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Various approaches to daily milk yield prediction from alternative milk recording scheme

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ABSTRACT

The objective of this research was to compare different approaches to daily milk yield prediction from alternative milk recording scheme (single morning and evening milking records). The data used in this study were 3.730 individual test-day milk yield records collected from November 2004 to November 2005 on 560 cows reared on 15 family farms in Croatia. Daily milk yield, as well as, daily fat and protein content were predicted by several different approaches. The correlations between true and estimated daily milk yield are slightly lower when prediction is based on evening milkings, while the correlations between true and estimated daily fat as well as protein content are slightly higher when prediction is based on evening milkings. Model D, which included single yields as covariate as well as effect of daily interval, and model E, which also included effect of lactation stage as lactation curve by Ali and Schaeffer, gives the best fit to the data both for prediction of daily milk yield or milk content (fat and protein) based on morning or evening milkings. Differences between those two models were minor and statistically insignificant, so we would recommend use of model D in practice as the model which could be easier to implement in routine work.
(Keywords: alternative milk recording scheme, daily milk yield, prediction, cows)

INTRODUCTION

Milk recording provides data acquisition on milk yield which are necessary for genetic evaluation and herd management of dairy animals. Numerous milk recording schemes have been developed in many countries in the last decades (*Porzio*, 1953; *McDaniel*, 1969; *Wiggans*, 1981) with purpose of supplementation of the standard four-weekly testing scheme (A4) which is considered as the most expensive one. The alternative milk recording (morning or evening) testing scheme was designed to gain lower cost and to retain reasonable accuracy in daily milk yields prediction. The accuracy of daily milk yield prediction is the most important factor in alternative milk recording scheme. With aim to predict daily milk yield from single milking weights various models have been developed. Depending on the model, different factors that influence milk production were taken into account, like breed, parity, lactation stage, and the interval between successive milkings (*Hargrove*, 1994; *Cassandro et al*., 1995; *Klopčič*, 2004). The milking interval is the most important factor when daily milk yield is predicting from morning or evening milkings. The objective of this research was to compare different approaches to daily milk yield prediction from alternative milk recording scheme (single morning and evening milking records).

MATERIALS AND METHODS

The data used in this study were 3.730 individual test-day milk yield records collected from November 2004 to November 2005 on 560 cows reared on 15 family farms in Croatia. At each recording, milk yield was measured in the evening and in the morning. Daily milk yield was computed as evening plus morning measured yield. Also, at each milking, initial time of current milking and initial time of previous milking for each animal was registered. The interval between successive milkings was computed as the time from the beginning of previous milking to the beginning of current milking. For analysis of milk composition three samples were taken from each cow: one sample at each milking (evening and morning) and one proportional milk sample. Logical control of data was performed according to *ICAR* standards (2003). Additionally, a linear regression of daily to evening or morning records was fitted in order to detect outliers. Residuals over three standard deviations were taken as outliers and deleted from data set. Variability of daily, morning and evening milk yield, fat and protein content as well as daily and nightly interval between successive milkings are reported in *Table 1*.

Table 1

Descriptive statistics for milk traits (n=3.730)

Trait	Milk yield, kg			Fat content, %			Protein content, %		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Daily	19.79	6.39	32.28	4.34	0.81	18.65	3.50	0.43	12.42
Morning	10.51	3.56	33.88	4.21	0.85	20.24	3.48	0.44	12.63
Evening	9.26	3.11	33.53	4.45	0.93	20.85	3.52	0.45	12.73
Nightly interval, min	766.00	54.92	7.17						
Daily interval, min	676.93	54.56	8.06						

Correlations between daily, morning or evening milk yield as well as fat and protein content are shown in *Table 2.* It is evident that evening milkings have lower correlations with daily yields than morning milkings which is in agreement with published results (*Lee and Wardrop*, 1984; *Cassandro et al*., 1995; *Trappmann et al*., 1998; *Liu et al*., 2000).

