ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 64 90 Number 3, 2016

http://dx.doi.org/10.11118/actaun201664030791

DEVELOPMENT TO ENSURE OF THE RESULT RELIABILITY OF PRODUCTION INDICATORS IN THE MILK RECORDING DURING ITS COMPUTERIZATION

Pavel Hering[1], Pavel Kopunecz[2], Oto Hanuš[1], Martin Tomáška[3], Marcela Klimešová[1], Radoslava Jedelská[1], Jaroslav Kopecký[1]

[1] Dairy Research Institute, Ltd., Ke Dvoru 12a, 160 00 Praha 6, Czech Republic
[2] Czech-Moravian Breeders Corporation, Inc., Benešovská 123, 252 09 Hradištko, Czech Republic
[3] Dairy Research Institute, JV, Dlhá 95, 010 01 Žilina, Slovak Republic

Abstract

HERING PAVEL, KOPUNECZ PAVEL, HANUŠ OTO, TOMÁŠKA MARTIN, KLIMEŠOVÁ MARCELA, JEDELSKÁ RADOSLAVA, KOPECKÝ JAROSLAV. 2016. Development to Ensure of the Result Reliability of Production Indicators in the Milk Recording During its Computerization. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 64(3): 791–801.

Milk recording (MR) is an essential breeder measure. Results are important for inheritance check. The occurrence of errors in the data may compromise the efficiency of breeding of dairy cows. The aim was possibility to reduce the incidence of MR database errors. Analyses of frequency distribution of MR data deviations from different sources and estimations of limits of difference acceptability in milk recording were performed. The results of MR control days of flowmeter in parlor (DMY) were paired to the AVG7 results (average for 7 days) from the same flowmeter (n = 16,247, original recordings of complete lactations). The individual differences in milk yield indicators were calculated between successive MR control days (DMY – R, monthly interval, the reference value (R) = previous DMY) for MR data file. A statistically significant correlation coefficient (AVG7 and DMY) was 0.935 ($P < 0.001$) and was higher in comparison to the previous assessment under AMS conditions (automatic milking system; 0.898; $P < 0.001$). This means that 87.3% of the variability in the milk yield values for MR (DMY) can be explained by variations in the AVG7 values and vice versa. Difference tests confirmed significant differences ($P < 0.001$) 0.76 and 0.55 kg between DMY (in MR) and AVG7 for original and also refined data file. Mentioned differences, although statistically significant, correspond only to 2.96 and 2.15% relatively. The use of multi–day milk yield average from the electronic flowmeter is an equivalent alternative to the use of record from one MR control day. Results are used in MR practice.

Keywords: cow, raw milk, milk yield, fat, protein, somatic cell count, milked cattle breeding

INTRODUCTION

Milk recording (MR) is an essential breeder measure (Hering *et al.*, 2005). Its results are important to inheritance check. The error occurrence in the data may compromise the efficiency of breeding work about dairy cows. There are presently involved 93.9% of dairy cows (Kvapilík, Růžička and Bucek *et al.*, 2014) in MR of the Czech Republic. The MR authorized through ICAR (International Committee for Animal Recording, 2008) is important for the recognition of international trade in breeding material. Therefore, the used partial methodological and technological procedures in MR must be validated for the possibility authorization of the MR whole. As stated by prof. Taufer (1869–1940; cit. Hering *et al.*, 2005): "There are no cultivating actions without a yield control and any culture breed dies without genetic transmission control. Therefore the control of parental matter husbandry and nutrient circles cannot only be a temporary improvement action but a permanent cultivating work. This fact has to be accepted not only by those managing yield and genetic transmission control but also by those in whose herds the control is carried out."

The gradual process of computerization and automation in breeder technologies (ventilation, milking, feeding) introduces a number of issues into own method and course of MR, especially in terms of method and reliability of data acquisition useful in breeding of dairy cattle, which means in the subsequent breeding work. Also recently our breeder public discussed some of these issues. The outcome of that discussion is need of validation of the acceptable limits of result variability in subsequent control days of MR in identical herd. It means limits of MR result stability respectively or vice versa limits of acceptable MR result dynamics of the herd and individual animals over time (from day to day, from month to month, from the MR control day to the MR control day). The object of verification is therefore still physiologically acceptable variability of the MR values during the lactation curve. At the same time the question of the possibility and acceptability of the summarization or aggregation of some MR data to eliminate some potential errors was solved. For instance such as using the average milk yield from several previous days in case of availability of data from electronic flow milk-meters instead of individual value from MR control day and so on. However, at that point it is necessary to keep the ICAR request (2006, 2008, 2010, 2012) regarding the expression of yield of milk components where this is possible to apply the analytical results of milk components, which are obtained once a month generally, only to relevant day milk sample and yield. That is such a sure complication of potential solving of combinations of milk yield and composition, which could be offered for MR.

ICAR commission, in the context of awarding new special stamp of eligibility for MR performance (Czech Republic (CR) MR already has been bearer of this new special stamp), checks the complexity of MR system. It means not only the activities associated only with practical field MR (ICAR, 2008). Also activities that start by preparing of MR and continue by control of animal identification, right milk sampling and system of data processing and publication are included into official audit. The process by which an ICAR member organization checks the system of relevant MR implementation is also included in audit. The Czech Moravia Breeders Association has a system of field MR checking (Hering *et al.*, 2008). This system is currently being introduced into the system of MR as so called super–control. This is the routine confirmation of correct MR performance including proper sampling in the MR. That is confirmed by laboratory analysis of subsequently obtained samples and by result comparison with values which were measured in milk samples in the framework of routine MR. The super–control must conform to the following rules (ICAR Guidelines, Kuopio, 2006):

1. all measurements must be made by equipment which was approved by ICAR;
2. all equipment must be properly installed, calibrated and used;
3. animals must be properly identified;
4. super–control discovers and identifies inconsistent or inaccurate results;
5. inaccurate or inconsistent results will be replaced with proper information (for instance, in case that these have been measured) or these are removed from the official MR;
6. super–control has not to be performed by identical person who has made routine MR.

