

Genetic and genomic relationships among Canadian Holstein dairy cattle population and international Holstein bulls

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Availability and usage of genotypes

- **Rapid advancements in breeding programs**
- **Increased exchange of genotypes among countries**
- **Increased genetic progress**
- **Higher gains in reliabilities of estimated breeding values**

Top countries sending bull genotypes to CDCB in 2025

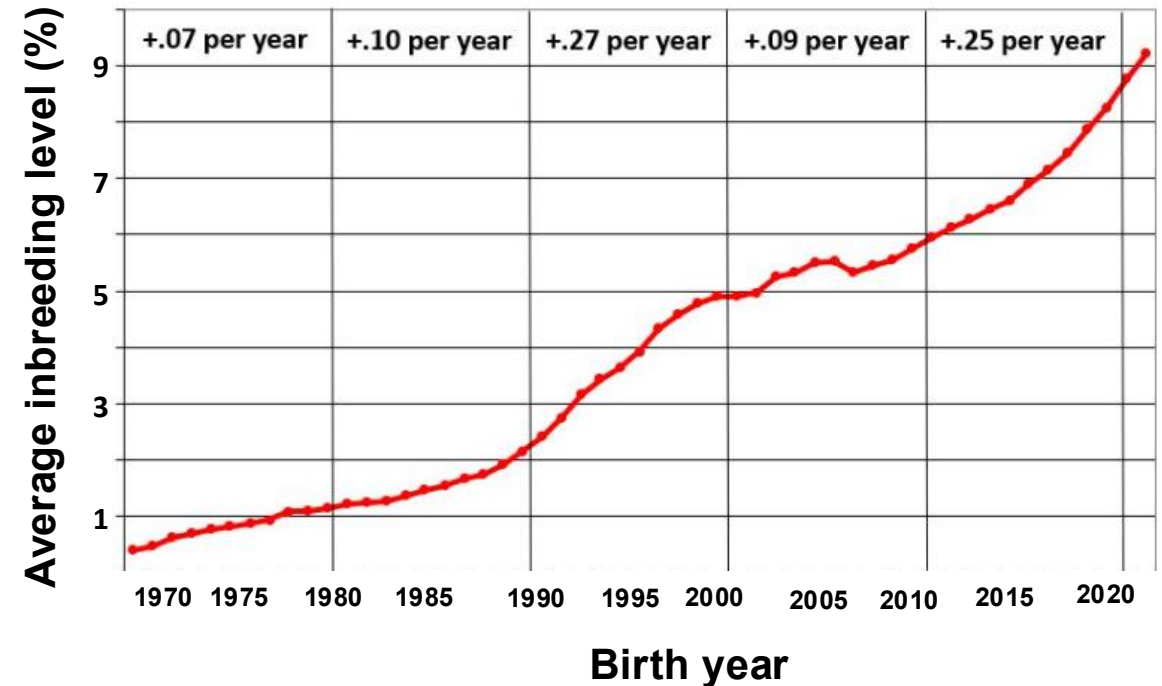
Country	Number of bull genotypes
United States (USA)	386,313
Canada (CAN)	62,201
Germany (DEU)	30,309
Italy (ITA)	25,926
Switzerland (CHE)	19,065
The Netherlands (NLD)	16,413
France (FRA)	10,240

(Source: Council on Dairy Cattle Breeding, 2025)

Increased genetic relatedness

- Rising inbreeding levels
- Reduce genetic variation
- Could limit the response to selection
- Increase the frequency of genetic defects

Inbreeding trend in Canadian Holsteins



(Van Doormaal, 2024)

Relationship value represents the percentage of DNA a sire shares with active females within a given population *(Van Doormaal et al., 2003)*

- **Estimated using pedigree data (R-values)**
- **Estimated using genomic data (GR-values)**

