SIMULATION STUDY ON THE EFFECTS OF INCORPORATING EXTERNAL GENETIC EVALUATION RESULTS

Z. W. Zhang, R.L. Quaas and E. J. Pollak
Department of Animal Science, Cornell University, Ithaca, NY 14853, USA

INTRODUCTION
Ideally a sire should be evaluated with all available data, however sometimes progeny data are not all submitted to the same evaluation centers. In such cases, sire rankings differ from one evaluation center to another due to both sampling of progeny data and differences in analytical methods.

Cunningham et al (1998) reported an example of such situation. There were 107 Angus bulls in the American Simmental Association (ASA) multiple breed system that also were published in the Fall 1997 Angus Sire Evaluation Report. The average accuracies for the Angus expected progeny differences (EPDs) were .98, .97, .96, and .93 for Birth Weight (BWT), Weaning Weight (WWT), Yearling Weight (YWT), and Maternal Milk (MMK). The average accuracies for the ASA EPDs were .38, .35, .35, and .30 for BWT, WWT, YWT, and MMK and EPDs were dissimilar.

Incorporating published external information provides another way to improve accuracy other than combining original data. The earliest effort can be traced back to the procedure by Henderson (1975). He described incorporation of sire evaluations from records of artificial insemination sired daughters in other herds into the intraherd predictions. Quaas (1979) gave a general derivation for Henderson’s procedure. Van Vleck (1982) obtained a different version of derivation for the purpose of teaching as well as for establishing the logical basis for an approximation in the procedure.

Quaas and Zhang (2001) presented a similar procedure in a Bayesian framework to incorporate external information. The purpose of this study is to investigate the effect of implementing the procedure using simulated data. In this procedure the external information is assumed to be contained in the external genetic evaluations and accuracies.

MATERIAL AND METHODS
Simulated data. Two populations (internal and external) were simulated with each consisting of parents and non-parents. Parents included 15 male founders and 20 female founders, as well as their progeny. The founders were randomly replaced by their progeny at each year with one year lag before mating. Females were randomly mated with males with exception of avoiding full sib and parent-offspring mating. All the female progeny were kept and half of male progeny were randomly culled. The maximum number of male and female mated each year were 20 and 30. The total number of years was 5.

Each female parent additionally produced 3 non-parent progeny with performance records. Parents did not have performance records themselves. The females in the external population were mated to external males with same age or older to reproduce external non-parent progeny. The internal females were mated to internal males and a subset of external males (called external sires) of the same age or older to reproduce the non-parent progeny of internal
population. External sires were randomly selected from the external males with frequency of 50%. External sire had 50% more progeny in external population than internal population on average.

Three traits – birth (BWT), weaning weight (WWT), and post weaning gain (PWG) –were simulated corresponding to the simulated pedigree. Genetic and environmental dispersion parameters were similar to those estimated from ASA data (Tables 1).

Table 1. Genetic/residual covariance

<table>
<thead>
<tr>
<th>Trait</th>
<th>BWT</th>
<th>WWT</th>
<th>PWG</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWT</td>
<td>37:61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WWT</td>
<td></td>
<td>1060:2982</td>
<td></td>
</tr>
<tr>
<td>PWG</td>
<td>52:50</td>
<td>446:218</td>
<td>723:2528</td>
</tr>
</tbody>
</table>

The two populations were replicated 160 times. The true breeding values and estimated breeding value (EBV) using the following best linear unbiased prediction (BLUP) procedures were investigated.

Joint: Regular BLUP with combined internal and external data;
Internal: Regular BLUP using internal data only;
External: Regular BLUP using external data only;
Incorporative: Incorporative BLUP with internal data and external estimated breeding values (EBVs) and accuracies. Constants were added to the external EBVs to simulate a base difference.