Super–control is already introduced with different principles in whole row of breeder developed countries similarly as in the CR MR (ICAR, 2008).

To develop a methodology for MR (milk sampling, volume measuring etc.) the studies of the effects of time intervals and milking frequency on milk volumes and composition are important. The results of the MR and inheritance control for the purposes of breeding work and control of dairy cow health are calculated from whole day milk yield (Wirtz *et al.*, 2007). Therefore, different authors methodically studied the estimations of the total milk production results and conversions from various partial variants of sampling during milking (Sedláková, 1969; Brauner and Hanuš, 1984; Liu *et al.*, 2000; Klopčič *et al.*, 2003; Hand *et al.*, 2006; Hering *et al.*, 2009, 2010; Roelofs *et al.*, 2007; Gantner *et al.*, 2009; Remond *et al.*, 2009; Jenko *et al.*, 2010; Hanuš *et al.*, 2011a, b).

The aim of this analysis is usable information and a contribution to methodology of reduction of the error incidence (errors due to sampling, measuring of volumes, milk analysis and data acquisition and transfer) in the MR and heredity control process.

MATERIAL AND METHODS

Locations, Rearing Conditions in Dairy Herds and Individual Samples of Milk

A) Barn equipped by tandem milking parlor 2×4 from Lukrom Milk fitted with an electronic flowmeters Afiflo 2000 (Israeli manufacture) was chosen for testing. Used flowmeters were calibrated regularly in accordance with relevant ICAR guidelines in the framework of technical maintenance of milking parlor equipment. This stable is located in South Bohemia County (48° 50.02598'N, 14° 24.44337'E, altitude 550 m). The parlor was also equipped with automatic identification of animals directly to the milking stall. Thus were eliminated possible errors arising by identification of dairy cows through the entrance gate of milking parlor. There are housed dairy cows of Czech Fleckvieh (CF) and Holstein (H) breed, mostly hybrids CF × H. There were closed 152 standard lactations in this herd in control year (2012–2013) with average milk yield of 8,414 kg milk with a fat content of 3.88% (326 kg) and protein content of 3.32% (280 kg).

The data from official MR through Plemdat Hradištko were used to comparison the daily milk yield (DMY; Afiflo 2000) and calculated average (AVG7). There were used data for period 08/2013–07/2014 with 56,224 records of DMY in total. These data were selected according to the official MR control days. Data on the composition of individual milk samples has been available for each official record. In this way each cow had a database 1–10 records (standardized lactation) along reproduction performance dynamics of the herd during the calendar year. The study thus corresponds to the real conditions. The dairy cows with records of whole lactation were chosen for evaluation. The variability of DMY (in kg) in electronic records of milking parlor (regular intervals of twice a day milking) was compared to mean yield from relevant last period (average milk yield from last 7 days including the day of current DMY (AVG7 in kg)) in the model comparison. Then, with respect to the variability these results were compared visually with results of the former same evaluation for the automatic milking system (AMS; different intervals between the milking and the possible varying number of daily milking; Hanuš *et al.*, 2014).

This location was chosen for a completely robust system of milking, animal identification and sampling of milk. When used individual electronic identification of animals according to the pedometer in the parlor standing, without application of identification by the milking parlor gateway, the occurrence of possible errors in milk yield determination is reduced to a minimum. For the other systems the effects of unpredictable animal behavior on identification error rate can be more remarkable.

B) The model MR data file (list of herds, n = 24) was used to assess the relative (%) incidence of relative (%) individual deviations (n = 85,107) in indicators of milk yield between consecutive control days of MR (monthly intervals). There were applied various technologies of milking in milking parlors and represented by both milked breeds of cattle (mainly CF; and in minority H). The observation period was from December 11th 2012 to January 16th 2014. All milking parlors were equipped with electronic milk flowmeter.

Analyses of Milk Samples and Dairy Laboratories

Obtained individual milk samples were treated by preservative tablets D & F Control Microtabs (0.03% bronopol), and transported under cold conditions (< 8 °C) into laboratory. Samples were analyzed in an accredited laboratory (LRM Brno Tuřany and LRM Buštěhrad, ČMSCH Hradištko): the fat content (F, %); the crude protein (P, %); the somatic cell count (SCC, in $10^3.ml^{-1}$). There were used: milk infraanalyzers Bentley and Combi Foss 6000 (F and P); flow fluoro–opto–electronic cytometry Somacount and Combi Foss 6000 for SCC (Bentley Instruments, Chaska, USA; Foss Electric Denmark). These instruments were regularly calibrated to the standard method and checked in official proficiency testing.

Statistical Evaluation of the Data and Their Differences by Different Sources of Results in MR

The assumption of normal data frequency distribution of the monitored milk indicator (milk yield, F and P) was taken into account for statistical testing of results. This is valid the more for the differences between DMY and AVG7. Therefore, the use of paired t–test is warranted. Only for milk indicator SCC the logarithmic data (log_{10}) transformation was used (Ali and Shook, 1980; Shook, 1982) because of the absence of the normal frequency distribution for individual milk samples (lognormal frequency distribution of values) and then consequently the geometric mean.

A) The results of MR control days of flowmeter in parlor (DMY) were paired to the AVG7 results from the same flowmeter (n = 16,247, original recordings of complete lactations). In this way the database was reduced to n = 1,501. The basic statistic parameters for milk indicators (F, P and SCC) were calculated but especially for both indicators of milk yield (DMY and AVG7) and also for the difference between them: arithmetic mean x; for SCC also geometric mean xg; standard deviation sd; coefficient of variation vx; median m. Complete lactations were processed graphically in the form of the lactation curve for variable flowmeter daily records and corresponding AVG7. File of differences (DMY – AVG7) was also refined by Grubbs outlier test (at a probability level of 0.05). Next calculations were performed in the original (n = 1,501) and adjusted (n = 1,406) data file. Also linear regression was performed between the results of milk yield AVG7 and DMY from MR. Paired t–test was calculated for classification of significance of difference in milk yield (between MR (DMY) and AVG7).

