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PREDICTION OF LACTATION MILK YIELD USING VARIOUS MILK RECORDING METHODS**

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Abstract: The objective of this study was to determine the effect of various milk recording methods (A4, AT4, A6, AT6) on prediction accuracy of 100, 200 and 305-day milk yield. The data used in this study were 11,430 individual test-day milk yield records collected from November 2004 to November 2006 on 813 cows reared on 15 family farms in Croatia. Milk recording was performed according to A4 and A6 milk recording method by the field officer of the Croatian Livestock Centre. From the corrected database with test-day records, two different datasets were created. The first dataset (A4; n = 7,500) included test day records collected every four weeks, while the second dataset (A6; n = 3,830) included test day records collected every six weeks. When lactation milk yields were predicted from alternative milk recording methods (AT4, AT6), daily (24 h) milk yield was estimated from single evening or morning milk yield using linear model that taken into account effect of interval between successive milkings. Lactation milk yield was calculated for three different days in milk (100, 200 and 305 days) using the Test Interval Method (TIM) that is reference method by ICAR *(ICAR, 2003).*

Results show that the alternate milk recording method at 4-week intervals provides low bias and high accuracy of prediction of 100, 200 and 305-milk yields, while milk recording methods at 6-week intervals gives prediction of 305-milk yield with higher bias and lower accuracy.

Key-words: dairy cows, prediction, lactation milk yield, milk recording methods

Introduction

Milk recording provides collection of data necessary for genetic evaluation and herd management of dairy animals. The referent milk recording method by the International Committee for Animal Recording *(ICAR, 2003)* is the A4 method. In the last decades, various milk recording methods have been

developed *(Porzio, 1953; McDaniel, 1969; Wiggans, 1981)* with the purpose of supplementing the standard four-week testing scheme (A4) which is considered to be the most expensive one. Increased participation in milk recording and cost reduction could be achieved by extending the interval between successive milk recordings, by measuring only evening or morning record per test-day (alternative milk recording method) or by their combination.

Many researchers have investigated the effect of reducing the frequency of milk recording to prediction accuracy of lactation yields. *Hargrove, 1994* and *Wangler et al., 1996* reported that with the extension of interval between successive recordings, the prediction accuracy decreases as well as the cost of recordings. *Crosse et al. (1988)* quoted that the relative error in prediction of lactation milk yield ranged from 2.7 to 6% if the interval lasted from one to ten weeks. *Cattin-Vidal (1990)* also determined the increase of prediction error induced by the extension of interval between recordings. *McDaniel (1969)* reported that 93% of the proportional differences between actual milk yield and milk yield predicted from monthly samples were less than 0.05 and that 100% of the proportional differences between the actual and predicted milk yield were less than 0.10. When milk yield was predicted from bimonthly samples, 78% of the proportional differences between actual predicted milk yields were less than 0.05, while 98% of the proportional differences between the actual and predicted milk yield were less than 0.10. *McDaniel (1969)* concluded that accurate progeny testing could be based on samples taken as much as two months apart. *Pander et al. (1993)* determined that the use of less frequent than A4 recording result in costs reduction without a proportional loss in accuracy when estimating 305-day yield. When the total lactation milk yield is considered, the accuracy of all methods (A4, AT4, A6, and AT6) is greater than 98% *(Aleandri et al., 2003)*. *Berry et al. (2005)* reported that with heifers, the A8 scheme predicts on average a 305-day yield similar to A4-predicted 305-day yield.

Alternative milk recording method that is weighting and sampling one milking (evening or morning) on consecutive test day requires estimation of daily values. The accuracy of daily milk yield estimation depends of the method used for estimation *(Hargrove, 1994; Liu et al., 2000)* while if estimation accuracy of total lactation milk yield is considered, between different estimation methods for daily yields noticeable difference has not been detected *(Cassandro et al., 1995)*. *Liu et al., 2000* reported that use of estimated daily yields from alternative milk recording method in test-day model genetic evaluation results in lower reliability of cow EBV (estimated breeding value) than use of true daily yields (standard milk recording method – A4). Based on evaluation of the effect of different milk recording methods on the ranking of top cows (1%), *Cassandro et al., 2003* determined the rank correlation about 89%, however,

usage of AT4 method in comparison to the A4 method, resulted in the inconsiderable effect on the decrease of selection intensity for the dams of sires path. Previous studies *(McDaniel, 1969; Anderson et al., 1989; Aleandri et al., 2003; Berry et al., 2005)* show that prediction error of A4 milk recording method was negligible so that the A4-predicted 100, 200 and 305-day yields have been taken to be the most accurate reflection of the actual 100, 200 and 305-day yields.

The objective of this study was to determine the effect of various milk recording methods on prediction accuracy of 100, 200 and 305-day milk yield.

