ACCURACY OF ESTIMATION OF BREEDING VALUE USING SIMPLIFIED MILK RECORDING SYSTEMS

Exactitude de l'estimation de la valeur d'élévage employant systèmes de contrôle laitier simplifiés

Exactitud de la estimación del valor de cría empleando sistemas de control lechero simplificados

O. MADSEN *
L. G. CHRISTENSEN **

INTRODUCTION

In most countries the official milk recording system is based on monthly tests. Each test is performed by weighing the milk from evening and morning milking. Normally fat tests are made on a joint sample from evening and morning milking. Normally fat tests are made on a joint sample from evening and morning milkings. In the present paper this system will be referred to as the standard system.

Basically the aim of a simplified milk recording system is to predict total lactation with yield at a lower cost than in the standard system.

PREDICTORS OF LACTATION YIELD

In the standard system a weighted sum of daily tests is used as a predictor of total yield:

$$P = \sum_{i=1}^{n} d_i Y_i \qquad [1]$$

where

P = Estimated lactation yield.
Y = Test yield.
d = Number of days, which the daily test is taken to represent.
n = Number of tests.

* Institute of Animal Science, The Royal Veterinary and Agricultural University, 23 Rolighedsvej, 1958 Copenhagen V, Denmark.
** National Institute of Animal Science, Department of Cattle Experiments, 25 Rolighedsvej, 1958 Copenhagen V, Denmark.

Thus when 10 tests are performed at regular intervals during the lactation the weight factors (d_i's) will all have a value near 30.

In simplified recording systems the number of tests during the lactation be decreased; it may be performed by alternative morning/evening weighing of milk instead of weighing milk both morning and evening. In both cases, however, the new predictor of lactation yield (P^l) may be written

$$P^l = \sum_{i=1}^{n^l} d_i{}^l Y_i \qquad [2]$$

Also in [2] the weightfactors (d_i's) are the number of days, which the daily test is supposed to represent. Thus in this paper no attention will be paid to multiple regression predictors.

In the following discussion it will be assumed that P and P^l are predictors of the same trait. This is equivalent to considering P and P^l as predictors of two separate traits with a genetic correlation of 1 and equal additive genetic variance.

Single lactations

Lactation yield calculated from a simplified system (P^l) is equal to lactation yield calculated from the standard system (P) plus the difference between yield calculated from the two systems (L)

$$P^l = P + L$$

The phenotypic variance of P^l is

$$\sigma^2_{Pl} = \sigma^2_P + \sigma^2_L + \sigma_{PL} \qquad [3]$$

Assuming that P and L are uncorrelated [3] can be written

$$\sigma^2_{Pl} = \sigma^2_P + \sigma^2_L \qquad [4]$$

The phenotypic variance of the standard method is well known. As the variance of the deviation between this method and simplified methods has been calculated in several investigations the phenotypic variance of simplified methods can be calculated from [4].

When selection is done on basis of yield in a single lactation the accuracy of evaluation of breeding value in the standard milk recording system is $r_{IA} = \sqrt{h^2} = \sqrt{\sigma^2_A/\sigma^2_P}$ where σ^2_A = the additive genetic variance.

The accuracy of estimation of breeding value in the simplified system is $r^l_{IA} = \sqrt{\sigma^2_A/\sigma^2_{Pl}}$. As the additive genetic variance is assumed to be the same in the two systems, the relative efficiency (E) of the simplified system is

$$E = r^l_{IA} / r_{IA} = \sqrt{\sigma^2_P / \sigma^2_{Pl}} \qquad [5]$$

Defining k_o as the ratio between phenotypic variance of the simplified system and phenotypic variance of the standard system [5] can be written

$$E = \sqrt{1 / k_o}$$

For a fixed population and a fixed recording system k_o is a constant.

