Council on Dairy Cattle Breeding
Research Updates

Kristen Parker Gaddis, Ph.D., CDCB Research Geneticist

Genomic Nominators & Laboratories Workshop – July 31, 2024

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Overview

- Recent implementations
  - Health evaluation updates
  - 305-AA
- Projects in progress
  - Milking speed evaluation
  - Fertility evaluations
  - Herd-level sustainability
  - Mobility & Hoof health
- Long-term projects
  - Lactation factors project
  - Single-step evaluation
  - Enteric methane emissions

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STRUCTURE & NEW FACES

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Research & Development Team

Dr. John Cole –

Chief Research & Development Officer

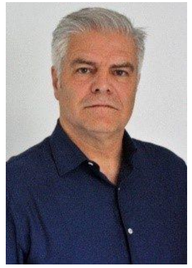
Dr. Andres Legarra – Senior Geneticist

Dr. Nick Wu – Computational Statistician

Dr. Kristen Parker Gaddis – Geneticist

Innovation Team

Dr. Javier Burchard – Chief Innovation Officer



Dr. Duane Norman – Technical Advisor

Dr. Malia Caputo – Postdoctoral researcher

Dr. Ashley Ling – Support Scientist

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RECENT IMPLEMENTATIONS

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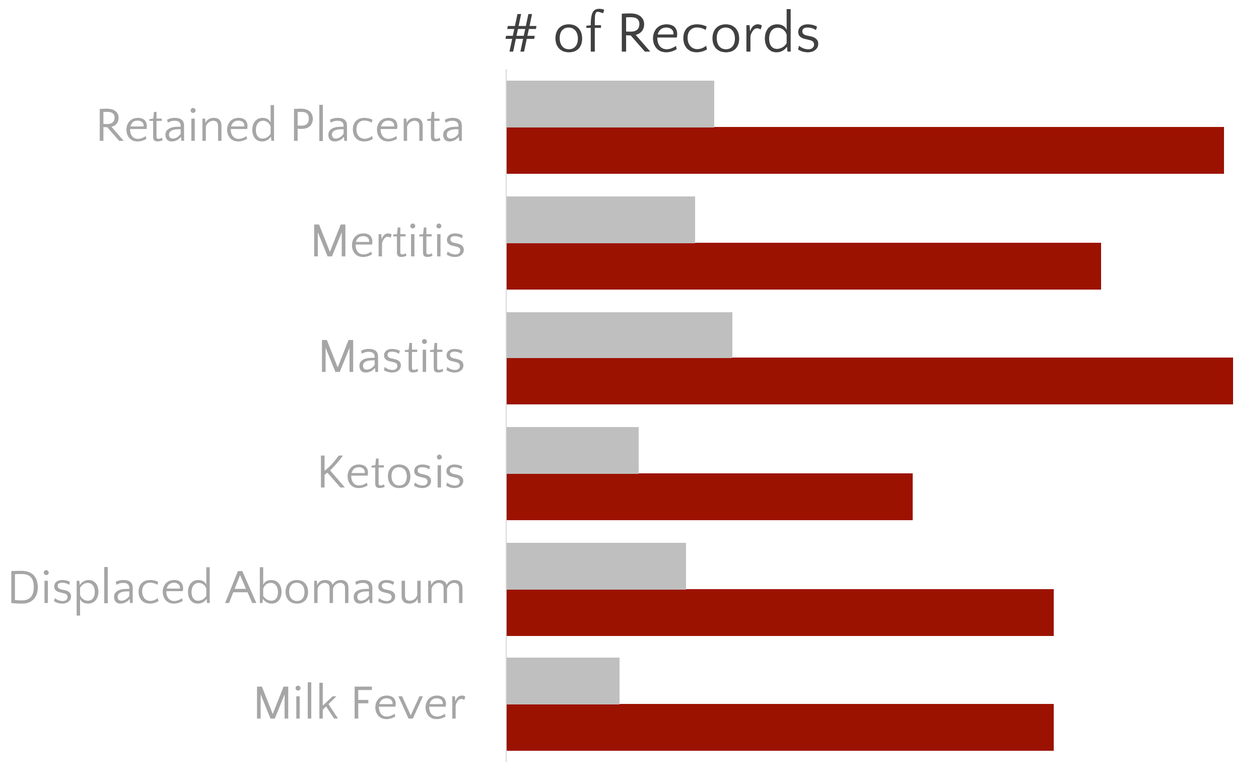
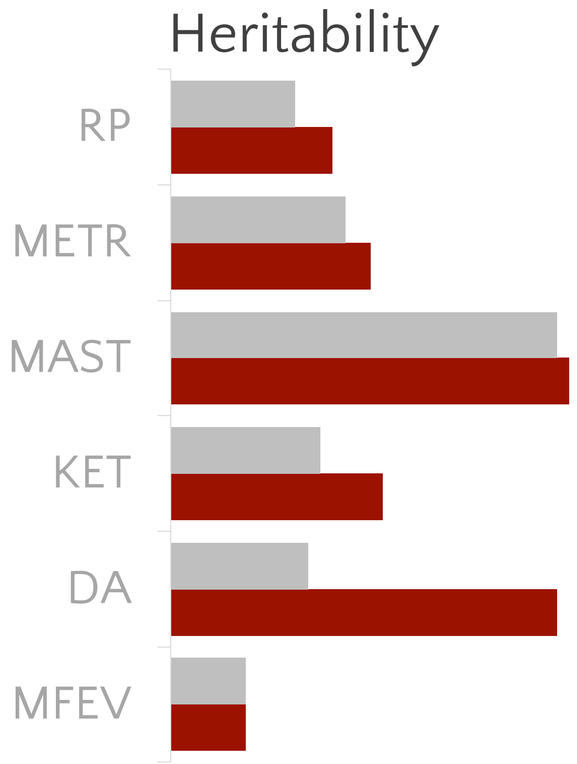
Health Traits – April 2024

Dec. 2018 (HO) Dec. 2023 (HO, JE, BS)





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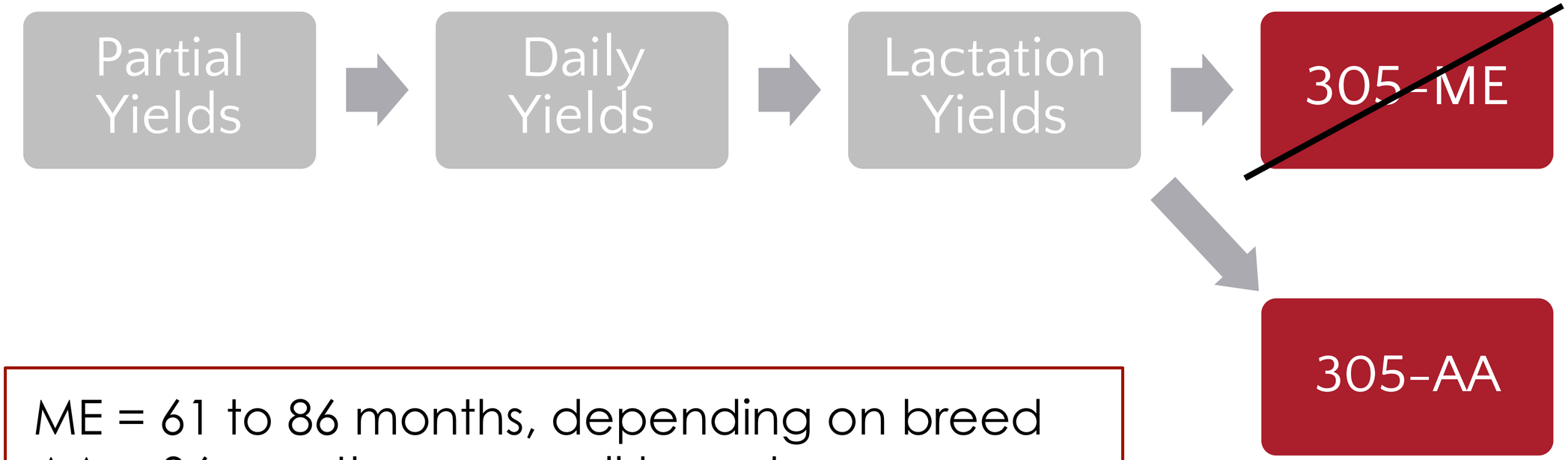
End Result: Better health evaluations