Table 2

Correlations between daily, morning or evening milk yield, fat and protein content

Trait	daily – morning		daily – evening		morning – evening	
	r	p	r	p	r	p
Milk yield, kg	0.965	<0,0001	0.953	<0,0001	0.841	<0,0001
Fat content, %	0.893	<0,0001	0.911	<0,0001	0.628	<0,0001
Protein content, %	0.972	<0,0001	0.974	<0,0001	0.894	<0,0001

If milk composition is taken into consideration, both, the correlation between daily and morning fat content and correlation between daily and morning protein content are lower than correlation among daily and evening contents. The similar results were reported by *Klopčič* (2004). The lowest correlation with its daily measurements has fat content measured on single milkings, which means that the accuracy of daily yield prediction from single records will be lowest if prediction of fat content is observed.

Table 3

Selected approaches to daily milk yield (fat and protein content) prediction

model	statistical model
A	$y_i = 2m_i$; ($y_i = m_i$)
B	$y_i = \mu + b_1 m_i + e_i$
C	$y_{ij} = \mu_j + b_{1j} m_{ij} + b_{2j}(d_{ij} - 158)^*$
D	$y_i = \mu + b_1 m_i + b_2 t_i + e_i$
E	$y_i = \mu + b_1 m_i + b_2 t_i + b_8 (d_i / 305) + b_9 (d_i / 305)^2 + b_{10} \ln(305 / d_i) + b_{11} \ln^2 (305 / d_i) + e_i$

y: daily yield, μ: intercept, m: evening or morning yield (content), t: interval between successive milkings, d: lactation stage (days), e: residual, *modified DeLorenzo and Wiggans' model, each milking interval classes *j* has one regression (*DeLorenzo* and *Wiggans*, 1986).

For statistical analysis the SAS/STAT package was used (*SAS Institute Inc*., 2000). Daily milk yield and daily fat content were predicted by five (A, B, C, D, E) different approaches, while the daily protein content was predicted using four (A, B, D, E) different approaches (*Table 3*). Different approaches to daily milk yield prediction from alternative milk recording scheme were compared on the basis of the correlation between true and estimated daily milk yields (r), bias (mean difference between estimated and true yields) and accuracy (standard deviation of the difference between estimated and true yields).

RESULTS AND DISCUSSION

Table 4 shows correlations between true and estimated daily milk yields, as well as bias and accuracy of different approaches to daily milk yield prediction from morning or evening milkings. The model with the highest correlation and lowest bias fits the best to the data set. The correlation enhances with the complexity of the models which means that the most complex model, model E, gives the best fit to the data both for prediction of daily milk yield based on morning or evening milkings. Correlations are slightly lower when prediction is based on evening milkings which is in agreement with the results obtained by *Liu et al*. (2000) and our previous research (*Jovanovac et al*., 2005). Simple doubling of the morning or evening milkings, model A, gives the highest bias (±1.274 kg or 6.44% of actual daily milk yield) and highest accuracy (1.931 kg or 9.76% of actual daily milk yield). Similar results were reported in literature (*Cassandro et al.,* 1995; *Jovanovac et al*., 2005). In all models, with exception of model A, bias and accuracy were lower when daily milk yield was predicted based on morning milkings.

Table 4

Correlations between true and estimated daily milk yields, bias and accuracy of different approaches to daily milk yield prediction from morning or evening milkings

Model	Morning milking			Evening milking		
	r[1]	Bias[2]	Accuracy[3]	r[1]	Bias[2]	Accuracy[3]
A	96.48	1.274	1.931	95.34	-1.274	1.931
B	97.01	0.006	1.542	96.01	0.027	1.747
C	97.66	0.078	1.439	96.63	-0.144	1.657
D	98.16	$1.552*10^{-15}$	1.214	97.45	$4.695*10^{-17}$	1.413
E	98.18	$-2.900*10^{-15}$	1.205	97.47	$-2.130*10^{-15}$	1.409

[1]Correlations between true and estimated daily milk yields, [2]Mean difference between estimated and true yields (kg), [3]Standard deviation of the difference between estimated and true yields (kg).

