Calculation of Interbull Weighting Factors for the Finnish Test Day Model

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Introduction

Interbull has given a new procedure to calculate weighting factors for use in international genetic evaluations (Interbull, July 2000 mimeo). The procedure consists of two steps. Step 1 calculates the reliability based on an animal's own performance records. Step 2 uses this reliability of progeny and mates to calculate a weight for each bull.

The Step 1 of the new procedure cannot be applied as such for the Finnish test day model. The multiple trait multiple lactation random regression test day model that is used in Finland (Lidauer et al., 2000) does not easily translate to the notation used to describe Step 1 for either of the alternatives, multiple trait or repeatability model, presented. The genetic and permanent environmental variance-covariance matrices are used for parameters of a lactation curve while the residual and herd-test-day random effects correspond to test day yields. Consequently, sizes of the matrices do not match.

In the following, an alternative procedure, that replaces Step 1, is described. The procedure is used for the Finnish test day model and it is similar to that used for the Canadian test day model (Schaeffer et al, 2000). The main difference between the proposed and the Canadian procedure, in addition to differences in model, is that of accounting for effects of contemporary groups in a different manner.

Calculation of weighting factors for a random regression test day model

The Interbull procedure for weighting factors for the genetic evaluation has two steps. In Step 1, reliability based on own performance is estimated. In Step 2, sources of information are combined and, most importantly, weighting factors for sires are computed. Because the second step does not pose any problems, the following will only consider Step 1.

Step 1 of the Interbull procedure for the Finnish test day model

The fundamental idea in the interbull procedure of Step 1 is to account the most important factors that affect reliability. Step 1 considers proportion of genetic variability in the trait, repeatability of the trait over several lactations as well as size of the contemporary comparison group. These factors can be most easily accounted by noting that the reliability and prediction error variance (PEV) are directly related. Calculating the inverse of the mixed model equations in order to obtain PEV is, however, impossible in our case. Hence, some approximation is needed.

The effects included in the approximation of PEV were herd-test-day (HTD), animal genetic random regression (RR), and permanent environmental RR equations in coefficient matrix of the mixed model equations (MME). Two permanent environmental effects are in use: one for within lactations (w) and repeated over all lactations, another for within each of the later lactations (L).

Let the coefficient matrix part in the MME for individual *i* be $\mathbf{C}_i = \begin{bmatrix} \mathbf{C}_{i,g} & \mathbf{C}_{i,gp} \\ \mathbf{C}'_{i,gp} & \mathbf{C}_{i,p} \end{bmatrix}$ where $\mathbf{C}_{i,g} = \mathbf{Z}'_{i,g}\mathbf{R}_i^{-1}\mathbf{Z}_{i,g} + \mathbf{G}_0^{-1}$ is the submatrix for animal genetic equations with $\mathbf{Z}_{i,g}$ having the RR coefficients pertaining to individual *i* for

genetic effects and $\mathbf{G}_0^{-1}$ is the variance component matrix for the animal genetic effects, $\mathbf{C}_{i,gp} = \left[\mathbf{Z}'_{i,g}\mathbf{R}_i^{-1}\mathbf{Z}_{i,w} \quad \mathbf{Z}'_{i,g}\mathbf{R}_i^{-1}\mathbf{Z}_{i,L}\right]$ is the submatrix linking genetic equations to the permanent environmental equations with $\mathbf{Z}_{i,w}$ and $\mathbf{Z}_{i,L}$ having the RR coefficients pertaining to individual *i* for within and later permanent environmental effects, respectively, and $\mathbf{C}_{i,p}$ corresponding to the permanent environmental effects.

Two steps were performed in order to calculate PEV of cow *i*:

A) HTD was absorbed to $\mathbf{C}_i$: $\mathbf{C}_i^* = \mathbf{C}_i - \mathbf{F}_i\mathbf{H}_i^{-1}\mathbf{F}_i'$ where $\mathbf{H}_i$ is diagonal block for HTD equations for the herd in which cow *i* made her test day records, and $\mathbf{F}_i$ is matrix in the MME linking HTD to the $\mathbf{C}_i$ matrix. Note that any non-zero elements that should be generated between matrix blocks of different animals are ignored.

B) Permanental effect equations were absorbed to the animal genetic part: $\mathbf{B}_i = \mathbf{C}_{i,g}^* - \mathbf{C}_{i,gp}^*\left(\mathbf{C}_{i,p}^*\right)^{-1}\mathbf{C}_{i,gp}^{*\prime}$ where the $\mathbf{C}_{i,xx}^*$ matrix corresponds to appropriate submatrix of the $\mathbf{C}_{i,xx}$ after step A.

The breeding value sent to Interbull can be calculated as:

$$\text{EBV}_i = \mathbf{k}'\mathbf{a}_i$$

$$\text{V(EBV}_i) = g_i = \mathbf{k}'\mathbf{G}_0\mathbf{k}$$

where

$\mathbf{a}_i$ is a vector of estimated breeding values for animal *i*, and $\mathbf{k}$ is a vector with coefficients used to calculate a trait of interest. Now, PEV of the desired breeding value for cow *i* can be calculated as:

$$m_i = \mathbf{k}'\left(\mathbf{B}_i\right)^{-1}\mathbf{k}$$

Reliability based on data is calculated as:

$$R_i(o) = 1 - m_i / g_i$$

Discussion

Calculation of reliability through its relationship to PEV gave a procedure that is theoretically sound and computationally feasible. However, some further work needs to be done in order to quantify quality of the reliability values calculated by the proposed procedure although it is unlikely that accounting for other fixed effects in the model has any significant impact on the approximation. In addition, currently, time to compute reliabilities is about 40 hours. In contrast, it takes about 38 hours to estimate breeding values. The apparent slow performance of the reliability calculations is due to not accounting for parallelism in the computing procedure as done in the breeding value estimation. Further gain in computing power is expected to be quite easily achievable with additional programming.

Literature

Lidauer, M., Mäntysaari, E.A., Strandén, I. & Pösö, J. 2000. Multiple trait random regression test-day model for all lactations. *Interbull bulletin 25*, 81-86.

Schaeffer, L.R., Jamrozik, J., Kistemaker, G.J. & Van Doormaal, B.J. 2000. Experience with a test-day model. *J. Dairy Sci. 83*, 1135-1144.