# 56TH FLORIDA DAIRY PRODUCTION CONFERENCE

## UNIVERSITY OF FLORIDA

Straughn IFAS Extension Center
Gainesville, Florida
December 1, 2022

UF | IFAS
UNIVERSITY of FLORIDA

# WELCOME

On behalf of all the faculty of the University of Florida welcome to the 56th Florida dairy production conference.

The Florida Dairy Production Conference started in 1964 and aims to create a program which brings together some of the newest research, innovations, recommendations, and ideas for improving the sustainability and profitability of the Florida dairy industry. The presented information provides practical take-home messages for dairy farmers and highlights emerging trends in the dairy industry. The conference strives to provide a friendly learning and sharing atmosphere with networking opportunities for our target audience of dairy owners and employees, allied dairy industry professionals, students and dairy educators that includes great opportunities for networking. This years conference will include aspects of nutrition, reproduction and calf management, as well as a dedicated afternoon discussing the role of heat-stress on dairy cattle production.

A full synopsis of the meeting and complete proceedings including links to recorded presentations can be found here: https://animal.ifas.ufl.edu/dairy/conferences--meetings/florida-dairy-production-conference/

Regards,

John Bromfield    Peter Hansen
Geoffrey Dahl    José Santos
Lané Haimon    Matti Moyer

The Organizing Committee

FDPC 2022

## SCHEDULE OF EVENTS

9:55 AM **Welcome and introduction.** *Saqib Mukhtar, Associate Dean, UF/IFAS Extension*

**Lané Haimon, Chair**

10:00 AM **What have we learned about feed efficiency in dairy cows.** *Jose Santos. Dept. of Animal Sciences, University of Florida*

10:25 AM **Strategic use of ovarian data to improve pregnancy outcomes following timed AI.** *Rafael Bisinotto. Dept. Large Animal Clinical Sciences, University of Florida*

10:50 AM BREAK

11:10 AM **Considering dairy calf social behavior to improve welfare.** *Emily Miller-Cushon. Dept. of Animal Sciences, University of Florida*

11:35 AM **The impact of season and heat stress on uterine disease.** *John Bromfield. Dept. of Animal Sciences, University of Florida*

12:00 PM LUNCH

**Zack Seekford, Chair**

2:00 PM **Making a dairy cow that is genetically more resistant to heat stress.** *Peter Hansen. Dept. of Animal Sciences, University of Florida*

2:40 PM **Heat abatement during the pre-weaning phase: Friend or Foe?** *Ricardo Chebel, Dept. Large Animal Clinical Sciences, University of Florida*

3:20 PM **Alleviating heat stress.** *Geoffrey Dahl, Dept. Animal Sciences, University of Florida*

4:00 PM RECEPTION

# 56th Florida Dairy Production Conference Sponsors

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tamifasching@techmixglobal.com

# What Have We Learned About Feed Efficiency in Dairy Cows

**José E.P. Santos and Mariana N. Marinho**
Department of Animal Sciences
University of Florida

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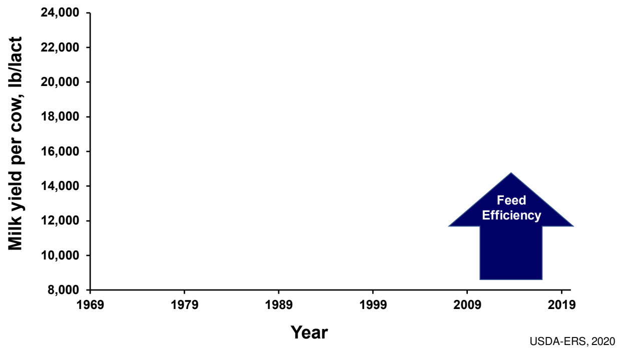
## Milk Production in the Last 50 Years




USDA-ERS, 2020

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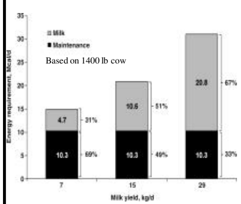
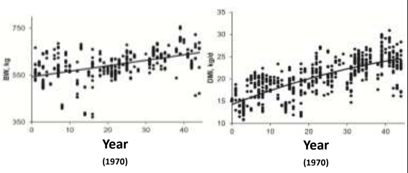
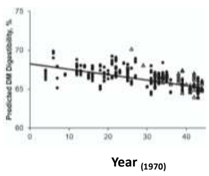
## Feed Efficiency Over the Years




Capper et al. (2009) J. Animal Sci. 87:2160




Potts et al. (2017) J. Dairy Sci. 100:5400–5410

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## Larger Cows, Increased Intake ....

- ✓ **Maintenance requirements: 700 kg cow (1,540 lb cow)**
  - ✓NRC (2001): $700^{0.75}\ x\ 0.08 = 10.9$ Mcal per day (**~ 14.5 lb of DM** of a lactating cow diet)
  - ✓NASEM (2021): $700^{0.75}\ x\ 0.10 = 13.6$ Mcal per day (**~ 17.8 lb of DM** of a lactating cow diet)

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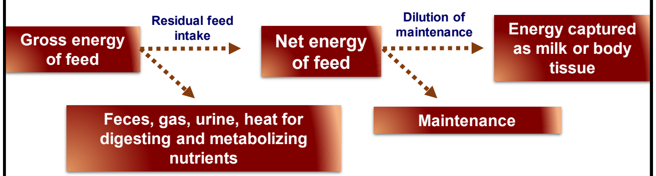
## Nutrient Partition




- ✓To improve the proportion of feed energy captured in milk:
  - ✓Increase milk production relative to maintenance (**Dilution of maintenance**)
  - ✓Increase the conversion of GE to NE (**Improve RFI**)

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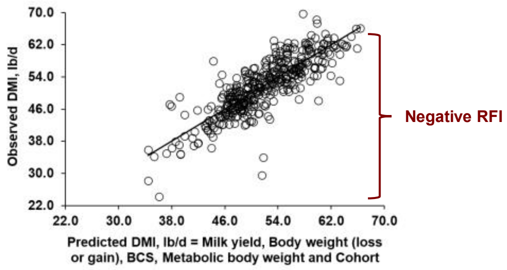
## Residual Feed Intake

- ✓ Residual feed intake (RFI) is a trait that measures feed conversion efficiency adjusting for other factors
- ✓ Differs from Gross Feed Efficiency (ECM/DMI):
  - ✓ Energy required for production, maintenance, tissue accretion/loss, and adjusted for cohort




Nehme Marinho et al. (2021) J. Dairy Sci. 104: 5493-5507

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## Factors Affecting Feed Efficiency

- ✓ Simply increasing yield of ECM improves gross feed efficiency, but improvement decrease as intake increases
  - ✓ Preventing diseases
  - ✓ Diet formulation
  - ✓ Improving the animal's intrinsic ability to utilize nutrients

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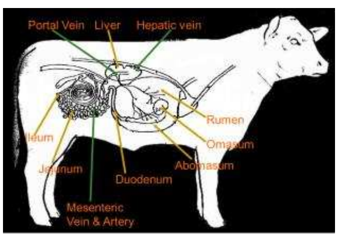
## Inflammatory Disease and Nutrient Flux

- ✓Control
  - ✓Steers received saline (no inflammation)
- ✓Challenge
  - ✓Intra-tracheal challenge with 10 mL containing 1 x $10^9$ CFU of *Mannheimia haemolytica* at hour 0




Burciaga-Robles et al. (2009)

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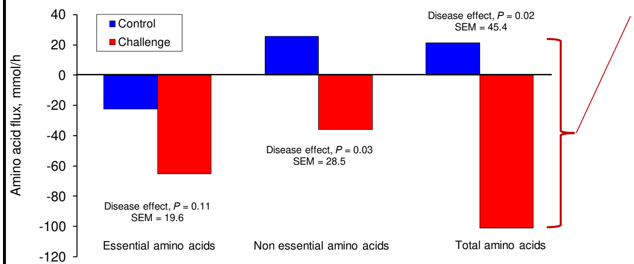
## Amino Acid Hepatic Flux in Steers Without (Control) or with (Challenge) an Intratracheal Challenge with *M. haemolytica*

At 0.67 efficiency, this is equivalent to the true protein in 8 kg of milk (18 lbs)

Difference of 2.6 moles/day → ~ 380 g of AA for a 400 kg steer




Burciaga-Robles PhD Dissertation (2009)

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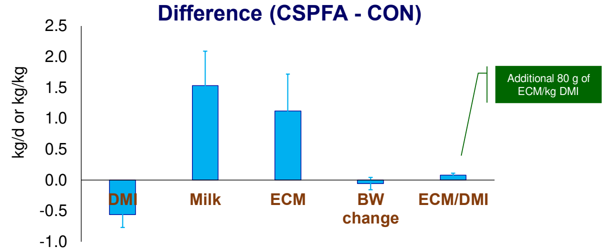
## Diet Formulation

- ✓Meta-analysis of addition of dietary FA as Ca salts of palm FA
  - ✓33 publications
    - ✓Control = 3.45% FA
    - ✓CSPFA = 5.02% FA




dos Santos Neto et al. (2021) J. Dairy Sci. 104:9752–9768

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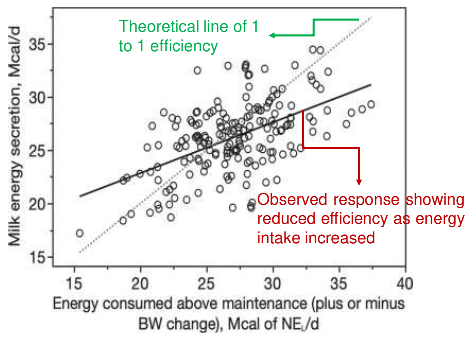
## Efficiency of Consumed Energy Converted into Milk Energy




51 experiments reporting milk energy outputs and net energy consumption in dairy cattle

Bach et al. (2019) J. Dairy Sci. 103:5709–5725

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## Materials and Methods

**✓ Study 1**

- ✓Retrospective cohort study
- ✓Data from **399** cows, 154 primiparous and 245 multiparous cows
- ✓Experimental freestall barn with individual feeding gates

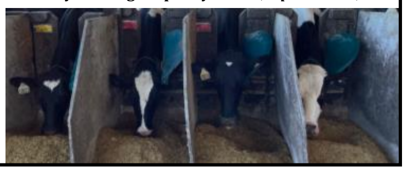
**✓ Study 2**

- ✓Retrospective cohort study
- ✓Data from **851** cows, 342 primiparous and 509 multiparous cows
- ✓Experimental freestall barn with individual feeding gates

**Linear model to predict DMI:**

$$\mathbf{DMI} = \mu + \mathbf{milk\ energy} + \mathbf{BW}^{0.75} + \mathbf{body\ E\ change} + \mathbf{parity} + \boldsymbol{Trt(experiment)} + \boldsymbol{e}$$

$$\mathbf{RFI} = \mathbf{Observed} - \mathbf{Predicted}$$



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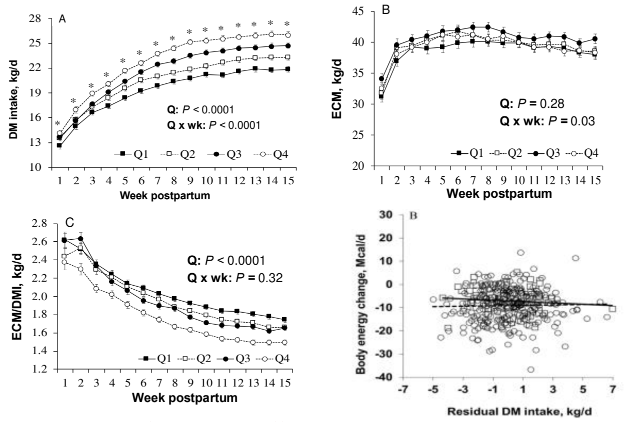
## Association Between RFI and Performance up to 105 DIM




N = 393 Holsteins with daily ECM yield, DMI, BW, and BCS

Nehme Marinho et al. (2021) J. Dairy Sci. 104: 5493-5507

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## Association Between RFI and Incidence of Diseases and Survival

N = 393 Holsteins with daily ECM yield, DMI, BW, and BCS

| | RFI in mid-lactation, quartiles | | | | | |
|---|---|---|---|---|---|---|
| Item | Q1 | Q2 | Q3 | Q4 | SEM | P-value |
| Cows, n | 98 | 98 | 99 | 98 | --- | --- |
| Somatic cell score | 2.38 | 2.66 | 2.83 | 2.66 | 0.19 | 0.41 |
| Retained placenta, % | 12.2 | 13.3 | 11.1 | 14.3 | 3.3 | 0.92 |
| Metritis, % | 13.3 | 19.4 | 17.2 | 22.5 | 4.0 | 0.40 |
| Mastitis, % | 15.3 | 13.3 | 12.1 | 15.3 | 3.5 | 0.89 |
| Displaced abomasum, % | 1.0 | 2.0 | 3.0 | 4.1 | 1.5 | 0.60 |
| Lameness, % | 10.2 | 5.1 | 2.0 | 8.2 | 2.4 | 0.14 |
| Respiratory, % | 2.0 | 3.1 | 1.0 | 2.0 | 1.4 | 0.81 |
| Left herd by 300d, % | 10.2 | 13.3 | 5.1 | 9.2 | 2.9 | 0.29 |

Nehme Marinho et al. (2021) J. Dairy Sci. 104: 5493-5507

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## Association Between RFI and Reproductive Performance

N = 851 Holsteins with daily ECM yield, DMI, BW, and BCS

| | RFI in mid-lactation, quartiles | | | | | |
|---|---|---|---|---|---|---|
| Item | Q1 | Q2 | Q3 | Q4 | SEM | P-value |
| Cows, n | 212 | 213 | 213 | 213 | --- | --- |
| Inseminated, % | 98.4 | 99.1 | 97.7 | 99.1 | 0.8 | 0.7 |
| First AI | | | | | | |
| Pregnant d 74, % | 31.0 | 30.9 | 30.5 | 26.5 | 3.5 | 0.72 |
| Second AI | | | | | | |
| Pregnant d 74, % | 38.5 | 29.0 | 27.4 | 17.6 | 4.2 | <0.001 |
| Pregnancy per AI all AI, % | 31.4 | 30.6 | 31.2 | 24.5 | 2.2 | 0.03 |
| Pregnant by 300 d, % | 79.0 | 80.7 | 82.4 | 71.5 | 3.3 | 0.05 |
| 21-d cycle pregnancy rate | 21.2 | 21.1 | 22.0 | 16.6 | 1.9 | 0.02 |

