Improved method for calculating daily yields from alternate testing schemes

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Abstract

The alternating morning and evening testing scheme, even though it is less accurate than a standard supervised milk recording programme, is more and more implemented on the farm level to reduce costs. In France, this scheme is widely used with Lactocorders. As this technique provides milk yields from both morning and evening milkings ("Z" testing schemes), a new approach was developed to improve estimated 24-hour daily fat and protein yields, by extending the current German model to estimate daily yields in alternate testing schemes. In the new model, the other milk yield of a test-day was considered as an additional covariate. Separate regressions for 96 combinations of parity, milking interval class and lactation stage were fitted as in the current model. The new extended model was applied to a French data set for deriving regression factors, which were subsequently validated using an independent, later recorded French data set. Comparing the results of the extended to the current model, remarkable improvement in accuracy of 24-hour daily yield estimates can be seen, especially for extremely unbalanced milkings with large differences between morning and evening yields. With the new model, errors estimated for fat and protein yields were significantly reduced. Correlations between true and estimated daily fat yields derived from morning (evening) milkings increased from 0.923 to 0.952 (from 0.914 to 0.935) for first lactation and from 0.927 to 0.959 (from 0.923 to 0.947) for later lactation, respectively. The correlations of the new model exceeded 0.982 for protein yield. The newly developed model was proven to be more suited for estimating daily yields with Z schemes.

Keywords: alternate testing scheme, Lactocorder technique

1.0 Introduction

Presently in France, the use of EMM is increasing, particularly with Lactocorders. This technique is well adapted to alternating morning and evening testing schemes, in which both milk yields of a test-day are available, whereas only one sample is taken to estimate the daily fat and protein yields ("Z" testing schemes, Leclerc *et al*, 2004). Therefore, the milk yield of the other milking of the test-day can be used as an additional covariate to increase the accuracy of estimated daily fat and protein yields. This can be done by extending the German model (Liu *et al*., 2000), which considers parity, milking interval and lactation stage for estimating daily yields from single milkings. The objective of this study is to apply the new, extended model to real data and compare the results to the basic model. The intention is to implement the new model in practice and this study can be considered as a validation of the model.

2.0 Material and methods

For this joint project, two data sets were provided by French milk recording organisations. The first one consisted of 24,491 test-day records of 8,655 cows. It was used for deriving new regression factors. The second data set with 22,407 test-day records of 8,190 cows was used for the validation. The data structure for both data sets is described in table 1. Only milkings from Holstein cows were considered. Correlations among morning, evening and daily yields are shown for both data sets in tables 2 and 3, respectively. Morning milkings have higher correlations with daily milkings than evening milkings. Rather low correlations between single and daily milkings are found for fat content, whereas correlations for protein yield and protein content are higher than 0.90. For means, standard deviations, minima and maxima, there are nearly no differences between both data sets (Table 4).

Table 1. Description of data sets.

	Data set(I) for deriving regression factors	Data set (II) for validation
No. test-day records	24,491	22,407
No. cows	8,655	8,190
No. herds	169	156
No. milkings per cow	2.8	2.7
Recording period	January 2008 - November 2009	November 2008 - March 2010

Table 2. Data set (I). Correlations among morning, evening and daily yields (24,491 milkings).

Trait	AM - PM	AM - DMY	PM - DMY
Milk, kg	0.844	0.967	0.952
Fat, kg	0.707	0.925	0.923
Protein, kg	0.829	0.963	0.949
Fat, %	0.521	0.887	0.851
Protein, %	0.903	0.980	0.970

Table 3. Data set (II) Correlations among morning, evening and daily yields (22,407 milkings).

Trait	AM - PM	AM - DMY	PM - DMY
Milk, kg	0.821	0.961	0.947
Fat, kg	0.697	0.921	0.921
Protein, kg	0.781	0.951	0.931
Fat, %	0.552	0.901	0.854
Protein, %	0.919	0.984	0.973

Table 4: Means, Standard Deviation, Minimum and Maximum of variables of both data sets (N = 46,898 milkings).

