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Genetic Evaluation for Resistance to Metabolic Diseases in Canadian Dairy Breeds

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Health Recording and Genetic Evaluation in Canada

- **2007: nation-wide health recording**

  Mastitis, Displaced Abomasum, Ketosis, Milk Fever, Retained Placenta, Metritis, Cystic Ovaries, Lameness

- **2014: genetic evaluation for mastitis resistance**
- **December 2016: implementation of genetic evaluation for metabolic disease resistance**

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Traits

- **Metabolic disease traits (MET) :**
  - **Clinical Ketosis (CK)**
  - **Displaced Abomasum (DA)**
    - 0 – no case

      1 – at least one case
    - in 100d after calving
  - **Sub-clinical Ketosis (SCK) = Milk β-hydroxybutyrate (BHB)**
    - at first test-day, between 5 and 45 DIM

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Traits

- **Indicator traits:**
  - **Fat to Protein Ratio (F:P)**
    at first test-day, between 5 and 45 DIM
  - **Body Condition Score (BCS)**
    from first lactation first classification

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Traits

- Lactations 1 – 5 only
- First and later lactations health and milk recording traits: different but correlated traits
- Observations from lactations >2: repeated records of lactation 2

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Data for GE

- **Producer recorded health traits**
  - All herds with **CK** or **DA** recording
  - Minimum disease frequency: 1% per herd-year
- **BHB**
  - All herds included
- **F:P** and **BCS**
  - Only herds with **CK** or **DA** recording

Time threshold for all traits: April 2007

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Data for GE: August 2016

	# Cow-Lactation Records	# Cows
Ayrshire	36,765	20,697
Holstein	1,621,630	965,762
Jersey	34,088	21,745

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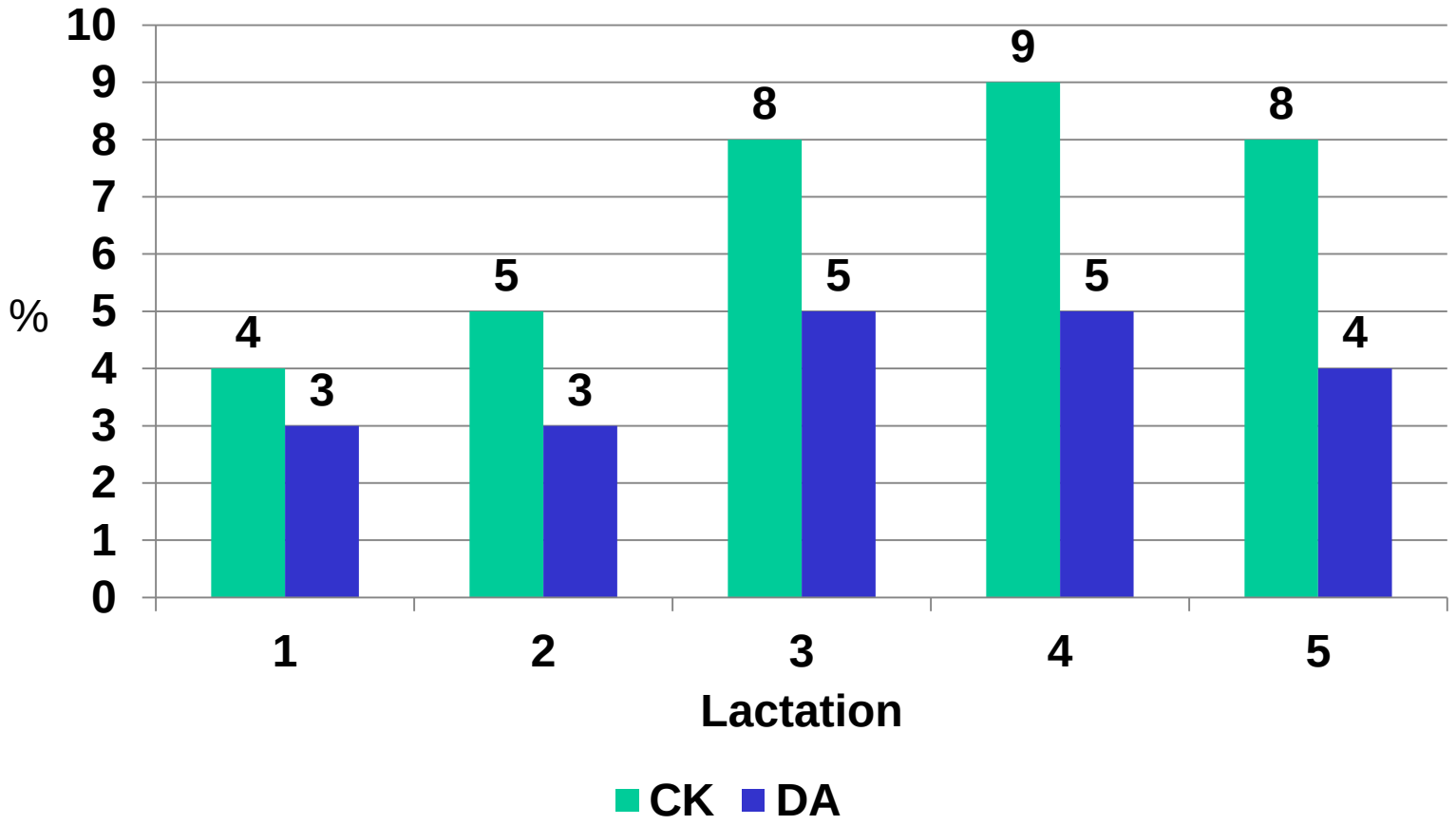
Holstein Data for GE: August 2016:
Frequency (%) of clinical cases by lactation