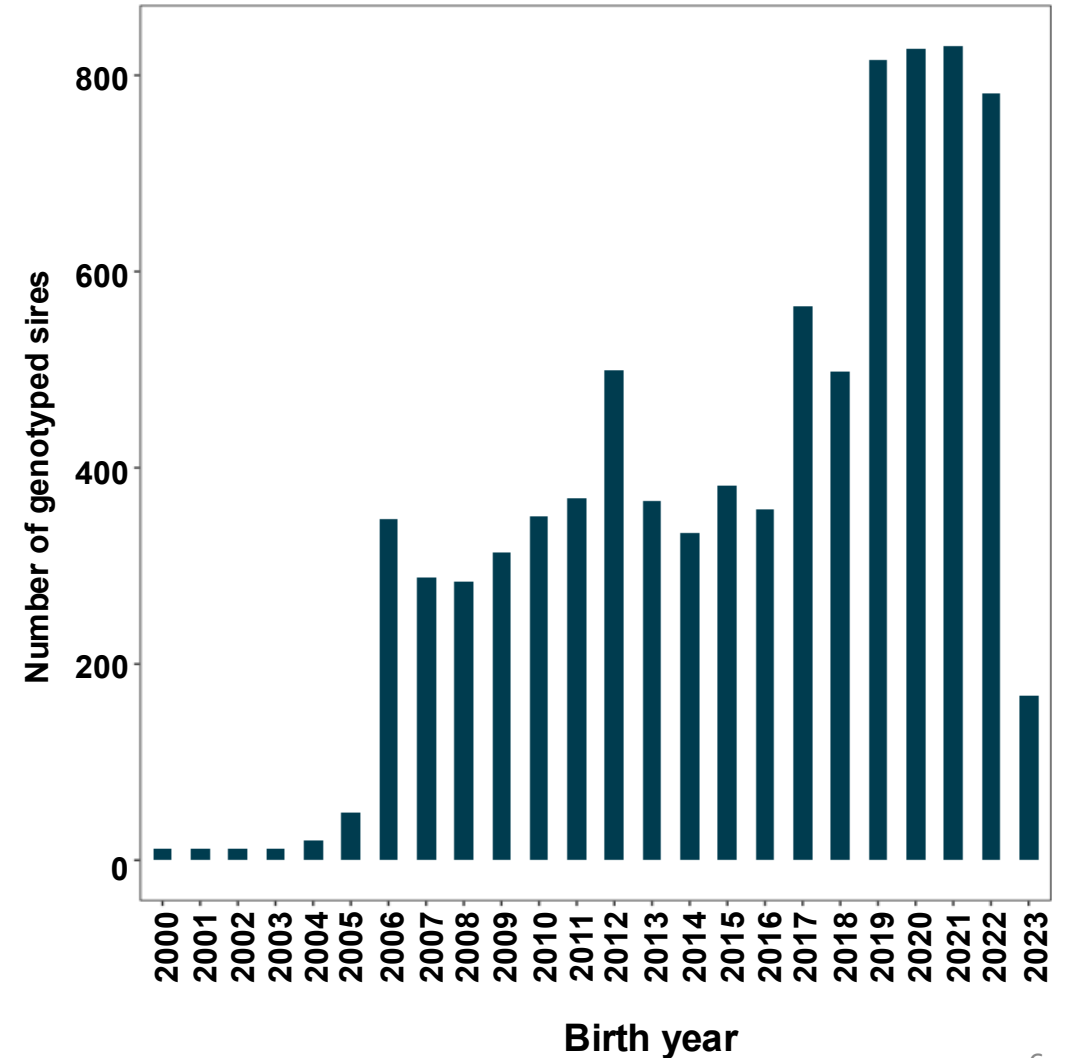
Expected future inbreeding (EFI) can be estimated as half the relationship value of the sire

Assess the current average genetic relationship among foreign and domestic bulls and active Canadian Holstein cows using both pedigree and genomic data

Data structure

	Number of animals
Sires	8,491
Dams	131,139
Genotyped animals	146,698
Pedigree	616,258

