Analysis of the accuracy of a method for estimating 24-hour fat (percentage and yields) with robots protocols and one single sample

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Summary

The increase in the number of farms using Automatic Milking System (AMS) and the practical difficulties in milk recording, lead to examine ways to adapt and simplify protocols to the realities on the ground. One way consists by using an ICAR Peeters and Galesloot method of estimating 24-hour fat (percentage and yields) with robots based on one single sample (Peeters and Galesloot, 2002). The aim of this study is to analyze the accuracy of this multiple regression model with six factors at two level: on test day record and on lactation. The method was tested for fat percentage and yields from one single sample (the first) unadjusted and adjusted in comparison with a reference 24-hour. The validation study of regression coefficients of the model was done on an independent data set. The accuracy of the model was estimated from a large dataset.
The analysis of the results shows that the correlations are improved using one single sample adjusted instead of one single sample unadjusted compared with a reference 24-hour, respectively 0.786 instead 0.714 for fat percentage and 0.912 instead of 0.852 for fat yields.
Given these results, French Genetics Breeding decided to allow the use of the Peeters and Galesloot method's on robots protocols for all cows with one single sample during the sampling period and use it as estimated 24-hour fat for genetic evaluation.

Keywords: milk recording, robots, 24-hour fat percentage, adjustment

Introduction

The number of dairy farms in France using Automatic Milking System increased significantly from 50 in 2000 to 3400 in 2017. This exponential growth creates difficulties for the Milk Recording Organizations (MRO): cost of milk recording, use of sampling equipment… Currently the French Guidelines of milk recording suggests to estimate 24-hour milk yields from weights of the last 2 days and to collect at least two samples during the sampling period (between 12 and 24 hours). The objective of this study is to propose an evolution of the robots protocols to meet the expectations of the MRO, the breeders, the required quality for cow management and genetic evaluation. On the published literature, several studies have been made to answer some of these issues and challenges for automated systems (Bouloc, 2001; Peeters and Galesloot, 2002; Hand et al., 2006; Leclerc et al., 2012, Bourrigan, 2013).
The current study was conducted in 2016-2017 and consisted to:
- test an ICAR method for estimating 24-hour for fat percentage and yields from a single sample on robots protocols (ICAR Guidelines, 2017),
- evaluate the accuracy of the method on test day record and on lactation,
- propose changes of the French milk recording Guidelines, according to the results achieved.

Material and methods

- Presentation of the Peeters and Galesloot model tested in the study

The method is based on a multiple regression model that includes fat percentage, protein percentage, milking interval and milk weight of the sampled milking, milking interval and milk weight of the previous milking (Table 1).

Table 1: Presentation of the simple model Peeters and Galesloot

Fat% 24-hour estimated = b0 + b1Fat%(n) + b2Protein%(n) + b3MI(n) + b4 MI(n-1) + b5Milk(n) + b6Milk(n-1)
b0 = intercept
b1 to b6 = regression coefficients
MI = Milking interval
Milk = Milk weight
(n) = milking sampled
(n-1) = previous milking

This simple model can be completed by an interaction between milking interval (4 classes) and the ratio of fat to protein percentage (4 classes) of the sampled milking (complex model). Both models were compared during this study, the accuracies (correlations) were similar between both models. Only the results of the simple model are presented in this paper.

- Description of the datasets used in the study

Data collected by Milk Recording Organizations were selected in order to constitute relevant datasets for the different steps of the study. Milkings from robots with an interval between both milkings lower than 4 hours, a milk weight lower than 1 kg, a sampling period lower than 12 hours have been removed. At least two samples per cow during the sampling period were required to ensure a reliable reference population.

In a first step, a regression formula was derived from a data set of 386 643 milkings from years 2014/2015.

In a second step, the regression formula has been used on an independent dataset of 434 232 milkings from years 2015/2016 to estimate accuracy (bias and correlation).

