

Qualitas⁺

Single-step models in the Swiss cattle genetic evaluation

Adrien Butty, Mirjam Spengeler, Peter von Rohr

19. August 2020 **Qualitas**⁺ 1

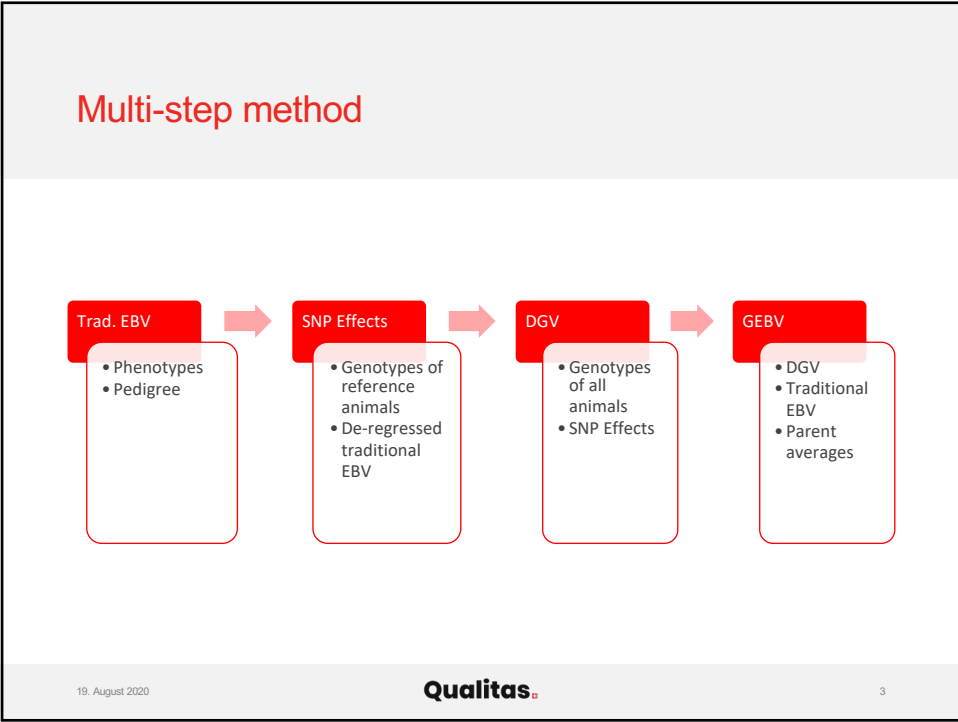
1

Single-step project at Qualitas AG

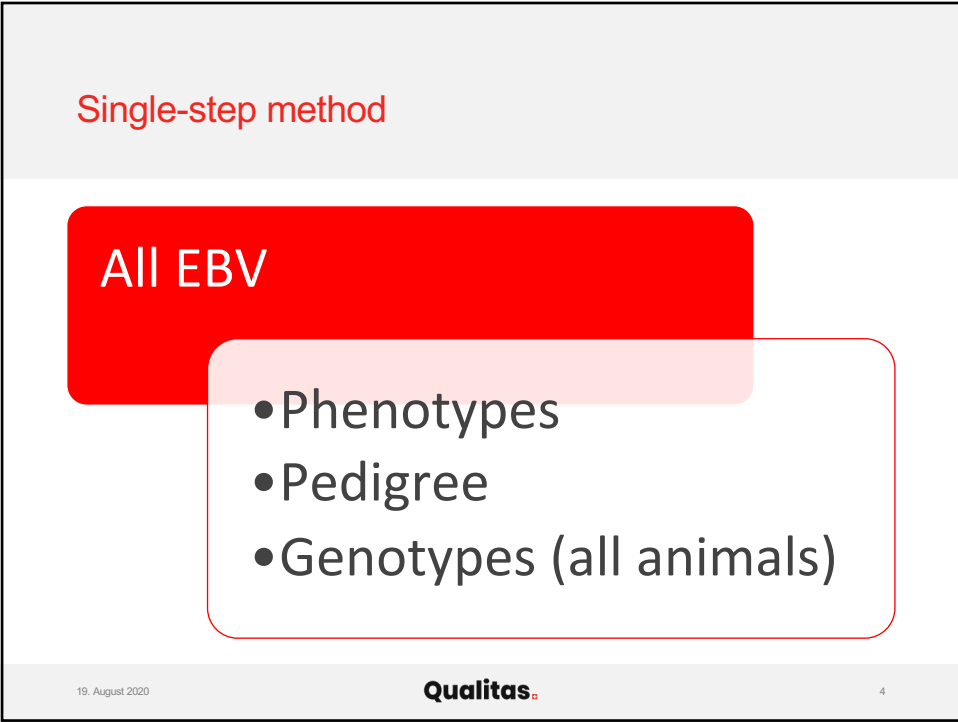
Implementation of the single-step approach for all genetic evaluations