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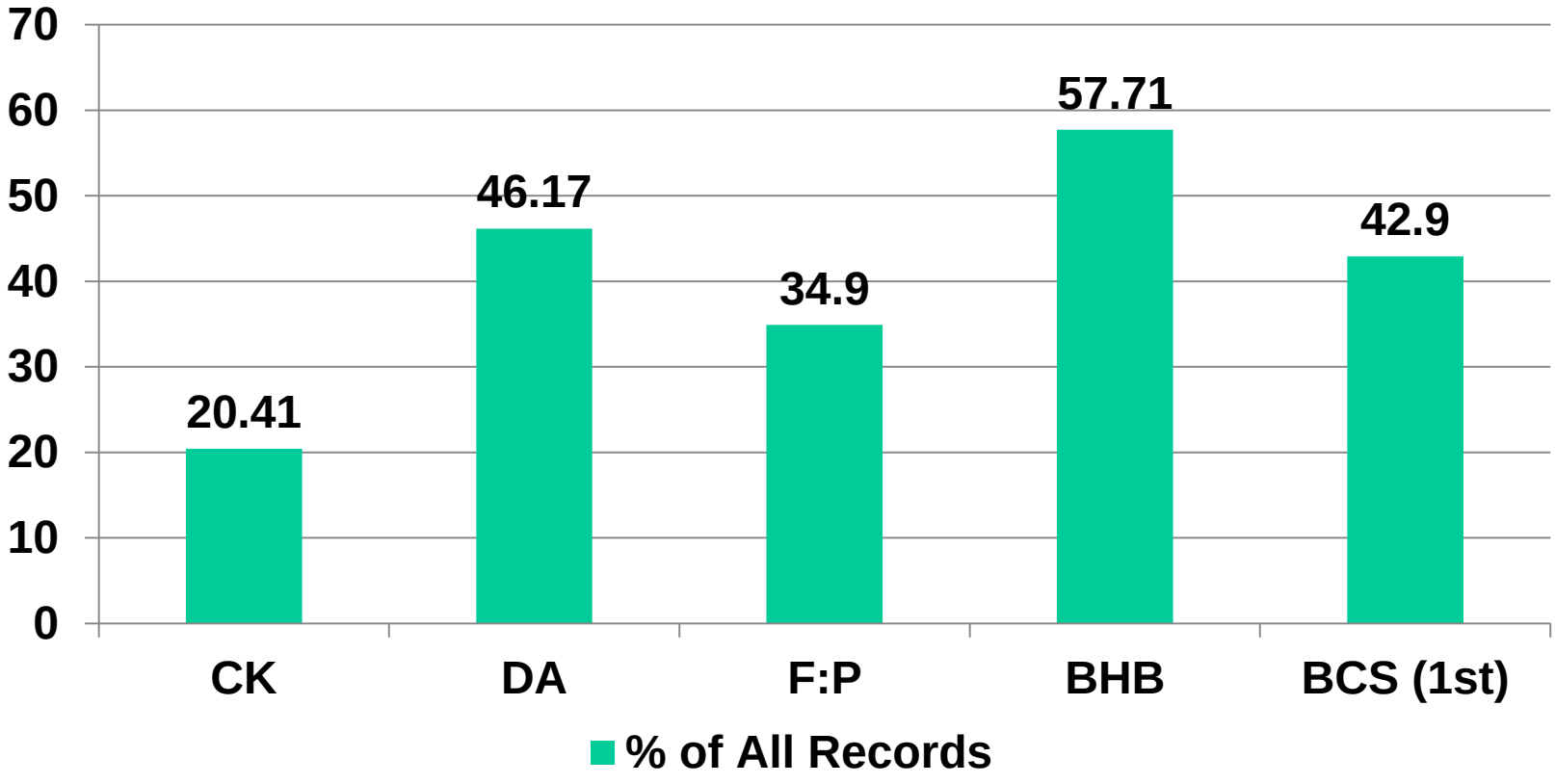
Holstein Data for GE: August 2016

