Single-step genetic evaluation for claw health traits in Switzerland

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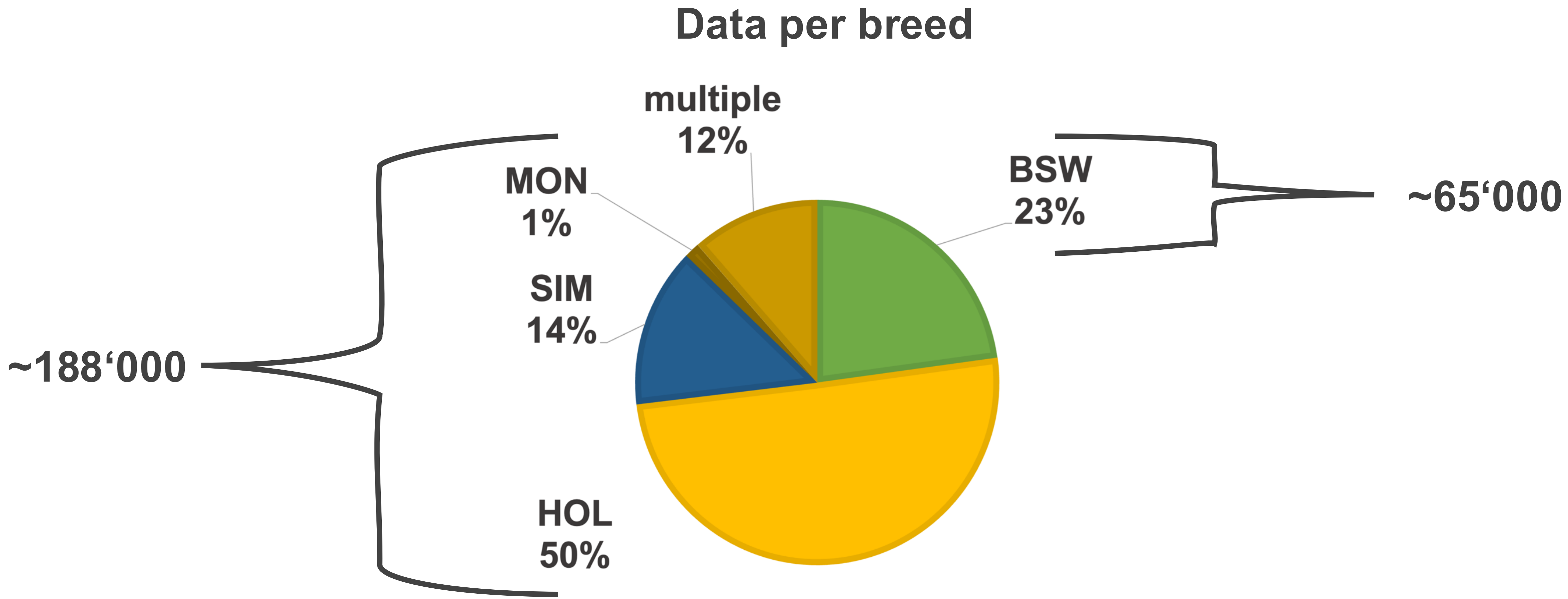
Interbull meeting, Louisville

Claw health in Switzerland

- Third important culling reason
- Higher costs for farmers
- Resource project started in 2019
- Claw health data recorded by hoof trimmers during routine care
- Goal: Development of first breeding values for claw health
    - Single-step evaluation

Raw data


Data per breed
multiple
12%
BSW
23%
MON
1%
SIM
14%
HOL
50%
~65‘000
~188‘000

Phenotypes and genotypes

Phenotypes per animal and month:

- Brown Swiss:
  33’464
- Holstein:
  104’276

Phenotype & genotype:

- Brown Swiss:
  2‘894
- Holstein:
  5‘284

Genotyped animals:

- Brown Swiss:
  146‘609
- Holstein:
  490‘761

Prevalences

Trait	Brown Swiss (in %)	Holstein (in %)
Dermatitis digitalis	7.8	20.9
White line disease	10.2	9.9
Other infectious diseases	37.6	45.8
Other non-infectious diseases	13.5	20.7