B) The individual differences in milk yield indicators were calculated between successive MR control days (DMY – R, monthly interval, the reference value (R) = previous DMY) for MR data file. These deviations were expressed in relative way in % (100% = R) in absolute value (unsigned). The incidence of these deviations was also expressed in % (100% = all cases) in intervals according to their percentage values (in absolute value, without sign).

RESULTS AND DISCUSSION

A) Basic statistical characteristics of milk yield indicators for data from milking parlor are listed in the Tab. I. The average values and their variability are comparable to previous trials especially in CF for automatic milking system (Hanuš *et al.*, 2014).

I: *Basic statistical characteristics of milk recording indicators from flowmeter in milking parlor, original data file*

I/P	DMY kg	AVG7 kg	F%	P%	SCC	log SCC	DMY – AVG7
n	1,501	1,501	1,207	1,207	674	674	1,501
x	25.64	24.88	4.07	3.47	481	2.3632	0.76
sd	8.44	8.35	0.525	0.358	1,012	0.4672	3.038
vx %	32.9	33.6	12.9	10.3	210.3		399.5
min	3.4	3.57	2.18	2.34	9	0.9542	–21.49
max	59.1	52.23	6.46	4.72	9,999	4	30.91
xg					231		
m	25.6	24.59	4.03	3.47	197	2.2934	0.54
t/s							9.7/P < 0.001

I/P, indicator/parameter; DMY, daily milk yield; AVG7, 7 days average of DMY; F, fat; P, protein; SCC, somatic cell count (10^3.ml^{-1}); log SCC, logarithm$_{10}$ of SCC; DMY – AVG7, difference; n, number of cases; x, arithmetic mean; sd, standard deviation; vx, variation coefficient (in %); min, minimum; max, maximum; xg, geometric mean; m, median; t/s, t-test criterion value/probability of difference significance

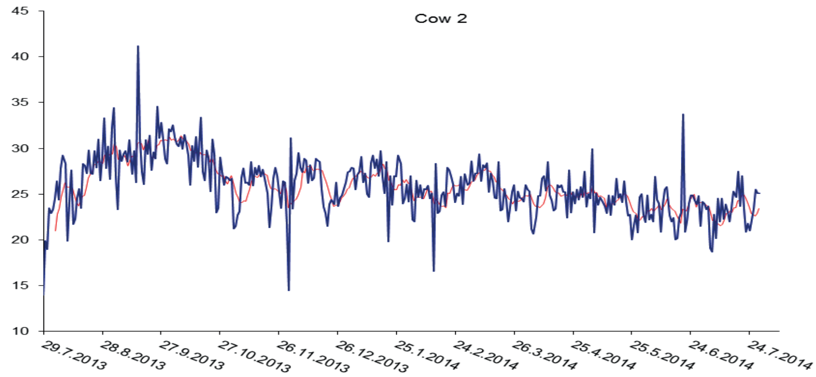
II: *Basic statistical characteristics of milk recording indicators from flowmeter in milking parlor, refined data file*

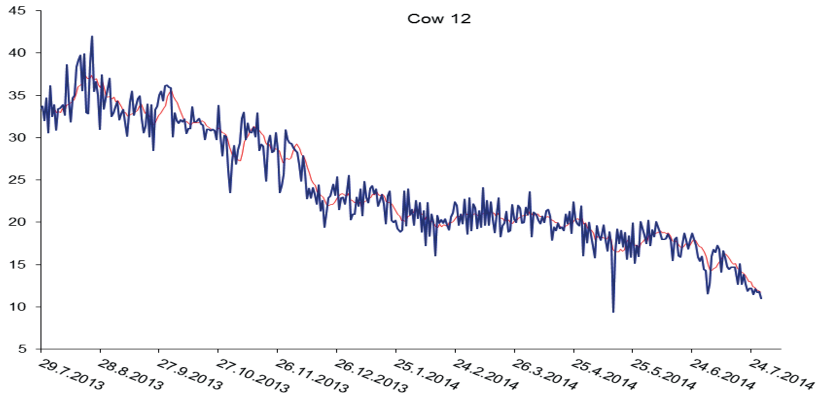
I/P	DMY kg	AVG7 kg	F%	P%	SCC	log SCC	DMY – AVG7
n	1,406	1,406	1,117	1,117	609	609	1,406
x	25.64	25.1	4.06	3.47	453	2.3581	0.55
sd	8.33	8.27	0.509	0.353	934	0.4524	1.612
vx %	32.5	33	12.5	10.2	206.2		294.9
min	3.4	3.57	2.21	2.34	14	1.1461	–4.5
max	53.5	52.23	6.46	4.72	9,999	4	5.64
xg					228		
m	25.4	24.76	4.02	3.46	196	2.2923	0.49
t/s							12.7/P < 0.001

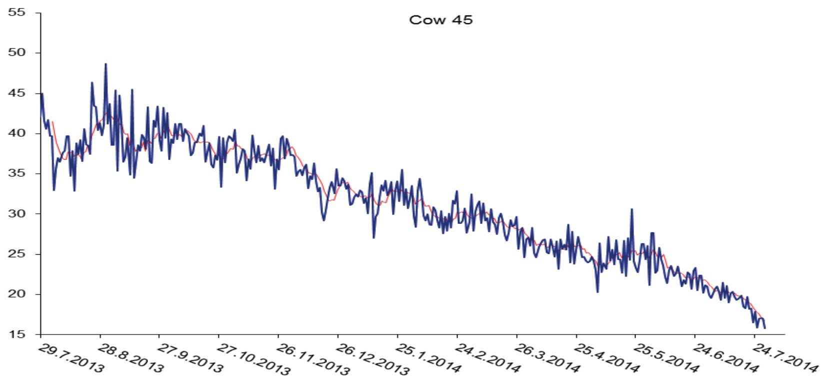
The variation coefficients were: for DMY in the MR 32.9%; for AVG7 33.6%. A similar conclusion could also be said for milk components and production of milk components, where appropriate variation coefficients were: 12.9% for F; 10.3% for P. The SCC geometric mean 231 10^3.ml^{-1} shows a higher proportion of subclinical mastitis, but this still corresponds to the practical conditions in MR performance. The data file can be considered as representative for mentioned purpose. The corresponding values for refined data file are listed in the Tab. II.