Completeness of data by trait



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Model

- Multiple-trait (9 traits in total)
- Linear
- Animal model

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Model
MET and F:P

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

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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Model
BCS

$$y = HRC + AST + a + e$$

fixed effects:

HRC: herd – round – classifier

AST: age – stage of lactation – time of classification

random effects:

a: animal additive genetic

e: residual

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Genetic Parameters

- Subset of Holstein data
- ~ 36,000 cows with ~ 53,000 records
- Same model as for GE
- Bayesian methods (Gibbs sampling)
- Holstein estimates to be used for Ayrshire and Jersey

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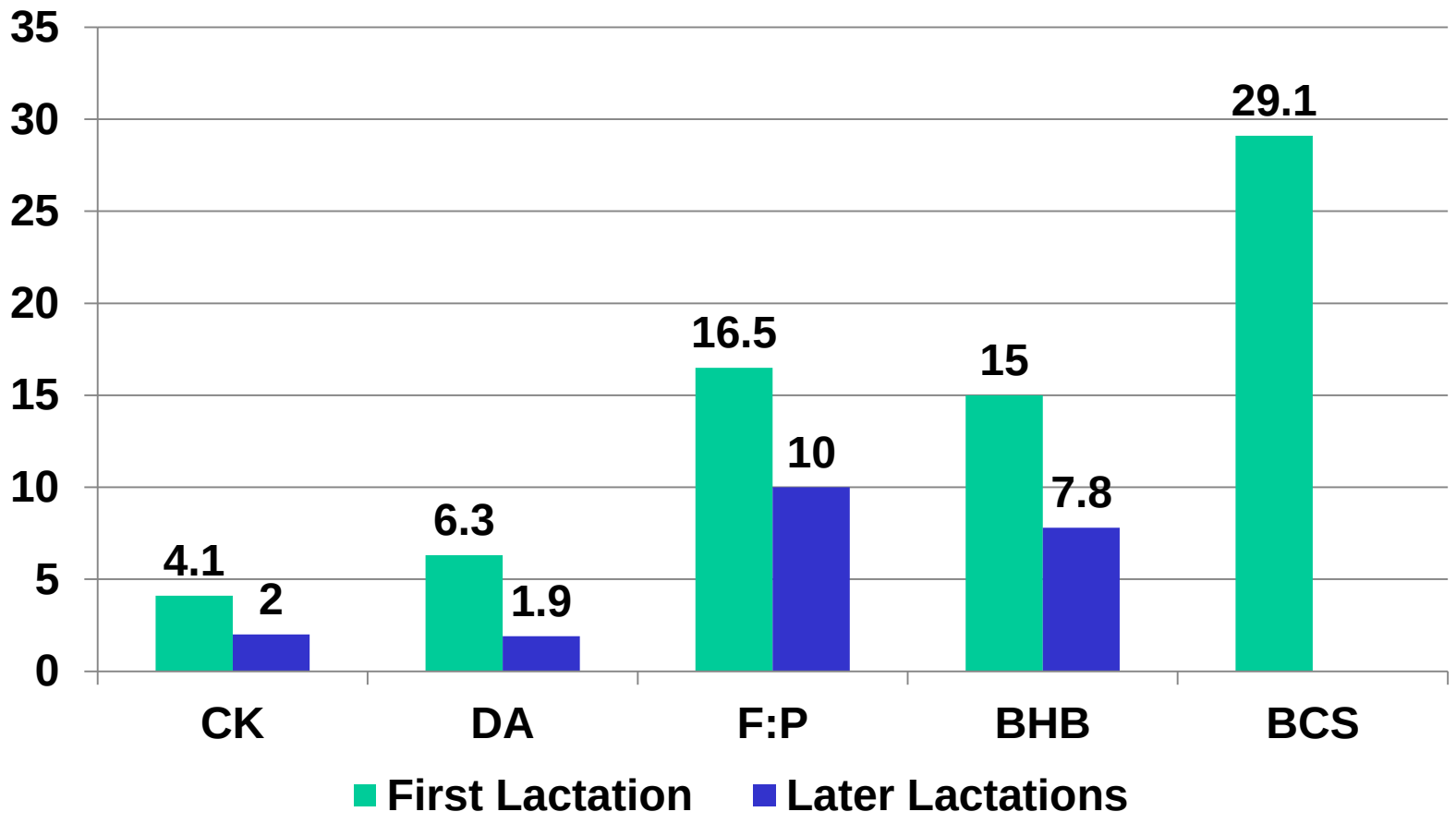
Heritability (x100)