Figure 1

Bias of different approaches to daily approaches to daily milk yield prediction from morning milkings

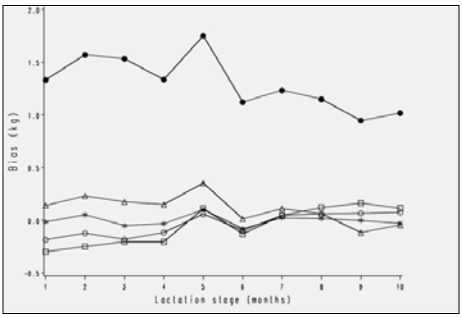
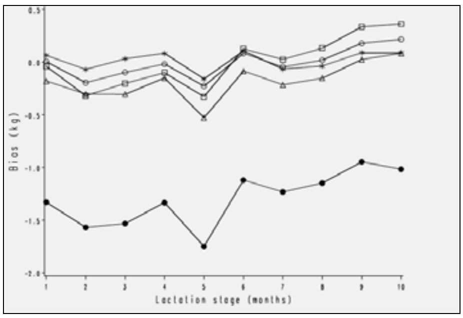


Figure 2

Bias of different milk yield prediction from evening milkings



Solid line with symbol *dot* – model A, solid line with symbol *square* – model B, solid line with symbol *triangle* – model C, solid line with symbol *circle* – model D, solid line with symbol *star* – model E.

Figure 1 and *2* show bias of different approaches to daily milk yield prediction from morning or evening milkings, respectively. Simple doubling of single yields (model A) underestimated daily milk yield if prediction is based on morning milkings and overestimated if prediction is based on evening milkings. The lowest bias for all lactation stages was observed in model E, which takes into account effect of lactation stage as lactation curve by *Ali* and *Schaeffer* (1987) which is in agreement with our previous research (*Jovanovac*, 2006).

The correlations between true and estimated daily fat contents, as well as bias and accuracy of different approaches to daily fat content prediction from morning or evening milkings are shown in *Table 5*. The most complex model, model E, gives the best fit to the data if prediction of daily fat content based on morning milkings is observed, while, if prediction of daily fat content based on evening milkings is observed, model D fits the best. Correlations are slightly lower when prediction is based on morning milkings which was expectable because correlation between evening and daily fat content was higher than the correlation between morning and daily fat content. These results are in agreement with the reported results (*Liu et al.*, 2000; *Klopčič*, 2004). With the complexity of the models, bias as well as accuracy decrease. The model A, which is model without any correction of morning or evening fat content or the most simple one, gives the highest bias and highest accuracy as well as lowest correlation between true and estimated daily fat contents. In all models, with exception of model A, bias and accuracy were lower when daily milk yield was predicted based on evening milkings.

Table 5

Correlations between true and estimated daily fat contents, bias and accuracy of different approaches to daily fat content prediction from morning or evening milkings

Model	Morning milking			Evening milking		
	r[1]	Bias[2]	Accuracy[3]	r[1]	Bias[2]	Accuracy[3]
A	89.29	-0.120	0.388	91.11	0.120	0.388
B	90.95	0.005	0.334	92.52	0.004	0.304
C	89.96	-0.045	0.385	91.02	0.028	0.372
D	91.67	$1.967 \cdot 10^{-17}$	0.321	92.61	$-1.940 \cdot 10^{-17}$	0.302
E	91.78	$-1.428 \cdot 10^{-16}$	0.319	92.48	$-3.092 \cdot 10^{-16}$	0.298

[1]Correlations between true and estimated daily fat contents, [2]Mean difference between estimated and true contents (%), [3]Standard deviation of the difference between estimated and true contents (%).

