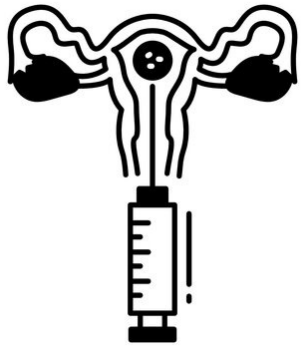
THE INCREASING POPULARITY OF EMBRYO TRANSFER HAS IMPLICATIONS FOR U.S. DAIRY CATTLE FERTILITY EVALUATIONS



A. M. Miles[1]*, J. L. Hutchison[1], and P. M. VanRaden[1]

*[1] Animal Genomics and Improvement Laboratory, Agricultural Research Service, United States Department of Agriculture, Beltsville, MD 20705-2350, USA; *asha.miles@usda.gov*

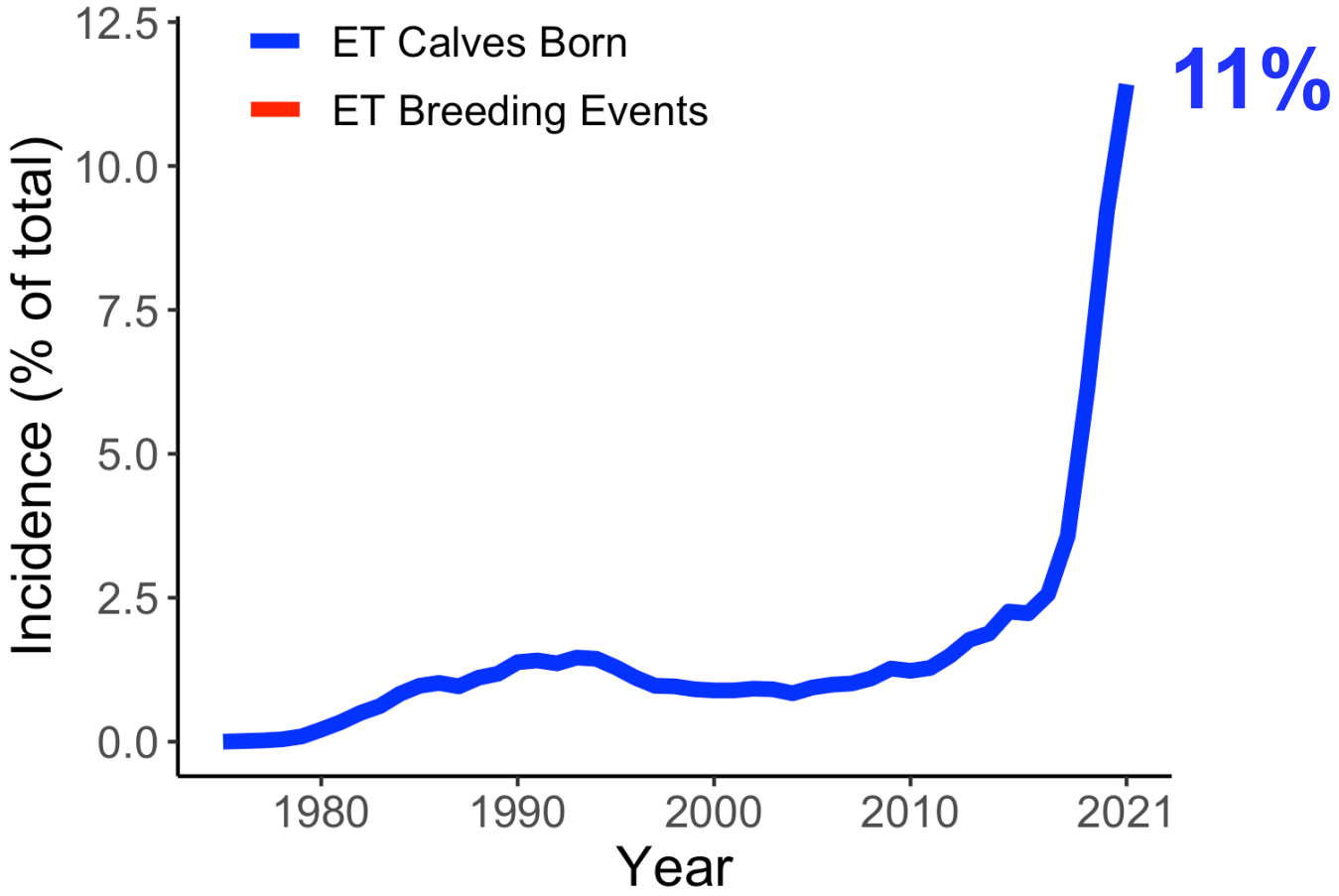
REASONS COWS EXIT THE HERD

Termination Code	Holstein	Jersey	Other Breeds[1]
Unspecified	29.8 %	30.3 %	28.7 %
Low production	22.0 %	27.4 %	18.7 %
Reproduction problems	14.9 %	11.7 %	18.4 %
Mastitis or high SCC	12.6 %	11.8 %	12.4 %
Locomotion problems	4.7 %	1.2 %	5.0 %
Udder problems	0.1 %	0.1 %	0.2 %
Undesirable conformation	0.0 %	0.0 %	0.0 %
Bad behavior	0.0 %	0.0 %	0.1 %

[1]Ayrshire, Brown Swiss, Guernsey, Milking Shorthorn, Red & White

From: Norman et al (2021)