	Mean	Std. Dev.	Minimum	Maximum
Daily Milk-kg	28.3	8.15	2.3	67.02
Milk-kg (AM)	15.7	4.62	1.1	48.6
Milk-kg (PM)	12.6	3.89	1.2	45.8
Fat-% (AM)	3.78	0.74	1.50	8.94
Fat-% (PM)	4.24	0.79	1.50	9.00
Daily Fat-kg	1.11	0.31	0.07	2.97
Fat-kg (AM)	0.58	0.17	0.03	1.89
Fat-kg (PM)	0.53	0.17	0.03	2.04
Protein-% (AM)	3.19	0.36	1.92	5.65
Protein-% (PM)	3.25	0.37	1.55	5.62
Daily Protein-kg	0.90	0.23	0.11	1.99
Protein-kg (AM)	0.49	0.13	0.04	1.54
Protein-kg (PM)	0.40	0.11	0.03	1.42
Milking interval (AM)	13.3	0.71	9.7	17.1
Milking interval (PM)	10.7	0.71	6.9	14.4
Parity*	2.4	1.5	1.0	9.0
Lactation stage (DIM)	165	96.4	7.0	360.0

The German model (Liu *et al.*, 2000) for estimating daily yields from single morning or evening milkings considers separate regressions for every combination of parity i, milking interval j, and lactation stage k:

$$y_{A4}{}^{[ijk]} = b_0{}^{[ijk]} + b_1{}^{[ijk]}\, y_{AT}{}^{[ijk]}$$

The effects considered in the model as well as the definition of effect classes are described in table 5.

Table 5. Definition of effect classes considered in the model.

Trait	No. classes	Class definition
Parity	2	1st lactation, 2nd and later lactations
Milking interval	4	AM: < 13h; 13h-13.5h; 13.5 h-14h; ≥14h PM : ≥ 11h; 10.5h-11h; 10 h-10.5h; < 10h
Stage of lactation	12	30 days per class

The new approach which is presented here also considers the milk yield of the other milking of a test-day. This means that the milk yield of the morning milking is used as a covariate when the evening milking is taken for analysing the contents – and vice versa.

Morning milking: $y_{A4}{}^{[ijk]} = b_0{}^{[ijk]} + b_1{}^{[ijk]}\, y_{AT\text{-}am}{}^{[ijk]} + \mathbf{b_2}{}^{[ijk]}\, \mathbf{Milk_{-pm}}{}^{[ijk]}$

Evening milking: $y_{A4}{}^{[ijk]} = b_0{}^{[ijk]} + b_1{}^{[ijk]}\, y_{AT\text{-}pm}{}^{[ijk]} + \mathbf{b_2}{}^{[ijk]}\, \mathbf{Milk_{-am}}{}^{[ijk]}$

3.0 Results

Table 6 shows correlations between true and estimated daily yields. Higher correlations obtained with morning milkings indicate that daily yields estimated from morning milkings are more accurate than those from evening milkings, and thus for all traits. Compared to first parities, later parities lead to slightly better estimates for daily yields. In general correlations between true and estimated daily fat yield are considerably lower than those for milk and protein yields. Correlations from the extended model are remarkably higher than those from the current model both for fat and protein yields, which confirms that the new approach can increase accuracy of estimated daily yields from alternating testing schemes. Table 7 shows that residual standard deviations also decrease with the extended model.

Table 6: Correlations between daily and estimated yields by lactation.

		Factors from current model		Factors from extended model	
Trait	Lactation	AM-DMY	PM-DMY	AM-DMY	PM-DMY
M-kg	1	0.964	0.949	1.00 [1]	1.00 [1]
	2+	0.973	0.961	1.00 [1]	1.00 [1]
F-kg	1	0.923	0.914	0.952	0.935
	2+	0.927	0.923	0.959	0.947
P-kg	1	0.959	0.944	0.988	0.982
	2+	0.965	0.951	0.990	0.985

AM = Morning milking, PM = Evening milking, DMY = Daily milking

[1] 1.00 since both milk yields of a test-day are known when Lactocorder technique is used.

Table 7. Standard deviation of residuals.

		Current model		Extended model	
Trait	Lactation	AM-DMY	PM-DMY	AM-DMY	PM-DMY
F-kg	1	0.09000	0.09485	0.07164	0.08243
	2+	0.12596	0.12962	0.09489	0.10794
P-kg	1	0.05274	0.06173	0.02899	0.03527
	2+	0.06382	0.07469	0.03423	0.04196

In tables 8a and 8b, differences between true and estimated daily fat and protein yields are shown for both approaches. Differences are expressed in percentage of true daily yield. For all traits, the percentage of extreme differences is higher for pm-milkings than for am-milkings, which confirms the lower accuracy of yields derived from the evening milkings.

