An Integrated Approach To Improve Dairy Cow Fertility

Victor Cabrera, Assistant Professor- Management
Paul Fricke, Professor - Reproductive Physiology
Pam Ruegg, Professor - Physiology and Management
Randy Shaver, Professor - Nutrition
Milo Wiltbank , Professor -Reproductive Physiology
Kent Weigel, Professor and Chair Breeding and Genetics

University of Wisconsin-Madison

THE UNIVERSITY of WISCONSIN MADISON

United States Department of Agriculture
National Institute of Food and Agriculture

UW Extension
University of Wisconsin–Extension

"This project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2010-85122-20612 from the USDA National Institute of Food and Agriculture." Project started March 1st, 2010

Overall Objective

- To improve reproductive efficiency of lactating dairy cows using an interdisciplinary extension and research team that will identify and remove barriers to reproductive success and link outcomes of basic and applied research with an innovative extension delivery program
- Five aims address this overall objective

THE UNIVERSITY of WISCONSIN MADISON

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

UW Extension
University of Wisconsin–Extension

"This project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2010-85122-20612 from the USDA National Institute of Food and Agriculture." Project started March 1st, 2010

SPECIFIC AIM 1

Prediction of Pregnancy Using Machine Learning Algorithms

Objective:

To develop a user friendly and intuitive on-farm tool to help farmers make decisions about breeding specific cows.

Data:

A total of 129,245 breeding records and 28 explanatory variables were available for primiparous cows, and 195,128 breeding records and 31 explanatory variables were available for multiparous cows obtained from 26 dairy farms in the Alta Genetics Advantage Progeny Testing Program (2000- 2010) .

Machine Learning Algorithms:

Naïve Bayes classifier; Bayesian network; Decision Trees; Bagging

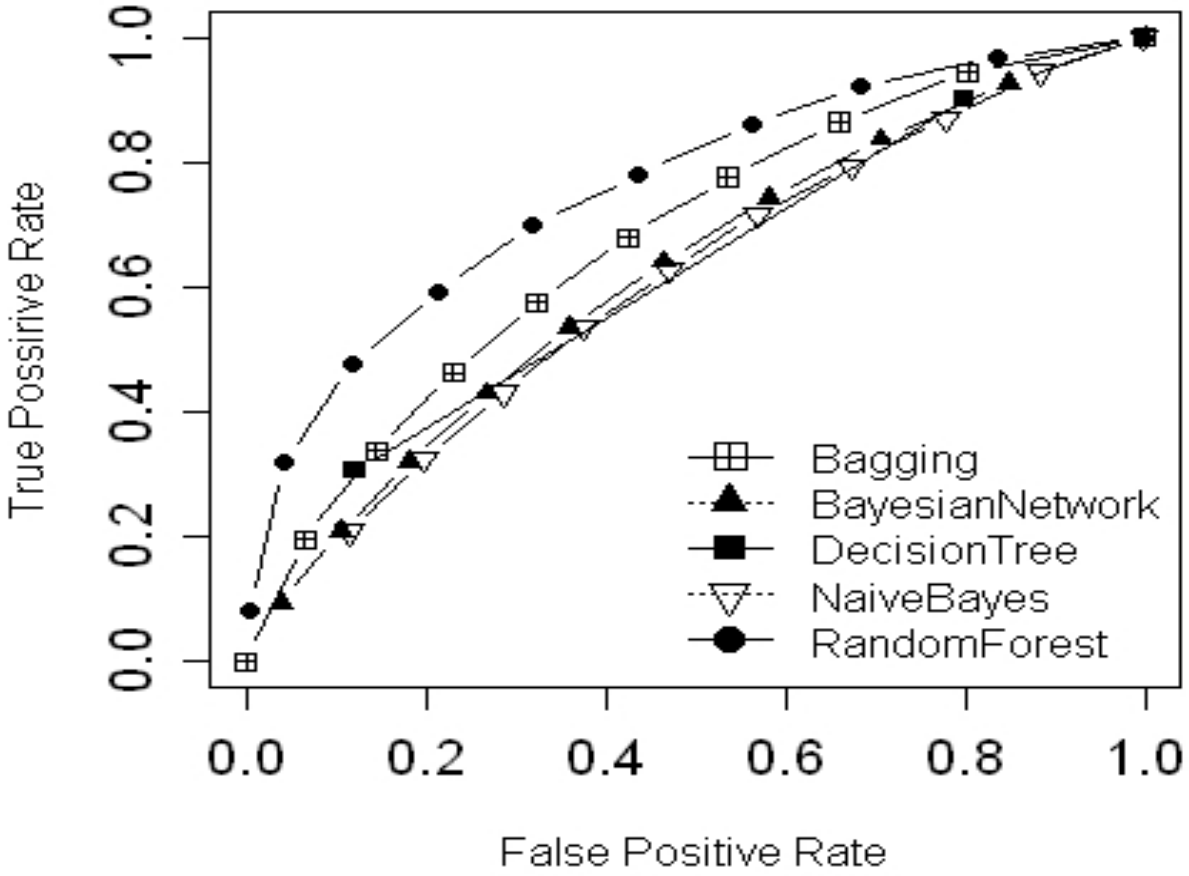
THE UNIVERSITY of WISCONSIN MADISON

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

UW Extension
University of Wisconsin–Extension

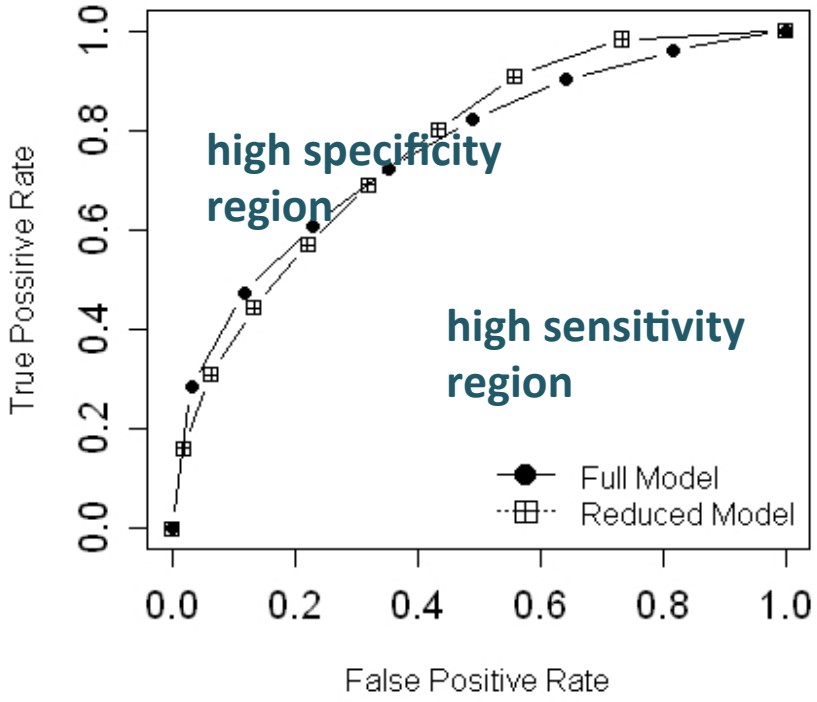
"This project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2010-85122-20612 from the USDA National Institute of Food and Agriculture." Project started March 1st, 2010

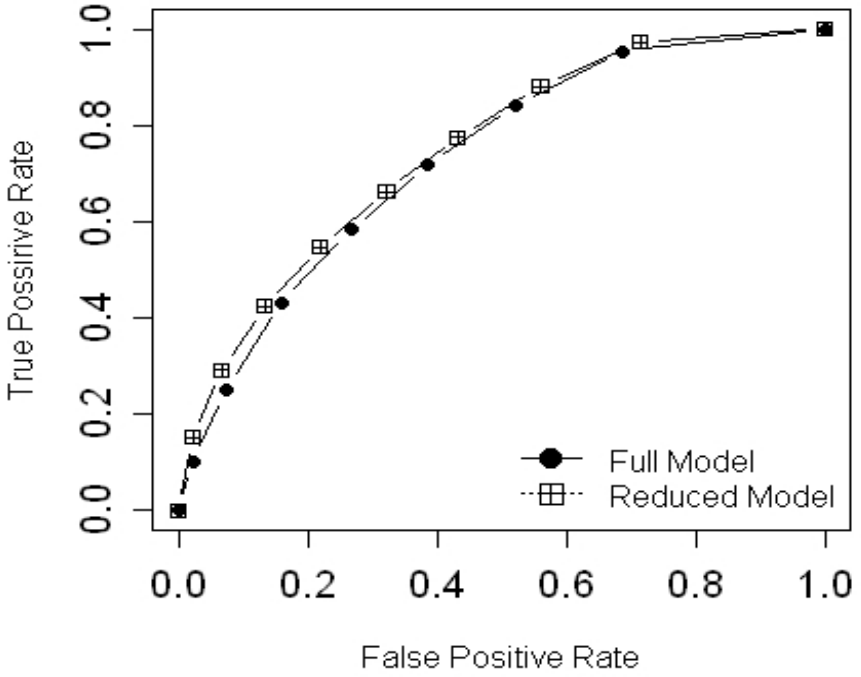
Results



Random Forest Model performed best.

Explanatory Variables = Incidence of ketosis, number of AIs, herd average conception rate, days in milk at AI, incidence of mastitis.





Primiparous cows
72.3% Correct

Multiparous Cows
73.6%

SPECIFIC AIM 2: Determine the impact of specific nutritional components on reproductive performance of lactating dairy cows.

Experiment 1: Evaluate the association of individual components of the diet on fertility traits of dairy cattle.

Data: Complete diets were obtained and Dairy Comp 305 backups for fertility and other traits evaluated in 50 dairy farms.