Pedigree depth was 30 generations
Pedigree completeness was > 99%



Progeny contribution

Contribution to sire

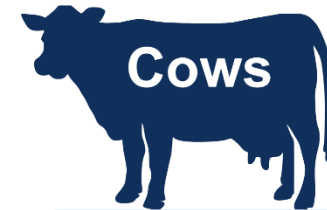
$$C_{si} = \sum_{i=1}^m \left(\frac{1}{2}\right) C_i$$

$$C_i = \begin{cases} 1 & \text{if active} \\ 0 & \text{if not active} \end{cases}$$

Contribution to dam

$$C_{di} = \sum_{i=1}^m \left(\frac{1}{2}\right) C_i$$

Active Cows and Heifers



Test date in
April 2024



≤30 mo
No "left herd" date

Direct contribution

$$R_i = \begin{cases} C_i & \text{if } S_i=0 \text{ and } D_i=0 \\ 0.75 C_i + 0.5 C_{Si} & \text{if } S_i \neq 0 \text{ and } D_i=0 \\ 0.75 C_i + 0.5 C_{Di} & \text{if } S_i=0 \text{ and } D_i \neq 0 \\ 0.5 C_i + 0.5 C_{Si} + 0.5 C_{Di} & \text{if } S_i \neq 0 \text{ and } D_i \neq 0 \end{cases}$$



$$Rvalue_i = \frac{R_i}{n}$$

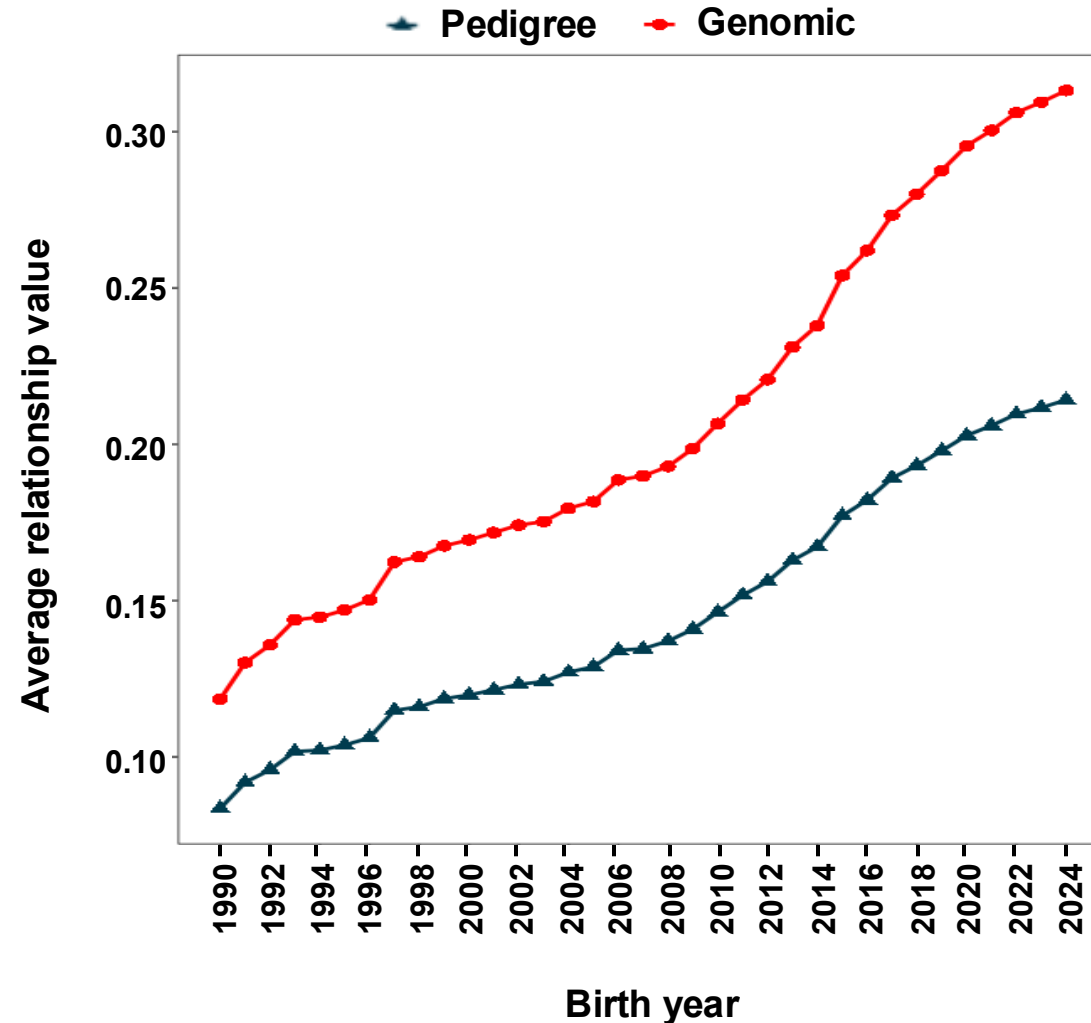
R_i = total direct contribution of animal i based on the active cows and heifers