19. August 2020 **Qualitas**⁺ 2

2

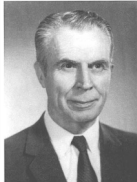


3



4

The classic BLUP animal model



C.R. Henderson

$$\begin{bmatrix} \mathbf{X}'\mathbf{X} & \mathbf{X}'\mathbf{Z} \\ \mathbf{Z}'\mathbf{X} & \mathbf{Z}'\mathbf{Z} + \mathbf{A}^{-1} \end{bmatrix} \begin{bmatrix} \hat{\mathbf{b}} \\ \hat{\mathbf{a}} \end{bmatrix} = \begin{bmatrix} \mathbf{X}'\mathbf{y} \\ \mathbf{Z}'\mathbf{y} \end{bmatrix}$$

Fixed Effects
Phenotypes

Pedigree relationship
Estimated Breeding Values (EBV)

19. August 2020 Qualitas 5

5

The single-step GBLUP model

$$\begin{bmatrix} \mathbf{X}'\mathbf{X} & \mathbf{X}'\mathbf{Z} \\ \mathbf{Z}'\mathbf{X} & \mathbf{Z}'\mathbf{Z} + \mathbf{H}^{-1} \end{bmatrix} \begin{bmatrix} \hat{\mathbf{b}} \\ \hat{\mathbf{a}} \end{bmatrix} = \begin{bmatrix} \mathbf{X}'\mathbf{y} \\ \mathbf{Z}'\mathbf{y} \end{bmatrix}$$

Fixed Effects
Phenotypes

Pedigree and genomic relationship
EBV

19. August 2020 Qualitas 6

6

A new relationship matrix: H

$$H^{-1} = \underbrace{A^{-1}}_{\text{pedigree relationship}} + \begin{bmatrix} 0 & 0 \\ 0 & \underbrace{G^{-1}}_{\text{genomic relationship}} - \underbrace{A_{22}^{-1}}_{\text{pedigree relationship of the genotyped animals}} \end{bmatrix}$$

19. August 2020 Qualitas ®

7

G inverse is dense and needs too much computing resources: alternatives?

1. Keep the number of genotypes low through removing of males culled before getting any progeny
proposed by Koivula et al. JABG (2018)
2. Extend the G (or G^{-1}) matrix with newly genotyped animals without recomputing it all
proposed by Fernando et al. GSE (2016)
3. Use ssGTBLUP method that does not need the setup and inversion of the G matrix
proposed by Mäntysaari et al. JAS (2017)
4. **Use the Algorithm for Proven and Young (APY)**
proposed by Misztal et al. JAS (2014)

19. August 2020 Qualitas ®

8

The Algorithm for Proven and Young (APY)

- Developed in 2014 by Misztal et al.
- Needs a group of core animals (proven) for which a full G matrix will be set up.
- Recursively compute relationships from core to all animals
- Is less resource intensive than setting up and inverting a full G matrix
- Leads to same EBV than with a full G matrix for GBLUP models, to highly similar EBV for ssGBLUP models

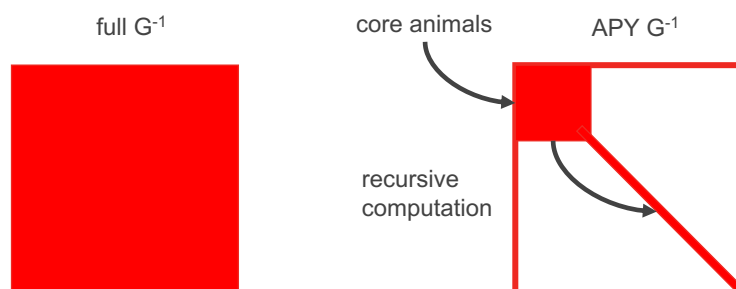
19. August 2020

Qualitas

9

9

How to simplify the set up of G^{-1} ?



