Single and Multiple-Breed Genomic Predictions for Conformation Traits of Canadian Dairy Goats

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Louisville, Kentucky
July 14-17, 2021
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Dairy Goat Classification System

- Managed by the CGS for Canadian dairy goat breeds
- Non-selective system, all first lactation does in participating herds
  - Later lactation does and bucks are optional
- Traits are scored on a 1 to 9 scale by trained classifiers

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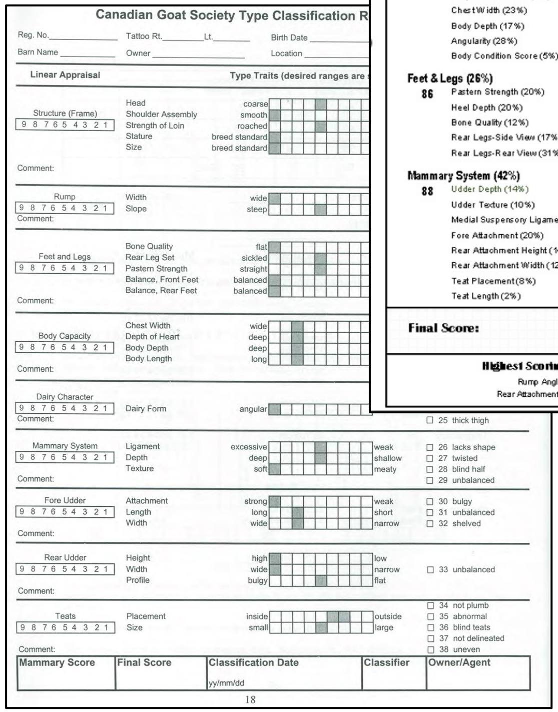
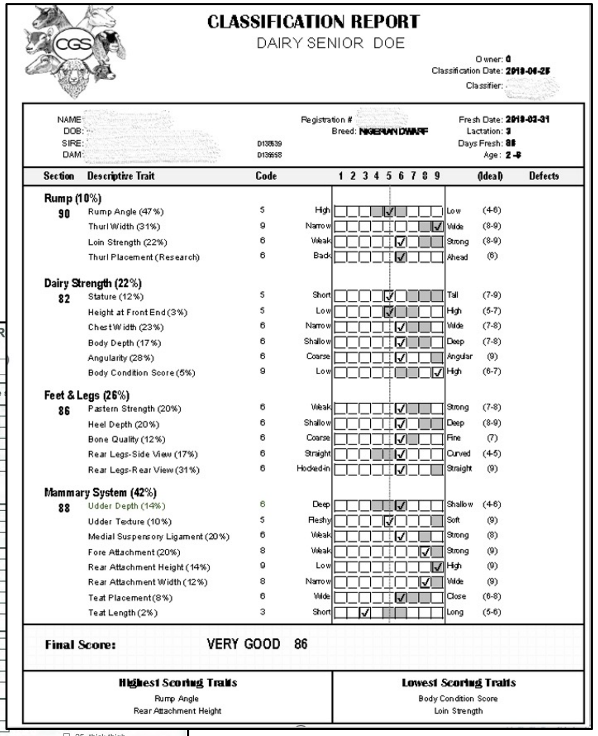
Traits Classified

- Traits and sub-indexes scored have changed over time
- Genetic evaluation system uses traits equivalent to the original classification system

Original	Pre-2012	Current
• General Appearance • Feet & Legs • Body Capacity • Dairy Character • Suspensory Ligament • Fore Udder • Rear Udder • Teats	• Structure • Rump • Feet & Legs • Body Capacity • Dairy Character • Mammary System • Fore Udder • Rear Udder • Teats	• Rump • Dairy Strength • Feet & Legs • Mammary System



Pre-2012



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Genetic Evaluation System

- Genetic evaluations are computed by the Canadian Centre for Swine Improvement (CCSI) and available through GoatGenetics.ca
- Multiple-breed evaluations
- Single-trait animal models for conformation traits
  - **Fixed effects** – breed, parity, age class, days in milk
  - **Random effects** – herd-year-classifier and animal additive genetic

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Multiple-Breed Genetic Evaluations

- **Common for small ruminant populations**
  - Many breeds and small populations for individual breeds
  - High use of crossbreeding and ancestral relationships between breeds