Material and methods

Data

The data used in this study were 11,430 individual test-day milk yield records collected from November 2004 to November 2006 on 813 cows reared on 15 family farms in Croatia. From all cows 56.4% belonged to the Holstein breed, while 43.5% of all cows belonged to the Simmental breed. Milk recording was performed according to A4 and A6 milk recording method by the field officer of the Croatian Livestock Centre. At every recording, milk yield was measured in the evening and in the morning. Daily milk yield was computed as evening plus morning measured yield. At each milking, initial time of current milking and initial time of previous milking for each animal was recorded. The interval between successive milkings was computed as the time from the beginning of previous milking to the beginning of current milking. 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. Test day records with missing evening or morning milk yield and milking interval, as well as with unreasonable calving date, lactation stage and lactation number, and ordinal number of milk recording were deleted from the database.

Datasets

From the corrected database with test-day records, two different datasets were created. The first dataset (A4; n = 7,500) included test day records collected every four weeks, while the second dataset (A6; n = 3,830) included test day records collected every six weeks. Additionally, three different subsets were created from these two datasets according to available control records, that is different subsets for the calculation of lactation milk yield in 100, 200 and 305-day in milk.

Prediction of daily (24 h) milk yield

Preliminary analysis of variance showed that the interval between successive milkings, had significant effect ($P < 0,001$) on the variation of partial

(evening or morning) milk yield *(Jovanovac et al., 2005; Gantner et al., 2006).* Therefore, the interval between successive milkings was taken into account when daily milk yield was predicted based on evening or morning record. Daily (24 h) milk yield was estimated from single evening or morning milk yield using following fixed linear model:

$$\mathbf{y_i = \mu + b_1 m_i + b_2 t_i + e_i}$$

where:

y_i – daily milk yield;

μ – intercept;

m_i – evening or morning milk yield;

t_i – interval between successive milkings;

e_i – residual.

Prediction of lactation milk yields

Lactation milk yield was calculated for three different days in milk: 100, 200 and 305 days. Lactation milk yield of each animal was calculated using the Test Interval Method (TIM) that is reference method by ICAR (ICAR, 2003).

$$\mathbf{LMY = I_0 M_1 + I_1 \frac{M_1 + M_2}{2} + I_2 \frac{M_2 + M_3}{2} + ... + I_{n-1} \frac{M_{n-1} + M_n}{2} + I_n M_n}$$

where:

M_1, M_2, …, M_n – milk yielded in the 24 hours of the recording day, kg (actual or predicted);

I_1, I_2, ,,,, I_{n-1} – the intervals between recording dates, days;

I_0 – the interval between the lactation period start date and the first recording date, days;

I_n – the interval between the last recording date and the 100^{th}, 200^{th} and 305^{th} lactation day, days.

The effect of the different milk recording methods on prediction accuracy of 100, 200 and 305-day yields was tested by the analysis of variance using the GLM procedure of SAS *(SAS Institute Inc., 2000).* Duncan's multiple range tests were used to test the significance of the difference between the tested milk recording methods. The null hypothesis was that no significant differences existed between 100, 200 and 305-day yield predicted from the different recording methods.

The relationship between lactation yields calculated based on AT4, A6 and AT6 milk recording methods and referent lactation yields calculated based on A4 milk recording method was determined from a correlation analysis.

Results and discussion

The results shown in table 1 indicate that the differences between 100-day milk yields predicted from A4, AT4, A6 and the AT6 milk recording methods were not statistically significant ($P > 0.05$). The differences between 200-day milk yield predicted from referent milk recording method (A4) and 200-day milk yield predicted from AT4, A6 and AT6 milk recording methods weren't statistically significant ($P > 0.05$). The 305-day milk yield predicted from the 4-week milk recording methods (A4, AT4) and from 6-week milk recording methods (A6, AT6) differ statistically highly significant ($P < 0.01$).

Table 1 Least square means of 100, 200 and 305-day yields predicted from various milk recording methods
Tabela 1. Srednje vrednosti najmanjih kvadrata prinosa 100, 200 i 305 dana procenjene na bazi različitih metoda kontrole mlečnosti

Lactation duration Trajanje laktacije	A4	AT4	A6	AT6
100 days/dana	2,499.4^{A}	2,484.6^{A}	2,566.5^{A}	2,539.6^{A}
200 days/dana	4,644.5^{A}	4,620.2^{A}	4,587.5^{A}	4,580.0^{A}
305 days/dana	7,679.9^{A}	7,692.3^{A}	6,504.3^{B}	6,519.1^{B}

*the values within same row marked with the same letter are not significantly different ($P > 0.01$)/
*vrednosti u istom redu označene istim slovima nisu signifikantno različite ($P > 0.01$)