Again, the lowest accuracy is found for fat yield: the differences between the true and estimated daily yields greater than 10% of daily yield represent more than 24% of the cases for fat (am or pm milkings) instead of 18.1% for protein with pm milkings and 10.7% with am milkings. With the extended model, only 15% of the milkings result in a difference of higher than 10% for fat, and 3% for protein.

Table 8a. Percentage of milkings with absolute difference between true and estimated daily fat yield (in %).

		Current model		Extended model	
Trait	Difference	AM milking	PM milking	AM milking	PM milking
	< 1%	10.1	10.1	12.9	10.5
	1-5%	37.1	36.1	44.8	38.9
F-kg	5-10 %	28.5	28.6	28.2	30.6
	10-20 %	18.1	18.1	12.0	16.4
	≥ 20 %	6.2	7.1	2.2	3.6

Table 8b. Percentage of milkings with absolute difference between true and estimated daily protein yield (in %).

		Current model		Extended model	
Trait	Difference	AM milking	PM milking	AM milking	PM milking
	< 1%	14.8	11.7	22.8	19.2
	1-5%	48.0	41.0	61.7	57.5
P-kg	5-10 %	26.6	29.2	14.3	20.5
	10-20 %	9.2	14.9	1.1	2.7
	≥ 20 %	1.5	3.2	0.1	0.1

Table 9 shows that differences between true and estimated daily yields increase with increasing differences between morning and evening milk yields. With the extended model, these differences are reduced, especially for very unbalanced milkings. This confirms that accuracy of estimates for fat and protein yield can be remarkably improved with the extended model.

Table 9. Mean differences between true and estimated daily yield depending on proportion of milk yield AM to milk yield PM.

		Current model		Extended model		Current model		Extended model	
		F-kg		F-kg		P-kg		P-kg	
AM / PM[1]	No.	AM	PM	AM	PM	AM	PM	AM	PM
0 -	3	-0.77	0.73	-0.35	0.29	-0.58	0.63	-0.17	0.18
0.25 -	29	-0.27	0.36	-0.09	0.12	-0.31	0.38	-0.12	0.11
0.50 -	132	-0.19	0.23	-0.10	0.07	-0.18	0.22	-0.08	0.05
0.75 -	1830	-0.09	0.08	-0.05	0.02	-0.08	0.08	-0.04	0.01
1.00 -	9371	-0.02	0.01	-0.03	-0.01	-0.01	0.01	-0.01	-0.01
1.25 -	8048	0.02	-0.03	-0.01	-0.03	0.02	-0.03	0.00	-0.02
1.50 -	2256	0.07	-0.08	0.01	-0.05	0.06	-0.07	0.01	-0.03
1.75 -	536	0.14	-0.12	0.03	-0.08	0.10	-0.12	0.02	-0.05
2.00 -	202	0.25	-0.22	0.08	-0.12	0.18	-0.21	0.05	-0.09

[1]Proportion of milk yield AM to milk yield PM.

4.0 Conclusions

For all traits, higher accuracy can be achieved with morning milkings. Comparing the three traits, milk, fat and protein yields, the lowest accuracy is found for fat yield. The extended model, which considers the milk yield of the other milking of a test-day, leads to more accurate estimated fat and protein yields, and thus it should be highly recommended to estimate fat and protein yields with "Z" testing schemes. With this testing scheme both milk yields are known anyway and therefore there is no disadvantage when compared with classical schemes.

For all regions or farms that use an alternating testing scheme but do not work with EMM (such as Lactocorders), daily milk yield still has to be estimated ("T" schemes, according to the ICAR nomenclature). In these cases the German approach (model 6, Liu *et al*., 2000) should be applied.

Finally, it is recommended to derive regression factors from a data set representative of the situation of the country and which includes milkings of at least a whole year, to obtain complete lactations and to remove potential seasonal effects or the impact of short lactations.

In conclusion, the new model reduces disadvantages of alternating testing schemes. Accuracy of estimates for daily fat and protein yields from am or pm milkings is improved. This is especially true for very unbalanced milkings with large differences between morning and evening milk yield which very often lead to large estimation errors.

5.0 Acknowledgements

We thank the French Regional Milk Recording Organizations of Alsace, CAIAC and OPTIVAL for having provided the date used in this study.

6.0 References

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