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ASYMMETRIC TIME INTERVAL BETWEEN EVENING AND MORNING MILKING AND ITS EFFECT ON THE TOTAL DAILY MILK YIELD

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Abstract

CHLÁDEK, G., HANUŠ, O., FALTA, D., JEDELSKÁ, R., DUFEK, A., ZEJDOVÁ, P., HERING, P.: *Asymmetric time interval between evening and morning milking and its effect on the total daily milk yield.* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 3, pp. 73–80

Samples of milk obtained in the course of evening and morning milking performed in variable time intervals of either 11 and 13 hours (n = 1.282) or 10 and 14 hours (n = 370) were collected with the aim to quantify the effect of the length of a variable (asymmetric) time interval between evening and morning milking on the total amount and composition of daily milk production of dairy cows. Milk samples were analysed in an accredited (EN ISO 17025) laboratory in Brno-Tuřany (Czech Republic) and the following contents of individual milk components were estimated: fat (F; $g.100g^{-1}$), total protein (TP; $g.100g^{-1}$), lactose (L; lactose monohydrate; $g.100g^{-1}$), and somatic cell counts (SCC; $10^3.ml^{-1}$) were estimated in. It was found out that with the increasing total daily milk production the shares of evening and morning milk yield increased as well; however, the percentages of evening and/or morning yields in the total yield remained practically unchanged and represented 43.5 % and 56.5% or 40.4 % and 59.6 % in variants with intervals of 11 and 13 hours and/or 10 and 14 hours, respectively. In the variant with the milking interval of 11 and 13 hours, values of correlation coefficients between the above parameters (i.e. F, TP, L, SCC, and log SCC) of evening and morning milk yields on the one hand and the total milk performance on the other ranged from the minimum r = 0.896 (F) to the maximum r = 0.980 (TP). In the variant with the interval of 10 and 14 hours, the corresponding values of correlation coefficients were r = 0.848 (F) and r = 0.983 (TP). These correlations were statistically highly significant in all cases ($P \leq 0.001$). Further, linear regression equations enabling the estimation of milk parameters of the total milk yield on the base of results obtained in evening and morning milking was calculated as well. Values of coefficients of determination (R^2) of these equations ranged from 0.803 (F) to 0.960 (TP) and from 0.718 (F) to 0.966 (TP) for intervals of 11:13 hours and of 10:14 hours, respectively.

dairy cow, milk, milking interval, fat, protein, somatic cell counts, prediction equations

At present, a trend of increasing economic efficiency is a dominating phenomenon in dairy cattle industry. Regarding the current stagnation of milk prices, a decrease of production costs may be one of its major tools. For this reason the farmers concentrate their dairy cows in barns equipped with modern technologies and machinery as well as modified organisation of production. These sophisticated technologies involve above all multiple milking per day and application of automatic (robotic) milking systems. As usual, these new systems are often combined with asymmetric time intervals between morning and evening milkings (HERING *et al.*, 2003, 2007 and 2009; LÖVENDAHL and BJERRING, 2006; ICAR, 2008; CHLÁDEK *et al.*, 2009 a, b).

Efforts concerning cost reduction involve also trends focused to a decrease in costs of cattle milk recording (MR). These efforts are based above all on the need of shortened methods of milk sampling in MR. To maintain at least the current numbers of dairy cows in the system of MR for the purpose of adequate breeding work and acknowledgement of results of monitoring performance and heredity in cattle by competent authorities (i.e. International Committee for Animal Recording – ICAR) it is necessary to develop prediction methods providing a reliable estimate of overall MR results by means of shortened and/or alternating methods of milk sampling. These methods are used in systems of milking twice or three-times a day with either symmetric or asymmetric time intervals between evening and morning milking (HERING *et al.*, 2003, 2007 and 2009; OUWELTJES 1998; HOGEVEEN *et al.*, 2001; JOVANOVAC *et al.* 2005; REMOND *et al.* 2009; JENKO *et al.* 2010). Studies on differences in components and technological properties of milk originating from morning and evening milking provide also supplementary data for deciding about various modifications of milking frequency (BRAUNER and HANUŠ, 1984; SKÝPALA *et al.*, 2008; SKÝPALA and CHLÁDEK, 2008).

