

Analysis of the accuracy of C method for estimating 24-hour (yields) with alternated protocols

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In France, the number of farms using alternated protocols has increased in the last ten years and the percentage has reached 25% in 2018. Milk Recording Organisations (MRO) want to adapt and simplify protocols to the realities encountered in the field by using ICAR methods to estimate 24-hour yields in alternated one-milking recording (T), one-milking sampling with milk weights from more than one milking (Z). Another way consists by using constant one-milking recording (C).

The aim of this study is to analyse the accuracy of the C method on test-day record and on lactation (milk yields, fat yields, protein yields, fat percent and protein percent). Performances adjusted based on method derived from “Liu method” from constant one-milking recording and alternated one-milking recording were compared with the reference on a 24-hour yields and 305-days lactation basis on a large dataset.

A validation of the model was done on an independent data set: 138 222 test-day - 12 666 lactations for training data vs 69 982 test-day - 6 381 lactations for validation study.

The model adjustment was estimated through Determination Coefficient (R^2), Mean bias and Standard Deviation of bias. The results show that on test-day record the R^2 is lower in pm milking compared with am milking. R^2 is higher than 0.939 for milk, protein yields and protein percent. Fat yields and fat percent show a higher residual variability, with R^2 between 0.871 and 0.881 for fat yields and 0.776 and 0.834 for fat percent, in favour of morning milking. On lactation, the loss of accuracy ($1-R^2$) in comparison with the reference 305-days is lower than 1.2% for T method and 6.0% for C method for all traits except for fat percent which the loss of accuracy reaches 3.9% and 14.8% respectively. For all traits, the results of accuracy are lower with C method compared with T method. Estimated bias is on average very low. The results obtained with C method in this study are similar to a study carried out by Berry *et al.* (2005) on alternative milk recording protocols.

Keywords: milk recording, alternated protocols, adjustment, 24-hour yields, 305-days lactation.

Summary

Introduction

In France, the percentage of dairy farms which use alternated one-milking recording (T), one-milking sampling with milk weights from more than one milking (Z) has increased by more than 10% between 2005 and 2018. Since 2011 and after a collaboration with the VIT (Germany), the French Guidelines allows to estimate 24-hour yields for T and Z protocols by using Liu's method approved by ICAR (Bourrigan, 2011; ICAR Guidelines, 2017; FGE Guidelines, 2018).

This method proposed by Milk Recording Organisations (MRO) to the breeders is able to simplify and to reduce the cost of milk recording with the condition to respect alternation milking between test-day records.

The aim of this work is to study the possibility of using constant one-milking recording (C method, ICAR Guidelines, 2017) to answer the expectations of the MRO's, the breeders, the required quality for cow management and genetic evaluation, with using of Liu's method.

On the published literature, a study has been made about the accuracy of predicting milk yields from alternative milk recording schemes and particularly on C method (Berry et al., 2005).

The current study was conducted in 2018 about C method and consisted:

- to test the method for estimating 24-hour for milk yields, fat percent, fat yields, protein percent, protein yields;
- to evaluate the accuracy of the method on test-day record and on lactation;
- to propose changes of the France Genetics Breeding (FGE) dairy cattle milk recording Guidelines, according to the results achieved.

Material and methods

Presentation of the "Liu's method" model used in the study

This method is based on a multiple regression model for estimating daily yields and component percent from pm or am milking (Table 1).

The French "Liu's method" model considers separate regressions (Table 2) for 120 combinations

- 5 milking interval classes;
- 2 parity classes;
- 12 lactation stage classes.

The regression coefficients of the "Liu's method" have been defined from a reference data set of 208 204 test-day records, 146 herds, 14 396 cows mainly Holstein breed (Table 3). A validation study of the model was done on an independent data set: 138 222 test-day records for training data (2/3) vs 69 982 test-day records for validation study (1/3).

Table 1. Presentation of the “Liu’s method”.

$yA4 [ijk] = b0 [ijk] + b1 [ijk] yAT [ijk]$ yA4 = estimated 24-hour b0 = intercept b1 = regression coefficient yAT = pm or am milking test-day results [ijk] = effect of parity, milking interval, lactation stage

Table 2. Definition of effect classes considered in the French “Liu’s method” model.