Results: Carbohydrate and Methionine

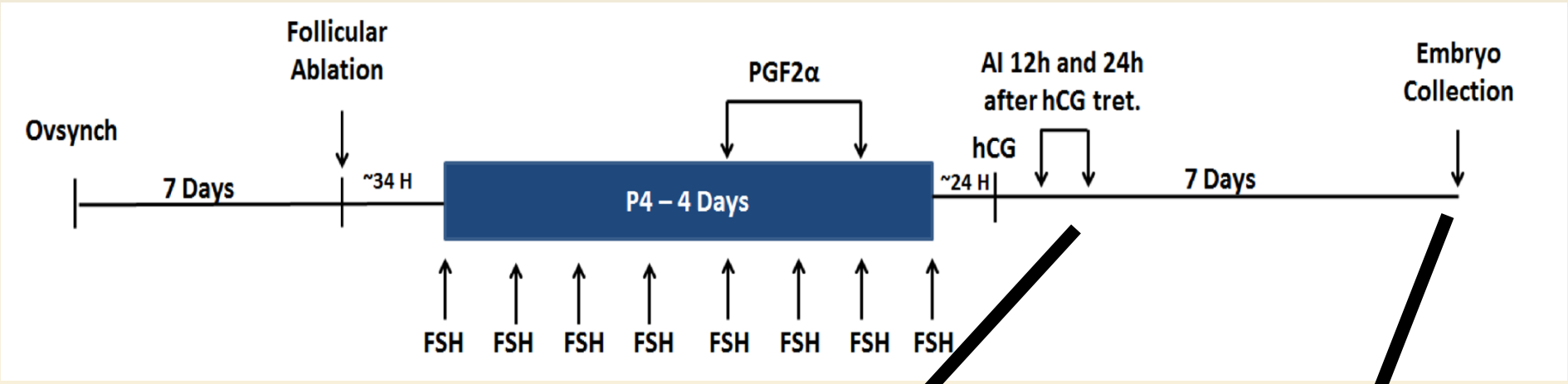
% NFC and 1st Service CR: $r = -0.51$ $P = 0.0002$

Methionine and 1st Service CR: $r = 0.30$ $P = 0.05$


305179
20g1½

± Methionine Supplementation (2.43 vs. 1.89 Met %MP)

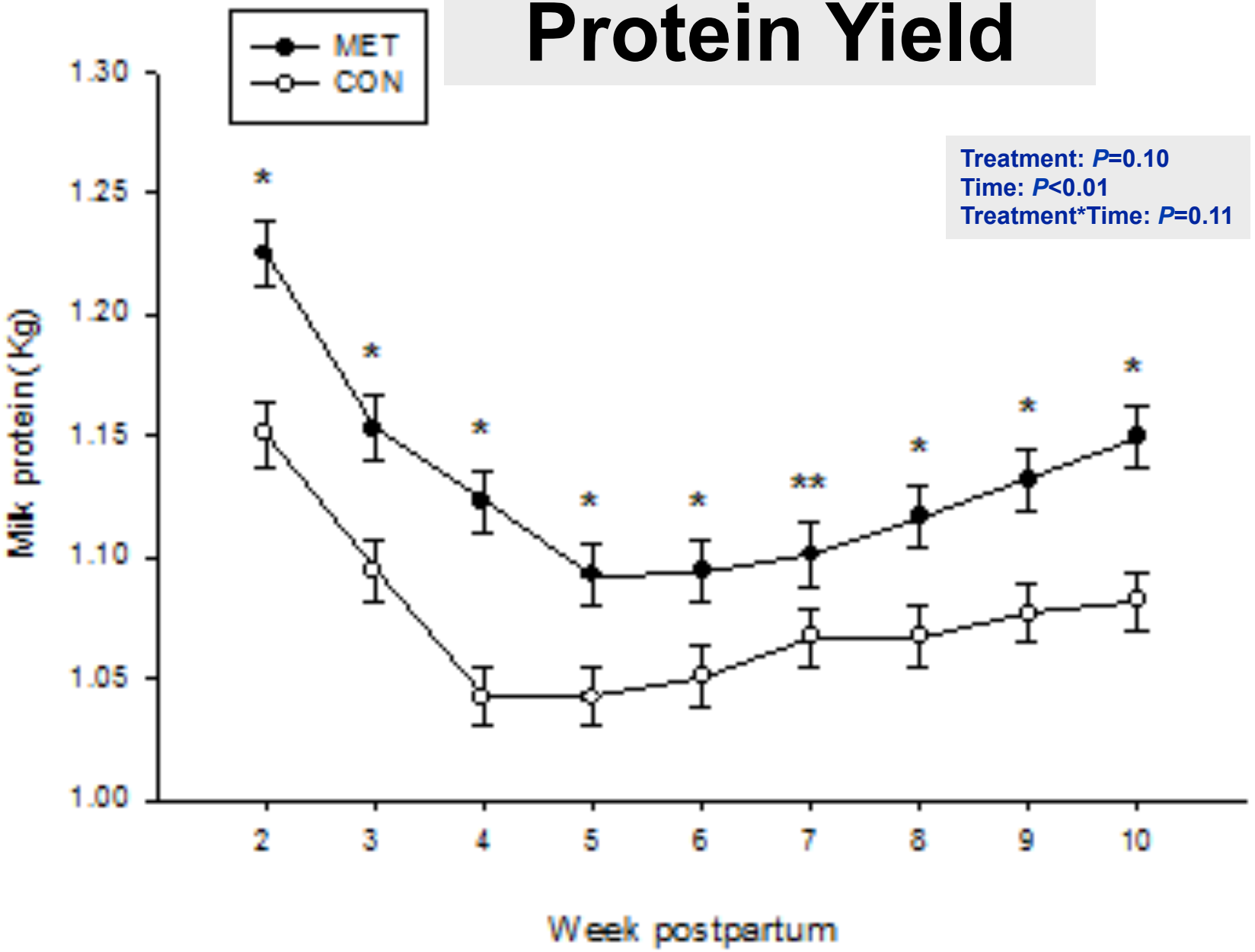
Synchronization and superovulation protocol



Ovulation
n = 853

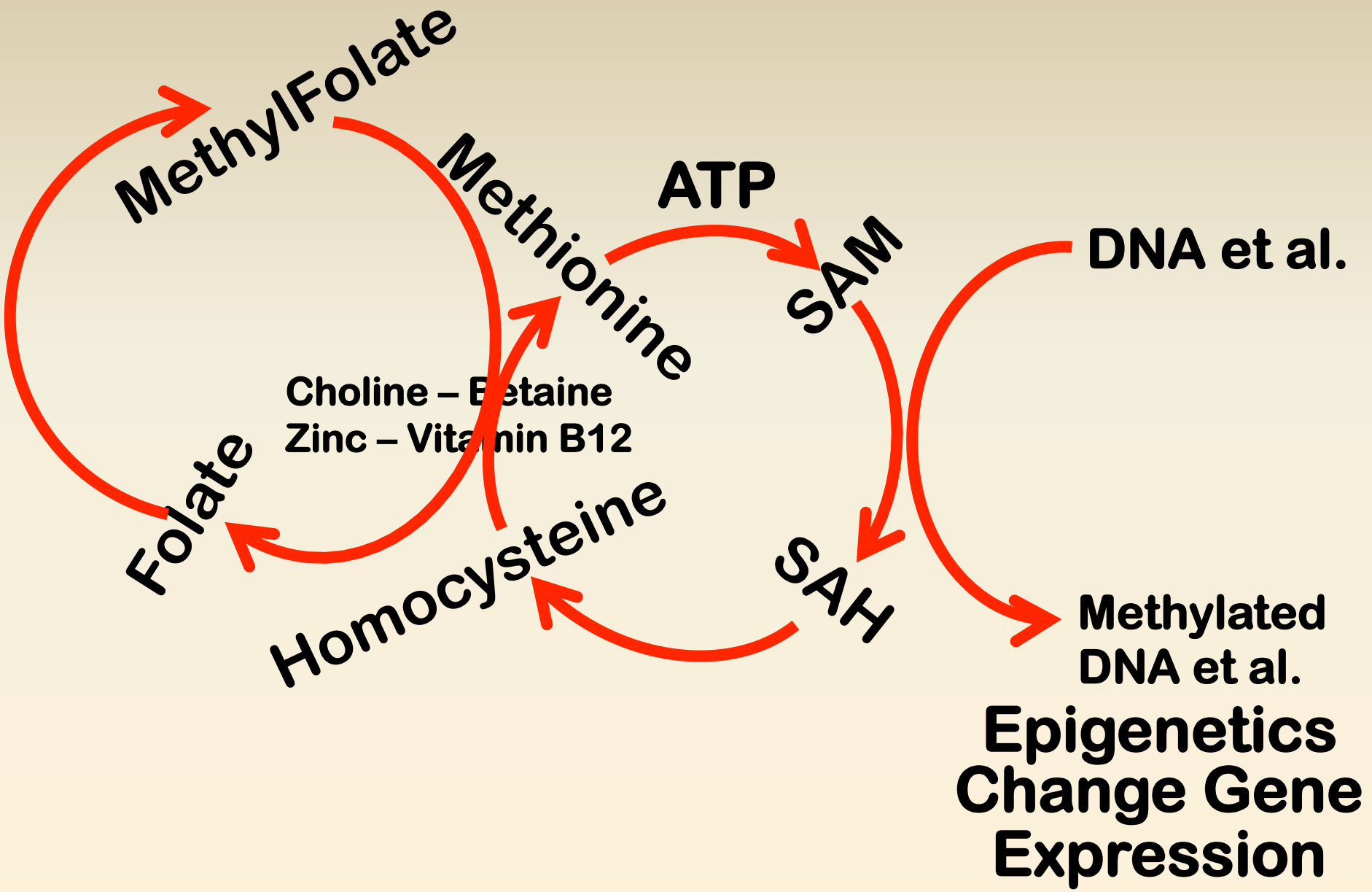
Fertilization
& Embryo Quality
n = 571

Protein Yield



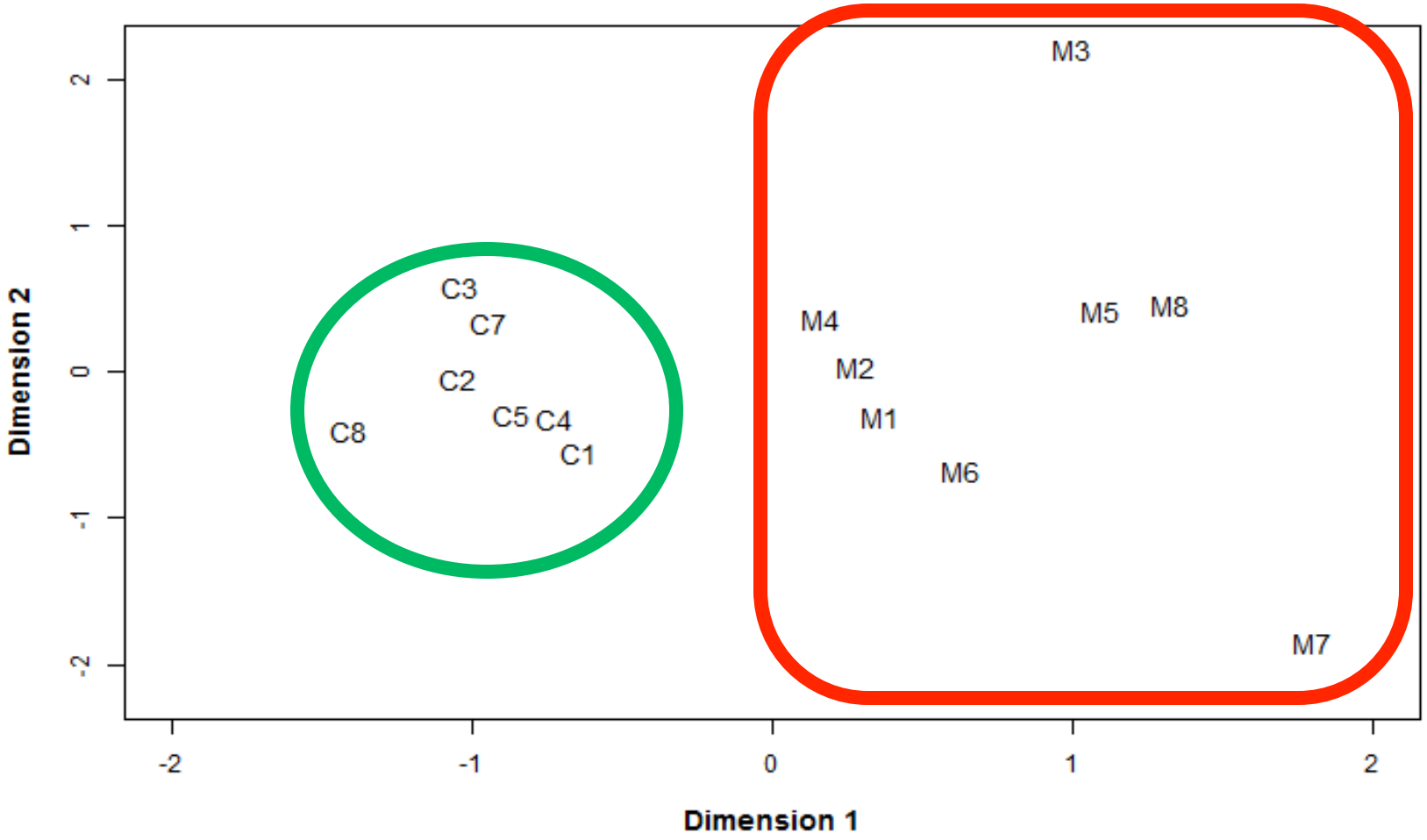
Embryos of superovulated cows fed MET or CON