In the Czech Republic a relatively high number of dairy cows (94.7%) are involved in the system of MR (KVAPILÍK *et al.*, 2010); this percentage is comparable with the majority of advanced countries and it is desirable to maintain this situation. World surveys (ICAR) mention values from 4; 13 and 17% (Mexico, Tunis and Turkey, respectively) to 100% (Switzerland). A similar percentage of dairy cows is monitored also in Slovakia (86 %). In other countries with a high level of cattle breeding these numbers of monitored animals range from 42% (Ireland) through 46% (Australia), 58% (Japan), 64% (united Kingdom), 71% (France), 73% (Canada, Italy, Austria), 78% (Slovenia), 79% (Finland), 85% (Germany), 86% (Sweden), 88% (The Netherlands), 94% (Denmark) to 97% (Norway). Regarding the aforementioned efforts to reduce the numbers of milk samples analysed within the framework of MR it is necessary to develop adequate methods of performance monitoring. This means that we should be able to use results of recording partial milk yields for a reliable estimation of the total daily milk production. Such estimated values can be then used for other estimates and calculations performed within the framework of MR and heredity monitoring with regard to requirements of breeding work and monitoring of health condition of dairy cows (WIRTZ *et al.*, 2007). The methodology of estimation of overall results as well as of conversion of results of various partial sampling variants was studied by a number of authors (LEE and WARDORP, 1984; PALMER *et al.*, 1994; LEE et al., 1995; LIU *et al.*, 2000; WEISS *et al.* 2002; KLOPČIČ *et al.*, 2003; GANTNER *et al.* 2008 and 2009).

The aim of this study was to quantify the effect of the length of asymmetric time intervals between evening and morning milking (11 and 13 hours or 10 and 14 hours) on the amount and composition of total daily milk yield.

MATERIAL AND METHODS

Analysis of milk samples

Samples obtained in evening and morning milking performed with intervals of either 11 and 13 hours (n = 1.282) or 10 and 14 hours (n = 370) were stabilised with D&F Control Systems Microtabs (bronopol, 0.03% in milk) and transported in cool boxes (< 10 °C) to the laboratory in Brno-Tuřany. This accredited dairy laboratory (meeting the requirements of the international standard EN ISO 17025) operates within the framework of the routine analytical system of MR organized by the Czech-Moravian Association of Cattle Breeders in Prague, Czech Republic (Českomoravská společnost chovatelů, a. s., Praha). Samples were analyzed for fat content (F; $g.100g^{-1}$), total protein (TP; $g.100g^{-1}$), lactose (L; lactose monohydrate; $g.100g^{-1}$), and somatic cell count (SCC; $10^3.ml^{-1}$). Analyses were performed in apparatuses Bentley 2000 (F, TP, L; filter technology of infrared spectrophotometry; Bentley Instruments, USA) and Somacount 500 (SCC; FC flow fluoro-opto-electronic cytometry; Bentley Instruments, USA). Both instruments were regularly calibrated and tested for their analytic capability (F, P, L, Research Institute of Cattle Breeding, NRL–RM Rapotín) according to methodologies published by HANUŠ *et al.*, 1998, 2001 and 2006; and ŘÍHA *et al.*, 2008 (PSB, State Veterinary Institute in Prague).

Statistic processing of milk sample analyses

Milk parameters (F, TP, L, SCC) of evening and morning partial milk yields were used for weighted calculation of their percentages in the total milk yield. These calculated values were used as a reference set of data corresponding to proportional samples of partial milk yields in individual days. SCC data were logarithmic transformed to log SCC because of well-known inherent properties of frequency distribution of this parameter (ALI and SHOOK, 1980; RENEAU *et al.*, 1983 and 1988; RENEAU, 1986; HANUŠ *et al.*, 2001). In sets of partial milk yields the following statistical characteristics were calculated: arithmetic means (), standard deviations (s_x), and coefficients of variability (Vx). Results concerning partial milk yields were thereafter assigned to reference values using the method of linear regression. Determination coefficients (R^2), correlation coefficients (r) and straight line equation (ideal y = 1x + 0) were computed using Excel and Unistat 5.1 programmes.