n = number of active cows and heifers

S_i and D_i = sire and dam

Results - Average relationship values

- Average genetic relationship increases over time
- Mirrors the observed increase in inbreeding
- GR-values were ~1.5 higher than R-values but increase in parallel



Comparison of relationships and inbreeding

Birth Year	R-values	GR-values	EFI*	GFI*	Inbreeding coefficients
2014	16.7	23.8	8.1	11.6	7.5
2015	17.7	25.4	8.4	11.9	7.8
2016	18.2	26.2	8.9	12.7	8.1
2017	18.9	27.3	9.1	13.1	8.6
2018	19.3	28.0	9.5	13.7	8.8
2019	19.8	28.8	9.7	14.0	9.3
2020	20.3	29.6	9.9	14.4	9.7
2021	20.6	30.0	10.1	14.8	10.1
2022	21.0	30.6	10.3	15.0	10.4
2023	21.2	30.9	10.5	15.3	10.8
2024	21.4	31.32	10.6	15.5	11.1

- **Correlation between R-values and inbreeding was 0.77**

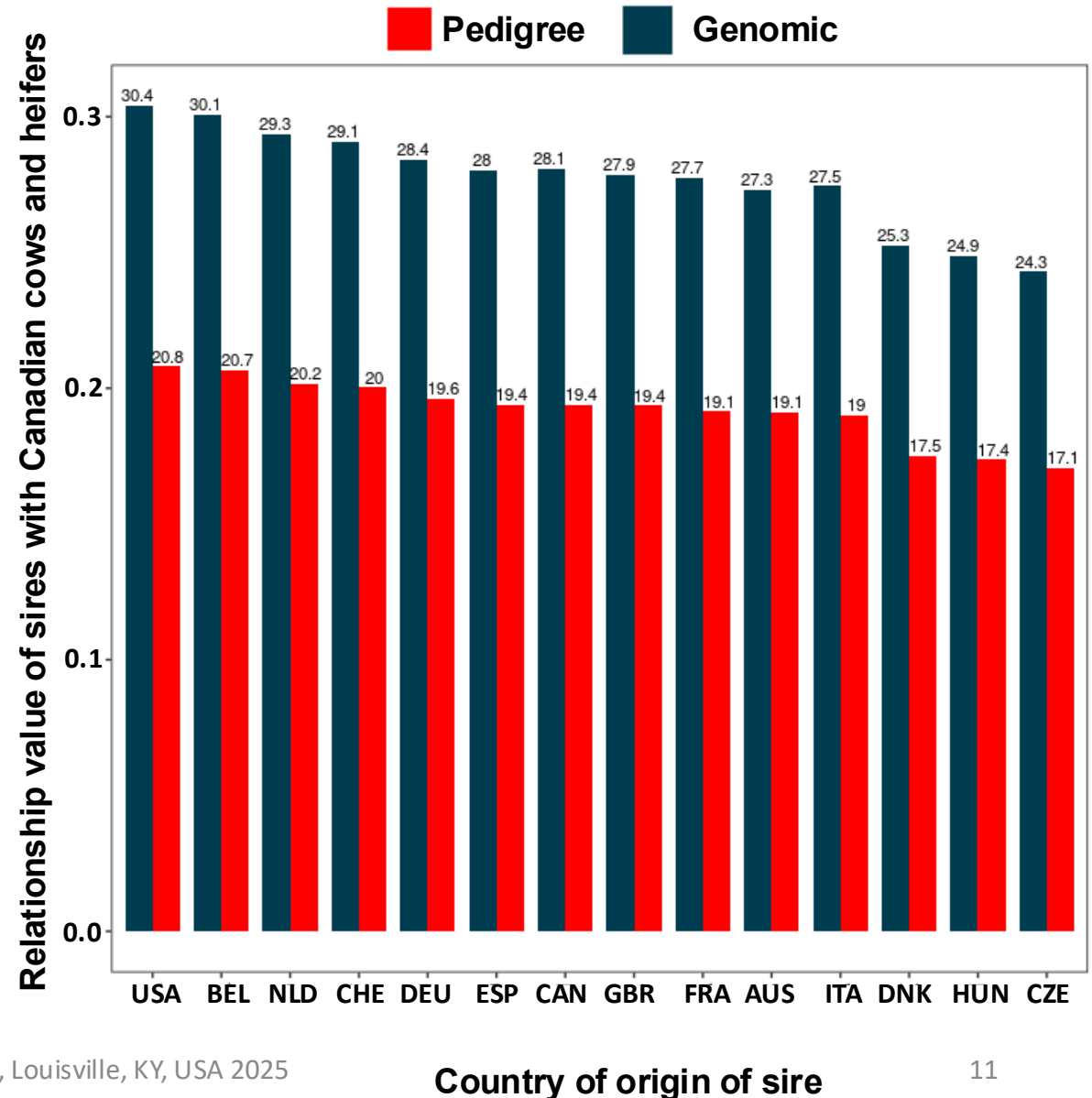
- **Correlation between GR-values and inbreeding was 0.76**

