Genomic Evaluation for Resistance to Fertility Disorders in Canadian Dairy Breeds

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Health Recording and Genetic Evaluation in Canada

- **2007**: national dairy health data collection system (8 diseases)

- **2014**: mastitis resistance (AY, HO, JE)
- **2016**: metabolic disease resistance (AY, HO, JE)

- **2020**: resistance to fertility disorders (AY, HO, JE)

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Fertility Disorders - Phenotypes

- Traits (0 = no case, 1 = at least one case):

  - Cystic Ovaries (**CO**): calving – 305 DIM
  - Metritis (**MET**): calving – 150 DIM
  - Retained Placenta (**RP**): calving – 14 DIM

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Fertility Disorders - Model

- Multiple-trait linear animal model

  H = (pedigree + genotypes) based relationships
- No ‘indicator’ traits in the model
- First and later lactations: different (correlated) traits
- Observations on lactations > 2 treated as repeated observations for lactation 2
- 6 traits in total

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Fertility Disorders - Model

$$y = H + YS + ASP + hy + a + pe + e$$

Fixed effects:

H: herd

YS: year – season

ASP: age – season – parity

Random effects:

hy: herd – year

a: animal additive genetic

pe: permanent environmental (lactations >1)

e: residual

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Fertility Disorders - Methods

- Single-Step method (MiX99 software)
- Reference population: all genotyped animals in the pedigree
- Estimation of GEBV (phenotypes + pedigree + genotypes)
- Calculation of DGV (reference)
- Estimation of SNP effects
- Calculation of DGV for other genotyped animals (not in Single-Step)

- GEBV - monthly, DGV (new animals) - weekly

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Fertility Disorders - Methods

- Proofs expressed as **RBV** (mean = **100**, SD = **5** for 'base' sires) with reversed sign: higher RBV = better resistance
- Combined CO, MET and RP proofs:
  - 1st and later lactation for a given disorder
  - equal weights (on RBV scale)
- Sire proof (any combined trait) '**Official**' when:
  - min. **5** herds with phenotypes
  - min. reliability of **70**% (HO) and **50**% (AY and JE)
- Sire '**Official**' for Fertility Disorders when 'Official' for any combined trait

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Fertility Disorders – Genetic Parameters

- Subset of HO data
- ~ **76,000** cows with ~ **120,000** records
- Same model as for GE
- Only A (= pedigree-based relationships) in genetic co-variance structure
- Bayesian method (Gibbs sampling)
- HO estimates to be used for AY and JE

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Fertility Disorders – Genetic Parameters

- Heritability: **0.02 ÷ 0.03** (across all traits)
- Genetic correlation between first and later lactation traits:
  from **0.55** (CO) to **0.70** (MET)
- CO genetically uncorrelated with MET and RP
- Genetic correlations between MET and RP:
  - **0.54** (first lactation)
  - **0.51** (later lactations)

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Data for GE: August 2020

	AY	HO	JE
Phenotypes	35,854	1,968,876	24,653
Cows	17,783	1,004,586	14,085
Sires	844	21,750	1,109
Pedigree	36,027	1,726,630	33,337

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Genotypes (50K or imputed) for GE: August 2020

	AY	HO	JE
Available	11,066	1,929,299	240,665
Genotyped Cows	1,500	59,186	1,039
Genotyped Sires	523	10,609	779
Genotyped Animals in Pedigree	**2,602**	**81,886**	**2,812**