Figure 3

Bias of different approaches to daily fat content prediction from morning milkings

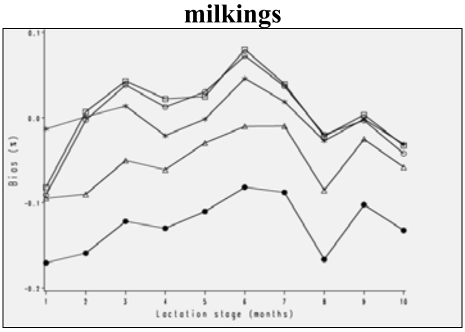
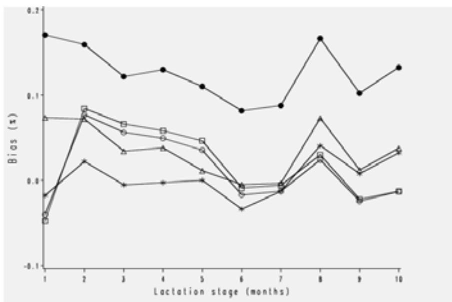


Figure 4

Bias of different approaches to daily fat content prediction from evening milkings



Solid line with symbol *dot* – model A, solid line with symbol *square* – model B, solid line with symbol *triangle* – model C, solid line with symbol *circle* – model D, solid line with symbol *star* – model E.

Figure 3 and *4* shows bias of different approaches to daily fat content prediction from morning or evening milkings, respectively. The lowest bias for all lactation stages was observed in model E if prediction is based on morning milking, while, if prediction based on evening milking is taken into consideration, model E has the lowest bias in first seven months of lactation, while at the end of lactation model D, which included evening fat content as covariate as well as effect of daily interval, shows lower bias.

The correlation between true and estimated daily protein contents increases with the complexity of the models for prediction from morning or evening milkings. That means that the most complex model, model E, gives the best fit to the data, both for prediction of daily protein content based on morning or evening milkings (*Table 6*). The differences between models are minor. Correlations are slightly higher when prediction is based on evening milkings which is in agreement with the results obtained by *Klopčič* (2004) and which differ from results reported by *Liu et al*. (2000). The model A, gives the highest bias, highest accuracy as well as lowest correlation between true and estimated daily protein contents which means that model A gives the lowest fit to the data.

Table 6

Correlations between true and estimated daily protein contents, bias and accuracy of different approaches to daily protein content prediction from morning or evening milkings

Model	Morning milking			Evening milking		
	r[1]	Bias[2]	Accuracy[3]	r[1]	Bias[2]	Accuracy[3]
A	97.24	-0.017	0.103	97.37	0.017	0.103
B	97.24	$-6.922*10^{-18}$	0.101	98.76	0.001	0.069
D	97.29	$5.415*10^{-17}$	0.100	98.78	$-1.171*10^{-16}$	0.068
E	97.48	$-3.339*10^{-16}$	0.097	98.78	$-7.790*10^{-17}$	0.068

[1]Correlations between true and estimated daily protein contents, [2]Mean difference between estimated and true contents (%), [3]Standard deviation of the difference between estimated and true contents (%).

Figure 5

Bias of different approaches to daily protein content prediction from morning milkings

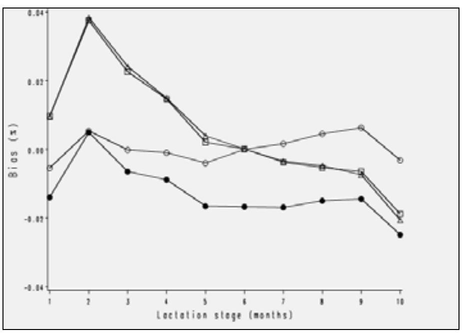
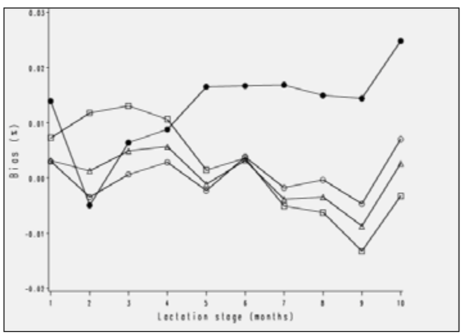


Figure 6

Bias of different approaches to daily protein content prediction from evening milkings



Solid line with symbol *dot* – model A, solid line with symbol *square* – model B, solid line with symbol *triangle* – model D, solid line with symbol *circle* – model E.