EMBRYO TRANSFER IS ON THE RISE



Miles et al., in review

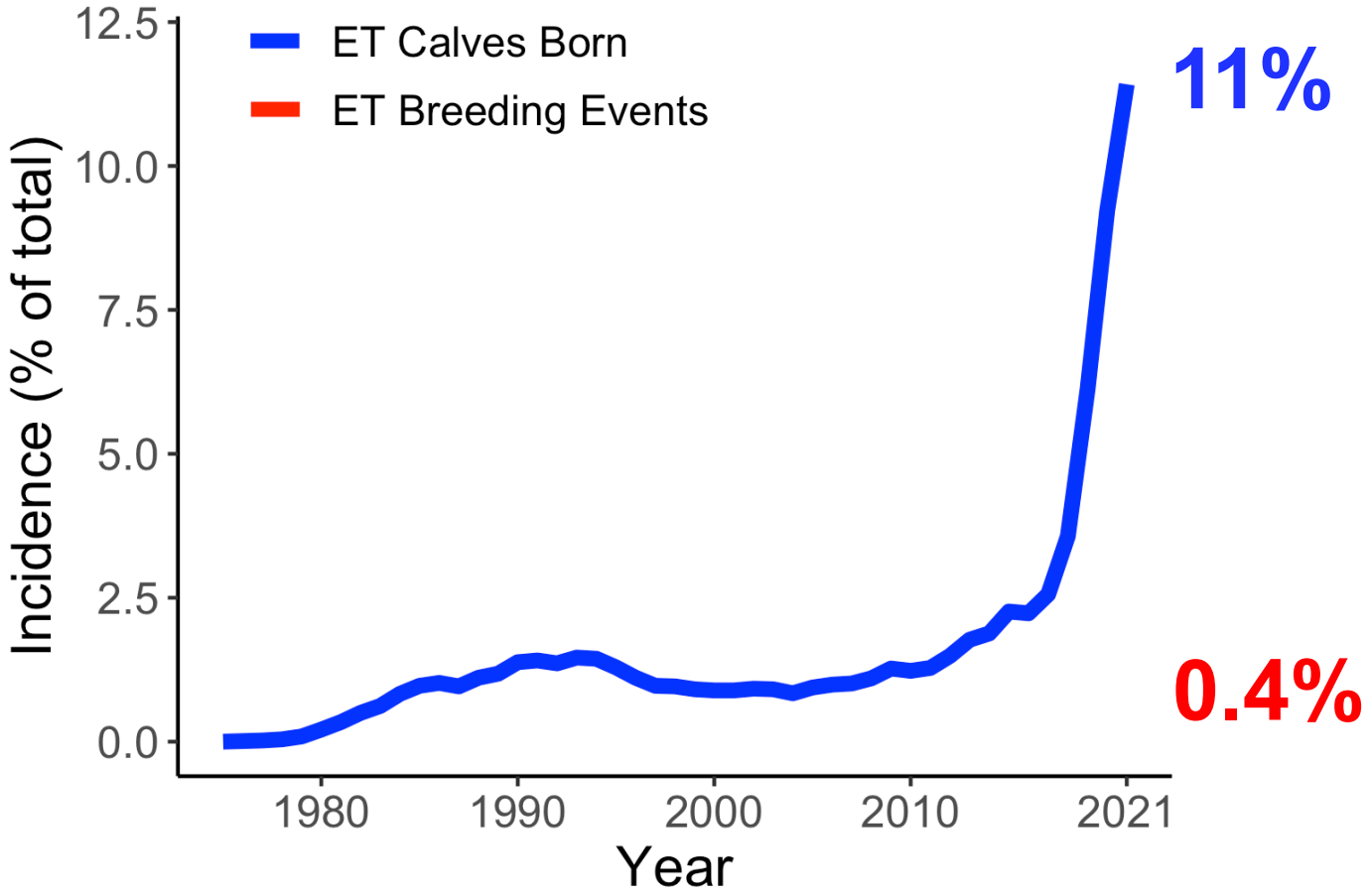
EMBRYO TRANSFER IS ON THE RISE

Maternal line and genotyped embryo of dam HOCAN13913420

Maternal Generation	0	1	2	3	4	5	6	7
Birth Year	2022	2020	2019	2018	2016	2015	2013	2012
Birth Month	3	11	6	3	11	6	12	6
Age @ Embryo Donation[1]	--	7	8	6	7	8	9	9
Generation Interval[1]	16	17	15	16	17	18	18	--

[1]months

EMBRYO TRANSFER IS ON THE RISE



COUNCIL ON DAIRY CATTLE BREEDING

Format 5

E: embryo donation

I: embryo implantation (sire)

J: embryo implantation (dam)

Miles et al., in review

ET REPORTING ERROR RATES

Code	Mating Type	ET Births	All Other Calvings	
A	AI	35,100	11,060,000	
G	AI (sexed semen)			
N	Natural Service			
E	Embryo Donation			
I/J	Embryo Implantation			

The rate at which ET is **incorrectly** reported

Miles et al., in review

ET REPORTING ERROR RATES

Code	Mating Type	ET Births	All Other Calvings	
A	AI	35,100	11,060,000	**0.3%**
G	AI (sexed semen)	14,833	1,175,795	**1.3%**
N	Natural Service	2,035	584,971	**0.4%**
E	Embryo Donation	0	13	**0.0%**
I/J	Embryo Implantation	372	29,416	**1.3%**

The rate at which ET is **incorrectly** reported

The rate at which ET is **correctly** reported

Miles et al., in review

THE PROBLEM

With embryo transfer, conception is not actually occurring

Unreported ET may bias fertility evaluations in the population

Previously, the US excluded all ET donors & recipients in evaluations

ET-associated records represent the most elite animals & herds so removing them is not necessarily the desired approach

APPROACH

1. Identified herds doing substantial amount of ET but with inconsistent reporting