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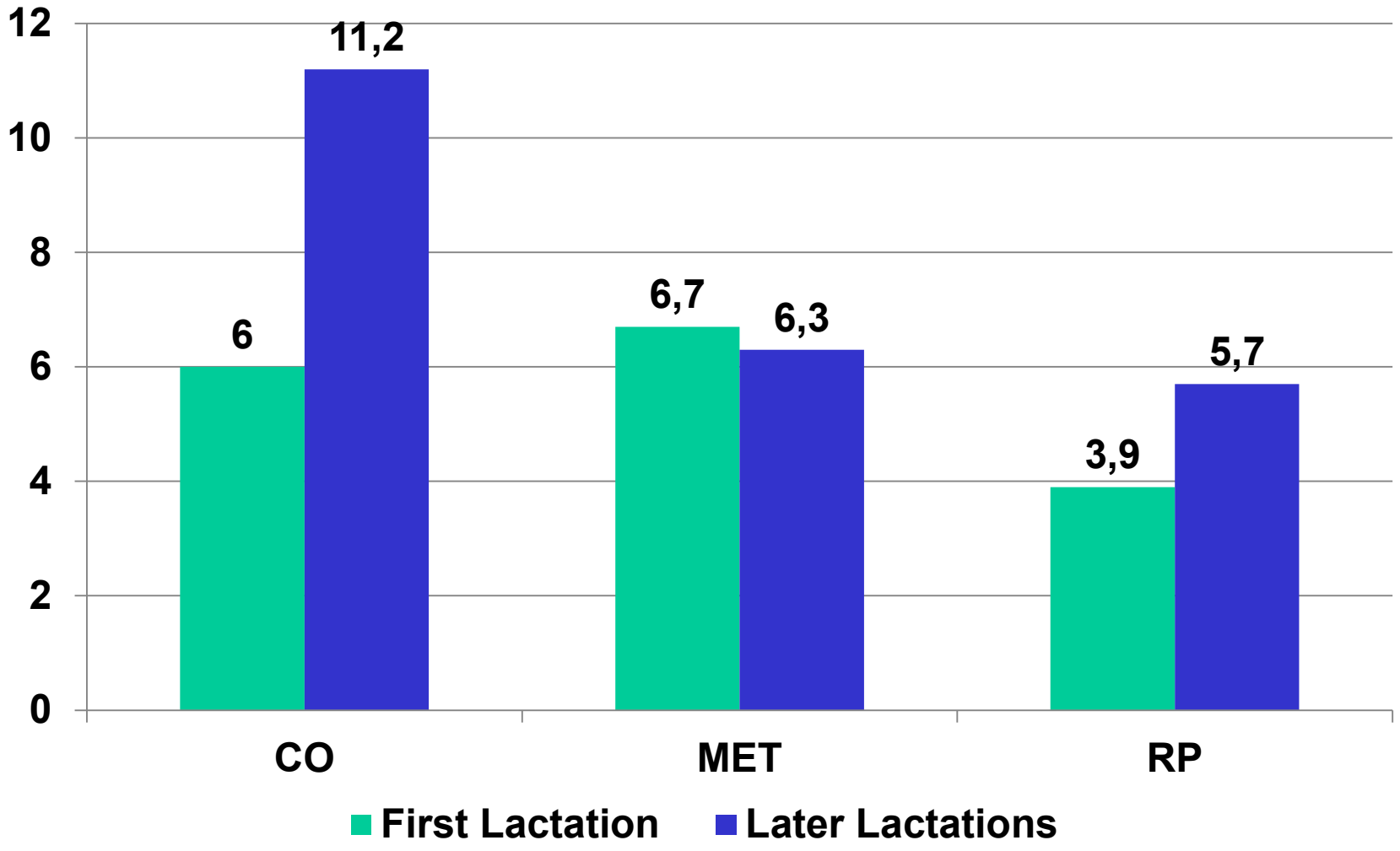
Fertility Disorders - Frequency (%) - HO



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Fertility Disorders – GE Results – August 2020
RBV for Official Sires

Breed	N	Mean	SD	Min	Max
AY	261	100	5.1 ÷ 5.7	79 ÷ 84	111 ÷ 115
HO	6,604	99 ÷ 101	5.0 ÷ 5.3	73 ÷ 80	114 ÷ 120
JE	124	100	4.8 ÷ 5.4	79 ÷ 89	110 ÷ 116

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Fertility Disorders – GE Results – August 2020
Average Reliability of RBV for Official Sires

Lactation	Trait	AY (N = 261)	HO (N = 6,604)	JE (N = 124)
First	CO	53	78	54
	MET	59	81	61
	RP	59	81	61
Later	CO	60	81	63
	MET	61	81	65
	RP	62	82	60
Average		**59**	**81**	**61**