Computation: External information is incorporated under a Bayesian framework. The prior for external sires’ BV \( (u_i) \) is \( p(u_i) = N(\mu, \sigma^2) \) rather than the typical \( N(0, A \otimes G) \). The prior mean is \( \mu \) (external EBV) plus an unknown constant \( b \) to account for base differences; \( U \) is an incidence matrix indicating source of external information (here \( U = 1 \)). The prior variance \( (G_{11}) \) is an approximation of external prediction error variance:

\[
G_{11}^{-1} = A_{11}^{-1} \otimes G_0^{-1} + \Lambda
\]

where \( A_{11} \) is the inverse of the relationship matrix corresponding to external sires with progeny in the internal population, \( G_0 \) is genetic covariance among the traits analyzed, \( \Lambda \) is block diagonal \( \{\Delta_i G_0^{-1} \Delta_i\} \) with a block for each external sire. \( \Delta_i \) is the diagonal matrix with elements \( \sqrt{\delta_{ij}} \). For \( j^\text{th} \) trait of \( i^\text{th} \) external sire

\[
\delta_{ij} = R^2/(1-R^2) = \left[1-(1-\text{BIF})^2\right]/\left(1-\text{BIF}\right)^2
\]

where BIF is the Beef Improvement Federation’s measure of accuracy.

RESULTS AND DISCUSSION

To illustrate the relationship among estimates using the four procedures, the results of a single simulation was randomly chosen out of 160 replicates. The EBVs of external sire from the
four procedures are plotted in Figure 1 for WWT. External result is closer to joint than internal result since external sires had 50% more progeny on average in external population than internal population. Incorporative result is the most similar to the joint. The other traits (BWT and PWG) followed the same pattern.

![Figure 1. Estimated breeding values using joint, internal, external and incorporative procedures.](image)

To demonstrate overall result of 160 replicates, variant correlation coefficients of EBVs were calculated for each replicate. The means and standard deviations of the correlation coefficients on WWT over 160 replicates are presented in Table 2.

**Table 2. Means and standard deviations of correlation coefficients among true breeding values (BV) and estimates on WWT from joint, internal, external and incorporative procedures (160 replicates).**

<table>
<thead>
<tr>
<th>Approach</th>
<th>True BV</th>
<th>Joint</th>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint</td>
<td>0.64 ± 0.14</td>
<td>0.67 ± 0.14</td>
<td>0.89 ± 0.08</td>
<td>0.30 ± 0.24</td>
</tr>
<tr>
<td>Internal</td>
<td>0.42 ± 0.19</td>
<td>0.67 ± 0.14</td>
<td>0.89 ± 0.07</td>
<td>0.30 ± 0.24</td>
</tr>
<tr>
<td>External</td>
<td>0.58 ± 0.16</td>
<td>0.89 ± 0.08</td>
<td>0.67 ± 0.14</td>
<td>0.30 ± 0.24</td>
</tr>
<tr>
<td>Incorporative</td>
<td>0.64 ± 0.14</td>
<td>1.00 ± 0.01</td>
<td>0.67 ± 0.14</td>
<td>0.89 ± 0.07</td>
</tr>
</tbody>
</table>

The accuracy of external sires’ EBVs were dramatically improved using incorporative procedure compared to internal procedure. This is illustrated by WWT on the randomly chosen replicate (Figure 2). The averages of accuracies of external sires over 160 replicates are demonstrated in Table 3 for all the three traits.
Figure 2. Accuracies of external sires using procedures of joint (+), internal (■), external (○) and incorporative (♦).

Table 3. The means and standard deviations of accuracies of external sires A

<table>
<thead>
<tr>
<th>Trait</th>
<th>Joint</th>
<th>Internal</th>
<th>External</th>
<th>Incorporative</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWT</td>
<td>0.27 ± 0.09</td>
<td>0.13 ± 0.07</td>
<td>0.20 ± 0.07</td>
<td>0.29 ± 0.08</td>
</tr>
<tr>
<td>WWT</td>
<td>0.24 ± 0.08</td>
<td>0.11 ± 0.06</td>
<td>0.18 ± 0.06</td>
<td>0.25 ± 0.08</td>
</tr>
<tr>
<td>PWG</td>
<td>0.21 ± 0.07</td>
<td>0.10 ± 0.05</td>
<td>0.16 ± 0.06</td>
<td>0.23 ± 0.07</td>
</tr>
</tbody>
</table>

A There were 3812 external sires over 160 replicates.

CONCLUSION
The procedure incorporating external information (EBVs and accuracy) succeeded in ranking external animals more similar to the true breeding values and estimates using joint data set than internal and external procedure. The accuracy of incorporative was improved comparing internal procedure. The amount of improvement depends on external accuracy.

REFERENCES