19. August 2020

Qualitas

10

10

Selection of core animals

Theoretically the best method: random selection

BUT

- Needs animals across all (most) generations
- Genotyped animals must have a complete pedigree
- Genotype imputation must be highly accurate

⇒ Our cattle population datasets fulfill the requirements

11

Tests on APY approach – current status

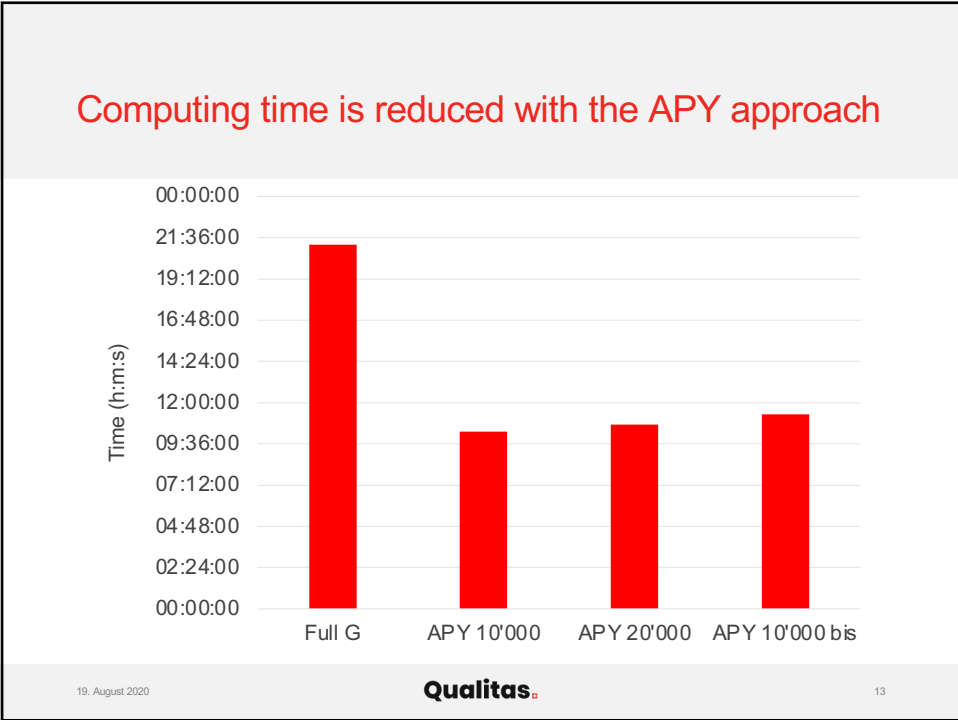
• Simplified dataset:

- Breed: Brown Swiss
- Trait: Udder support
- Origin: Only national information

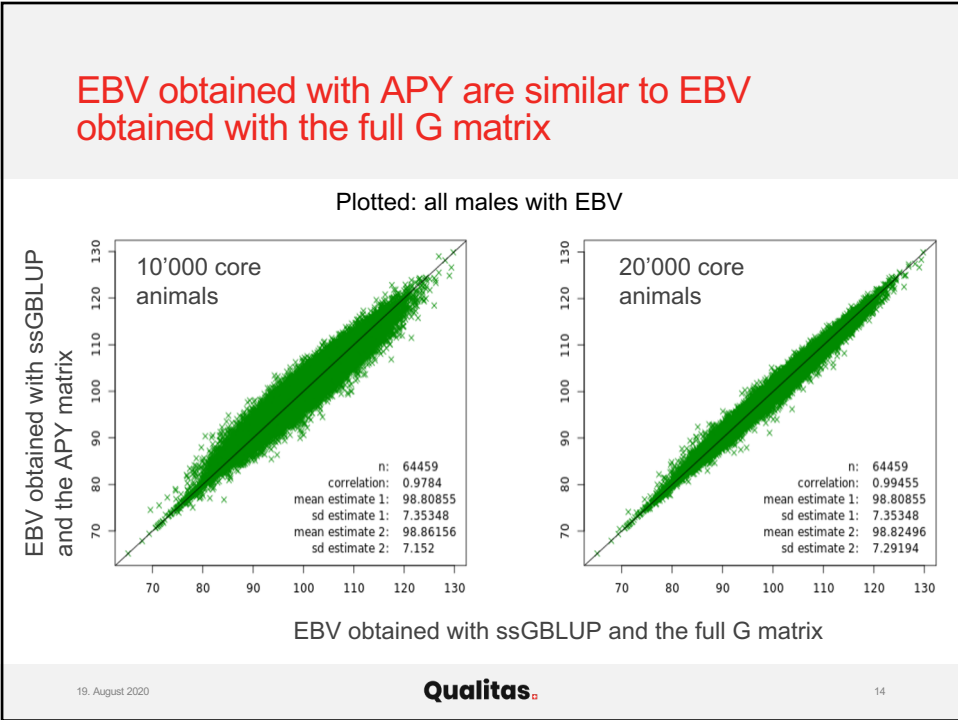
• Compare four scenarios:

1. ssGBLUP with full G matrix
2. ssGBLUP with APY G matrix that contains 10'000 core animals randomly selected
3. ssGBLUP with APY G matrix that contains 20'000 core animals randomly selected
4. Same than Scenario 2 but with 10'000 other randomly selected core animals

12

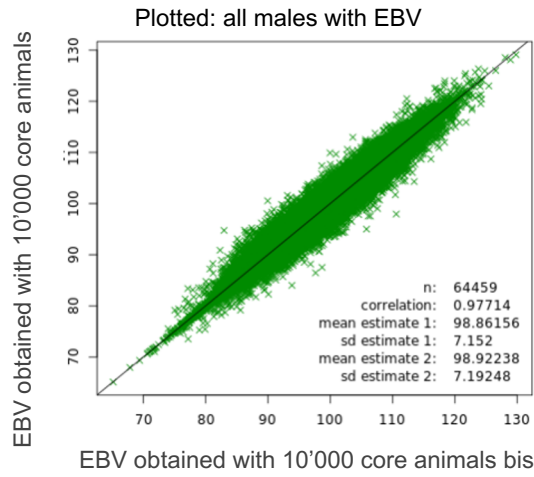


13



14

Random selection of core animals seems to be stable across samples



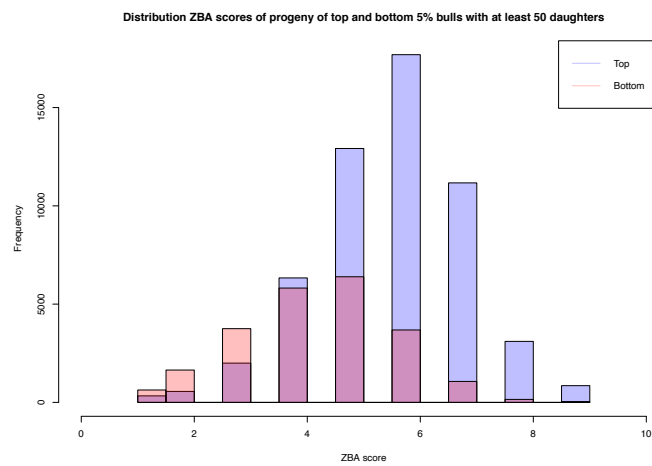
19. August 2020

Qualitas

15

15

Bulls with best and worst EBV also have progeny with better/worse phenotypes



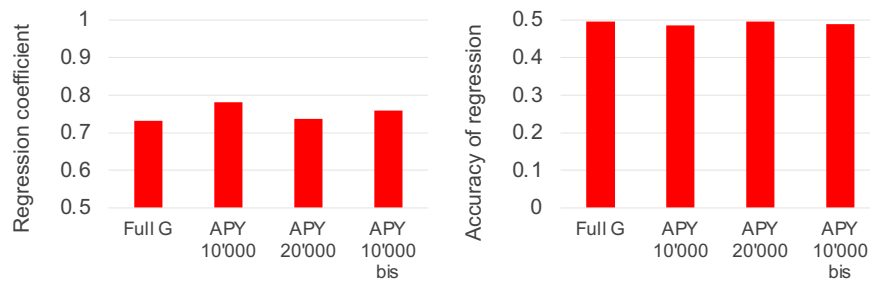
19. August 2020

Qualitas

16

16

Validation results are comparable between all scenarios



19. August 2020

Qualitas

17

17

Next steps

- Ensure stability of the EBV over evaluations when APY method is applied
- Develop ssGBLUP for multi-traits models
- Include internationally exchanged information into ssGBLUP models

➔ Implement ssGBLUP methods in all routine genetic evaluations for the Swiss cattle populations

19. August 2020

Qualitas

18

18