From traditional EBVs to GEBVs - in Nordic and International evaluation

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Abbreviations

- **DGV (SNP effects)**
  - Direct Genomic Value

- **EBV (phenotypic registrations)**
  - Estimated breeding value

- **GEBV (SNP effects + phenotypic registrations)**
  - Genomic Enhanced Breeding value
International estimation of breeding values

MACE – Multi Across Country Evaluation
Nordisk Avlsværdi Vurdering • Nordic Cattle Genetic Evaluation

National EBVs based on phenotypes
National EBVs based on phenotypes + genomic information

Is MACE working based on genomic EBVs?
National EBVs based on fænotypes + genomic information

No!

What then?

Is MACE working based on genomic EBVs?
INTERBULL and genomic EBVs (GEBVs)

Goals:
• IB want to make GEBVs usable across countries

Challenges:
• Take genomic selection among young bulls into account – avoid possible selection bias and problems with INTERBULLs normal test criteria
• Avoid double counting of genomic information, if more countries deliver GEBVs for the same bulls
Distribution of young bulls EBVs without genomic selection

Young bulls – pedigree information
Reliability 31-38% - yield
Distribution of young bulls EBVs without genomic and the same bulls EBV, when they get a progeny test

Young bulls – pedigree information
Reliability 31-38% - yield

Note the average is the same!

Progeny tested bulls
Reliability 80-95%
Distribution of young bulls EBVs with genomic

Young bulls – pedigree information
Reliability 31-38% - yield

Note
standard
deviation
increases

Young bulls – with genomic information
Reliability about 50%
Distribution of young bulls EBVs after genomic

Young bulls – pedigree information
Reliability 31-38% - yield

Young bulls – with genomic information
Reliability about 50%

Note standard deviation among selected bulls decrease and average increase
Distribution of young bulls EBVs after genomic

Young bulls – with genomic information
Reliability about 50%

Note average increases and standard deviation a bit smaller due to genomic selection of young bulls
Which effect does it have on estimation of breeding values?

• Traditional without genomic selection of young bulls
  \[ \text{EBV-bull calf} = \frac{1}{2} \text{EBV-dam} + \frac{1}{2} \text{EBV-sire} \]

• With genomic selection of young bulls
  \[ \text{EBV-bull calf} > \frac{1}{2} \text{EBV-dam} + \frac{1}{2} \text{EBV-sire} \]
Which effect does it have on estimation of breeding values?

- Genomic selection ignored/unknown leads to bias in EBVs
- Genomic selection “destroy” normal assumptions in relation to validation of EBVs
Which effect does it have on EBVs?

- The challenge depends on:
  - Reliability of DGVs
  - Intensity of selection
What has to be done?

- Take genomic selection into account in estimation of EBVs
- Work is going on all over the world
- The problem is important 3-4 years ahead when the first genomic selected bulls get lactating daughters
Problems with MACE and genomic information

- Genomic information about the same bull can be included from more countries. The normal MACE will double count the genomic information – as to independent tests even though the same genomic information is used.

- GMACE a method to avoid double counting of genomic information.
National EBVs based on fænotypes + genomic information

GMACE (Genomic MACE)
INTERBULL trend validation

Basis – 2 runs:

• Run including all data
• Run including all data minus the last four years of data

• Compare genetic trend – has to be equal – it means EBVs for proven bulls has to be stable when getting 2nd batch daughters
INTERBULL test – phenotypic registration

EBVs

All data minus 4 years

Test - genetic trend has to be the same!

Bulls birth year

95 96 97 98 99 00 01 02 03 04
INTERBULL test – genomic data?

EBVs

Genomic information no data

Data

Bulls birth year

95  96  97  98  99  00  01  02  03  04  05  06  07 08 09
INTERBULL test – Genomic information

EBVs

Genomic information
no data

Data

Bulls birth year


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INTERBULL TEST – Genomic information

EBVs

Genomic information
no data

Data

95 96 97 98 99 00 01 02 03 04 05 06 07 08 09

Bulls birth year

Test – genetic trend has to be the same!

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**INTERBULL TEST – Genomic information**

- EBVs
- Bulls birth year
- Data
- Genomic information
  - no data
  - weak relevant young bulls is born in 2008!!

Test – genetic trend has to be the same!
INTERBULL validation - genomic

Challenge 4 youngest birth years of bulls have only genomic information no daughters with data!
INTERBULL validation - genomic

Challenge 4 youngest birth years of bulls have only genomic information no daughters with data!