305-AA – August 2024



ME = 61 to 86 months, depending on breed
AA = 36 months across all breeds

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USDA

305-AA – Estimating New Yield Adjustments

DATA

Lactation Records
- Milk: 101.5 million
- Fat: 100.5 million
- Protein: 81.2 million

UNCHANGED

2X Milking Frequency
Previous Days Open

IMPROVED

SEASON-REGION

~~3 Geographical Regions~~ → 5 Climate Regions
~~Within Breed~~ → Across Breed

AGE-PARITY

~~Age Groups~~ → Age in Months
~~Mature Age~~ → Average Age (36mo)

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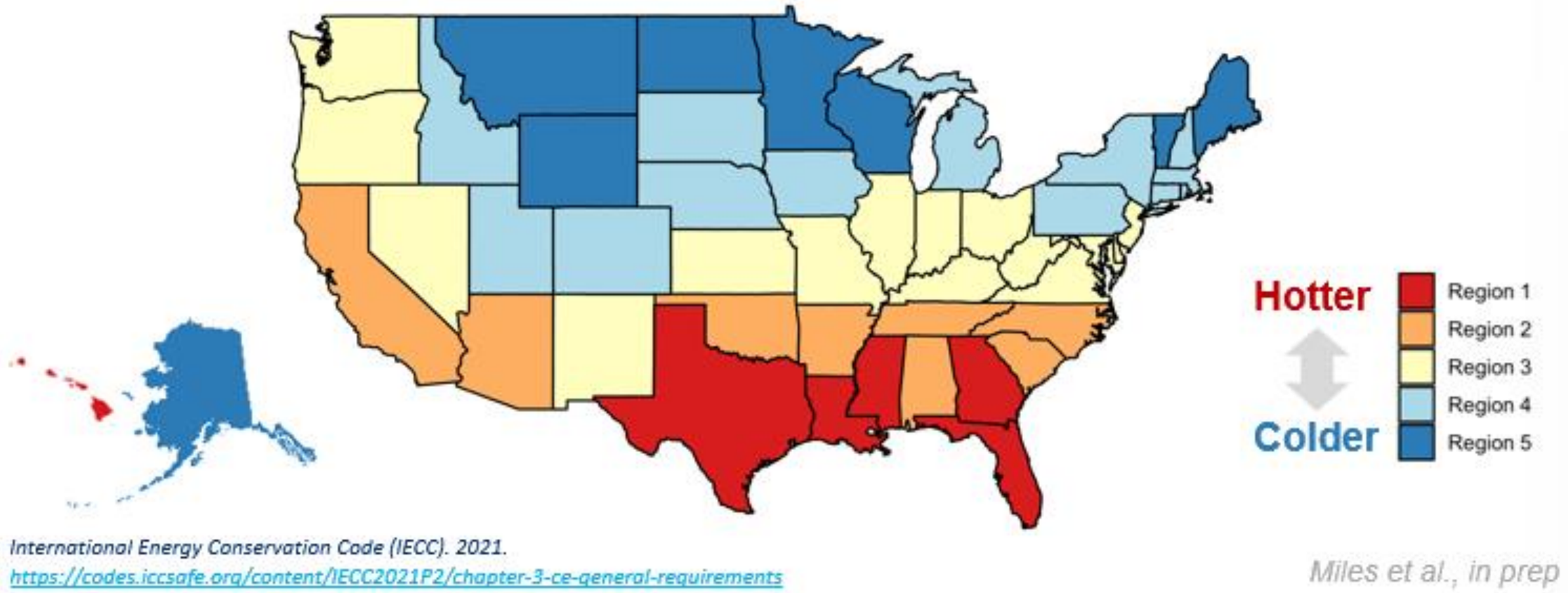
305-AA - New Climate-Based Regions



International Energy Conservation Code (IECC). 2021.
https://codes.iccsafe.org/content/IECC2021P2/chapter-3-ce-general-requirements

Miles et al., in prep

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305-AA

- Some changes in evaluations, but overall correlations are high
- Yield projections that better reflect the current population and management strategies resulting in more accurate estimates

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https://uscdcb.com/introducing-305-aa-the-new-standardized-yield-measurement/

PROJECTS IN PROGRESS

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Milking Speed Evaluations

- Milking Speed Task Force appointed by CDCB Board in November 2021
- Objective: Can we provide a genetic evaluation for milking speed?

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DRMS DAIRY RECORDS MANAGEMENT SYSTEMS
NAAB
NATIONAL DHIA
USDA
U.S. Registered Holsteins FOR MAXIMUM PROFIT
HOLSTEIN ASSOCIATION USA, INC.

Milking Speed – Data Overview

DeLaval	80
GEA	75
Lely	47
Boumatic	46
AfiMilk	45
SCR	13
DairyMaster	10
AIC Waikato	5
AMS Galaxy	3
Jantec	2
Universal	2

6+ Breeds

11 OEMs

31 States

~300 Herds

~250,000 Cows

~320,000 Lactations

~50 Million Observations

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Milking Speed – Genetic analyses

- **Avg_all** – average of all milkings in a lactation
- **Avg_TD** – average of milkings on test days
- **Avg_all_P1** – average of all milkings in first parity
- **Avg_TD_P1** – average of all test day milkings in first parity

Correlation with NM$ < 10%

	Avg_all	**Avg_TD**	**Avg_all_P1**	**Avg_TD_P1**
Avg_all	**0.37 (0.02)**	0.968	0.916	0.976
Avg_TD	0.821	**0.28 (0.02)**	0.944	0.991
Avg_all_P1	1.000	0.819	**0.38 (0.04)**	0.924
Avg_TD_P1	0.820	1.000	0.819	**0.21 (0.18)**

Heritability – diagonal
Genetic correlation – upper
Phenotypic correlation - lower

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Milking Speed Implementation

- Format 8 – Developed and provided to DRPCs to collect individual milk weights and times
- Current development has been for **average pounds milk per minute** using every milking record within a lactation from 5 to 305 DIM
- Possible inclusion in **December 2024** evaluations
- Continued research to investigate relationship to udder health (non-significant so far) and using a reduced amount of records

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Female fertility evaluations

- Task force assembled in 2024
- Industry feedback: Request was made for a full review of fertility traits by NAAB's Dairy Sire Evaluation Committee
- Also – how does the evolution of reproductive technologies impact our evaluations?