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Genetic Correlations (x100)

Lactation /Trait		First				Later				
		CK	DA	F:P	BHB	CK	DA	F:P	BHB	BCS
First	CK		77	42	68	70	59	7	34	-56
	DA			31	34	58	79	5	8	-39
	F:P				47	40	13	70	10	-41
	BHB					49	10	13	50	-61
Later	CK						53	31	51	-19
	DA							4	5	-9
	F:P								18	8
	BHB									3

Diseases well correlated among each other and across parities

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Genetic Correlations (x100)

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BHB strong indicator of CK (first and later lactations), followed by BCS and F:P

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Genetic Correlations (x100)

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	DA							4	5	-9
	F:P								18	8
	BHB									3

BHB, F:P and BCS moderate indicators of DA in first lactation. No associations in later lactations

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Genetic Evaluation Results

- Estimated Breeding Values and reliabilities for CK, DA, and SCK for first and later lactations
- Metabolic Disease Resistance Index (MDR) and its reliability

All evaluations expressed as Relative Breeding Values (RBV): mean =100 SD = 5 for base sires

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MDR Index

MDR = 0.5*SCK + 0.25*CK + 0.25*DA

All components: $0.5*RBV_{First} + 0.5*RBV_{Later}$

Sire MDR official when for first lactation SCK :

- **min. 20 daughters**
- **min. 10 herds**
- **min. reliability:**
  - **45**% Holstein
  - **35**% Ayrshire and Jersey

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MDR Index
Rationale

- Higher frequency and cost of CK compared to DA
- Sub-clinical ketosis (SCK) more common than CK
- Selection on SCK will induce a correlated response on CK and DA
- Higher heritability of SCK
- Quantity and quality of BHB records might be superior to producer-recorder health data

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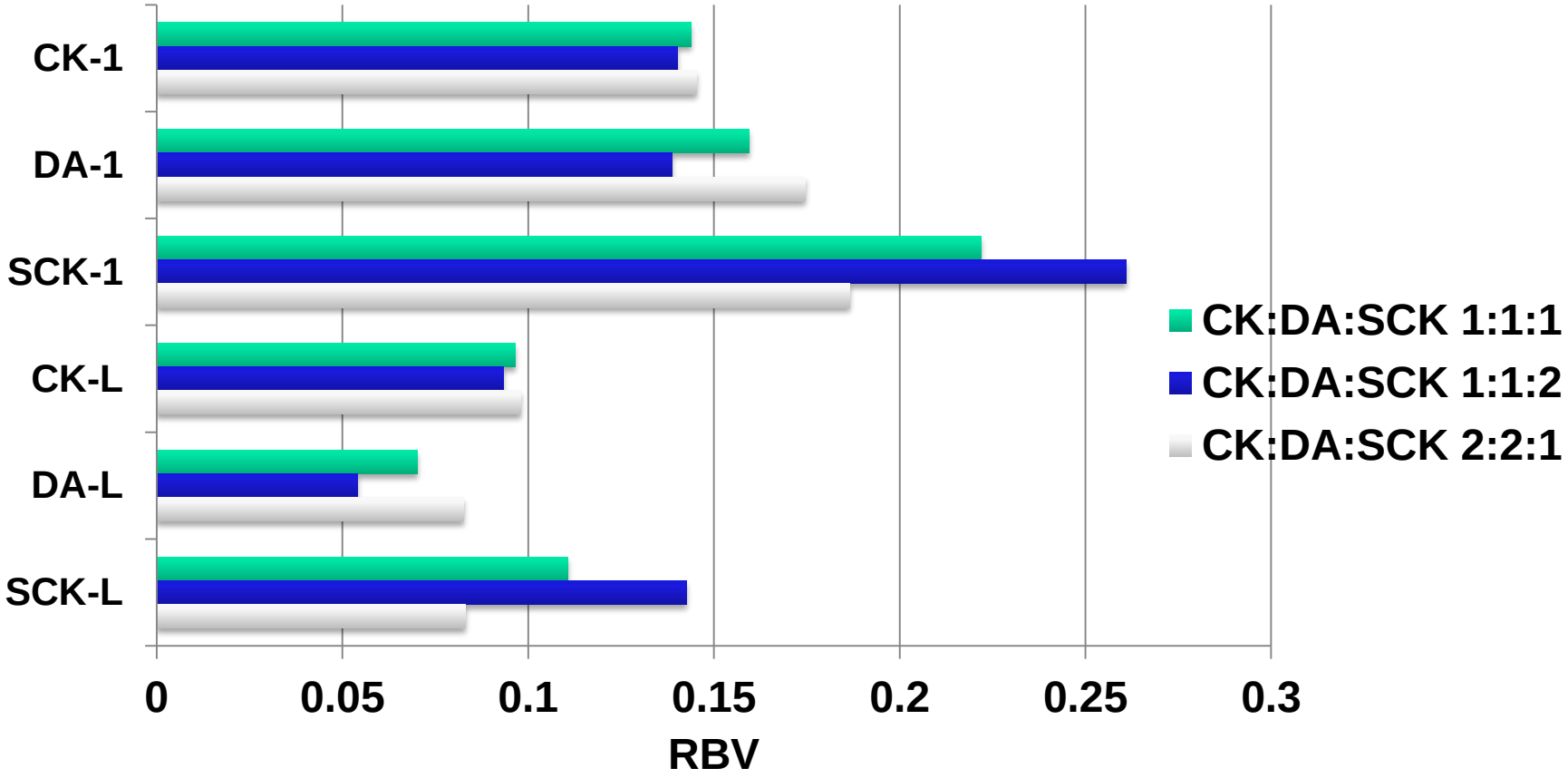
MDR Index