Nehme Marinho and Santos (2022) Front. Anim. Sci. 3:847574

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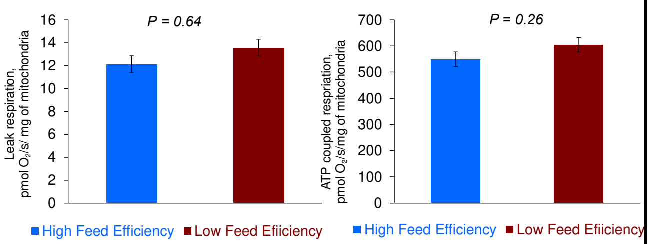
## Relationship Between RFI and Hepatic Mitochondrial Respiration




Nehme Marinho et al. in preparation

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## Phenotypic RFI and Total Tract Apparent Digestibility

| | Phenotypic feed efficiency | | | |
|---|---|---|---|---|
| Digestibility | Low Efficiency (+RFI) | High Efficiency (-RFI) | SEM | P-value |
| DM, % | 74.2 | 75.0 | 0.5 | 0.29 |
| OM, % | 76.5 | 77.1 | 0.6 | 0.52 |
| CP, % | 71.1 | 72.6 | 1.0 | 0.31 |
| NDF, % | 44.5 | 44.8 | 1.0 | 0.83 |
| Starch, % | 98.8 | 98.5 | 0.2 | 0.29 |
| Fat, % | 82.7 | 82.5 | 0.9 | 0.88 |

Means of digestibility analyzed at 65 and 125 d in the study

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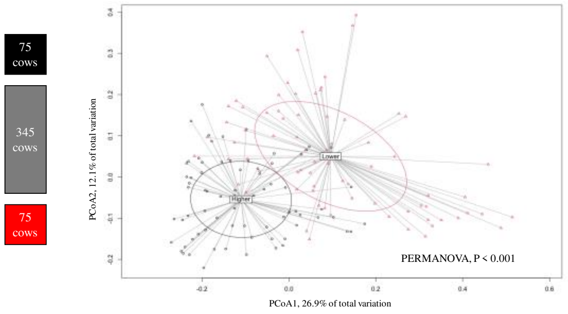
## RFI and Rumen Microbiome




Monteiro et al. (2022) In preparation

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## Phenotypic RFI and Ruminal Parameters

| | Phenotypic feed efficiency | | | |
|---|---|---|---|---|
| Digestibility | Low Efficiency (+RFI) | High Efficiency (-RFI) | SEM | P-value |
| pH | 6.4 | 6.3 | 0.05 | 0.12 |
| Acetate, *mMol/L* | 68.1 | 72.3 | 1.5 | 0.06 |
| Propionate, *mMol/L* | 25.4 | 27.7 | 1.0 | 0.11 |
| Butyrate, *mMol/L* | 14.6 | 16.0 | 0.5 | 0.08 |
| Total VFA, *mMol/L* | 113.1 | 121.2 | 2.2 | 0.02 |
| Ammonia N, mg/dL | 7.8 | 8.9 | 0.5 | 0.12 |

Means of digestibility analyzed at 65 and 125 d in the study

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## Can we Select for RFI?

- ✓ **Feed Saved (FSAV)**
  - ✓ Includes the economic values of cow body weight composite (BWC) with residual feed intake (RFI)
  - ✓ FSAV PTA represents the expected pounds of feed saved per lactation
- ✓ **Formulas:**

$PTA\ FSAV = -1(PTA\ RFI) - 151.8\ (PTA\ \text{BWC})$

$BWC = (0.23\ x\ stature) + (0.72\ x\ strength) + (0.08\ x\ body\ depth) + (0.17\ x\ rump\ width) - (0.47\ x\ dairy\ form)$: each unit represents 16 kg of mature BW

- ✓ **Example**

| | Cow A | Cow B | Cow C |
|---|---|---|---|
| Weight (lb) | 1500 | 1570 | 1430 |
| BWC | 0 | +1.5 | -1.5 |
| Milk yield (lb/lact) | 25,000 | 25,000 | 25,000 |
| Expected DMI (lb/lact) | 18,000 | 18,300 | 17,500 |
| Actual DMI (lb/lact) | 18,000 | 18,500 | 17,300 |
| RFI (lb/lact) | 0 | +200 | -200 |
| Feed saved (lb/lact) | 0 | -428 | +428 |

$PTA\ FSAV = -1(\mathbf{-200}) - 151.8\ (\mathbf{-1.5}) = \mathbf{+428}$ lb of feed saved per lactation

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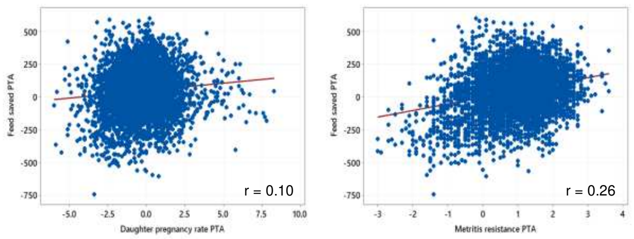
## Genetic Correlations Between Feed Saved and Daughter Fertility or Resistance to Metritis

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## Acknowledgements

- ✓Dr. Adeoye Oyebade
- ✓Ana Carolina M Silva
- ✓Juan M. Bollatti
- ✓Dr. Leandro F. Greco
- ✓Dr. Natalia Martinez
- ✓Dr. Marcos Zenobi
- ✓Richard Lobo
- ✓Dr. Roney Zimpel

FFAR Foundation for Food and Agriculture Research

CDCB COUNCIL ON DAIRY CATTLE BREEDING

UF IFAS Research UNIVERSITY of FLORIDA Department of Animal Sciences

The Foundation for The Gator Nation

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STRATEGIC USE OF OVARIAN DATA TO IMPROVE PREGNANCY OUTCOMES FOLLOWING TIMED AI
Rafael S. Bisinotto
Department of Large Animal Clinical Sciences, University of Florida, Gainesville, FL, USA
2022 Florida Dairy Production Conference
Gainesville, FL

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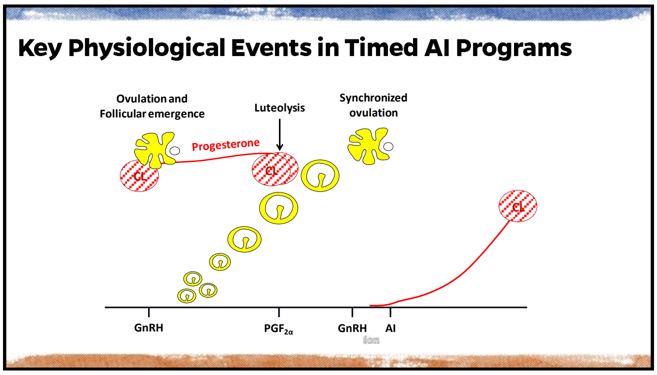
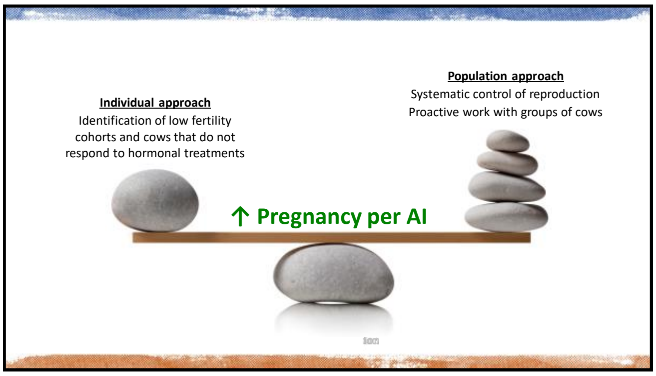
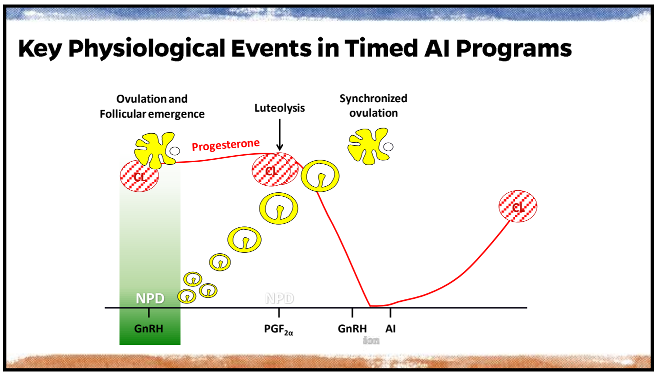

Key Physiological Events in Timed AI Programs
Ovulation and Follicular emergence
Luteolysis
Synchronized ovulation
Progesterone
CL
CL
CL
GnRH
PGF2α
GnRH
AI

2


Individual approach
Identification of low fertility cohorts and cows that do not respond to hormonal treatments
Population approach
Systematic control of reproduction
Proactive work with groups of cows
↑ Pregnancy per AI

3


Key Physiological Events in Timed AI Programs
Ovulation and Follicular emergence
Luteolysis
Synchronized ovulation
Progesterone
CL
CL
CL
NPD
GnRH
PGF2α
GnRH
AI

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## Targeted Progesterone Supplementation

30% of lactating dairy cows subjected to timed AI protocols lack a CL

*(Fricke et al., 2003; Stevenson et al., 2008; Bisinotto et al., 2010)*

Development of strategies for progesterone supplementation in dairy cows without CL during follicle growth that improve fertility reponses

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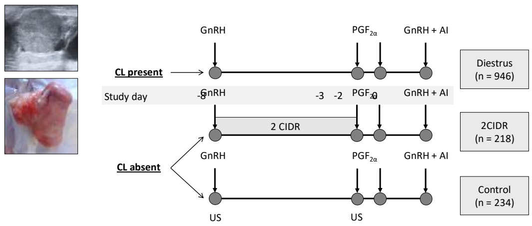
## Targeted Progesterone Supplementation




*Bisinotto et al. (2013) J. Dairy Sci. 96:2214-2225*

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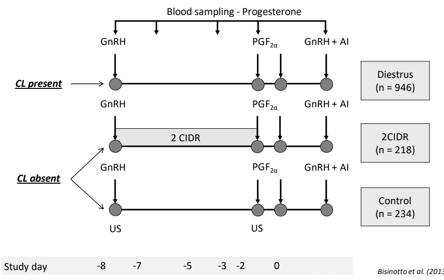
## Targeted Progesterone Supplementation




*Bisinotto et al. (2013) J. Dairy Sci. 96:2214-2225*

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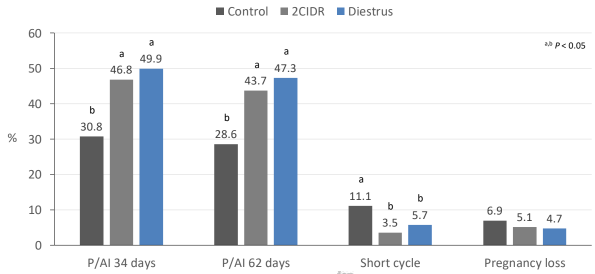
## Targeted Progesterone Supplementation




*Bisinotto et al. (2013) J. Dairy Sci. 96:2214-2225*

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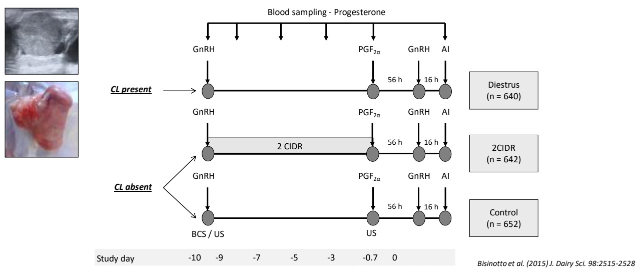
## Targeted Progesterone Supplementation

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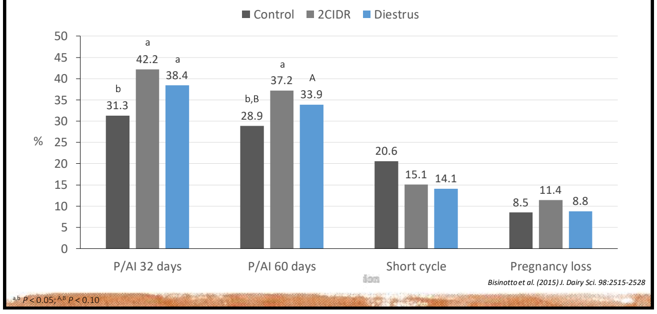
## Targeted Progesterone Supplementation

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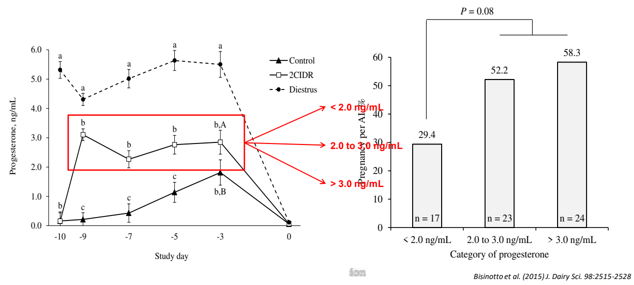
## Targeted Progesterone Supplementation

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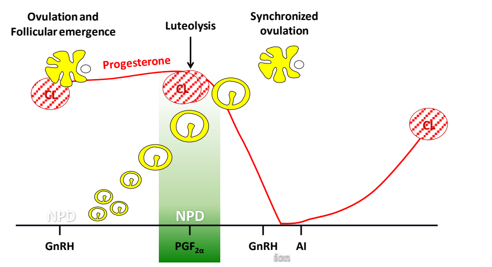
## Key Physiological Events in Timed AI Programs

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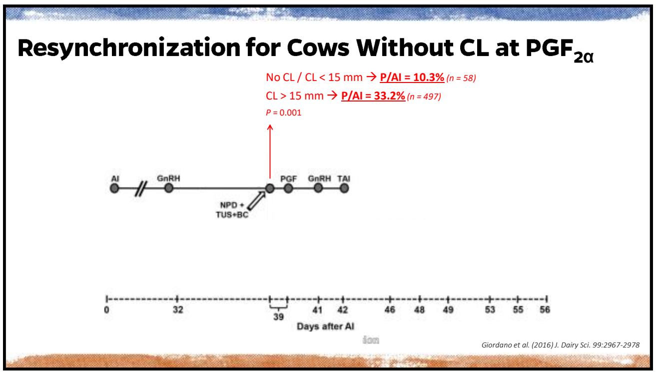
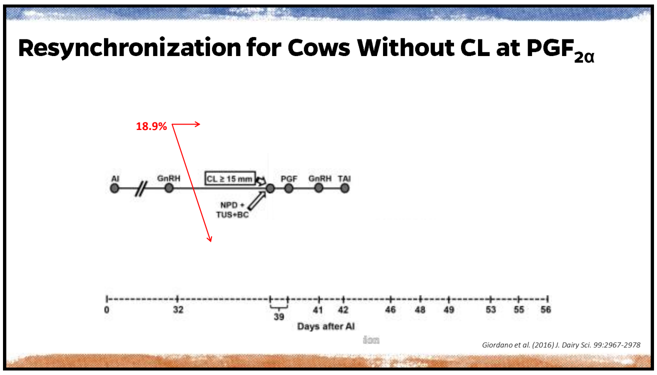
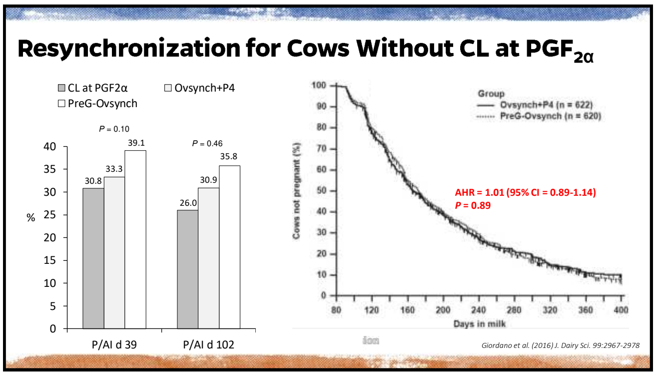