In a third step, this regression formula was applied for all selected data (previous datasets), a dataset of 820 875 milkings from 884 herds and 77 095 cows (Table 2) to analyze the impact on test day record and on lactation.

Table 2: Description of the dataset for analysis on test day record

	Dataset
# Milkings robots (individuals)	820 875
# Cows	77 095
# Herds	884
# Sample per cow	2.1
Average milk weight - kg	11.3
Average fat - %	3.97
Average protein - %	3.28
Average length between milking - hour:minute	9:34

The statistical analysis was carried out by comparing the reference 24-hour fat percentage with fat percentage (from the first milking sampled) unadjusted and adjusted.
For the analysis of lactation accuracy, the Fleischman calculation method's was used. A minimum of 7 test day records and a lactation length over 305 days were required. 10 981 lactations fulfilled these conditions (Table 3).

Table 3: Description of the dataset for analysis on lactation

	Dataset
# Lactations	10 981
# Herds	399
Average milk yields - kg	9 943
Average fat - %	3.79
Average fat yields - kg	377
Average duration of lactation - days	402

Results

- On test day record

The analysis of the accuracy (bias, correlations) on test day record of the estimating model taking into account the first milking sampled shows (Table 4):
- a gain of correlations (R^2) equal to + 8% between fat % adjusted and fat % unadjusted,
- a gain of correlations (R^2) equal to + 6% between fat yields adjusted and fat yields unadjusted.

Mean bias and standard bias are also improved for fat % and fat yields adjusted.

Table 4: Bias and correlations between reference 24-hour fat (% and yields) and unadjusted / adjusted single sample (N= 332 698 first milking sampled)

	Mean bias		Std bias		Correlations (R^2)	
Traits	*Unadjusted*	Adjusted	*Unadjusted*	Adjusted	*Unadjusted*	Adjusted
Fat %	*0.0315*	-0.0350	*0.4150*	0.0300	*0.714*	0.786
Fat yields - kg	*0.0100*	0	*0.1350*	0.0960	*0.852*	0.912

The analysis of mean bias by classes from fat % on the first milking sampled indicates that results of fat percentage adjusted are similar from fat reference 24-hour, whatever the level of fat percentage (Table 5).

Table 5: Effect of fat % on fat % adjusted single sample (N= 332 698 first milking sampled)

Classes of Fat %	% by classes	*Fat % unadjusted*	Fat % adjusted	Fat % Reference	Mean bias Ref - Adjust	Std bias Ref - Adjust
Fat % $\leq$ 3.00	12.0	*2.70*	3.08	3.11	0.017	0.365
3.00 < Fat % $\leq$ 3.50	21.7	*3.32*	3.52	3.50	-0.020	0.274
3.50 < Fat % $\leq$ 4.00	27.4	*3.80*	3.86	3.85	-0.010	0.260
4.00 < Fat % $\leq$ 4.50	20.8	*4.28*	4.20	4.21	0.004	0.278
4.50 < Fat % $\leq$ 5.00	10.9	*4.77*	4.55	4.57	0.009	0.318
5.00 < Fat % $\leq$ 5.50	4.6	*5.26*	4.90	4.91	0.008	0.370
Fat % > 5.50	2.7	*6.05*	5.44	5.42	-0.027	0.493

The analysis of the effect of milk weights from the first milking sampled on fat percentage indicates that mean bias is very similar between fat percentage adjusted and fat reference 24-hour, whatever the level of milk weights (Table 6).