Censor herdyears reporting

>10 % calves born by ET, but

< ½ the expected number of ET breeding events

APPROACH

2. Recalculated conception rate evaluations

BLUP Animal Model

(Wiggans and VanRaden 1989)

$$y_{ijkl} = m_{ij} + a_{kl} + p_{kl} + c_{ik} + e_{ijkl}$$

m_{ij} : management group
a_{kl} : animal effect
p_{kl} : permanent effect of environment
c_{ik} : herd-sire interaction
e_{ijkl} : residual variance

APPROACH

BLUP Animal Model
(Wiggans and VanRaden 1989)

$$y_{ijkl} = m_{ij} + a_{kl} + p_{kl} + c_{ik} + e_{ijkl}$$

2. Recalculated conception rate evaluations

Sire Conception Rate (SCR)

$$\frac{\text{\# confirmed successes}}{\text{\# inseminations}}$$

- Only data from most recent 4 years
- No genetic relationships (a_{kl})
- Additional environmental effects included

Interpretation

SCR 2%

Conception rate is predicted to be 2 percentage points higher than the average conception rate for the AI bulls in that breed

APPROACH

2. Recalculated conception rate evaluations

Heifer Conception Rate (**HCR**)	Cow Conception Rate (**CCR**)
% inseminated heifers that become pregnant at each service	% inseminated cows that become pregnant at each service

- Multi-trait model along with AFC and DPR
- All available data from 2003+ used
- Breeds evaluated together including regressions on inbreeding and heterosis

BLUP Animal Model
(Wiggans and VanRaden 1989)

$$y_{ijkl} = m_{ij} + a_{kl} + p_{kl} + c_{ik} + e_{ijkl}$$

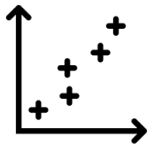
Interpretation

HCR, CCR 2%

Daughters of this bull are 2% more likely to become pregnant at each service than the average

