Acta agriculturae Slovenica, suplement 2 (september 2008), 195–200.

http://aas.bf.uni-lj.si

Agris category codes: L01, Q04 COBISS Code 1.08

COMPARISON OF CALCULATION METHODS OF DAILY MILK YIELD, FAT AND PROTEIN CONTENTS FROM AM/PM MILKINGS

Janez JENKO [a)], Tomaž PERPAR [a)], Betka LOGAR [a)], Jože VERBIČ [a)] and Milena KOVAČ [b)]

[a)] Agricultural Institute of Slovenia, Hacquetova 17, SI-1000 Ljubljana, Slovenia, e-mail: janez.jenko@kis.si
[b)] Univ. of Ljubljana, Biotechnical Fac., Dept. of Animal Science, Groblje 3, SI-1230 Domžale, Slovenia

ABSTRACT

For prediction of daily milk yield (DMY), daily fat percentage (DFP), and daily protein percentage (DPP) from alternate AM/PM recording scheme, three different methods were tested. The data comprised information on 483 813 test-day records. Methods were compared on the whole data set or just on the upper or the lower quartile of the records according to DMY, DFP, DPP, and milking interval (MI). Method 1 included DMY, DFP or DPP as a dependent variable in regression analysis. In Method 2 ratio of partial AM/PM to daily yield was included as a dependent variable, whereas Method 3 is based on doubling milk yield from AM/PM milking while DFP and DPP are expected to be the same as the AM or PM milking. The bias on the whole data set was low. With respect to high DMY, DFP, and DPP on the upper quartile of data set bias in underestimation of records was noticed for Method 1 whereas with this method, data from the lower quartile of data set were overestimated. With respect to the short MI on the average DMY was underestimated whereas DFP and DPP were overestimated with Method 3. DMY with long MI were overestimated on the average with Method 3 while DFP and DPP were underestimated. That kind of bias was not detected with Method 2.

Key words: cattle / dairy cows / milking / alternating recording scheme / bias / milk / composition / fat / proteins / models

PRIMERJAVA RAZLIČNIH METOD ZA IZRAČUN DNEVNIH MLEČNOSTI TER VSEBNOSTI MAŠČOB IN BELJAKOVIN IZ JUTRANJE ALI VEČERNE MOLŽE

IZVLEČEK

Za napoved dnevne količine mleka (DMY), dnevne vsebnosti maščobe (DFP) in dnevne vsebnosti beljakovin (DPP) na podlagi alternirajoče kontrole (molža zjutraj ali zvečer) smo uporabili tri metode. Primerjavo smo opravili na 483 813 dnevnih kontrolah mlečnosti. Primerjava je bila izvedena na celotnem podatkovnem setu ali le na zgornjem oziroma spodnjem kvartilu glede na DMY, DFP, DPP in interval med molžama (MI). DMY, DFP ali DPP so kot odvisne spremenljivke nastopale v Metodi 1. V Metodi 2 je kot odvisna spremenljivka nastopalo razmerje med delno (jutranja/večerna) in dnevno količino mleka, maščob in beljakovin. Metoda 3 ocenjuje DMY na podlagi podvojitve količine mleka zjutraj oziroma zvečer, medtem, ko delne vsebnosti maščob in beljakovin ostajajo enake dnevnim. V celotni množici podatkov je bila pristranost ocen nizka. V primeru visokih DMY, DFP in DPP so bili podatki v povprečju podcenjeni z metodo 1, medtem ko ta metoda nizke vrednosti preceni. Metoda 3 je v kratkih MI v povprečju podcenila DMY ter precenila DFP in DPP, medtem ko je v dolgih MI precenila DMY in podcenila DFP in DPP. Takšnih pristranosti ocen z metodo 2 ni zaznati.

Ključne besede: govedo / krave / molznice / molža / alternirajoča kontrola / pristranost / mleko / sestava / maščobe / beljakovine / modeli

INTRODUCTION

Recording system is important for herd management and genetic improvement in dairy cattle (Liu *et al.*, 2000). Under the constant pressure of reducing costs, several studies (Cassandro *et al.*, 1995; DeLorenzo and Wiggans, 1986; Klopčič *et al.,* 2003; Klopčič, 2004; Lee and Wardrop, 1984; Liu *et al.*, 2000; Wiggans, 1981) considered the implementation of alternate recording scheme (AT) based on morning (AM) or evening (PM) milking. Potential benefits from the adoption of AT recording scheme are the following: more herds can be served by one supervisor, recording costs per cow are lower (Everett and Wadell, 1970a, b; Hargrove and Gilbert, 1984), allowing more young bulls to be tested per year without reducing genetic gain (Schaeffer and Rennie, 1976), flexibility in scheduling the work of a supervisor is greater and the method disrupts the milking routine less (Cassandro *et al.*, 1995). The AT recording scheme with method proposed by Klopčič *et al.* (2003) and Klopčič (2004) was introduced in Slovenia in March 2004 replacing of the A4 (monthly records of daily milkings) ICAR standard reference recording scheme (Sadar *et al.*, 2005).