Repeated lactations

Accuracy of estimation of breeding value in the standard system is

$$r_{IA} = \sqrt{\frac{n \cdot h^2}{1 + (n-1)\, r}}$$

where

n = Number of lactations.
h^2 = Heritability in the standard system.
r = Coefficient of repeatability in the standard system.

The accuracy in the simplified system is

$$r'_{IA} = \sqrt{\frac{n\, h'^2}{1 + (n-1)\, r'}}$$

where

h'^2 = Heritability in the simplified system.
r' = Coefficient of repeatability in the simplified system.

Assuming that the covariance between yield in different lactations is unchanged, when the milk recording system is changed, the new coefficient of repeatability can be written

$$r' \cdot \sigma^2_p / \sigma^2_{pl} = r / k_o$$

The relative efficiency of the simplified system then becomes

$$E = \sqrt{\frac{1}{k_o} \cdot \frac{1 + (n-1)\, r}{1 + (n-1)\, r / k_o}} = \sqrt{\frac{1 + (n-1)\, r}{k_o + (n-1)\, r}} \qquad [6]$$

Using [6] the relative efficiency for varying values of k_o and varying number of lactations was calculated. At the calculation the original coefficient of repeatability was fixed at 0.4. Results are given in Table 1.

TABLE 1

RELATIVE EFFICIENCY OF SIMPLIFIED RECORDING SYSTEMS FOR EVALUATION OF COWS ON BASIS OF REPEATED LACTATIONS

	Number of lactations					
k_o	1	2	3	4	5	6
1.05	0.98	0.98	0.99	0.99	0.99	0.99
1.10	0.95	0.97	0.97	0.98	0.98	0.98
1.15	0.93	0.95	0.96	0.97	0.97	0.98
1.20	0.91	0.94	0.95	0.96	0.96	0.97
1.25	0.89	0.92	0.94	0.95	0.96	0.96
1.30	0.88	0.91	0.93	0.94	0.95	0.95
1.35	0.86	0.89	0.92	0.93	0.94	0.95
1.40	0.85	0.88	0.91	0.92	0.93	0.94

PROGENY TESTING

Under the same assumptions as used above, the relative efficiency of progeny test of bulls using simplified recording systems can be written as

$$E = \sqrt{\frac{(n-1)\,h^2 + 4}{(n-1)\,h^2 + 4k_o}} \qquad [7]$$

where

n = progeny group size.

By means of formula [7] the relative efficiency was calculated for varying values of k_o and varying progeny group size. The heritability was fixed at 0.25. Results are given in Table 2.

TABLE 2

RELATIVE EFFICIENCY OF SIMPLIFIED RECORDING SYSTEMS FOR EVALUATION OF BULLS ON BASIS OF PROGENY TESTING

	Progeny group size					
k_o	20	30	40	60	80	100
1.05	0.99	0.99	0.99	0.99	1.00	1.00
1.10	0.98	0.98	0.99	0.99	0.99	0.99
1.15	0.97	0.97	0.98	0.98	0.99	0.99
1.20	0.96	0.97	0.97	0.98	0.98	0.99
1.25	0.95	0.96	0.97	0.97	0.98	0.98
1.30	0.94	0.95	0.96	0.97	0.98	0.98
1.35	0.93	0.94	0.95	0.96	0.97	0.98
1.40	0.92	0.94	0.95	0.96	0.97	0.97

However, in a progeny test the accuracy can always be maintained by increasing the progeny group size. The number of daughters, which are needed to get the same accuracy from simplified recording systems as from standard recording can be calculated from [8].

$$n' = k_o \, n \frac{4\text{-}h^2}{4\text{-}h^2 \,/\, k_o} \qquad [8]$$

As the fraction in (8) is quite near 1, even though h^2 and k_o is varied considerably, n' with good approximation is equal to $k_o \cdot n$.

CUNNINGHAM and VIAL (1968) were examining accuracy of progeny test from the viewpoint of variance components in the analysis of variance. The outcome of that study is in fact identical to what is found in the present study as can be shown by algebraic rearrangement of [8].

