An overview of wished recording requirements to satisfy to the current evolution of milk recording organizations and selection programs in France

X. Bourrigan[1], H. Leclerc[1], G. Augier[2]

[1] Institut de l'Elevage, Département Génétique et Phénotype, 149, rue de Bercy, 75595 Paris, France
[2] France Conseil ELevage, 42, rue de Châteaudun, 75009 Paris, France

Abstract

The production context in dairy cattle farms nowadays faces important changes in France. Over the last 10 years, more than a third of dairy farms have disappeared or stopped dairy production, but their size has grown steadily from 42 cows to 54 cows. To cope with the increase in herd size and constraints related (including the difficulty of employing a cowman), more and more farmers bought a milking robot or milk meters as management tool for a daily monitoring. In this context, French milk recording organizations (MRO) have developed new protocols tailored to the needs of farmers and new equipments. The objective is to maintain a high penetration rate (around 70% of the cows) to ensure a selection base as wide as possible for classical and new traits for instance available through mid-infrared spectrometry (MIR) technology (fatty acids, indicator of metabolic status...). With the development of genomic selection, recording of new phenotypes is one of the major issues.
In this context, the challenge is twofold. On the one hand, we need to maintain a sufficient quality for genetic evaluation use but also for MRO so that they supply to farmers the technical support they need. On the other hand, we want to maintain the large size of the recording population (2.55 millions of cows in 2012). Over the last decade, French MRO have asked for new milking schemes answering to farmers' wishes in terms of flexibility, simplification and cost reduction.
Flexibility can be achieved by different approaches (increase or decrease of recording intervals, length of sampling period, supervision…). Ideas for more flexible recording systems to meet farmer and MRO's demands will be outlined. In any cases, the key is to have a clear description of the recording method for each performance.

Keywords : milk recording, milking schemes, flexibility, precision, biais.

Introduction

In France, over the last 10 years, many changes have occurred in dairy farms:

- the number of cows per dairy farm has increased on average of 12 cows since the last 10 years to reach more than 50 cows per farm in 2013 (table 1)
- the number of farms equipped with Automatic Milking System (AMS) increased significantly between 2003 and 2013 (from 175 to 2 556 AMS, i.e. nearly 15 times more). Most breeders with AMS would like to limit the duration of a robotic milk sampling to a manageable period of time and so the cost in terms of labor and sample analysis.
- the use of Electronic Milk Meters (EMM) is increasing particularly with Lactocorder and Tru-Test EMM (about 2 400 EMM used for milk recording in 2013).

All these evolutions create difficulties for the Milk Recording Organizations (MRO). The cost of milk recording is stable or increasing, whereas with a volatile milk price, farmers would like to limit its costs. For MRO, the development of new technologies requires expensive investment, such as sampling equipment for AMS… Even so, the main objective of MRO is to maintain the high percentage (close to 70% - table 1) of cows recorded.

In collaboration with the French Livestock Institute, French Milk Recording Organizations have developed and proposed new milk recording schemes in the past decade. Four unsupervised schemes have been developed in 2005 for farms with milk recording on 24-hour (B), milk recording on alternative milking (BT), milk recording on 24-hour for milk yield and only sampling on one alternative milking (BZ), milk recording with AMS (BR). The expansion of EMM, which are well adapted to alternative milking scheme, led to the development of a mixture of A and BT milking schemes, called CZ. The 24-hour milk yield is available, whereas only one sample is taken to estimate the daily fat and protein yields (Leclerc and al, 2004).

Since 2012, 24-hour performances obtained with AT and CZ schemes can be adjusted using Liu's method to increase the accuracy of estimated milk, fat and protein yields (Liu and al, 2000, Bünger and al, 2010).

On AMS, the French guidelines of milk recording suggests currently to estimate 24-hour milk yields from weights of the last 2 days (48 hours) and to collect and analyze all milk samples obtained on a period of at least 12 hours.