There were two objectives of this study. The first was to compare adequacy of different methods for the estimation of daily milk yield, fat and protein content on a whole data set. The second was to compare these three models in case of high or low daily milk yield (DMY), daily fat percentage (DFP) or daily protein percentage (DPP), and in case of short or long milking interval (MI).

MATERIAL AND METHODS

Data

Milk production data were collected from central cattle database GOVEDO, which is hosted at and maintained by Agricultural institute of Slovenia (Logar *et al.*, 2005). Data were combined from regular and supervised dairy recordings carried out from March 2004 through February 2008. Daily yields were calculated from AM and PM records. Database included altogether 497,842 records.

Table 1. Descriptive statistics of milk yield and milk composition

Trait	Number of records	Daily (D)		Evening (PM)		Morning (AM)	
		Mean	Std	Mean	Std	Mean	Std
Milk yield (MY), kg	483 813	18.1	7.1	8.8	3.6	9.2	3.8
Ratio PM : DMY	241 914			0.49	0.05		
Ratio AM : DMY	241 899					0.51	0.05
Fat yield, kg	483 813	0.74	0.29	0.37	0.15	0.38	0.16
Fat percentage, %	483 813	4.18	0.71	4.22	0.82	4.15	0.82
Ratio PM : DFY	241 914			0.49	0.07		
Ratio AM : DFY	241 899					0.51	0.07
Protein yield (PY), kg	483 813	0.61	0.22	0.30	0.11	0.31	0.12
Protein percentage, %	483 813	3.41	0.38	3.43	0.39	3.40	0.39
Ratio PM : DPY	241 914			0.49	0.05		
Ratio AM : DPY	241 899					0.51	0.05
Milking interval, min	483 813			705	44	732	47

Records were excluded from the analysis if days in milk (DIM) was less than 5 days, MI less than 540 minutes or more than 870 minutes, if there were more than two milkings per day or some problems detected at testing. For the analysis, 483 813 test-day records were prepared. They were collected from 120 971 lactations of 89 376 cows from 26 046 test-days in 5 051 herds. The data included records from successive AM/PM or PM/AM milkings with no traits missing. Variables included in the study were daily (D) as well as partial (P) milk yield, fat and protein percentage, MI, and DIM.

During the night, MI was on the average 26 minutes longer than daily interval (Table 1). PMY in AM milking was higher for 0.4 kg, compared to PM milking. Slightly higher values were observed for PFP and PPP from PM milking. On the other hand, partial fat yield (PFY) and partial protein yield (PPY) were higher from AM milking. The reason can be found in higher milk from AM than PM milk milking.

Prediction equations for daily milk yield, fat and protein content

Three methods were compared for estimation of daily milk yield, fat and protein content in AT recording scheme. Method 1 was proposed by Klopčič *et al.* (2003) and Klopčič (2004). Method 2 is a combination of DeLorenzo and Wiggans model (1986) and model by Klopčič *et al.* (2003) and Klopčič (2004) and was developed in Slovenia by Jenko *et al.* (2008). In Method 3, DMY is expected to be twice the amount of milk from AM or PM milkings, while DFP and DPP are expected to be the same as partial measurements. Adjustment factors for Method 1 and Method 2 were calculated on these dataset in a preliminary study (unpublished results)

Method 1:

$$\hat{y}_{ijk} = \hat{\mu}_{ij} + \hat{b}_{1ij} * x_{ijk} + \hat{b}_{2ij} * t_{ijk} \quad (1)$$

Daily value ($\hat{y}_{ijk}$) for record k and trait i (DMY, DFP or DPP) from milking j (AM, PM) is estimated by regression equation (1) which contains partial measurements (x_{ijk}) of the same trait and milking interval (t_{ijk}) as independent variables. Estimated $\hat{b}_{1ij}$ and $\hat{b}_{2ij}$ stand for regression coefficient and $\hat{\mu}_{ij}$ for intercept.