- **May increase the accuracy of single-step GEBV when:**
  1. **Genomic training populations are small**
  2. **Limited phenotypes are recorded**

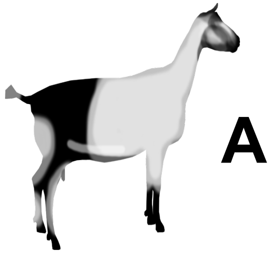
- **The benefits of multiple-breed genomic evaluation models may vary, depending on the consistency of gametic phase between breeds**
  - Brito et al. (2015) – Low consistency of gametic phase for Canadian Alpine and Saanen breeds
  - Carillier et al. (2014) – Higher theoretical accuracies observed for multiple-breed models for French Alpine and Saanen breeds

Objective

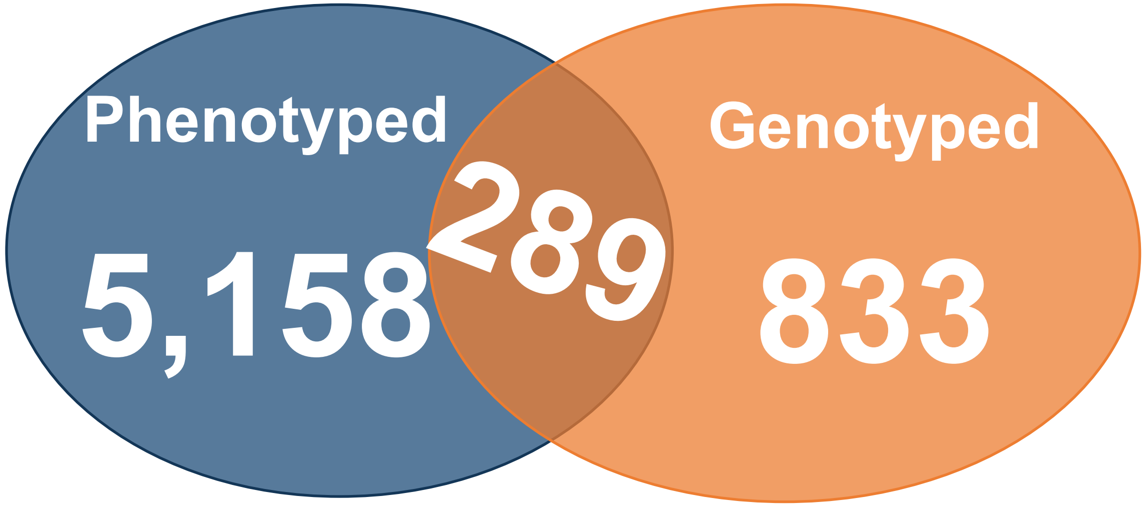
Compare the theoretical accuracy of single and multiple-breed single-step genomic evaluations for conformation traits of Canadian Alpine and Saanen goats.

