CALCIUM AND ENERGY BALANCE OF EARLY JERSEY COWS AND THE EFFECT OF AN ORAL CALCIUM SUPPLEMENTATION IN LACTATION PERFORMANCE

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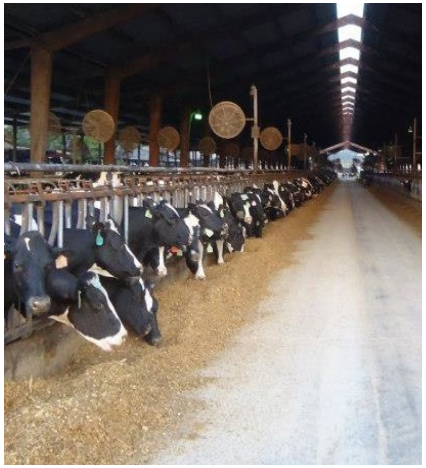
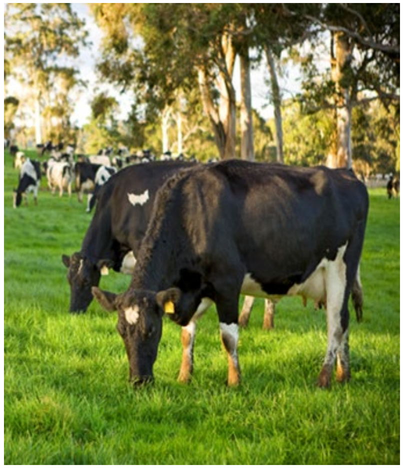
DVM, M.Sc, PhD student



Agenda

- Serum Ca dynamics in postpartum cows
- Key differences between breeds
- Association of blood calcium concentration in the first 3 days after parturition and energy balance metabolites at day 3 in milk with disease and production outcomes in multiparous Jersey cows
- A Randomized Clinical Trial Evaluating the Effect of an Oral Calcium Bolus Supplementation Strategy in Postpartum Jersey Cows on Mastitis, Culling, Milk Production, and Reproductive Performance

Background

3 weeks prepartum

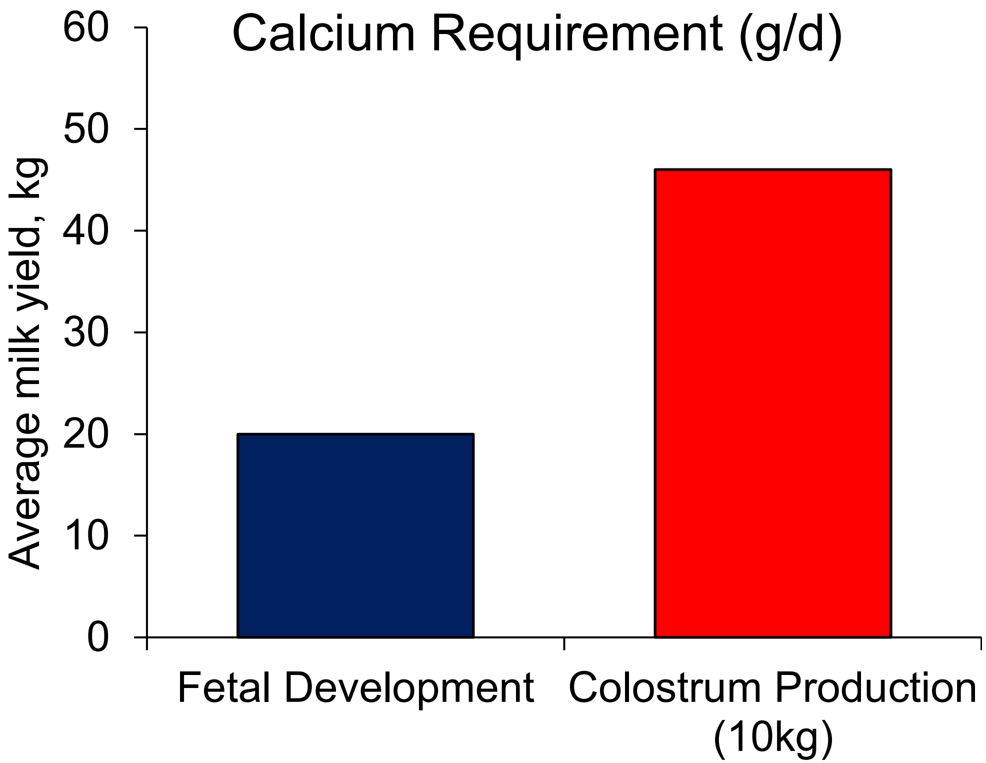
21 days in milk

Challenges:

- Change of physiological state
- Abrupt nutritional change
- Social stressors
- Inflammatory-infectious process in the reproductive tract
- 70% of the disease
- Energy demands increase by about 300%
- Calcium requirements are increased around 65%

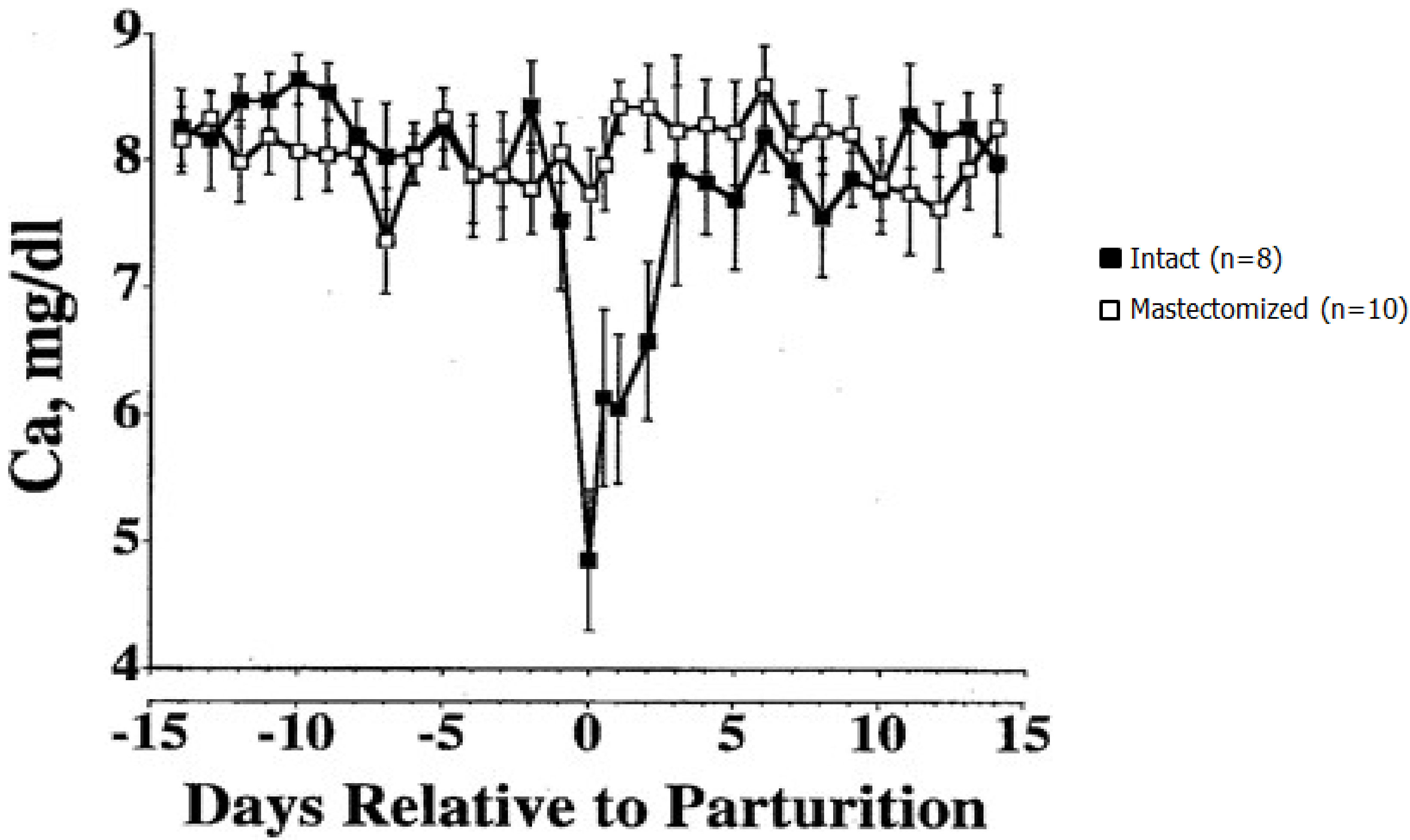
Bell, 1995; Darckely 1999

Background



- 2-4 g of Ca in the plasma pool
- Plasma pool must turnover 10+ times for colostrum production
- Adaptation requires coordination of several hormones and tissues