The correlations between the A4-predicted 100, 200 and 305-day milk yield and the milk yields predicted from AT4, A6 as well as from AT6 milk recording methods are presented in table 2. The correlations between A4 and AT4 were always higher than the correlations between A4 and A6 as well as the correlations between A4 and AT6. *Aleandri et al. (2003)* determined higher correlation between real production and 100, 240 and 305-day milk yields predicted from A4, AT4, A6 and AT6 recording methods, while the alternate recording methods taken at 4-week and 6-week periods and involving either all morning or all evening records give lower correlation between real and predicted production. *Hamed (1995)* reported strong correlation between 305-day milk yield estimated with the different methods, that is the correlations of 0.95 to 0.98 between total lactation yield predicted from A4 and A8 recording methods, as well as the correlation of 0.79 to 0.93 for the A12 method. *Berry et al. (2005)*, in a research of the prediction accuracy of 305-day milk yield from different milk recording methods, conclude that A8 method predicts a 305-day milk yield similar to A4 method.

Table 2 Correlation between referent (A4) and lactation milk yields predicted by various milk recording methods (AT4, A6, AT6)
Tabela 2. Korelacija između referentne (A4) i prinosa mleka u laktaciji predviđenog na bazi različitih metoda kontrole mlečnosti (AT4, A6, AT6)

Lactation duration Trajanje laktacije	A4 : AT4		A4 : A6		A4 : AT6		AT4 : AT6	
	r[1]	n	r[1]	n	r[1]	n	r[1]	n
100 days/dana	98.03	406	82.96	278	82.79	270	81.42	270
200 days/dana	99.14	240	97.42	112	96.60	110	95.95	110
305 days/daba	99.09	101	96.36	37	96.28	36	95.78	36

[1]Correlations between referent and predicted lactation daily milk yields/[1]Korelacije između referentnog i predviđenog dnevnog prinosa mleka u laktcaiji

The prediction bias of 100-day yield was highest when milk yield was predicted from AT6 method, while AT4 method gives the smallest bias (Figure 1). Higher values of 100-day yield were slightly underestimated while the lower values were slightly overestimated when 6-week milk recording methods (A6, AT6) were used.

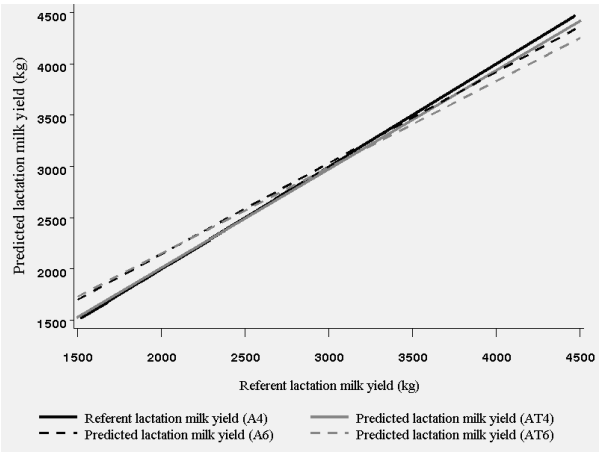

Figure 1 Prediction bias of 100-day milk yield from various milk recording methods
Slika 1. Predviđena pristrasnost prinosa mleka u laktaciji od 100 dana na bazi različitih metoda kontrole mlečnosti

Figure 2 shows prediction bias of 200-day milk yield from various milk recording methods. Lower values (< 3,500 kg) of lactation yield were overestimated while the higher values (> 5,500 kg) were underestimated when 200-day production was predicted from AT4, A6 as well as from AT6 method. The highest bias was observed when AT6 recording method was used.

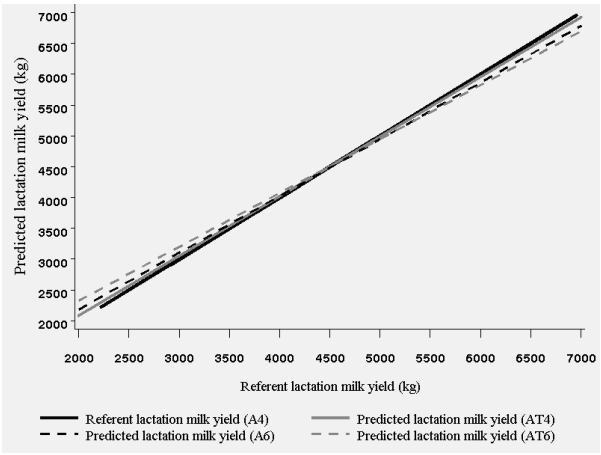

Figure 2 Prediction bias of 200-day milk yield from various milk recording methods
Slika 2. Predviđena pristrasnost prinosa mleka u laktaciji od 200 dana na bazi različitih metoda kontrole mlečnosti

The 6-week milk recording methods (A6, AT6) underestimated 305-day milk yield in amount of 500 – 1000 kg (Figure 3), that is the accuracy of 305-day milk yield prediction from A6 and AT6 method was very low. The alternative milk recording method that occurs every four weeks (AT4) enabled a more accurate prediction of 305-day milk yield.