RESULTS AND DISCUSSION

Percentages of partial milk yields in the total daily milk yield of dairy cows with different milk performance in experimental groups with asymmetric milking intervals of 11:13 h and 10:14 h are presented in Tabs I and II. These data indicate that the increase in total daily milk yield

I: *Share of evening and morning milk yields in the total daily milk production of dairy cows with different milk performance. Milking interval 11 and 13 hours (n = 1.282)*

Daily milk yield (kg)	Number of cows (n)	Evening milking (kg)	Morning milking (kg)	Total milk yield (kg)	Evening milking (%)	Morning milking (%)
< 20.0	292	5.9	7.8	13.7	43.1	56.9
20.1 to 25.0	170	9.7	12.7	22.4	43.3	56.7
25.1 to 30.0	249	11.7	15.7	27.4	42.7	57.3
30.1 to 35.0	273	14.0	18.0	32.0	43.8	56.2
35.1 to 40.0	153	16.3	20.5	36.8	44.3	55.7
> 40.1	145	19.6	25.2	44.8	43.8	56.2
Total	1.282	12.0	15.6	27.6	43.5	56.5

II: *Share of evening and morning milk yields in the total daily milk production of dairy cows with different milk performance. Milking interval 10 and 14 hours (n = 370)*

Daily milk yield (kg)	Number of cows (n)	Evening milking (kg)	Morning milking (kg)	Total milk yield (kg)	Evening milking (%)	Morning milking (%)
< 20.0	59	6.5	9.8	16.3	40.0	60.0
20.1 to 25.0	94	9.1	13.5	22.6	40.4	59.6
25.1 to 30.0	104	11.0	16.5	27.5	40.0	60.0
30.1 to 35.0	56	13.3	19.4	32.7	40.7	59.3
35.1 to 40.0	35	15.2	22.2	37.4	40.5	59.5
> 40.1	22	18.4	24.7	43.1	42.7	57.3
Total	370	11.0	16.1	27.1	40.4	59.6

(from 13.7 kg to 44.8 kg and from 16.3 kg to 43.1 kg, respectively) was associated with increasing partial milk yields both in the evening (from 5.9 kg to 19.6 kg and from 6.5 kg to 18.4 kg, respectively) and morning milking (from 7.8 kg to 25.2 kg and from 9.8 kg to 24.7 kg, respectively); however, percentages of individual partial milk yields in the total milk yield remained unchanged and ranged in the variant 11:13 hours from 42.7% to 44.3% and from 55.7% to 57.3% in the evening and the morning milking, respectively (Tab. I). A similar stability of percentages of individual partial milk yields was observed also in the variant with the milking interval of 10:14 hours, namely from 40.0% to 42.7% and from 57.3% to 60.0% in the evening and the morning milking, respectively (Tab. II). Slightly lower percentages were recorded by OUWELTJES (1998) in his experiment with the milking interval of 10:14 hours in dairy cows with the average daily milk production of 24.7 kg (57% and 43% in the morning and evening milking, respectively). GANTNER *et al.* (2009), as well, observed slightly lower partial milk yields in their experiment with 668 dairy cows milked twice a day in the interval of 12.8 and 11.2 hours between the morning and the evening milking, namely 53% (10.6 kg) and 47% (9.4 kg), respectively, of the total daily milk yield in of 20 kg. On the other hand, JOVANOVAC *et al.* (2008) obtained nearly identical results (56.1% and 43.8% for the morning and evening milking, respectively); however, in their experiment the average milk performance was slightly lower (19.78 kg) at the interval of 13.6 and 11.4 hours between the morning and the evening milking, respectively. LEE *et. al.* (1995) reported that there were differences in the amount of partial morning and evening milk yields (and, thus, also in their percentages in the total daily milk yield) in an experiment with the same milking interval: the morning milk yields were higher than evening milk yields. This fact was corroborated also by JENKO *et al.* (2010) who recorded in a group of primiparous dairy cows milked twice a day at the asymmetric interval of 11.8 and 12.2 hours 51.5% and 49.1% of morning and evening milk yields, respectively. A similar result was obtained also in a group of multiparous animals (i. e. 51.4% and 49.2%).