Background



Goff et al., 2002

Study #1

J. Dairy Sci. 104
https://doi.org/10.3168/jds.2020-19189

Association of blood calcium concentration in the first 3 days after parturition and energy balance metabolites at day 3 in milk with disease and production outcomes in multiparous Jersey cows

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Why is it important?

J. Dairy Sci. 101:1–11
https://doi.org/10.3168/jds.2018-14587

Epidemiology of subclinical hypocalcemia in early-lactation Holstein dairy cows: The temporal associations of plasma calcium concentration in the first 4 days in milk with disease and milk production

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- Ca was associated with the risk of metritis at 2, 3, and 4 DIM
- Ca concentration was associated with the risk of metritis or displaced abomasum diagnosis (or both) for 2nd parity animals at 2 DIM), and at 4 DIM for 3rd and greater lactations
- ↓ Ca concentration was associated with ↑ milk production at 1 DIM in primiparous and multiparous cows
- ↓ milk production when assessed at 4 DIM in multiparous cows
- Assessments of SCH at the individual cow level must take into account the DIM of Ca concentration measurement and parity of the cow, as the epidemiology of the disorder was demonstrated to be highly dependent on these variables

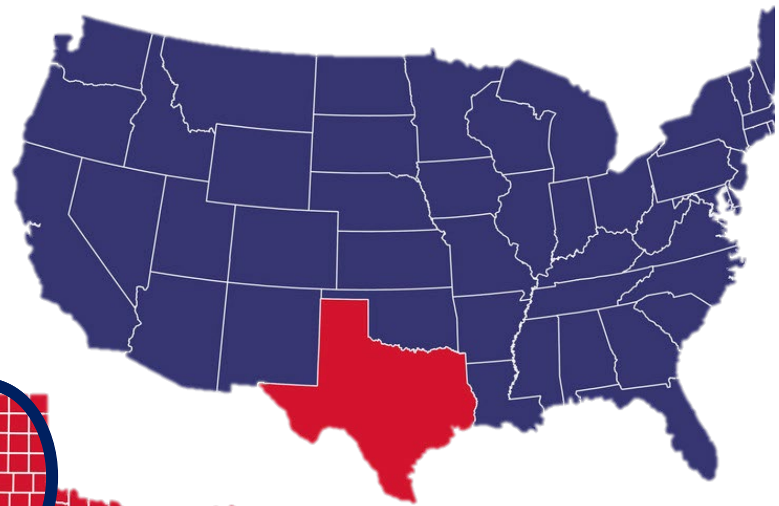
Why is it important?

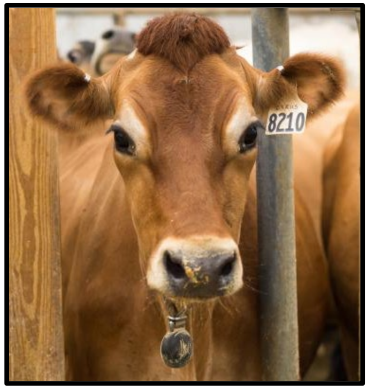
- Jersey vs. Holstein
  - Calcium demands (Cerbulis and Farrell, 1976)
    - greater milk total ash content
  - Calcium absorption
    - Vitamin D receptors (Goff et al., 1995)
  - Negative energy balance (Friggens et al., 2007; Olson et al., 2010)
    - ↑ energy demands
    - ↓ Glucose
    - ↑ Lipolysis
  - Energetic metabolism
    - FFA
    - BHB

Why is it important?

- Differences between breeds can influence the ability of extrapolating results and disorder classification performed in one breed to the other

- West TX is the 2nd largest region in concentration of Jersey cattle in the U.S
  - 64,251 cows (American Jersey Cattle Association, 2017)





Study #1

- **Objetive**
  - Evaluate the associations of plasma total Ca measured at 1 through 3 DIM and FFA, BHB, and glucose measured at 3 DIM with:
    - the risk of multiparous Jersey cows being diagnosed with early-lactation diseases and culling
    - milk production in the first 9 wk of lactation
    - the risk of pregnancy in the first 150 DIM

Cut points for SCH and appropriate DIM for SCH testing to better assess this metabolic disorder in Jerseys would benefit technicians in the field

Material and Methods

- Prospective Cohort Study
  - July – April/2018
  - West Texas
  - 380 purebred Jersey cows
  - Data was extracted from the farm's DC305

Material and Methods

Data collection regarding monthly milk yield, fertility and culling

Days pospartum

0 1 2 3 4 7 10 180

tCa tCa tCa
FFA
BHB
Glu

Metritis diagnosis

Purebred
No oral Ca
No twin
DCC < 260
2 Lact
≥ Lact

- **Calving** season (**warm**: cows calving from July 19 to September 22, 2018; **cool**: calving from September 23 to December 9, 2018)
- **Calving problem**: Cows that suffered from dystocia, stillbirth or both

Material and Methods: Statistics

- Data modeling were developed in SAS (version 9.4)

  - Multivariable Poisson regression models were built to evaluate the association of the analytes with the risks of early lactation disease and culling
  - Linear mixed models were used to evaluate the association of the analytes with milk production
  - Cox Proportional hazards modeling were built to assess the risk of pregnancy
  - ROC curves were performed using MedCalc (version 9.5.2.0)
    - Metabolites were dichotomized if the AUC was significantly different than 0.5
    - Dichotomizations were based on thresholds that maximized the Sn and Sp for classification purposes

