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Estimation of daily milk yield from alternative milk recording schemes in dairy sheep

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ABSTRACT

The objectives of this study were to develop and compare different models for estimation of daily milk yield from alternative milk recording scheme (single morning and evening milking records). In this study, 3.000 individual test-day milk yield records from Central data base of Agricultural institute of Slovenia were used. Data were collected from April 1999 to September 2002 on 565 sheep reared on 10 family farms in Slovenia. Daily milk yield as well as daily fat and protein content were estimated by several statistical models. Determination coefficients of models for estimation of daily milk yield as well as daily protein were slightly lower when estimation was based on evening milkings, while the determination coefficients of models were slightly higher when daily fat content was estimated from evening milking. With the complexity of the models the amount of explained variance increases and the bias between true and estimated daily yields decreases. Inclusion of other effects in models, beside single milking weights, like effects of breed, lactation stage and number of liveborns, did not significantly increase the amount of explained variance, so the differences between models used for estimation were minor and statistically insignificant, therefore we would recommend use of model A in practice. That model included only partial milk yield as linear regression so, because of its simplicity, the implementation in routine work is simple. Because in present research the information of the interval between successive milkings, which is the most important effect in estimation of daily yields, was not available there is a need for further investigation in which we would be able to take that effect into account.
(Keywords: alternative milk recording scheme, daily milk yield, estimation, sheep)

INTRODUCTION

Milk recording provides collection of milk yield data required for herd management as well as for genetic evaluation of dairy animals. In the last decades, numerous milk recording schemes have been developed in many countries (*McDaniel*, 1969; *Wiggans*, 1981; *Rosati et al*., 1998; *Sanna et al*., 1998; *Drobnic et al*., 2000) 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. When alternative milk recording scheme is used estimation of daily yield is necessary. For estimation of 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 et al., 2001). The milking interval was shown as the most important factor when daily milk yield is estimated from morning or evening milkings. Most of the studies on milk recording schemes were conducted on dairy cattle, but the same principles can also be applied to sheep. Currently, the common practice in estimation of daily milk yield from alternative milk recording schemes is simply doubling of the morning or evening yield which frequently results in biased estimates of the daily milk yield (*Jovanovac et al*., 2005). The objectives of this study were to develop and compare different models for estimation of daily milk yield from alternative milk recording scheme (single morning and evening milking records).

MATERIALS AND METHODS

In this study, 3.000 individual test-day milk yield records from Central data base of Agricultural institute of Slovenia were used. Data were collected from April 1999 to September 2002. During research, measurements were conducted on 565 sheep reared in 10 family farms in Slovenia. From all sheep 50.47% belonged to the Bovška breed, 20.32% belonged to the Improved Bovška breed, while 23.21% of all sheep belonged to the Istrian sheep. 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. Initial time of current milking and initial time of previous milking was not registered, so the interval between successive milkings could not be calculated. For analysis of milk composition three samples were taken from each animal: one sample at each milking (evening and morning) and one proportional milk sample. 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, as well as fat and protein content is reported in *Table 1*.

Table 1

Descriptive statistics for milk traits

Trait	Milk yield, ml			Fat content, %			Protein content, %		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
Daily	2950	1155.13	603.99	2850	6.19	1.15	2870	5.39	0.68
Morning	2950	583.02	322.95	2850	5.92	1.22	2870	5.40	0.72
Evening	2950	570.31	304.72	2850	6.46	1.35	2870	5.40	0.69

Correlations between daily, morning or evening milk yield as well as fat and protein content are presented in *Table 2*. Evening milkings have lower correlations with daily yields than morning milkings. Obtained correlations are in agreement with those that are published (*Lee* and *Wardrop*, 1984; *Cassandro et al*., 1995; *Trappmann et al*., 1998; *Liu et al*., 2000). The correlation between daily and morning protein content is higher than correlation among daily and evening contents, while the correlation between daily and morning fat content is lower than correlation among daily and evening contents. The similar results were reported by *Klopčič et al.* (2003). The lowest correlation with its daily measurements has fat content measured on single milkings, which means that the accuracy of daily yield estimation from single milking will be lowest if estimation of fat content is observed.