Milking interval classes	5 classes	pm milking: <10h; 10h-10.5h; 10.5h-11h; 11h-11.5h; >11.5h am milking: <12.5h; 12.5h-13h; 13h-13.5h; 13.5h-14h; >14h
Parity classes	2 classes	1 st lactation, 2 nd and later lactations
Lactation stage classes	12 classes	30 days per class

Data were collected by Milk Recording Organisations from herds in A4 scheme with use of Electronic Milk Meter Lactocorder and recording of one milk weight, one sample at each milking (pm and am). Data were selected in order to constitute two relevant datasets for the different steps of the study.

Description of both datasets used in the study

Five criteria has been used to exclude raw data : too large difference in milk weight between milking, permitted range of the daily recorded values (defined in ICAR Guidelines, 2017), records with missing information, days in milk between 5 and 360 days, number of lactation grower than 9 (Table 3).

In a first step, the reference 24-hour has been calculated from 208 204 test-day records for milk yields, fat percent and fat yields, protein percent and protein yields. In a second step, the regression coefficients of the “Liu’s method” was applied to the 208 204 test-day records respectively from pm and am milking to calculate 24-hour yields for C method and T method (both adjusted).

The statistical analysis was carried out by comparing the reference 24-hour yields on pm and am milking (for all traits) with C method adjusted and T method adjusted.

The results of the accuracy (R^2 , Mean bias, Standard Deviation of bias) published on test-day record come from the 69 982 test-day records used to validate the “Liu’s method” regression coefficients.

Table 3. Description of the dataset for analysis on test-day record.

Criteria	Data set
# Test-day records	208 204
# Cows (93% Holstein breed)	14 396
# Herds	146
Average milk weight pm - am milking - kg	12.9 - 15.9
Average fat pm - am milking - %	4.23 - 3.74
Average protein pm - am milking - %	3.26 - 3.20
Average interval pm - am milking - h:decimal	10.7 - 13.3

For the analysis of lactation results, the Fleischman calculation method's was used to define a reference 305-days lactation. A total of 19 047 lactations fulfilled the conditions (Table 4).

The statistical analysis was carried out by comparing the reference 305-days lactation (for all traits) respectively with C method adjusted (all pm and all am) and T method adjusted (pm/am and am/pm).

The results of the accuracy (R^2 , Mean bias, Standard Deviation of bias) published on lactation come from 6 381 lactations for validation study.

Table 4. Description of the dataset for analysis on lactation.

Criteria	Dataset
# Lactations 305 days	19 047
Average milk yields - kg	9 172
Average fat - %	3.85
Average fat yields - kg	351
Average protein - %	3.12
Average protein yields - kg	285

Results - Analysis of the accuracy

Results on test-day record

The level of accuracy on test-day record (Table 5) is the same between C method adjusted and T method adjusted on pm and am milking for all traits.

The results show that on test-day record the R^2 is lower in pm milking compared with am milking.

R^2 is higher than 0.939 for milk yields, protein yields and protein percent. Fat yields and percent show a higher residual variability, with R^2 between 0.871 and 0.881 for fat yields and 0.776 and 0.834 for fat percent, in favour of morning milking. For all traits, the results of Standard Deviation of bias are higher in pm milking compared with am milking.

Table 5. Mean bias, Standard Deviation of bias and Correlations (R^2) between reference 24-hour yields and C method adjusted, T method adjusted (N= 69 982)

Traits - Milking	Mean bias		SD of bias		Correlations (R^2)	
	C method adjusted	T method adjusted	C method adjusted	T method adjusted	C method adjusted	T method adjusted
Milk yields kg - pm	-0.02	-0.02	1.97	1.97	0.940	0.940
Milk yields kg - am	0.07	0.07	1.64	1.64	0.959	0.959
Fat% - pm	0.00	0.00	0.32	0.32	0.776	0.776
Fat% - am	0.00	0.00	0.28	0.28	0.834	0.834
Fat yields kg - pm	0.00	0.00	0.11	0.11	0.871	0.871
Fat yields kg - am	0.00	0.00	0.10	0.10	0.881	0.881
Protein% - pm	0.00	0.00	0.07	0.07	0.956	0.956
Protein% - am	0.00	0.00	0.06	0.06	0.971	0.971
Protein yields kg - pm	0.00	0.00	0.06	0.06	0.965	0.965
Protein yields kg - am	0.00	0.00	0.05	0.05	0.975	0.975

The results show that on lactation (Table 6) the loss of accuracy ($1-R^2$) in comparison with the reference 305-days lactation is:

- lower than 6.0% for C method adjusted for all traits (milk yields, fat yields, protein percent and protein yields) on all pm, all am milking except for fat percent which the loss of accuracy is equal to 14.8% on all pm milking,
- lower than 1.2% for T method adjusted for all traits (milk yields, fat yields, protein percent and protein yields) on pm/am, am/pm milking except for fat percent which the loss of accuracy is equal to 3.9% on am/pm milking.

