0.10; P < 0.001). Milking order was almost not correlated to ECM. Thus, there is an expected positive correlation between milking interval and yield.

EFFECTS OF SIMPLIFIED SAMPLING PROTOCOLS

A comparison of recording protocols with decreasing intensity is shown in Table 1, giving a number of performance parameters.

Table 1. Defined protocols, basic data, extrapolation performance and variance component ratios obtained from extrapolated yields.

Protocols		**Full**	**X_AM**	**X_PM**	**R_cow_int**	**R_htd_int**	**Simple**
Milking	*Evening*	*Y*	*Y*	*Y*	*(time only)*		
	Morning	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
Sample	*Evening*	*F&P*		*F&P*			
	Morning	*F&P*	*F&P*		*F&P*	*F&P*	*F&P*
Milking interval			*Exact*	*24-Exact*	*Exact*	*HTD*	*Ignored*
Basic data							
Morning interval h		*13.22 ± 0.89*					
ECM kg/d		*29.48 ± 7.69*					
Extrapolation model							
Mean	ECM/d	29.11	29.11	29.11	29.11	29.24	29.21
RMSE		*	1.04	1.15	2.32	2.41	2.53
Lower	P_5%	0	-1.49	-1.49	-3.26	-3.52	-3,74
Upper	P_95%	0	1.63	1.65	3.69	3.82	4.05
Uncertainty range		0	3.12	3.14	6.95	7.34	7.79
Variance ratios							
Repeatability, t		0.42	0.41	0.41	0.38	0.32	0.30
HerdTestDay eff. c^2		0.12	0.11	0.12	0.10	0.09	0.12

The reference “Full” protocol refer to recording and sampling at evening followed by a morning milking, and yields are sums of evening and morning yields, based on yields and composition at each milking. The reduction in sampling to either morning or evening sampling, but maintaining yield recording at both milkings is commonly used, and the extrapolated records have no bias in the mean yield, but have deviations from the “Full” giving a standard deviation of 1.04 or 1.15 kg ECM. That is equivalent to an uncertainty range of 3.14 kg ECM, covering 90 % of all milkings. By omitting yield information from evening milking, the standard deviation (RMSE) at least doubles (Protocols R_cow_int, R_HTD_int, and Simple), and the uncertainty range also doubles to 6.95 to 7.79 kg. Various ways of including milking interval in the extrapolation model were not providing very different results, and other ways than shown in table were not more successful.

When ECM data, were used for estimation of variance components, much like in breeding value estimation settings, estimates of repeatability may be seen as a proxy for heritability estimates. The estimates were based only on first parity cows, to simplify computations. The results here indicate that extrapolations based on two milkings are providing repeatability estimates very similar to the “Full” recording protocol. However, if yield information from evening the milking was omitted some decrease in repeatability was clear, and completely ignoring both yield and individual milking interval gave the lowest repeatability estimate. The “compromise” using a common interval for all cows in the herd at a given test day was not an effective solution, although it provided an estimate slightly better than completely ignoring evening information.

In conclusion, the results of this study show that variation in milking interval within herds is significant, and that milking order is not sufficiently constant to describe the individual differences between cows. The results show that any simplified recording protocol based on only one milking causes a loss in accuracy, but having yield information from the secondary milking is most important.

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