APPROACH

3. Assessed impact of edit



Correlate new and old values

Difference = new values – old values

Examine differences for each breed in context of bull popularity, ET usage, and genetic merit

IMPACTS ON SCR

		Change in Evaluation (%)				
	Bulls Compared	Min	Median	IQR	Max	**Correlation**
Ayrshire	6	-0.3	-0.1	0.4	0.3	0.98*
Brown Swiss	44	-0.9	-0.1	0.3	0.6	0.99*
Guernsey	14	-0.6	0.1	0.6	0.6	0.96*
Holstein	1379	-1.9	0.0	0.2	1.3	0.99*
Jersey	132	-1.4	-0.1	0.3	0.9	0.99*
Milking Shorthorn	1	0.0	0.0	0.0	0.0	--

Miles et al., in review

IMPACTS ON SCR

		Change in Evaluation (%)				
	Bulls Compared	Min	Median	IQR	Max	**Correlation**
Ayrshire	6	-0.3	-0.1	0.4	0.3	0.98*
Brown Swiss	44	-0.9	-0.1	0.3	0.6	0.99*
Guernsey	14	-0.6	0.1	0.6	0.6	0.96*
Holstein	1379	-1.9	0.0	0.2	1.3	0.99*
Jersey	132	-1.4	-0.1	0.3	0.9	0.99*
Milking Shorthorn	1	0.0	0.0	0.0	0.0	--

Miles et al., in review

IMPACTS ON SCR

	Bulls Compared	Change in Evaluation (%) Min	Median	IQR	Max	Correlation
Ayrshire	6	-0.3	-0.1	0.4	0.3	0.98*
Brown Swiss	44	-0.9	-0.1	0.3	0.6	0.99*
Guernsey	14	-0.6	0.1	0.6	0.6	0.96*
Holstein	1379	-1.9	0.0	0.2	1.3	0.99*
Jersey	132	-1.4	-0.1	0.3	0.9	0.99*
Milking Shorthorn	1	0.0	0.0	0.0	0.0	--

Previously overestimated

Previously underestimated

Miles et al., in review

IMPACTS ON SCR

		Change in Evaluation (%)				
	Bulls Compared	Min	Median	IQR	Max	**Correlation**
Ayrshire	6	-0.3	-0.1	0.4	0.3	0.98*
Brown Swiss	44	-0.9	-0.1	0.3	0.6	0.99*
Guernsey	14	-0.6	0.1	0.6	0.6	0.96*
Holstein	1379	-1.9	0.0	0.2	1.3	0.99*
Jersey	132	-1.4	-0.1	0.3	0.9	0.99*
Milking Shorthorn	1	0.0	0.0	0.0	0.0	--

Edit removed 252 herdyears (1.2% reduction)

Miles et al., in review

IMPACTS ON HCR

		Change in Evaluation (%)				
	Bulls Compared	Min	Median	IQR	Max	**Correlation**
Ayrshire	22	-0.5	0.0	0.3	0.3	0.98*
Brown Swiss	156	-0.6	-0.2	0.2	0.5	0.99*
Guernsey	43	-0.8	-0.2	0.3	0.3	0.99*
Holstein	13807	-1.6	-0.1	0.3	3.7	0.99*
Jersey	1574	-1.6	-0.9	0.3	1.5	0.99*
Milking Shorthorn	14	-0.4	-0.1	0.3	0.3	0.99*

Edit removed 237,414 herdyears (2.2% reduction)