Milk parameters of partial morning and evening milk yields and of the total daily milk yield recorded in groups with the milking intervals of 11:13 hours and of 10:14 hours, respectively, are presented in Tab. III. As one can see, in the group with the milking interval of 11:13 hours, the total milk yield was 27.6 kg (F 3.75 $g.100g^{-1}$, TP 3.32 $g.100g^{-1}$, L 4.89 $g.100g^{-1}$ and SCC 260 $10^3.ml^{-1}$ (log 2.014)). In the group with the milking interval of 10:14 hours, the corresponding daily milk yield was 27.1 kg (F 3.55 $g.100g^{-1}$, TP 3.41 $g.100g^{-1}$, L 4.80 $g.100g^{-1}$ and SCC 352 $10^3.ml^{-1}$ (log 2.079)). This means that in dairy cows under study, the performance and composition of milk were similar in both groups (i. e. with the milking intervals of both 11:13 hours and 10:14 hours). As far as the average values of

III: *Milk parameters of evening, morning, and total milk yields*

Milking interval	Milk yield	Parameter	Unit	$\bar{x}$	s_x	Vx
11 and 13 hours (n = 1.282)	Evening milking	Milk yield	kg	12.0	4.51	37.7
		Fat content	g.100g^{-1}	4.08	0.730	17.9
		Total protein content	g.100g^{-1}	3.34	0.298	8.9
		Lactose content	g.100g^{-1}	4.89	0.218	4.5
		SCC	10^3.ml^{-1}	302	657	218
		log SCC		2.059	0.584	28.4
	Morning milking	Milk yield	kg	15.6	5.65	36.2
		Fat content	g.100g^{-1}	3.51	0.665	19.0
		Total protein content	g.100g^{-1}	3.31	0.292	8.8
		Lactose content	g.100g^{-1}	4.89	0.222	4.5
		SCC	10^3.ml^{-1}	228	528	232
		log SCC		1.930	0.581	30.1
	Total	Milk yield	kg	27.6	9.92	35.9
		Fat content	g.100g^{-1}	3.75	0.631	16.8
		Total protein content	g.100g^{-1}	3.32	0.287	8.6
		Lactose content	g.100g^{-1}	4.89	0.214	4.4
		SCC	10^3.ml^{-1}	260	564	217
		log SCC		2.014	0.559	27.8
10 and 14 hours (n = 370)	Evening milking	Milk yield	kg	11.0	3.32	30.4
		Fat content	g.100g^{-1}	4.03	0.728	18.1
		Total protein content	g.100g^{-1}	3.43	0.280	8.2
		Lactose content	g.100g^{-1}	4.79	0.204	4.2
		SCC	10^3.ml^{-1}	426	730	171
		log SCC		2.195	0.621	28.3
	Morning milking	Milk yield	kg	16.1	4.49	27.8
		Fat content	g.100g^{-1}	3.23	0.736	22.8
		Total protein content	g.100g^{-1}	3.40	0.277	8.1
		Lactose content	g.100g^{-1}	4.80	0.197	4.1
		SCC	10^3.ml^{-1}	300	679	226
		log SCC		1.918	0.677	35.3
	Total	Milk yield	kg	27.1	7.53	27.8
		Fat content	g.100g^{-1}	3.55	0.649	18.3
		Total protein content	g.100g^{-1}	3.41	0.272	8.0
		Lactose content	g.100g^{-1}	4.80	0.192	4.0
		SCC	10^3.ml^{-1}	352	668	190
		log SCC		2.079	0.628	30.2

Note:
$\bar{x}$ – aritmetic mean;
s_x – standard deviation;
Vx – variation coefficient;
SCC – somatic cell count
log SCC – logarithm of the somatic cell count

the above milk parameters and their variability are concerned, our results correspond with results published by SKÝPALA and CHLÁDEK (2008), CHLÁDEK *et al.*, (2009 a, b), and GANTNER *et al.*, (2009). This means that our experimental groups of dairy cows showed standard average values and variability of all monitored milk parameters.

Values of coefficients of correlation of milk parameters under study existing between total daily milk yield on the hand and morning and evening partial milk yields on the other are presented in Tab. IV. As far as the interval of 11:13 hours is concerned, the highest values of correlation coefficient were recorded in the content of TP 0.967 and 0.980 (on the evening and the morning

IV: *Values and cogency of correlation coefficients of milk parameters under study*

Milk parameter	Milking interval 11 and 13 hours (n = 1.282)		Milking interval 10 and 14 hours (n = 370)	
	Evening	Morning	Evening	Morning
Milk yield	0.966 ***	0.978 ***	0.946 ***	0.970 ***
Fat content	0.896 ***	0.922 ***	0.848 ***	0.909 ***
Total protein content	0.967 ***	0.980 ***	0.970 ***	0.983 ***
Lactose content	0.962 ***	0.977 ***	0.945 ***	0.969 ***
SCC	0.963 ***	0.966 ***	0.938 ***	0.962 ***
log SCC	0.954 ***	0.960 ***	0.958 ***	0.964 ***