Method 2:

$$\hat{y}_{ijk} = x_{ijk} / \hat{F}_{ijk} \quad (2)$$

Method 2 (equation 2) estimates daily yield ($\hat{y}_{ijk}$) from the corresponding partial value (x_{ijk}) applying a factor from equation (4). Partial yield for PFY and PPY (equation 3) is calculated from partial milk yield (x_{milk}) and corresponding percentage (x_{ijk}).

$$x_{ijk} = x_{milk} * (x\%_{ijk}) / 100 \quad (3)$$

In method 2, factors ($\hat{F}_{ijk}$) to account for unequal MI are the ratios between partial and daily yield. Factors are derived by regression analysis containing milking interval (t_{ijk}) as the only independent variable. Estimated $\hat{f}_{ij}$ is the intercept of ratio and $\hat{b}_{ij}$ denotes corresponding regression coefficient.

$$\hat{F}_{ijk} = \hat{f}_{ij} + \hat{b}_{ij} * t_{ijk} \quad (4)$$

Method 3:

$$\hat{y}_{milk} = 2 * x_{milk} \quad (5)$$

Methods were evaluated on the basis of accuracy, bias, and correlation between estimated and true values. Additionally, the three methods were compared at extreme daily values for observed traits and extreme MI, where more problems were expected. Calculations were done by R statistics package (R Development Core Team, 2008).

RESULTS AND DISCUSSION

On the whole data set, correlation coefficients between the predicted and true value did not differ among the three methods (Table 2). The overall bias was zero as well. DFP is most accurately predicted by Method 1, whereas accuracy of DMY and DPP does not differ between the methods.

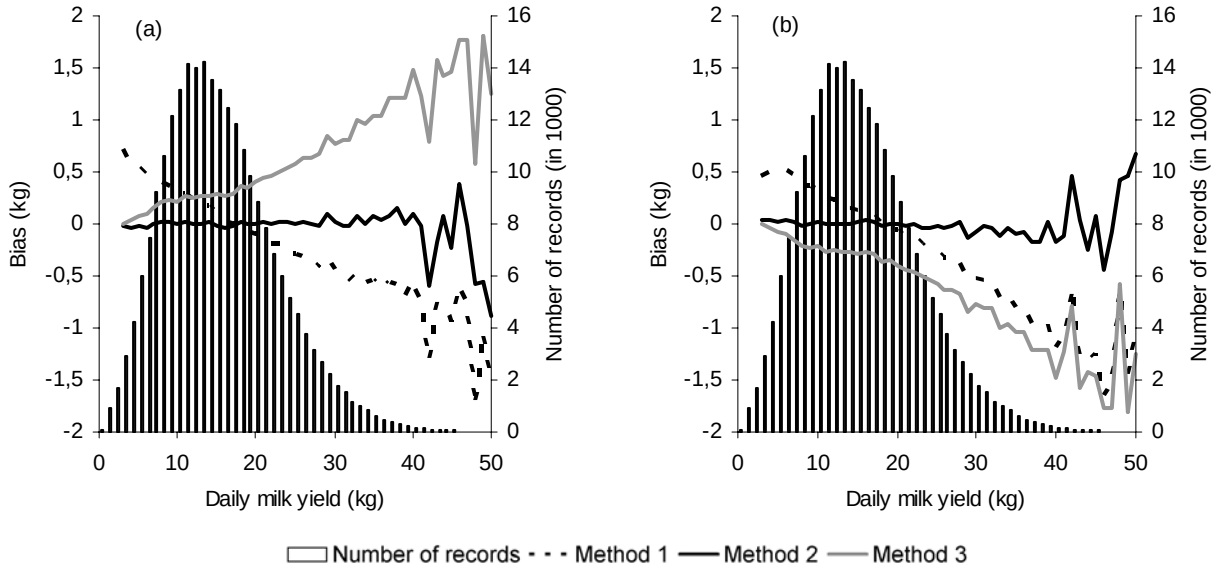

Figure 1. Bias of estimates for daily milk yield from AM (a) and PM milking (b) obtained by different methods.