Miles et al., in review

IMPACTS ON CCR

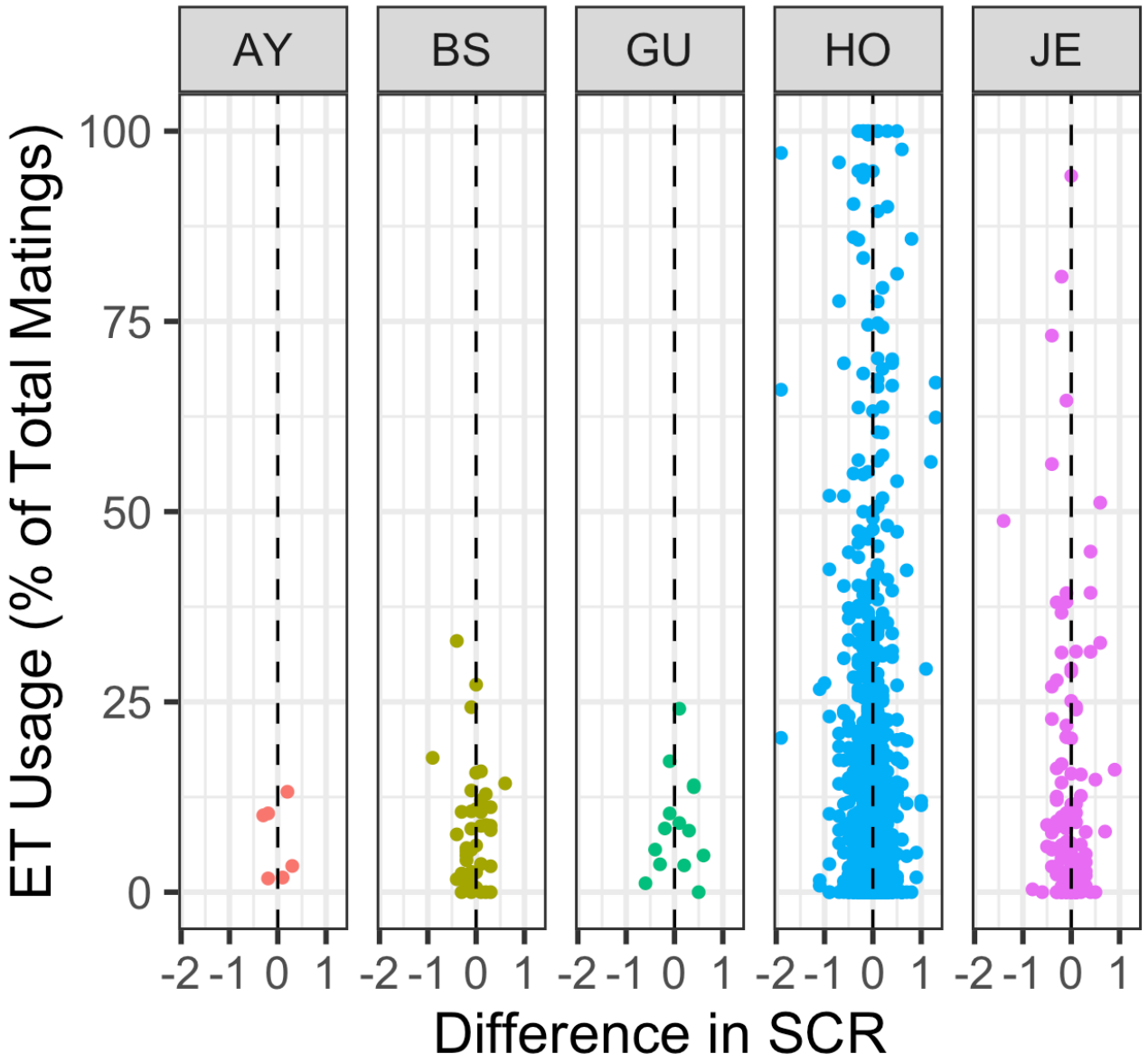
		Change in Evaluation (%)				
	Bulls Compared	Min	Median	IQR	Max	**Correlation**
Ayrshire	370	-0.8	-0.3	0.1	0.4	0.99*
Brown Swiss	1058	-1.5	-0.3	0.2	0.5	0.99*
Guernsey	805	-0.8	-0.3	0.1	0.3	0.99*
Holstein	47262	-1.6	-0.3	0.2	1.4	0.99*
Jersey	5303	-1.8	-0.3	0.2	1.0	0.99*
Milking Shorthorn	158	-0.9	-0.3	0.3	0.3	0.99*

Edit removed 323,618 herdyears (1.0% reduction)