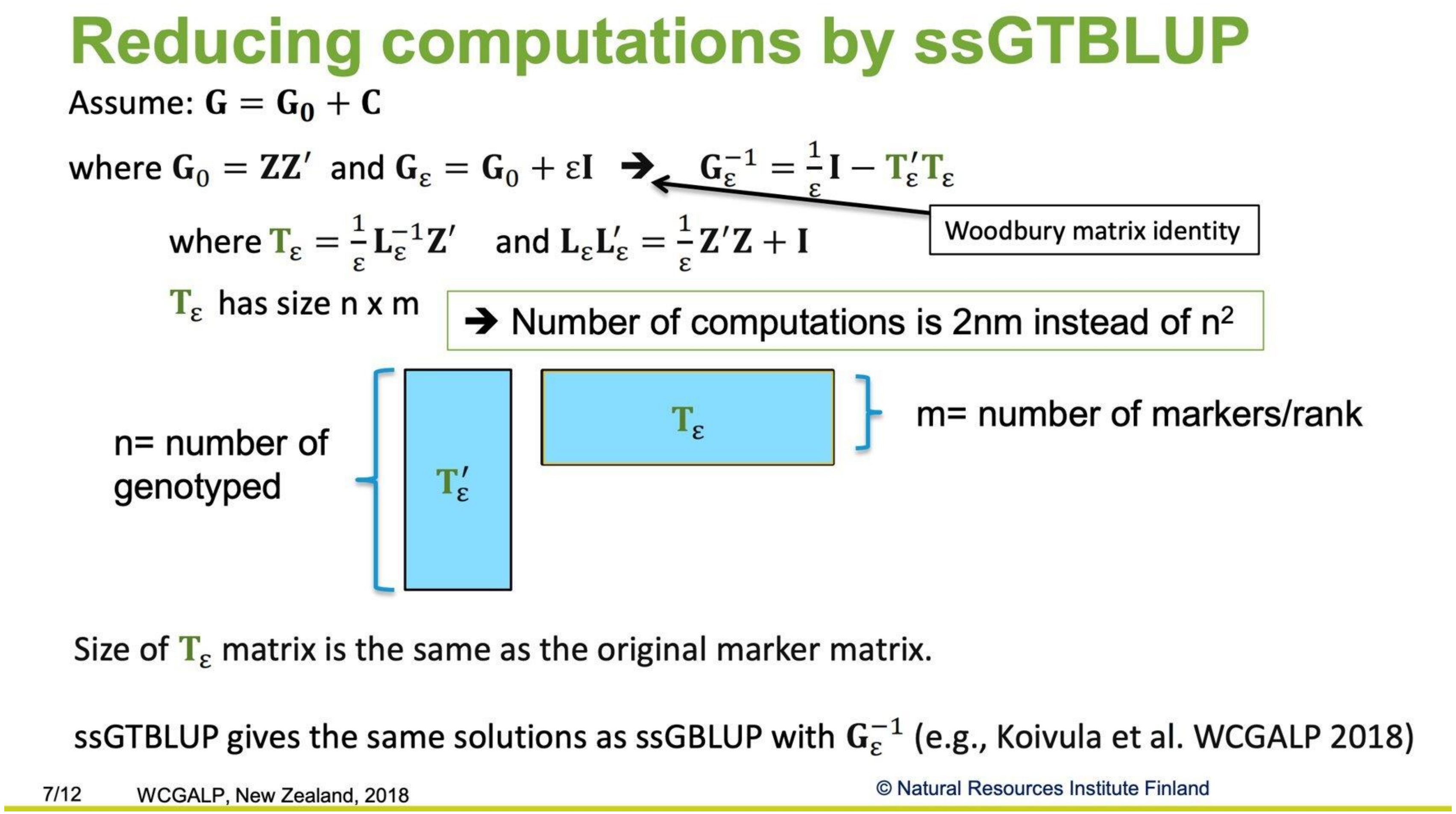
Model: linear multi-trait animal model

- Fixed effects:
  - Parity
  - Trimmer x year
  - Stage of lactation
  - Year-month,
  - Recombination and heterosis
    (only for HOL & SIM)