	MET	CON	
n	35	37	***P*-value**
CL number	17.0 ± 1.3	17.7 ± 1.5	0.90
Total ova/embryos recovered	9.1 ± 1.4	6.8 ± 1.0	0.18
% Ova/embryos recovered per CL	49.5 ± 4.9	35.8 ± 4.4	0.05
Number of fertilized ova	6.5± 1.1	5.5 ± 0.9	0.56
% Fertilized ova	74.7 ± 5.6	82.2 ± 3.8	0.27
Number of transferable embryos	5.0 ± 0.9	4.3 ± 0.1	0.57
% Transferable embryos	56.3 ± 6.5	62.5 ± 6.0	0.49
Number of degenerate embryos	1.5 ± 0.4	1.3 ± 0.4	0.75
% Degenerate embryos	18.5 ± 4.6	19.7 ± 4.7	0.83
% Degenerate of fertilized ova	25.1 ± 5.8	27.5 ± 6.0	0.74



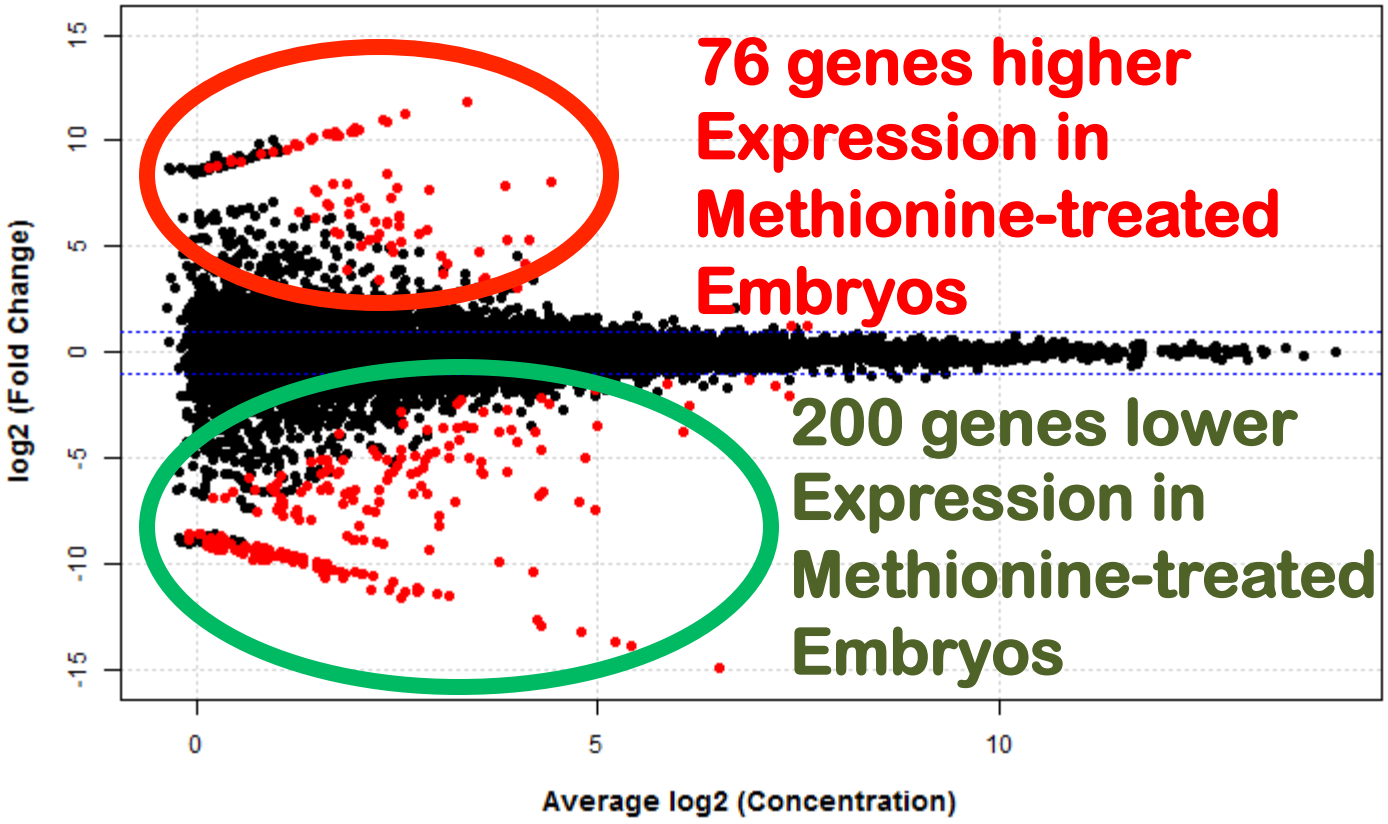
One Carbon Pathway

Multidimensional scaling (MDS) plot showing the relative similarities of the samples under study.



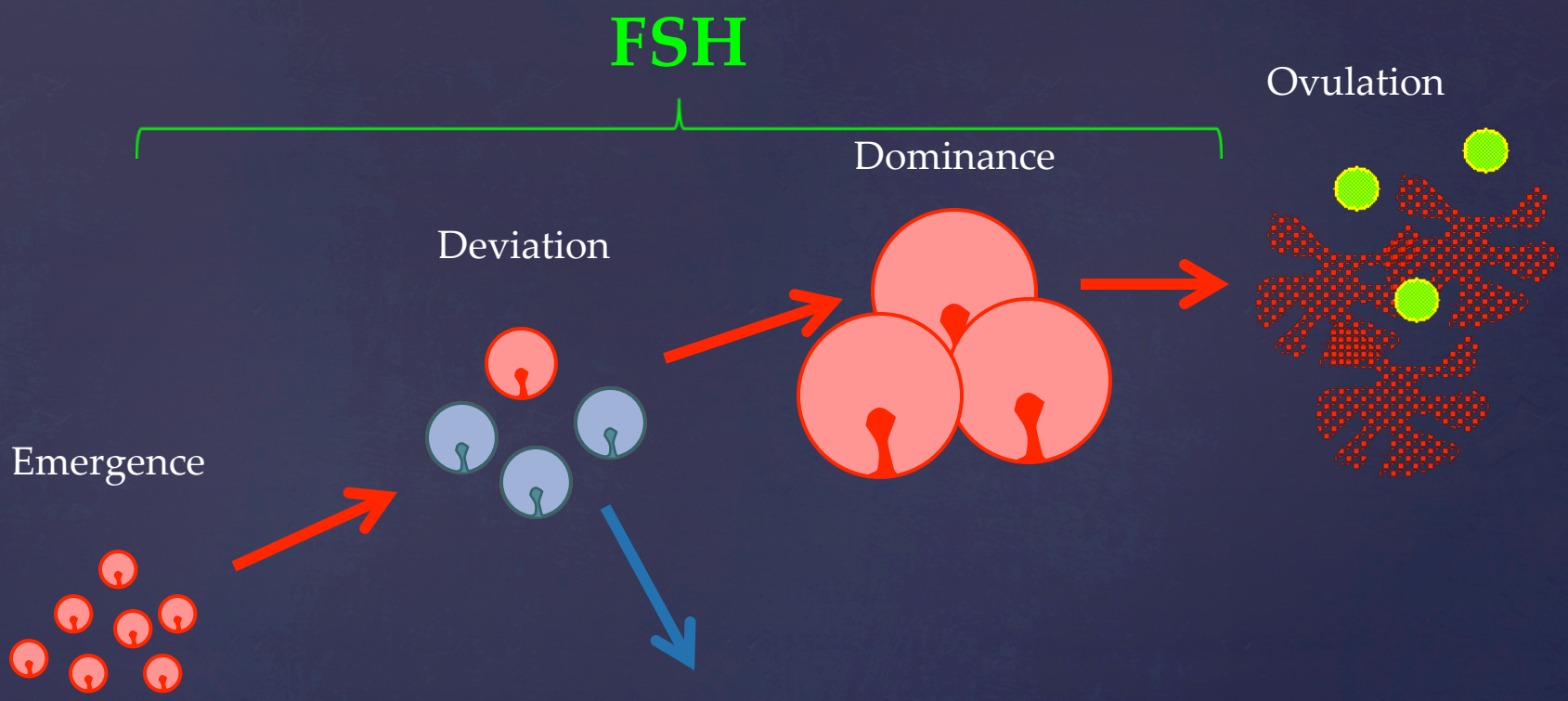
Plot of the log2 fold change against log2 average.

Differential expressed genes are highlighted in red.