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Fertility Disorders – GE Results – December 2019
Average Reliability of RBV for Young Bulls (Born in 2019)

Lactation	Trait	AY (N = 2,336)	HO (N = 70,027)	JE (N = 3,031)
First	CO	18	61	13
	MET	20	62	15
	RP	20	62	15
Later	CO	20	62	15
	MET	21	62	16
	RP	21	62	16
Average		**20**	**62**	**15**

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Fertility Disorders – GE Results – August 2020
Proof Correlations (x100) – HO Official Sires (N = 6,604)

- Combined RBV:
  - CO – MET: **23**
  - CO – RP: **12**
  - MET – RP: **74**

- Combined RBV – First/Later lactation RBV:

	First	Later
CO:	**96**	**97**
MET:	**94**	**95**
RP:	**95**	**96**

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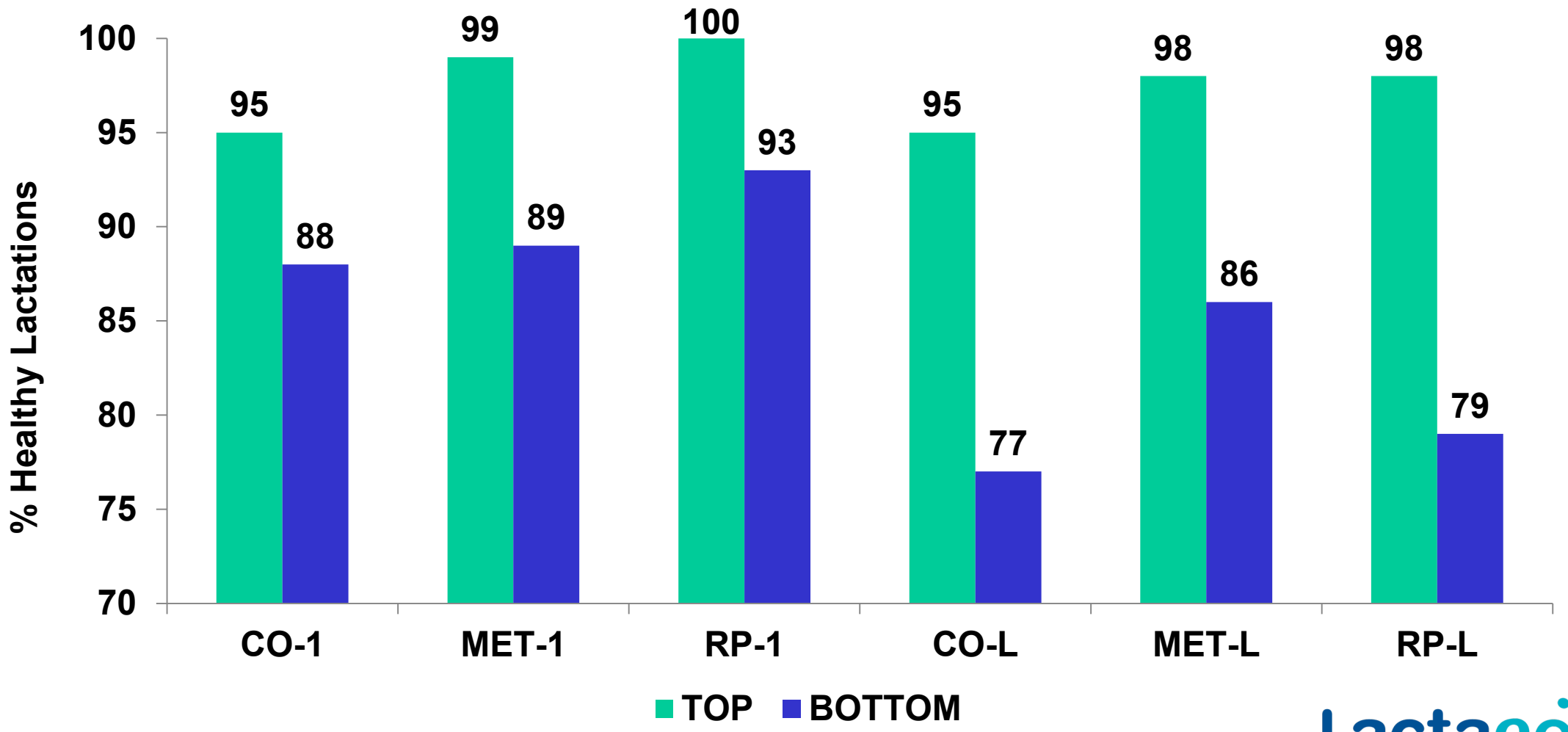
Top 10 vs. Bottom 10 HO Official Sires by (Combined) Trait RBV