Miles et al., in review

CLOSER LOOK: SCR

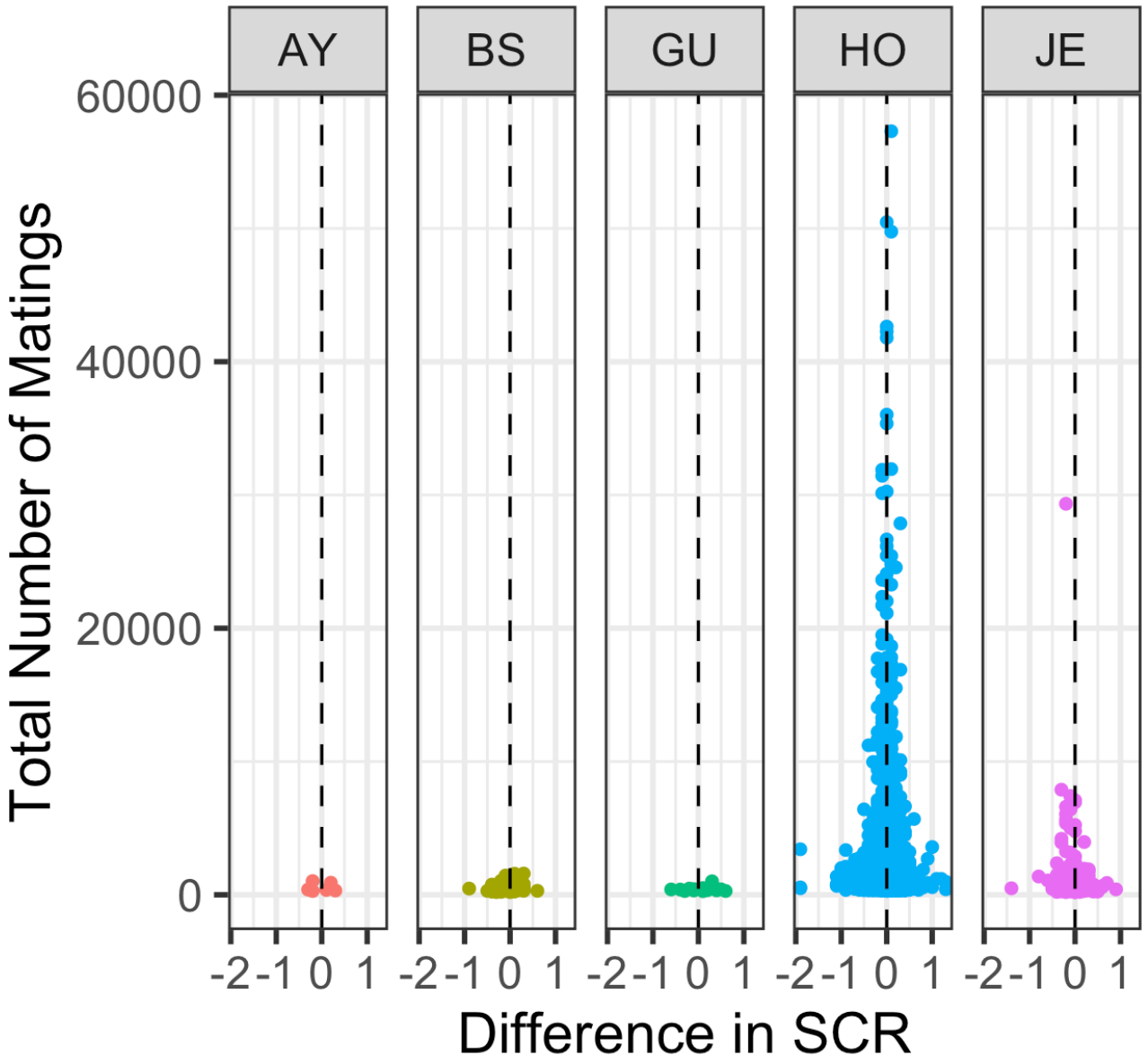
Impacts by bull popularity for ET



Miles et al., in review

CLOSER LOOK: SCR

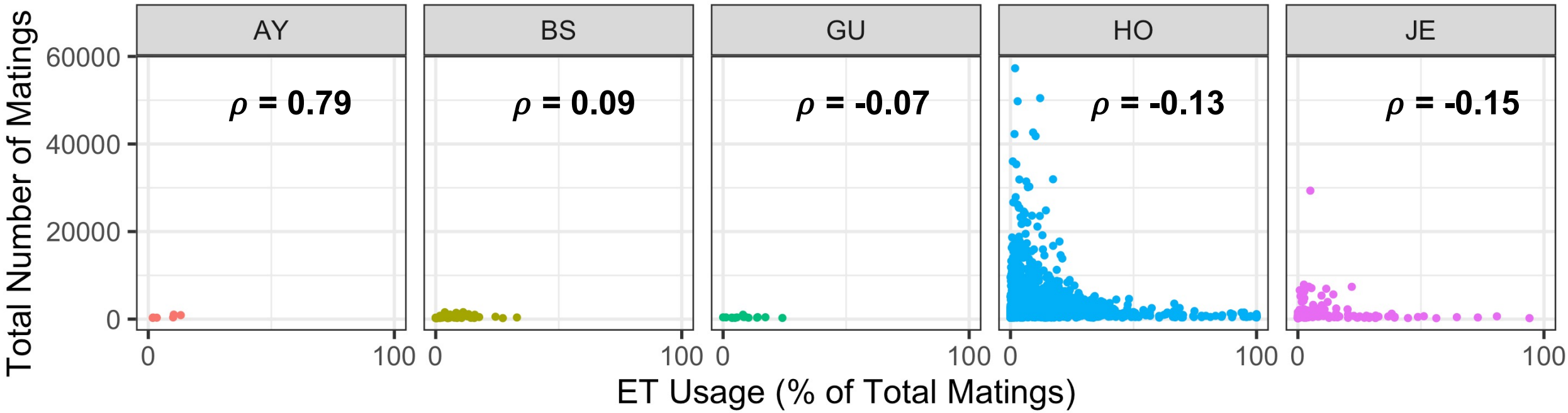
Impacts by overall bull popularity



Miles et al., in review

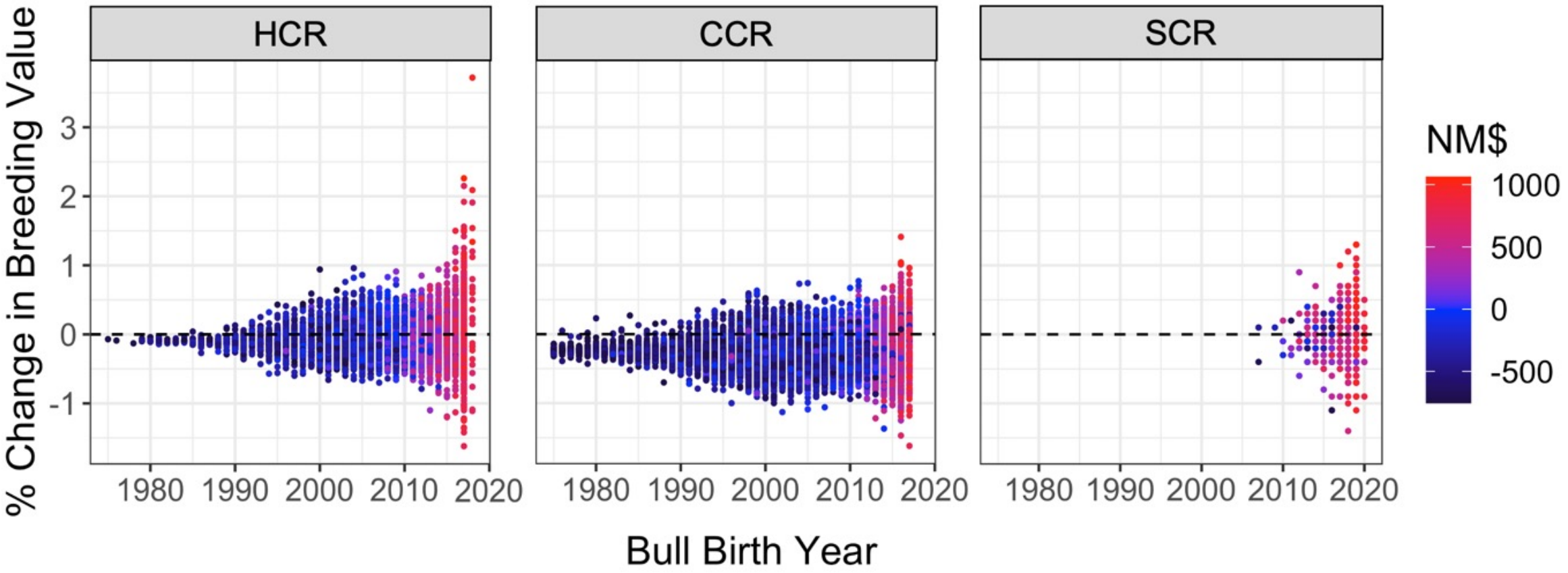
CLOSER LOOK: SCR

Bull popularity correlation with ET usage



Miles et al., in review

ELITE YOUNG BULLS MOST AFFECTED



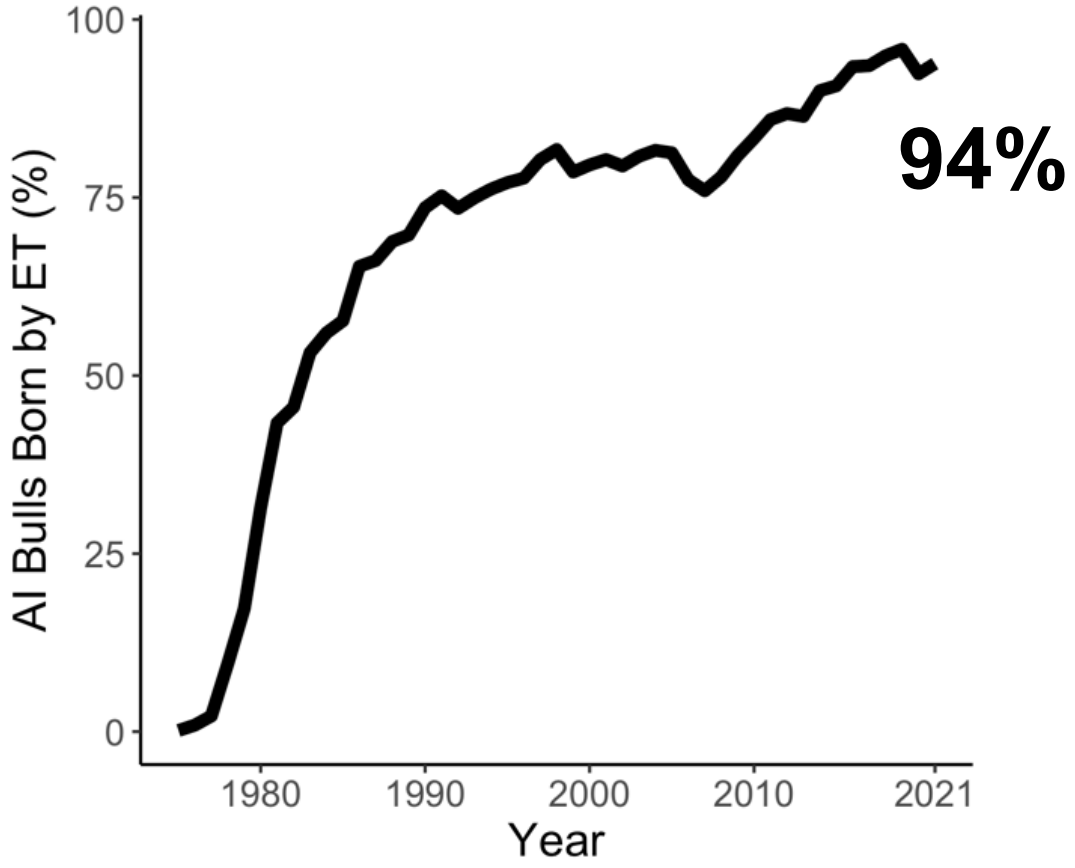
Miles et al., in review

FUTURE RESEARCH NEEDS

- Other reproductive traits
  - Daughter Pregnancy Rate, Age at First Calving, Gestation Length
- Data needs
  - Accurate reporting of breeding events
  - Multiple ovulation v. IVF
  - Fresh v. frozen embryos
  - Embryo grade and stage
  - Recipient synchrony
  - FSH protocol

ET: Data Collection & Utilization

http://guidelines.beefimprovement.org/index.php/Embryo_Transfer_(ET):_Data_Collection_And_Utilization



ET for cows may continue to increase, as it has for AI bulls

Key Messages

- These edits were implemented in CDCB April 2022 Evaluations
- Effects for SCR, CCR, and HCR were overall small, except for elite new bulls popular for ET usage
- Acquiring high quality ET records will be essential to providing accurate fertility evaluations in the future

THANK YOU

Data were available to the authors from CDCB under USDA Agricultural Research Service Material Transfer Research Agreement #58-8042-8-007. While CDCB offers data stewardship, sole ownership and rights pertaining thereto remain with the producer and we thank U.S. dairy producers for sharing their data for research use. Special thanks to Duane Norman of CDCB for his review and feedback on this research.

This work was supported by USDA-ARS project 8042-31000-002-00-D, “Improving Dairy Animals by Increasing Accuracy of Genomic Prediction, Evaluating New Traits, and Redefining Selection Goals”

Contact: asha.miles@usda.gov