Resynchronization for Cows Without CL at PGF2α
No CL / CL < 15 mm → P/AI = 10.3% (n = 58)
CL > 15 mm → P/AI = 33.2% (n = 497)
P = 0.001
AI
GnRH
PGF
GnRH
TAI
NPD + TUS+BC
0 32 39 41 42 46 48 49 53 55 56
Days after AI
Giordano et al. (2016) J. Dairy Sci. 99:2967-2978

13


Resynchronization for Cows Without CL at PGF2α
18.9%
AI
GnRH
CL ≥ 15 mm
PGF
GnRH
TAI
NPD + TUS+BC
0 32 39 41 42 46 48 49 53 55 56
Days after AI
Giordano et al. (2016) J. Dairy Sci. 99:2967-2978

14


Resynchronization for Cows Without CL at PGF2α
CL at PGF2α
Ovsynch+P4
PreG-Ovsynch
P = 0.10
P = 0.46
30.8
33.3
39.1
26.0
30.9
35.8
%
P/AI d 39
P/AI d 102
Group
Ovsynch+P4 (n = 622)
PreG-Ovsynch (n = 620)
AHR = 1.01 (95% CI = 0.89-1.14)
P = 0.89
Cows not pregnant (%)
Days in milk
Giordano et al. (2016) J. Dairy Sci. 99:2967-2978

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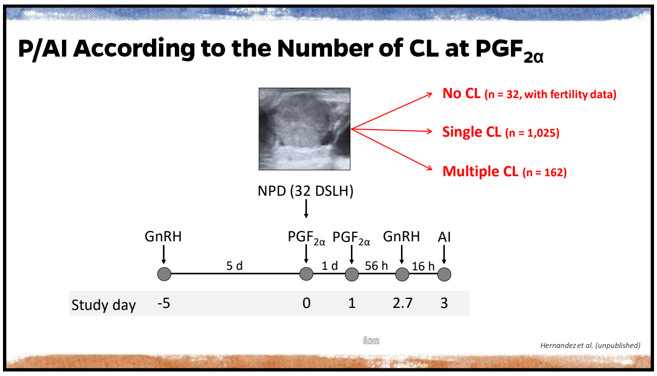
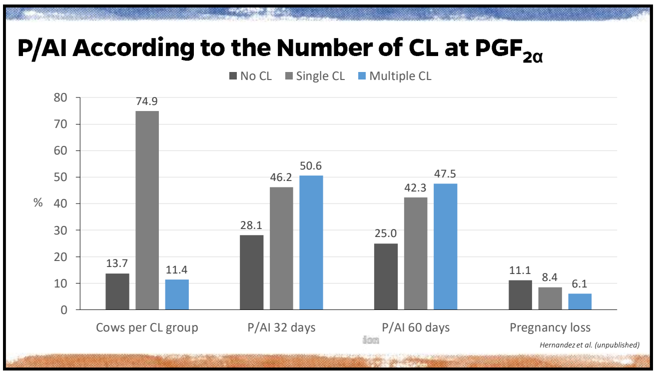
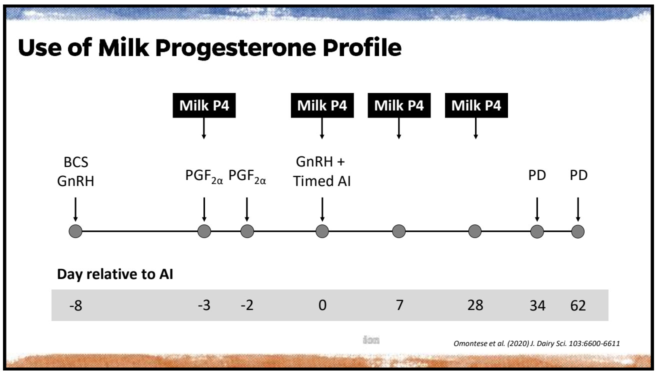

P/AI According to the Number of CL at PGF2α
No CL (n = 32, with fertility data)
Single CL (n = 1,025)
Multiple CL (n = 162)
NPD (32 DSLH)
GnRH
PGF2α
PGF2α
GnRH
AI
5 d
1 d
56 h
16 h
Study day -5 0 1 2.7 3
Hernandez et al. (unpublished)

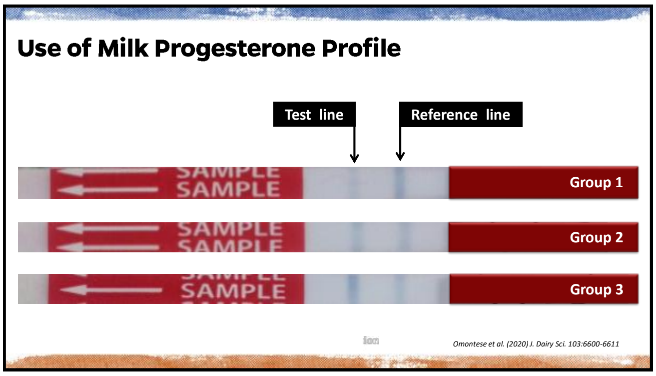
16


P/AI According to the Number of CL at PGF2α
No CL
Single CL
Multiple CL
%
80
70
60
50
40
30
20
10
0
13.7
74.9
11.4
28.1
46.2
50.6
25.0
42.3
47.5
11.1
8.4
6.1
Cows per CL group
P/AI 32 days
P/AI 60 days
Pregnancy loss
Hernandez et al. (unpublished)

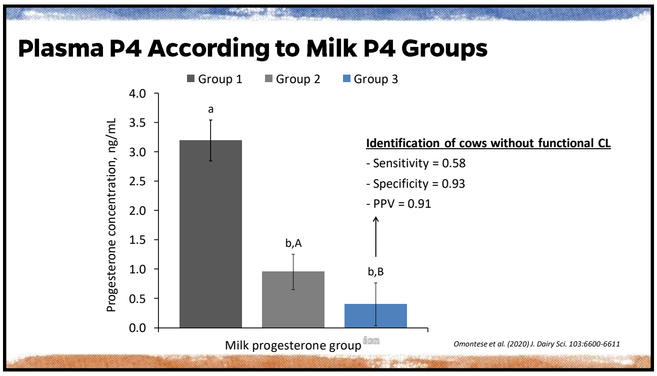
17


Use of Milk Progesterone Profile
Milk P4
Milk P4
Milk P4
Milk P4
BCS
GnRH
PGF2α
PGF2α
GnRH +
Timed AI
PD
PD
Day relative to AI
-8
-3
-2
0
7
28
34
62
Omontese et al. (2020) J. Dairy Sci. 103:6600-6611

18

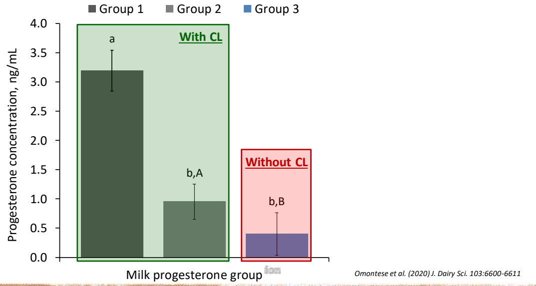

Use of Milk Progesterone Profile
Test line
Reference line
SAMPLE
Group 1
SAMPLE
Group 2
SAMPLE
Group 3
Omontese et al. (2020) J. Dairy Sci. 103:6600-6611

19


Plasma P4 According to Milk P4 Groups
Group 1
Group 2
Group 3
Progesterone concentration, ng/mL
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
a
b,A
b,B
Identification of cows without functional CL
- Sensitivity = 0.58
- Specificity = 0.93
- PPV = 0.91
Milk progesterone group
Omontese et al. (2020) J. Dairy Sci. 103:6600-6611

20

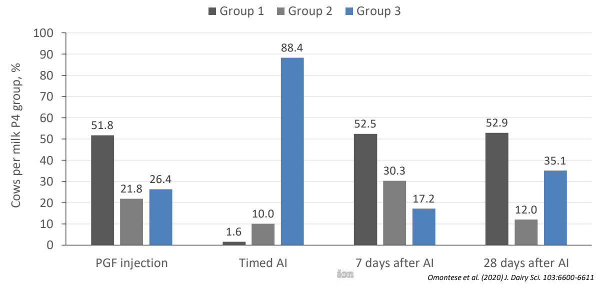
## Plasma P4 According to Milk P4 Groups




*Omontese et al. (2020) J. Dairy Sci. 103:6600-6611*

21

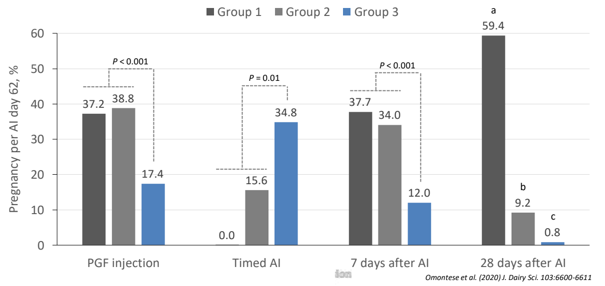
## Distribution of Cows According to Milk P4 Group




*Omontese et al. (2020) J. Dairy Sci. 103:6600-6611*

22

## P/AI According to Milk P4 Group



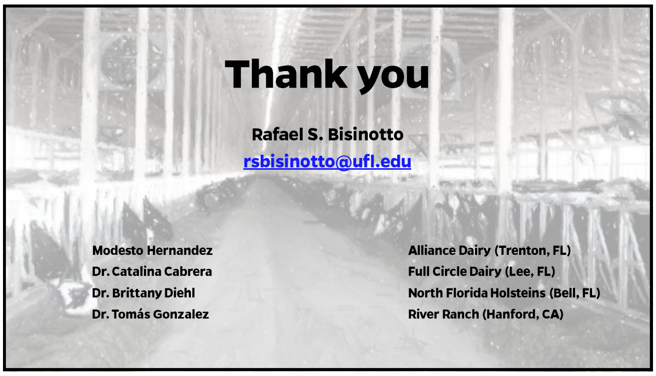

*Omontese et al. (2020) J. Dairy Sci. 103:6600-6611*

23

## Conclusions

- Ovarian status at key points reflect
  - Hormonal milieu that support establishment and maintenance of pregnancy (oocyte maturation, embryo development, uterine function)
  - Response to exogenous hormonal treatments
- Use of cow side test based on ultrasonography and (increasingly) progesterone concentrations allows for evaluation of ovarian status at key points in a way that is integrated with reproductive management routines
- Information on ovarian status at key points allow for decision making and implementation of alternate protocols for cows with different physiological needs

24


Thank you
Rafael S. Bisinotto
rsbisinotto@ufl.edu
Modesto Hernandez
Dr. Catalina Cabrera
Dr. Brittany Diehl
Dr. Tomás Gonzalez
Alliance Dairy (Trenton, FL)
Full Circle Dairy (Lee, FL)
North Florida Holsteins (Bell, FL)
River Ranch (Hanford, CA)

25

# Considering dairy calf social behavior to improve welfare

*56th Florida Dairy Production Conference*
December 1, 2022

**Emily Miller-Cushon**
Associate Professor
Department of Animal Sciences,
University of Florida

UF IFAS
UNIVERSITY of FLORIDA

1

## Social housing for dairy calves

- In the United States, 63% of calves were housed individually as of the 2014 NAHMS survey (USDA, 2016)
- Public perception of social housing is more positive (Perttu et al., 2020)
- Canada is moving towards requiring social housing for calves

NATIONAL FARM ANIMAL CARE COUNCIL
https://www.nfacc.ca/codes-of-practice/dairy-cattle

2

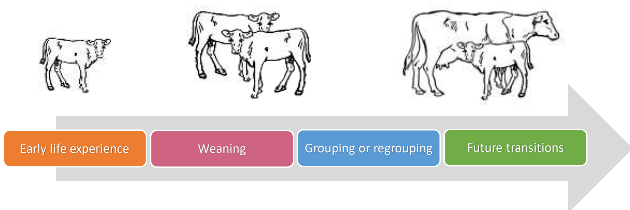
## Social housing affects calf welfare

- Individually-housed calves will work for access to a social companion[1]
- Calves choose to spend more time with familiar social companions and prefer to feed socially[2]
- Reduced fear and reactivity to novelty in group-housed calves[3]
- Potential for long-term effects on social ability[4]

[1]Holm et al., 2002; [2]Faervik et al., 2007, Miller-Cushon et al., 2016; [3]Jensen et al., 1997; Costa et al., 2014; [4]Veissier et al., 1994

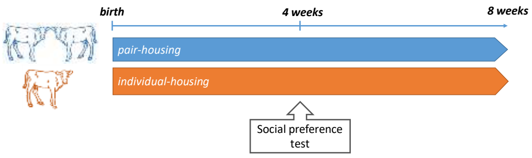
3

## Early social experience and adaptability




4

## Response to novel social environments

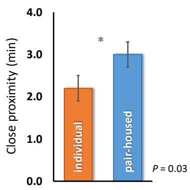



Lindner et al., 2022.

5


6

## Response to novel social environments

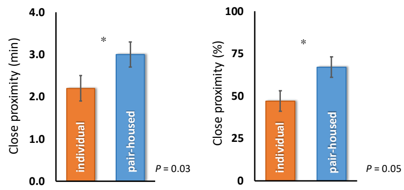



Time near either calf in the test arena

Lindner et al., 2021. JDS. 104:10090-10099.

7

## Response to novel social environments



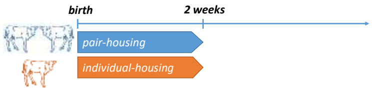

Time near either calf in the test arena

Percentage of time near the more familiar calf

Lindner et al., 2021. JDS. 104:10090-10099.

