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The accuracy of 200-day milk yield estimation in cows on the basis of test yields from the 100-day period

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SUMMARY

The accuracy of 200-day milk yield estimation in cows, obtained on the basis of 4 test yields taken in the first 100 days of lactation, was compared with the accuracy achieved when the 4 yields were recorded during the whole 200-day period. In the study, daily milk yields in a herd of 156 cows were used. Relative estimation error (with regard to the real yields of appropriate cows), mean estimation error and error variance were computed for 100 and 200 days of lactation. Mean error values of 200-day milk yield estimation by test yields from the 100-day period were comparable to the values obtained when the yields were taken during the 200-day period. The error variance turned out to be even slightly smaller for the 200-day yield estimation based on the 100-day period. This suggests that the method presented might be used to predict longer period yields with data from shorter ones.

KEY WORDS: lactation curve, milk yield.

1. Introduction

The breeder is interested in the economic effect of his work, and the market demands a product of good quality. Naturally, the breeder of dairy cattle is interested in obtaining the maximum milk yield from his herd, but other parameters of milk are important as well. Milk yield is a low-heritable trait. For various milk traits the heritability values are as follows: 0.20 for milk yield; 0.16 for fat; and 0.17 for protein (Tijani at al., 1999). El-Saied et al. (1999) reported similar values: 0.24 for milk yield, 0.17 for protein, and 0.12 for somatic cells. The values of these traits depend largely on environmental conditions. The above quoted paper (Tijani at al., 1999) established the value of environmental effect at 50% for milk yield, and 51% for fat

yield. Milk yield is mainly influenced by the interaction of the genotype-environment factors (Shanks at al., 1981). The contour of the lactation curve depends on the breed of cattle, but even within one breed curves might deviate from the typical contour (Abubakar and Buvanendran, 1981; Gaskings and Craig, 1980; Madalena at al., 1979; Wood, 1980).

In turn the contour of the lactation curve determines the milk yield to a certain extent. That is why attempts to maintain an optimal lactation curve are of economic significance (Kruszyński at. al., 1994). The more accurate the estimation of milk yield, the more favourable the breeding strategy, which influences milk production (Carvalheira, 2002).

The aim of this study is to develop a method of estimating milk yield in cows earlier and with sufficient accuracy for breeding practice. Though the problem is not new (Perz, 1998), it is still one of current importance.

In the case of cattle, fast assessment is important. An early estimation of the individual cow's milk yield can enable the breeder to make quicker breeding decisions. Besides, a more accurate estimation of the yield of particular individuals would reduce the number of daughters that need to be taken into account for the assessment of their sire.

2. Materials and methods

The study was performed on material that comprised the daily milk yields of cows which were Black and White crosses with a substantial addition of Holstein-Friesian. The daily yields were recorded for 200 days after calving. The data were obtained from 15 individuals (heifers) with similar calving dates (between December 1999 and February 2000) from a herd numbering 156 cows.

In the present study the scaling method has been used to estimate the milk yield for a 100 and 200-day lactation. 200-day yields were estimated, because data of daily yields for this number of days were available and therefore the accuracy of the estimation could be verified. The scaling method (representing a Bayesian approach) makes use of a mean lactation curve and deviations from it of individual yields.

Figure 1 shows the contour of the mean lactation curve for the group of cows studied. The curve drawn with a black line is the mean daily yield. To this line a sixth degree polynomial has been fitted (white line). The lactation curve is made up of three parts: first a rising one, then the middle part where the yield reaches a maximum value, and finally a gently declining one. However, not all lactation curves have such a typical contour. According to a study by Brzozowski and Jasiorowski (1990), in 7.2% of cows an untypical contour of the lactation curve has been found.