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	0.969	<0.0001	0.966	<0.0001	0.873	<0.0001
Fat content, %	0.891	<0.0001	0.913	<0.0001	0.627	<0.0001
Protein content, %	0.974	<0.0001	0.972	<0.0001	0.894	<0.0001

For statistical analysis the SAS/STAT package was used (*SAS* Institute Inc., 2000). Daily milk yield as well as daily fat and protein content were estimated by several statistical models (*Table 3*). Models were compared on the basis of the determination coefficient (R^2), variability coefficient for standard error (CV_e) and root mean square error (σ_e). Differences between statistical models were tested according to *Mead* (1970).

Table 3

Statistical models for estimation of daily milk yield, fat and protein content

Model	df	Factors included in model								
		B	N	m	sl	sl^2	sl^3	$sl_{Wilmink}$	$sl_{Guo\text{-}Swalve}$	$sl_{Ali\text{-}Schaeffer}$
A	2			+						
B	3			+	+					
C	4			+	+	+				
D	5			+	+	+	+			
E	4			+				+		
F	6			+					+	
G	6			+						+
I	4	+		+						
J	7	+	+	+						

df–degree of freedom, B–breed, N–number of liveborn; m–morning or evening milk yield, sl–lactation stage, Wilmink–lactation stage as Wilmik curve (*Wilmink*, 1987), Guo-Swalve–lactation stage as Guo-Swalve curve (*Guo* and *Swalve*, 1995), Ali-Schaeffer–lactation stage as Ali-Schaeffer curve (*Ali* and *Schaeffer*, 1987).

RESULTS AND DISCUSSION

Determination coefficient (R^2), variability coefficient for standard error (CV_e) and root mean square error (σ_e) for models used to estimate daily milk yield from single milking weights are shown in *Table 4*. The model with the highest determination coefficient and lowest root mean square error fits the best to the data set. The amount of explained variance enhances with the complexity of the models. Determination coefficient (R^2) values for models based on morning milk yield ranged from 0.9533 in model A, which included only partial milk yield as linear regression, to 0.9546 in model D, F and G that included, beside partial milk yield as linear regression, also effect of lactation stage as cubic curve, as lactation curve by Guo and Swalve and as lactation curve by Ali and Schaeffer. Determination coefficients (R^2) are slightly lower when estimation is based on

evening milkings which differ from the results obtained by *Klopčič et al*. (2001). These results indicate that estimation of daily milk based on morning milking will be more reliable than those based on evening milking, which is in agreement with published results (*Cassandro et al*., 1995; *Lee et al*., 1984; *Liu et al*., 2000; *Jovanovac et al*., 2005).

Table 4

Determination coefficient (R^2), variability coefficient for standard error (CV_e) and root mean square error (σ_e) for models used to estimate daily milk yield from single milking weights

Model	df	Morning milking			Evening milking		
		R^2	CV_e	σ_e	R^2	CV_e	σ_e
A	2	0.9533	11.2658	128.6690	0.9470	12.0024	137.2427
B	3	0.9545	11.1159	126.9939	0.9486	11.8108	135.0906
C	4	0.9545	11.1117	126.9451	0.9489	11.7880	134.8297
D	5	0.9546	11.1113	126.9412	0.9489	11.7898	134.8505
E	4	0.9545	11.1169	127.0051	0.9487	11.8102	135.0837
F	6	0.9546	11.1059	126.8798	0.9490	11.7743	134.6727
G	6	0.9546	11.1129	126.9593	0.9491	11.7691	134.6134
I	4	0.9541	11.1759	127.6424	0.9473	11.9720	136.8949
J	7	0.9541	11.1788	127.6732	0.9473	11.9671	136.8295

The bias in model A for estimation of milk yield, both from morning or evening milking was low (*Figure 1* and *2*). Higher values were slightly underestimated while the lower values of daily milk yield were slightly overestimated when model A was used for estimation.