- Random effects:
  - Herd-year-season
  - Permanent environmental effect

- Repeatability model
- Binary trait (0/1 coded)

ssGTaBLUP



Reducing computations by ssGTBLUP

Assume: $\mathbf{G} = \mathbf{G_0} + \mathbf{C}$

where $\mathbf{G}_0 = \mathbf{ZZ}'$ and $\mathbf{G}_\varepsilon = \mathbf{G}_0 + \varepsilon\mathbf{I}$ ➔ $\mathbf{G}_\varepsilon^{-1} = \frac{1}{\varepsilon}\mathbf{I} - \mathbf{T}_\varepsilon'\mathbf{T}_\varepsilon$

Woodbury matrix identity

where $\mathbf{T}_\varepsilon = \frac{1}{\varepsilon}\mathbf{L}_\varepsilon^{-1}\mathbf{Z}'$ and $\mathbf{L}_\varepsilon\mathbf{L}_\varepsilon' = \frac{1}{\varepsilon}\mathbf{Z}'\mathbf{Z} + \mathbf{I}$

$\mathbf{T}_\varepsilon$ has size n x m

➔ Number of computations is 2nm instead of n^2

m= number of markers/rank

n= number of genotyped

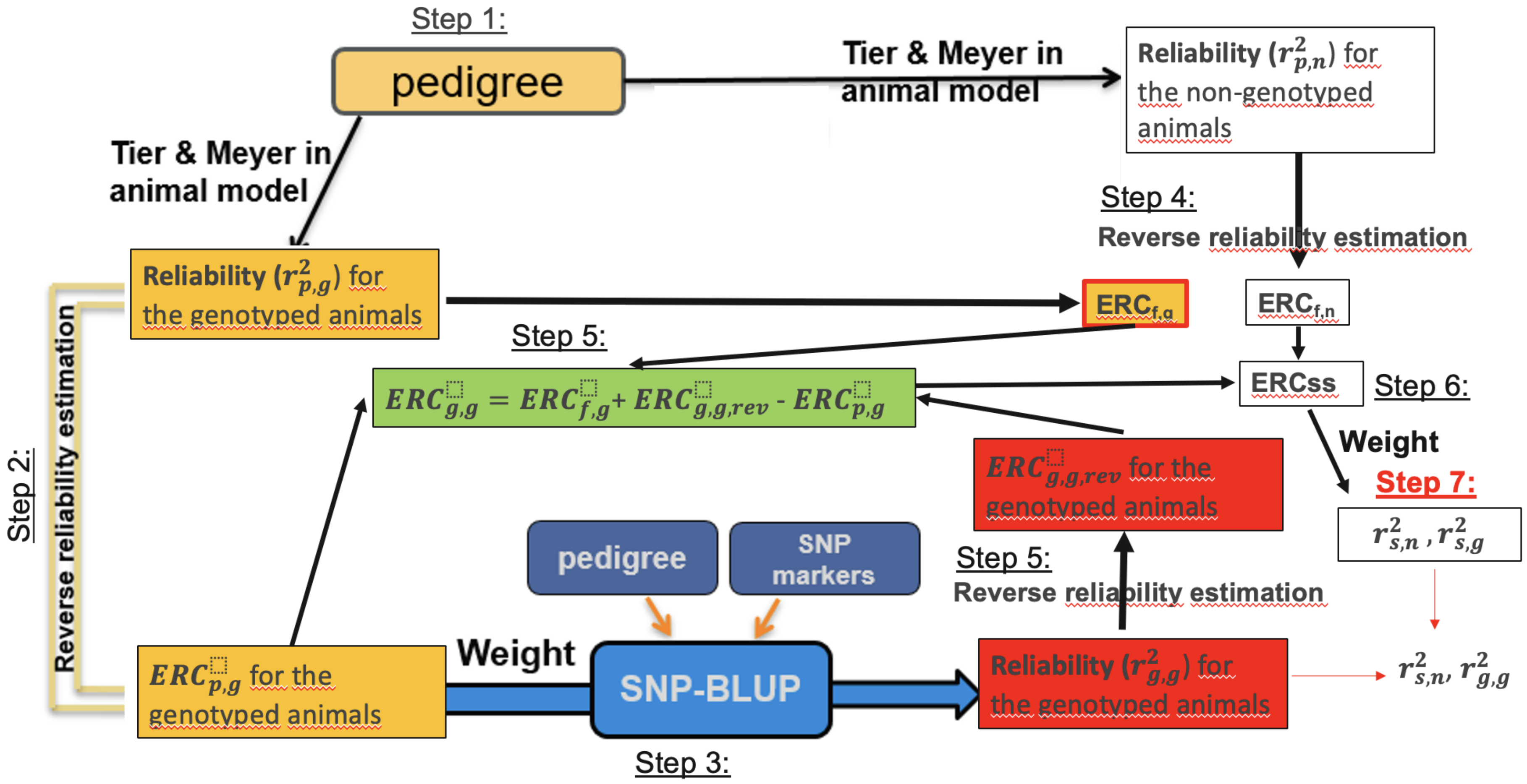
Size of $\mathbf{T}_\varepsilon$ matrix is the same as the original marker matrix.