The bias of different approaches to daily protein content prediction from morning or evening milkings is shown on *Figure 5* and *6*. The lowest bias for all lactation stages, both for prediction of daily protein content based on morning or evening milkings, was observed in model E, which takes into account effect of lactation stage as lactation curve by *Ali* and *Schaeffer* (1987). This is in agreement with our previous study (*Jovanovac*, 2006).

CONCLUSIONS

Based on present study following conclusions can be made: the correlation between true and estimated daily milk yield is slightly lower when prediction is based on evening milkings, while the correlation between true and estimated daily fat as well as protein content is slightly higher when prediction is based on evening milkings. With the complexity of the models, correlation between true and estimated daily yields increases, while bias as well as accuracy decrease. Model D, which included single yields as covariate, as well as, effect of daily interval, and model E, which also included effect of lactation stage as lactation curve by *Ali* and *Schaeffer* (1987) gives the best fit to the data both for prediction of daily milk yield or milk content (fat and protein) based on morning or evening milkings. Differences between those two models were minor and statistically insignificant, so we would recommend use of model D in practice as easier to implement in routine work.

REFERENCES

Ali, T.E., Schaeffer, L.R. (1987). Accounting for covariances among test day milk yields in dairy cows. Can. J. Anim. Sci., 67. 637-664.

DeLorenzo, M.A., Wiggans, G.R. (1986). Factors for estimating daily yield of milk, fat, and protein from a single milking for herds milked twice a day. J. Dairy Sci., 69. 2386-2394.

Casandro, M., Carnier, P., Gallo, L., Mantovani, R., Contiero, B., Bittante, G., Jansen G.B. (1995). Bias and Accuracy of Single Milking Testing Schemes to Estimate Daily and Lactation Milk Yield. J. Dairy Sci., 78. 2884-893.

Hargrove, G.L. (1994). Bias in Composite Milk Samples with Unequal Milking Intervals. J. Dairy Sci., 77. 1917-1721.

ICAR – International Committee for Animal Recording (2003). Guidelines approved by the General Assembly held in Interlaken, Switzerland, on 30 May 2002, Roma, 19-39.

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. 3. 27-29.

Jovanovac, S., Gantner, V., Klopčič, M., Kompan, D. (2006). Effect of parity and stage of lactation on daily milk yield and milk content. 41st Croatian and 1st International Scientific Symposium of Agricluture, 13-17 February 2006, Opatija, 591-592.

Klopčič, M. (2004). Optimization of Milk Recording Practices in Dairy Cows. Degree Diss., University of Ljubljana, Slovenia.

Lee, A.J., Wardrop, J. (1984). Predicting Daily Milk Yield, Fat Percent, and Protein Percent from Morning or Afternoon Tests. J. Dairy Sci., 67. 351-360.

Liu, Z., Reents, R., Reinherdt, F., 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. 2672-2682.

McDaniel, B.T. (1969). Accuracy of sampling procedures for estimation yields: a rewiew. J. Dairy Sci., 52. 1742-1761.
Porzio, G. (1953). A new method of milk recording. Anim. Breed., 21. 344.
SAS/STAT User's Guide (2000). Version 8. Cary, NC, SAS Institute Inc.
Trappmann, W., Schwaer, P., Pauw, R., Tholen, E. (1998). Alternierende Milchkontrolle als Alternative zur A4 – Kontrolle. Züchtungskunde, 70. 2. 85-95.
Wiggans, G.W. (1981). Methods to estimate milk and fat yields from a.m./p.m. plans. J. Dairy Sci., 64. 1621.

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