For all traits, the results of accuracy are lower on C method compared with T method, while mean bias is on average very low on C method and T method for all traits.

The level of Standard Deviation of bias is higher for C method than T method with large difference for some traits (milk yields, fat yields).

Results on lactation

Table 6. Mean bias, Standard Deviation of bias and Correlations (R^2) between reference 305-days lactation and C method adjusted, T method adjusted (N= 6 381).

Traits 305 days - Milking	Mean bias	SD of bias	Correlations (R^2)
C method adjusted			
Milk yields kg - all pm	0.5	352.5	0.966
Milk yields kg - all am	21.3	262.7	0.978
T method adjusted			
Milk yields kg - pm/am	11.1	154.8	0.997
Milk yields kg - am/pm	10.7	152.2	0.997
C method adjusted			
Fat% - all pm	0.004	0.18	0.852
Fat% - all am	0.018	0.18	0.856
T method adjusted			
Fat% - pm/am	0.009	0.10	0.964
Fat% - am/pm	0.009	0.10	0.961
C method adjusted			
Fat yields kg - all pm	0.6	18.4	0.940
Fat yields kg - all am	1.1	18.4	0.940
T method adjusted			
Fat yields kg - pm/am	0.9	12.0	0.989
Fat yields kg - am/pm	0.8	12.2	0.988
C method adjusted			
Protein% - all pm	0.000	0.48	0.955
Protein% - all am	-0.001	0.34	0.973
T method adjusted			
Protein% - pm/am	-0.001	0.22	0.996
Protein% - am/pm	-0.001	0.21	0.997
C method adjusted			
Protein yields kg - all pm	0.3	9.6	0.971
Protein yields kg - all am	0.5	7.5	0.981
T method adjusted			
Protein yields kg - pm/am	0.4	4.3	0.997
Protein yields kg - am/pm	0.4	4.3	0.997

Discussion and conclusion

This French study about the analysis of the accuracy of C method for estimating 24-hour yields was carried out on test-day record, on lactation from two relevant datasets. The study also allowed to update the accuracy results of T method carried out by FGE in 2011.

Milk weights and analysis results have been estimated by an ICAR approved method, the Liu's method in this current case. The regression formula has been defined from a first relevant dataset and validated from a second independent dataset.

On test-day record, the accuracy of C method adjusted (equal to T method adjusted) is better on am milking compared with pm milking for all traits analysed (milk, fat, protein). The lowest level of R^2 concerns fat percent with respectively 0.776 and 0.834 in pm milking and am milking.

On lactation, the loss of accuracy of C method is equal to 14.8% and 14.4% for fat percent (respectively on all pm and all am milking), equal to 6% for fat yields on both milking.

The loss of accuracy of T method is equal to 3.9% and 3.6% for fat percent (respectively on pm/am and am/pm milking), equal to 1.2% and 1.1% for fat yields (respectively on am/pm and pm/am milking). For all statistical criteria and all traits analysed, the level of accuracy is lower on C method compared with T method.

The results of C method accuracy's obtained in this French study have been compared with those obtained by the Berry and al., 2005 study's on 305-days lactation for milk yields, fat yields and protein yields. The comparison between both studies showed that:

- the level of R^2 is better from 2% to 3% in the French study;
- overall the level of Mean bias and Standard Deviation of bias is the same;
- the level of performance 305-days lactation is different (performance level of 6 000 kg in Berry and al., study against more than 9 000 kg in the French study).

After analyzing the results of this French study, the FGE board has proposed a program of implementation of C method in the dairy cattle milk recording Guidelines by the end of 2019 with conditions:

- to use the Liu's method for estimating 24-hour yields;
- to describe a Standard Operating Procedure (SOP);
- to define ponderations (for milk yields, fat percent, fat yields, protein percent, protein yields) among the level of individual lactation qualification model use by FGE and applied for genetic evaluation.

The latest ICAR survey about global 24-hour calculation trends in classical milk recording systems (ICAR Conference 2019 - Prague) showed that 5 ICAR organisations in the world use constant one-milking recording (C) scheme.

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