Estimation of Parameters for Heterogeneous Variance Adjustment on Test-Day Data

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- **Heterogeneous variance adjustment**
  - **Meuwissen et al. (1996)**
  - **Pool and Meuwissen (2000)**

    Gengler and Wiggans (2001)
  - **Pena and Ibañez (2002)**
- **Objectives**
  - **Validate two HV adjustment methods for TD data of Nordic yield evaluation by a simulation study**
  - **Apply the methods on a sample data set**

MATERIALS AND METHODS

Basic model for simulation

- **y** =**Xb** + **Ch** + **Za** + **Wp** + **e**

  y – TD milk observations with HV structure

  b – fixed effects (herd year, herd slope, age at calving, days carried calf, test year-month and lactation curve)

  h – random herd-test-day effect

  a – random additive genetic animal effect

  p – random non-genetic animal effect

  e – measurement error

  X, **C**, **Z**, **W** – design matrices

Heterogeneous variance adjustment

- *Meuwissen et al.* (1996) – **MEU-1**

$$\mathbf{y}_{ij} = \lambda^{-1}{}_{ij} \cdot (\mathbf{X}_{ij}\mathbf{b} + \mathbf{C}_{ij}\mathbf{h} + \mathbf{Z}_{ij}\mathbf{a} + \mathbf{W}_{ij}\mathbf{p} + \mathbf{e}_{ij})$$

- *Pool and Meuwissen* (2000), *Gengler and Wiggans* (2001) – **MEU-2**

$$\mathbf{y}_{ij} = \mathbf{X}_{ij}\mathbf{b} + \lambda^{-1}{}_{ij} \cdot (\mathbf{C}_{ij}\mathbf{h} + \mathbf{Z}_{ij}\mathbf{a} + \mathbf{W}_{ij}\mathbf{p} + \mathbf{e}_{ij})$$

Heterogeneous variance adjustment

- **Calculation of the adjustment factors**

$$\lambda_{ij} = \exp(-0.5 \cdot (\beta_{1j} + \beta_{2ip}))$$

- **Variance model**

$$s_{ijpk} = \mu + \beta_{1j} + \beta_{2ip} + \varepsilon_{ijpk}$$

β_{1j} – fixed effect for year-month *j*

β_{2ip} – random effect of herd *i* × test period *p*

Data sets for simulation

Sampled from Swedish Red Breed herds of the Nordic test-day model yield evaluation

- **200 large herds**
  483 946 first lactation milk yield observations
  18 observations in average *per HTD*
- **200 randomly sampled herds**
  267 446 first lactation milk yield observations
  10 observations in average *per HTD*

Simulation process I.

1. **Simulation of homogeneous observations**

   Fixed effects: BLUE solution of a BLUP run on sampled data

   Random effects: generated from normal distributions using Cholesky decomposition of (co)variance matrix

Simulation process II.

2. **Simulation of heterogeneity**

   Fixed effect: BLUE solutions of variance model from the real data

   Random effect: generated from a first order AR process (given ρ and σ^2_{hy} or σ^2_{htm})

3. **Dividing of generated homogeneous observations by generated scaling factors**

Simulated variance models

Each model variant was applied for *both data set*

HY-model

$\rho = 0.6$ $\rho = 0.9$

σ^2_{hy}	σ^2_{hy}	σ^2_{hy}	σ^2_{hy}
=	=	=	=
0.1	0.5	0.1	0.5

HTM-model

$\rho = 0.93$ $\rho = 0.98$

σ^2_{htm}	σ^2_{htm}	σ^2_{htm}	σ^2_{htm}
=	=	=	=
0.1	0.5	0.1	0.5

16 **model × data alternatives in total**
Each simulation was replicated *5* times

Estimation of the variance model parameters from real data

- **Data set**
  - Extension of the large herds data set
  - *483 946* first lactation milk, protein and fat yield observations
  - *306 035* second lactation milk, protein and fat yield observations
- **Model**
  - Six-trait TDM with the same fixed and random effects as in the basic model for simulation

RESULTS

Simulation – HY model

True values	ρ	**0.6**	**0.6**	**0.9**	**0.9**
	σ^2_{hv}	**0.1**	**0.5**	**0.1**	**0.5**
Large herds					
MEU-1	ρ	**0.59**	**0.59**	**0.88**	**0.89**
	σ^2_{hy}	**0.11**	**0.50**	**0.11**	**0.52**
MEU-2	ρ	**0.61**	**0.59**	**0.91**	**0.90**
	σ^2_{hy}	**0.10**	**0.48**	**0.10**	**0.49**
Randomly sampled herds					
MEU-1	ρ	**0.58**	**0.60**	**0.89**	**0.89**
	σ^2_{hy}	**0.11**	**0.51**	**0.11**	**0.50**
MEU-2	ρ	**0.61**	**0.61**	**0.92**	**0.90**
	σ^2_{hy}	**0.10**	**0.50**	**0.10**	**0.48**

Simulation – HTM model

True values	ρ	**0.93**	**0.93**	**0.98**	**0.98**
	σ^2_{htm}	**0.1**	**0.5**	**0.1**	**0.5**
Large herds					
MEU-1	ρ	**0.93**	**0.93**	**0.98**	**0.98**
	σ^2_{htm}	**0.11**	**0.54**	**0.11**	**0.52**
MEU-2	ρ	**0.94**	**0.93**	**0.99**	**0.98**
	σ^2_{htm}	**0.09**	**0.49**	**0.09**	**0.48**
Randomly sampled herds					
MEU-1	ρ	**0.94**	**0.94**	**0.99**	**0.98**
	σ^2_{htm}	**0.12**	**0.55**	**0.13**	**0.60**
MEU-2	ρ	**0.95**	**0.92**	**0.99**	**0.98**
	σ^2_{htm}	**0.09**	**0.49**	**0.10**	**0.47**

Estimates from real data set – HY-model

		1. lactation			2. lactation		
		milk	protein	fat	milk	protein	fat
MEU-1	ρ	0.75	0.74	0.72	0.80	0.77	0.78
	σ^2_{hy}	0.07	0.08	0.08	0.07	0.08	0.07
	σ^2_{ε}	0.35	0.36	0.39	0.52	0.54	0.72
MEU-2	ρ	0.84	0.85	0.83	0.77	0.78	0.82
	σ^2_{hy}	0.07	0.07	0.07	0.07	0.07	0.06
	σ^2_{ε}	1.46	1.55	1.84	1.12	1.24	1.59

Estimates from real data set – HTM-model

		1. lactation			2. lactation		
		milk	protein	fat	milk	protein	fat
MEU-1	ρ	0.98	0.98	0.98	0.98	0.98	0.98
	σ^2_{hy}	0.08	0.09	0.09	0.07	0.08	0.08
	σ^2_{ε}	0.31	0.33	0.38	0.40	0.41	0.57
MEU-2	ρ	0.93	0.95	0.94	0.95	0.95	0.93
	σ^2_{hy}	0.10	0.09	0.09	0.09	0.09	0.08
	σ^2_{ε}	1.13	1.39	1.66	0.91	1.00	1.58

CONCLUSIONS

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- Herd sizes are sufficient large to estimate parameters for the variance model with both HV adjustment methods

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- Parameter estimates depends on the applied adjustment method and variance model
- To make a choice between the two heterogeneous variance adjustment methods more investigation will be necessary about the effect of the methods on the estimated breeding values.

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Thank you for your attention