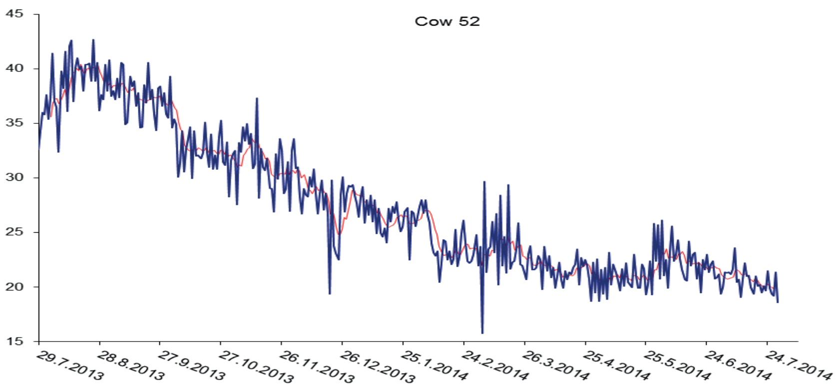
There is possible to compare (Tab. I and II) the arithmetic means and medians of relevant files of dairy indicators. Except SCC, particularly for milk yield (MR and milking parlor) and milk components these values are very close. This indicates a high probability of normal frequency distribution of data in the relevant files. Consequently, the use of introduced statistical methods and estimates is justified. In the SCC case (Tab. I and II), there is median relatively close to the geometric mean. This confirms previous experience about normalization of SCC data distribution by logarithmic transformation where a lognormal data frequency distribution for individual SCC can be assumed (Ali and Shook, 1980; Shook, 1982).

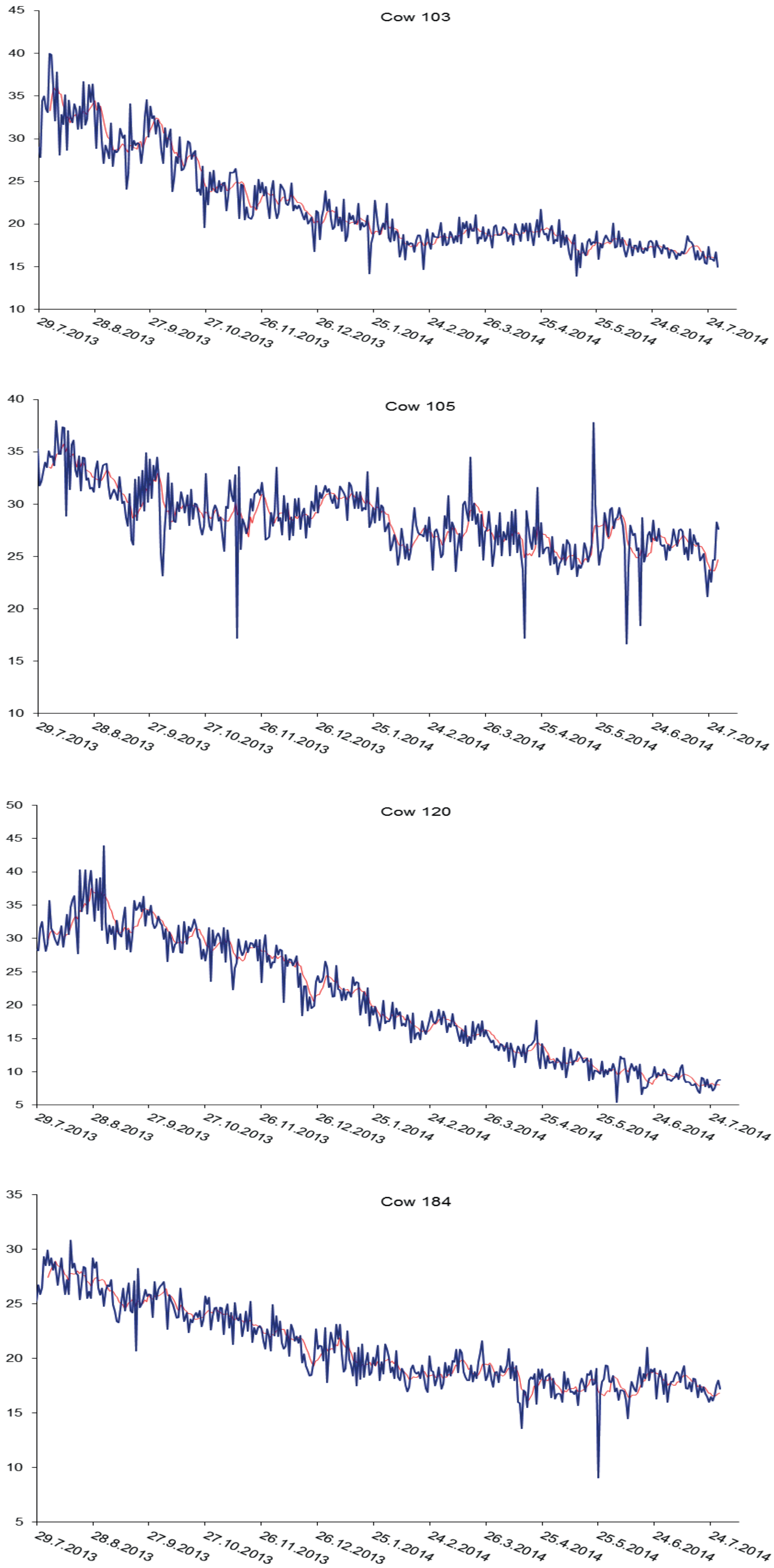
The lactation curves for DMY from data of electronic flowmeter in milking parlor and their corresponding lactation AVG7 curves (values of moving arithmetic means) were displayed for selected cows. This comparison includes the real values of milk yield indicators in relevant lactation curves for the possibility of practical orientation. In this way the evaluation is carried out without the application of model solution (for instance according to Wood) which is included in the recent works of some authors (Quinn *et al.*, 2006a, b; Khazaei and Nikosiar, 2008; Golebiewski *et al.*, 2011; Kopec *et al.*, 2013) in order to attempt to refine the genetic improvement of milk yield. This comparison is used to assess the variability of data from the milking parlor and automatic milking system (AMS). Lower variability compared curves AVG7 and DMY is logical and obvious (Fig. 1). If these curves are compared to the same assessment about AMS (Hanuš *et al.*, 2014; Fig. 2) it is apparent that this assessment (Fig. 1) includes lower variability of DMY values around the AVG7 curve than the AMS rating (Fig. 2). Greater DMY variability around AVG7 is undoubtedly determined by the relatively irregular intervals between milking and further by higher incidence of multiple daily milking in the AMS case as compared to twice a day milking and regular between milking intervals in this evaluation.