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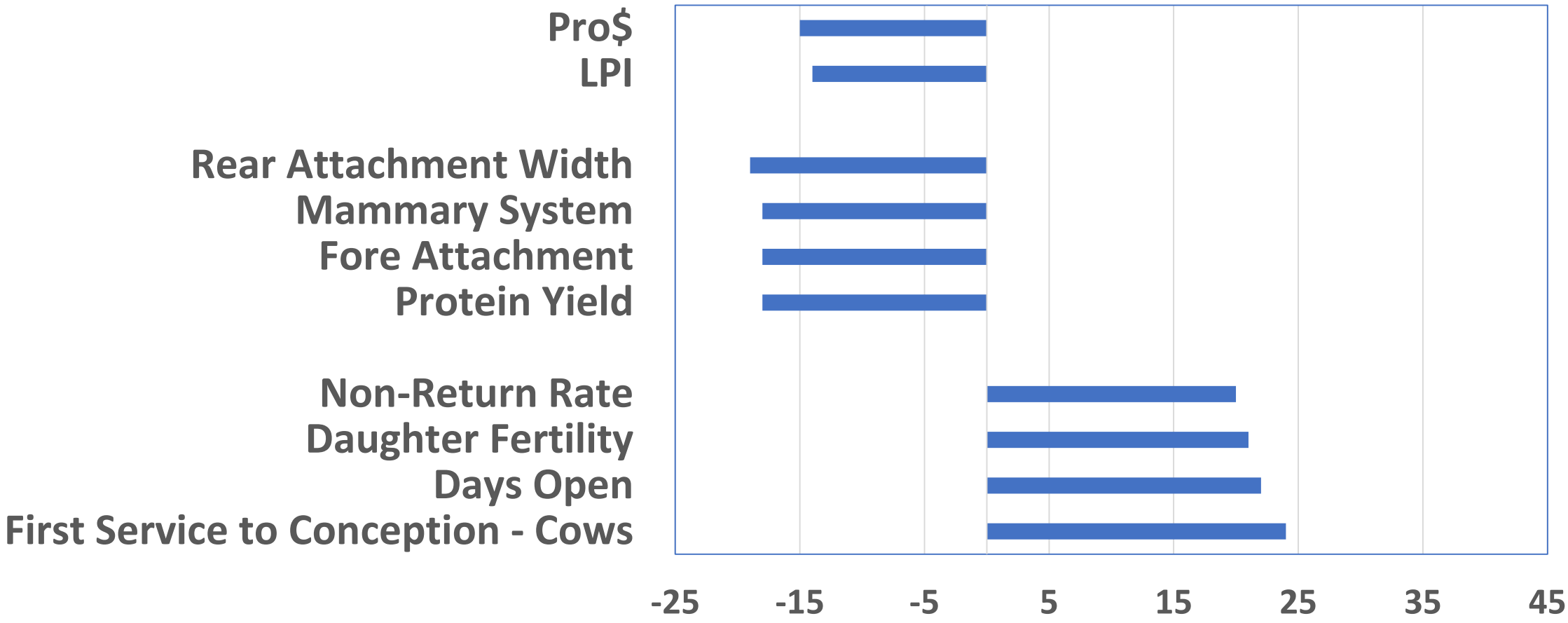
LPI & Genotyped HO Sires (N = 9,816)
Correlations: (Combined) CO - Other Traits



