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Session 2 "Breeding scheme optimization: balancing breeding goal(s), genetic progress and diversity"

MODELLING THE TRANSITION FROM CONVENTIONAL TO GENOMIC SELECTION IN GERMAN MERINO SHEEP BREEDING BY STOCHASTIC SIMULATIONS

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BACKGROUND

- Merino sheep as predominant sheep breed (70%) in Germany (LSV BW 2022)
- Division into herdbook & commercial breeding → genetic gain is spread by selling rams to commercial breeders
- Since 2014: pedigree-based BLUP breeding value estimation (BVE)
- Natural mating → no relevance of reproduction technologies (AI, MOET)

  → low reproduction rate of sires → limiting genetic gain

  → high genetic diversity within the breed (Schmid et al. 2023)

(MLR Baden-Württemberg 2012)

AIM OF THE STUDY

German sheep farming as low-input sector → high interest in efficient but cost-effective breeding strategy

⬇

Potential of genomic selection (GS) is evident also for sheep & implemented in other countries‘ breeding programs (Rupp et al. 2016)

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Aim: Evaluation of implementation strategies of GS for the German Merino breeding program

⬇

Simulation of a simplified version of the German Merino breeding program with real genotypic data in MoBPS (Modular Breeding Program Simulator) (Pook et al. 2020) & comparison of alternative breeding strategies with GS to a reference scenario with pedigree-based BVE

SIMULATION TIMELINE

Real genotype data input

from 785 German Merino sheep (Ovine50kSNP v2 Bead Chip (Illumina, San Diego, USA))

Random simulation for 5 generations to build up founder population

Founder population, starting point of general breeding program

Pedigree-based BLUP breeding value estimation for 10 generations to build up age structure

Breeding cycle 0: starting population for scenarios

Reference scenario with pedigree-based BLUP breeding value estimation

Different scenarios with ssGBLUP breeding value estimation

Genotyping of active breeding rams (n=469) in breeding cycle 0 as starting reference population