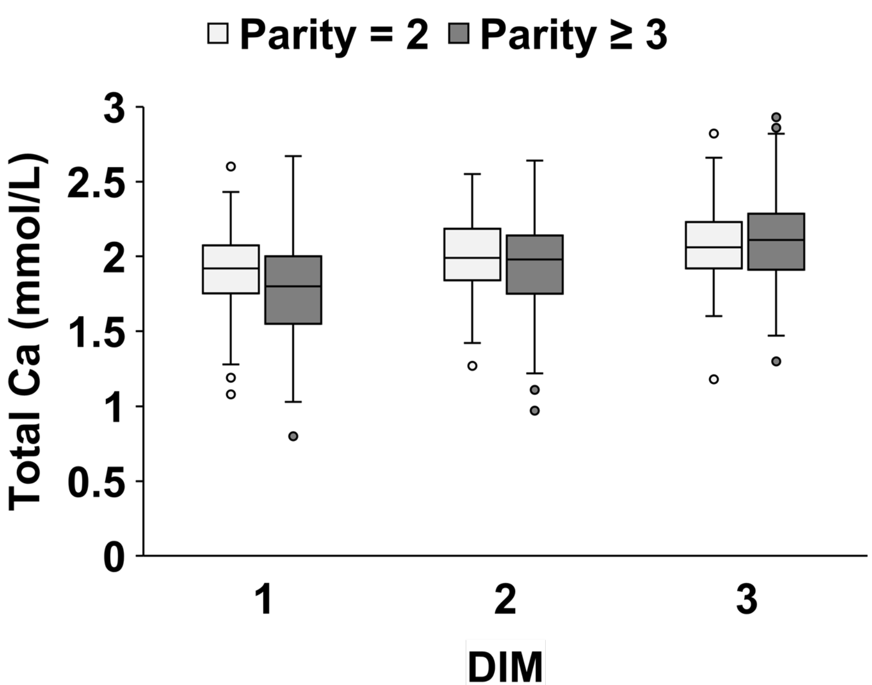
Descriptive Statistics

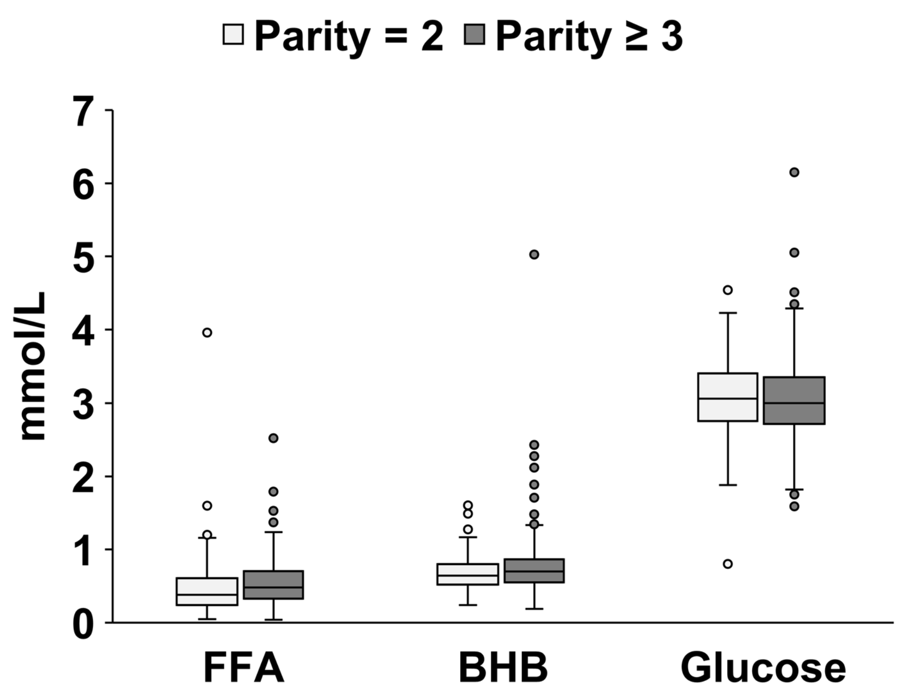
Disorder	n (%)
Stillbirth	14 (3.7)
Dystocia	11 (2.9)
Retained placenta	3 (0.8)
Left displaced abomasum	1 (0.3)
Metritis	100 (26.3)
Mastitis	46 (12.1)
Culling (sold/died)	36 (9.5)

Descriptive Statistics

	DIM		
Plasma total Ca concentration	**1**	**2**	**3**
1 DIM in 2nd parity cows (n = 147)			
r	**1.00**	**0.65**	**0.08**
P-value	**-**	**<0.01**	**0.32**
1 DIM in ≥3 parity cows (n = 233)			
r	**1.00**	**0.52**	**0.06**
P-value	**-**	**<0.01**	**0.39**

Descriptive Statistics





Risk of metritis

Variable	Relative risk	95% CI	P-value
Parity			
2	–	–	–
≥3	–	–	0.26
Calving season			
Cool	–	–	–
Warm	0.58	0.39 - 0.86	<0.01
Calving-related problem(s)	2.32	1.26 - 4.25	<0.01
Retained placenta	7.29	2.39 - 22.24	<0.01
FFA ≥0.43 mmol/L at 3 DIM	1.78	1.20 - 2.66	<0.01

Risk of metritis

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- ↓ blood Ca concentrations impair innate immunity (Kimura et al., 2006; Martinez et al., 2014)
- Parity dependency and temporality of Ca association (Neves et al., 2017)
- No correlation of Ca at 1 and 3 DIM was evidenced for our dataset
- Holstein vs. Jersey
- Consequence other than a risk factor for the disease
- ↑ FFA can adversely affect oxidative burst and the phagocytic capacity of PMNL (Scalia et al., 2006)

Variable	Relative risk	95% CI	P-value
Intercept	–	–	<0.01
Parity			
2	–	–	–
≥3	–	–	0.26
Calving season			
Cool	–	–	–
Warm	0.58	0.39 - 0.86	<0.01
Calving-related problem(s)	2.32	1.26 - 4.25	<0.01
Retained placenta	7.29	2.39 - 22.24	<0.01
FFA ≥0.43 mmol/L at 3 DIM	1.78	1.20 - 2.66	<0.01

Risk of culling

Variable	Relative risk	95% CI	P-value
Parity			
2	–	–	–
3	4.36	2.02 - 9.43	<0.01
Body condition score			
1	–	–	–
2	0.41	0.23 - 0.74	<0.01
3	0.30	0.12 - 0.72	<0.01
Glucose at 3 DIM	1.75	1.16 - 2.64	<0.01
BHB at 3 DIM	1.63	1.0 - 2.64	0.08
FFA at 3 DIM	2.18	1.03 - 4.60	0.05
Total Ca at 3 DIM ≤1.99 mmol/L	2.93	1.74 - 4.94	<0.01

Risk of culling

- **Literature is inconsistent**
  - **↓ [Ca] associated with culling in the first 2 weeks postpartum (Seifi et al., 2011; Roberts et al., 2012).**
  - **[Ca] concentration <2.00 mmol/L had increased risk of being culled in the first 60 DIM (Venjakob et al. 2018)**
  - **↓ [Ca] within 12 h after parturition tendendof increased tCa concentration and the risk of culling within 60 DIM (Neves et al., 2018)**
  - **Lipolysis before parturition is a known risk factor for metritis (Chapinal et al., 2011; Giuliodori et al., 2013)**
    - **↑ metritic cows are more likely to be culled (Wittrock et al., 2011)**
    - **↑ FFA associated with metritis and culling**