8

## Effects of early social contact on behavior

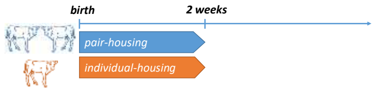


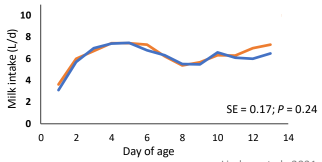

**How does early life social contact affect adaptation to group-housing?**

Lindner et al., 2021. JDS. 104:10090-10099.

9

## Effects of early social contact on behavior

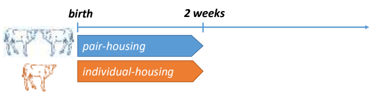


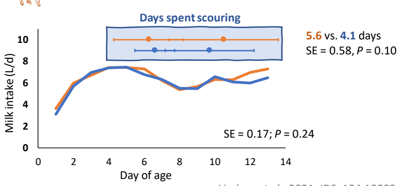




Lindner et al., 2021. JDS. 104:10090-10099.

10

## Effects of early social contact on behavior

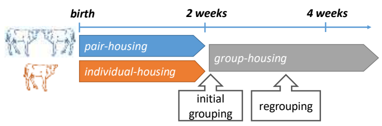



Lindner et al., 2021. JDS. 104:10090-10099.

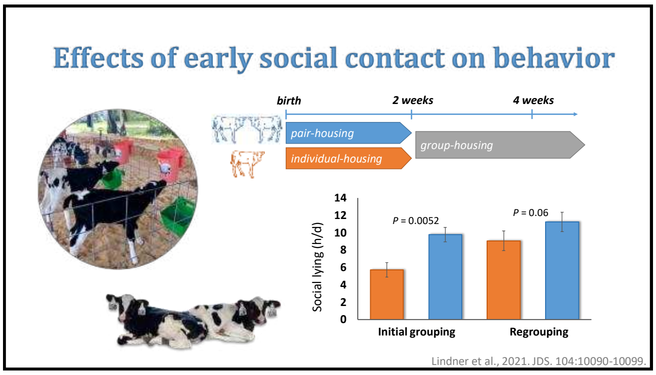
11

## Effects of early social contact on behavior

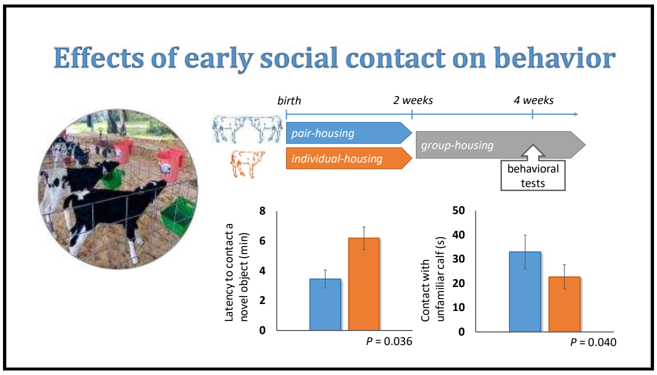



Lindner et al., 2021. JDS. 104:10090-10099.

12


Effects of early social contact on behavior
birth
2 weeks
4 weeks
pair-housing
individual-housing
group-housing
Social lying (h/d)
14
12
10
8
6
4
2
0
P = 0.0052
P = 0.06
Initial grouping
Regrouping
Lindner et al., 2021. JDS. 104:10090-10099.

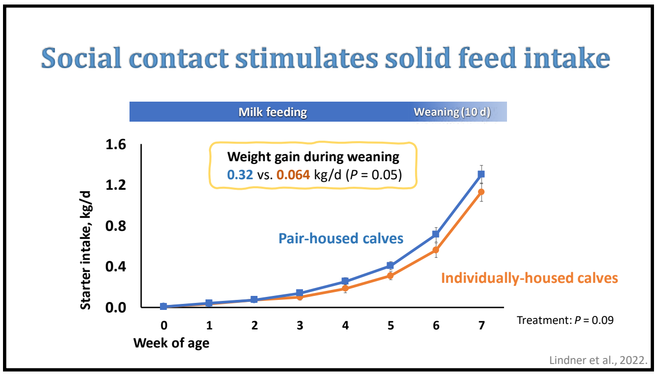
13


Effects of early social contact on behavior
birth
2 weeks
4 weeks
pair-housing
individual-housing
group-housing
behavioral tests
Latency to contact a novel object (min)
8
6
4
2
0
P = 0.036
Contact with unfamiliar calf (s)
50
40
30
20
10
0
P = 0.040

14

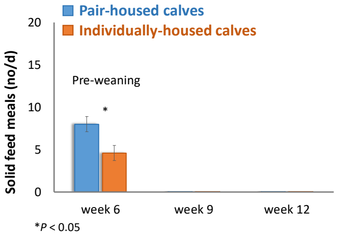

Social contact affects feeding behavior
• Reduced feed neophobia1
• Social facilitation and social learning
1Costa et al., 2015.

15


Social contact stimulates solid feed intake
Milk feeding
Weaning (10 d)
Weight gain during weaning
0.32 vs. 0.064 kg/d (P = 0.05)
Starter intake, kg/d
1.6
1.2
0.8
0.4
0.0
Pair-housed calves
Individually-housed calves
0
1
2
3
4
5
6
7
Week of age
Treatment: P = 0.09
Lindner et al., 2022.

16

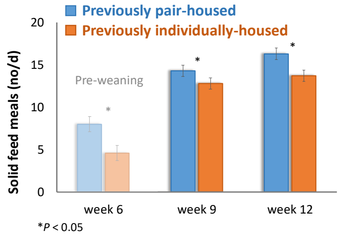
## Social housing and post-weaning behavior




Miller-Cushon and DeVries, 2016

17

## Social housing and post-weaning behavior




Miller-Cushon and DeVries, 2016

18

## Summary

**Social housing supports development of social behavior and improves adaptability to novel environments**

19

## Summary

Social housing supports development of social behavior and improves adaptability to novel environments

**Social housing supports solid feed intake and early life performance**

20

## Summary

Social housing supports development of social behavior and improves adaptability to novel environments

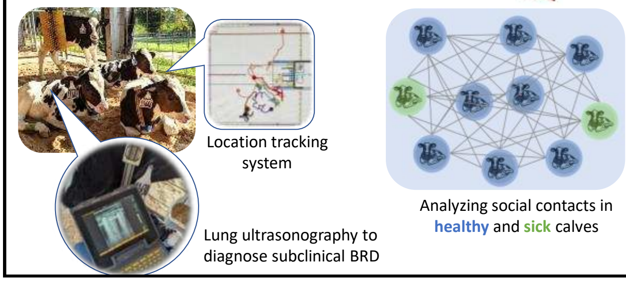
Social housing supports solid feed intake and early life performance

**What's next?**

- **What about long-term effects?**
- **What can social behavior tell us?**

21

## What can social behavior tell us?

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USDA NIFA

2020-67030-31337
2019-67015-29571

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emillerc@ufl.edu
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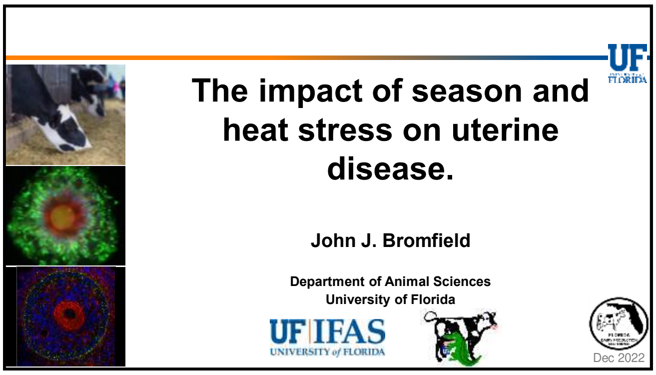
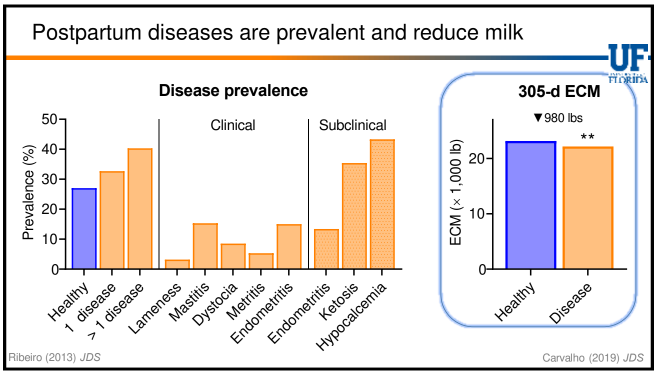
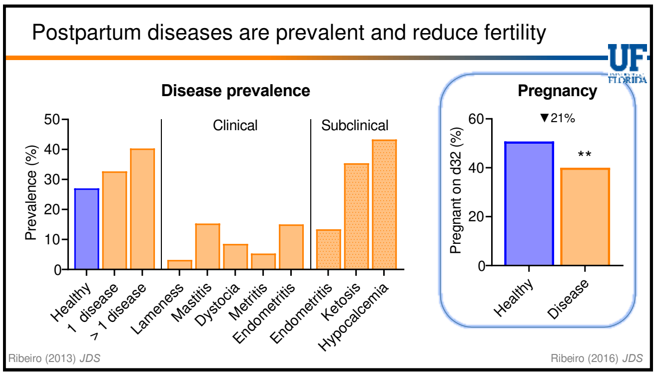
24


The impact of season and heat stress on uterine disease.
John J. Bromfield
Department of Animal Sciences
University of Florida
UF IFAS
UNIVERSITY of FLORIDA
Dec 2022

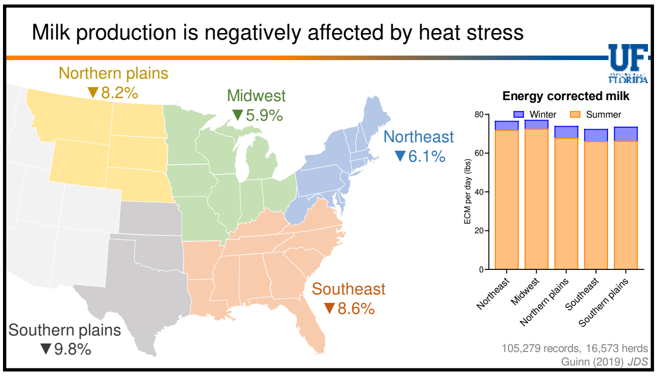
1


Postpartum diseases are prevalent and reduce milk
Disease prevalence
Prevalence (%)
Clinical
Subclinical
Healthy
1 disease
> 1 disease
Lameness
Mastitis
Dystocia
Metritis
Endometritis
Endometritis
Ketosis
Hypocalcemia
305-d ECM
▼980 lbs
ECM (× 1,000 lb)
**
Healthy
Disease
Ribeiro (2013) JDS
Carvalho (2019) JDS

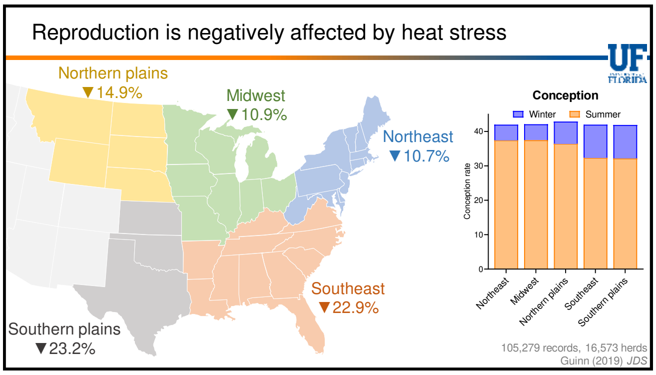
2


Postpartum diseases are prevalent and reduce fertility
Disease prevalence
Prevalence (%)
Clinical
Subclinical
Healthy
1 disease
> 1 disease
Lameness
Mastitis
Dystocia
Metritis
Endometritis
Endometritis
Ketosis
Hypocalcemia
Pregnancy
▼21%
Pregnant on d32 (%)
**
Healthy
Disease
Ribeiro (2013) JDS
Ribeiro (2016) JDS

3

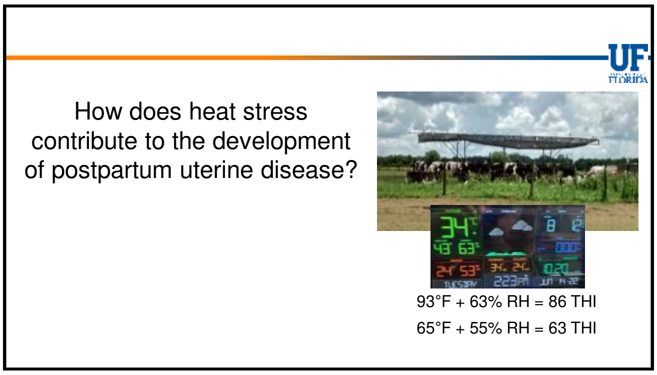

Milk production is negatively affected by heat stress
Northern plains
▼8.2%
Midwest
▼5.9%
Northeast
▼6.1%
Southeast
▼8.6%
Southern plains
▼9.8%
Energy corrected milk
Winter
Summer
ECM per day (lbs)
Northeast
Midwest
Northern plains
Southeast
Southern plains
105,279 records, 16,573 herds
Guinn (2019) JDS

4



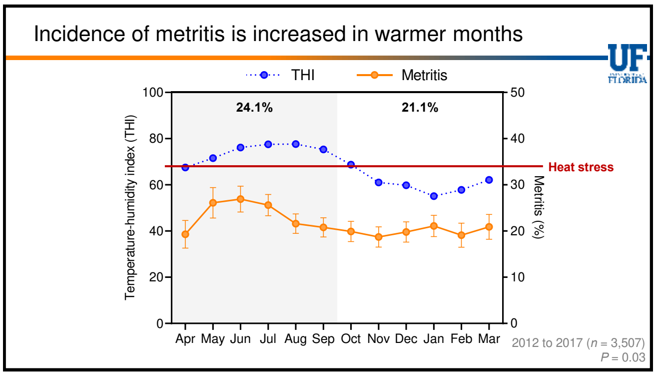
Reproduction is negatively affected by heat stress
Northern plains ▼14.9%
Midwest ▼10.9%
Northeast ▼10.7%
Southeast ▼22.9%
Southern plains ▼23.2%
Conception
Winter
Summer
Conception rate
Northeast
Midwest
Northern plains
Southeast
Southern plains
105,279 records, 16,573 herds
Guinn (2019) JDS


5



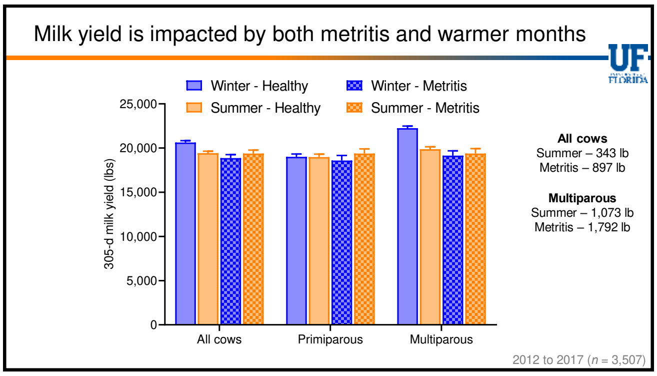
How does heat stress contribute to the development of postpartum uterine disease?
93°F + 63% RH = 86 THI
65°F + 55% RH = 63 THI