Basis – 2 runs:

• Run including all data
• Run including all data minus the last four years of data
• Compare genetic trend – has to be equal – it means GEBVs has to be stable when getting daughters
# INTERBULLs plan for GMACE

<table>
<thead>
<tr>
<th>Time schedule</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn 2009</td>
<td>Set up validation criteria</td>
</tr>
<tr>
<td>December 2009</td>
<td>GMACE ready for use</td>
</tr>
<tr>
<td></td>
<td>Request for data for validation and GMACE pilot run</td>
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<tr>
<td>January-February 2010</td>
<td>Pilot run GMACE</td>
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<tr>
<td>March 2010</td>
<td>Discussion of GMACE results</td>
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<tr>
<td>May 2010</td>
<td>GMACE test run</td>
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<tr>
<td>August 2010</td>
<td>GMACE routine run</td>
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</tbody>
</table>
NAV plans

1. Combine PA and DGV for young genomic tested animals (end 2009 - start 2010)
2. Blend DGV in the traditional NAV evaluation for all animals (work started – end spring 2010)
3. Investigate possibilities to improve the methods further? (2009 - 201?)
NAV plans

• Change from unofficial DGVs and official EBV’s (today) to official GEBVs (spring/summer 2010)

• Participate in INTERBULL test run with GEBVs in Mai 2010
Critical point in relation to blending

• Robustness of DGV
• Reliability of DGV – same for all animals/different from animal to animal?
Critical points in relation to GEBV

- Comparison of genomic tested one year old bulls and bulls with lactating daughters
  - Stability of DGV
  - Reliability of DGV
  - PA unbiased – bull dams are critical
German INTERBULL paper 2009

Best use of conventional EBV of bull dams and combination with direct genomic values

Dr. Stefan Rensing, Erik Pasman, Fritz Reinhardt, Vereinigte Informationssysteme Tierhaltung w.V. (vit), Verden/Germany
German Interbull paper 2009

• Overestimation of parent average (PA) for highly selected young bulls at least for production traits is it obvious
• Most probably due to over-estimated dam EBVs (preferential treatment)
• Question of unbiased PA has become new dimension in time of GEBVs. PA has high impact on combined genomic EBVs this high impact remains for longer time for animals without daughter information
German INTERBULL paper 2009

- SCC
  - Difference PA-EBV = 0,0
- Protein
  - Difference EBV-PA =-16,1 kg
  - Difference EBV-PA-only sires= -1,7 kg

Same results in Nordic countries
German INTERBULL paper 2009

- Bull dams own records for yield will lead to bias in PA and GEBV

- Critical for a fair comparison of genomic tested one year old bulls and bulls with lactating daughters!!
What to publish in Nordic countries?

- GEBVs – the future combination of information from DGV and EBV
- Esa will tell you how it can be done
Summary international

- Ignoring of genomic selection in EBVs create bias
- Genomic selection means that normal assumption in estimation of BV do not hold any more
- GMACE in 2010
- MACE has to continue
Summary – NAV plans

• NAV routine GEBV in 2010 assumptions:
  • Robust DGV
  • Knowledge about reliability of DGV
  • Bull dam information has to be looked at critically

Can it be fulfilled for all breeds?
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Traditional MACE

We still need MACE, since INTERBULL EBVs are used to increase number of bulls in the reference-group to improve predictions formulas for DGVs – has to be improved constantly
INTERBULL and the future

Exchange of SNP information between countries for all relevant young bulls are more efficient than GMACE. It means:

• A Nordic GEBV bull gets highest reliability on US scale by using US predictions formulas directly to calculate US DGV

and

• A US bull get highest reliability on Nordic scale by using Nordic predictions formulas directly to calculate Nordic DGV
INTERBULL and future

INTERBULL’s role:

• Short run - GMACE for international EBVs and traditional MACE for prediction formulas
• Long run ??
  • INTERBULL host calculation of prediction formulas
  • or INTERBULL partly superfluous
  • or role of national organizations are changed ?
Bull dams in reference population

• Note: several countries has found that bull dams in reference population do not increase reliability of genomic solutions

• Reason – presumably overestimation!

## Although I believe that equally large reason is the low accuracy of female EBVs
• You concentrated more on genetic trend
• I see 2 other Interbull expectations:
  • The consistency of GEBVs compared to EBVs
    If the accuracy (i.e. STD(GEBV)) is not consistent with r2 of EBVs, then the regression of current EBVs on GEBVs minus 4 years is not valid
  • The general accuracy of GEBVs.
    As ITB has to ”bless” the GEBVs to be usable in international trade, ITB has to approve the GEBVs accuracy. Currently only material that has r2 >0.5 can be exported. And there is no rule to judge that!
Esa’s own opinion: INTERBULL will have equally or more important role as a reference lab, even when countries will start more to calculate their own GEBVs - If countries would only import, then the ”company vision” could be possible, but since they also want to export, a international reference organization is needed.