Variable	Relative risk	95% CI	P-value
Parity			
2	[illegible]	[illegible]	[illegible]
3	4.36	2.02 - 9.43	<0.01
Body condition score			
1	[illegible]	[illegible]	[illegible]
2	0.41	0.23 - 0.74	<0.01
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Glucose at 3 DIM	1.75	1.16 - 2.64	<0.01
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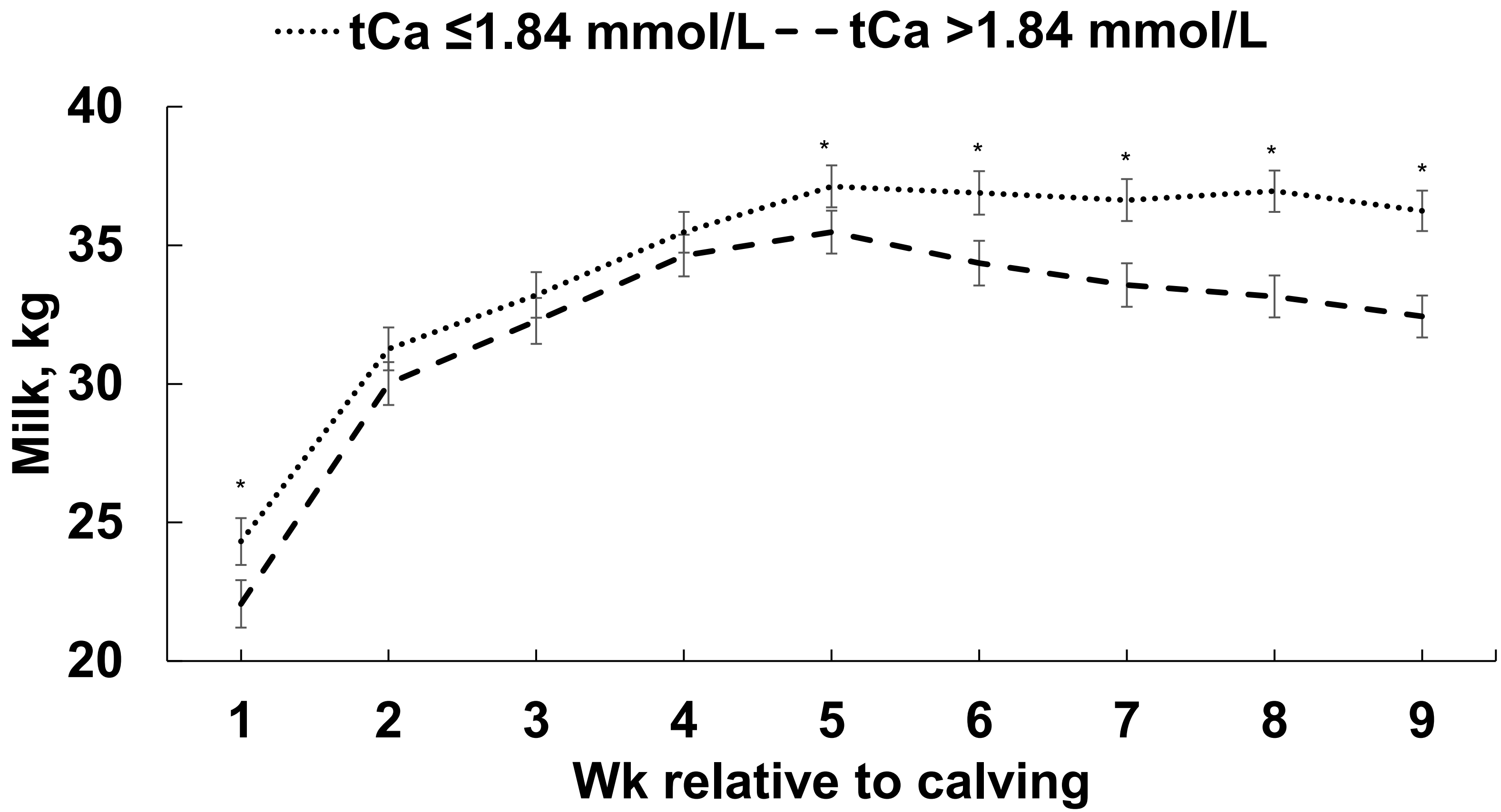
Total Ca at 3 DIM ≤1.99 mmol/L	2.93	1.74 - 4.94	<0.01

Milk Yield

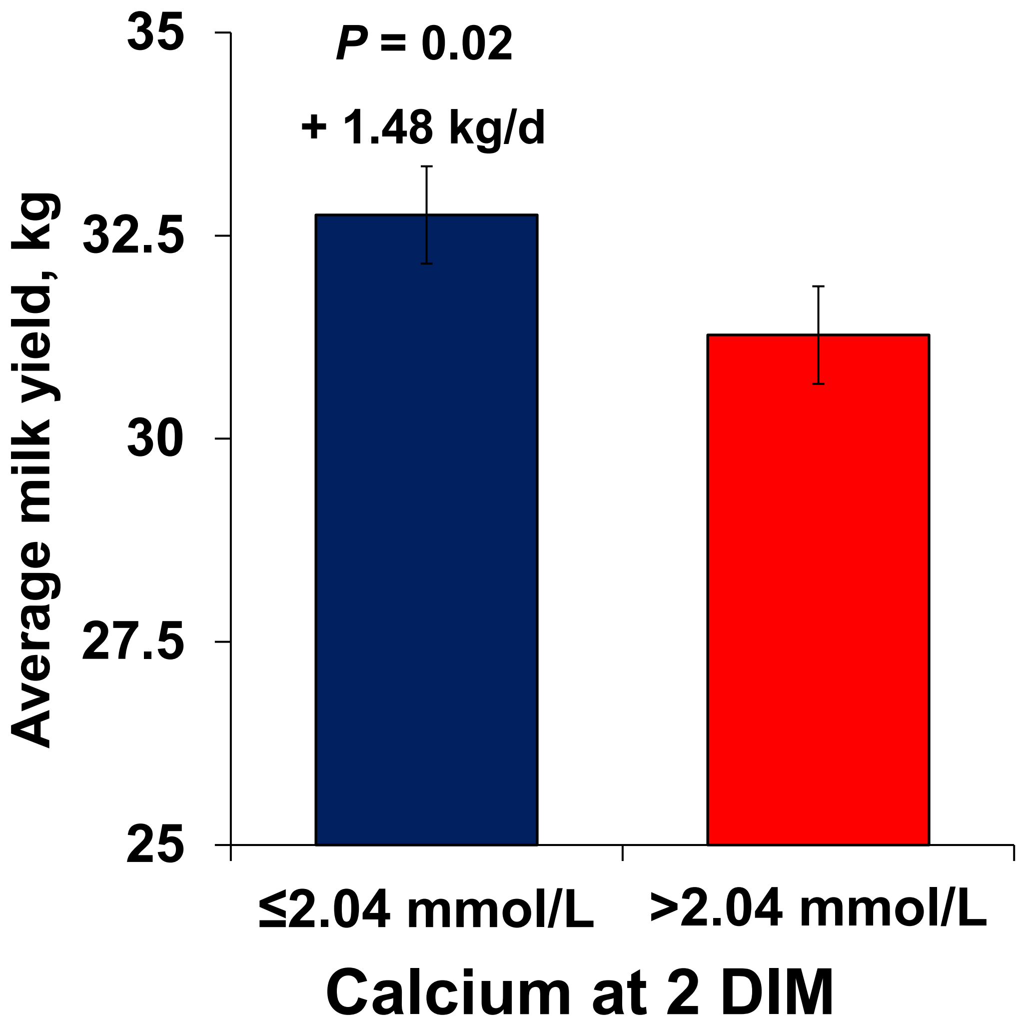
	1 DIM			2 DIM		
Variable	Estimate	SE	P-value	Estimate	SE	P-value
Parity						
2	Ref	-	-	Ref	-	-
3	-0.10	0.64	0.88	0.19	0.64	0.76
BCS Score						
1	Ref	-	-	Ref	-	-
2	2.79	0.89	<0.01	2.81	0.91	<0.01
3	4.49	1.15	<0.01	4.32	1.17	<0.01
Calving season						
Cool	Ref	-	-	Ref	-	-
Warm	1.22	0.63	0.05	1.23	0.66	0.06
Gestation length (d)	0.19	0.06	<0.01	0.20	0.06	<0.01
Metritis	-0.45	0.69	0.51	-0.52	0.70	0.46
Mastitis	-3.24	0.92	<0.01	-3.18	0.93	<0.01
Dichotomized total Ca variable	-	-	<0.01	1.48	0.66	0.02
Weekly test*Dichotomized total Ca variable	-	-	0.02	-	-	0.35

Milk Yield



tCa ≤1.84 mmol/L
tCa >1.84 mmol/L
40
35
30
25
20
Milk, kg
*
*
*
*
*
*
1
2
3
4
5
6
7
8
9
Wk relative to calving