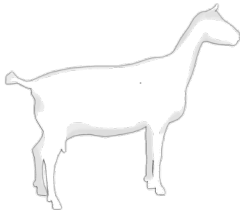
Phenotypes and Genotypes

- Registered Alpine and Saanen bucks and does from across Canada were genotyped



Alpine





Saanen

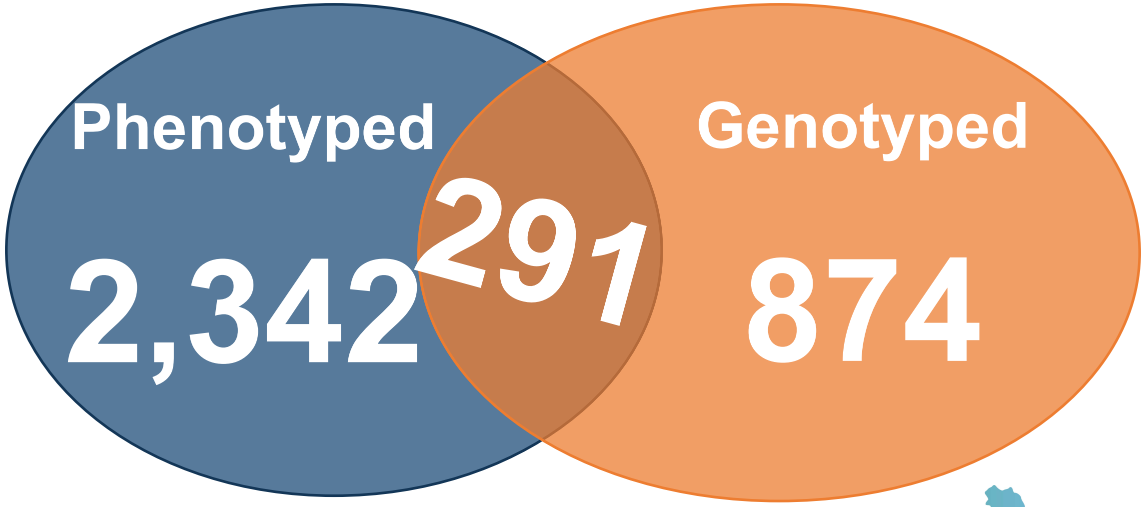


Image Source: Canadian Goat Society, Classification Manual, 2020

Methods – Genetic Evaluations

- BLUPf90 family programs used to estimate genetic parameters and predict (G)EBV
  - Optimal scaling parameters: tau = 1.0 and omega = 0.8

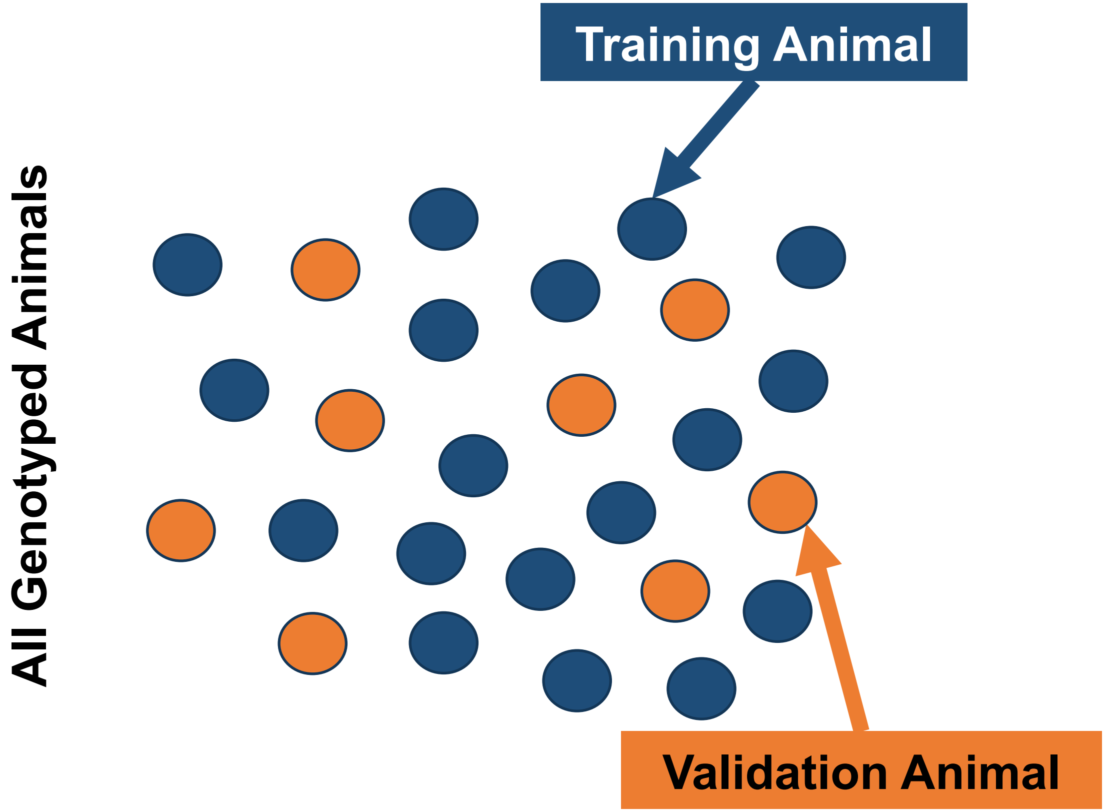
- **Genetic Evaluation Models:**
  - Single-trait animal models, with effects as in routine genetic evaluations
  - (G)EBV were predicted with full datasets and validation datasets, where phenotypes were removed for selection candidates and their descendants