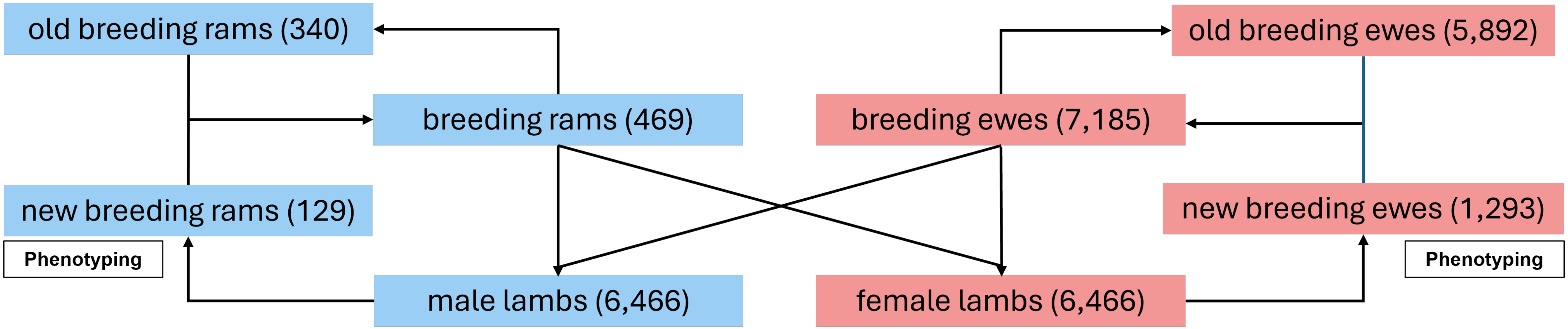
Breeding cycle 10: end of simulation

100 independent runs per scenario

SIMULATED SCENARIOS

Reference scenario

Ped pedigree-based BLUP BVE



SIMULATED SCENARIOS

ssGBLUP scenarios

Top 25% ♂

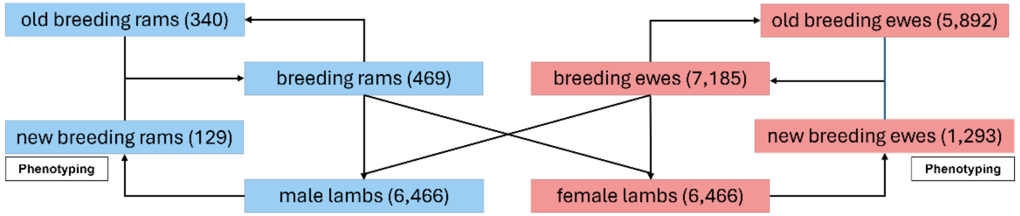
Top 50% ♂

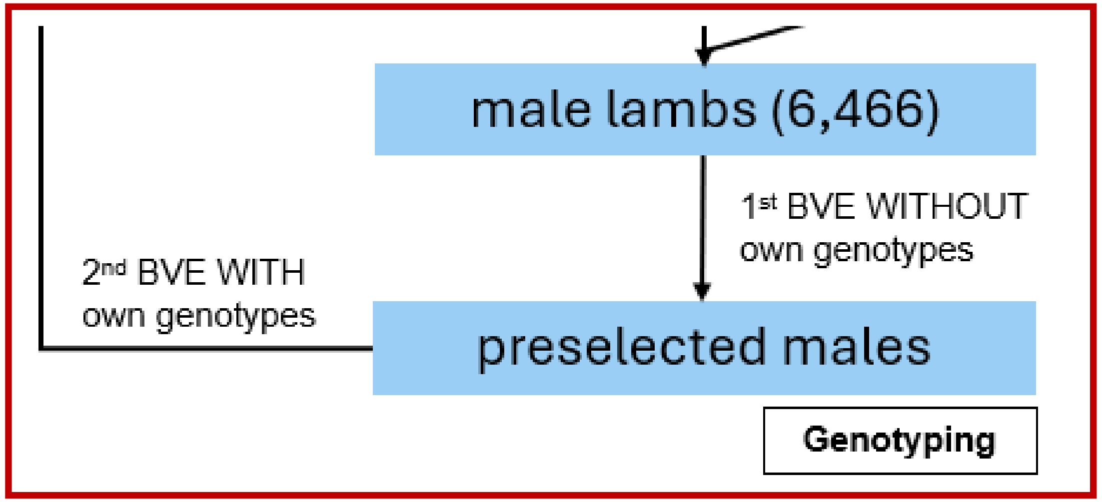
100% ♂

100% ♂ + Top 25% ♀

100% ♂ + Top 50% ♀

100% ♂ + 100% ♀





SIMULATED SCENARIOS

ssGBLUP scenarios

Top 25% ♂

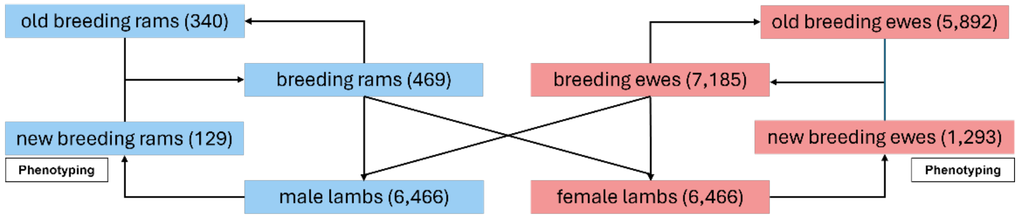
Top 50% ♂

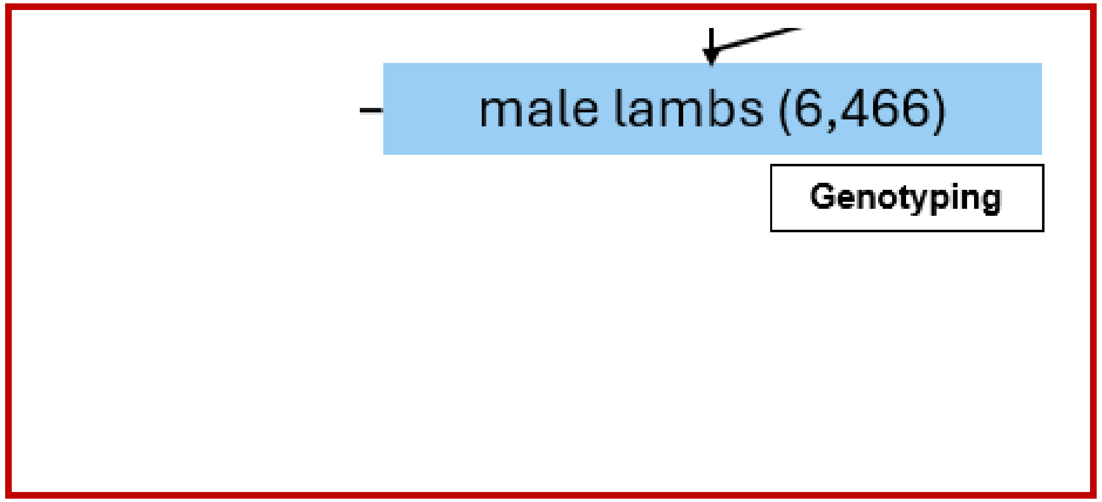
100% ♂

100% ♂ + Top 25% ♀

