Comparison of statistical models to estimate daily milk yield in single milking testing schemes

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ABSTRACT

Different statistical models were compared to estimate daily milk yield from morning or evening milking test results. The experiment was conducted on 14 family farms with 325 recorded cows. The amount of explained variance was higher for models including the effects of partial milk yield, the interval between successive milkings, the interaction between partial milk yield and the milking interval and the farm (R² = 0.976 for AM, R² = 0.956 for PM) than for models including partial milk yield effect only (R² = 0.957 for AM, R² = 0.937 for PM). Estimates of daily milk yield from linear models were more accurate than those obtained by doubling single milking weights. The results show that more complex model gives the best fit to the data. Differences between models according to determination and correlation coefficient were minor. Further investigations on larger sets of data are needed to draw more general conclusion.

Key words: Milk recording, AT method, Daily milk yield, Estimation.

Introduction

The accuracy of daily milk yield estimation is an important factor for single milking testing schemes. In order to estimate daily milk yield from single milking weights various models have been proposed. Depending on the model, different factors that affect milk production were taken into account, like parity, stage of lactation and the interval between successive milkings (Hargrove, 1994; Cassandro et al., 1995; Klopcič, 2004). The milking interval is the most important factor when estimating daily milk yield from partial yields. The objectives of this study were to develop and compare models to estimate daily (24 hours) milk yield from single morning (AM) and evening (PM) milking records.

Material and methods

The data used in this study were 2,994 individual test-day milk yield records collected from Table 1. Descriptive statistics of milk traits

| Trait                | Mean  | SD   | CV    | Min  | Max  |
|----------------------|-------|------|-------|------|------|
| Daily milk yield     | kg    | 19.78| 6.99  | 35.35| 4.00 | 59.90|
| Morning milk yield    | "     | 11.10| 3.93  | 35.42| 2.00 | 32.70|
| Evening milk yield    | "     | 8.67 | 3.25  | 37.45| 1.90 | 27.20|
| Nightly interval      | hour  | 13.63| 0.74  | 5.40 | 11.47| 15.68|
| Daily interval        | "     | 10.48| 0.74  | 7.04 | 8.33 | 13.43|
Results and conclusions

Determination coefficient ($R^2$) values for models based on morning milk yield ranged from 0.957 in model A, which included only partial milk yield as covariate, and 0.976 in model D which included effects due to the farm, milking interval, partial milk yield as well as the interaction between partial milk yield and the milking interval (Table 3). $R^2$ values for models based on evening milkings ranged from 0.937 (model A) to 0.956 (model D). These results indicate that estimation of daily milk based on morning milking will be more reliable than on evening milking. Reliability is slightly higher for more complex models than in the simplest one (model A).

Correlation between actual and milk yield estimated on AM milking varied from 0.978 (model A and E) to 0.988 (model D) and from 0.968 (model A) to 0.993 (model E). These results indicate that estimation of daily milk based on morning milking will be more reliable than on evening milking. Reliability is slightly higher for more complex models than in the simplest one (model A).

Table 2. Selected statistical models for estimation of daily milk yield.

| Model | df | Factors included in model | m | t | m*t | F |
|-------|----|---------------------------|---|---|-----|---|
| A     | 2  | YES                       | NO| NO| NO  | NO|
| B     | 3  | YES                       | YES| NO| NO  | NO|
| C     | 4  | YES                       | YES| YES| YES | NO|
| D     | 17 | YES                       | YES| YES| YES | YES|
| E     | m*2 | doubling single AM or PM milk yield |

$df =$ degree of freedom, $m =$ AM or PM milk yield, $t =$ daily or nightly milking interval in minutes, $m*t =$ interaction between $m$ and $t$, $F =$ farm

Table 3. Determination coefficient ($R^2$), variability coefficient for standard error ($CV_e$) and root mean square error ($\sigma_e$) for models used to estimate daily milk yield from single milking weights.

| Model | df | Morning milking | Evening milking |
|-------|----|-----------------|-----------------|
|       | $R^2$ | $CV_e$ | $\sigma_e$ | $R^2$ | $CV_e$ | $\sigma_e$ |
| A     | 2   | 0.957 | 7.354 | 1.454 | 0.937 | 8.906 | 1.761 |
| B     | 3   | 0.971 | 6.055 | 1.197 | 0.953 | 7.709 | 1.524 |
| C     | 4   | 0.973 | 5.872 | 1.161 | 0.953 | 7.688 | 1.520 |
| D     | 17  | 0.976 | 5.561 | 1.099 | 0.956 | 7.318 | 1.447 |

November 2004 to March 2005 on 325 cows reared in 14 family farms in Croatia. At each recording, milk yield was measured in the evening and in the morning. Three samples were taken from each cow: one sample at each milking (evening and morning) and one proportional milk sample that was taken for regular recording. Variability of daily, morning and evening milk yield, as well as day and night interval between successive milkings are reported in Table 1.

For statistical analysis the SAS/STAT package was used (SAS Institute Inc., 2000). Daily milk yield was estimated by four different statistical models and by doubling AM or PM.
and E) to 0.979 (model D) on PM milking. These results are in agreement with those reported by Liu et al. (2000). It is obvious that high correlation indicates the best suitability of the model.

Estimation of daily milk yield can be based on the regression coefficients given in table 4. All parameter estimates were statistically significant. The reason for choosing only A and B models lay in the fact that this models are simple to use in practice and they still give adequate accuracy in estimation of daily milk yield. We recommend use of model B in practice, but there is a need for further investigations with larger sets of data.

### REFERENCES

Cassandro, 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.

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

Mead, R., 1970. Plant density and crop yield. Appl. Statist., 19:64-81.

SAS/STAT User’s Guide. 2000. Version 8. Cary, NC, SAS Institute Inc.

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### Table 4. Parameter estimates for models A and B ($P < 0.01$).

| Model | Parameter | Morning milking | | | Evening milking | | |
|---|---|---|---|---|---|---|
| | | estimate | SE | | estimate | SE | |
| A | intercept | 0.4726 | 0.1429 | | 1.7109 | 0.1648 | |
| | partial yield | 1.7385 | 0.0121 | | 2.0830 | 0.0178 | |
| B | intercept | 15.7233 | 0.7351 | | 14.0955 | 0.7165 | |
| | partial yield | 1.7437 | 0.0099 | | 2.1662 | 0.0161 | |
| | interval | -0.0187 | 0.0009 | | -0.0209 | 0.0012 | |