Milk Yield

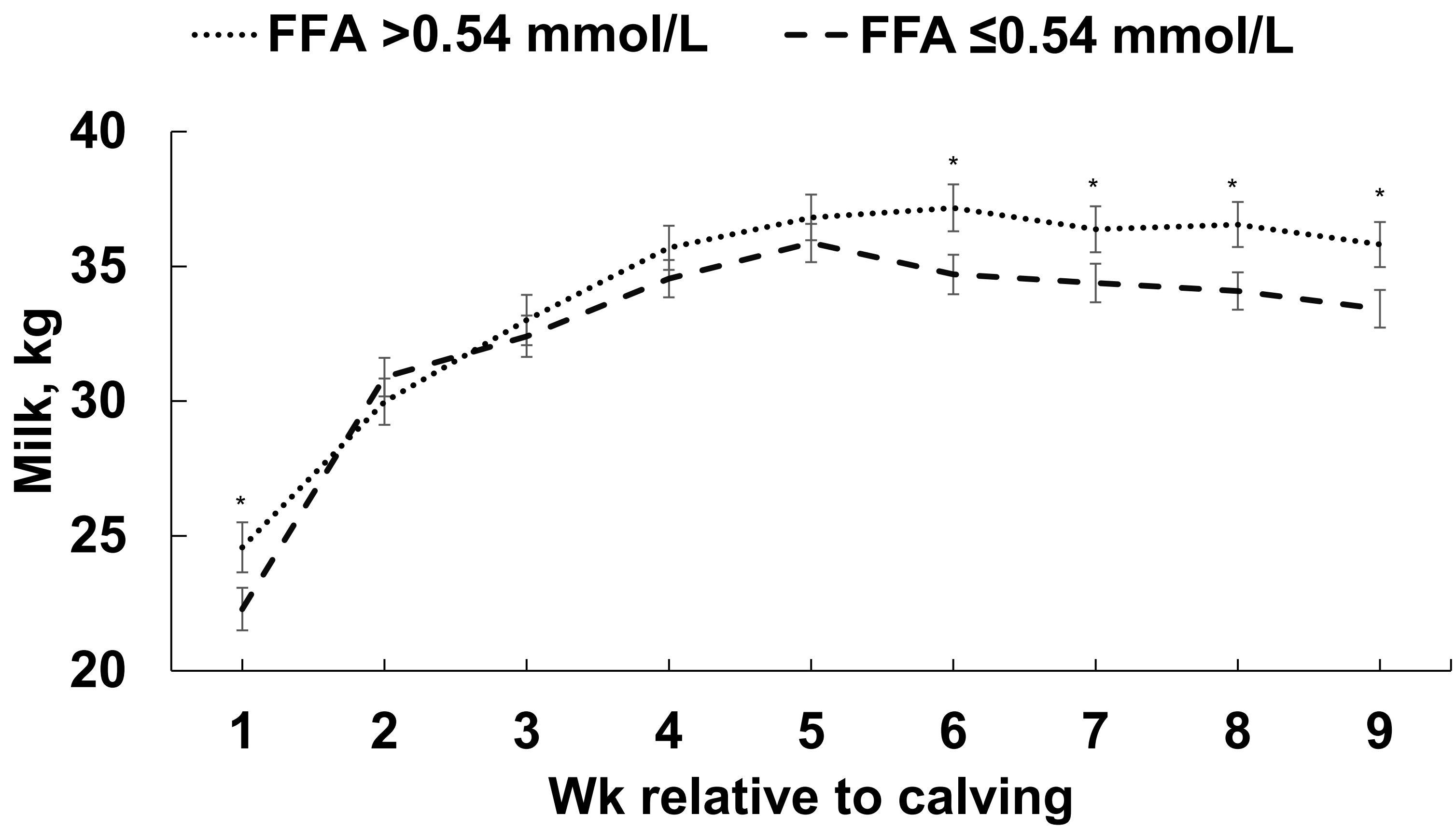


P = 0.02
+ 1.48 kg/d
35
32.5
30
27.5
25
Average milk yield, kg
≤2.04 mmol/L
>2.04 mmol/L
Calcium at 2 DIM

Milk Yield

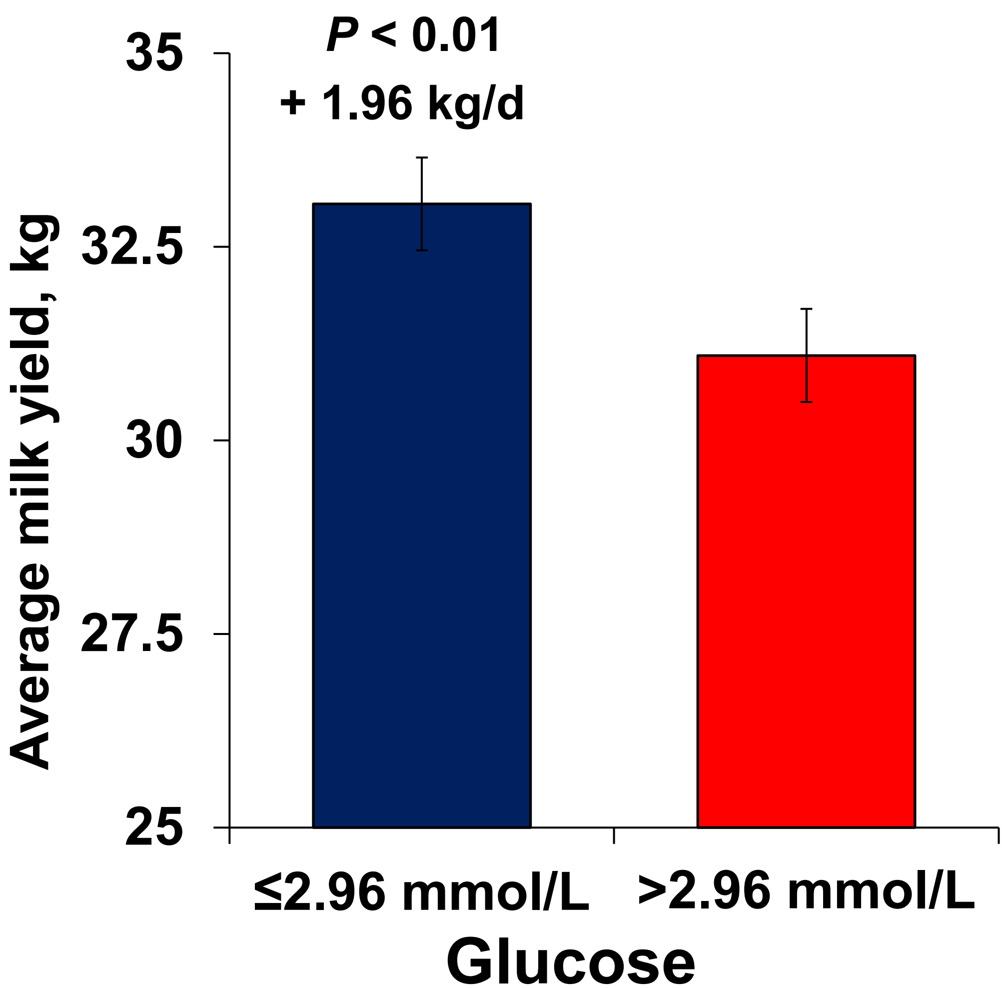
Variable	Estimate	SE	P-value
Parity			
2	Ref		
≥3	-0.24	0.63	0.70
BCS Score			
1	Ref		
2	2.38	0.90	<0.01
3	3.44	1.17	<0.01
Season			
Cool	Ref		
Warm	1.30	0.62	0.04
Gestation length (d)	0.19	0.06	<0.01
Metritis	-0.41	0.69	0.55
Mastitis	-3.12	0.92	<0.01
FFA ≥0.37 mmol/L			<0.01
Weekly milk test*FFA ≥0.37 mmol/L			0.01
Glucose ≤2.96 mmol/L	1.96	0.61	<0.01