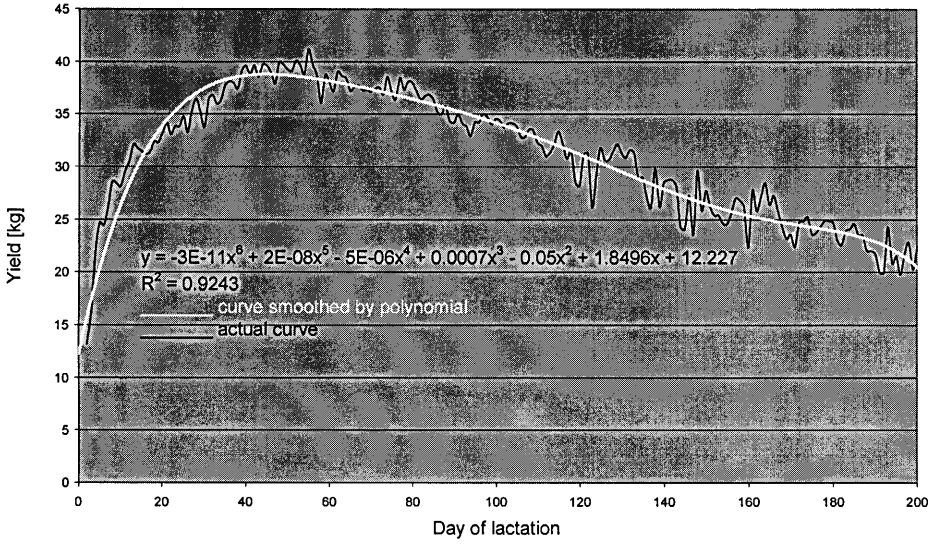

Figure 1. Mean lactation curve (actual and smoothed with a polynomial)

Yield estimation using the scaling method (Perz, 1998)

1. The mean lactation curve for the group of cows under consideration has been determined as a line connecting points which are mean yields on subsequent days of lactation for the group of cows studied (black line in Figure 1).

2. The mean curve has been smoothed using polynomials of the second to sixth degree (the white line in Fig. 1 represents the graph for a sixth degree polynomial), fitted to the curve by polynomial regression.

3. For each cow the scaling coefficient has been calculated. The scaling coefficient is the arithmetic mean of the quotients of the actual yields for the individual under consideration, and the yields obtained from the mean curve or a polynomial fitted to the mean curve for the herd studied, for selected test days (four in the case of this work). In Figure 2 the squares denote the actual yields of the cow on selected days, and the triangles stand for the yields taken from the mean curve for the same days.

4. The estimated milk yield of an individual cow has been obtained by multiplying the total yield from the mean lactation curve (sum of mean daily yields) by the scaling coefficient.

The 200-day milk yield in each individual has been established for two cases:

1. Test yields used for the calculation of the scalling coefficient originated from the 100-day period only. In what follows this case of estimation of the mean error and variance on curves will be called "200 from 100".