Currently Evaluated Female Fertility Traits
Daughter pregnancy rate (DPR)
Cow conception rate (CCR)
Heifer conception rate (HCR)
Early first calving (EFC)

Areas under review:

- Phenotypic data
- Data extraction process
- Data editing
- Genetic models

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Herd Sustainability Metrics

- Increased pressure by consumers and retailers regarding the footprint agriculture has on the environment and society
- Desire for **quantitative** over qualitative measures that directly relate to agriculture
- The International Committee for Animal Recording (ICAR) created a Sustainability Task Force to focus on information collected through milk recording as it relates to sustainability
    - List of **key traits and standardized methods** to calculate

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ICAR
THE GLOBAL STANDARD FOR LIVESTOCK DATA

Herd Sustainability Metrics – Proof of Concept

Preliminary data from all 4 DRPCs

ICAR SUSTAINABILITY TASK FORCE TRAIT CATEGORIES				
FEEDING & PRODUCTION	FERTILITY	HEALTH	LONGEVITY	YOUNG STOCK
AVG DIM	**AVG CALVING INTERVAL**	**AVG SCC**	**AVG CULLING AGE**	**AVG AGE FIRST CALVING**
N = 10,003	**N = 9,905**	**N = 9,830**	**N = 10,041**	**N = 10,095**

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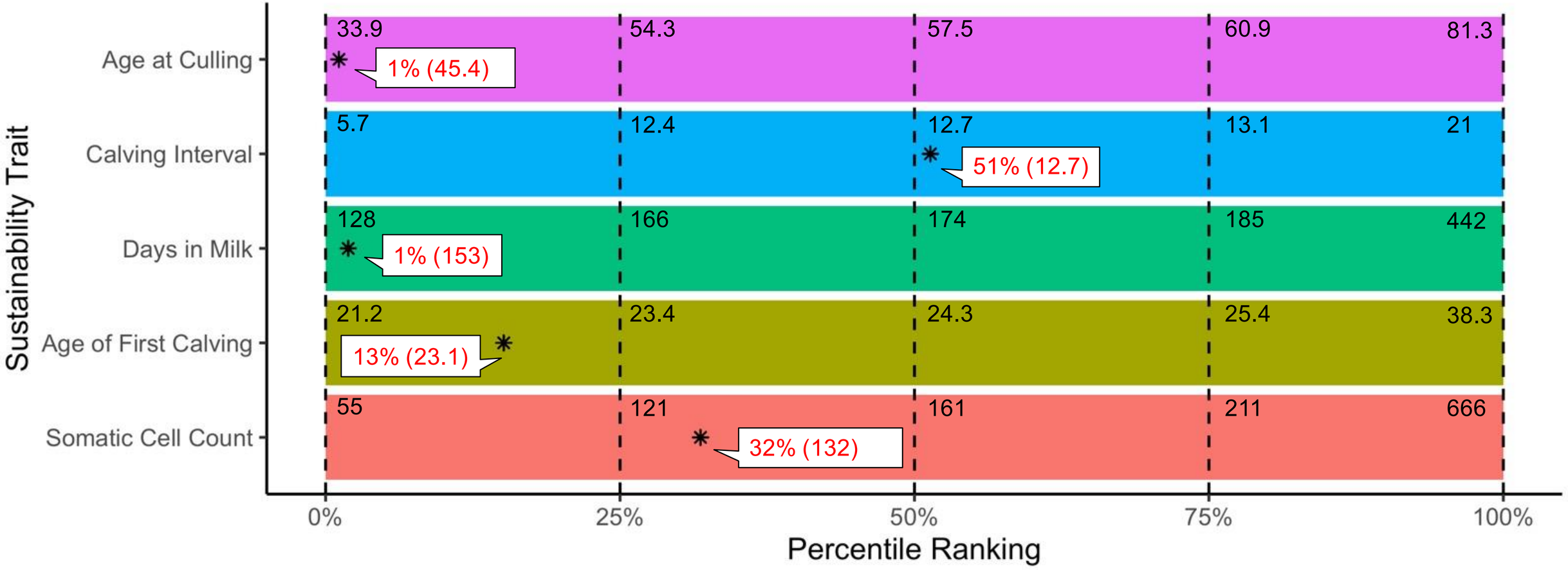
S < 250
M 250 – 999
L 1000+

Herd Sustainability Metrics – Demographics

	R1			R2			R3			R4			R5		
	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
AY							7			22			14		
BS				4			30			23	3		33	4	
DL										2					
FL													1	2	
GU	1						7			17	1		26	2	
HO	46	34	19	61	68	206	900	193	55	3248	**443**	213	1938	629	165
JE	6	2	3	28	18	34	108	18	3	131	18	7	105	15	4
MS				1			1			2			4		
WW													3		
XB							1								
XD						4				1			1		
XX	20	17	14	34	8	24	208	26	11	407	51	18	302	41	11

Herd Sustainability Metrics – Example



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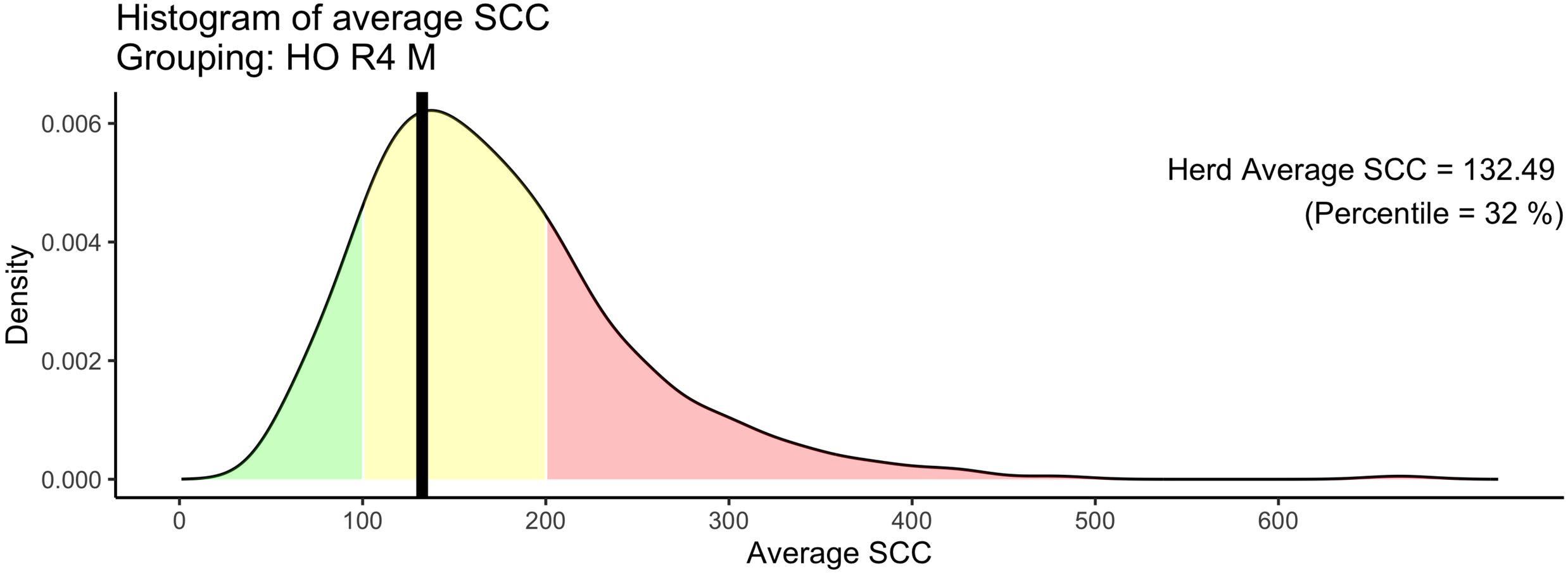
Herd Sustainability Metrics – Example



