Genetic variation in macro- and micro-environmental sensitivity for milk yield in Swedish Holsteins

Acknowledgement

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- www.robustmilk.eu
- The Swedish Dairy Association (Svensk Mjölk, Stockholm, Sweden)
Introduction
What is macro- and micro-environmental sensitivity?

- Genetics of macro-environmental sensitivity
  - Environmental change is known, e.g. feed, soil, herd
  - Measured as G x E (e.g. rg) or slope of a reaction norm

- Genetics of micro-environmental sensitivity
  - Environmental change is unknown; can be animal specific
  - Measured as difference in environmental variance
Introduction: empirical evidence

- Genetic variation in macro-environmental sensitivity
  - Genotype by environment interaction
  - Many studies have found non-unity genetic correlations
  - Significant variance in slope of reaction norm

- Genetic variation in micro-environmental sensitivity
  - Genetic heterogeneity of environmental variance
    - Hill and Mulder (2010)

- Not much known about relationship between both types of environmental sensitivity
Objective

- To estimate genetic variance in macro- and micro-environmental sensitivity in Swedish Holsteins

- To estimate genetic correlations between macro- and micro-environmental sensitivity
  - Lactation milk yield
Material and Methods

- Swedish Holsteins
- 142,565 first lactation records
  - 305-day milk yield calculated with Test Interval Method
- 762 sires; at least 2 generations of male ancestors were traced back for sires
  - On average 187 daughters per sire
The quantitative genetic model

- Combine linear reaction norm with heterogeneous environmental variance

\[ P = \mu + A_{int} + A_{sl}x + \exp(\sigma_E^2 + 0.5A_v)e \]

\[ G = \begin{bmatrix} \sigma_{A_{int}}^2 & \sigma_{A_{int}, A_{sl}} & \sigma_{A_{int}, A_v} \\ \sigma_{A_{sl}}^2 & \sigma_{A_{sl}, A_v} \\ \sigma_{A_v}^2 \end{bmatrix} \]

- \( A_{int} \) = breeding value for intercept
- \( A_{sl} \) = breeding value for slope of linear reaction norm
- \( A_v \) = breeding value for environmental variance
Statistical model

- DHGLM in ASREML (Rönnegård et al., 2010; Felleki et al., 2012)
- Sire model – most information comes from half-sibs in different environments (Mulder et al., 2013; GSE 45:23)
- \( \mathbf{y} = \mathbf{Xb} + \mathbf{Zs}_{\text{int}} + \mathbf{Zx}s_{\text{sl}} + \mathbf{e} \)
  - Herd-year mean was used as covariate in reaction norm
- \( V(\mathbf{e}) = \exp(\mathbf{Xb} + \mathbf{Wh}_v + \mathbf{Zs}_v) \)
  - Random herd-year-season effect
- Algorithm iterates between both models until convergence
Results

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Se</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_{A_{sl}}^2$</td>
<td>11096</td>
<td>2288</td>
</tr>
<tr>
<td>$\sigma_{A_{av}}^2$</td>
<td>0.043</td>
<td>0.008</td>
</tr>
<tr>
<td>$r_{A_{A_{int,Asl}}}$</td>
<td>0.808</td>
<td>0.062</td>
</tr>
<tr>
<td>$r_{A_{A_{int,Av}}}$</td>
<td>0.626</td>
<td>0.073</td>
</tr>
<tr>
<td>$r_{A_{Asl,Av}}$</td>
<td>0.765</td>
<td>0.098</td>
</tr>
</tbody>
</table>

Selection on higher level increases the slope and the variance:

’ Cows get more sensitive’
Genetic correlation between macro-environments

Genetic correlations mostly > 0.9; not much reranking
Genetic correlation between milk yield and micro-environmental sensitivity as a function of environment

Genetic correlation between milk yield and micro-environmental sensitivity is higher in herds with a higher milk yield
Bulls with high versus low variance: expected performance of daughters

Daughters of bulls with low variance have flatter slopes and a lower average milk yield.

Correlated responses in level and slope.
Conclusion

- Existence of genetic variation in macro- and micro-environmental sensitivity in cows

- Macro-environmental and micro-environmental sensitivity are positively correlated for milk yield
  - Selection on lower variance results in a flatter slope

- Selection on higher milk yield leads to higher slope and higher variance
  - Cows are more sensitive, but some room for simultaneous improvement of milk yield and environmental sensitivity
Thank you for your attention!

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