Note:
*** = $P \leq 0.001$.
SCC – somatic cell count
log SCC – logarithm of the somatic cell count

V: *Regression equations of milk parameters under study*

Milk parameter	Milking interval 11 and 13 hours (n = 1,282)		Milking interval 10 and 14 hours (n = 370)	
	Evening	Morning	Evening	Morning
Milk yield	$y = 2.122x + 2.300$ ($R^2 = 0.932$)	$y = 1.708x + 0.883$ ($R^2 = 0.957$)	$y = 2.110x + 3.934$ ($R^2 = 0.895$)	$y = 1.633x + 0.774$ ($R^2 = 0.940$)
Fat content	$y = 0.775x + 0.595$ ($R^2 = 0.803$)	$y = 0.875x + 0.684$ ($R^2 = 0.851$)	$y = 0.755x + 0.513$ ($R^2 = 0.718$)	$y = 0.802x + 0.968$ ($R^2 = 0.826$)
Total protein content	$y = 0.932x + 0.206$ ($R^2 = 0.936$)	$y = 0.962x + 0.142$ ($R^2 = 0.960$)	$y = 0.941x + 0.186$ ($R^2 = 0.940$)	$y = 0.965x + 0.129$ ($R^2 = 0.966$)
Lactose content	$y = 0.945x + 0.268$ ($R^2 = 0.945$)	$y = 0.941x + 0.289$ ($R^2 = 0.955$)	$y = 0.891x + 0.526$ ($R^2 = 0.894$)	$y = 0.942x + 0.275$ ($R^2 = 0.939$)
SCC	$y = 0.826x + 10.36$ ($R^2 = 0.926$)	$y = 1.032 + 24.72$ ($R^2 = 0.933$)	$y = 0.859x - 14.42$ ($R^2 = 0.881$)	$y = 0.947x + 67.53$ ($R^2 = 0.926$)
log SCC	$y = 0.913x + 0.134$ ($R^2 = 0.910$)	$y = 0.924x + 0.232$ ($R^2 = 0.922$)	$y = 0.970x - 0.049$ ($R^2 = 0.918$)	$y = 0.895x + 0.363$ ($R^2 = 0.929$)

Note:
SCC – somatic cell count
log SCC – logarithm of the somatic cell count
x – partial milk yield
y – total milk yield
R^2 – coefficient of determination

milk yield, respectively); a very similar results were obtained also in the group with the milking interval of 10:14 hours (0.970 and 0.983 for the evening and the morning milk yield, respectively). In general, it can be stated that values of correlation coefficients of all milk parameters under study (including milk production) were very high (the minimum value of 0.848 for F in evening milk yield in the variant with the milking interval of 10:14 hours) and statistically highly significant. CHLÁDEK *et al.*, (2009 a) also mentioned very high values of coefficients of correlation existing between partial milk yields on the one hand and total milk yield on the other (up to 0.979); also these data were statistically highly significant. High values of correlation coefficients for the same relationship (i.e. 0.89 to 0.98 and/or 0.956 to 0.976) were reported also by GANTNER *et al.*, (2009) and JOVANOVAC *et al.*, (2009). Besides, GANTNER *et al.*, (2009) mentioned that the 305 day milk yield predicted from 4-week milk recording methods (A4, AT4) and from 6-week milk recording methods (A6, AT6) were statistically highly significantly different ($P < 0.01$). However, these authors found out very small differences between both methods not only in A4 and AT4 but also A6 and AT6.

Regression equations of relationships existing between milk parameters of partial evening and morning milkings on the one hand and the total daily milk yield on the other are presented in Tab. V. As one can see, linear regression equations were used in all cases. Values presented in this table indicate that regression equations of all milk parameters under study showed high coefficients of determination, which ranged from 0.718 (F in partial evening milk yield in case of the interval of 10:14 hours) to 0.957 (morning milk yield in variant with the interval of 11:13 hours). Similarly high values of coefficients of determination (0.937 to 0.976) for the linear model of regression relationships between partial milk yields and the total milk yield were mentioned also by JOVANOVAC *et al.*, (2008). WEISS *et al.*, (2002), as well, wrote that the relation between milking interval, production rate and milk fat content followed linear regressions. As compared with milking interval of 11:13 hours, there is a slight but permanent tendency to lower coefficients of correlation and determination in the majority of variables under study (excepting contents of TP and SCC) in the variant with the milking interval of 10:14 hours.