Milk Yield



FFA >0.54 mmol/L
FFA ≤0.54 mmol/L
40
35
30
25
20
Milk, kg
*
*
*
*
*
1
2
3
4
5
6
7
8
9
Wk relative to calving

Milk Yield



P < 0.01
+ 1.96 kg/d
35
32.5
30
27.5
25
Average milk yield, kg
≤2.96 mmol/L
>2.96 mmol/L
Glucose

Milk Yield

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Association of immediate postpartum plasma calcium concentration with early-lactation clinical diseases, culling, reproduction, and milk production in Holstein cows

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Association of postpartum hypocalcemia with early-lactation milk yield, reproductive performance, and culling in dairy cows

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Association of low serum calcium concentration after calving with productive and reproductive performance in multiparous Jersey cows

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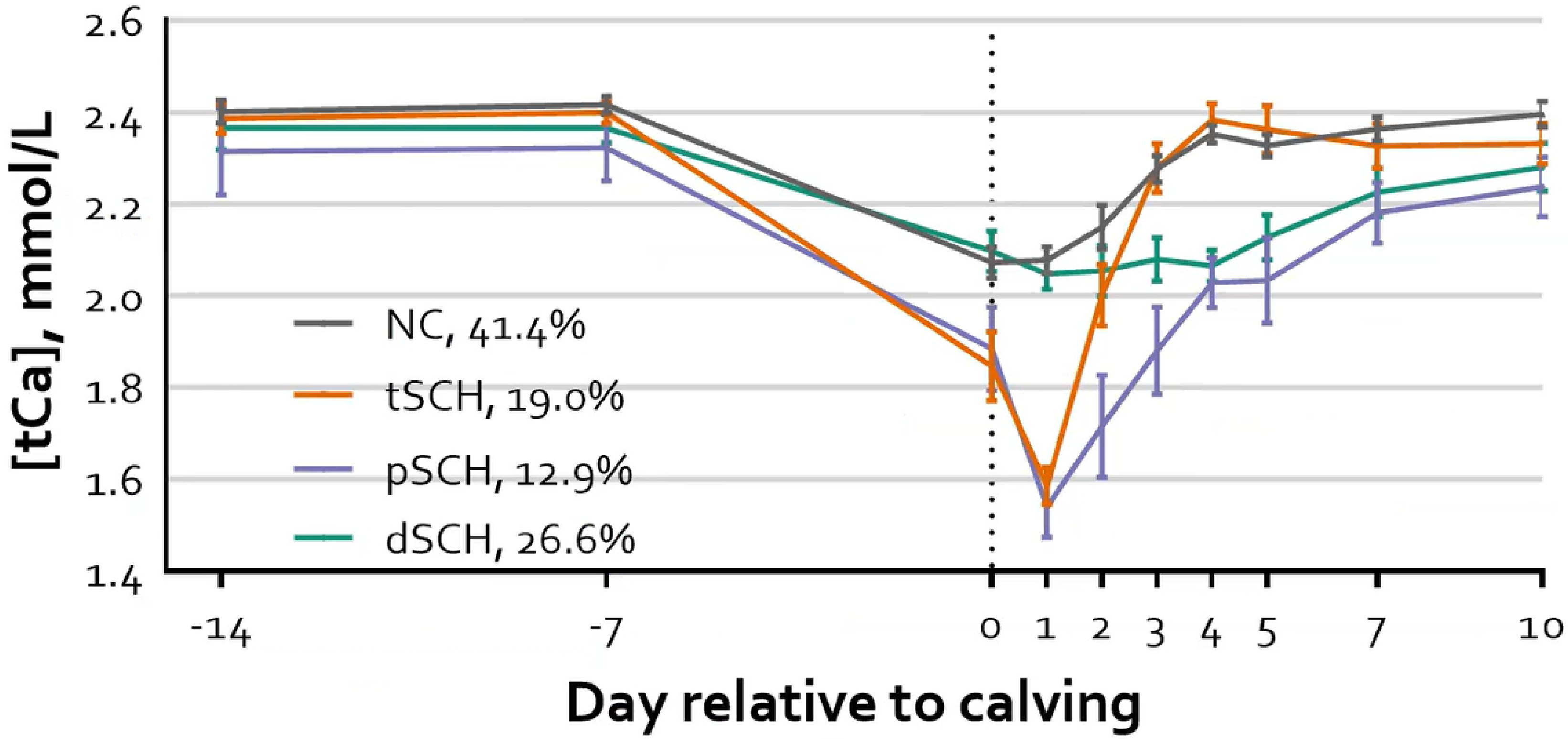
Discussion



McArt and Neves., 2020

Conclusions

- Multiparous Jersey cows with lower [Ca] in the first 2 DIM and reduced glucose at 3 DIM were more likely to have increased milk production across the first 9 wk of lactation
- Cows with increased concentration of FFA at 3 DIM had an overall higher milk production; however, they were also more likely to develop metritis within 10 DIM
- Reproduction was not affected by time to cure in this dataset
- More studies evaluating the association of Ca and energy balance markers during the transition period with lactation performance while including a greater number of herds are needed to best characterize subclinical hypocalcemia and hyperketonemia in Jersey cows

Study #2

animals

MDPI

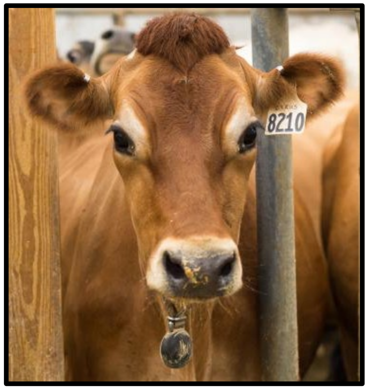
Article

A Randomized Clinical Trial Evaluating the Effect of an Oral Calcium Bolus Supplementation Strategy in Postpartum Jersey Cows on Mastitis, Culling, Milk Production, and Reproductive Performance

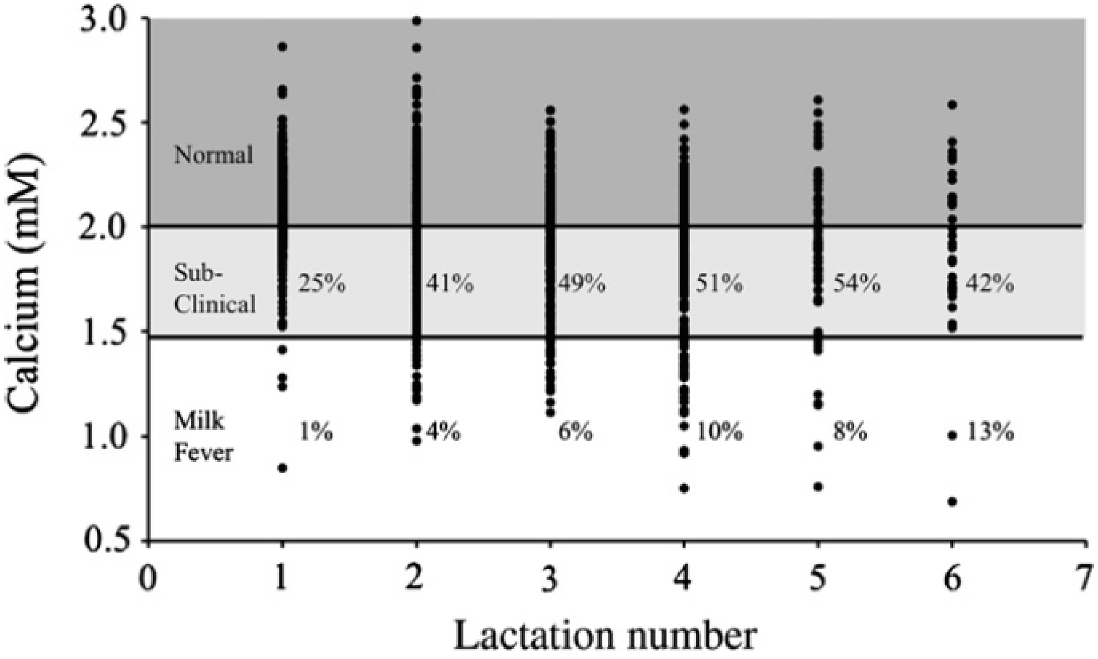
Paulo R. Menta [1], Leticia Fernandes [1], Diego Poit [1], Maria Luiza Celestino [1], Vinicius S. Machado [1] and Rafael C. Neves [2,*]