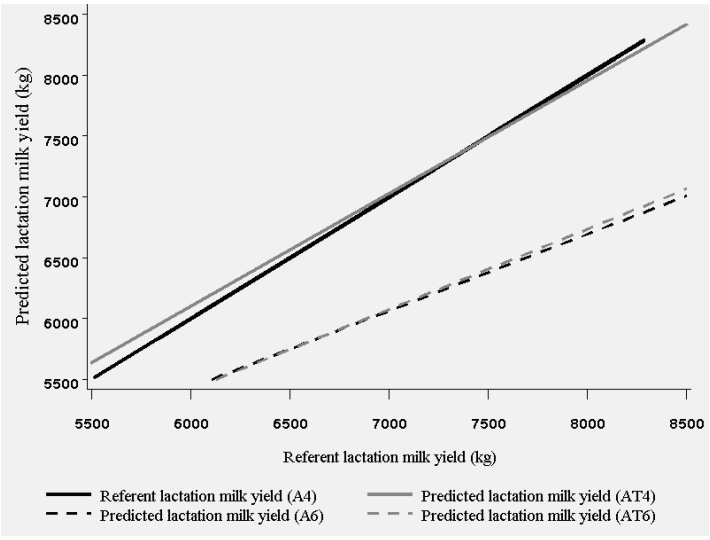

Figure 3 Prediction bias of 305-day milk yield from various milk recording methods
Slika 3. Predviđena pristrasnost prinosa mleka u laktaciji od 305 dana na bazi različitih metoda kontrole mlečnosti

Cassandro et al. (1995) determined that AT4 milk recording method enable prediction of 305-day lactation milk yield with low bias and high accuracy.

Conclusion

From the present research, the following conclusions could be made:

- The 100-day and 200-day milk yields predicted from referent milk recording method (A4) and the 100-day and 200-day milk yield predicted from AT4, A6 and AT6 milk recording methods did not differ statistically significant ($P > 0.05$);
- The 305-day milk yield predicted from 4-week milk recording methods (A4, AT4) and from 6-week milk recording methods (A6, AT6) differ statistically highly significant ($P < 0.01$);
- The correlations between 100, 200 and 305-day milk yield predicted from A4 and AT4-predicted were always higher than the correlations between A4 and A6 as well as between A4 and AT6;
- The alternate milk recording method at 4-week intervals provides low bias and high accuracy of prediction of 100, 200 and 305-milk yields, while milk recording methods at 6-week intervals gives prediction with high bias and low accuracy.

Predviđanje prinosa mleka u laktaciji korišćenjem različitih metoda kontrole mlečnosti

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Rezime

Cilj istraživanja je bio određivanje uticaja različitih metoda kontrole mlečnosti (A4, AT4, A6, AT6) na tačnost predviđanja prinosa mleka u laktaciji od 100, 200 i 305 dana. Podaci korišćeni u istraživanju su podaci sakupljenih od novembra 2004 do novembra 2006 godine na 15 porodičnih farmi u Hrvatskoj. Kontrola mlečnosti je rađena prema metodama A4 i A6 od strane terenskog radnika Hrvatskog stočarskog centra. Prinos mleka po lataciji je izračunat za tri različita dana (100, 200 i 305 dana) korišćenjem Test Interval Method. Kada su prinosi mleka u laktacijama određivani korišćenjem alternativnih metoda (AT4, AT6), dnevni prinos mleka je procenjivan iz delimičnog prinosa korišćenjem linearnog modela koji je uzimao u obzir utcaj intervala između uzastopnih muža. Rezultati pokazuju da se prinosi 100 dana i 200 dana predviđeni korišćenjem A4 metode i prinosi 100 i 200 dana predviđeni metodama AT4, A6

i AT6 nisu signifikantno razlikovali (P > 0.05). Prinos mleka u laktaciji od 305 dana predviđen metodom 4 nedelje (A4, AT4) i metodama 6 nedelja (A6, AT6) se razlikovao veoma visoko signifikantno (P < 0.01). Korelacije između prinosa mleka za laktaciju od 100, 200 i 305 dana predviđenog na osnovu A4 i AT4-su takođe bile uvek više u odnosu na korelacije između A4 i A6, kao i između A4 i AT6. Alternativni metod kontrole mlečnosti u 4-nedeljnim intervalima obezbeđuju nisku pristrasnost i visoku tačnost predviđanja prinosa mleka u laktacijama od 100, 200 i 305 dana, dok metode kontrole mlečnosti u 6-nedeljnim intervalima daju predviđanja sa većom pristrasnošću i manjom preciznošću.

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