Cow 2
45
40
35
30
25
20
15
10
29.7.2013
28.8.2013
27.9.2013
27.10.2013
26.11.2013
26.12.2013
25.1.2014
24.2.2014
26.3.2014
25.4.2014
25.5.2014
24.6.2014
24.7.2014

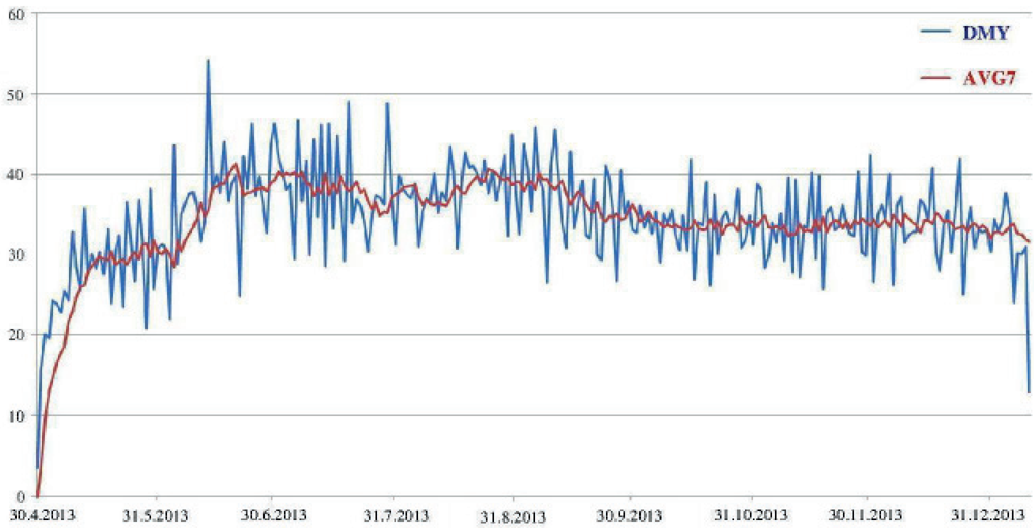

Cow 12
45
40
35
30
25
20
15
10
5
29.7.2013
28.8.2013
27.9.2013
27.10.2013
26.11.2013
26.12.2013
25.1.2014
24.2.2014
26.3.2014
25.4.2014
25.5.2014
24.6.2014
24.7.2014


Cow 45
55
50
45
40
35
30
25
20
15
29.7.2013
28.8.2013
27.9.2013
27.10.2013
26.11.2013
26.12.2013
25.1.2014
24.2.2014
26.3.2014
25.4.2014
25.5.2014
24.6.2014
24.7.2014

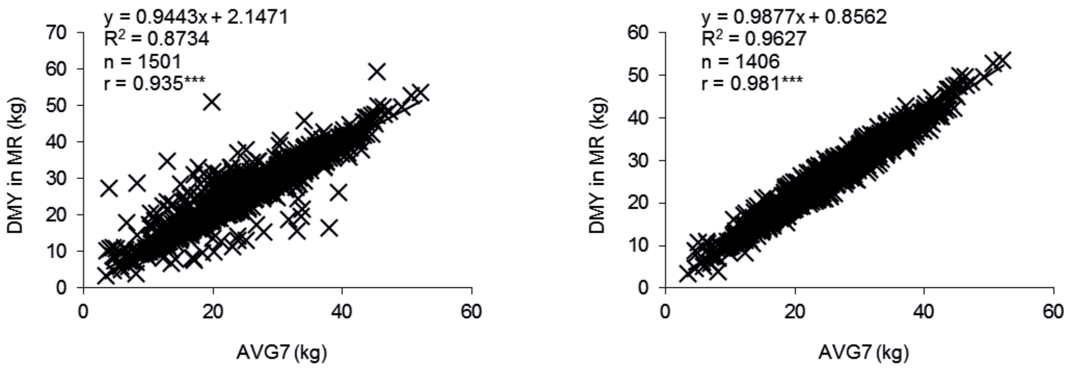

Cow 52
45
40
35
30
25
20
15
29.7.2013
28.8.2013
27.9.2013
27.10.2013
26.11.2013
26.12.2013
25.1.2014
24.2.2014
26.3.2014
25.4.2014
25.5.2014
24.6.2014
24.7.2014



1: *Different types of whole lactation curves for daily milk yield (DMY, blue line) from electronic flowmeters in milking parlor and corresponding AVG7 lactation curves (red line)*



2: *Comparison of daily records of electronic flowmeter (daily milk yield, DMY) and AVG7 through lactation curves for automatic milking system (AMS)*



3: *Figures of linear regressions between AVG7 (7 days average of DMY) and DMY (daily milk yield) results in milking parlor for original (n = 1,501) and refined data file (n = 1,406; *** = P < 0.001)*

These conclusions can be numerically confirmed comparing the values of standard deviations (AMS, 3.3 kg (CF) and 3.29 kg (H) > 3.038 (n = 1,501 and 1.612 for n = 1,406 (for refined data file by outlier test)) kg (CF × H)) individual differences between DMY and AVG7 (Tab. I and II).