Gene	Name	log2 FC	FDR
LAPTM5	Lysosomal protein transmembrane 5	-14.9	4.7×10^{-9}
NKG7	Natural killer cell group 7 sequence	-13.6	4.4×10^{-8}
VIM	Vimentin	-13.8	1.8×10^{-7}
TYROBP	TYRO protein tyrosine kinase binding protein	-13.2	3.2×10^{-6}
IFI6	Interferon, alpha-inducible protein 6	-12.6	1.5×10^{-5}
CUFF.2147.1	Novel transcript unit	-8.2	1.5×10^{-5}
LOC505451	Olfactory receptor, family 1, subfamily J, member 2-like	-13.0	1.5×10^{-5}
SLAMF7	Signaling lymphocyte-activating molecule family 7 family member 7	-10.4	3.5×10^{-5}
LOC788199	Olfactory receptor 6C74-like	-10.4	7.6×10^{-5}
LCP1	Lymphocyte cytosolic protein 1 (L-plastin)	-9.9	1.1×10^{-4}

Model



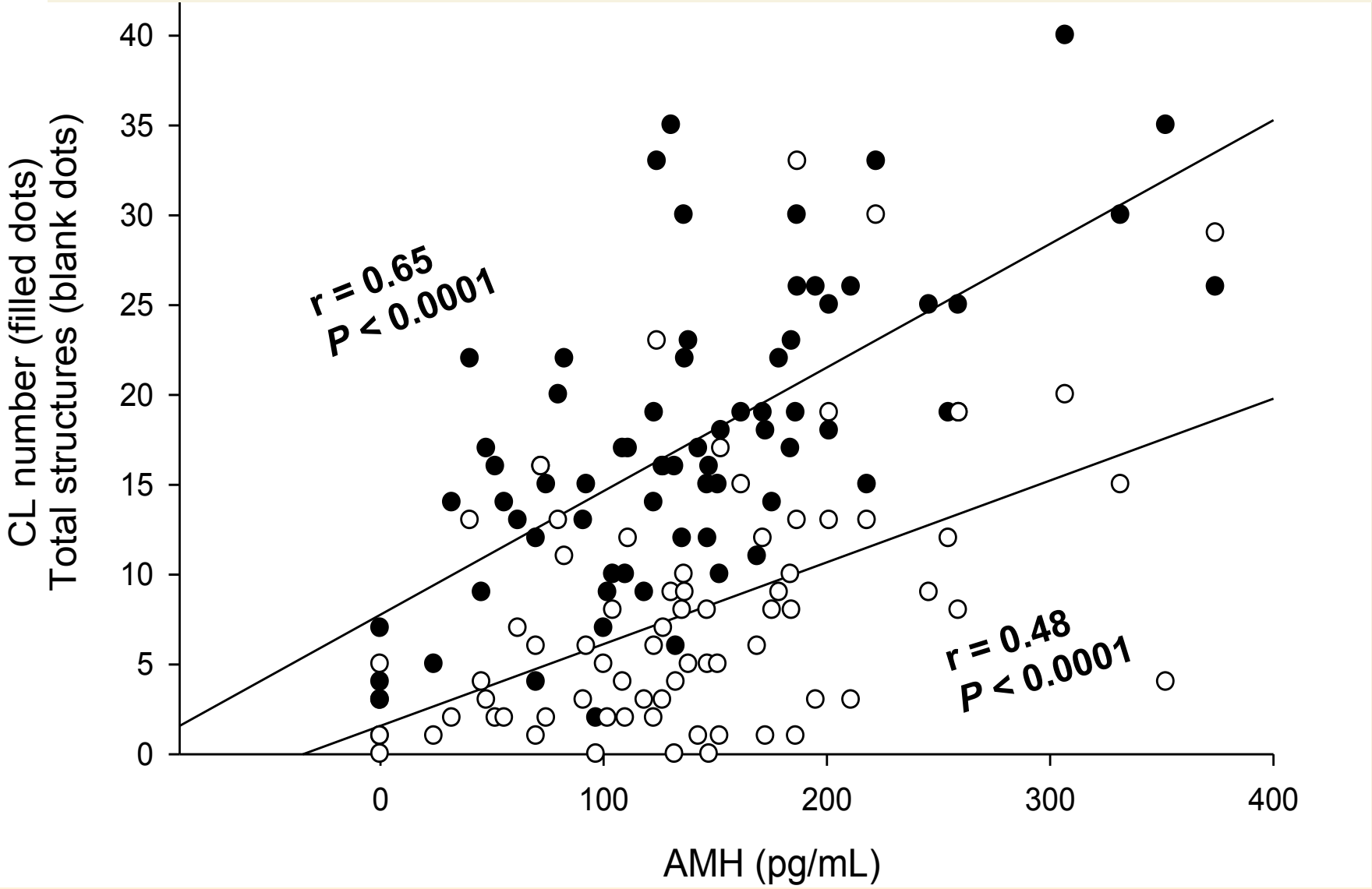
±Propylene Glycol (↑/↓INSULIN)

Ovulation Rate: 88.5% vs. 80.5% P = 0.002

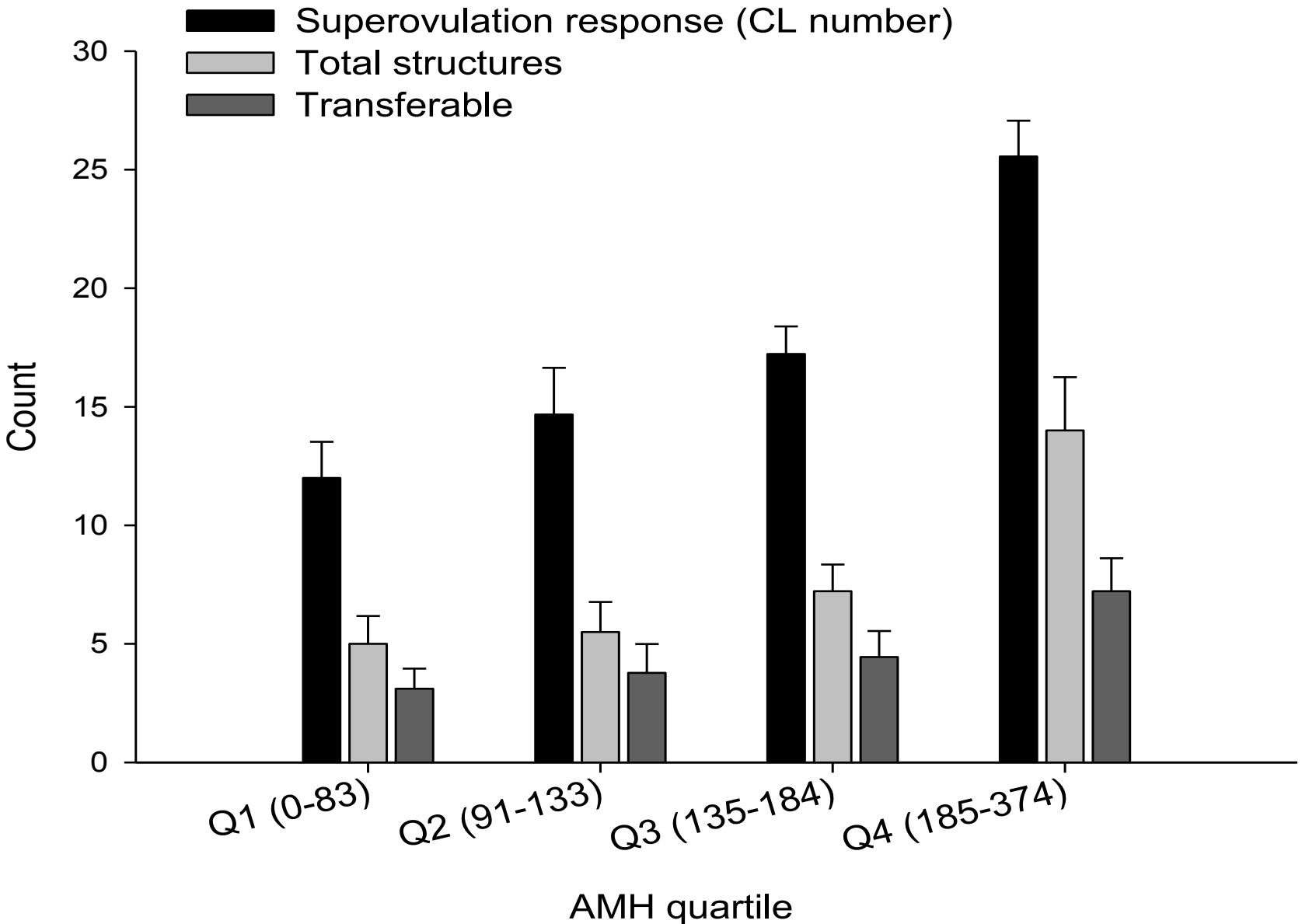
Fertilization Rate: 73.7% vs. 63.4% P = 0.02

No effect on other embryo measures

Relationship of AMH to CL number and embryos/oocytes recovered.

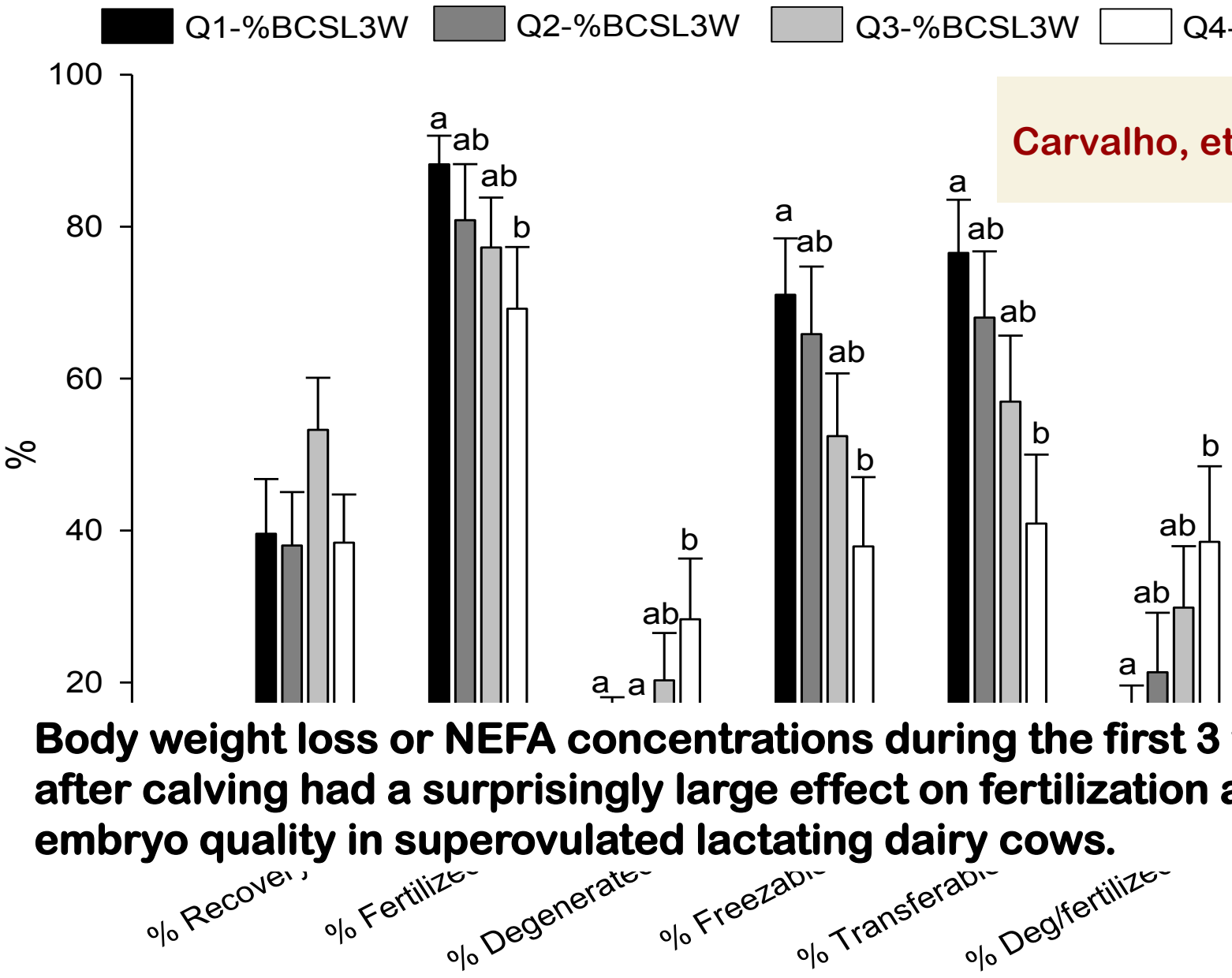


Circulating AMH is a strong predictor of superovulatory response



Carvalho, et al., 2013; Effect of postpartum body weight change and circulating NEFA on embryo quality in superovulated dairy cows.