ssGTBLUP gives the same solutions as ssGBLUP with $\mathbf{G}_\varepsilon^{-1}$ (e.g., Koivula et al. WCGALP 2018)

7/12 WCGALP, New Zealand, 2018 © Natural Resources Institute Finland

Slide by Ismo Stranden, WCGALP 2018

Reliability estimation



Step 1:

pedigree

Tier & Meyer in animal model

Reliability ($r^2_{p,n}$) for the non-genotyped animals

Tier & Meyer in animal model

Reliability ($r^2_{p,g}$) for the genotyped animals

Step 2: Reverse reliability estimation

Step 4: Reverse reliability estimation

$ERC_{f,g}$

$ERC_{f,n}$

Step 5:

$ERC^{\square}_{g,g} = ERC^{\square}_{f,g} + ERC^{\square}_{g,g,rev} - ERC^{\square}_{p,g}$

ERCss

Step 6:

Weight

Step 7:

$r^2_{s,n}$, $r^2_{s,g}$

$ERC^{\square}_{g,g,rev}$ for the genotyped animals

Step 5: Reverse reliability estimation

pedigree

SNP markers

$ERC^{\square}_{p,g}$ for the genotyped animals

Weight

SNP-BLUP

Step 3:

Reliability ($r^2_{g,g}$) for the genotyped animals

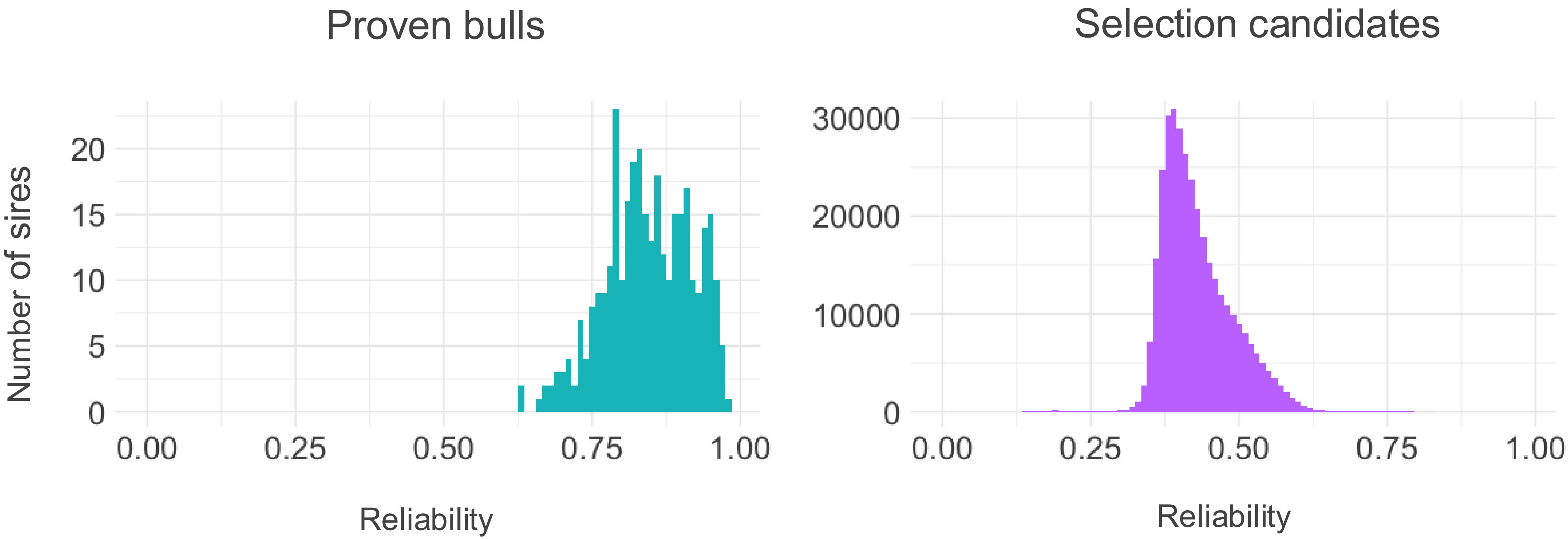
$r^2_{s,n}$, $r^2_{g,g}$

Heritabilities

Trait	Brown Swiss	Holstein
Dermatitis digitalis	0.03 (0.006)	0.09 (0.003)
White line disease	0.07 (0.009)	0.05 (0.004)
Other infectious diseases	0.04 (0.004)	0.04 (0.002)
Other non-infectious diseases	0.04 (0.007)	0.06 (0.004)