*EFI – Pedigree Expected Future Inbreeding

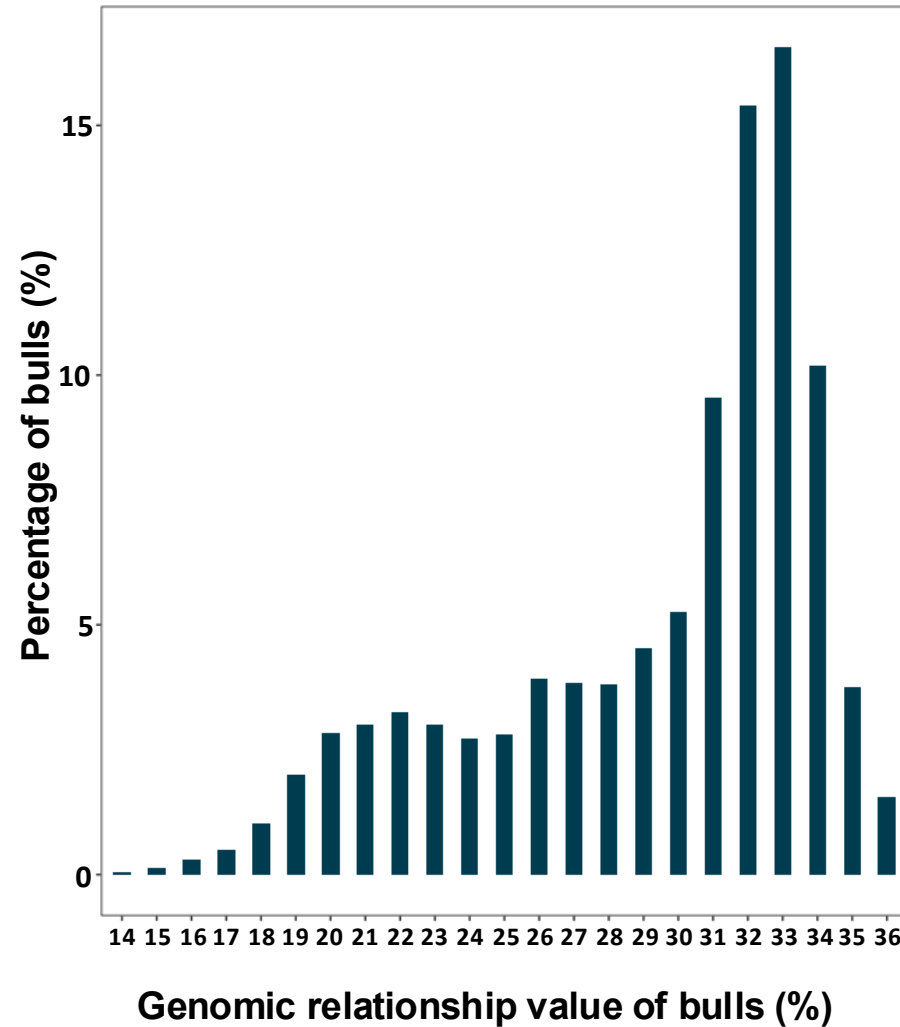