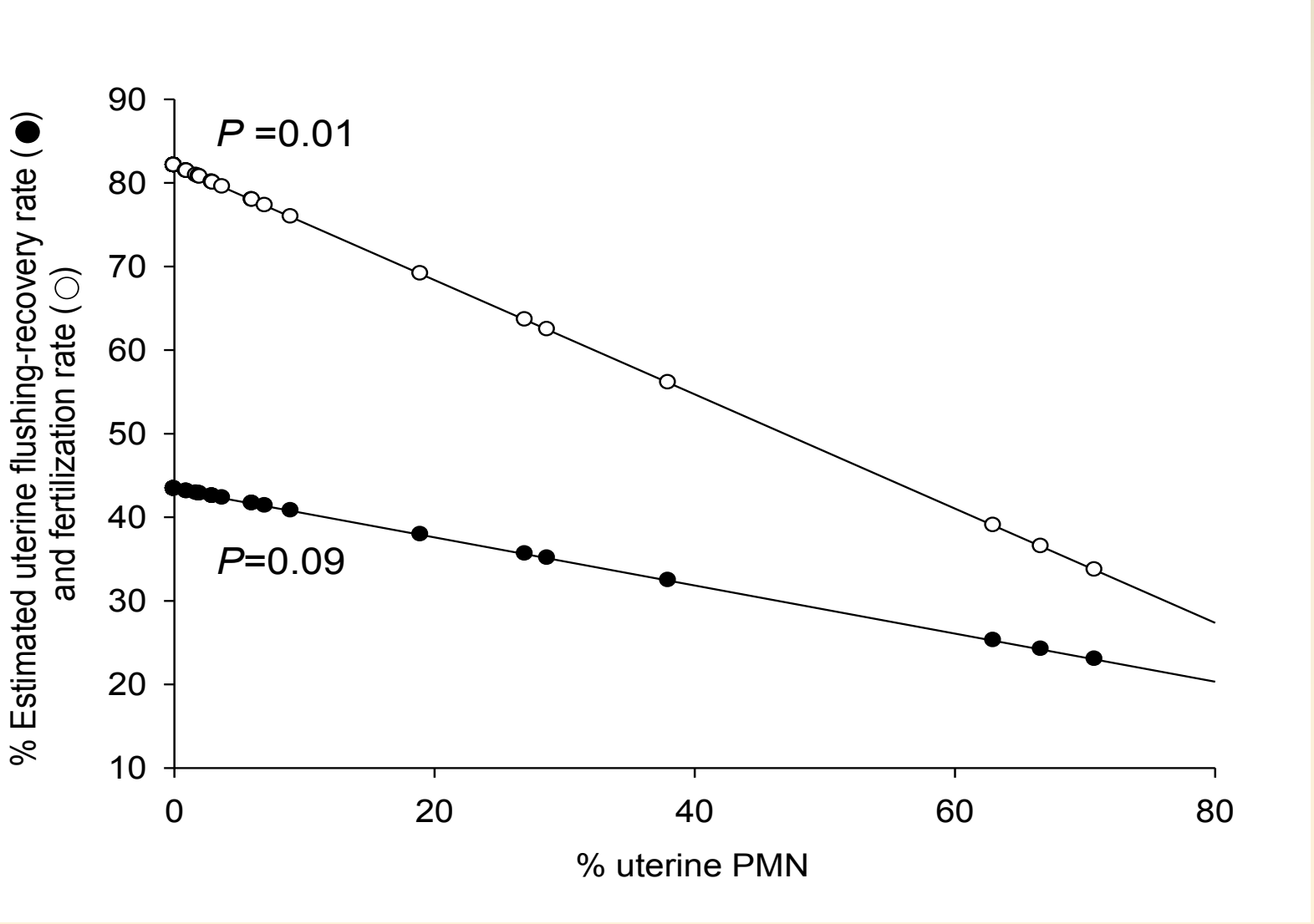
r^2 *P* Value	% Degenerated	% Fertilized	% BWC 3rd week	% BWC 10th week
NEFA	**0.23** **0.05**	**-0.13** **0.27**	**-0.44** **<0.001**	**-0.57** **<0.001**
% Transferable	**-0.67** **<0.001**	**0.66** **<0.001**	**0.40** **0.001**	**0.38** **0.002**
% Degenerated	**1.00**	**-0.07** **0.56**	**-0.25** **0.04**	**-0.31** **0.01**
% Fertilized ova		**1.00**	**0.28** **0.02**	**0.21** **0.09**
% BWC 3rd week			**1.00**	**0.71** **<0.001**



Carvalho, et al., 2013

Body weight loss or NEFA concentrations during the first 3 weeks after calving had a surprisingly large effect on fertilization and embryo quality in superovulated lactating dairy cows.

Effect of subclinical endometritis of fertilization



SPECIFIC AIM 3

Quantify the impact of mastitis on fertility and pregnancy loss in lactating dairy

Objective:

1. Determine if the occurrence of pregnancy loss will be greater in cows that experience mastitis.
2. Help to elucidate associations between mastitis case severity, pathogen type, and pregnancy loss.

Data:

Data obtained from 2,800 cows from four large commercial dairy herds which are being enrolled from calving until confirmed pregnant at 150 days post-AI

THE UNIVERSITY of WISCONSIN MADISON

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

UW Extension
University of Wisconsin–Extension

"This project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2010-85122-20612 from the USDA National Institute of Food and Agriculture." Project started March 1st, 2010

FARM 1. IMPACT OF MASTITIS ON REPROD

PARAMETER	NO MASTITIS	MASTITIS		
		Before AI	Between AI and1st Preg	After 1st Preg
Conception rate	37.3 (179/480)	22.9 (19/83)	11.8 (4/34)	35.9 (46/128)
Service per conception	2.3	2.4	2.9	2.5
DIM at first CM	0.0	34.8	96.3	194.6
Days open	147.5	163.2	190.9	161.7
Interbreeding interval	42.5	42.6	45.5	41.1

Ongoing Results

FARM	COWS ENROLLED	CLINICAL CASES
Farm 1	739	1070
Farm 2	747	2626
Farm 3	636	285
Farm 4	114	70
Total	**2,236**	**4,051**

- A total of 2800 cows need to be enrolled
- First TAI pregnancy loss is expected to be 4%
- Cases (pregnancy losses) will be compared against controls (pregnant cows) to determine the effect of mastitis in reproductive performance.

SPECIFIC AIM 4

the impact of reproductive performances using optimization and simulation techniques.

Objective 1:

Examine the use and impact of synchronization programs on reproductive performance and culling rates in dairy herds in WI.

Objective 2:

To assess the economic impact of reproductive performance of dairy cattle under optimal replacement policies using optimization techniques.

Data:

Data was obtained DHI records and benchmarks.

THE UNIVERSITY of WISCONSIN MADISON

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

UW Extension
University of Wisconsin–Extension

"This project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2010-85122-20612 from the USDA National Institute of Food and Agriculture." Project started March 1st, 2010

Souza et al., 2013

Impact of timed AI use on reproduction and culling rate in Wisconsin dairy herds.

Wisconsin farms (n = 200; 600 cows/herd; 12,427 kg/lactation).

Determined in each herd using DC305.

Divided into quartiles

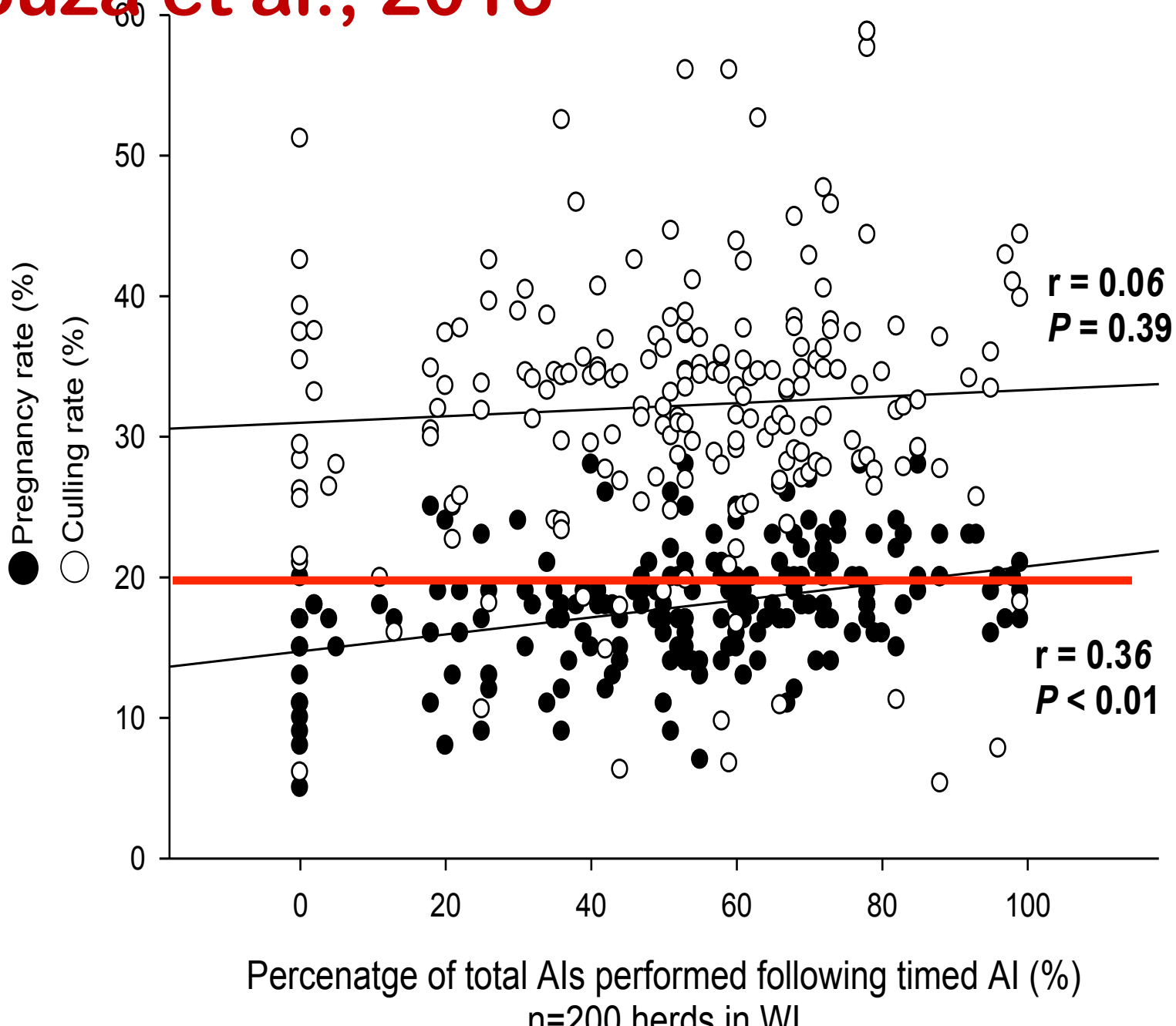
(0-36%; 37-55%; 56-69%; 67-99%)

Average VWP was 57.4 d and % pregnant to 1st AI (P/1stAI) was 36.6%.