Expected responses: CK – DA – SCK

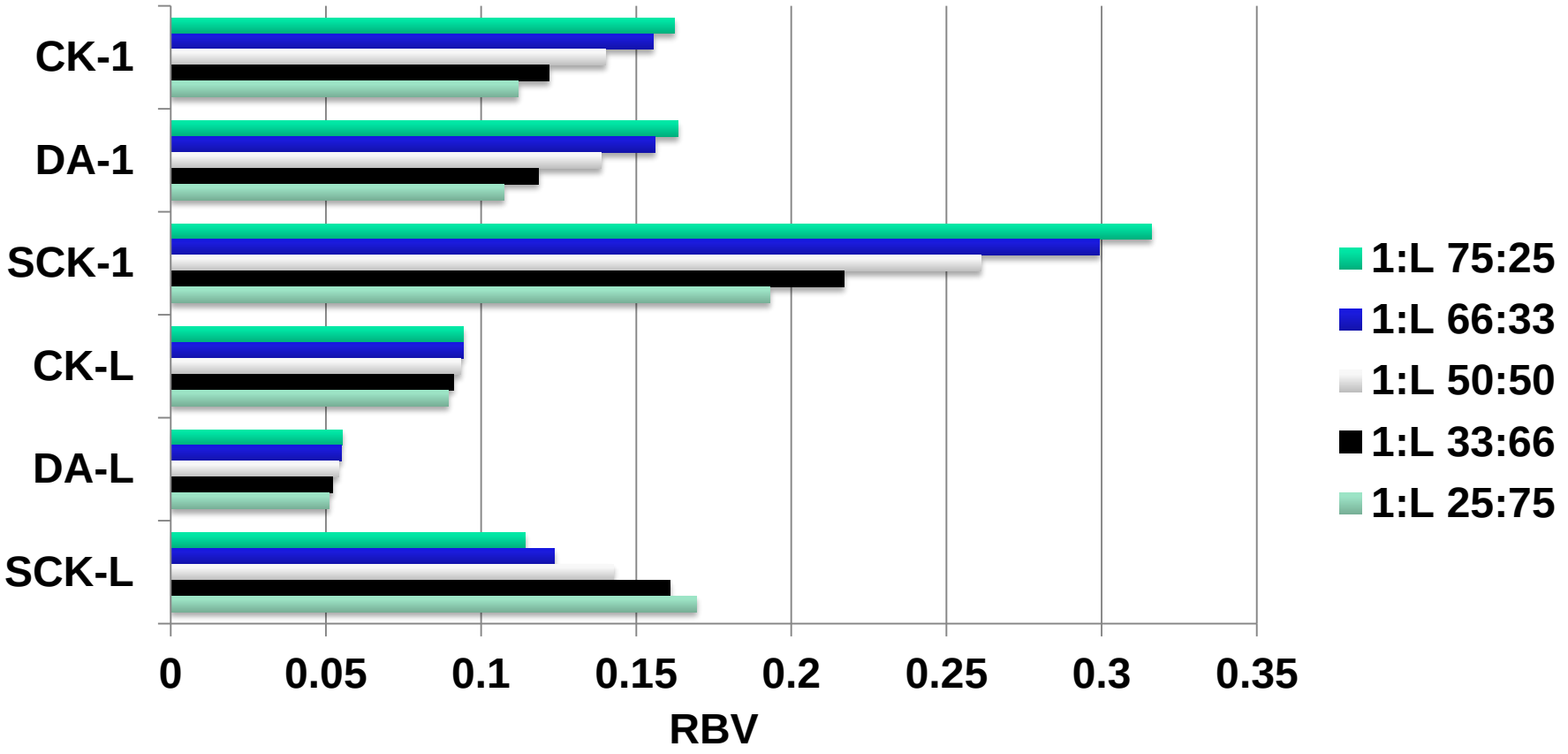
Weights: combined traits



MDR Index

Expected responses: CK – DA – SCK

Weights: First (1) vs. Later (L)



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GE Summary
Sires with official MDR index