- **Single-Breed and Multiple-Breed Models:**
  - Genetic parameters were calculated across breeds for the multiple-breed analyses
  - Breed was modelled as a fixed effect

Methods - Validation Design

Forward Validation

- All animals born > 2012 with average full dataset EBV accuracy > 0.40



Forward Cross-validation

- Subsets of 100 animals eligible for validation population
- Results averaged over 10 replicates

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Methods - Validation Design

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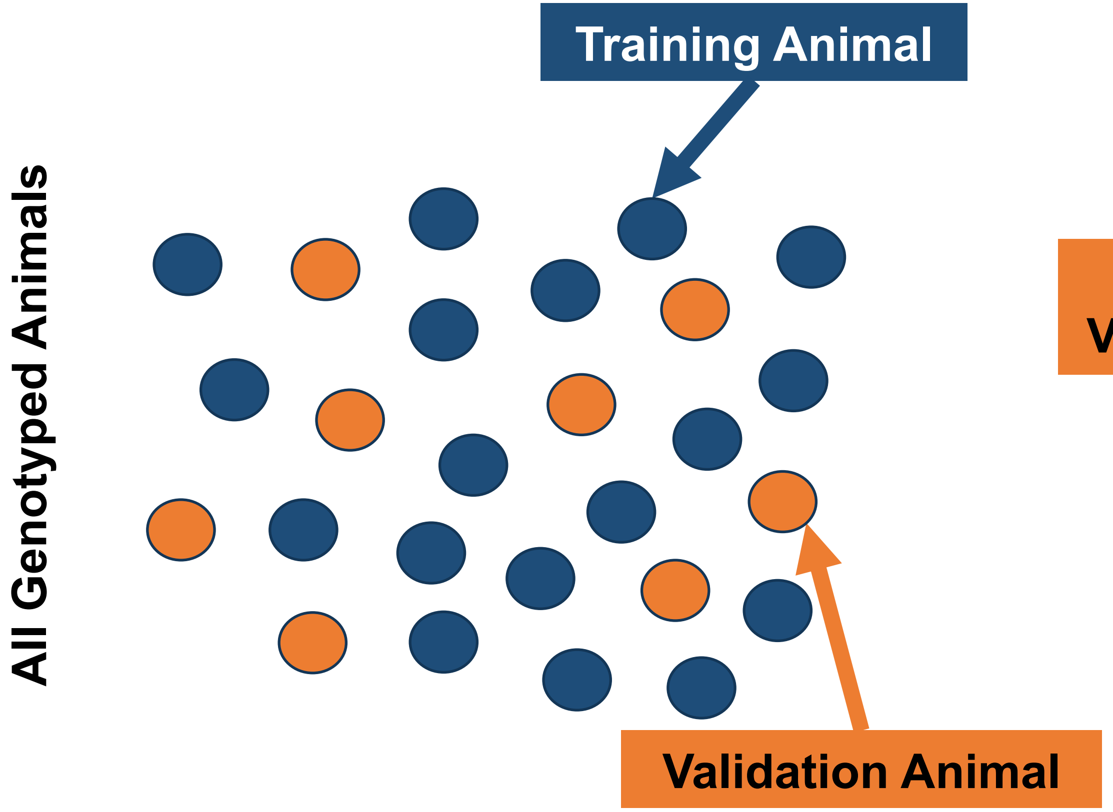