Introduction

- Cows develop clinical and subclinical hypocalcemia
  - Sequestration of Ca into mammary gland
- Jersey cows are more susceptible
  - Greater [Ca] in colostrum
  - Fewer vitamin D_3 receptor expression in the intestine



- Older cows are more susceptible
  - Greater colostrum production
  - Smaller number of vitamin D_3 binding sites in the intestine



Reinhardt et al. (2011).

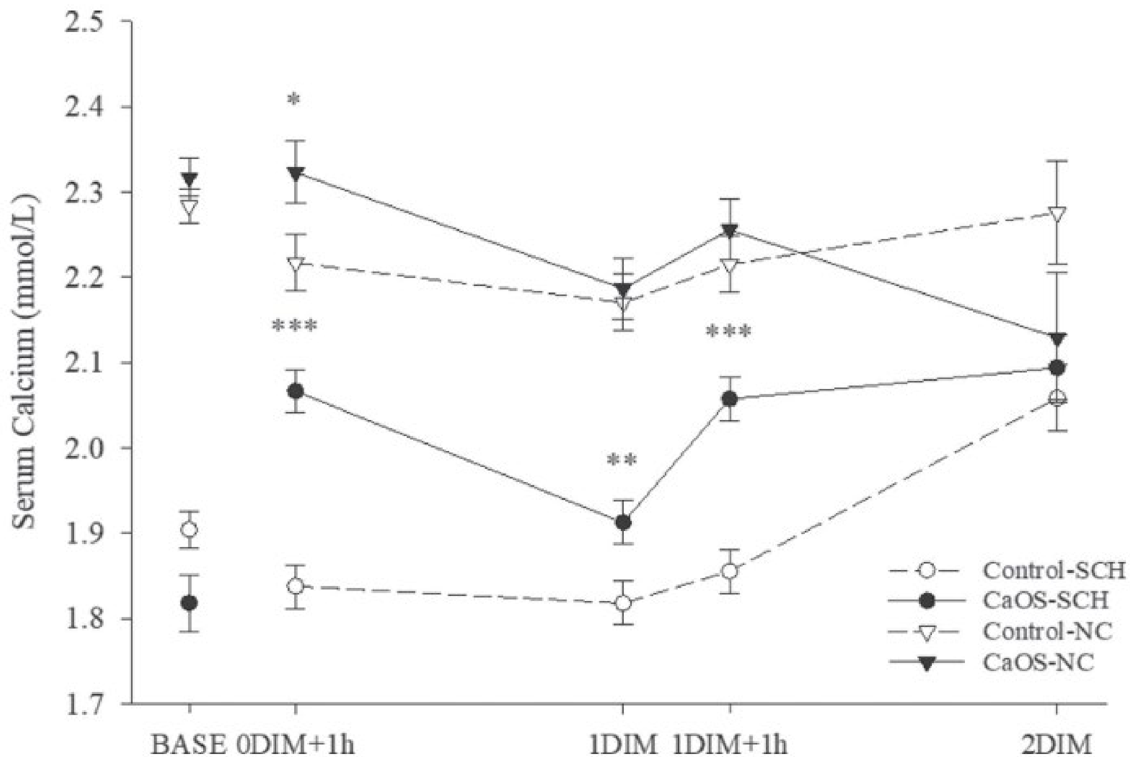
Introduction

- Acidogenic diets have not been demonstrated to be as effective for SCH prevention as for CH (Reinhardt et al., 2011)

- Strategies to mitigate the potential effects of SCH via postpartum oral Ca supplementation are still widely adopted

- In the U.S. for instance, 80% of the large farms used some combination of injectable, drench, or oral Ca as a preventative strategy to postpartum diseases (USDA, 2014)

Introduction



- Benefits are incosistent
- High milk producers
- Lame cows
- Parity
- Data limited for Jersey cows

Oetzel and Miller, (2012); Valldecabres et al., (2018); Valldecabres and Silva-del-Rio, (2020)

Introduction

VS

Objective

- **Objective**
  - Determine the effect of an oral Ca supplementation strategy applied to multiparous Jersey cows on:
    - health outcomes
    - reproductive performance
    - milk production

- **Hypothesis**
  - Postpartum oral Ca supplementation would:
    - decrease the odds of clinical diseases
    - improve milk production
    - reproductive performance

Material and Methods

- Randomized clinical trial – CTRL and TRT
  - July/2018 – April/2019
  - West Texas
  - 852 purebred Jersey cows
  - Data was extracted from the farm's DC305
    - Milk yield
    - DIM at pregnancy
    - Culling
    - Mastitis incidence
  - **TRT:** two doses of a commercial oral Ca bolus (Bovikalc®, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO, USA)
    - calcium chloride and calcium sulfate (43 g of Ca per bolus);
  - **CTRL**: No oral Ca supplementation

Material and Methods

Data collection regarding health events monthly milk yield, fertility and culling