100% ♂ + Top 50% ♀

100% ♂ + 100% ♀





SIMULATED SCENARIOS

ssGBLUP scenarios

Top 25% ♂

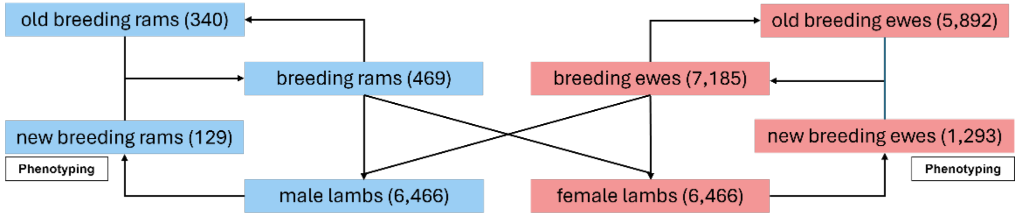
Top 50% ♂

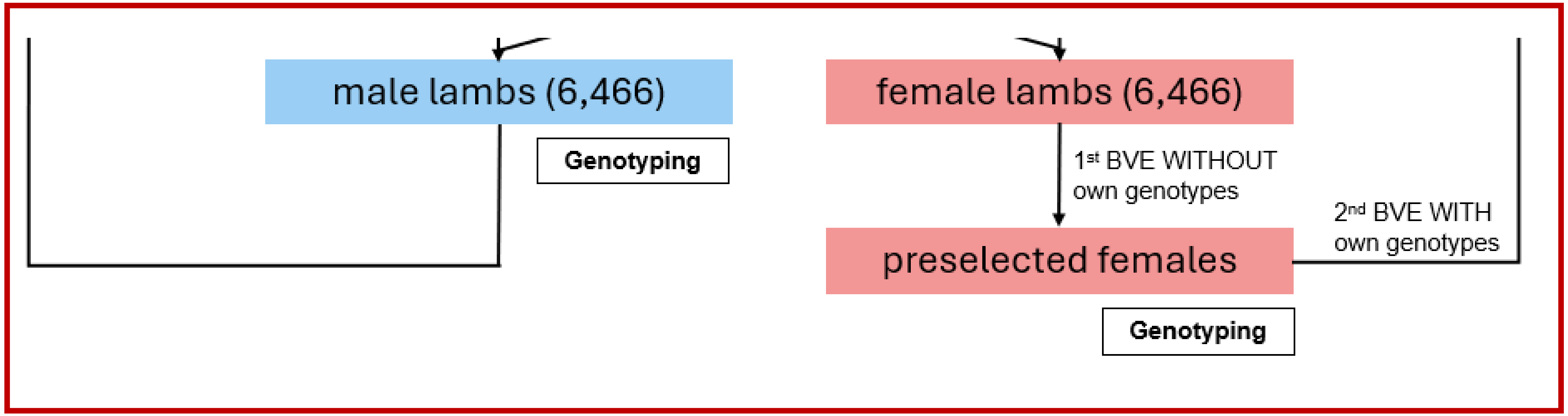
100% ♂

100% ♂ + Top 25% ♀

100% ♂ + Top 50% ♀

100% ♂ + 100% ♀





SIMULATED SCENARIOS

ssGBLUP scenarios

Top 25% ♂

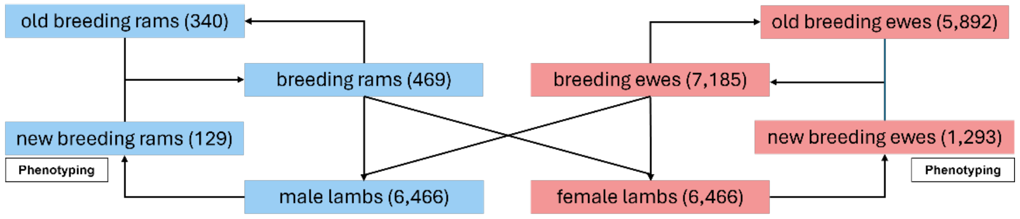
Top 50% ♂

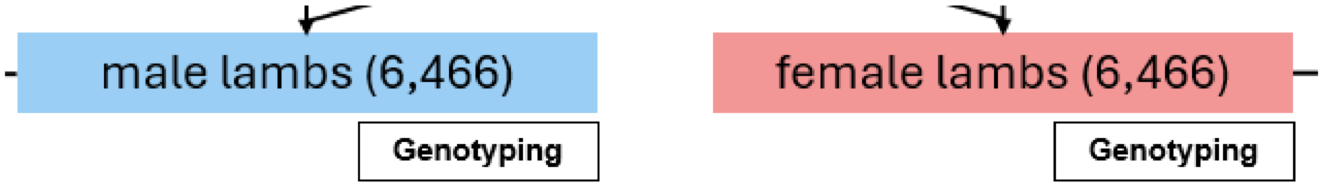
100% ♂

100% ♂ + Top 25% ♀

100% ♂ + Top 50% ♀

100% ♂ + 100% ♀





SIMULATED TRAITS & FURTHER SPECIFICATIONS

Health trait

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Production trait