6



Incidence of metritis is increased in warmer months
THI
Metritis
24.1%
21.1%
Heat stress
Temperature-humidity index (THI)
Metritis (%)
Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
2012 to 2017 (n = 3,507)
P = 0.03

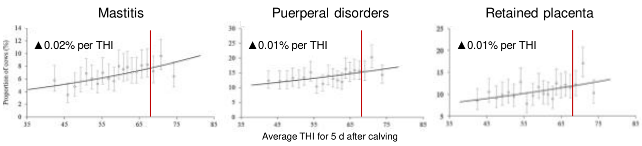

7



Milk yield is impacted by both metritis and warmer months
Winter - Healthy
Winter - Metritis
Summer - Healthy
Summer - Metritis
305-d milk yield (lbs)
All cows
Primiparous
Multiparous
All cows
Summer – 343 lb
Metritis – 897 lb
Multiparous
Summer – 1,073 lb
Metritis – 1,792 lb
2012 to 2017 (n = 3,507)


8

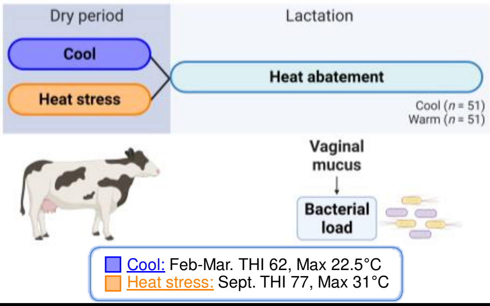
## Elevated THI increases disease incidence




2013 to 2015 ($n$ = 22,212)
Gernand (2019) JDS

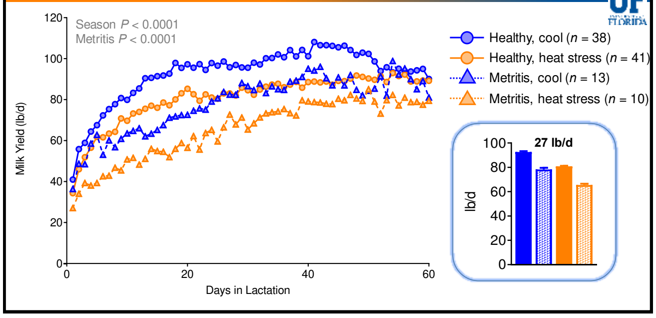
9

## How does heat stress in the dry period effect health?



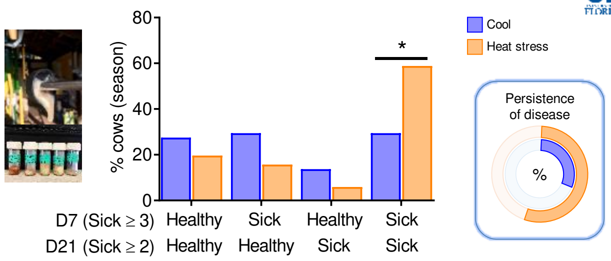

10

## Heat stress compounds effect of metritis on milk production



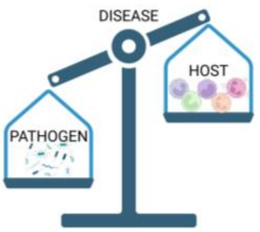

11

## Heat stress increases persistence of disease




12

## Why does heat stress increase disease?



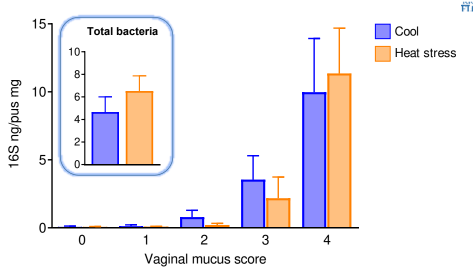

Disease progression is a balance
- Pathogen abundance
- Limiting pathogens (immunity)
- Control of inflammation
- Tolerating pathogens

Could heat stress increase bacteria prevalence?

13

## Vaginal discharge increases bacterial load

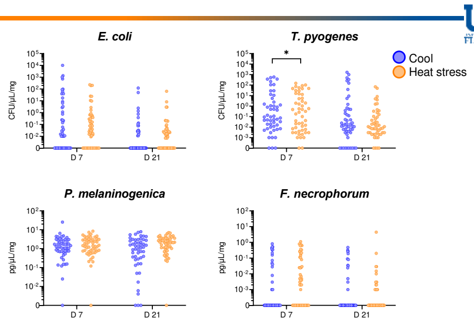
Day 7 postpartum




Score $P < 0.05$

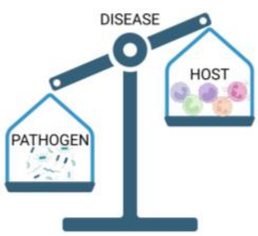
14

## Heat stress does not alter bacterial load




15

## Why does heat stress increase disease?

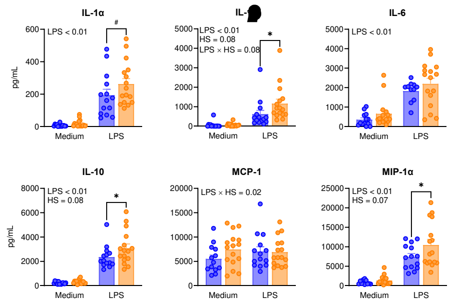



Disease progression is a balance
- ~~Pathogen abundance~~
- Limiting pathogens (immunity)
- Control of inflammation
- Tolerating pathogens

Could heat stress alter host immune function?

16

## Heat stress exacerbates later immune responses

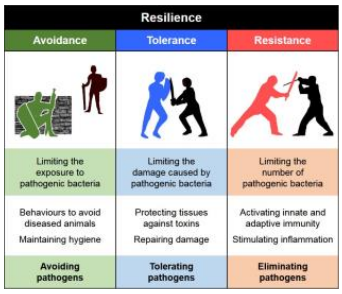


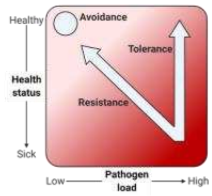

Increased tissue damage & prolonged disease.

IFNγ, IL-4, IL-8, IL-17A, IL-36RA, CXCL10, MIP-1β, TNFα, VEGF-A

17

## Cows avoid, tolerate and resist pathogens




Sheldon et al (2020) *Therio*

18

## Take home message

- heat stress increases the incidence & persistence of uterine disease
- heat stress does not alter pathogen abundance
- heat stress exacerbates immune responses


Cow physiology is altered by heat stress that increases susceptible to disease.

19

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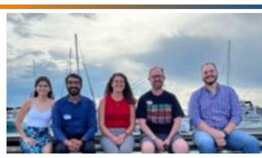
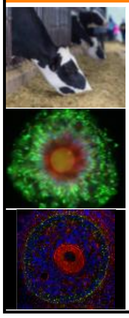
Paula Molinari
Mackenzie Dickson
Rosabel Ramirez
Geoff Dahl
KC Jeong

**Swansea University**
Martin Sheldon

USDA NIFA
2020-67015-31015



20



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University of Florida

UF | IFAS
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## Making a dairy cow that is genetically more resistant to heat stress

Peter J. Hansen
Dept. of Animal Sciences
University of Florida

**56th Florida Dairy Production Conference**

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### Energy Corrected Milk (lb/day)

| Region | Winter | Summer | % Reduction |
|---|---|---|---|
| Northeast | 76.7 | 72.1 | 6.0% |
| Midwest | 77.2 | 72.8 | 5.7% |
| Northern Plains | 74.1 | 67.9 | 8.3% |
| Southeast | 72.5 | 66.4 | 8.6% |
| Southern Plains | 73.6 | 66.4 | 9.9% |

2

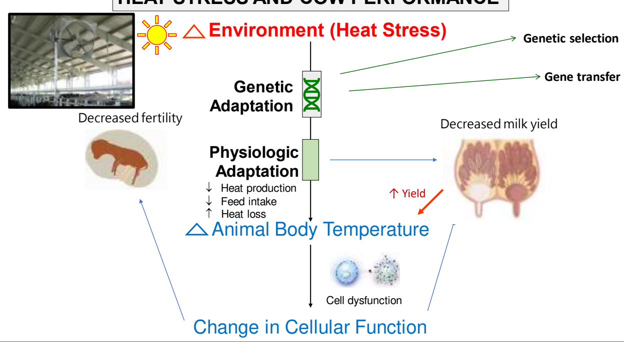
### Conception Rate (%)

| Region | Winter | Summer | % Reduction |
|---|---|---|---|
| Northeast | 42.0 | 37.5 | 10.7% |
| Midwest | 42.1 | 37.5 | 10.9% |
| Northern Plains | 42.9 | 36.5 | 14.9% |
| Southeast | 42.0 | 32.4 | 22.9% |
| Southern Plains | 41.9 | 32.2 | 23.2% |

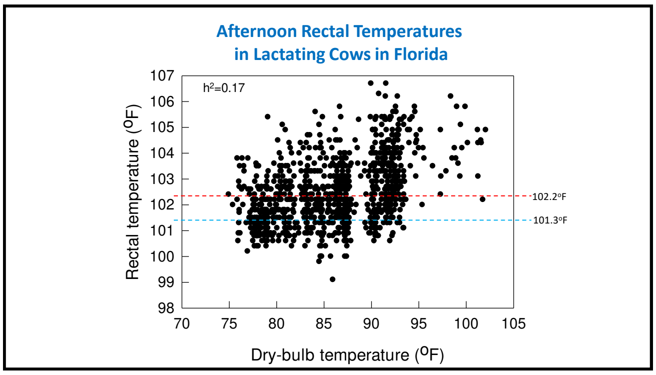
Guinn et al., J Dairy Sci. 102:11777

3

### HEAT STRESS AND COW PERFORMANCE

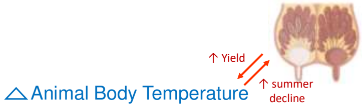



4




5

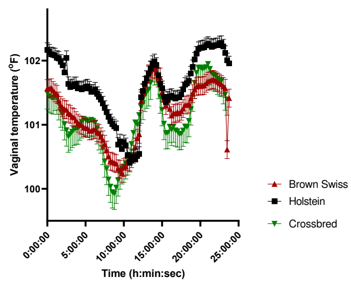
Differences in body temperature regulation during heat stress and seasonal depression in milk yield between Holstein, Brown Swiss and crossbred cows




6

7

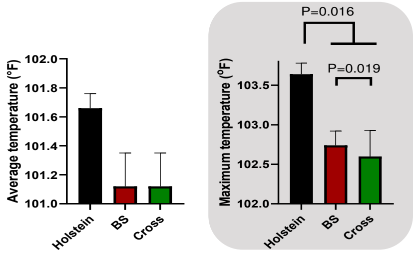
## Breed effects on daily variation in vaginal temperature




Breed, P<0.0001
Breed x time, P<0.0001

8

## Maximum and average vaginal temperature




Breed, P=0.220

Breed, P=0.034

9

## Conclusion

Genetic differences in regulation of body temperature do not necessarily equate to differences in maintenance of milk yield during heat stress; there are genes related to thermotolerance independent of those involved in body temperature regulation.

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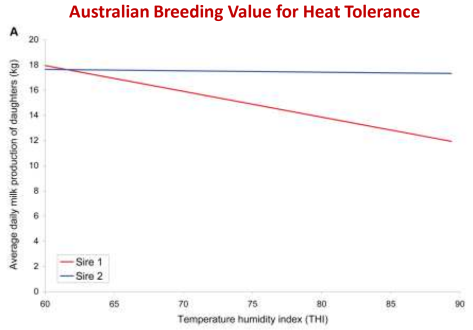
## Australian Breeding Value for Heat Tolerance




Hayes BJ, Bowman PJ, Chamberlain AJ, Savin K, van Tassell CP, et al. (2009) A Validated Genome Wide Association Study to Breed Cattle Adapted to an Environment Altered by Climate Change. PLOS ONE 4(8): e6676. https://doi.org/10.1371/journal.pone.0006676 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0006676

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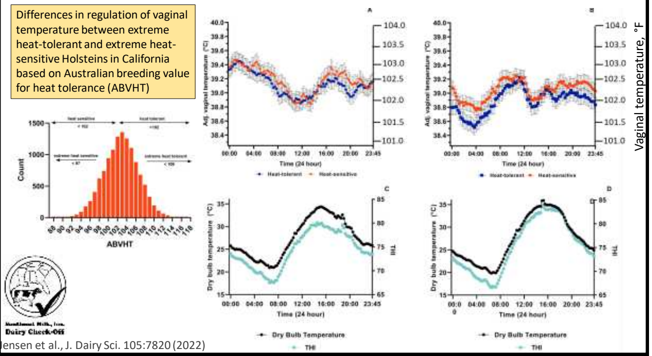
Differences in regulation of vaginal temperature between extreme heat-tolerant and extreme heat-sensitive Holsteins in California based on Australian breeding value for heat tolerance (ABVHT)




ensen et al., J. Dairy Sci. 105:7820 (2022)

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△ Animal Body Temperature

Jensen et al.: AUSTRALIAN BREEDING VALUE FOR HEAT TOLERANCE 7824

**Table 1.** Genomic correlations between Holstein Australian breeding value for heat tolerance and the US genomic PTA for cows located on a commercial California dairy (n = 2,131)[1]

| | US genomic breeding values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | PTA milk | PTA fat | PTA fat% | PTA Pro | PTA Pro% | PTA NM$ | PTA DPR | PTA PL | PTA SCS |
| Breeding value for heat tolerance | −0.275 | −0.420 | −0.129 | −0.470 | −0.250 | −0.395 | 0.160 | −0.062 | −0.033 |
| *P*-value | 2.20E-16 | 2.20E-16 | 2.638E-09 | 2.20E-16 | 2.20E-16 | 2.20E-16 | 1.20E-13 | 0.00438 | 0.126 |

[1]Pro = protein; NM$ = net merit $; DPR = daughter pregnancy rate; PL = productive life.