Days pospartum

0 1 2 3 4 7 10 180

TRT

Metritis diagnosis

Purebred
No oral Ca
No twin
DCC < 260
2 Lact
≥ Lact

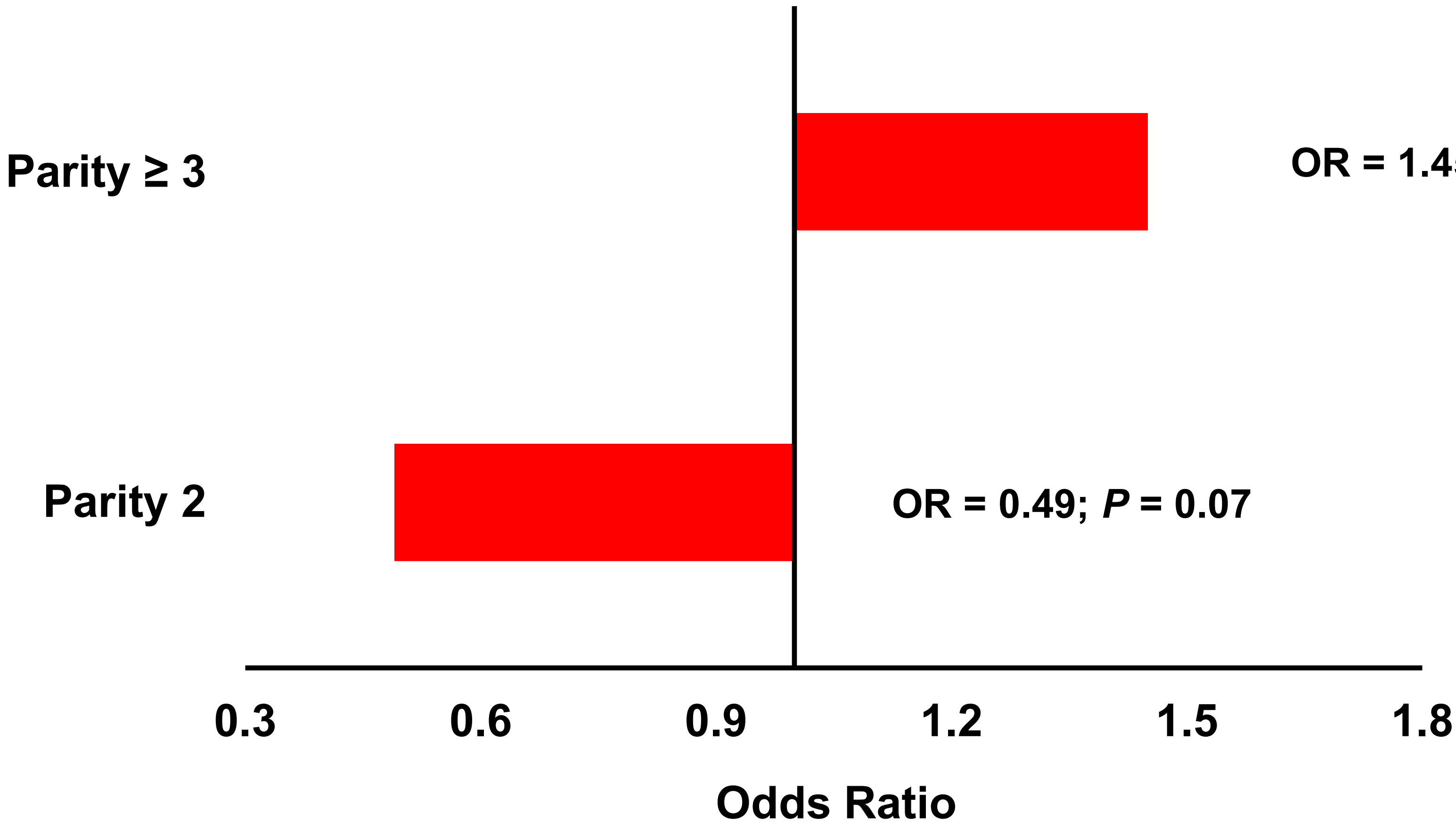
1st bolus: within 1h after calving

2nd boluses: occurred around 21 h after calving

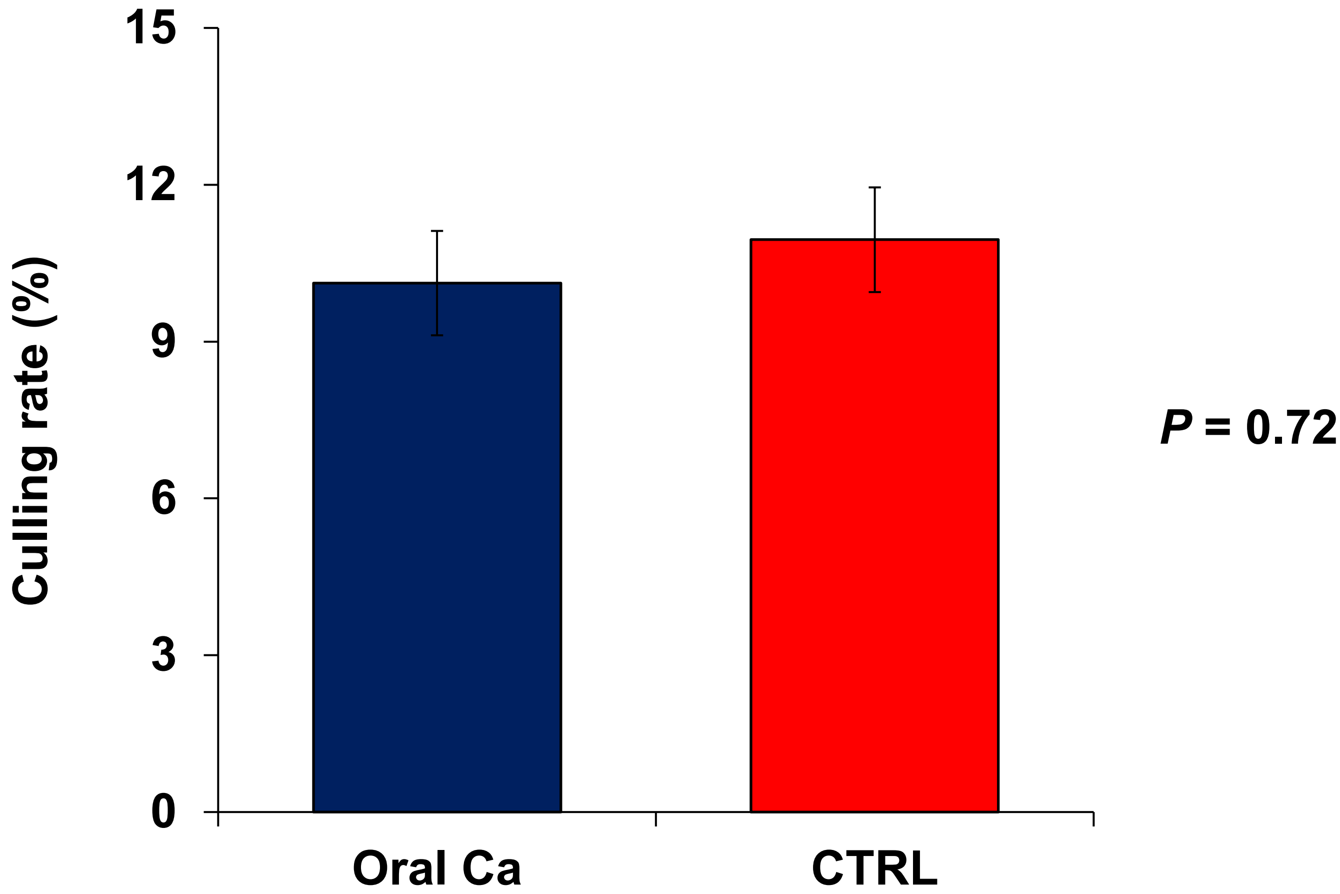
Mastitis within 60 DIM

Variable	Estimate	SE	P-value
Postpartum Ca supplementation			
Control	Ref	–	–
Treatment	-0.72	0.39	0.06
Parity			
2	Ref	–	–
≥3	-0.15	0.30	0.62
Calving problem			
No	Ref	–	–
Yes	-1.36	0.73	0.06
Parity × Treatment	1.08	0.47	0.02

Mastitis within 60 DIM



Culling within 60 DIM



Reproductive Performance

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Variable	Estimate	SE	P-value	HR
Postpartum Ca supplementation				
Control	Ref	–	–	
Treatment	0.04	0.10	0.67	1.04
Parity				
2	Ref	–	–	
≥3	-0.01	0.10	0.91	0.99
Calving problem				
No	Ref	–	–	
Yes	-0.37	0.26	0.16	0.69

Milk yield

Variable	Estimate	SE	P-value
Postpartum Ca supplementation			
Control	Ref	–	–
Treatment	0.24	0.69	0.73
Parity			
2	Ref	–	–
≥3	0.50	0.41	0.22
Test number	–	–	<0.01
Calving season			
Warm	Ref	–	–
Cool	-0.97	0.40	0.02
Gestation length (d)	0.15	0.04	<0.01
Body condition score			
Thin	Ref	–	–
Normal	0.76	0.72	0.29
Over-conditioned	1.64	0.99	0.10

Conclusions

- Prophylactic postpartum Ca supplementation to multiparous Jersey cows had no effects on:
  - culling
  - milk yield
  - Reproduction

- Second parity cows that were supplemented with oral Ca boluses tended to have reduced odds of mastitis compared to non-supplemented cows

- Our data do not support blanket oral Ca supplementation in Jersey cows as the effects were minimal to none; however, targeted oral Ca supplementation for subpopulations of cows and at different times relative to parturition remain to be investigated

Acknowledgment

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