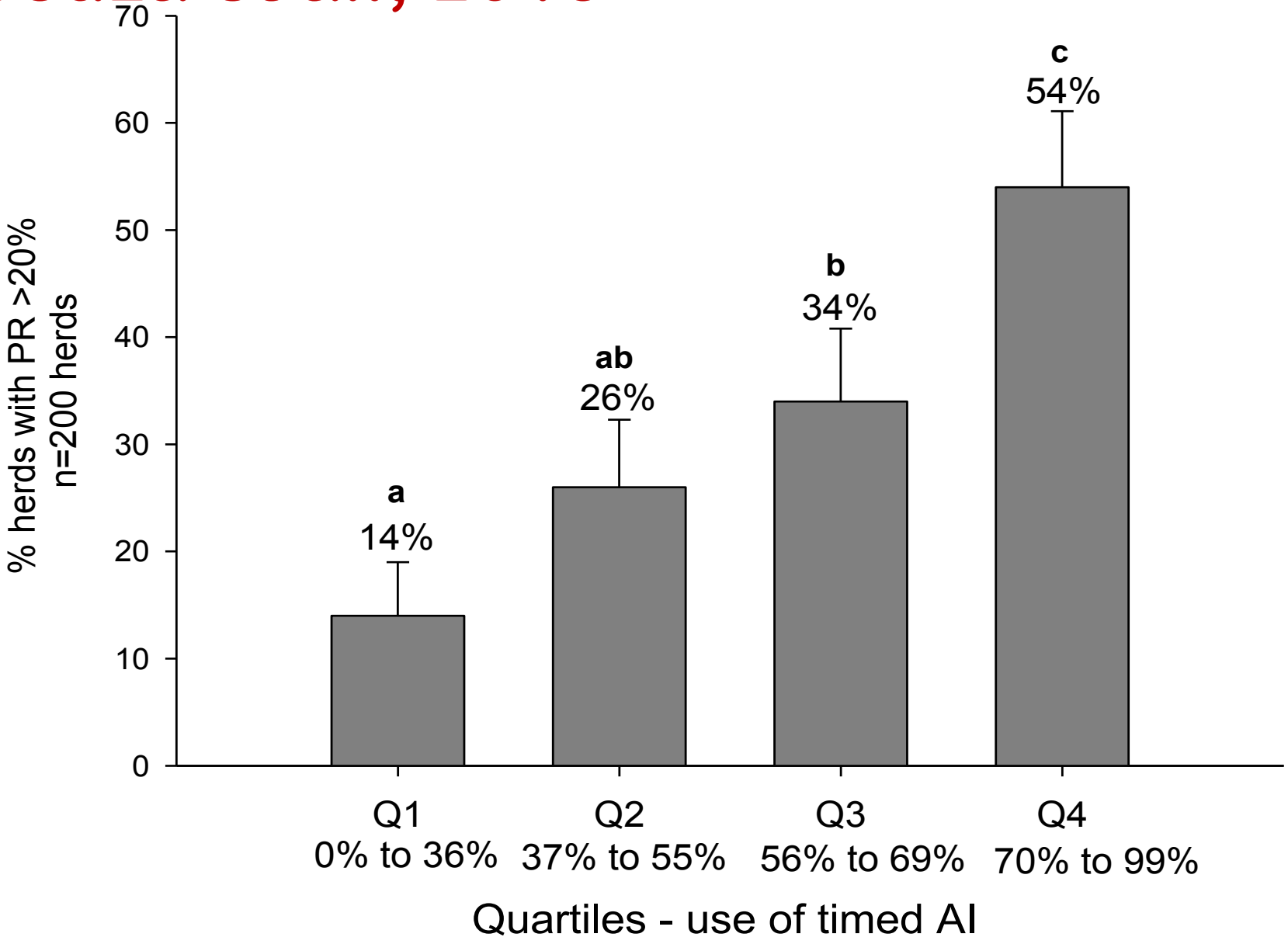
Souza et al., 2013

Variable	Quartiles - use of timed AI* Q1 (0% to 36%)	Q2 (37% to 55%)	Q3 (56% to 69%)	Q4 (70% to 99%)
Average lactating herd size (n)	663.5	673.8	719.5	582.4
Voluntary waiting period (days)	49.6[a]	53.8[a]	58.9a[b]	67.5[b]
Conception to 1st AI (%)	35.2[a]	35.5[a]	36.1[a]	39.6[b]
Service rate, VWP set at 50DIM (%)	48.7	53.0	53.0	49.9
Pregnancy rate, VWP at 50DIM (%)	15.9	17.2	16.9	17.5
Service rate, actual VWP (%)	48.8[a]	54.4[b]	56.9[b]	57.1[b]
Pregnancy rate, actual VWP (%)	15.8[a]	17.7b	18.1b	19.9[b]
Culling rate (%)	35.8	37.7	35.4	40.5
Days open, pregnant cows (days)	139.6[a]	133.3	136.2	130.8[b]
Days in milk, all lactating cows (days)	209.4[a]	201.4	205.2	199.6[b]