Breed	N	MDR				Reliability			
		Mean	SD	Min	Max	Mean	SD	Min	Max
AY	108	100	5	87	120	65	12	49	96
HO	1720	100	5	81	115	74	11	43	99
JE	99	100	5	86	110	62	13	41	93

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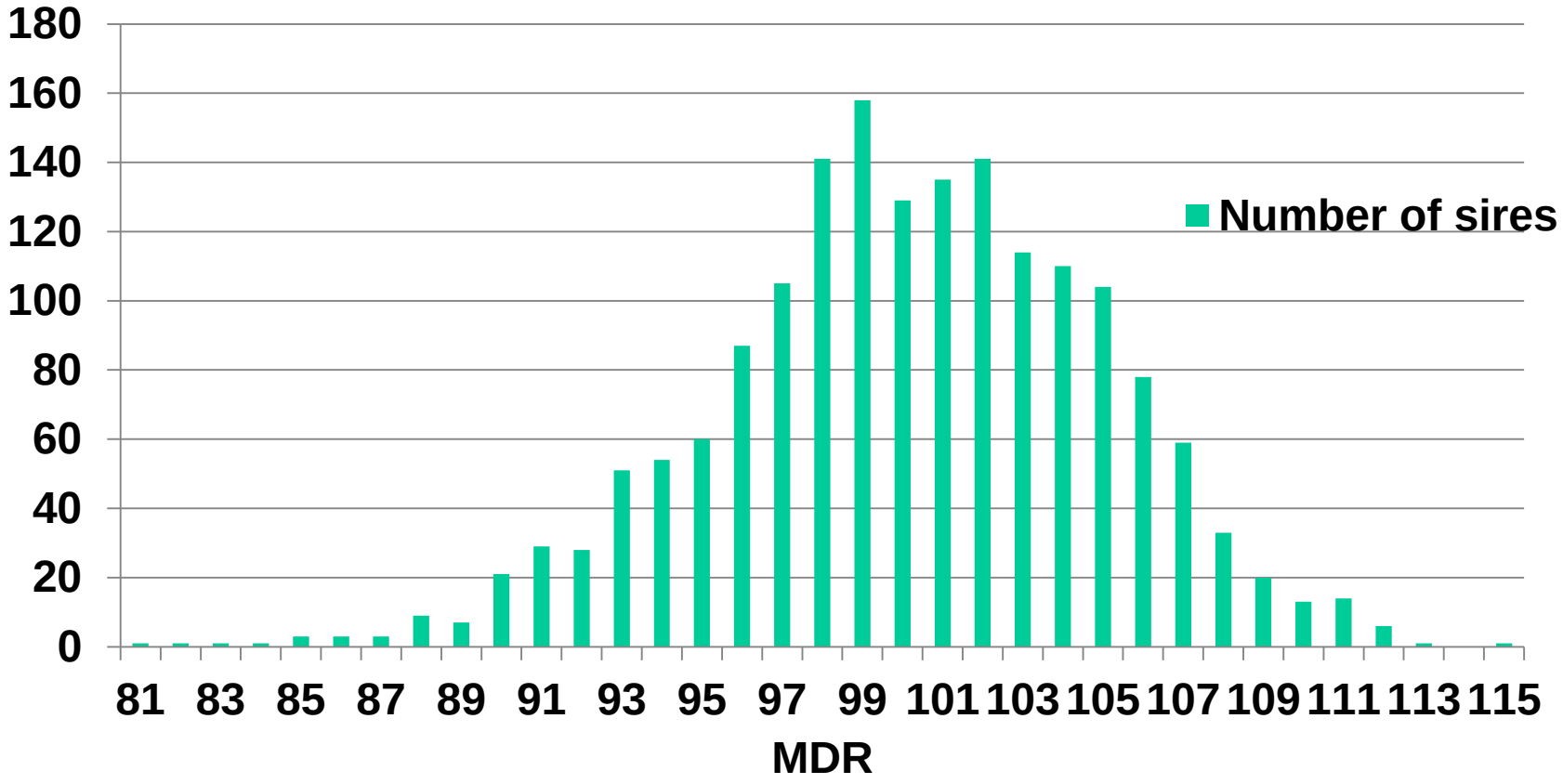
GE Summary