Our high values of coefficients of determination demonstrate that equations calculated in this study can be successfully used for the estimation of milk composition in the total daily milk yield using values of partial evening and/or morning milk yields in variants with milking intervals of both 11:13 hours and 10:14 hours. These predictions may be used for example in MR when using a shortened method of milk sampling. As far as the comparison of evening and morning milk yields is concerned, we can observe a slight but general tendency towards higher values of coefficients of determination in case of morning milk yields (both in variants of 11:13 and 10:14 hours). This is obviously due to a higher milk production in the morning milking (and therefore a higher percentage of partial morning milk yield in the total daily milk yield). JOVANOVAC *et al.* (2008) observed a similar tendency; for equations derived from the morning partial milk yield these authors reported the range of coefficients of determination 0.957 to 0.976 while for the evening milking these coefficients ranged only from 0.937 to 0.956. Also GANTNER *et al.* (2009) wrote that, in general, the estimates based on morning records were more accurate than those based on evening samples regardless to the method of estimation.

CONCLUSIONS

This study demonstrated that there were marked relationships between milk parameters recorded in partial morning and evening milk yields (i. e. milk quantity, F, TP, L and SCC) on the one hand and those of the total daily milk yield in both groups of dairy cows with asymmetric milking interval (i. e. 11:13 hours and 10:14 hours, respectively). Although there is no doubt that a fully reliable result of prediction of milk parameters of the total daily milk yield may be obtained only on the base of collection of weighed milk samples originating from individual partial milk yields, it may sometimes be necessary to use an alternative method. Our results indicate that the estimation of milk parameters of the total daily milk yield on the base of values recorded in partial evening and/or morning milking is possible also in systems with asymmetric milking time intervals. Presented prediction equations may be used in the form of a reference table when converting actual results of e.g. MR analyses by means of a shortened method. It is therefore expected that the obtained results could be used in the methodology of MR in the Czech Republic. This methodology could be also used by ICAR as a base for an official audit of MR results.

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REFERENCES

ALI, A. K. A., SHOOK, G. E., 1980: An optimum transformation for somatic cells concentration in milk. J. Dairy Sci., 63 pp. 487–490. ISSN 0022-0302.

BRAUNER, J., HANUŠ, O., 1984: Technologické vlastnosti mléka a jeho chemické složky u večerního, ranního a celkového výdojku. (Technological properties of milk and its chemical components in evening, morning, and total milk yield, in Czech). Výzkum v chovu skotu, 1984, 3, pp. 5–9. ISSN 0139-7265.

GANTNER, V., JOVANOVAC, S., KLOPCIC, M., CASSANDRO, M., RAGUZ, N., KUTEROVAC, K., 2009: Methods for estimation of daily and lactation milk yields from alternative milk recording scheme in Holstein and Simmental cattle breeds. Ital. J. Anim. Sci., 8 (4), 2009, pp. 519–530. ISSN 1594-4077.

GANTNER, V., JOVANOVAC, S., RAGUŽ, N., KLOPČIČ, M., SOLIČ, D., 2008: Prediction of lactation milk yield using various milk recording methods. Biotechnology in Animal Husbandry 24 (3–4), pp. 9–18, 2008 ISSN 1450-9156.

HANUŠ, O., BENDA, P., JEDELSKÁ, R., KOPECKÝ, J., 1998: Design a vyhodnocení prvního celostátního testu kvality rutinních analýz základního složení mléka. (Design and evaluation of the first national qualitative testing of routine milk analyses, in Czech). Acta univ. agric. et silvic. Mendel. Brun. (Brno) 1998, XLVI, 3, pp. 33–53. ISSN 1211-8516.

HANUŠ, O., BJELKA, M., TICHÁČEK, A., JEDELSKÁ, R., KOPECKÝ, J., 2001: Analýza nezbytnosti a účelnosti transformací dat u souborů výsledků některých mléčných parametrů. (Substantiation and usefulness of data transformations in sets of results of analyses of some milk parameters, in Czech). Chov a šlechtění skotu pro konkurenceschopnou výrobu: sborník referátů VÚCHS Rapotín, 2001, s. 122–135.