Figure 1

Bias in model A for estimation of daily milk yield from morning milkings

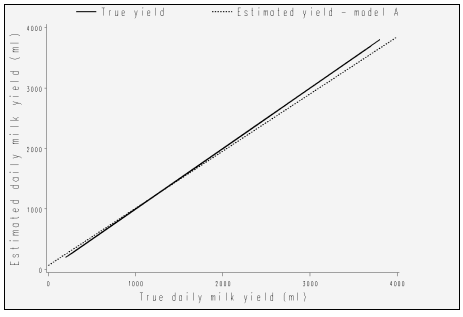
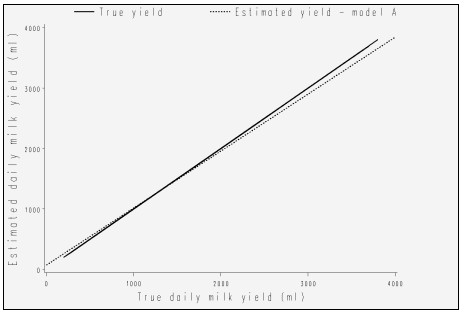


Figure 2

Bias in model A for estimation of daily milk yield from evening milkings



Determination coefficient (R^2) for models used to estimate daily fat content from morning milking is ranged from 0.8196 (model A) to 0.8369 (model G) (*Table 5*). Determination coefficients are slightly higher when prediction is based on evening 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 those obtained by *Liu et al*. (2000).

Table 5

Determination coefficient (R^2), variability coefficient for standard error (CV_e) and root mean square error (σ_e) for models used to estimate daily fat content from single milking

Model	df	Morning milking			Evening milking		
		R^2	KV_e	σ_e	R^2	KV_e	σ_e
A	2	0.8196	7.8990	0.4881	0.8526	7.1100	0.4392
B	3	0.8360	7.5322	0.4655	0.8573	6.9980	0.4322
C	4	0.8362	7.5286	0.4652	0.8584	6.9730	0.4307
D	5	0.8367	7.5191	0.4646	0.8584	6.9728	0.4307
E	4	0.8364	7.5260	0.4651	0.8580	6.9830	0.4313
F	6	0.8367	7.5219	0.4648	0.8586	6.9694	0.4305
G	6	0.8369	7.5152	0.4644	0.8587	6.9660	0.4303
I	4	0.8281	7.7140	0.4767	0.8599	6.9352	0.4284
J	6	0.8284	7.7119	0.4766	0.8600	6.9371	0.4285

Figure 3

Bias in model A for estimation of daily fat content from morning milkings

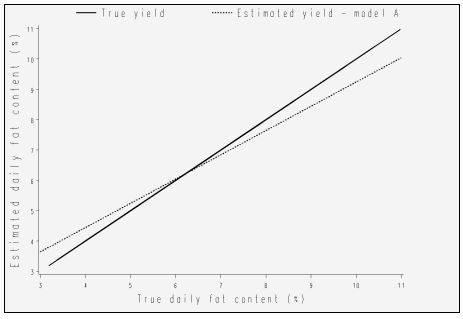


Figure 4

Bias in model A for estimation of daily fat content from evening milkings

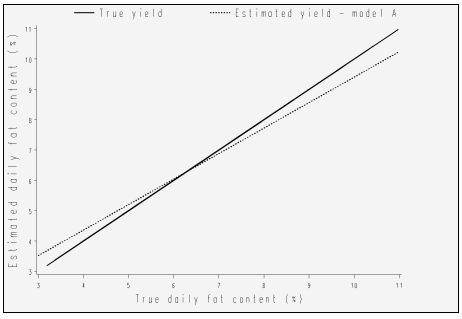


Figure 3 and *4* show bias in model A for estimation of daily fat content from morning or evening milkings, respectively. Lower values (<5%) of daily fat content were overestimated while the higher values (>8%) were underestimated when model A were used for estimation.