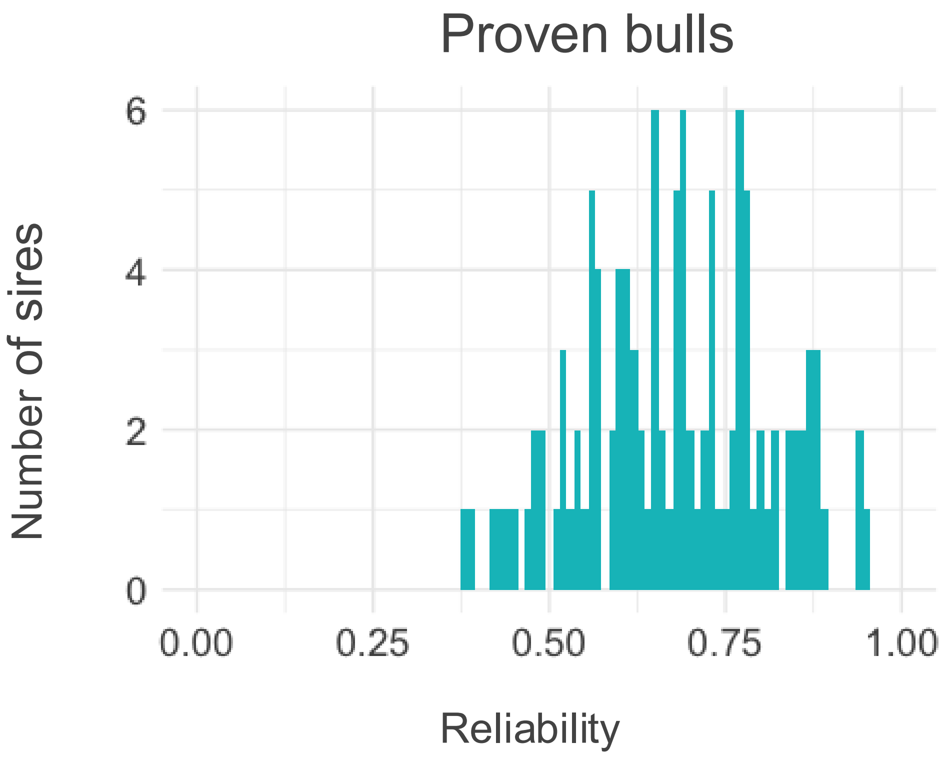
Reliabilities

Dermatitis digitalis - Holstein



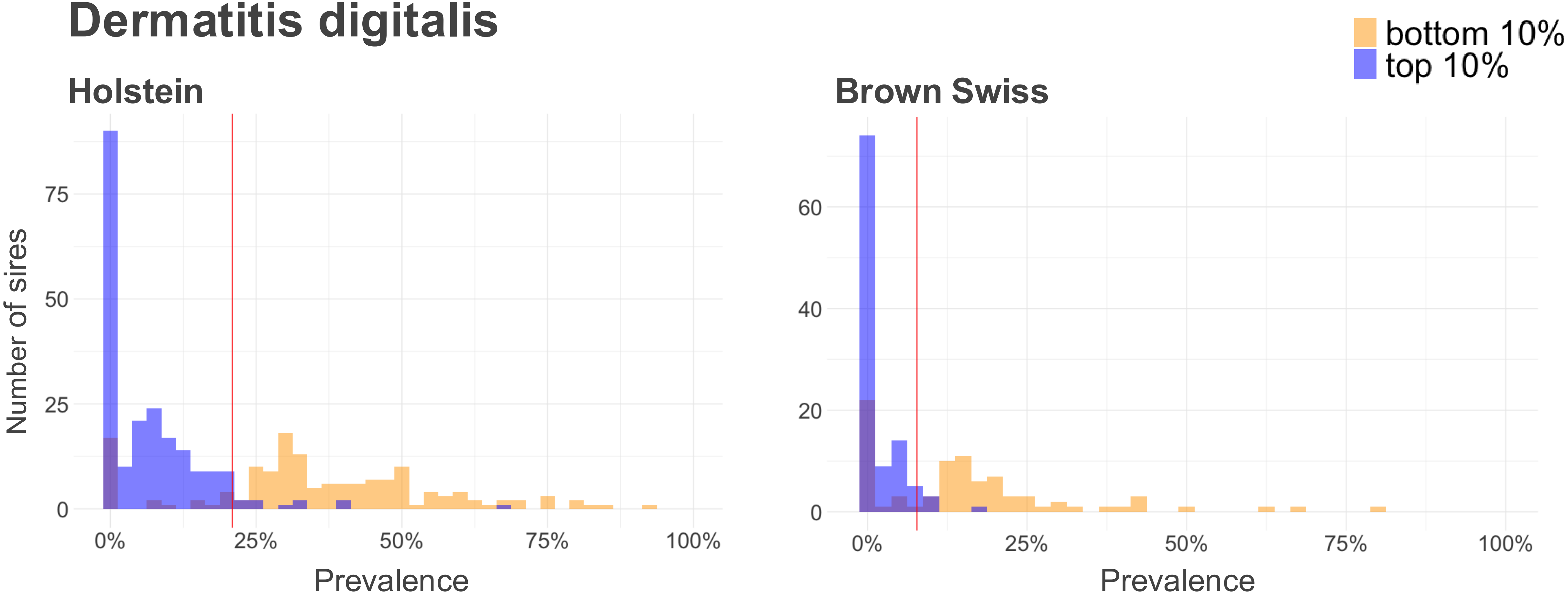
Reliabilities

Dermatitis digitalis – Brown Swiss



Top-Bottom comparison

Dermatitis digitalis



Results

- Differences daughter prevalence top-bottom comparison: 14% - 35%

- Final result: claw health index
  - Evaluation specific weights
  - First publication in April 2025

Challenges

- Limited number of phenotypes
- Large number of genotyped animals with a weak genetic relationship with those providing phenotypic data
    - Definition of genetic groups
    - Avoid outliers

Outlook

- Participation in the development of the new MACE EBV for claw health traits
  - Test run September 2025
- MACE integration

Thank you for your attention!

Questions?

Thanks for funding!

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Landwirtschaft BLW
Office fédéral de l'agriculture OFAG
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