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## Top 10 US Bulls for Heat Tolerance - 2020

| NAAB Code | NAME | Heat Tolerance | Reliability | Net Merit |
|---|---|---|---|---|
| 94HO10809 | OCEAN-VIEW SURFER | 118 | 38 | -407 |
| 7H7463 | KLUMBS DURHAM PONTIAC | 116 | 38 | -494 |
| 29HO11614 | KED OUTSIDE JEEVES | 116 | 38 | +81 |
| | BARDALE ADAN JAKE IMP | 115 | 38 | |
| 100H8282 | SKAGVALE HIGH COUNTRY | 115 | 38 | -995 |
| 7H7746 | MR DERRY PROMOTION | 115 | 38 | -850 |
| 7H8175 | WINDY-KNOLL-VIEW PRONTO | 115 | 38 | -163 |
| 7H2681 | MARKWELL NOBEL | 114 | 38 | |
| 147HO2420 | SHEMA JEEVES CAMERON - ET | 114 | 38 | +116 |
| 7H9397 | BUCKHORN-ACRES RAID-RED | 114 | 38 | -232 |

Cameron
Born 3/18/2010

14

## Bottom 10 US Bulls for Heat Tolerance - 2020

| NAAB Code | NAME | Heat Tolerance | Reliability | Net Merit |
|---|---|---|---|---|
| 11HO12237 | PEAK ALTAFLADON-ET | 86 | 38 | +599 |
| 29H8375 | RICECREST LANTZ-ET | 87 | 38 | -461 |
| 777H10661 | STANTONS ADAGIO-ET | 88 | 38 | +324 |
| 7HO13313 | S-S-I ERASER P EXPRESSO | 88 | 38 | +386 |
| 29HO18505 | ABS EPHRAM-ET | 88 | 38 | +407 |
| 29HO16714 | DE-SU 11236 BALISTO-ET | 88 | 38 | +480 |
| 7HO14174 | OCD ALLTIME LATROBE-ET | 89 | 38 | +498 |
| 7HO13264 | S-S-I HEADWAY ALLTIME-ET | 89 | 38 | +314 |
| 7HO13461 | S-S-I AICON REMINGTON-ET | 89 | 38 | +235 |
| 551H3753 | ST GEN NOBLE ABBOTSFORD | 89 | 38 | +687 |

Alltime
Born 6/18/2014

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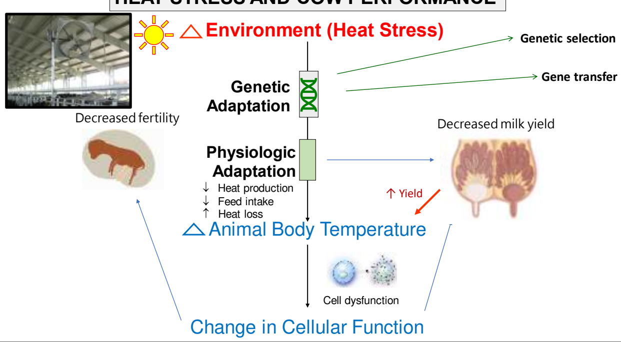
## HEAT STRESS AND COW PERFORMANCE

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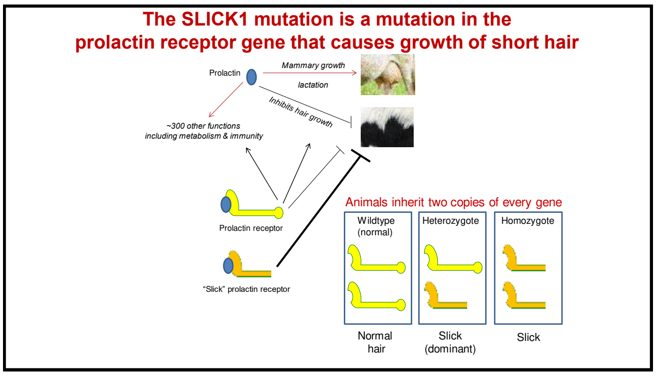
17

18


The SLICK1 mutation is a mutation in the
prolactin receptor gene that causes growth of short hair
Prolactin
Mammary growth
lactation
Inhibits hair growth
~300 other functions
including metabolism & immunity
Prolactin receptor
"Slick" prolactin receptor
Animals inherit two copies of every gene
Wildtype
(normal)
Heterozygote
Homozygote
Normal
hair
Slick
(dominant)
Slick

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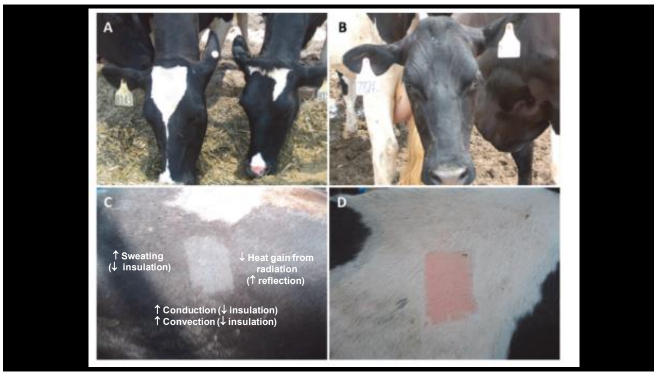
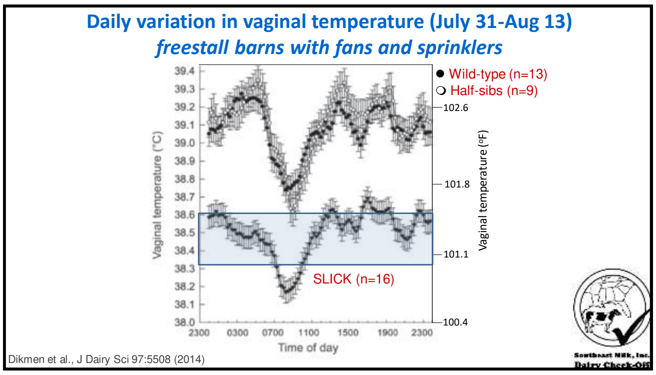
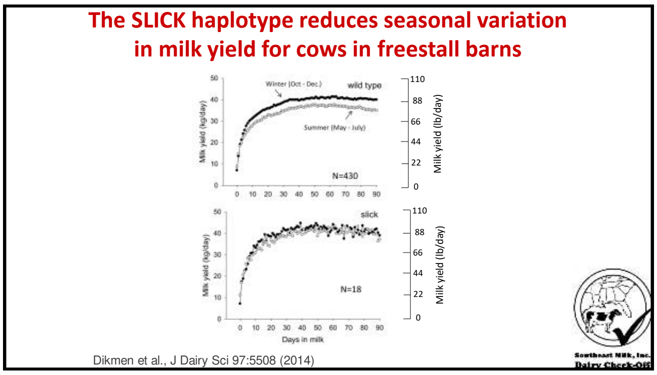

A
B
C
D
↑ Sweating
(↓ insulation)
↓ Heat gain from
radiation
(↑ reflection)
↑ Conduction (↓ insulation)
↑ Convection (↓ insulation)

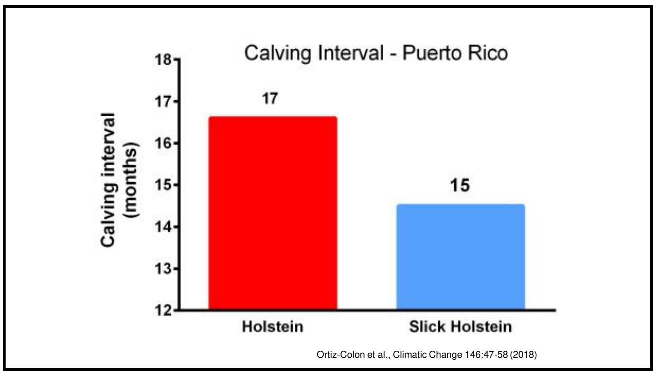
20


Daily variation in vaginal temperature (July 31-Aug 13)
freestall barns with fans and sprinklers
● Wild-type (n=13)
○ Half-sibs (n=9)
SLICK (n=16)
Vaginal temperature (°C)
Vaginal temperature (°F)
Time of day
Dikmen et al., J Dairy Sci 97:5508 (2014)

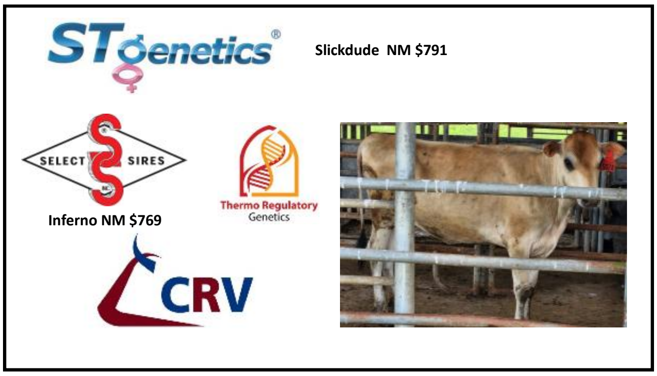
21


The SLICK haplotype reduces seasonal variation
in milk yield for cows in freestall barns
wild type
Winter (Oct - Dec.)
Summer (May - July)
N=430
slick
N=18
Milk yield (kg/day)
Milk yield (lb/day)
Days in milk
Dikmen et al., J Dairy Sci 97:5508 (2014)

22

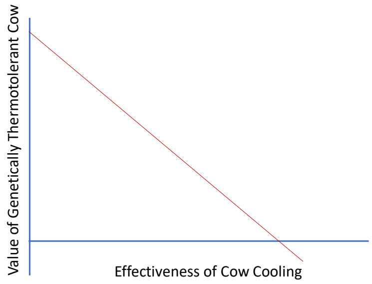

Calving Interval - Puerto Rico
Calving interval (months)
17
15
Holstein
Slick Holstein
Ortiz-Colon et al., Climatic Change 146:47-58 (2018)

23


STgenetics
Slickdude NM $791
SELECT SIRES
Inferno NM $769
Thermo Regulatory Genetics
CRV

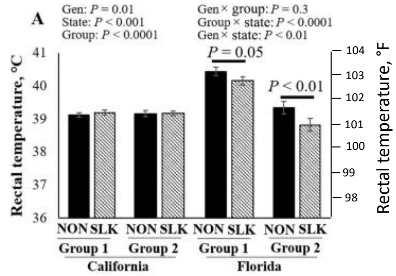
24

How Useful Is It to Produce a Genetically Thermotolerant Dairy Animal?




25

**The slick gene improves body temperature regulation in heifers in Florida but not in California**




Carmickle et al., J Dairy Sci. 105: 9216 (2022)

26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## Acknowledgements

Serdal Dikmen


| | |
|---|---|
| Tim Olson | UF Anim Sci |
| Froylan Sosa | UF Anim Sci |
| Thiago Amaral | UF Anim Sci |
| Camila Cuellar | UF Anim Sci |
| Laura Jensen | UF Anim Sci |
| Sofia Ortega | UF Anim Sci |
| Colleen Larson | UF/IFAS Extension |
| Miguel Torrado | UF Dairy Unit |
| Eric Williams | UF Dairy Unit |
| Serdal Dikmen | Uludag University |
| Anna Denicol | UC-Davis |
| Allie Carmickle | UC-Davis |
| Tad Sonstegard | Acceligen |
| Jennie Pryce | Ag Victoria |
| DataGene | Melbourne Australia |

Froylan Sosa and Colleen Larson

L.E. "Red" Larson Endowment

FOUNDATION FOR FOOD & AGRICULTURE RESEARCH

BARD

UF Dairy Unit, Hague Florida
Larson Dairy, Okeechobee Florida
Gracewood Dairy, Okeechobee, Florida
Maddox Dairy, Riverdale CA
Da Silva Dairy, Vanderham West Dairy, Wreden Ranch - CA

USDA United States Department of Agriculture

National Institute of Food and Agriculture

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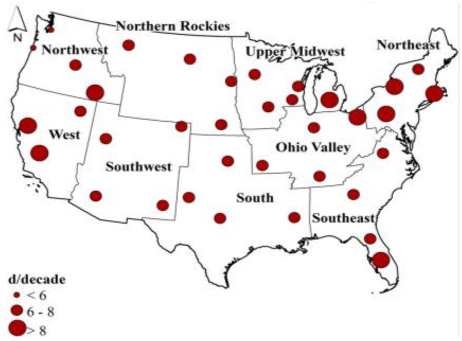
# Heat abatement during the pre-weaning phase: Friend or Foe?

A. B. Montevecchio[1] and R. C. Chebel[1,2]
[1]Department of Large Animal Clinical Sciences
[2]Department of Animal Sciences

1

## Projected decadal increases in heat stress (THI ≥ 70) between 2000 to 2100

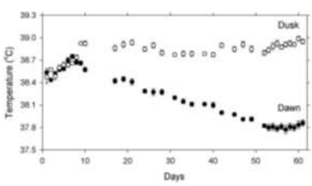


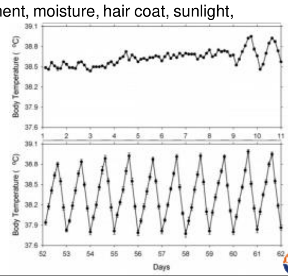

Gunn et al., 2019. Plos One. https://doi.org/10.1371/journal.pone.0214665

2

## Thermal Stress and Calves

- Thermoregulation = mechanism by which mammals maintain tightly controlled body temperature in order to survive
  - In thermoneutral conditions, mammals do not expend any additional energy
- Thermoneutral zones are dependent on:
  - Ambient temperature and air movement, moisture, hair coat, sunlight, bedding, and rumination




Piccione et al., 2003 (BMC Physiology 3:7)

3

## Thermal Stress and Calves

- Projected costs associated with impaired performance of replacement heifers due to heat stress:
  - Heifers 0 to 1 year of age: US$ 12.1 million/y
  - Heifers 1 to 2 years of age: US$ 36.2 million/y
- Models used were adapted from finishing beef cattle

St. Pierre et al. (2013)

4

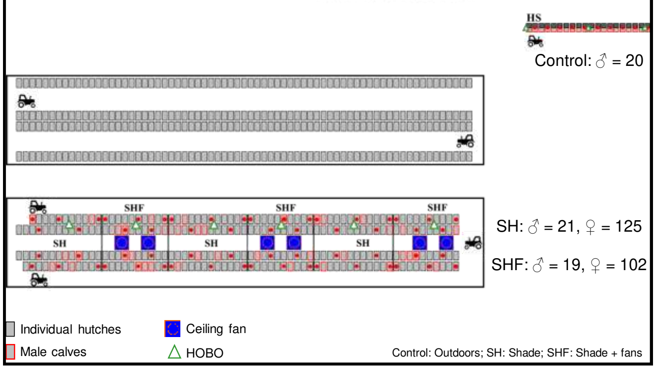

During the SE Dairy Stewardship Program held in 2018 in southern GA and FL, producers "demanded" research on best housing strategies for pre-weaned calves in the SE