Souza et al., 2013

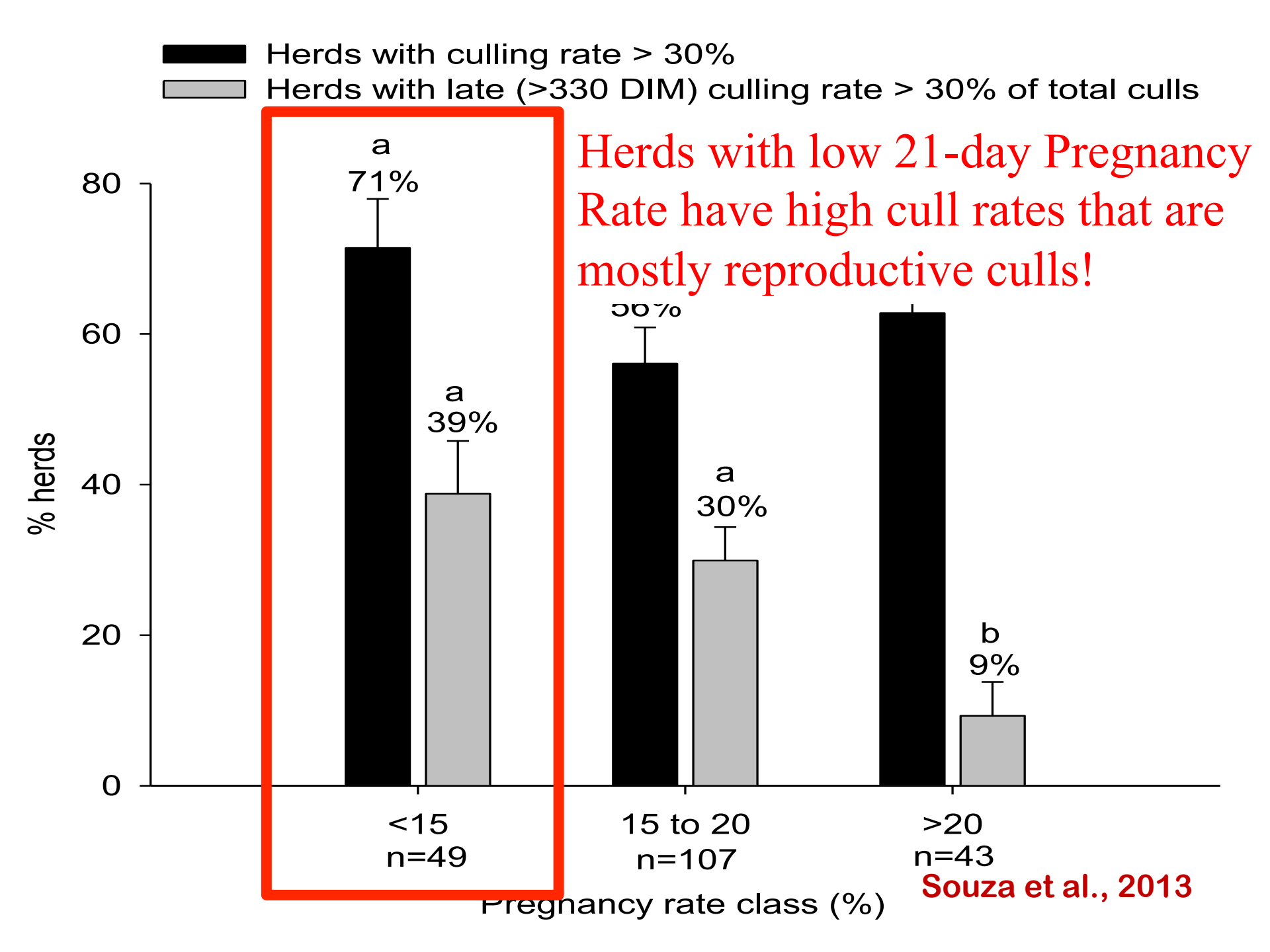


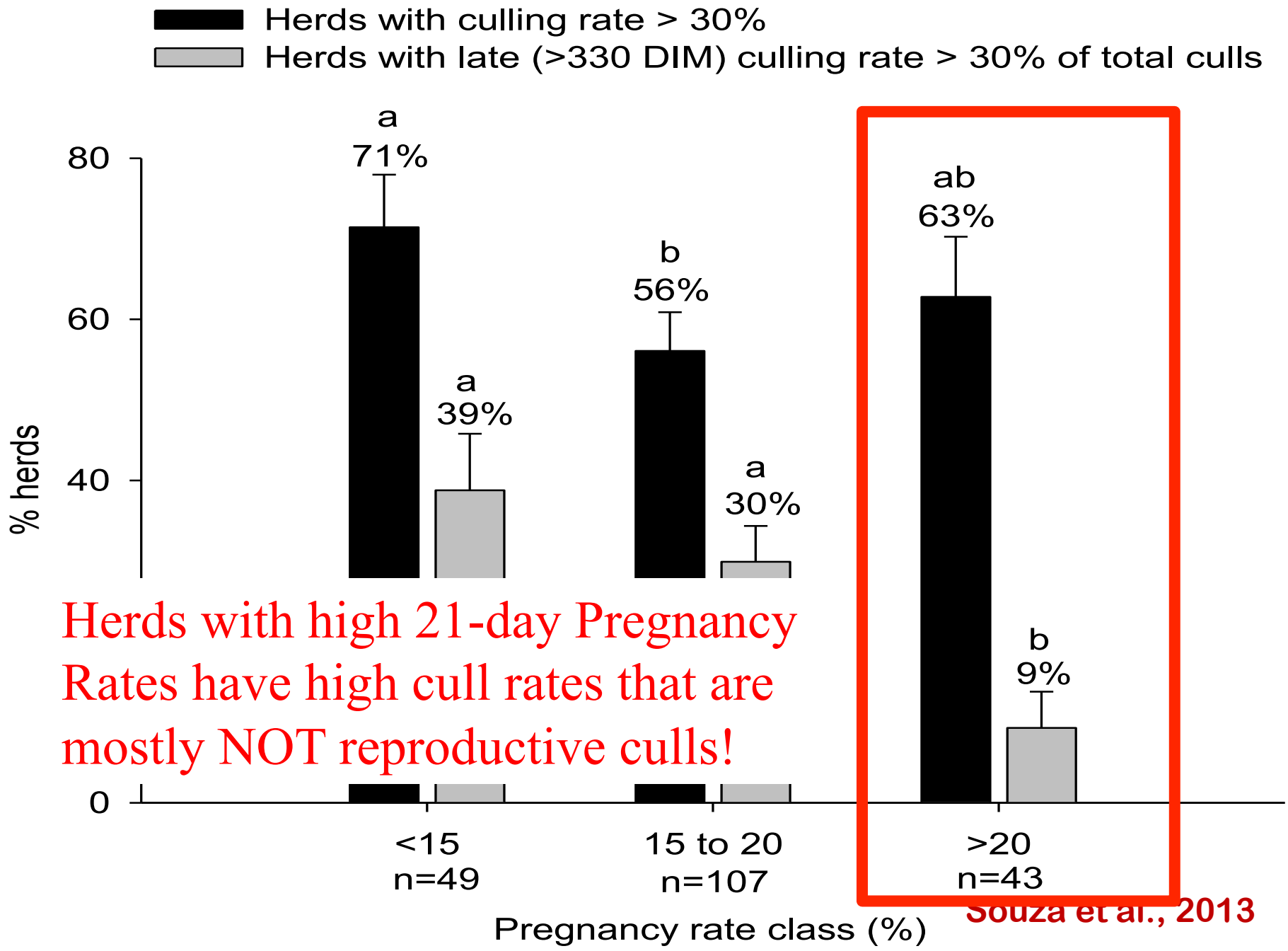
Souza et al., 2013



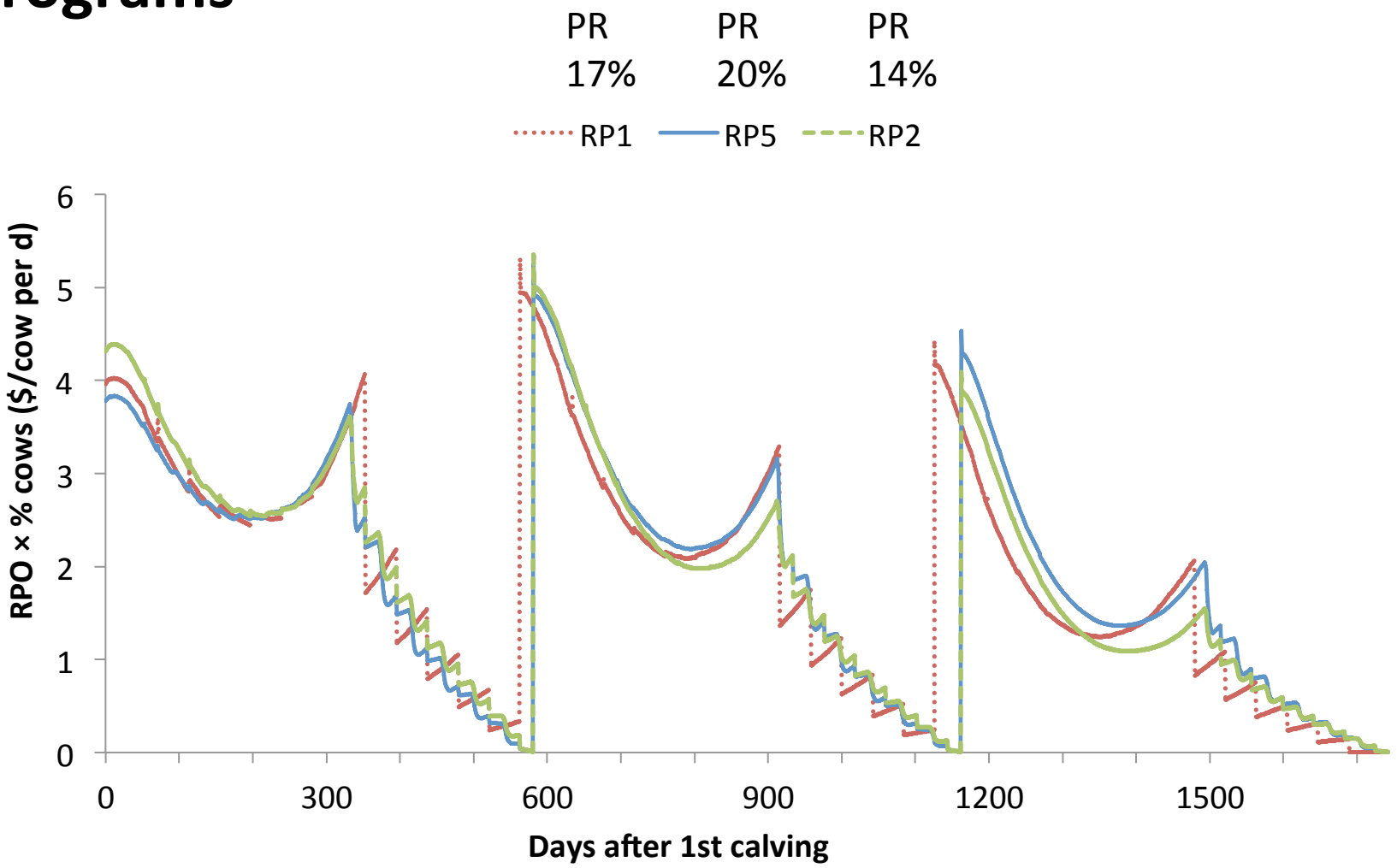
Souza et al., 2013

Variable	Quartiles - use of timed AI* Q1 (0% to 36%)	Q2 (37% to 55%)	Q3 (56% to 69%)	Q4 (70% to 99%)
Average lactating herd size (n)	663.5	673.8	719.5	582.4
Voluntary waiting period (days)	49.6[a]	53.8[a]	58.9a[b]	67.5[b]
Conception to 1st AI (%)	35.2[a]	35.5[a]	36.1[a]	39.6[b]
Service rate, VWP set at 50DIM (%)	48.7	53.0	53.0	49.9
Pregnancy rate, VWP at 50DIM (%)	15.9	17.2	16.9	17.5
Service rate, actual VWP (%)	48.8[a]	54.4[b]	56.9[b]	57.1[b]
Pregnancy rate, actual VWP (%)	15.8[a]	17.7b	18.1b	19.9[b]
Culling rate (%)	35.8	37.7	35.4	40.5
Days open, pregnant cows (days)	139.6[a]	133.3	136.2	130.8[b]
Days in milk, all lactating cows (days)	209.4[a]	201.4	205.2	199.6[b]


Herds with culling rate > 30%
Herds with late (>330 DIM) culling rate > 30% of total culls
Herds with low 21-day Pregnancy Rate have high cull rates that are mostly reproductive culls!
% herds
80
60
40
20
0
a
71%
a
39%
a
30%
b
9%
<15
n=49
15 to 20
n=107
>20
n=43
Pregnancy rate class (%)
Souza et al., 2013