Holstein Sires with official MDR index



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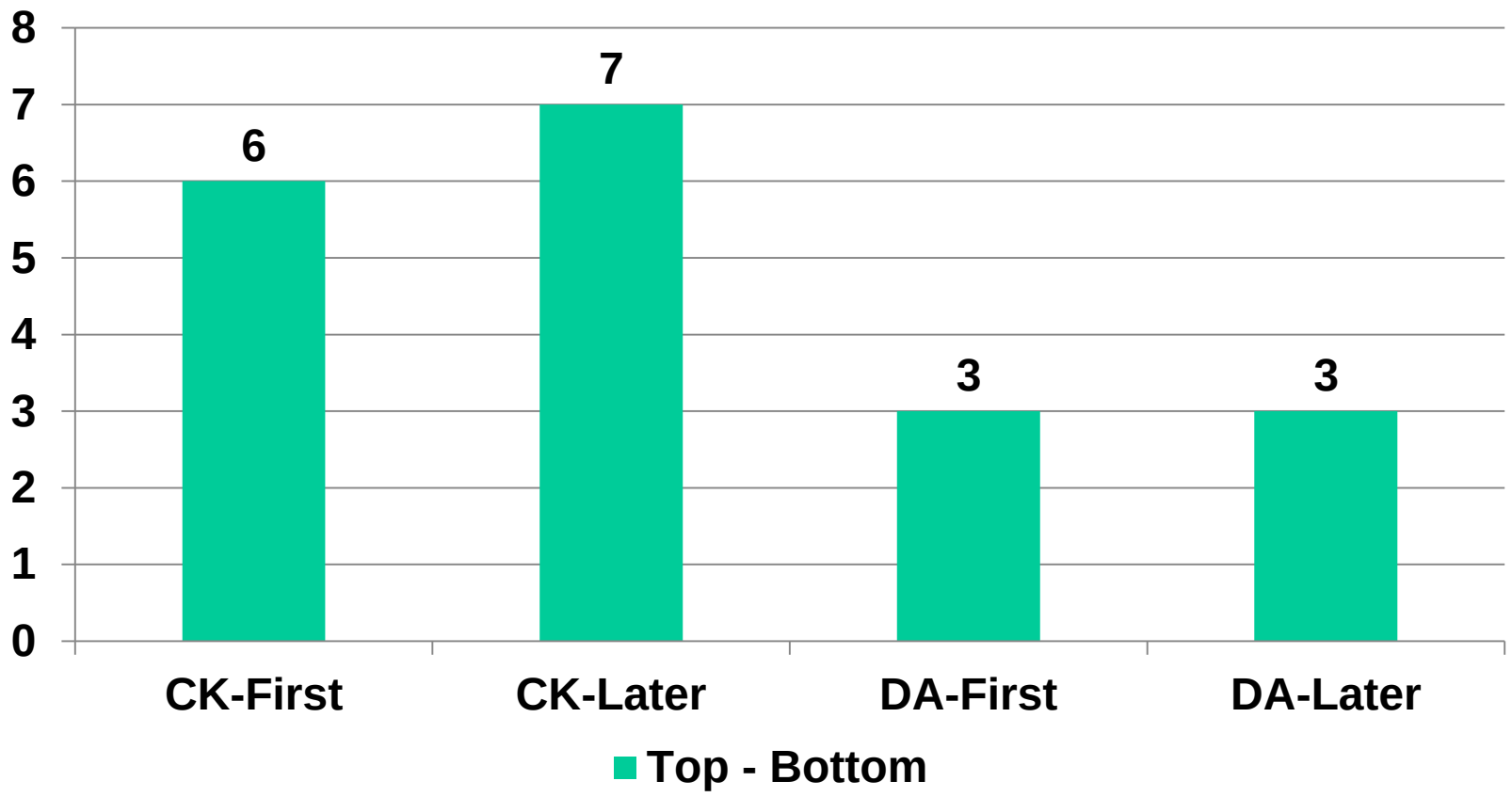
Holstein Sires with official MDR index