5

## Collaborating Herd

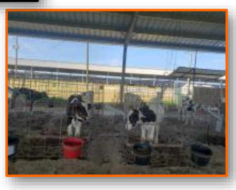
6

## Materials and Methods

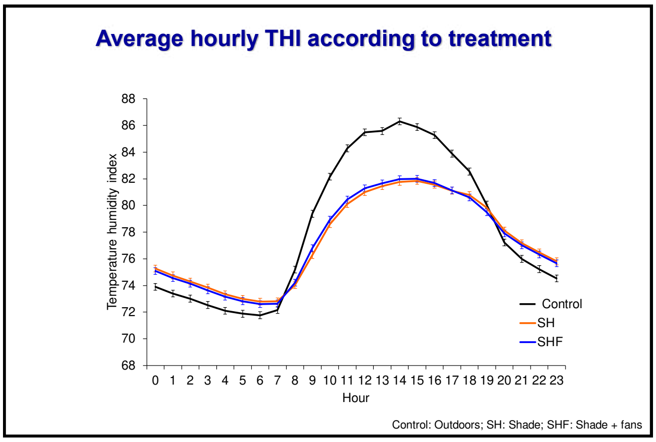



7

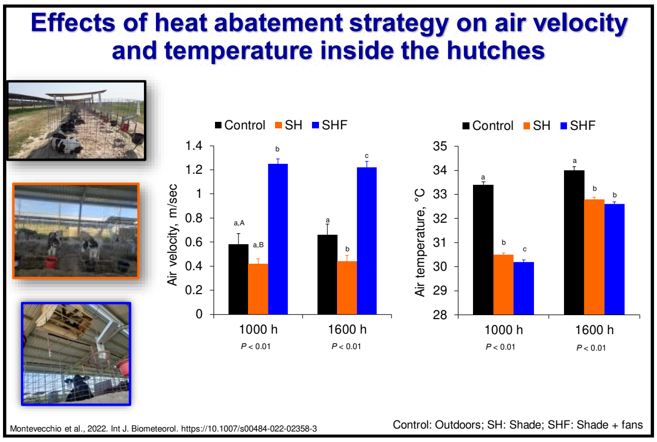
## Experimental design: Males

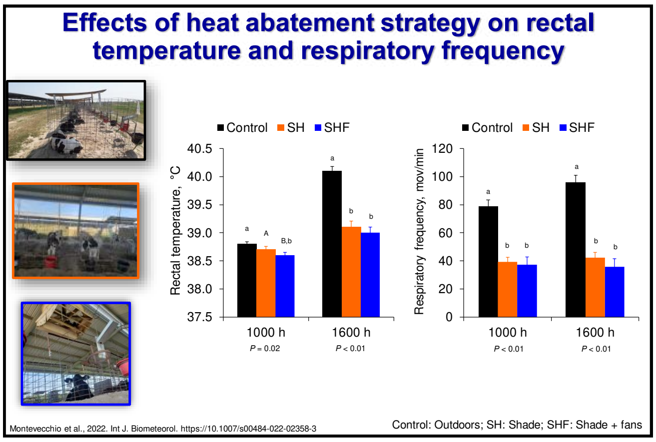

8


Average hourly THI according to treatment
Temperature humidity index
Hour
Control
SH
SHF
Control: Outdoors; SH: Shade; SHF: Shade + fans

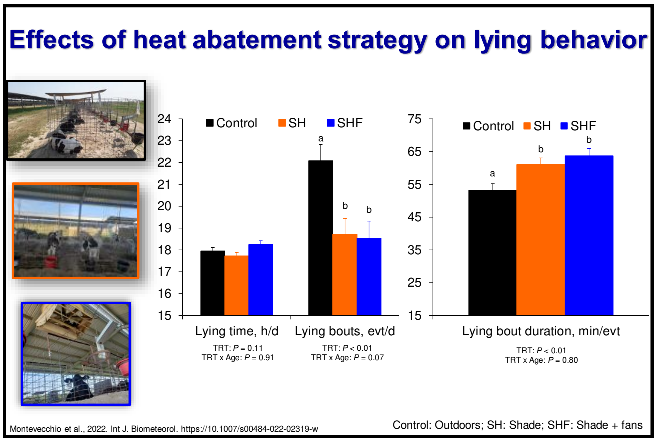
9


Effects of heat abatement strategy on air velocity and temperature inside the hutches
Control SH SHF
Air velocity, m/sec
1000 h
P < 0.01
1600 h
P < 0.01
Air temperature, °C
1000 h
P < 0.01
1600 h
P < 0.01
Montevecchio et al., 2022. Int J. Biometeorol. https://10.1007/s00484-022-02358-3
Control: Outdoors; SH: Shade; SHF: Shade + fans

10


Effects of heat abatement strategy on rectal temperature and respiratory frequency
Control SH SHF
Rectal temperature, °C
1000 h
P = 0.02
1600 h
P < 0.01
Respiratory frequency, mov/min
1000 h
P < 0.01
1600 h
P < 0.01
Montevecchio et al., 2022. Int J. Biometeorol. https://10.1007/s00484-022-02358-3
Control: Outdoors; SH: Shade; SHF: Shade + fans

11


Effects of heat abatement strategy on lying behavior
Control SH SHF
Lying time, h/d
TRT: P = 0.11
TRT x Age: P = 0.91
Lying bouts, evt/d
TRT: P < 0.01
TRT x Age: P = 0.07
Lying bout duration, min/evt
TRT: P < 0.01
TRT x Age: P = 0.80
Montevecchio et al., 2022. Int J. Biometeorol. https://10.1007/s00484-022-02319-w
Control: Outdoors; SH: Shade; SHF: Shade + fans

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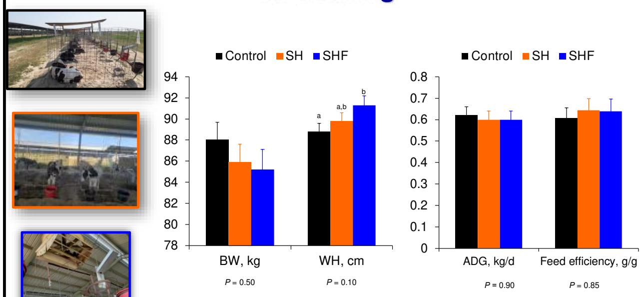
## Effects of heat abatement strategy on performance at weaning




Montevecchio et al., 2022. Int J. Biometeorol. https://10.1007/s00484-022-02358-3

Control: Outdoors; SH: Shade; SHF: Shade + fans

13

## Experimental design: Females

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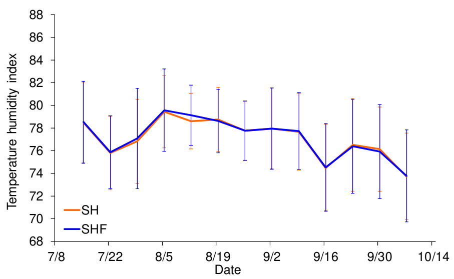
## Average daily THI according to treatment and date




SH: Shade; SHF: Shade + fans

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## Effects of heat abatement strategy on rectal temperature, respiratory frequency, and the risk of hyperthermia

| Variables (±SEM) | SH | SHF | P – value |
|---|---|---|---|
| | | 1000 h | |
| Air velocity, m/sec | 0.41 ± 0.05 | 1.20 ± 0.05 | < 0.01 |
| Air temperature, °C | 30.5 ± 0.1 | 30.2 ± 0.1 | 0.02 |
| Rectal temperature, °C | 38.8 ± 0.02 | 38.7 ± 0.03 | 0.02 |
| Hyperthermia, % | 30.2 ± 2.0 | 21.0 ± 1.9 | < 0.01 |
| Respiratory frequency, mov/min | 41.4 ± 1.2 | 38.9 ± 1.1 | 0.12 |
| | | 1600 h | |
| Air velocity, m/sec | 0.43 ± 0.05 | 1.19 ± 0.06 | < 0.01 |
| Air temperature, °C | 32.9 ± 0.1 | 32.7 ± 0.1 | 0.09 |
| Rectal temperature, °C | 39.2 ± 0.03 | 39.1 ± 0.03 | 0.43 |
| Hyperthermia, % | 62.1 ± 4.4 | 56.4 ± 4.6 | 0.37 |
| Respiratory frequency, mov/min | 44.4 ± 1.3 | 41.7 ± 1.3 | 0.15 |

SH: Shade; SHF: Shade + fans

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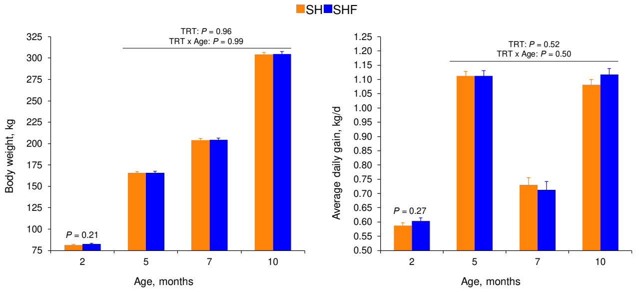
## Effects of heat abatement strategy on body measures after weaning




SH: Shade; SHF: Shade + fans

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## Effects of heat abatement strategy on reproductive responses of heifers

| Variable | SH | SHF | *P* – value |
|---|---|---|---|
| First insemination | | | |
| Median age at 1st AI, mo | 12.5 | 12.6 | 0.30 |
| Pregnancy at 35 d, % (n) | 55.3 (114) | 48.2 (85) | 0.44 |
| Pregnancy at 88 d, % (n) | 53.5 (114) | 45.9 (85) | 0.41 |
| Pregnancy loss, % (n) | 3.2 (63) | 4.9 (41) | 0.69 |
| Re-inseminations | | | |
| Pregnancy at 35 d, % (n) | 44.3 (122) | 43.7 (103) | 0.95 |
| Pregnancy at 88 d, % (n) | 40.2 (122) | 38.8 (103) | 0.82 |
| Pregnancy loss, % (n) | 9.3 (54) | 11.1 (45) | 0.78 |
| Median age at pregnancy, mo | 13.6 | 13.9 | 0.33 |
| Heifers censored, % | 8.0 | 16.8 | |

1st AI: 85.6% sex-sorted semen
≥ 2nd: 40.3% sex-sorted semen

SH: Shade; SHF: Shade + fans

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## Effects of treatment on BW and age at calving and calf characteristics

| Variable | SH | SHF | *P* – value |
|---|---|---|---|
| Starting 1st lactation, % | 86.4 | 76.2 | 0.27 |
| Age at calving, mo (±SEM) | 22.2 ± 0.14 | 22.3 ± 0.16 | 0.85 |
| BW at calving, kg (±SEM) | 613.7 ± 6.4 | 619.0 ± 6.9 | 0.52 |
| Dystocic calving, % | 8.3 | 5.2 | 0.46 |
| Calf characteristics | | | |
| Male, % | 22.2 | 27.3 | 0.48 |
| Twins, % | 0.93 | 0.00 | 0.40 |
| Stillbirth, % | 0.93 | 2.60 | 0.45 |
| Body weight at birth, kg (±SEM) | 38.7 ± 0.42 | 38.3 ± 0.52 | 0.52 |

SH: Shade; SHF: Shade + fans

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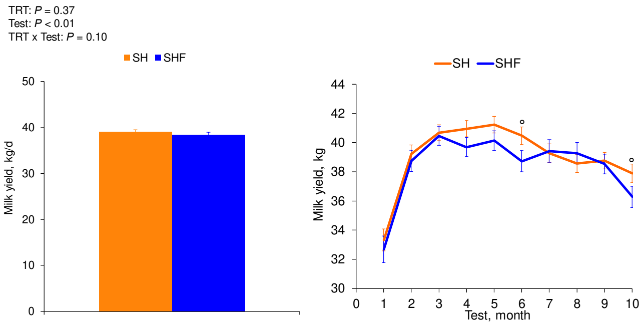
## Effects of treatment on milk yield

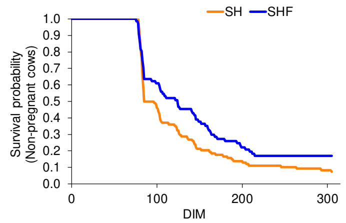



SH: Shade; SHF: Shade + fans

25

## Effects of treatment on hazard of pregnancy

| Responses | SH | SHF | *P* - value |
|---|---|---|---|
| Hazard of pregnancy | Ref. | 0.67 (0.49, 0.93) | 0.02 |




SH: Shade; SHF: Shade + fans

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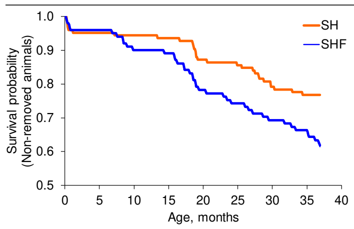
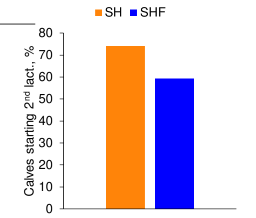
## Effect of treatment on lifetime hazard of removal

| Responses | SH | SHF | *P* - value |
|---|---|---|---|
| Hazard of removal | Ref. | 1.79 (1.11, 2.90) | 0.02 |




9 SH and 5 SHF remain in the herd as first lactation cows

SH: Shade; SHF: Shade + fans

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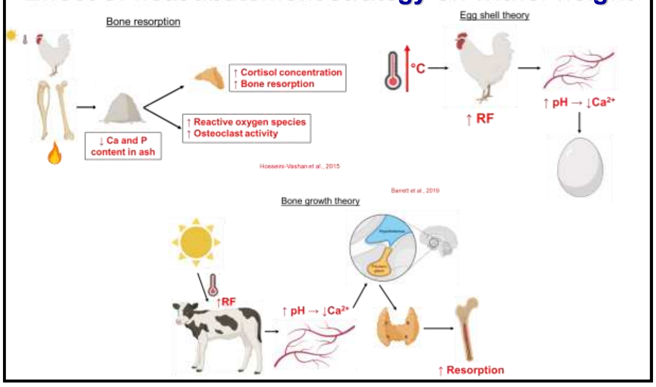
## Effect of heat abatement strategy on wither height

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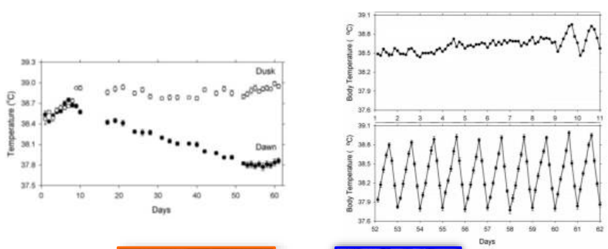
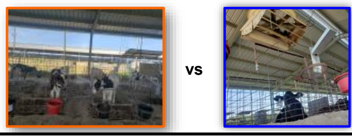
## Development of thermoregulatory ability




Piccione et al., 2003

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## Effect of heat abatement strategy on survival

12 months

1st AI

| | SH | SHF | *P* |
|---|---|---|---|
| P/AI1, % | 53.5 | 45.9 | 0.41 |

12 months

1st AI

| | SH | SHF | *P* |
|---|---|---|---|
| P/AI1, % | 51.4 | 38.4 | 0.16 |

| | SH | SHF | *P* |
|---|---|---|---|
| 2nd lact., % | 76.8 | 61.4 | 0.04 |

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## Take Home Message

- Exposure of calves to outdoor conditions during summer in southern GA affected calf thermoregulation and comfort (♂)
- Provision of shade+fan marginally increased wither height at weaning compared with housing outdoors (♂)
- Within a barn, provision of fans did not affect pre-weaning performance and impaired survival to the second lactation (♀)
- Unless calves/heifers will be housed throughout their lives inside a barn, the current data does not support benefits to the use of fans during the pre-weaning phase

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## Thank you!