HANUŠ, O., GENČUROVÁ, V., HERING, P., KLIMEŠ, M., 2006: Quality assurance of protein analyses in the Czech milk recording system. In Focus, 2006, 30, 1, pp. 16–18. ISSN 1534-8334.

HERING, P., HANUŠ, O., JEDELSKÁ, R., GENČUROVÁ, V., KOPECKÝ, J., HEŘMAN, F., JANECKÁ, M., 2009: Studie možnosti odběrů individuálních vzorků mléka a objektivního vyhodnocení výsledků analýz pro kontrolu užitkovosti v režimu nepravidelného trojího denního dojení. (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, LI, 187, 3, 2009, pp. 42–50. ISSN 0139-7265.

HERING, P., HANUŠ, O., JEDELSKÁ, R., REJLEK, V., KOPECKÝ, J., 2007: Validace spolehlivosti vybraných metod odběru vzorků mléka pro zajištění věrohodnosti výsledků analýz mléka v kontrole užitkovosti dojnic v České republice. (The validation of authenticity of chosen sampling methods for provision of analytic result reliability in milk recording of dairy cows in the Czech Republic, in Czech). Výzkum v chovu skotu, XLIX, 179, 3, 2007, pp. 40–49. ISSN 0139-7265.

HERING, P., HANUŠ, O., JEDELSKÁ, R., ZLATNÍČEK, J., 2003: Studie věrohodnosti alternativ a výsledků kontroly užitkovosti pro trojí denní dojení. (A study of the reliability of the alternatives and results of the milk recording for the three times milking per day in the Czech Republic, in Czech). Výzkum v chovu skotu, 2003, 2, pp. 1–18. ISSN 0139-7265.

HOGEVEEN, H., OUWELTJES, W., de KONING, C. J. A. M., STELWAGEN, K., 2001: Milking interval, milk production and milk flow-rate in an automatic milking system. Livest. Prod. Sci. 72 (1–2), 2001, pp: 157–167. ISSN 0301-6226.

CHLÁDEK, G., FALTA, D., KOMZÁKOVÁ, I., HANUŠ, O., JEDELSKÁ, R., HERING, P., KRÁLÍČEK, T., 2009 a: Vztah mezi celkovým nádojem a dílčími výdojky dojnic dojených dojicím robotem. (Correlation between whole and partial milk yields of dairy cows milked using an automatic milking system, in Czech). Acta univ. agric. et silvic. Mendel. Brun., LVII, 5, 2009, s. 149–157. ISSN 1211-8516.

CHLÁDEK, G., HANUŠ, O., FALTA, D., KOMZÁKOVÁ, I., JEDELSKÁ, R., HERING, P., KRÁLÍČEK, T., 2009 b: Kontrola užitkovosti v systémech robotizovaného dojení krav. (Milk recording of dairy cows milked using the automatic milking system, in Czech). Výzkum v chovu skotu, LI, 188, 4, 2009, pp. 3–11. ISSN 0139-7265.

ICAR – International agreement of recording practices: 2.1.8. Milking recording in automatic milking systems (AMS). ICAR, 2008, pp. 51–54.

JENKO, J., PERPAR, T., GORJAC, G., BABNIK, D., 2010: Evaluation of different approaches for estimation of daily yield from single milk testing scheme in cattle. J. Dairy Res. 77 (2), 2010, pp: 137–143. ISSN 0022-0299.

JOVANOVAC, S., GANTNER, V., KUTEROVAC, K., KLOPČIČ, M., 2005: Comparison of statistical models to estimate daily milk yield in single milking testing schemes. Ital. J. Anim. Sci. 4 (Supl. 3), 2005, pp: 27–29, ISSN 1594-4077.

KLOPČIČ, M., MALOVRH, Š., GORJANC, G., KOVAČ, M., OSTERC, J., 2003: Prediction of daily milk fat and protein content using alternating (AT) recording scheme. Czech J. Anim. Sci., 48, 11, 2003, pp. 449–458. ISSN 1212-1819.