Table 1: Evolution of the penetration rate (cows recorded by MRO/total dairy population), average herd size and repartition among the various milking schemes between 2003 and 2013

Year	penetration rate	berd size	% of dairy herds recorded according to milking scheme[1]				
			A	AT - BT	B	AR - BR	CZ - BZ
2003	66 %	40.4	90.1 %	9.8 %	/	0.1 %	/
2005	68 %	41.5	85.5 %	13.6 %	/	0.9 %	/
2007	66 %	41.5	78.4 %	16.7 %	2.3 %	1.0 %	1.6 %
2009	68 %	46.1	73.2 %	17.8 %	3.6 %	2.9 %	2.5 %
2011	69 %	48.1	68.2 %	18.9 %	5.6 %	4.6 %	2.7 %
2013	69 %	52.1	65.6 %	19.0 %	6.0 %	6.7 %	2.7 %

[1] Definition of 8 milking schemes of milk recording used in France :
A : supervised 24 hours milking
AT: supervised alternative milking
B : unsupervised 24 hours milking
AR : supervised 24 hours robotic milking
BR: unsupervised 24 hours robotic milking
CZ: supervised/unsupervised 24 hours with sampling on only one milking (the supervised one)
BZ: unsupervised 24 hours with sampling on only one milking
BT: unsupervised alternative milking

Currently milk recording has three purposes:

- the measure of the daily performance which is used for management (milk quality, feeding, herd monitoring...),
- the estimation of the lactation yield from all test-day recorded during this period (technical data for the breeder and technicians, official lactation performance),

- the genetic evaluation based on lactation (305 days) or test-day model. The latter can be flexible with respect to milking schemes since the frequency and interval between test-day is automatically taken into account (instead of weight in the lactation model). Moreover, the milking schemes are taken into account in the test-day genetic evaluation planned in France through a heterogeneous variance model.

This paper comes back on three previous studies done between 2003 and 2012 (Leclerc et al., 2004 - full report of Leclerc and Delacroix, 2004; Bünger et al., 2010 and its updating by Bourrigan, 2011; and Leclerc et al., 2012 with detailed report by Bourrigan, 2013), based on different datasets that met specific needs. The aim of this paper is to summarize the comparisons of “low demanding” (AT, CZ) and AMS milking schemes with the supervised milking schemes, called A, used as standard reference and to propose an evolution of ICAR guidelines towards greater flexibility and scalability of milking schemes to meet current needs.

Material and Methods

Three datasets fitted to the objectives of each initial study were used. In all cases, it is quite large datasets with between 13 and 90 thousands of test-day (table 1). On dataset 1, data was collected on an experimental farm of crossbred cows (Le Pin au Haras) belonging to INRA. Recordings were much more frequent than on a commercial farm (separate morning and evening milk yield for each day with a extreme milking interval : 10-14h and once a week separate sampling). This enabled to model various milking schemes. Moreover, cows being registered during a long period, it enables to model the complete lactation yields. Average performances are detailed on table 3.

Table 2: Description of the datasets

	Dataset 1	Dataset 2	Dataset 3
Specificity	Lactation study	EMM with milking time	Robotic Milking
# Test-day records selected	13 574	89 828	52 361
# Cows	290	18 101	19 783
# Herds	1	286	268
# of lactation > 180 days	328	N/A	N/A
Average milking interval	10-14h	10h45-13h15	N/A
Recording period	2000-2001	2008-2011	2009-2011
Breed	Crossbred (50% Holst – 50% Norm)	93.5% Holstein	N/A

Table 3: Average performance and model adjustment for each datasets

		Dataset 1	Dataset 2	Dataset 3
Specificity		Lactation study	EMM with milking time	Robotic Milking
Mean Milk (kg)		20.1	27.9	26.9
Mean Fat (kg)		0.850	1.116	1.084
Mean Protein (kg)		0.659	0.901	0.873
Model adjustment	Parity	Not adjusted	2 classes : 1st, 2nd and +	Not adjusted
	Milking interval		5 classes : AM : <12.5 ; 12.5-13 ; 13-13.5 ; 13.5-14; ≥ 14 PM : ≤ 10 ; 10-10.5 ; 10.5-11 ; 11-11.5 ; >11.5	
	Lactation stage		12 stages of 30 days	

Dataset 2 was delivered by MRO using Lactocorders in east of France. It was a large dataset obtained on A milking scheme where morning and evening sampling were analysed separately. AT and CZ milking schemes could be modelled from this dataset by the deletion of some information. Milking times were registered to enable the adjustment for milking interval (classes are detailed on table 2) on “low demanding” milking schemes as AT and CZ.
Dataset 3 was obtained from raw file extracted from 4 AMS brands. The non standardized format of raw file does not simplify this study. Half of the data were deleted due to an unreliable ID to do the jointure with cow characteristics data. It prevented to have enough data to develop adjusted model taken into account parity, milking interval, lactation stage and sampling time (AM or PM). At least two sampled milking were required per test-day to make sure that reference fat and protein yields and percent were properly estimated.