In case of searching of maximal tolerable deviation (Basovník, 2014; max. 20% of milk yield between the control day and the corresponding five-day average) between DMY in the MR and multiple-day electronic flowmeter average (to eliminate possible errors) there can be used the results of this file (Tab. I and II). The standard deviation of the mean difference (DMY – AVG7) was 3.038 (1.612) kg. This is multiplied by a factor of 1.96 for the confidence interval with a probability level of 95% (with two-sided definition of acceptable deviation – exceeding the maximum value): 3.038 × 1.96 = 5.95 kg; 1.612 × 1.96 = 3.16 kg (for data file refined by relevant outlier test). In case that DMY is 100% then acceptability limit is relatively ± 23 and ±12%. There should be small proportion of cases over this higher limit from biological point of view.

In case of original data file adjustment (at the level of 95% by outlier test) the number was limited by 95 cases and thereby the incidence of error of unknown origin was reduced. This reduction which represents a relatively large deviations with respect to the assumption of a normal frequency distribution amounted to 6.3% (the original file is 100%). Of course not all of these values can be described as an error.

Linear regression between AVG7 and DMY results are shown in Fig. 3. A statistically significant correlation coefficient was 0.935 (P < 0.001) and was higher in comparison to the previous similar assessment under AMS conditions (0.898; P < 0.001). This means that 87.3% of the variability in the milk yield values for MR (DMY) can be explained by variations in the AVG7 values and vice versa. This is by 6.7% more possibilities for explanation than in AMS case (as compared to Hanuš *et al.*, 2014). Higher values of correlation and determination 0.981 (P < 0.001) and 96.3% possibilities for the variability explanation are shown in Fig. 3 for refined data set (after outlier test). This is consistent also with a correlation coefficient indicated for comparable conditions (electronic flowmeter and milking parlor with regular milking) 0.981 (Handt *et al.*, 2006; Quist *et al.*, 2007). Higher correlation coefficient between DMY and AVG7 as well as already said lower standard deviation of daily individual differences between DMY and AVG7, as compared to the AMS case (Hanuš *et al.*, 2014), is again determined by the aforementioned interference of rather irregular intervals between milking and a higher incidence of multiple daily milking at AMS.

Difference tests confirmed (Tab. I and II) significant differences (P < 0.001) 0.76 and 0.55 kg between DMY (in MR) and AVG7 for original and also refined data file. These differences were not significant at the AMS (P > 0.05; Hanuš *et al.*, 2014). Mentioned differences, although statistically significant (because of their lower variability and higher number of case (n) in the data file), correspond only to 2.96 and 2.15% relatively (Tab. I and II). Usually as convention there is generally tolerated deviation of 5% in cases of technical analysis. Furthermore this is fact that mentioned differences randomly correspond to the case of one dairy herd and one milking parlor. These observed differences can be randomly mutually lowered or cancelled in the population. Mentioned evaluation contributes mainly to assess the relationship issues. Therefore, it is possible to consider the observed differences as practically negligible. The official rating of cow lactations should not be significantly affected due to the subsequent use of data for genetic improvement of dairy cattle.

It is necessary to respect the binding rules of ICAR when considering the above mentioned results and conclusions into account for the practical application in the MR: the values of laboratory analysis of individual milk samples (F, P, SCC) can be referenced only to specific corresponding values of milk yield.

B) In the Tab. III, there are provided the basic statistical results of the selected file from MR. Average milk yield was 23.53 kg with variability 35.6%. There is good agreement between the arithmetic mean and median for milk yield and milk components (F and P). This is different from the SCC where is good agreement between the geometric mean and median on the contrary (112 and 93 $10^3.ml^{-1}$) and where the SCC arithmetic mean is 310 $10^3.ml^{-1}$. These can be considered a common phenomenon for the individual milk samples in MR with certain incidence of subclinical mastitis in animals (approximately from 20 to 25%, usually *Staphylococcus aureus* etiology; Benda *et al.*, 1997). This demonstrates the applicability of the results to the frequency distribution test of deviations of subsequent checks under routine conditions in the MR.

There is captured the frequency distribution (%) of relative deviations (%) of milk yield and composition indicators between successive control days in MR in the Tab. IV. This is done at intervals by their percentages independently of the direction of deviation (positive or negative). The value from the previous MR control day was used as reference value to determination of relevant deviation. This deviation is defined by physiological dynamics of lactation curve and can be randomly affected by errors (human or equipment factors). The possible limitation of acceptable deviation to 20% for milk yield (Basovník, 2014) was discussed for possible elimination of errors in documents on milk yield in MR. However, this limitation should be valid for deviation between MR control day result and corresponding five-day average (therefore, there should be virtually eliminated the influence of the lactation dynamics). Then, it was considered

III: *Basic statistical results of indicators of individual milk samples from control day of milk recoding*

I/P	kg of milk	F%	P%	SCC	log SCC
n	85,107	79,235	79,235	43,220	43,220
x	23.53	4.09	3.59	310	2.0493
sd	8.376	0.615	0.362	772.3	1.649
vx %	35.6	15.0	10.1	249.1	80.5
min	3	2	2.02	2	0.3010
max	83.60	6.99	5.98	9999	4
xg				112	
m	23.15	4.07	3.60	93	1.9683

IV: *Frequency of individual differences of milk yield and composition indicators (in %) between consecutive control days (month interval) in milk recording (MR) according to their percentage value (reference value is previous MR value)*