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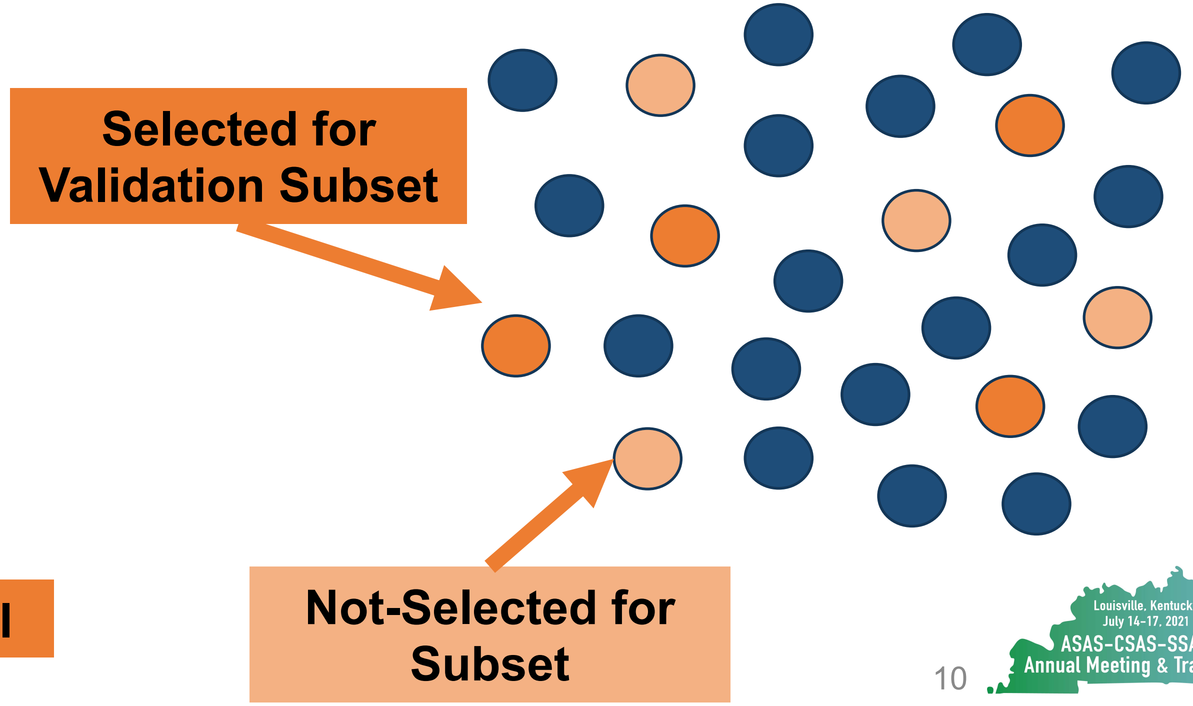

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Methods – Theoretical Accuracy

- Theoretical accuracy (ACC) of (G)EBV was calculated from the standard error of prediction (*s*), accounting for inbreeding (*f*):

$$\mathrm{ACC}_i = \sqrt{1 - \frac{(s_i)^2}{(1+f_i)\sigma_a^2}}$$

(Van Vleck, 1993)

- Average (G)EBV accuracy of each trait was calculated for selection candidates, using the reduced validation datasets

- The average expected gain in theoretical accuracy of GEBV compared to EBV was assessed for various subsets of the population for both genotyped and non-genotyped animals

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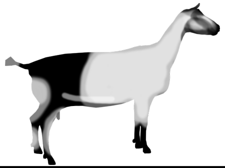
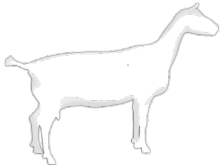
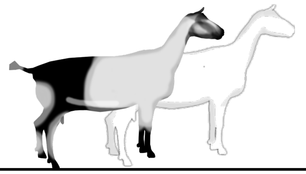
Heritability Estimates







Trait	Abr.	Alpine	Saanen	Both
Body Capacity	BC	0.22 ± 0.02	0.11 ± 0.03	0.19 ± 0.02
Dairy Character	DC	0.16 ± 0.02	0.16 ± 0.04	0.17 ± 0.02
Feet and Legs	FL	0.17 ± 0.03	0.11 ± 0.03	0.16 ± 0.02
Fore Udder	FU	0.28 ± 0.03	0.23 ± 0.04	0.26 ± 0.02
General Appearance	GA	0.31 ± 0.03	0.21 ± 0.04	0.27 ± 0.02
Rear Udder	RU	0.22 ± 0.03	0.14 ± 0.03	0.19 ± 0.02
Suspensory Ligament	SL	0.18 ± 0.02	0.13 ± 0.04	0.15 ± 0.02
Teats	TE	0.18 ± 0.03	0.12 ± 0.04	0.16 ± 0.02

