RELIABILITY OF COW'S BREEDING VALUE FOR AVERAGE LIFE-TIME PRODUCTION

J. Přibyl and J. Přibylová

Res. Inst. Anim. Prod. Uhříněves, P.O. Box 1, 104 01 Praha 10, Czech Republic

INTRODUCTION

The estimation of breeding value is assessed with an error minimized by the test set-up, appropriate production recording and methodology of data evaluation. Reliability of the estimated constants is determined by inversion of left hand side matrix of the system (Searle, 1971 ; Henderson, 1984). The reliability is contained in breeding value. Thereby, it is of less importance for the actual animal selection. The main use of this coefficient is in design of the milk recording collection and the procedure for the data evaluation to minimize the expected error.

The variability of breeding value and production deviation from contemporaries was described by Přibyl (1986). The formula for the error of breeding value estimation depending on the number of tested bulls and number of herds was derived by Herrendörfer *et al*. (1974). Effect of the relationship among the animals on reliability of breeding value was studied by Mostager (1970 and 1971). The influence of the HYS size, number of non-related contemporaries and the incidence of direct comparison of tested animals within the HYS at a different level of heritability were studied by Tosh, Wilton (1994). Schmitz *et al*. (1991) showed, that the prolongation of HYS leads to increase of uncontrolled variability.

Cow selection is aimed at average life-time milk production. Prediction of the breeding value for the average life-time production according to the known first lactations can be attained only with partial reliability (Přibyl and Přibylová, 2001).

The goal of this study was to estimate the expected reliability of breeding value for average life-time milk production of the cow depending on the number of contemporaries within HYS and a variable number of paternal half-sisters.

METHODS

Breeding value for first lactation. The reliability of breeding values is simulated using an animal model. Only the first lactations and two effects - HYS and animal, are considered. The cow is compared to a variable number of contemporaries within the herd that are not related to her. Her father and fathers of contemporaries have also daughters in the other herds, one daughter in each of them. All the herds are of the same size.

The reliability is stated from the inverse of the coefficient matrix. With the increasing number of individuals within the HYS, it is prolonged which results in the higher unexplained residual variability, while the genetic variability remains constant. The milk production variability within the HYS with *n* animals is given by the function :

$$\sigma^2_n = 0.43323832 + 0.00759844 \cdot n - 0.00070867 \cdot n^2 + 0.00004240 \cdot n^3 - 0.00000096 \cdot n^4$$

Reliability according to 3 lactations. Average of life-time production is predicted from the first 3 lactations (Přibyl and Přibylová, 2001). The reliability is established iteratively on the basis of selection index, by which we simulate MT – AM with relationship over 3 generations (both parents known). Each cow has contemporaries within the herd, which are not related to each other. Each dam has only one producing daughter. Each sire has (z) daughters, each in a different herd. The size of all herds is the same. The phenotypic variances and covariances are corrected for the variability depending on the HYS length, effective number of observations within HYS (Přibyl, 1986) and reliability of parental breeding values (Přibyl and Přibylová, 1996) .

The total corrected variability is :

$$\sigma^2_P = (\sigma^2_n - r^2_J \,.\, \sigma^2_g) / w$$

where r^2_J - reliability of proband

σ^2_g - genetic variability

w - effective number of observations within HYS

Index for the sire is based on combination of partial indexes of (z) daughters by their reliabilities (Přibyl and Přibylová, 1998). For the value of the sire's and dam's reliabilities we substitute in the previous step calculated values of cows and bulls. For the given size of the herd and the given number of daughters of sire, the entire sequence is iteratively repeated three times (3 generations of ancestors). Genetic and economic parameters (discounted economic values) are adopted from Dědková, Wolf (2001) and Přibyl and Přibylová (2001).

RESULTS AND DISCUSSION

Reliability of the breeding value in the first lactation. Table 1 represents the case, when all contemporaries are progeny of the same sire. If the cow and her contemporaries do not have any half-sisters, reliability of the breeding value estimation increases depending on the number of contemporaries from 0.16 to 0.260. With the increasing number of half-sisters it rises up to 0.326. The increment in both respects is a progressively less information-rich curve.