Table 6 shows determination coefficient (R^2), variability coefficient for standard error (CV_e) and root mean square error (σ_e) for models used to estimate daily protein content from morning or evening milking. Determination coefficient (R^2) for models used to estimate daily protein content from morning milking are ranged from 0.9643 in model A to 0.9646 in models F and G which included, beside partial milk yield as covariate, also effect of lactation stage as lactation curve by *Guo* and *Swalve* (1995) and as lactation curve by *Ali* and *Schaeffer* (1987). Determination coefficients are slightly higher when prediction is based on morning milkings which is in agreement with the

results obtained by *Liu et al*. (2000) and which differ from results reported by *Klopčič et al*. (2003). The differences in accuracy between models were minor and statistically insignificant, both for estimation based on morning or evening milking.

Table 6

Determination coefficient (R^2), variability coefficient for standard error (CV_e) and root mean square error (σ_e) for models used to estimate daily protein content from single milking

Model	df	Morning milking			Evening milking		
		R^2	KV_e	σ_e	R^2	KV_e	σ_e
A	2	0.9643	2.3715	0.1276	0.9604	2.5107	0.1352
B	3	0.9644	2.3689	0.1275	0.9630	2.4279	0.1308
C	4	0.9645	2.3672	0.1274	0.9630	2.4281	0.1308
D	5	0.9645	2.3675	0.1274	0.9630	2.4275	0.1307
E	4	0.9645	2.3673	0.1274	0.9630	2.4283	0.1308
F	6	0.9646	2.3640	0.1272	0.9631	2.4266	0.1307
G	6	0.9646	2.3660	0.1273	0.9630	2.4279	0.1308
I	4	0.9645	2.3689	0.1275	0.9607	2.5031	0.1348
J	7	0.9645	2.3691	0.1275	0.9607	2.5029	0.1348

Figure 5

Bias in model A for estimation of daily protein content from morning milkings

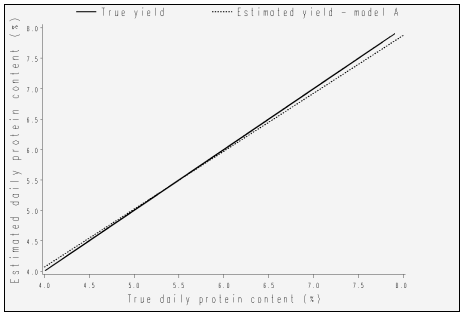
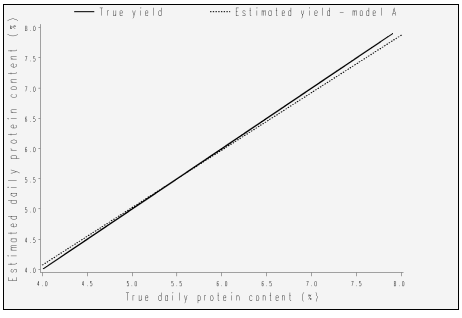


Figure 6

Bias in model A for estimation of daily protein content from evening milkings



The bias in model A for estimation of daily protein content from morning or evening milkings is shown on *Figure 5* and *6*. Lower values of daily protein content were slightly overestimated while the higher values were slightly underestimated, so the bias in model A, both for estimation based on morning or evening milking was negligible.

CONCLUSIONS

Based on present research the following conclusions can be made: the amount of explained variance was slightly lower when estimation of daily milk yield as well as daily protein was based on evening milkings, while the amount of explained variance was slightly higher when daily fat content was estimated from evening milking. With the

complexity of the models the amount of explained variance increases and the bias between true and estimated daily yields decreases. Inclusion of other effects in models, beside single milking weights, like effects of lactation stage, breed and number of liveborns, did not significantly increase the amount of explained variance, so the differences between models used for estimation were minor and statistically insignificant, therefore we would recommend use of model A in practice. That model included only partial milk yield as linear regression so, because of its simplicity, the implementation in routine work is simple. Because in present research the information of the interval between successive milkings, which is the most important effect in estimation of daily yields, was not available there is a need for further investigation in which we would be able to take that effect into account.

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