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Heritabilities of and genetic correlation

	Health trait	Production trait
Health trait	**0.1**	-
Production trait	-0.1	**0.3**

- 1000 purely additive QTLs for each trait
- Trait standardization: mean=100; SD=sqrt(10)

- Selection was based on a TMI with equal weights for each trait
- Information of animals from the last 10 breeding cycles in BVE
- On average, rams contributed equally to each next generation

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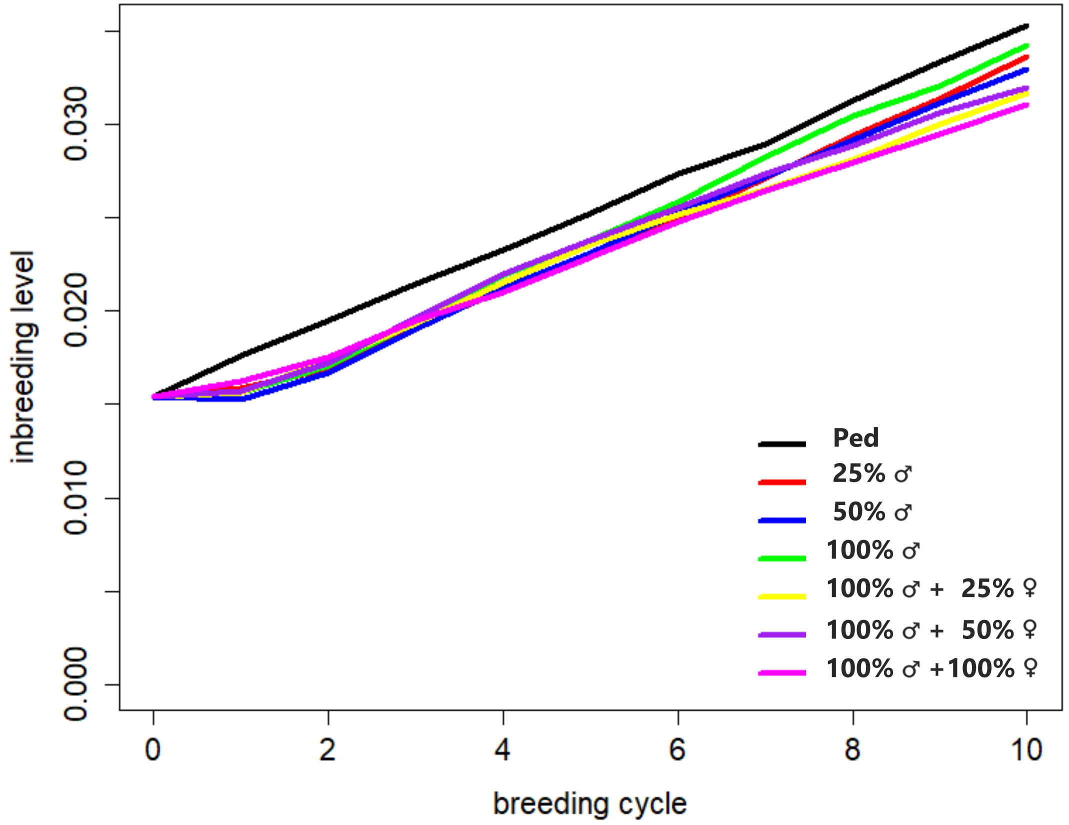
GENETIC GAIN