Image Source: Canadian Goat Society, Classification Manual, 2020

Accuracy of Selection Candidates

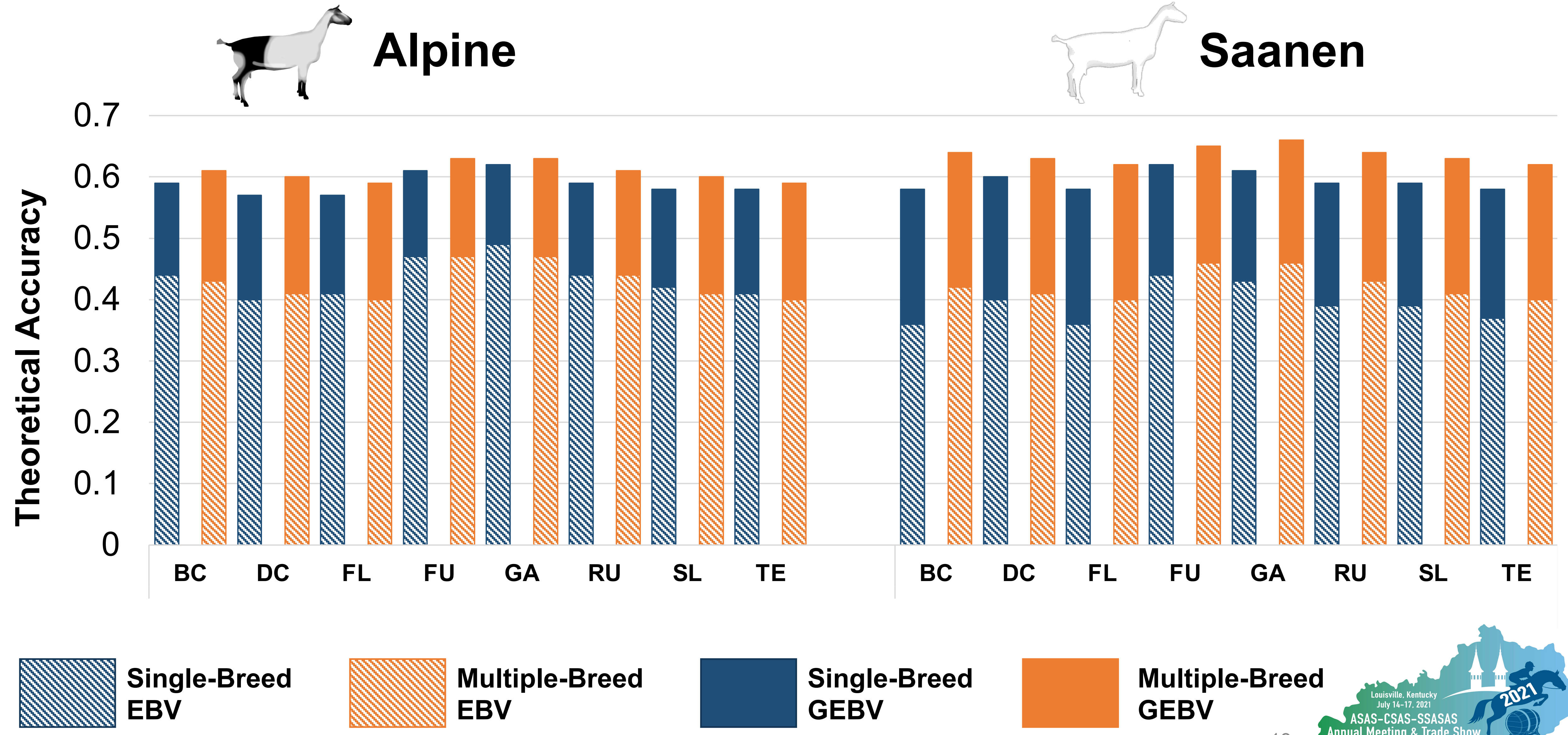
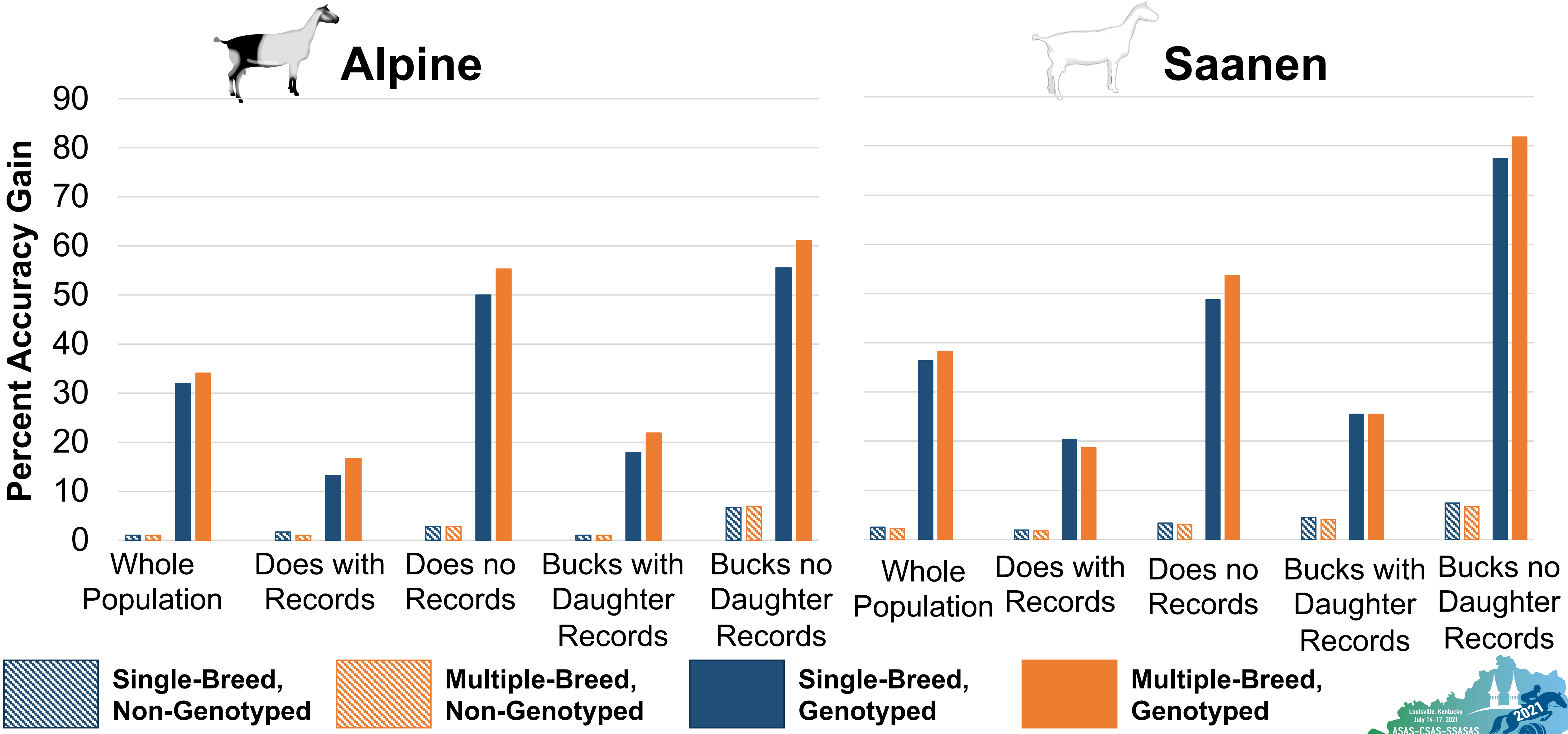


Image Source: Canadian Goat Society, Classification Manual, 2020

Gain in Accuracy from GEBV



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Conclusions

1. GEBV for selection candidates from multiple-breed analyses were consistently more accurate than single-breed analyses.
2. Substantial gains to selection accuracy are expected from the implementation of genomic evaluations for conformation traits, especially for unclassified does (49 to 55%) and bucks without daughter classification records (56 to 82%).

Acknowledgements

Project Team:

Centre for Genetic Improvement of Livestock:
Erin Massender
Hinayah Rojas de Oliveira
Flavio Schenkel
Christine Baes

Purdue University:
Luiz Brito

Canadian Centre for Swine Improvement:
Laurence Maignel
Mohsen Jafarikia
Brian Sullivan

Data Provision:

We thank the CGS and CCSI for providing data and all producer herds that participated in collecting samples for this project.

Funding:

This research was funded by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), through the Ontario Agri-Food Innovation Alliance.

Thank You!

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