The three methods did not perform equally when observed over a range of daily milk yields (Fig. 1). Close to the average the differences are not important and thus, the methods worked well for a large proportion of records. However, extreme records where the differences become larger are especially important for selection or culling decision. The Method 1 overestimates low DMY and underestimates high DMY from either AM or PM milking. Because of longer MI during the night (Table 1), Method 3 overestimates DMY from AM milking and underestimates DMY from PM milking (Fig. 1). Bias in DMY was the smallest with Method 2 on the observed interval.

Further analysis was focused on lower or upper quartile where the most problems were expected. The boundaries were set to 12.9 kg for DMY, 3.71% for DFP, and 3.14% for DPP for the lower quartile and to 22.4 kg for DMY, 4.62% for DFP, and 3.66% for DPP for the upper quartile. Differences in correlation coefficient between methods were negligible either for lower and upper quartile (Table 2). On the average, Method 1 overestimates DMY, DFP, and DPP for 0.3 kg, 0.20% and 0.02% in the lower quartile, respectively. The values were low for DMY and

DPP. In both cases, they were smaller than 10% of standard deviation. The bias in DFP was larger and accounted for 1/3 of standard deviation. The Method 1 was biased in upper quartile as well. The size of bias was similar to lower quartile, but the values were underestimated. However, the Method 1 performed well when judged on accuracy, especially in DFP. On the other hand, Method 2 and Method 3 were unbiased for all traits in lower as well as upper quartile. Method 3 revealed as the least accurate method for estimating daily milk records.

Table 2. Correlation, bias, and accuracy in the complete dataset, lower, and upper quartile

Trait	Method	Whole data set			Lower quartile [3]			Upper quartile [4]		
		r [1]	Bias	Acc [2]	r [1]	Bias	Acc [2]	r [1]	Bias	Acc [2]
Daily milk yield (DMY), kg	Method 1	0.980	0.0	0.961	0.897	0.3	0.816	0.925	−0.4	0.864
	Method 2	0.980	0.0	0.961	0.908	0.0	0.823	0.928	−0.0	0.862
	Method 3	0.971	0.0	0.943	0.881	−0.0	0.776	0.894	−0.0	0.800
Daily fat percentage (DFP), %	Method 1	0.879	0.00	0.815	0.657	0.20	0.533	0.710	−0.21	0.612
	Method 2	0.879	−0.01	0.775	0.657	−0.00	0.423	0.709	−0.01	0.508
	Method 3	0.871	0.00	0.761	0.639	0.00	0.400	0.701	0.00	0.496
Daily protein percentage (DPP), %	Method 1	0.975	0.00	0.952	0.902	0.02	0.827	0.921	−0.03	0.859
	Method 2	0.975	0.00	0.950	0.902	0.00	0.814	0.921	0.00	0.848
	Method 3	0.974	0.00	0.949	0.900	0.00	0.809	0.920	0.00	0.846

[1] Correlation coefficient between the estimated and measured DMY, DFP and DPP; [2] Accuracy; [3] DMY < 12.9 kg for DMY, DFP < 3.71% for DFP, and DPP < 3.14% for DPP; [4] DMY > 22.4kg for DMY, DFP > 4.62% for DFP, and DPP > 3.66% for DPP

The dataset was also split to the upper and lower quartile on the basis of milking interval. Lower quartile contained records with MI shorter than 690 minutes and upper quartile with MI longer than 750 minutes. Differences in the correlation coefficient between methods were again negligible (Table 3).

Table 3. Correlation, bias, and accuracy in the lower and the upper quartile with respect to short or long MI

Trait	Method	Lower quartile [3]			Upper quartile [4]		
		r [1]	Bias	Acc [2]	r [1]	Bias	Acc [2]
Daily milk yield (DMY), kg	Method 1	0.975	0.0	0.951	0.982	0.1	0.962
	Method 2	0.975	0.0	0.950	0.982	0.0	0.964
	Method 3	0.973	−1.3	0.950	0.980	1.4	0.951
Daily fat percentage (DFP), %	Method 1	0.856	0.00	0.789	0.895	0.00	0.834
	Method 2	0.856	−0.01	0.757	0.895	0.00	0.780
	Method 3	0.854	0.16	0.740	0.893	−0.14	0.791
Daily protein percentage (DPP), %	Method 1	0.968	0.00	0.940	0.977	0.00	0.956
	Method 2	0.967	0.00	0.937	0.977	0.00	0.953
	Method 3	0.967	0.01	0.936	0.976	−0.01	0.953

[1, 2] For description see Table 2; [3] Milking interval < 690 min; [4] Milking interval > 750 min

In the lower quartile, Method 3 underestimates DMY for 1.3 kg, whereas DFP and DPP are overestimated for 0.16%, and 0.01%, respectively. Method 3 overestimates DMY in the upper quartile for 1.4 kg, whereas DFP and DPP are underestimated on the average for 0.14% and

0.01%, respectively. For estimation of DMY and DPY, the accuracy between the methods does not differ much. DFP is estimated with the highest accuracy with method 1.