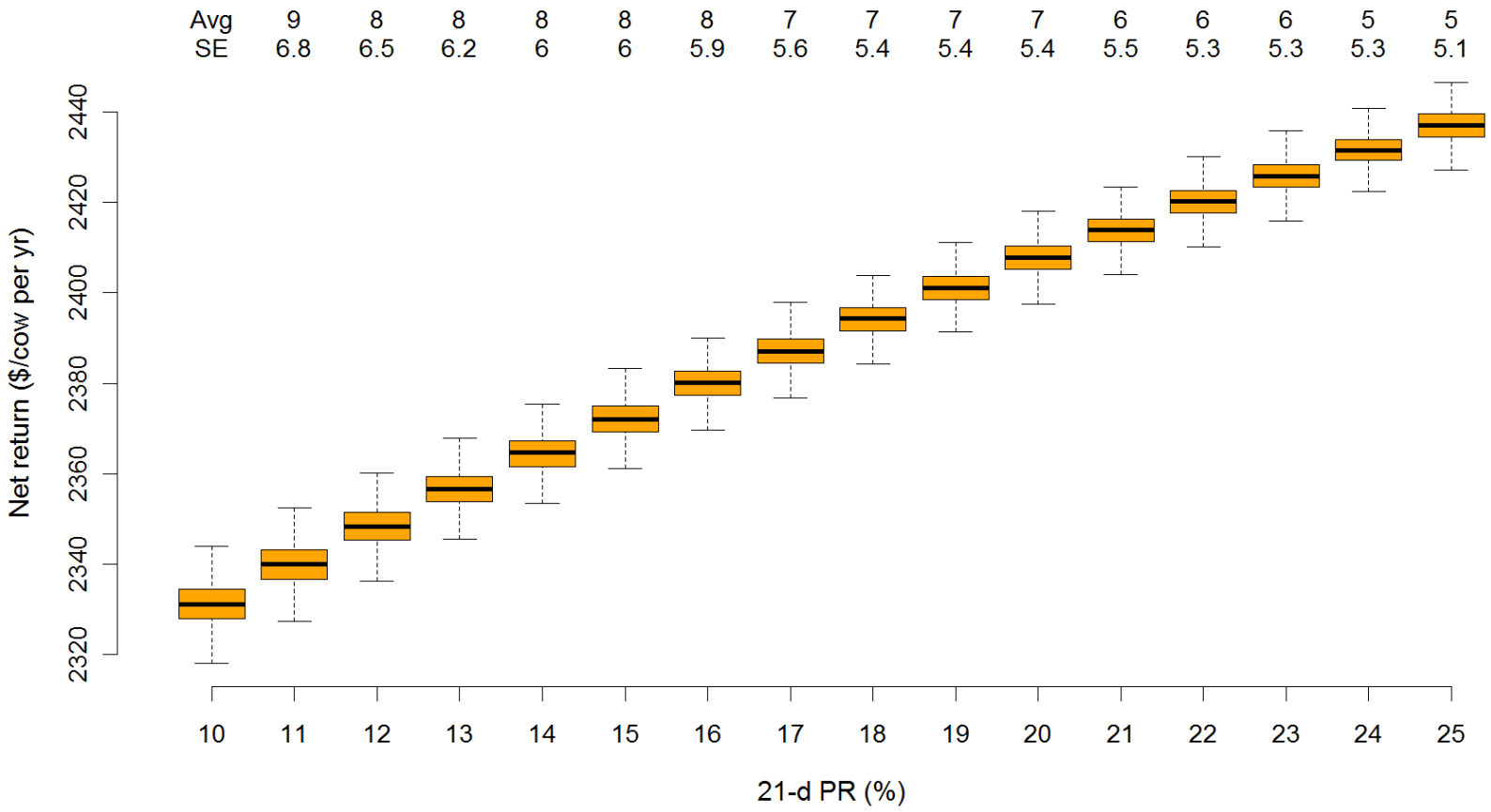

Herds with culling rate > 30%
Herds with late (>330 DIM) culling rate > 30% of total culls
% herds
80
60
40
0
a
71%
a
39%
b
56%
a
30%
ab
63%
b
9%
<15
n=49
15 to 20
n=107
>20
n=43
Pregnancy rate class (%)
Herds with high 21-day Pregnancy Rates have high cull rates that are mostly NOT reproductive culls!
Souza et al., 2013

Sources of differences between reproductive programs



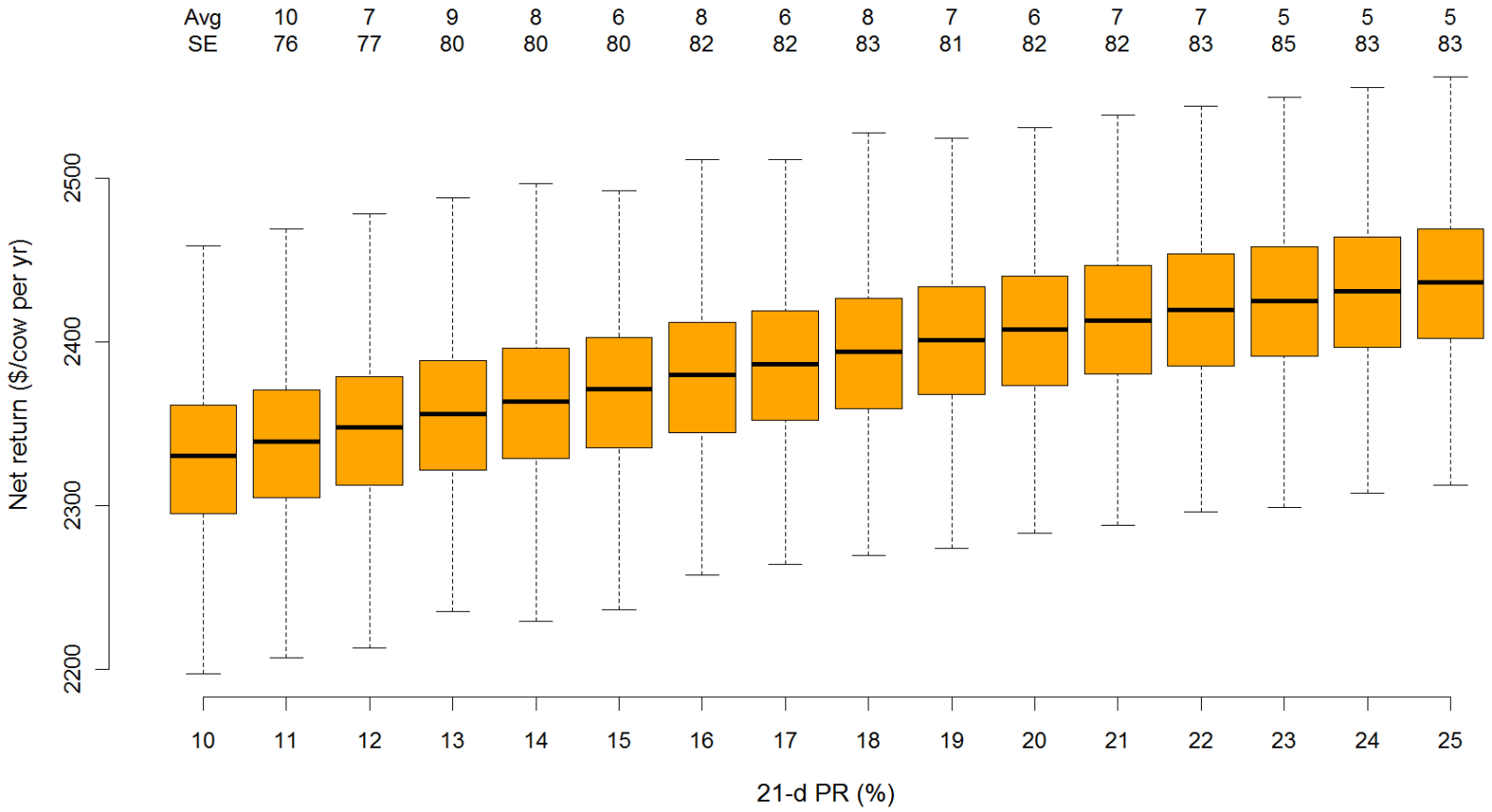
- A. S. Kalantari and V. E. Cabrera (2012)

Variation in the net return without Milk production variation with 2,000 Replicates



- A. S. Kalantari and V. E. Cabrera (2013; in review)

Variation in the net return including Milk production variation with 2,000 Replicates



SPECIFIC AIM 5

Repro Money Program

Objective:

To improve reproductive efficiency and profitability of the dairy farms by means of farmer-directed team-base program called Repro Money

Data:

Data obtained from farm records of all farms that enrolled and completed the program (n=13) between Fall 2010 and Summer 2012 was analyzed before and after participating in the program to evaluate the program's impact on enhancing reproductive performance and herd profitability.

"This project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2010-85122-20612 from the USDA National Institute of Food and Agriculture." Project started March 1st, 2010

OUTCOME	BEFORE PROGRAM	AFTER PROGRAM	IMPROVEMENT	*P*-value
21-d Preg Rate (%)	19	22	3	0.0083
Insemination Risk (%)	53	56	5	0.0003
Conception Rate (%)	37	42	3	0.0016
Cows AI 21d	61	79	17	0.0141

Economic Gain = $55/cow per year (0 to $278)

Repro Money Extension Efforts

- Webpage for program news & updates
- 27 dairy farms currently enrolled and ongoing
- National meetings poster presentations (ADSA, DCRC, AABP)
- State-wide yearly workshop showcasing our results:
  - Winter 2013: 22 workshops
  - More than 500 participants
    - Farmers, industry representatives, technical college students, industry professionals.

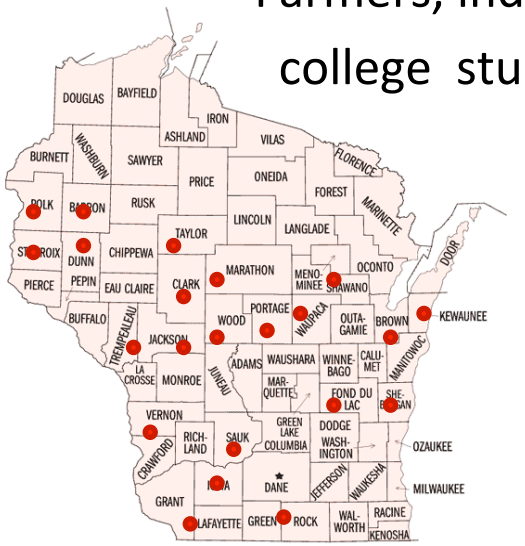


Figure 1: Workshop locations

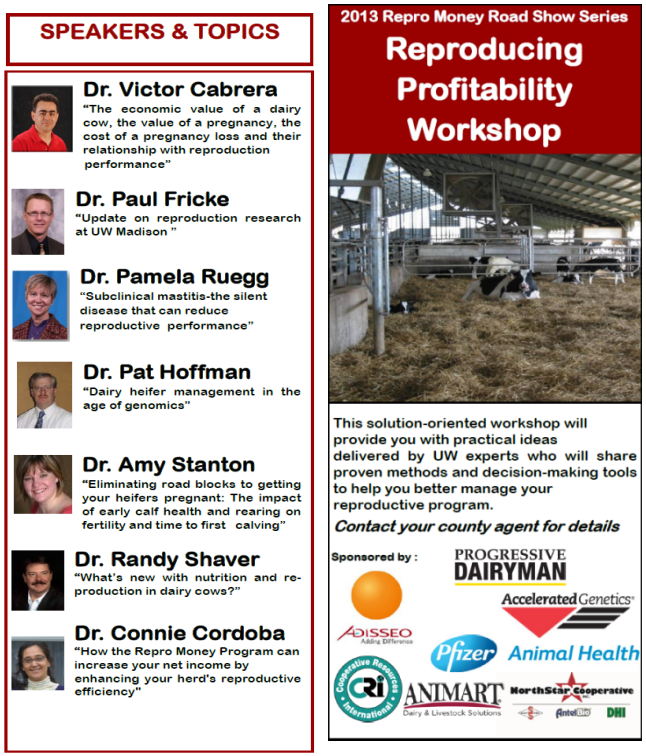


Figure 2: Workshop flyer

An Integrated Approach To Improve Dairy Cow Fertility

Specific Aim 1: Predicting Fertility
Saleh Shahinfar, Ph.D. Student
Kent Weigel, Professor and Chair Breeding and Genetics

Specific Aim 2: Nutrition-Reproduction
Alexandre Souza, Post Doctoral fellow
Milo Wiltbank , Professor -Reproductive Physiology
Randy Shaver, Professor - Nutrition

Specific Aim 3: Mastitis-Reproduction
Maria José Fuenzalida Valenzuela, Ph.D. Student;
Paul Fricke, Professor - Reproductive Physiology
Pam Ruegg, Professor - Physiology and Management
Carol Hulland, Milk Quality

Specific Aim 4: Economics of Reproduction
Afshin Kalantari, Ph.D. Student
Victor Cabrera, Assistant Professor- Management

Specific Aim 5: Repro Money Extension Program
Victor Cabrera, Assistant Professor- Management
Connie Cordoba, M.V, M.S.; Extension Speciallist

THE UNIVERSITY of WISCONSIN MADISON

USDA
United States Department of Agriculture
National Institute of Food and Agriculture