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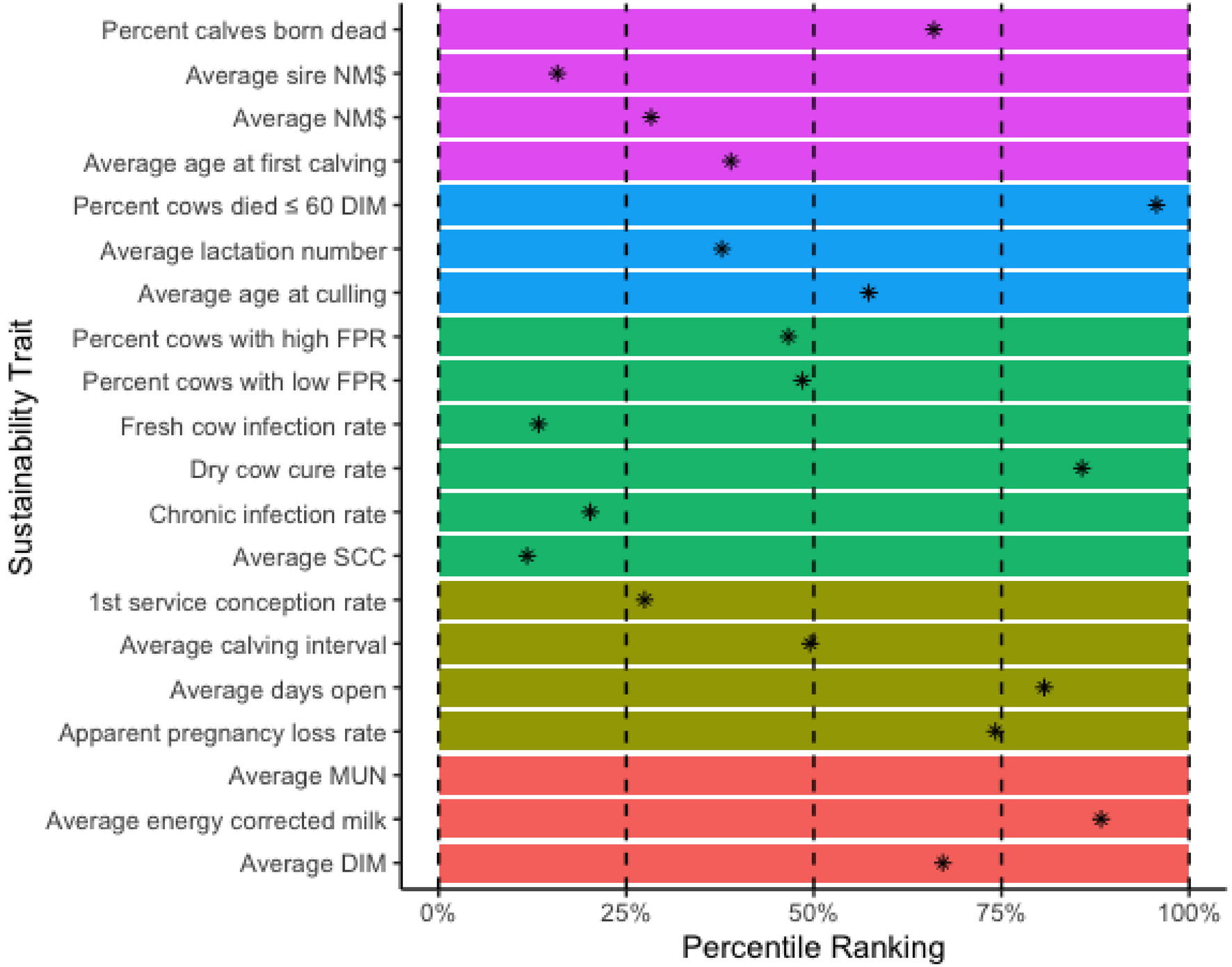
Herd Sustainability Metrics – Expanded traits



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Herd Sustainability Metrics – Next steps

- Proof of concept ☑
- Provide producers with information about their herd using national data
- Develop operational plan

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Hoof Health & Mobility

- Addressing hoof health, mobility, and lameness remain a top priority for the dairy industry
- Initiative at CDCB to aggregate high-quality data in development of a genetic evaluation to improve hoof health and mobility

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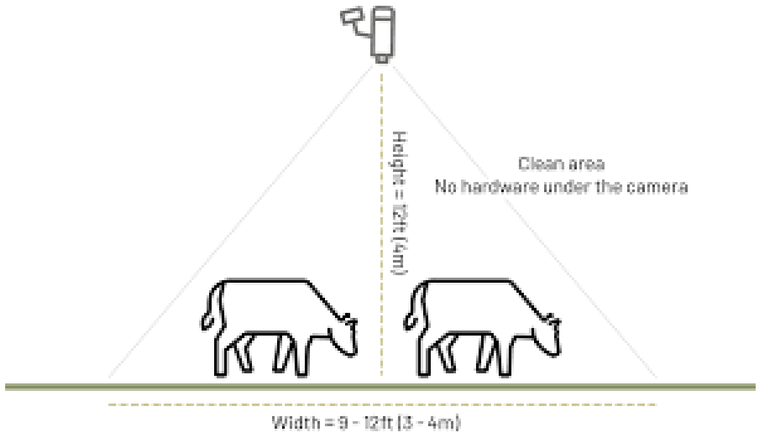
UNIVERSITY OF MINNESOTA

Hoof Health & Mobility – Data Sources

- Mobility scores – collected autonomously through CattleEye with a score from 1 to 100
- Lesion data – collected through collaboration with trained hoof trimmers



Hoof Health & Mobility – Available Data

	Herd 1 (MN)	Herd 2 (IA)	Herd 3 (AZ)	Herd 4 (CA)
Unique cows	1,885	1,435	5,097	2,133
Cow-lactations	2,901	1,931	6,603	2,133
Timespan	2021 to 2024	2021 to 2024	2022 to 2024	2024
Breeds	**HO**, XX	**HO**, JE, XX	BS, **HO**, JE	**HO**, JE
No. mobility scores	550,709	310,729	1,010,742	86,792
Average mobility score	35.8	36.9	36.0	36.4
Lesion incidence	14.6%	9.4%	8.9%	13.0%

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Hoof Health & Mobility – Preliminary results

- Continuing to collect data on these herds & expand to additional herds
- Pursuing opportunities to incorporate additional mobility and lesion data
- Active research on-going for trait definition, genetic evaluation, and economic impact

Trait definition	Heritability
Mobility score exceeds 50 during lactation (linear)	0.10 (SE = 0.02)
Mobility score exceeds 50 during lactation (threshold)	0.16 (SE = 0.03)
Lactational mean mobility score	0.27 (SE = 0.04)
Log-variance of mobility score throughout lactation	0.06 (SE = 0.02)
Lesion indicator throughout lactation (threshold)	0.05 (SE = 0.02)