Interval of values of relative deviations (%)	kg of milk/day in MR	F%	P%	SCC	log SCC
to 5	24.3	31.4	60.3	5.3	24.1
5.1–10.0	21.3	24.4	25.6	5.3	19.6
10.1–15.0	16.1	16.5	8.3	5.2	14.3
15.1–20.0	11.1	10.6	3.2	5.3	9.9
20.1–25.0	6.8	6.4	1.5	4.9	7.7
25.1–30.0	4.4	4.0	0.7	4.8	5.6
30.1–45.0	6.2	4.8	0.4	13.2	9.9
over 45	9.8	1.9	0.1	55.9	8.9

MR, milk recording

a method of application of the substitute derivation of more likely value for practical database or value shredding. Logically, the frequency of deviation occurrence decreases with their increasing value for milk yield, fat and protein. The lower frequency of deviations with higher relative value compared to milk yield was found for F and in particular for P. In SCC is the opposite trend and frequency of deviations increases with their increasing values due to the lactation dynamics, but mainly due to the dynamics of the incidence of subclinical and clinical mastitis in the herd, due to various stresses and possible errors at milk sampling, analysis, and data transfer. Thus the SCC repeatability is decreasing. This trend becomes back an opposite character, like to F and P but in particular to milk yield, after logarithmic transformation of SCC values due to the basic property of a logarithmic scale.

Unfortunately, it is practically impossible to express the proportion of error source on the given deviation in the comparison to the physiological effects of lactation for individual specific values. When the conventional model theory of normal frequency data distribution with a confidence level of 95% for the inclusion of the data into the file is taken into account which means the assumption that 5% of measurements may be affected by errors (outliers), then the contemplated tolerance limit of deviation of milk yield between consecutive control days could be 50% (Tab. IV). The table can serve only to approximate estimates the distribution of deviations in discussions about the acceptability of deviations. With regard to process (preferable file) and the result it is possible to consider the above mentioned estimates (A) as more reliable for any practical application.

However, the question of replacement of values under practical conditions in MR is soluble only with difficulties also under mentioned circumstances. If it is accepted logical possibility of error in the control day (equipment including human factor) so it can not be excluded in a multi-day average (equipment). And again there is a possibility for including of an error into calculation which can result at certain types of devices for instance from error reading of dairy cows when entering into milking parlor. This is because of unforeseen and unpredictable behavior of animals. Despite that it is necessary to implement efforts to minimize the likelihood of errors in MR and dairy cattle genetic improvement.

CONCLUSION

Evaluation of occurrence frequency of various types of result deviations in the MR performance which is classified according to various MR data sources and continuous estimates of their discriminatory limits support the implementation of super-control process in MR (ICAR, 2008; Hering *et al.*, 2008) to reduce the occurrence of error results. The use of multi–day milk yield average from the electronic flowmeter is an equivalent alternative to the use of record from one MR control day.

When considering the methods of elimination any error of milk yield investigation via substitution of possibly erroneous value by any other relevant validated value the relative value from 12 to 23% seems to be as a justifiable value of the maximum permissible deviation (between the control day and corresponding multi–day average from the electronic flowmeter) for error identification. The second value is more realistic, because at obtaining of first value the original data set was refined at probability level of 95% via outlier test just with limitation of error rate of unknown origin.

When considering the account of those results and conclusions in the practical MR performance there is necessary to respect the obligatory ICAR rule: the values of laboratory analyzes of individual milk samples (F, P, SCC) may be referenced only to specific corresponding daily milk yields.

Acknowledgement

The results were obtained by methodical development with institutional support MZe RO1415 and APVV–0357–12.

REFERENCES

ALI, A. K. A. and SHOOK, G. E. 1980. An optimum transformation for somatic cells concentration in milk. *Journal of Dairy Science*, 63: 487–490.

BASOVNÍK, M. 2014. Milk recording for 25. [in Czech]. *Chovatelské impulsy*, 1: 3–5.

BENDA, P., VYLETĚLOVÁ, M. and TICHÁČEK, A. 1997. A method of prevalence estimation of intramammary *Staphylococcus aureus* and *Streptococcus agalactiae* infection in herds by examination of bulk milk samples. *Czech Veterinary Medicine*, 42(4): 101–109.

BRAUNER, J. and HANUŠ, O. 1984. Milk technological properties and its chemical composition in evening, morning and total milking. [in Czech]. *Výzkum v chovu skotu*, XXVI(3): 5–9.

GANTNER, V., JOVANOVAC, S., KLOPČIČ, M., CASSANDRO, M., RAGUŽ, N. and KUTEROVAC, K. 2009. Methods for estimation of daily and lactation milk yields from alternative milk recording scheme in Holstein and Simmental cattle breeds. *Italian Journal of Animal Science*, 8(4): 519–530.

GOŁĘBIEWSKI, M., BRZOZOWSKI, P. and GOŁĘBIEWSKI, L. 2011. Analysis of lactation curves, milk constituents, somatic cell count and urea in milk of cows by the mathematical model of Wood. *Acta Veterinaria Brno*, 80: 73–80.

HAND, K. J., LAZENBY, D., MIGLIOR, F., KELTON, D. F. and QUIST-MOYER, M. A. 2006. Use of daily milk weight to predict lactation and 24–hour yields. In: *Proc. 35th ICAR Session Mtg., Kuopio, Finland. European Association of Animal Production*, Rome, Italy: 48–52.

HANUŠ, O., HERING, P., CHLÁDEK, G., FALTA, D., ROUBAL, P. and JEDELSKÁ, R. 2014. Reliability of milk recording data under conditions of automatic milking system. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 62(5): 911–917.

HANUŠ, O., HERING, P., CHLÁDEK, G., ROUBAL, P., DUFEK, A., JEDELSKÁ, R. and HEŘMAN, F. 2011a. Milk composition estimation according to samples which were obtained during morning and evening at triple milking a day with fixed interval in the framework of milk recording. [in Czech]. *Výzkum v chovu skotu/Cattle Research*, LIII(1): 21–30.

HANUŠ, O., HERING, P., ROUBAL, P., LANDOVÁ, H., DUFEK, A., JEDELSKÁ, R., JANECKÁ, M., HEŘMAN, F. and VANĚK, P. 2011b. Validation of prediction reliability for total day milk composition from shortened sampling variants in milk recording. [in Czech]. *Výzkum v chovu skotu/Cattle Research*, LIII(4): 11–24.