CALCULATION OF RELATIVE EFFICIENCY (NUMERICAL EXAMPLE)

Table 3 gives an example of calculation of relative efficiency of simplified recording systems. The variances of the differences between yield calculated from monthly milk recording and yield calculated from simplified recording systems are taken from IPSEN and KJELDSEN (1973).

TABLE 3

RELATIVE EFFICIENCY OF EVALUATING COWS AND BULLS USING SIMPLIFIED RECORDING SYSTEMS
(Numerical example)

Recordings per lactation	σ^2_L		k_o		Relative efficiency			
					Bulls, 80 daught.		Cows, 3 lactations	
	Milk	Butterfat	Milk	Butterfat	Milk	Butterfat	Milk	Butterfat
6	34.000	88	1.04	1.10	1.00	0.99	0.99	0.97
4	68.000	193	1.08	1.21	0.99	0.98	0.98	0.95
3	124.000	324	1.15	1.36	0.99	0.97	0.96	0.91

The variances of milk yield are of same magnitude as found in previous investigations (CUNNINGHAM and VIAL, 1968; EVERETT *et al.*, 1968). The phenotypic variances in the standard recording system are taken to be 800,000 Kg^2 milk and 900 Kg^2 butterfat.

From Table 3 it appears that the relative efficiency in evaluation of breeding value for milk production is higher than the relative efficiency in evaluation of breeding value for production of butterfat. This difference is not necessarily universally true as the relative magnitude of σ^2_L for yield of butterfat is based exclusively on the investigation by IPSEN and KJELDSEN (1973).

Of course the relative efficiencies in Table 3 will only be true, when the breeding structure is the one given in the table. Thus, if progeny groups are bigger than 80 daughters, and cows have more than 3 lactations, the relative efficiencies will be higher than the figures given in table 3. However, changes will be small, if the breeding structure is not changed drastically from what is assumed in Table 3.

Relative genetic gain

Under the assumption that around half of the genetic gain in the population comes from bulls and half from cows, realistic estimates of the relative genetic gain in the whole population can be calculated. Results for bimonthly, trimonthly and quarter-monthly recording are given in Table 4.

TABLE 4

Relative genetic gain using different simplified recording systems

	Selection criteria	
Interval between recordings	Milk yield	Butterfat yield
2 months	99	98
3 months	98	96
4 months	97	94

The results applies, if only recording systems are changed. It is however, realistic to assume that more cows will be recorded, if recording systems are simplified. In that case the relative genetic gains will be greater than shown above.

Discussion

Relative genetic gain using simplified recording systems was previously estimated by Keown and Van Vleck (1971). In that investigation no restrictions were applied regarding equality of genetic variance for different recording systems, and the genetic correlation between recording systems did not necessarily have to be unity. However, no attention was paid to breeding structure in that investigation. Relative genetic gain was calculated, as if only individual selection was performed in the population. In the present investigation more assumptions were made. This was inevitable in order to examine the role of the breeding structure.

The assumption that the additive genetic variance is the same in different recording systems is probably justified, if at least 3 or 4 tests are taken at regular intervals during the lactation. In that case the effect of the same genes are measured using different systems, and the additive genetic variance can logically not be changed very much.

Van Vleck and Henderson (1961) showed that the genetic correlation between predictors of lactation yield of the type discussed in this paper is very close to unity. Thus also this assumption seems justified.

The other two assumptions, which were used in the present paper: no correlation between P and L in [3] and no change of covariance between yield in repeated lactations, when recording systems are changed, cannot easily be checked. The main results of the present study will, however, not be changed drastically, if these assumptions are not perfectly fulfilled.

The results by KEOWN and VAN VLECK (1971) are similar to results concerning selection for milk in the present paper. The results concerning selection for butterfat cannot be checked against any result from the literature.

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