As regards as the models used to improve the precision of yield estimations on “low demanding”:

- For AM/PM milking (AT scheme) on dataset 2, we used an extension of the adjustments proposed by Liu et al. (2000). Daily yields (milk, fat or protein) are estimated from single morning or evening milking considering separate regressions for every combination of parity *i*, milking interval *j*, and lactation stage *k* (classes described in table 3)

$$y_{\mathrm{ATadjust.}}{}^{[ijk]} = b_0{}^{[ijk]} + b_1{}^{[ijk]}\, y_{AT}{}^{[ijk]}$$

- For CZ scheme on dataset 2, in which both milk yields of a test-day are available, whereas only one sample is available to estimate the daily fat and protein yields, we proposed to extend the methods developed for AT schemes by including in the model 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: $y_{A4}{}^{[ijk]} = b_0{}^{[ijk]} + b_1{}^{[ijk]}\, y_{AT\text{-}am}{}^{[ijk]} + b_2{}^{[ijk]}\, Milk_{\text{-pm}}{}^{[ijk]}$
  Evening milking: $y_{A4}{}^{[ijk]} = b_0{}^{[ijk]} + b_1{}^{[ijk]}\, y_{AT\text{-}pm}{}^{[ijk]} + b_2{}^{[ijk]}\, Milk_{\text{-am}}{}^{[ijk]}$

- For robotic scheme, current French recommendation for AMS milk recording are:
  1/ Milk intervals must be greater than or equal to 4 hours for all samples used to estimate 24-hour fat and protein percentage.
  2/ The reference 24-hour rate (calculated for fat and protein percentage), use all milk and samples records collected on a period of at least 12 hours.
  Adjustment for covariates is a planed improvement for the future years, when datasets will be easier to obtain. Using a sampling period of 12 hours, 7.9 % of cows do not have sample because they did not come to the AMS during this period.

Results

Two kinds of results are presented. On the one hand, we focus on the precision of daily yield through the correlation (R^2) obtained on studied milking schemes (AT, CZ and R) in comparison with the reference one (A). On the other hand, we look at the number of test-day necessary to reach a certain level of precision (95 and 98%) in a four week interval milking scheme (on dataset 1). This give a view on precision obtained in a lactation yield context (table 5).

Impact of studied milking schemes on the daily yield

Table 4 shows that precision obtained on AT milking scheme on two different datasets (1 and 2) give quite different precision (both without adjustment). They can be explained by large difference in fat content resulting in large milking interval (10-14h). In dataset 2, AT milking scheme with adjustment (compared with unadjusted AT scheme) increases the accuracy (R^2) of milk yields (+ 2 % in am milking, + 2,6 % in pm milking), fat yields (+ 2,9 % for am milking, 1,1 % for pm milking), but in all case, the level of accuracy is less than 0,90 for fat yields. For protein yields, the correlations are higher than 0.93 with adjustment.

Table 4: Correlation (R^2) between true and estimated daily yields

			Milk		Fat		Protein	
	Dataset	Adjustment[1]	AM	PM	AM	PM	AM	PM
AT	1	No	0.955	0.908	0.802	0.824	0.949	0.897
AT	2	No	0.939	0.914	0.865	0.863	0.928	0.902
AT	2	Yes	0.959	0.940	0.894	0.874	0.952	0.933
CZ	1	No			0.856	0.932	0.996	0.996
CZ	2	No			0.903	0.896	0.993	0.990
CZ	2	Yes			0.931	0.916	0.994	0.991
R	3	No			0.965		0.995	

[1]Adjusted using regression on parity i, milking interval j, lactation stage k and other milking milk yield (morning milk yield for the evening milking and vice versa) as a covariate.

For CZ milking scheme, as for AT, the difference between datasets 1 and 2 are quite large for fat yield. The explanation remains the same. The CZ scheme with adjustment increases the accuracy for fat yields, + 3 % in am milking and 2 % in pm milking. The level of accuracy is greater than 0,916 for fat yields. The correlations are higher than 0.99 for protein yields with or without adjustment.