Mean true breeding values and standard deviations (SD) and increases in genetic gain relative to ‚Ped' (reference scenario) after 10 breeding cycles

Scenario (Proportion genotyped)	Rams				Ewes			
	Health trait		Production trait		Health trait		Production trait	
Ped	1.38 (0.16)	-	1.93 (0.12)	-	1.40 (0.11)	-	1.93 (0.09)	-
25% ♂	1.55 (0.14)	+13%	2.18 (0.12)	+13%	1.46 (0.10)	+5%	2.01 (0.10)	+5%
50% ♂	1.63 (0.16)	+18%	2.26 (0.11)	+17%	1.50 (0.11)	+8%	2.04 (0.10)	+6%
100% ♂	1.73 (0.15)	+26%	2.34 (0.11)	+21%	1.58 (0.11)	+13%	2.10 (0.09)	+9%
100% ♂ + 25% ♀	1.83 (0.14)	+33%	2.52 (0.12)	+30%	1.67 (0.10)	+20%	2.26 (0.10)	+17%
100% ♂ + 50% ♀	1.84 (0.13)	+33%	2.53 (0.12)	+31%	1.71 (0.09)	+22%	2.31 (0.10)	+20%
All lambs ♂♀	1.85 (0.16)	+34%	2.54 (0.12)	+31%	1.72 (0.10)	+23%	2.32 (0.10)	+21%

INBREEDING

Development of inbreeding during the simulation displayed as the average kinship of the breeding rams in each breeding cycle



DISCUSSION

- Increasing genetic gain with increasing numbers of available genotypes → increasing EBV accuracy
- Highest marginal gain when initially including GS on the male side
- Higher benefit of GS for the lower heritable health trait
- Higher benefit on the male side than on the female side → replacement rate & higher contribution of males (Granleese et al. 2019)
- Higher inbreeding for the Ped scenario than for GS scenarios (also observed in Granleese et al. 2019 & Pook et al. 2021)

  → GS allows more between-family-selection/less co-selection of relatives (Daetwyler et al. 2007)

TRANSFER OF THE SIMULATION INTO PRACTICE

- Simplifications: only two traits, same phenotyping timepoint for both traits
  → in practice: currently 19 traits & progeny testing schemes (Martin et al. 2023)
- No health trait implemented in the current breeding program but likely to change in the future
  → Breeding for improved immunocompetence towards gastrointestinal nematodes (Bishop et al. 2002; Schmid et al. 2024)
- Two-step selection → considered more economically realistic (as also described in Horton et al. 2015 and Lillehammer et al. 2020)
  → Low economic value of sheep → majority of income from governmental subsidies for landscape management & conservation grazing (BLE 2022)
- Simulation of herdbook population → transfer of genetic gain into production herds not considered

TRANSFER OF THE SIMULATION INTO PRACTICE

Tuesday, session 68, 3 pm:
Schmid et al.: Genomic analyses of parasite resistance traits in German crossbred Merino

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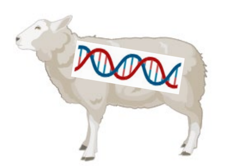
CONCLUSION & OUTLOOK

- Potential of GS was shown also for German Merino sheep



→ Genotyping all lambs maximized genetic gain

→ but genotyping 25% of preselected top male lambs showed greatest relative benefit on genetic gain

- Study provides a comprehensive basis for discussions on possible GS breeding strategies for the German Merino breeding program

- More research left (e.g., including genotyping costs & economic evaluations) & infrastructure (routine sampling, connection of genotyping, performance testing & BVE) necessary before practical implementation

Curious about more?

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THANK YOU FOR YOUR ATTENTION!

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