Our study revealed that the decision as to which method should be chosen for the estimation of DMY, DFP, and DPP is important. It is necessary to analyse the effect of methods not only on the whole data set but also on the lower or upper portion of DMY, DFP, DPP, and MI.

CONCLUSIONS

Three methods were analysed in the Slovenian dairy recording system. Correlation coefficient among estimated and measured value were high and almost the same. Bias imposed by the level of production or milking interval could be removed with the application of appropriate method. Method 1 produced biased but more accurate estimates at extremes, especially in DFP, whereas Method 3 proved to be biased with respect to short or long MI. That kind of bias was not detected with Method 2, while the accuracy was close to Method 1. Hereby Method 2 was introduced in the Slovenian dairy recording scheme.

REFERENCES

Cassandro, M./ Carnier, P./ Gallo, L./ Mantovani, R./ Contiero, B./ Bittane, G./ Jansen, G.B. Bias and accuracy of single milking testing schemes to estimate daily and lactation milk yield. J. Dairy Sci., 78(1995), 2884–2893.

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

Everett, R.W./ Wadell, L.H. Sources of variation affecting the difference between morning and evening daily milk production. J. Dairy Sci., 53(1970a)10, 1424–1429.

Everett, R.W./ Wadell, L.H. Sources of variation affecting ratio factors for estimating total daily milk yield from individual milkings. J. Diary Sci., 53(1970b)10, 1430–1435.

Hargrove, G.L./ Gilbert, G.R. Differences in morning and evening sample milkings and adjustment to daily weights and percents. J. Dairy Sci., 67(1984), 194–200.

Jenko, J./ Perpar, T./ Logar, B./ Sadar, M./ Ivanovič, B./ Jeretrina, J./ Verbič, J./ Podgoršek, P. Comparison of different models for estimating daily yields from a.m./p.m. milkings in Slovenian dairy scheme. In: Technical Presentations 36th ICAR Session, Niagara Falls, New York, United States, 2008-06-16/20. ICAR, 2008, 93–100.

Klopčič, M./ Malovrh, Š./ Gorjanc, G./ Kovač, M./ Osterc, J. Prediction of daily milk fat and protein content using alternating (AT) recording scheme. Czech J. Anim. Sci., 48(2003)11, 449–458.

Klopčič, M. Optimizacija vrednotenja proizvodnosti krav v mlečni usmeritvi [Optimization of milk recording practices in dairy cows]. PhD thesis. Ljubljana, University of Ljubljana, Biotechnical faculty, Zootechnical Department, 2004, 171 p.

Lee, A.J./ Wardrop, J. Predicting daily milk yield, fat percent, and protein percent from morning or afternoon tests. J. Dairy Sci., 67(1984), 351–360.

Liu, Z./ Reents, R./ Reinhardt, F./ Kuwan, K. 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), 2672–2682.

Logar, B./ Podgoršek, P./ Jeretina, J./ Ivanovič, B./ Perpar, T. Online-available milk-recording data for efficient support of farm management. In: Knowledge transfer in cattle husbandry: new management practices, attitudes and adaptation (Eds.: Kuipers, A./ Klopčič, M./ Cled, T.). Wageningen, The Netherlands, Wageningen Academic Publishers. EAAP Series, 117(2005), 227–230.

R Development Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, 2008. http://www.R-project.org.

Sadar, M.,/ Podgoršek, P./ Perpar, T./ Logar, B./ Ivanovič, B./ Jeretina, J./ Prevolnik, M. Rezultati kontrole prireje mleka in mesa Slovenija 2004 [Results of animal recording, Slovenia 2004]. Ljubljana, Agricultural institute of Slovenia, 2005, 50 p.

Schaeffer, L.R./ Rennie, J.C. AM-PM testing for estimating lactation yields. Can. J. Anim. Sci., 56(1976), 9–15.

Wiggans, G.R. Methods to estimate milk and fat yields from a.m./p.m. plans. J. Dairy Sci., 64(1981), 1621–1624.