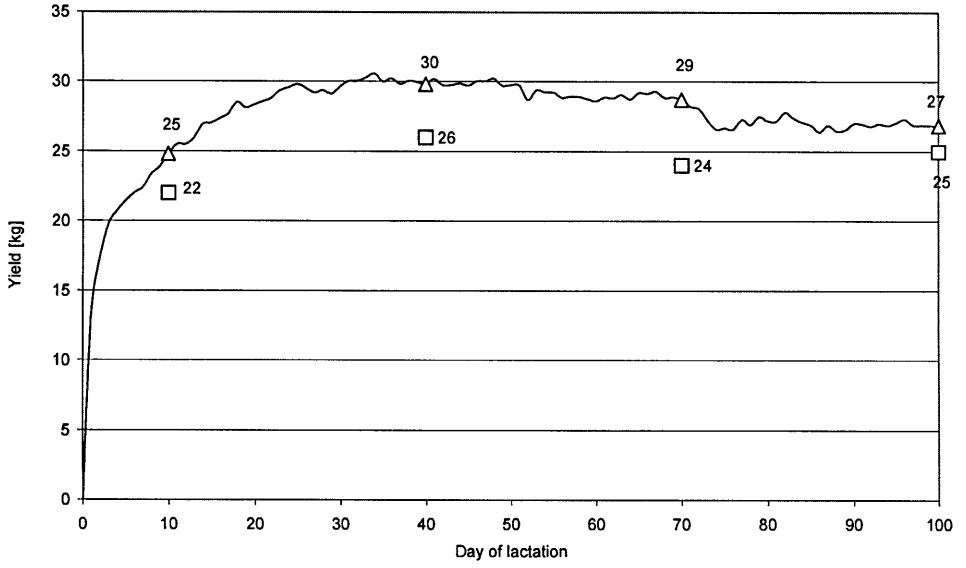

Figure 2. Illustration for the scaling method description (4 test yields have been marked – Δ's show milk yield [volume in kg beside triangle] for selected day from actual curve, □'s show milk yield [volume in kg beside square] obtained from mean curve or smoothed with polynomial fitted to the actual mean curve)

2. Test yields used for the calculation of the scaling coefficient came from the entire 200-day period. The mean error and variance for such an estimation will be referred to as "200 from 200".

In order to adhere to the prescribed rules of assessment, from the collected data (daily yields) the following days have been selected for (simulated) test yields: 10^{th}, 40^{th}, 70^{th} and 100^{th} from the date of calving in the case of the 100-day curve, and days: 20^{th}, 80^{th}, 140^{th}, and 200^{th} from the same date in the case of a 200-day curve.

Mean relative error in the group of cows studied has been adopted as a criterion of the quality of yield estimation by the scaling method. The error of a cow's milk yield estimation was calculated according to the formula below (taking the sum of daily yields for a particular cow as the actual value of yield for the period considered):

$$\delta_w = \frac{m - m_o}{m_o} 100\%, \tag{1}$$

where δ_w denotes the relative error, m – yield determined by the scaling method [kg] and m_o – the actual yield [kg].

Variance of yield estimation error has been adopted as a second criterion of quality.

3. Results and discussion

For a 200-day yield the following values have been calculated: the relative error of a cow's milk yield estimation (formula 1), the mean value of error, and the variance of the estimation error. The results obtained are listed in Table 1.

Table 1 shows the mean values of yield estimation error for a 200-day period using test yields for 100- and 200-day periods.

Table 1. Mean error of milk yield estimation in percentage and variance of milk yield estimation error

Mode of yield estimation		Curves for milk yield estimation					
		mean curve	curve smoothed with polynomial of degree				
			2	3	4	5	6
200 from 100	mean error	1.24	5.99	6.15	6.24	2.36	2.53
	variance	30.69	34.44	34.32	34.76	33.21	33.11
200 from 200	mean error	0.72	10.49	3.80	2.42	3.45	1.57
	variance	31.97	36.64	35.16	34.45	35.06	33.87

When yield estimation for a 200-day period is based on data from the 100-day period ("200 from 100"), using the mean curve for scaling furnishes the most accurate results (lowest value of mean error). Greater mean error values were obtained when a curve smoothed with a polynomial of the fifth and sixth degree was used in the scaling. Decidedly inferior estimation results were obtained when the curve was smoothed with a polynomial of the second, third and fourth degree.

Estimation of yield for a 200-day period using data from a 200-day period ("200 from 200") when the mean curve was employed for the scaling is even more accurate than in the previous case ("200 from 100") – and has the lowest mean error value. This is due to the estimation being based on the data for the entire period considered (200 days). In the case of using the mean lactation curve smoothed with polynomials of 2^{nd} to 6^{th} degree the largest mean value of the error was found for the estimation using a second degree polynomial. The most accurate estimation using polynomials turned out to be that in which a sixth degree polynomial was used (the lowest value of mean estimation error). Subsequent greater values of the mean estimation error were obtained for polynomials of the fourth, fifth, and third degree. The variance of yield estimation error shows similar values for all the cases considered (Table 1).