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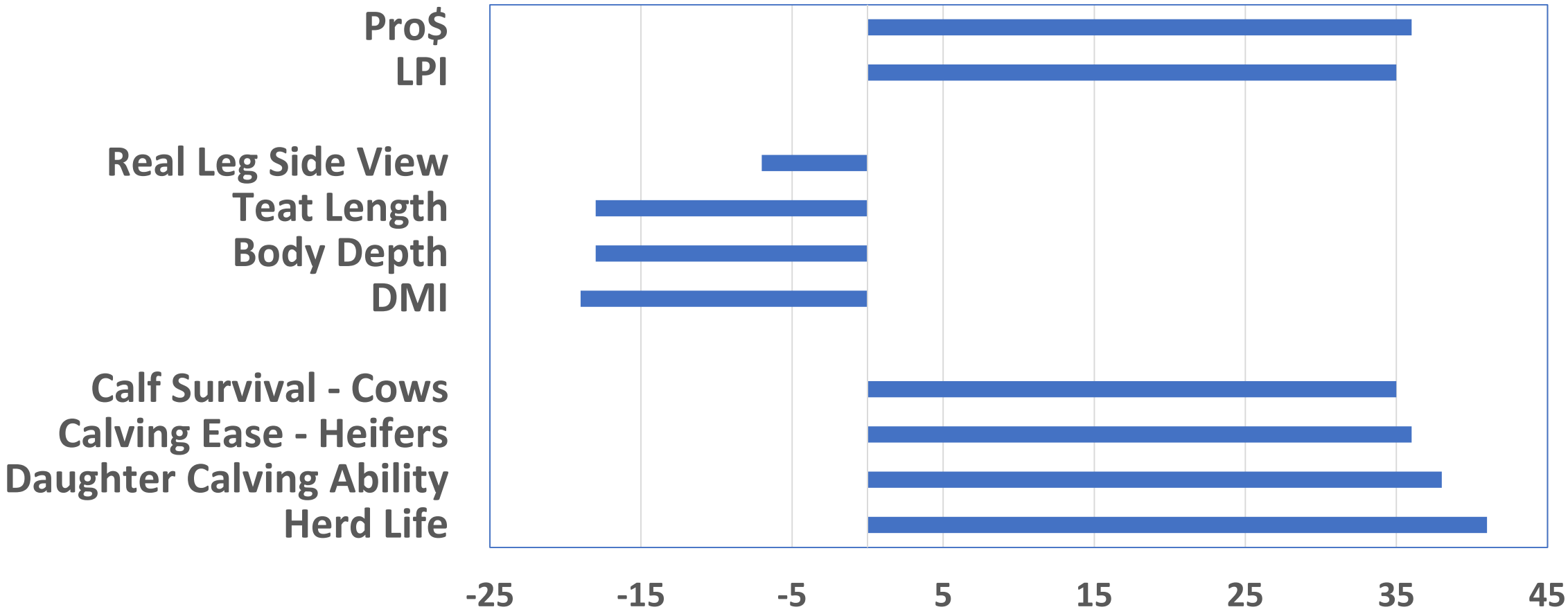
LPI & Genotyped HO Sires (N = 9,816)
Correlations: (Combined) MET - Other Traits



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Summary

- GE system for resistance to fertility disorders developed
- **Single-Step** method
- 3 traits: **Cystic Ovaries**, **Metritis**, **Retained Placenta**
- 3 breeds: **Ayrshire**, **Holstein**, **Jersey**
- Holstein genetic parameters used for all breeds
- RP and MET: favorably correlated with LPI and Pro$
- CO: small unfavorable correlation with LPI and Pro$

- First official release: **December 2020**

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Acknowledgements

- All dairy producers recording health data are gratefully acknowledged
- Research Funded by:
  DairyGen Council of Lactanet and NSERC of Canada, Dairy Research Cluster Initiative: Dairy Farmers of Canada, Agriculture and Agri-Food Canada, Canadian Dairy Commission, Ontario Genomics

NSERC CRSNG
Dairy Farmers of Canada
Les Producteurs laitiers du Canada
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Canadian Dairy Commission
Commission canadienne du lait
UNIVERSITY of GUELPH
CGIL
Ontario Genomics
THE Resilient Dairy GENOME PROJECT
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