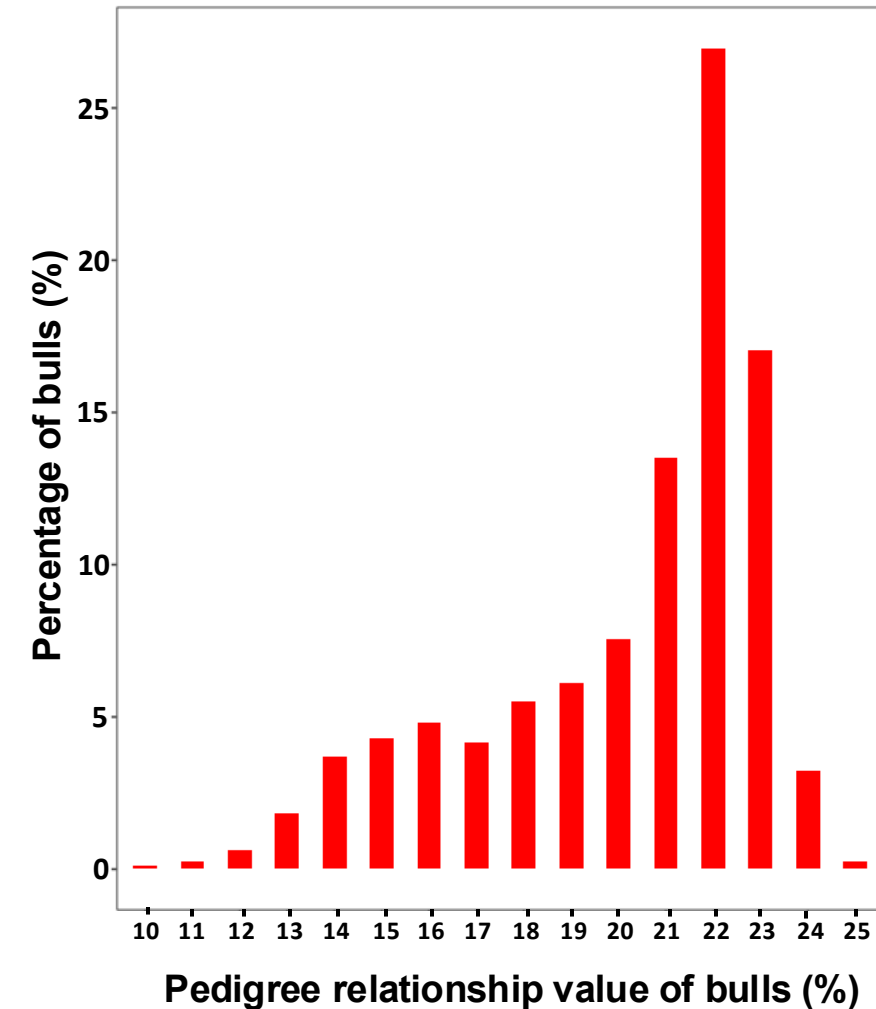
*GFI – Genomic Future Inbreeding