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CDCB Internships 2024

Mobility, BCS, and yield

Gabriella (Ella) Dodd
Ph.D. student at University of Guelph

Beef x Dairy

Agustin Chasco
Ph.D. student at University of Wisconsin - Madison

Phenotypic fertility investigation

Gaurav Dutta
Ph.D. student at University of Connecticut

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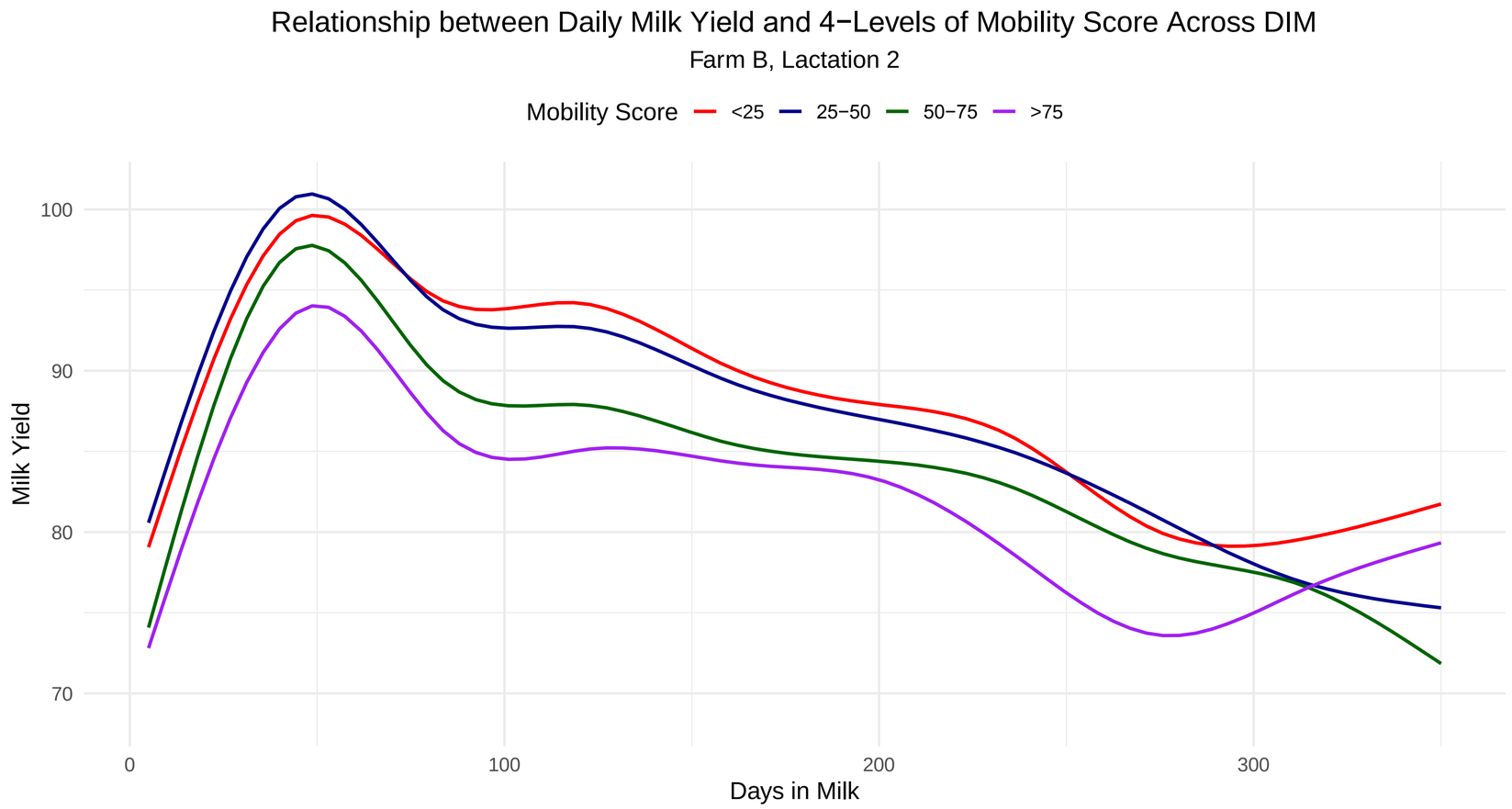

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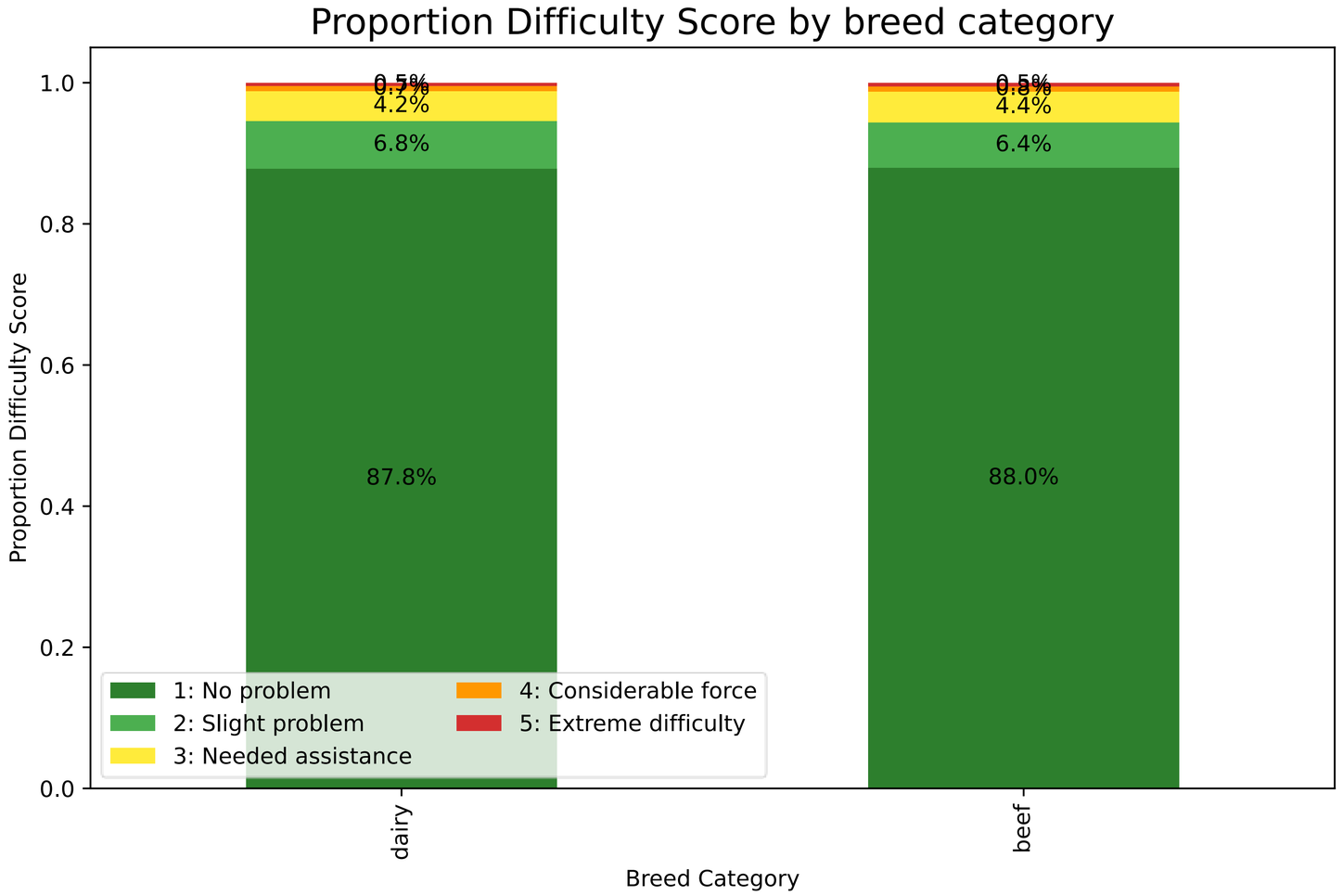
Calving ease comparison of dairy sires vs. beef sires