Although the smoothing of the lactation curve had a negative impact on exactitude of estimation, it could be particularly useful in cases when data for daily yields are not available, which is a frequent situation in breeding practice.

In order to generalize the results pertaining to milk yield the Duncan test (Żuk, 1989, p. 126) has been used to compare the mean values. First the uniformity of variance was checked (see data in Table 1) by means of the Bartlett test (Kala, 1999,

p. 85). Since positive results were obtained – error variances were uniform both for the results compared in columns as well as in rows – the Duncan test could be applied. Consequently, the results of the mean value of milk yield error (Table 1) for the columns and rows of this table were compared.

Comparisons of values in particular rows in Table 1 make it possible to establish whether the modes of yield estimation differ from one another. In other words: Is it possible to estimate a 200-day yield using data for a 100-day period? The only estimation which shows highly significant differences was the one where a second degree polynomial has been used. Estimation by means of measurements from a 100-day period is even more accurate. This is so because of a shorter time span between consecutive test yields. The results in the remaining columns of Table 1 do not differ significantly, which confirms that it is possible to estimate a 200-day yield on the basis of test yields from the first 100 days of lactation.

From a comparison of the mean values of the estimation error for the estimation of a 200-day yield on the basis of test yields from the 100-day period ("200 from 100" – row 1 of Table 1) it follows that there is a significant difference between estimations performed using a mean curve and polynomials of the second, third and fourth degree.

From a comparison of the mean values of estimation errors in case of estimating a 200-day yield with data for the 200-day period ("200 from 200" – row 3 of Table 1) it follows that there is a highly significant difference between estimations using polynomials of the sixth and second degree, polynomials of the fourth and second degree, polynomials of the fifth and second degree, and of the third and second degree.

An average lactation curve and differences between it and individual yields have also been used by Jaffrezic et al. (2002). A similar approach to that of Perz (1998) to the assessment of modelling individual lactation curves for cows is represented by Koonawootrittriron et al. (2002).

4. Conclusions

For the group of individuals studied the accuracy of total 200-day milk yield estimation by the method presented, using data from the first 100 days of lactation is comparable to the accuracy attained when test yields span the whole 200-day period. This suggests that the scaling method could enable the estimation of yields over a longer period by using data from shorter periods, encouraging further, broader study, encompassing more cows.

If data for the construction of the complete mean lactation curve are not available, the scaling method still enables the estimation of yields for a longer period by smoothing the curve with polynomials. Polynomials of higher degrees (third upward) are particularly suitable for this purpose.

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Dokładność oceny 200-dniowej wydajności mlecznej krów na podstawie udojów próbnych z okresu 100-dniowego

STRESZCZENIE

Porównano dokładność szacowania 200 dniowej wydajności mlecznej krów na podstawie czterech udojów dziennych z okresu początkowych 100 dni laktacji oraz określonej za pomocą 4 wydajności dziennych z okresu 200 dniowego. Do badań wykorzystano wydajnosci codzienne. Wyliczono względny błąd szacowania wydajności mlecznej dla 100 i 200 dni laktacji dla każdej krowy (w stosunku do wydajności rzeczywistej otrzymanej ze zsumowania wydajności codziennych), średni błąd szacowania oraz wariancję błędu dla tych szacowań. Średnia wartość błędu szacowania wydajności 200-dniowej za pomocą udojów z okresu 100-dniowego była porównywalna ze średnią wartością błędu szacowania wydajności 200-dniowej za pomocą udojów próbnych z całego okresu 200-dniowego. Wariancja błędu okazała się nawet mniejsza dla szacowania wydajności okresu 200 dniowego za pomocą udojów z okresu 100-dniowego. Sugeruje to, że w zaprezentowany w pracy sposób można szacować wydajność w dłuższym okresie na podstawie wydajności z okresu krótszego.

SŁOWA KLUCZOWE: krzywa laktacji, wydajność mleczna.