The precision level obtained with a robot milking scheme with a sampling period of 12 hours is quite acceptable in view of correlation higher than 0.965 for fat and 0.995 for protein yields.

Impact of "low demanding" milking schemes on lactation yield

When we focus on the number of test-day necessary to reach a precision of 95% and 98% (table 5) in a four week interval milking schemes on dataset 1 (without any adjustment), we see that for milk yield, those levels are reached quickly with 2 and 4 test-day whatever the time of the first recording (morning or evening). For protein, with CZ4, the first recording is sufficient as it should be expected in view of table 4. With AT4, the situation is quite different since it needs 5 or 6 test-day to reach the 98% precision. For fat yield, the situation is even more critical. With CZ4 milking schemes, 2 or 3 monthly test-day are needed to reach 95% and 6 to 7 for the 98% level. With AT4, 5 to 7 test-day are needed for the 95% level. The 98% level can not be reached.

However, this dataset correspond to an extreme situation, the worst one, with a 10-14 hours interval. The comparison of AT4 and CZ4 shows a clear advantage of recording milk yield on 24 hours to improved estimation of fat and protein yields.

Table 5: Number of milk recording to reach a correlation (R^2) of 95% and 98% between reference milking schemes (A4) and estimated cumulative yield on lactation (with a strict interval of 4 weeks) of “low demanding” milking schemes (AT4 and CZ4)

			Milk		Fat		Protein	
	Dataset	1st recording	95%	98%	95%	98%	95%	98%
AT4	1	AM	2	4	7	Never	2	5
AT4	1	PM	2	4	5	Never	3	6
CZ4	1	AM			3	7	1	1
CZ4	1	PM			2	6	1	1

Discussion

Milk Recording Organizations and breeders would like to reduce costs of milk recording and limit the constraints related to the milk samples collection.

Different alternatives were studied to simplify milk recording. In all cases, it’s imperative before using new milking schemes, to ensure they give a sufficient accuracy and a null or very low bias for their use in the daily and lactation scale: technical support to dairy farms, lactation yield estimation, genetic evaluation…

The implementation of adjustment factors for milk, fat and protein yields is a factor of development of ”low demanding” schemes. In France, the percentage of farms in AT scheme has increased of 10% between 2003 and 2013. The B scheme is another responses to the request of breeders (6 % of herds in 2013) allowing more flexibility in their work organization and a cost reduced. On the other hand, it requires monitoring in data quality through various indicators.

The development of AMS in France has imposed evolutions of milking schemes. A study conducted in 2012 showed that the restriction to a single sample unadjusted had a large impact on the accuracy of the proposed milking schemes. The development of adjustment factors for a single sampled milking can be a promising alternative for AMS in the future.

Other areas of improvement and simplification of milk recording will studied. They deal with the increase or decrease in the number of test-day control in farms (and thus milk recording intervals), the length of the sampling period...

Until now, rigorous milking schemes were requested for genetic evaluation... this need is more or less necessary now. Test-day models require 4 to 5 well positioned records on the lactation to reach an information level higher than the one obtained with a 305d lactation model. Unfortunately, for some cows, test-day records will not be well positioned; these cows do not achieve the level of precision required for the index to be published. Genomic opens a new area in which we must not stop milk recording. Milk recording will always be essential, to update genomic prediction equations, but also to enable to select new traits on milk composition (fatty acids, protein, casein, calcium…) trough the opportunities offered by MIR analysis.

The situation is not so simple for technical support. If farmers want to have high quality advice by the MRO technician, they can not subscribed to milk recording 4 to 6 times a year... especially if they want to benefit in the future of new developments in terms of herd management enable by MIR spectrum (acidosis, gestation diagnosis…).

As a conclusion, all the milking schemes proposed in the last decades aim to maintain a high penetration rate of milk recording in France with a sufficient level of accuracy for genetic evaluation and technical support.

In this context, France and probably other countries wish a simplification of ICAR recording guidelines to enable more flexibility and make evolution easier. One possible solutions would be to define the minimal requirements in comparison with the A4 standard (for instance, those obtained with an AT milking schemes with a 6 week interval) and on the basis of a referenced study (with accuracy (R^2) and bias results), to approve automatically the milking scheme over this limits. Each country could develop models that meet its constraints and adjustment factors adapted to its data (race, production level ...).

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