Beef x Dairy

Agustin Chasco
Ph.D. student at University of Wisconsin – Madison



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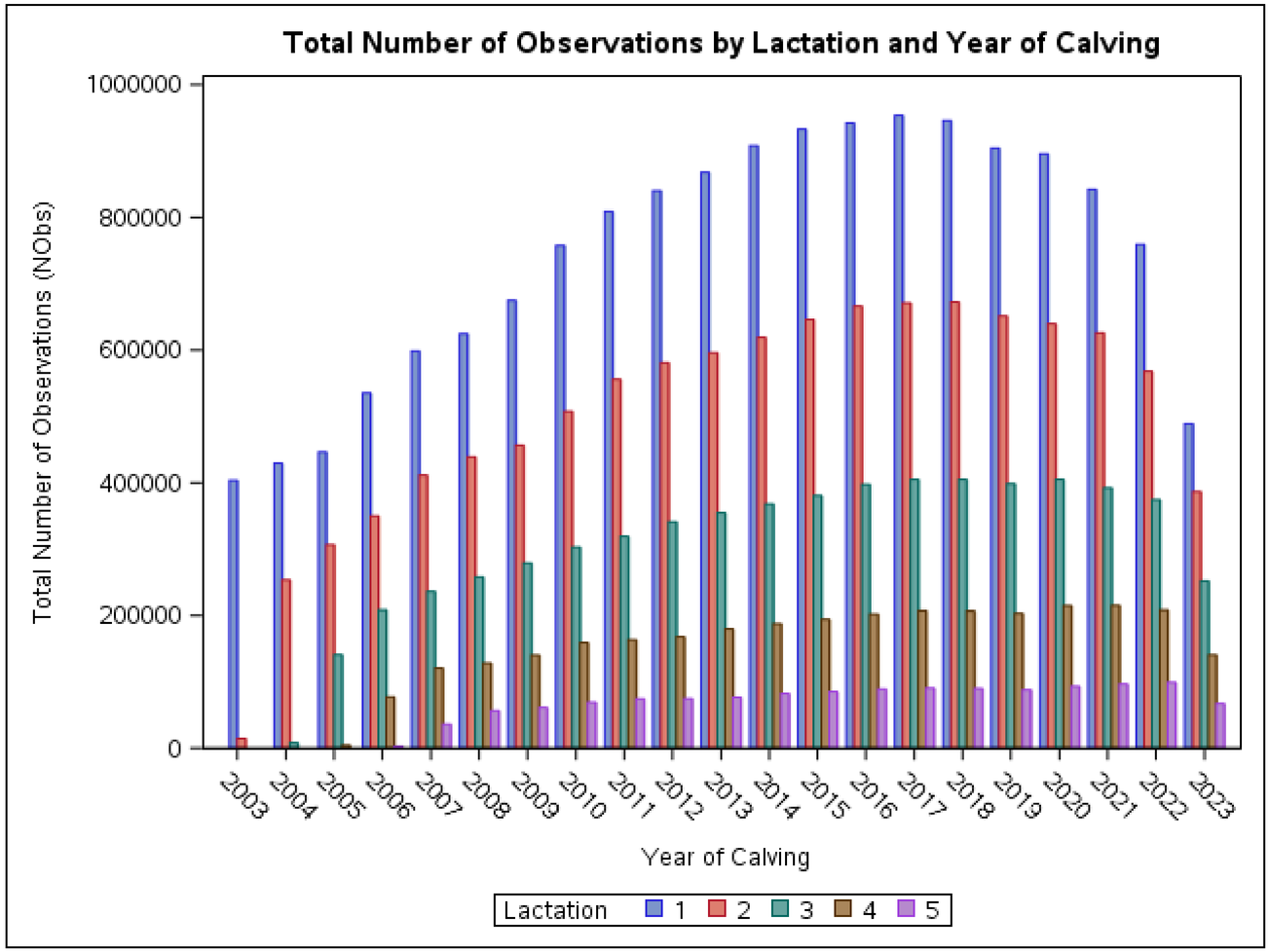

Phenotypic fertility investigation

Gaurav Dutta

Ph.D. student at University of Connecticut

DPR and CCR records available by year and lactation

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LONG-TERM PROJECTS

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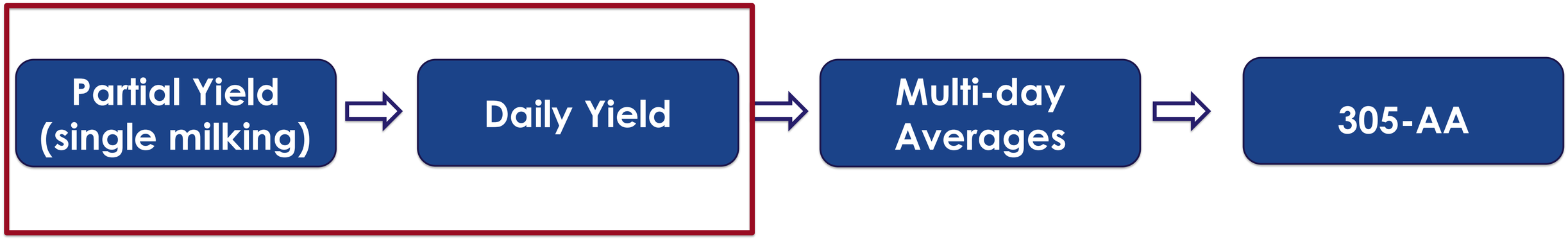
Lactation Factors Project

- **Objective**: Collect new data reflective of current US dairy management practices to update the yield and component trait predictions