Difference in % Healthy Daughters: Top 10 – Bottom 10



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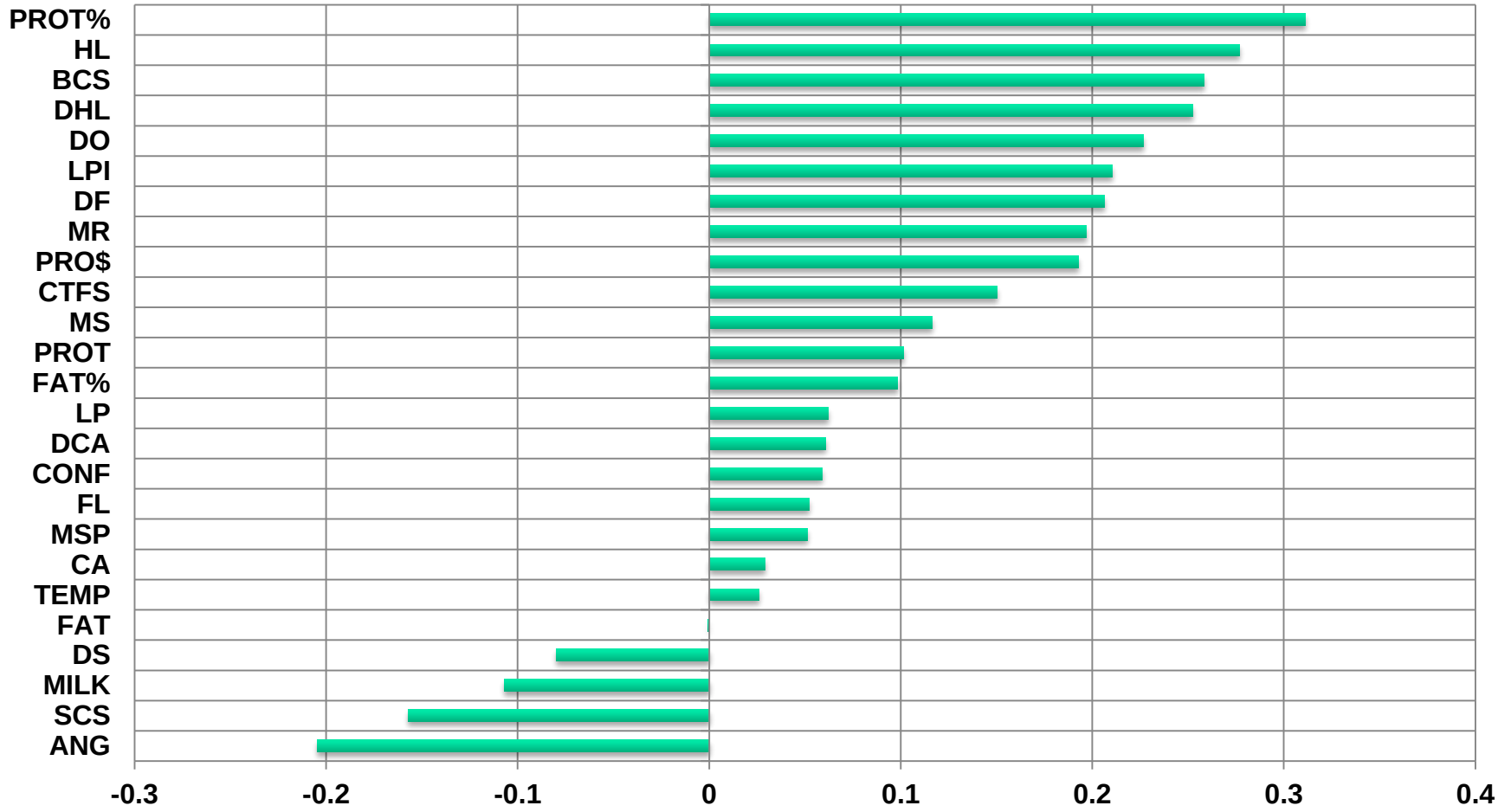
MDR and EBV for other traits

Holstein sires (N=1520)



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Summary

- GE system for metabolic disease resistance developed
- 3 breeds: Ayrshire, Holstein, Jersey
- Holstein genetic parameters for all breeds
- Genomic evaluation: Holstein
- RBV published for bulls only
- Cows: (G)PA
- MDR index recommended for sire selection
- First official release: December 2016

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