KVAPILÍK, J., RŮŽIČKA, J., BUCEK, P., 2010: Chov skotu v České republice. Hlavní výsledky a ukazatele za rok 2009. (Cattle breeding in the Czech Republic. Main results asnd parameters for the year 2009, in Czech). Praha 2010, 95 pp. ISBN 978-80-904131-4-6.

LAZENBY, D., BOHLSEN, E., HAND, K. J., KELTON, D. F., MIGLIOR, F., LISSEMORE, K. D., 2002: Methods to estimate 24-hour yields for milk, fat and protein in robotic milking herds. Proceedings of 33rd ICAR session, Interlaken, Switzerland, 2002.

LEE, C., POLLAK, E. J., EVERETT, R. W., MCCULLOCH, C. E., 1995: Multiplicative factors for estimation of daily milk component yields from single morning or afternoon tests. J. Dairy Sci., 78, 1995, pp. 221–235. ISSN 0022-0302.

LEE, A. J., WARDORP, J., 1984: Predicting daily milk yield, fat percent, and protein percent from morning or afternoon tests. J. Dairy Sci., 67, 1984, pp. 351–360. ISSN 0022-0302.

LIU, Z., REENTS, R., REINHARDT, F. T., 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. J. Dairy Sci., 83, 2000, pp. 2672–2682. ISSN 0022-0302.

LÖVENDAHL, P., BJERRING, M. A., 2006: Detection of carryover in automated milk sampling equipment. J. Dairy Sci., 89, 2006, pp. 3645–3652. ISSN 0022-0302.

OUWELTJES, W., 1998: The relationship between milk yield and milking interval in dairy cows. Livest. Prod. Sci., 56 (3), 1998, pp. 193–201. ISSN 0301-6226.

PALMER, R.W., JENSEN, E. L., HARDIE, A. R., 1994: Removal of within-cow differences between morning and evening milk yields. J. Dairy Sci., 77, 1994, pp. 2663–2670. ISSN 0022-0302.

REMOND, B., POMIES, B., JULIEN, C., GUINARD – FLAMENT, J., 2009: Performance of dairy cows milked twice daily at contrasting intervals. Animal. 3 (10), 2009, pp: 1463–1471. ISSN 1751-7311.

RENEAU, J. K., APPLEMAN, R. D., STEUERNAGEL, G. R., MUDGE, J. W. 1983 and 1988: Somatic cell count. An effective tool in controlling mastitis. Agricultural Extension Service, University of Minnesota, AGFO-0447, 1983 and 1988.

RENEAU, J. K., 1986: Effective use of dairy herd improvement somatic cell counts in mastitis control. J. Dairy Sci., 69, 1986, pp. 1708–1720. ISSN 0022-0302.

ŘÍHA, J., HANUŠ, O., LEDVINA, D., GENČUROVÁ, V., SOJKOVÁ, K., JEDELSKÁ, R., KOPECKÝ, J., 2008: Autorizovaný software AS 1 – MSM 2678846201. (Authorized software AS 1 – MSM 2678846201, in Czech) SomaRing, www.vuchs.cz/software/somaring; In: Výzkum v chovu skotu, L, 183, 3, 2008, pp. 70. ISSN 0139-7265.

SKÝPALA, M., FALTA, D., CHLÁDEK, G., 2008: Změny obsahových složek mléka vlivem denní doby dojení. (Changes of the milk components owing to daily milking time, in Czech) Sborník 11. mezinárodní konference Den mléka 2008, 2008, pp. 73–74. ISBN 978-80-213-1822-9.

SKÝPALA, M., CHLÁDEK, G., 2008: Složení a technologické vlastnosti mléka získaného z ranního a večerního dojení. (The chemical composition and technological properties of milk obtained from the morning and evening milking, in Czech) Acta univ. agric. et silvic. Mendel. Brun., LVI, 5, 2008, pp. 187–198. ISSN 1211-8516.

WEISS, D., HILGER, M., MEYER, H.H.D., BRUCKMAIER, R.M., 2002: Variable milking interval and milk composition. Milchwiss.-Milk Sci. Int., 2002, 57 (5), pp. 246–249, ISBN 0026-3788.

WIRTZ, N., BÜNGER, A., KUWAN, K., REINHARDT, F., REENTS, R., 2007: Calculation of the lactation performance from daily milk recording data. 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, 2007, pp. 49–53. ISBN 978-90-8686-030-2.

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