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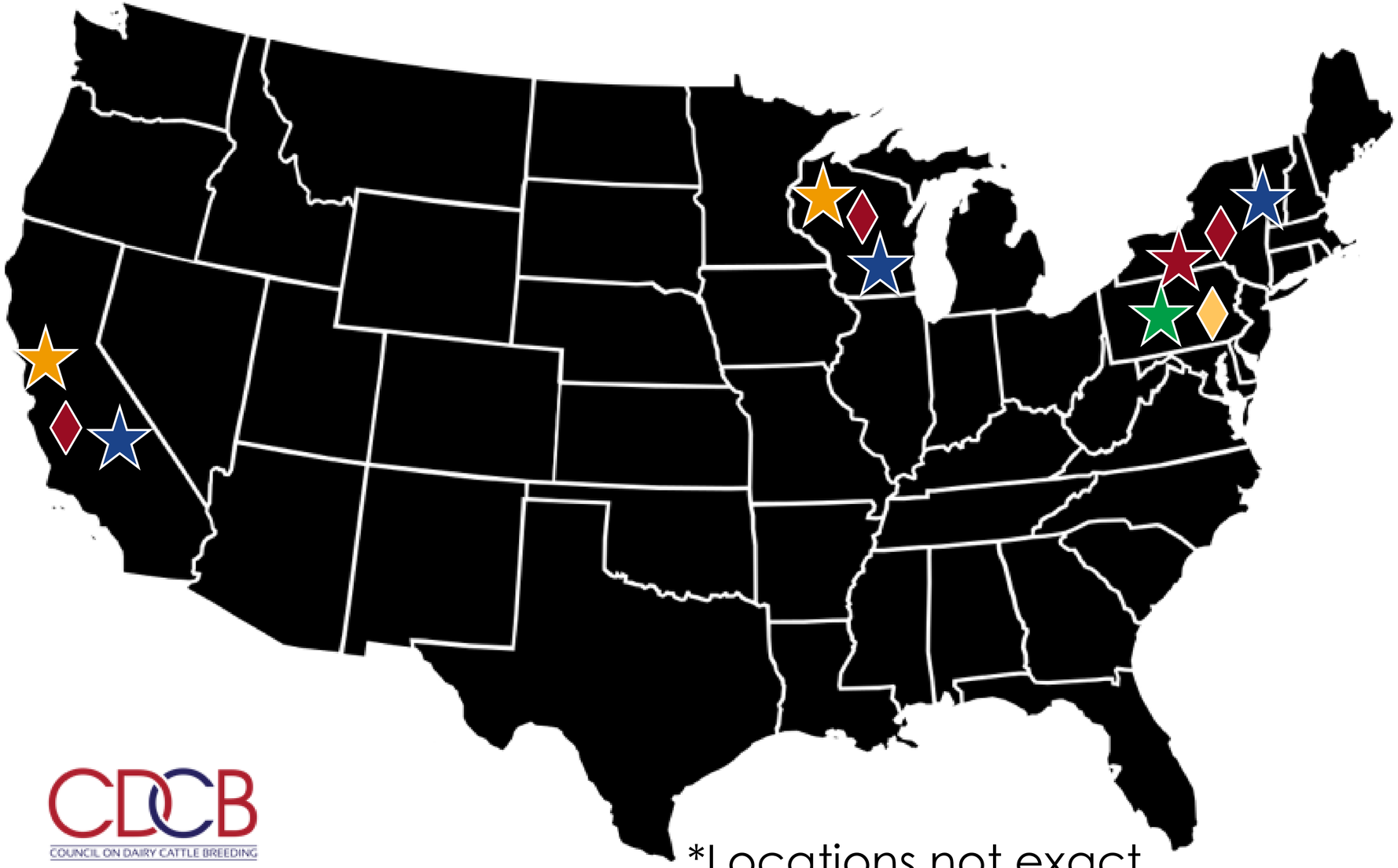
Lactation Factors Project – Status Update



Labs:

- 3 enrolled
- 1 in preparation

Farms:

- 1 completed
- 3 in progress
- 2 in preparation
- 1 discovery region

*Locations not exact

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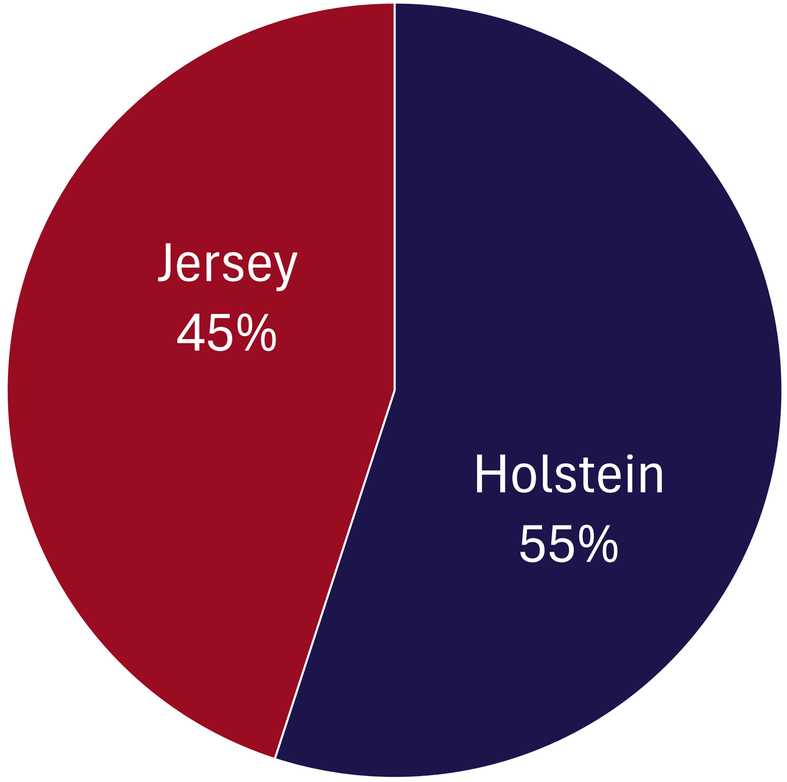
Lactation Factors Project – Running Sample Totals

- All farms:
  - 199,333 milk samples
  - 8,730 cows
  - > 210 million milk data
  - 327 TMR samples



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Lactation Factors Project – Next Steps

- Continue to enroll farms and labs (15 farms in total)
- Continue analyzing factors affecting daily milk yields
- Continue investigating individual cow fatty acid as it relates to production, health, and nutrition
- Create a national database of milk spectral data

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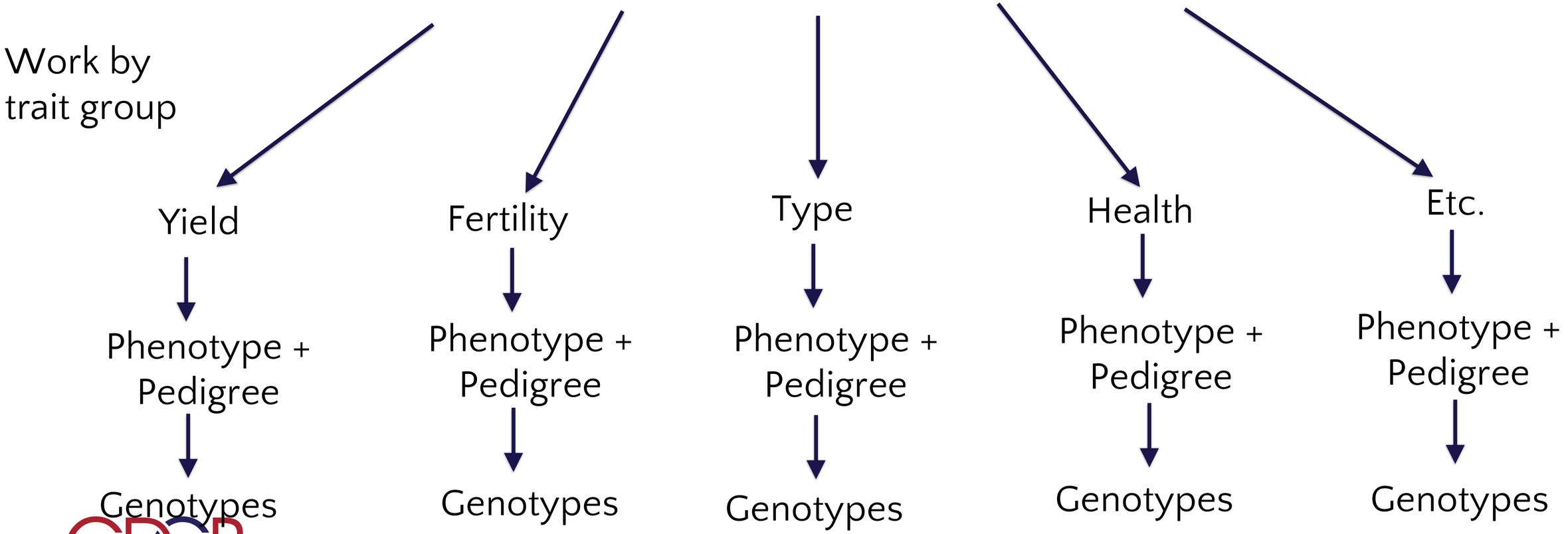
Single-step methodology