Table 6: Effect of sampling milk weights on fat % adjusted single sample (N= 332 698 first milking sampled)

Classes of Milk weights - kg	% by classes	*Fat % unadjusted*	Fat % adjusted	Fat % Reference	Mean bias Ref - Adjust	Std bias Ref - Adjust
Milk ≤ 8.0	19.5	*4.31*	4.18	4.18	-0.004	0.335
8.0 < Milk ≤ 10.0	22.7	*4.05*	3.99	3.99	-0.008	0.294
10.0 < Milk ≤ 12.0	20.6	*3.89*	3.91	3.91	-0.006	0.291
12.0 < Milk ≤ 14.0	15.1	*3.74*	3.83	3.84	-0.002	0.288
14.0 < Milk ≤ 16.0	9.9	*3.61*	3.78	3.79	0.006	0.288
16.0 < Milk ≤ 18.0	5.9	*3.49*	3.72	3.73	0.006	0.294
Milk > 18.0	6.4	*3.30*	3.64	3.64	-0.004	0.306

- **On lactation records**

The analysis of the accuracy (bias, correlations) of the estimating model on lactation performance shows (Table 7):

- a gain of correlations (R^2) equal to + 5% between fat % adjusted and fat % unadjusted,
- a gain of correlations (R^2) equal to + 3% between fat yields adjusted and fat yields unadjusted.

Table 7: Bias and correlations on lactation (N= 10 981 lactations)

	Mean bias		Std bias		Correlations (R^2)	
Traits	*Unadjusted*	Adjusted	*Unadjusted*	Adjusted	*Unadjusted*	Adjusted
Fat - %	*0.0382*	-0.0290	*0.2045*	0.1639	*0.828*	0.876
Fat yields - kg	*3.8380*	-0.3770	*20.81*	16.62	*0.922*	0.948

Discussion - Conclusion

This study shows that the Peeters and Galesloot method's of estimating 24-hour for fat (percentage and yields) with robots based on a single sample improves the accuracy of the data compared with one single sample unadjusted.

The regression formula defined from a first relevant dataset has been validated from a second independent dataset and confirms the reliability of the model.

On test day record, the gain of accuracy is 8% for fat percentage and 6% for fat yields. On lactation data, the gain of correlations is 5% for fat percentage and 3% for fat yields.

The analysis of the effect of fat percentage or of sampling milk weights do not show any difference between fat percentage adjusted with Peeters and Galesloot regression method and the reference fat percentage 24-hour.

In July 2017, the milk recording Guidelines of France Genetics Breeding has included the Peeters and Galesloot method's on robots protocols for all cows with one single sample. The requirements defined in the Guidelines are as follows:

- in the case of one single sample during the sampling period of 12 to 24 hours, fat percentage of the sample must be estimated by the Peeters and Galesloot method's, approved by ICAR,
- for each cow at each test day record with one single sample adjusted, there is a specific information registered on the genetic national database (same principle with Liu method's).

The use of this method by the Milk Recording Organizations is an answer to the expectations of the breeders to simplify the protocol and to reduce the cost of milk recording with robots while maintaining a sufficient accuracy for cow management and genetic evaluation purpose.

List of References

Bouloc, N., 2001. Milk recording and automatic milking system, characteristics and possibilities for simplification of milk recording. Institut de l'Elevage, France, 14 p.

Peeters, R., Galesloot, P.J.B., 2002. Estimating Daily Fat Yield from a Single Milking on Test Day for Herds with a Robotic Milking System. Journal of Dairy Science. 85:682-688.

Hand, K.J., Lazenby, D., Miglior, F., Kelton, D.F., 2006. Comparison of Protocols to Estimate 24-hour Fat and Protein Percentages for Herds with a Robotic Milking System. Journal of Dairy Science. 89:1723-1726.

Leclerc, H., Huquet, B., Minery, S., Bourrigan, X., Thomas, G., Saunier, D., 2012. Analysis of the accuracy of protocols in robotic milking herds for estimation of 24-hour fat and protein (percentage and yields) - Proceedings of the 38th Biennal Session of ICAR, Cork, Ireland.

Bourrigan, X., 2013. Study about the possibility of changes robots protocols in milk recording - Report n°001371045 - Institut de l'Elevage, France, 30 p.

ICAR Guidelines., 2017. Procedure 1 of Section 2 - Cattle Milk Recording - Computing 24-hour yields - Estimation of fat and protein yield (Galesloot and Peeters, 2000).