Relationships between bulls and active females

- R-values of international bulls and with active Canadian cow population ranged from 17.1% to 20.8%
- GR-values of international bulls and with active Canadian cow population ranged from 24.3% to 30.4%
- Narrower range of R-values values in 2024 (17.1% to 20.8%) compared to (4.2% to 11.7%) in 2004
(Van Doormaal et al., 2004)
- Canadian bull R-values increased from 11.7% in 2004 to 19.4% in 2024

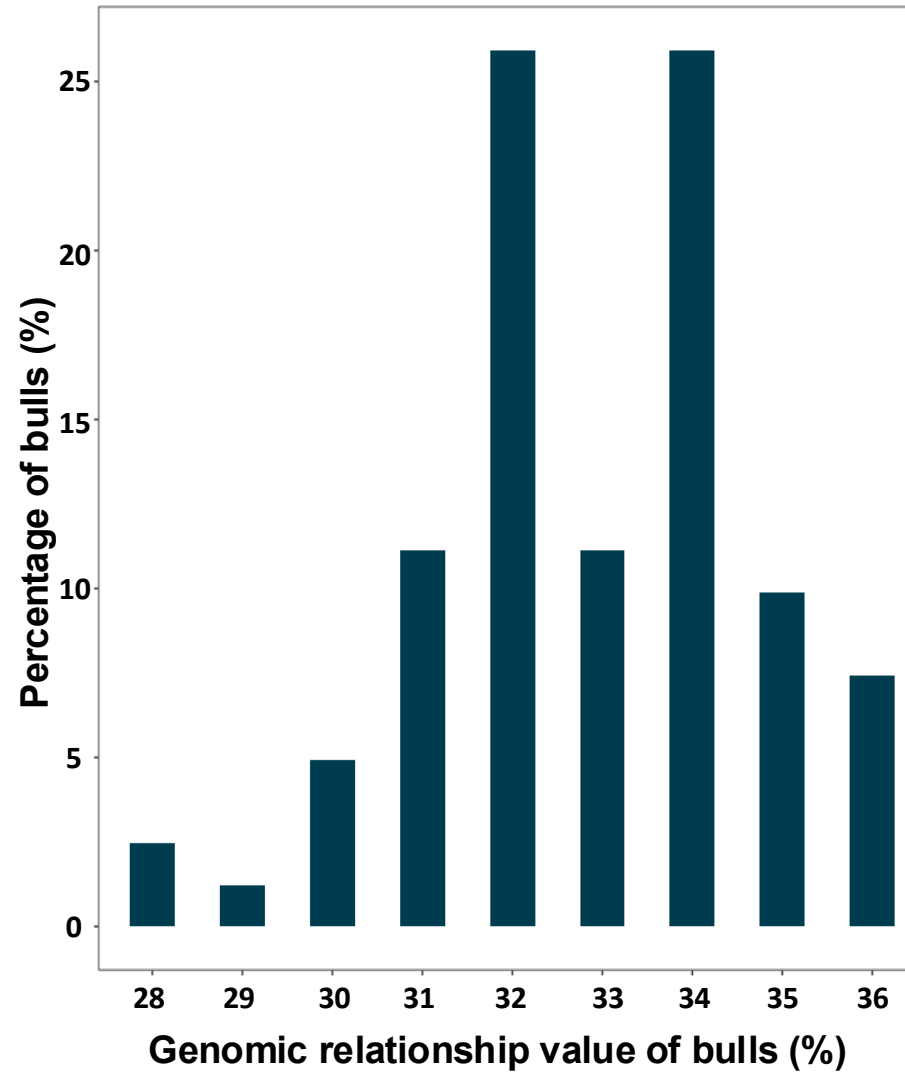
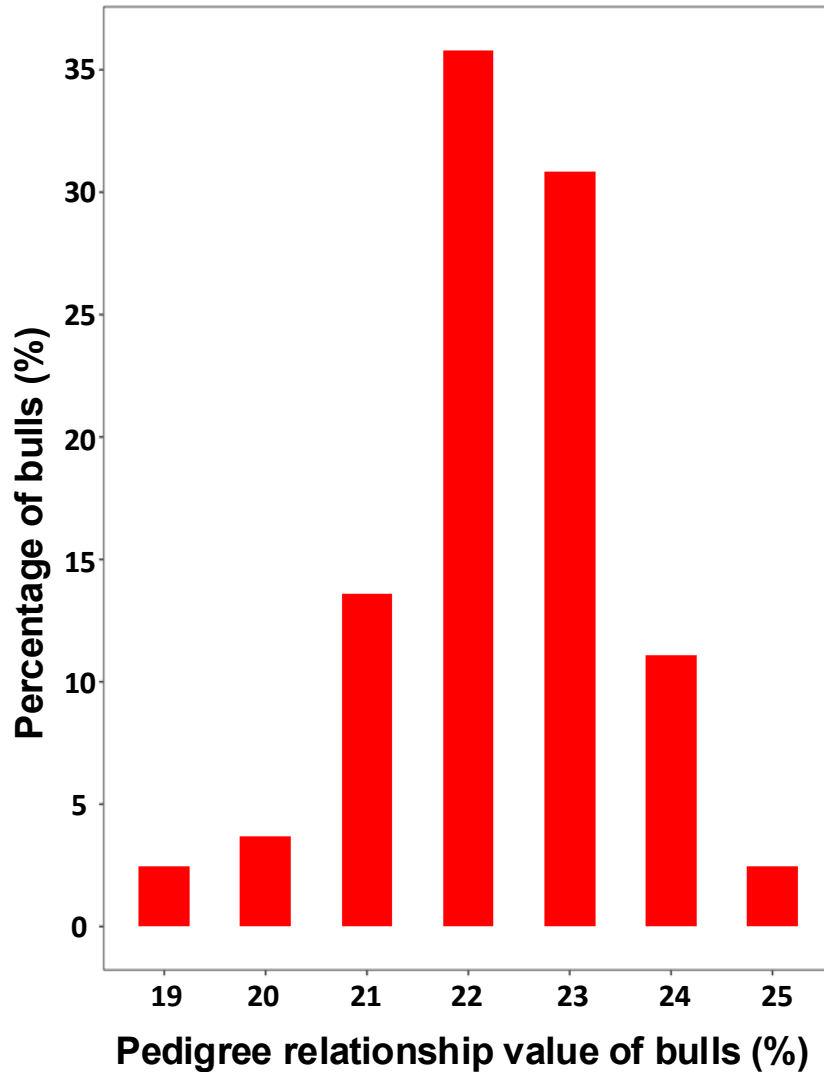


Proportion of all bulls and relationship values



- R-values ranged from 10% to 25%
- GR-values ranged from 14% to 36%
- Highlights opportunity to select less related bulls

Top 100 LPI bulls



- R-values ranged from 19% to 25%
- GR-values ranged from 28% to 36%
- Highlights substantial contribution to active population

The average genetic relatedness of international and Canadian bulls to active Canadian cow population has increased over time

The range of genetic relationships of international with active Canadian population has narrowed

Managing inbreeding will require a collaborative efforts of academia, AI companies and producers

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