Rebuilding a significant portion of the evaluation pipeline



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Single-step – Details

- UGA software works well, but some modifications and options are necessary

- Model details – sire models, breed-specific traits, threshold model

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Single-step – Next steps

- Include MACE proofs
- Testing on a large scale across all trait groups and traits in parallel
- Checking and verifying results

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Enteric Methane Emissions

Greener Cattle Initiative

The Greener Cattle Initiative is a consortium of stakeholders who share knowledge, leverage investments and accelerate research to identify, develop and/or validate scientifically sound, commercially feasible and socially responsible practices and technologies that reduce enteric methane emissions from dairy and beef cattle to slow the effects of climate change.

Enteric Methane Emissions – Goals

phenotyping
4,000 lactating cows
(6 research farms over 3 years)

measure CH_4 production, feed intake, milk energy, body weight, and milk spectra for 6-8 weeks in mid-lactation

selective breeding

develop genomic evaluations for methane emission traits

milk spectrometry

evaluate the use of milk spectra to predict CH_4 emissions

microbiome

reveal the composition/activity of the rumen microbiome of cows with low & high CH_4 emissions
using metagenomics and metabolomics

exchange ruminal contents of low and high methane-emitting cows
decipher the relative contributions of hosts and microbes to CH_4 production

GCI – Selective Breeding

- Recent studies have shown that methane traits are heritable
- Data collection has started on commercial farms in addition to research sites
- Genomics facilitates selection for traits like methane emissions through the phenotyping of a select group of genotyped cows (creating a reference population)

Research Partners

Francisco Peñagaricano, quantitative genomics
Hilario C Mantovani, rumen microbiology
Heather M White, nutritional physiology
Kent A Weigel, breeding & genetics

Michael J VandeHaar, sustainable food systems
Robert J Tempelman, statistical genetics

James E Koltes, genomics & bioinformatics
Ranga Appuhamy, nutrition/sustainable agriculture

José EP Santos, nutrition, health & fertility
Kwang C Jeong, microbiology & food safety

Ransom L Baldwin, nutritional genomics
Paul M VanRaden, sustainable breeding goals
Asha Miles, genomics & microbiology
Elizabeth A French, precision feeding
Kenneth F Kalscheur, sustainable production

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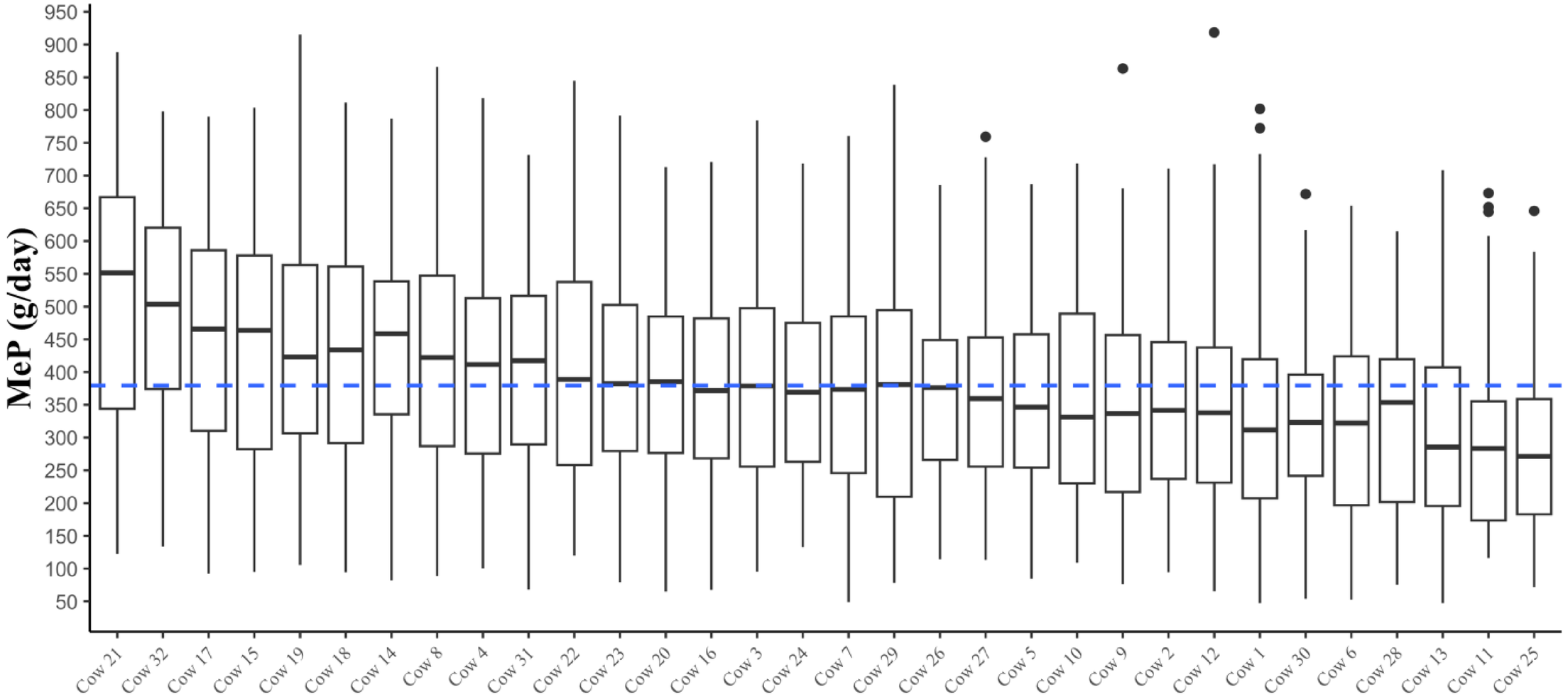
Enteric Methane Emissions – variability



Martinez Boggio et al., 2024

Enteric Methane Emissions – Preliminary Results

Findings suggest that CH_4 traits have considerable variability, moderate heritability, and favorable correlations with feed efficiency

<u>Trait definitions:</u>

Residual methane intensity (RMI) – methane production regressed on NEL and MBW

h^2 = 0.35 ± 0.15

Residual methane yield (RMY) **–** methane production regressed on DMI

h^2 = 0.18 ± 0.15

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Martinez Boggio et al., 2024

Final remarks

- CDCB research initiatives and collaborations are growing
- Many short- and long-term projects are underway to improve and enhance CDCB services to the industry

Recent & On-going CDCB Research

- Health trait evaluation updates
- 305-AA
- Milking speed evaluations
- Fertility evaluation investigation
- Hoof health & mobility
- Herd sustainability metrics
- Beef x dairy impacts
- Lactation factors
- Single step methodology
- Enteric methane emissions
- Heat stress
- Inbreeding & genetic diversity

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ACKNOWLEDGMENTS

U.S. dairy producers

Member sectors and collaborators

USDA AGIL

CDCB staff

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THANK YOU FOR YOUR ATTENTION

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