Table 1. Reliability of the breeding value estimation of a cow in the first lactation. All contemporaries are progeny of the same sire

Contemporaries	Paternal half-sisters								
	0	10	20	30	40	50	60	80	100
1	0.160	0.207	0.225	0.234	0.240	0.244	0.247	0.251	0.253
3	0.226	0.264	0.278	0.286	0.290	**0.294**	**0.296**	**0.299**	**0.301**
5	0.245	0.280	**0.293**	**0.300**	**0.305**	0.308	0.310	0.313	0.315
9	0.257	0.290	**0.303**	0.310	0.314	0.317	0.319	0.322	0.324
15	0.260	0.292	**0.304**	0.311	0.316	0.319	0.321	0.324	**0.326**

In regard to the number of contemporaries only, the critical limit is 3 to 5. Beyond this minimal limit, the increment in reliability with the increased amount of information is negligible. In the breeding value estimation, the sire is practically always known. If it reaches several tens of daughters (30 and more) then, for the cow evaluation, he becomes more important than the numbers of contemporaries within HYS. Bold numbers in table 1 show combinations of the numbers of contemporaries and half-sisters, in which 90 % of the maximum attainable value of reliability has been exceeded.

The given case is the lower limit of the attained reliability, for which we presumed that all the contemporaries are related to the same sire. The lower the relationship between contemporaries, the higher is the reliability value. When contemporaries were unrelated it reached up to $r^2 = 0.399$, which is by 22 % more in comparison with previous case. In the field, the reliability is between the given extremes, because the contemporaries are to a certain degree always related. These results agree with Tosh and Wilton (1994).

In order to predict the reliability of breeding value for average of life-time production, a multiplication of listed values by 0.90 is needed (Přibyl and Přibylová, 2001).

The reliability of prediction the life-time production from first three lactations. Breeding goal is the highest possible production during cow's life span. All contemporaries are not related to each other. 3 generations of ancestors were used for the evaluation and previous generations have an equal structure and amount of information as the youngest generation.

Table 2. Reliability of the breeding value estimation of the sire for the average life-time production

Contemporaries	Daughters							
	10	20	30	40	50	60	80	100
1	0.436	0.581	0.663	0.717	0.755	0.783	**0.822**	**0.849**
3	0.534	0.670	0.742	0.786	**0.817**	**0.839**	0.869	0.889
5	0.556	0.689	0.758	0.801	**0.829**	0.850	0.878	0.897
9	0.570	0.701	0.768	0.809	**0.837**	0.857	0.884	0.901
15	0.572	0.703	0.770	0.810	**0.838**	0.858	0.885	**0.902**

Table 3. Reliability of the breeding value estimation of the cow for the average life-time production

Contemporaries	Paternal half-sisters								
	0	10	20	30	40	50	60	80	100
1	0.195	0.331	0.363	0.382	0.395	0.403	0.41	0.419	0.425
3	0.287	0.436	0.457	0.471	0.480	**0.485**	**0.490**	**0.495**	**0.499**
5	0.315	0.463	**0.482**	**0.495**	**0.503**	0.508	0.512	0.517	0.520
9	0.333	0.479	**0.498**	0.510	0.517	0.522	0.525	0.530	0.533
15	0.337	**0.483**	0.501	0.513	0.520	0.525	0.528	0.533	**0.535**

Sires, 3 lactations. Reliabilities for the average of life-time production are given in table 2. They increase from $r^2 = 0.436$ in case of 1 contemporary within HYS and 10 daughters up to $r^2 = 0.902$ with 15 contemporaries within HYS and 100 daughters, each with 3 lactations. Due to consideration of generations of ancestors, at a low quantity of information (progeny and contemporary) a relatively high reliability has been reached already. After the number of contemporaries in the herds reached 5, the reliability does not appreciably change with increasing of numbers. 90 % of maximal reliability is exceeded at 80 daughters and only 1 contemporary within HYS, or 50 daughters and 3 contemporaries. As the number of daughters increases the effect of contemporaries becomes less apparent. Considering that there usually are sufficient number of progeny in sire testing, it is permissible to have a small number of contemporaries in herds (about 3) without any obvious effect on the resulting reliability of the breeding value estimation.

Cows, 3 lactations. Reliabilities are shown in table 3. In the isolated evaluation of the herd, the breeding value for life-time production is predicted with reliability from 0.195 to 0.337. The reliability increases up to 0.535 with inclusion of parents. Upon exceeding the number of contemporaries in the herd by 5 and number of half-sisters by 20, the reliability of the cow's breeding value rises only a little with information input.

CONCLUSION

1. By utilizing yield in the first 3 lactations and maximizing other information, including 3 generations of ancestors, attainable reliability of the breeding value prediction for the average life-time production of cow is $r^2 = 0.535$ (analogous value for sire is 0.902).
2. Reliability of the breeding value estimation increases in case the contemporaries are not related.
3. If the number of half-sisters exceeds about 50 half-sisters, at least 90 % of maximal attainable value of reliability is attained, practically regardless the contemporary number within the herd.
4. After reaching 5 contemporaries within HYS, the further increment of reliability is small.
5. Regarding the cow's breeding value reliability, it is possible to substitute the number of contemporaries by a higher number of half-sisters.

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