HERING, P., BUCEK, P., HŘEBEN, F., PYTLOUN, P., PYTLOUN, J. and MATOUŠ, E. 2005. *100 years of milk recording in Bohemia, Moravia and Silesia*.

HERING, P., HANUŠ, O., DUFEK, A., SAMKOVÁ, E., JEDELSKÁ, R., KRÁLÍČEK, T. and KOPECKÝ, J. 2010. Estimation of milk composition in daylong sample in milk recording from partial result of morning and evening milking in the system of triplicate milking a day with variable interval. [in Czech]. *Výzkum v chovu skotu/Cattle Research*, LII(3): 12–21.

HERING, P., HANUŠ, O., JEDELSKÁ, R., GENČUROVÁ, V., KOPECKÝ, J., HEŘMAN, F. and JANECKÁ, M. 2009. Study of individual milk sampling possibility and objective analytical result evaluation for milk recording in the case of irregular triple milking per day. [in Czech]. *Výzkum v chovu skotu/Cattle Research*, LI(3): 42–50.

HERING, P., HANUŠ, O., JEDELSKÁ, R., KRÁLÍČEK, T. and KOPECKÝ, J. 2008. Development of new part of milk recording system, so called supervision. [in Czech]. *Výzkum v chovu skotu/Cattle Research*, L(3): 54–65.

ICAR. 2006. *Guidelines*. Kuopio.

ICAR. 2010. International agreement of recording practices. *Approved by the general assembly held in Riga*, Latvia, on June, 479.

ICAR. 2012. International agreement of recording practices. *Approved by the general assembly held in Cork*, Ireland, on June, 580.

ICAR. 2009. Technical Series No. 13. In: *Proceedings of the 36 ICAR Biennial Session held in Niagara Falls*, USA, 16–20 June 2008, January, 458.

JENKO, J., PERPAR, T., GORJAC, G. and BABNIK, D. 2010. Evaluation of different approaches for estimation of daily yield from single milk testing scheme in cattle. *Journal of Dairy Research*, 77(2): 137–143.

KHAZAEI, J. and NIKOSIAR, M. 2008. *Approximating milk yield and milk fat and protein concentration of cows through the use of mathematical and artificial neural networks models. IAALD AFITA WCCA, World conference on agricultural information and IT*, 91–105.

KLOPČIČ, M., MALOVRH, Š., GORJANC, G., KOVAČ, M. and OSTERC, J. 2003. Prediction of daily milk fat and protein content using alternating (AT) recording scheme. *Czech Journal of Animal Science*, 48(11): 449–458.

KOPEC, T., CHLÁDEK, G., KUČERA, J., FALTA, D., HANUŠ, O. and ROUBAL, P. 2013. The effect of the calving season on the Wood's model parameters and characteristics of the lactation curve in Czech Fleckvieh cows. *Archives Animal Breeding*, 56(80): 808–815.

KVAPILÍK, J., RŮŽIČKA, Z., BUCEK, P. et al. 2014. Cattle rearing in the Czech Republic. [in Czech]. In: *Annual Report 2013*. Prague: ČMSCH a. s.

LIU, Z., REENTS, R., REINHARDT, F. T. and KUWAN, K. 2000. Approaches to estimating daily yield from single milk testing schemes and use of a.m.-p.m. records in test-day model genetic evaluation in dairy cattle. *Journal of Dairy Science*, 83: 2672–2682.

QUINN, N., KILLEN, L. and BUCKLEY, F. 2006a. Modeling fat and protein concentration curves fore to weekly records of milk production of cows in single herd. *Livestock Production*, 45: 13–23.

QUINN, N., KILLEN, L. and BUCKLEY, F. 2006b. Modelling fat and protein concentration curves for Irish dairy cows. *Irish Journal of Agricultural and Food Research*, 45: 13–23.

QUIST, M. A., LEBLANC, S. J., HAND, K. J., LAZENBY, D., MIGLIOR, F. and KELTON, D. F. 2007. Agreement of predicted 305-day milk yields relative to actual 305-day milk weight yields. *Journal of Dairy Science*, 90: 4684–4692.

REMOND, B., POMIES, B., JULIEN, C. and GUINARD-FLAMENT, J. 2009. Performance of dairy cows milked twice daily at contrasting intervals. *Animal*, 3(10): 1463–1471.

ROELOFS, R. M. G., JONG, G. and DE ROOS, A. P. W. 2007. Renewed estimation method for 24-hour fat percentage in AM/PM milk recording scheme. In: EAAP publication No. 121, *Proceedings of the 35th Biennal Session of ICAR*, Kuopio, Finland, June 2006, *Breeding, production recording, health and the evaluation of farm animals*.

SEDLÁKOVÁ, L. 1969. Quality and amount of morning and evening milk in dairy cows at identical milking interval in link with feeding systems. [in Czech]. *Živočišná Výroba/Czech Journal of Animal Science*, 14: 573–582.

SHOOK, G. E. 1982. Approaches to summarizing somatic cell count which improve interpretability. In: *Nat. Mast. Council*, Louisville, Kentucky: 1–17.
WIRTZ, N., BÜNGER, A., KUWAN, K., REINHARDT, F. and REENTS, R. 2007. Calculation of the lactation performance from daily milk recording data. In: EAAP publication No. 121, *Proceedings of the 35th Biennal Session of ICAR*, Kuopio, Finland, June 2006, *Breeding, production recording, health and the evaluation of farm animals*.

Contact information

Pavel Hering: hering@cmsch.cz
Pavel Kopunecz: kopunecz@cmsch.cz
Oto Hanuš: hanus.oto@seznam.cz
Martin Tomáška: tomaskamartin@gmail.com
Marcela Klimešová: marcela.vyletelova@seznam.cz
Radoslava Jedelská: radka.jedelska@seznam.cz
Jaroslav Kopecký: jaroslav.kopecky@email.cz