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UF UNIVERSITY of FLORIDA DAIRY SCIENCE RESEARCH

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Ricardo Chebel rcchebel@ufl.edu

USDA NIFA
Accession Number: 1022402

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# ALLEVIATING HEAT STRESS: WHO GETS COOLED AND WHY?

G. E. Dahl
Department of Animal Sciences
56th UF Dairy Production Conference
1 December 2022
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## OUTLINE

- Effective cooling approaches
- Water use estimates
- Priority for cooling?
  - Which group first?
    Lactating? Dry? Calves?
- Summary

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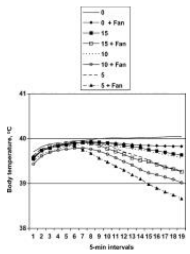
## EFFECTIVE COOLING




- Goal is 38.6 °C for core temperature
- Combination of water soakers and fans most effective
- Acute versus long term responses – will they match?

KSU via Collier et al., *J. Dairy Sci.* 89:1244–1253

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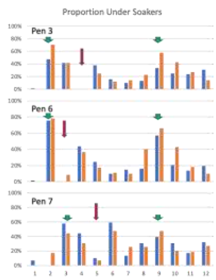


## WATER USE

- 25 -30 % under soakers at any time
- 233 L/cow/d; over half wasted
- "Blue" water – highest value, lowest supply

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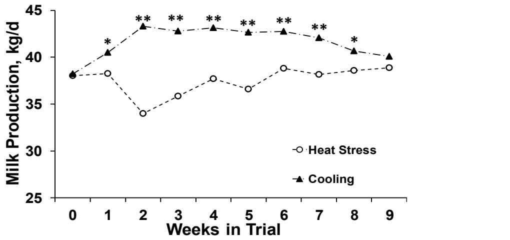
## HEAT STRESS REDUCES PRODUCTION OF EARLY LACTATION COWS




Tao and Dahl, Unpublished

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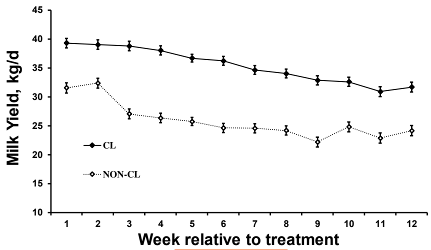
## HEAT STRESS REDUCES PRODUCTION OF MID AND LATE LACTATION COWS




Weng and Tao, Unpublished

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## HEAT STRESS DURING LACTATION

- **Depresses DMI**
- **Reduces milk yield**
- **Recent studies suggest additional metabolic effects beyond DMI**
- **Recovery dependent on duration, stage of lactation**

What about dry cows?

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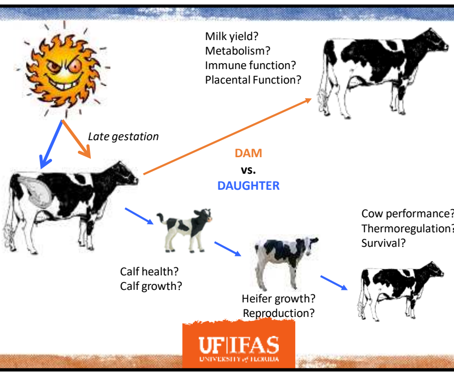


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## Gainesville, Florida, USA

- Sand bedded free stalls
- Fans over stalls
- Soakers over feedline
- Fans on at 70° F (21.1°C)
- Soakers on 1 min every 5 min at 72° F

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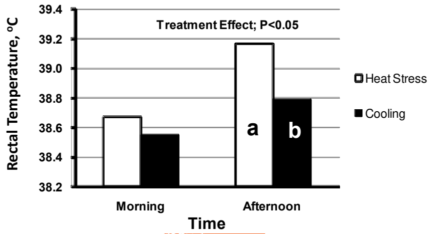
## HEAT STRESS INCREASES MEAN RECTAL TEMPERATURE




Do Amaral et al., *J. Dairy Sci.* 94:86–96

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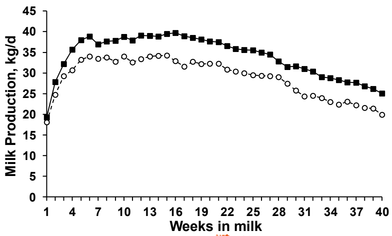
## COOLING DRY COWS INCREASES MILK




Tao et al., *J. Dairy Sci.* 94:5976–5986

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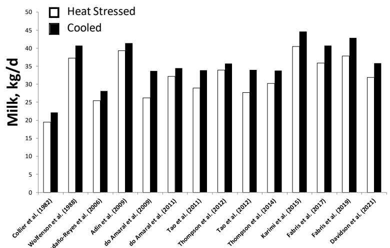
## COOLING DRY COWS INCREASES MILK

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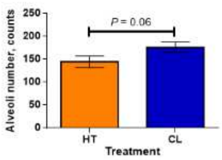
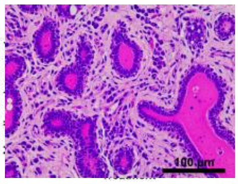
## HEAT STRESS DECREASES ALVEOLI NUMBER




H&E Stain

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## DRY IN COOL MONTHS IMPROVES PERFORMANCE

Table 1. Milk production and occurrence of mastitis, digestive and respiratory problems, retained fetal membranes, and metritis in cows dried during HOT months (Jun, Jul, Aug) or COOL months (Dec, Jan, Feb) in the first 80 DIM of the subsequent lactation

| | Dry during HOT months (Jun, Jul, Aug), n = 1,569 | | | | Dry during COOL months (Dec, Jan, Feb), n = 1,044 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | Value | Disease[1] | n | % | Value | Disease[1] | n | % | P-value |
| Milk production (kg) | 10,351 ± 59.8 | | | | 10,902 ± 73.3 | | | | 0.01 |
| Mastitis | | 0 | 1,286 | 82.0 | | 0 | 950 | 91.0 | 0.01 |
| | | 1 | 283 | 18.0 | | 1 | 94 | 9.0 | |
| Digestive | | 0 | 1,516 | 96.6 | | 0 | 973 | 93.2 | 0.01 |
| | | 1 | 53 | 3.4 | | 1 | 71 | 6.8 | |
| Respiratory | | 0 | 1,346 | 85.8 | | 0 | 942 | 90.2 | 0.01 |
| | | 1 | 223 | 14.2 | | 1 | 102 | 9.8 | |
| Retained fetal membranes | | 0 | 1,500 | 95.6 | | 0 | 1,013 | 97.0 | 0.06 |
| | | 1 | 69 | 4.4 | | 1 | 31 | 3.0 | |
| Metritis | | 0 | 1,500 | 95.6 | | 0 | 1,007 | 96.4 | 0.35 |
| | | 1 | 67 | 4.2 | | 1 | 38 | 3.5 | |

[1]Disease: 0 = cows without the disease; 1 = cows with the disease.

Thompson & Dahl, *Prof. Anim. Sci.* 28:628-631

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## DRY IN COOL MONTHS IMPROVES REPRODUCTIVE PERFORMANCE

Table 3. Milk production and reproductive performance of cows dried during HOT months (Jun, Jul, Aug) or COOL months (Dec, Jan, Feb) in the first 150 DIM of the subsequent lactation on a commercial farm in Florida

| Item | Dry during HOT months (Jun, Jul, Aug) | Dry during COOL months (Dec, Jan, Feb) | P-value |
|---|---|---|---|
| Milk production (kg) | 10,547 ± 67.0 | 11,005 ± 83.38 | 0.01 |
| Number of breedings (n) | 1,048 | 676 | 0.03 |
| Mean (no.) | 1.59 ± 0.02 | 1.51 ± 0.03 | |
| DIM to breeding (n) | 1,047 | 676 | 0.01 |
| Mean (d) | 97.0 ± 0.74 | 91.8 ± 0.92 | |
| DIM to pregnancy (n) | 1,051 | 679 | 0.01 |
| Mean (d) | 131.1 ± 0.85 | 125.9 ± 1.06 | |

Thompson & Dahl, *Prof. Anim. Sci.* 28:628-631

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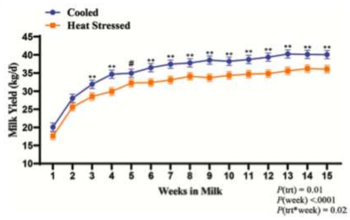
## EFFECTS ON FIRST CALF HEIFERS: COOLING INCREASES YIELD




Davidson et al, *J. Dairy Sci.* 104:2357-2368

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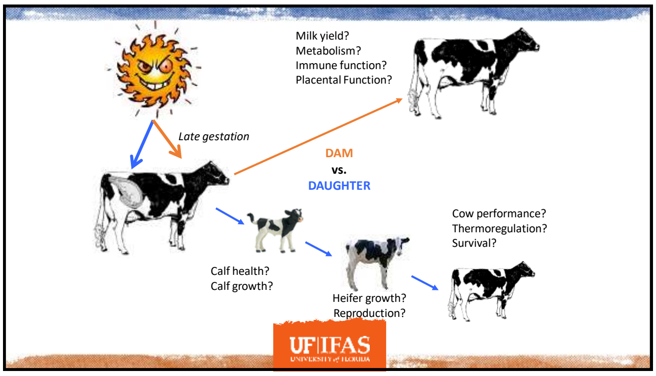
Milk yield?
Metabolism?
Immune function?
Placental Function?
Late gestation
DAM
vs.
DAUGHTER
Cow performance?
Thermoregulation?
Survival?
Calf health?
Calf growth?
Heifer growth?
Reproduction?
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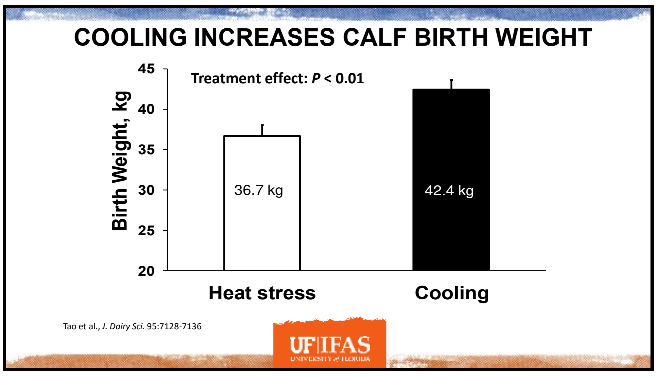
COOLING INCREASES CALF BIRTH WEIGHT
Treatment effect: P < 0.01
Birth Weight, kg
45
40
35
30
25
20
36.7 kg
42.4 kg
Heat stress
Cooling
Tao et al., J. Dairy Sci. 95:7128-7136
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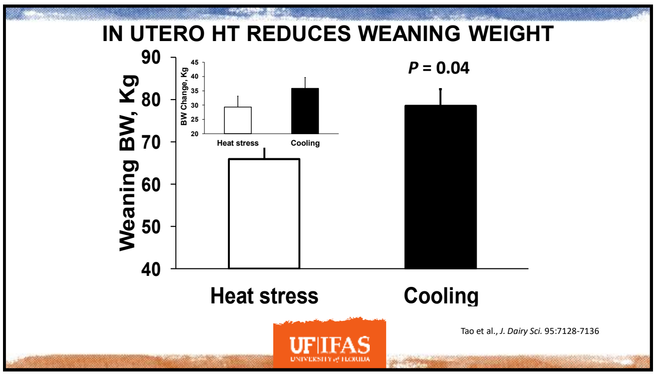
IN UTERO HT REDUCES WEANING WEIGHT
P = 0.04
Weaning BW, Kg
90
80
70
60
50
40
BW Change, Kg
Heat stress
Cooling
Heat stress
Cooling
Tao et al., J. Dairy Sci. 95:7128-7136
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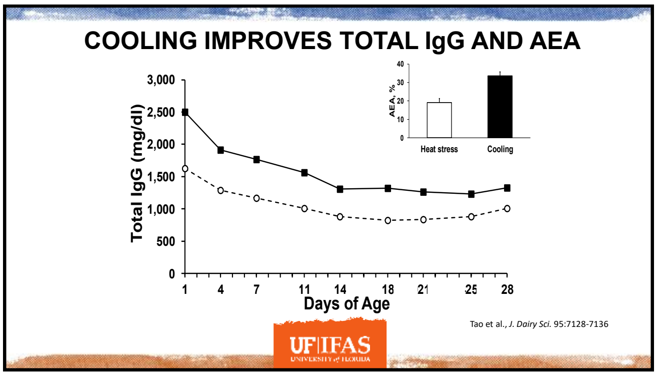
COOLING IMPROVES TOTAL IgG AND AEA
Total IgG (mg/dl)
3,000
2,500
2,000
1,500
1,000
500
0
1
4
7
11
14
18
21
25
28
Days of Age
AEA, %
Heat stress
Cooling
Tao et al., J. Dairy Sci. 95:7128-7136
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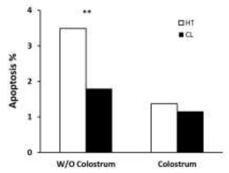
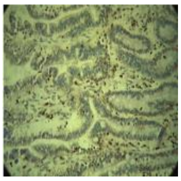
## IN UTERO HT ACCELERATES GUT CLOSURE



Ahmed et al. , *JDS Commun.* 2:https://doi.org/10.3168/jdsc.2021-0098.

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**Retrospective analysis of records of calves from 5 studies between 2007 and 2011**

Monteiro et al. , *J. Dairy Sci.* 99:8443-8450.

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| Heat Stress Experiments 2007 - 2011 | | | |
|---|---|---|---|
| | Bulls | Heifers | Total |
| Cooling | 31 | 41 | 72 |
| Heat Stress | 30 | 44 | 74 |
| Total | 61 | 85 | 147 |

Monteiro et al. , *J. Dairy Sci.* 99:8443-8450.

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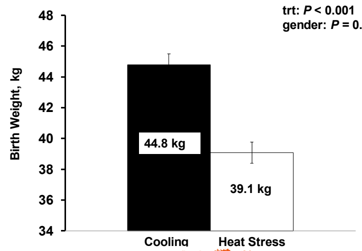
## BIRTH WEIGHT




Monteiro et al. , *J. Dairy Sci.* 99:8443-8450.

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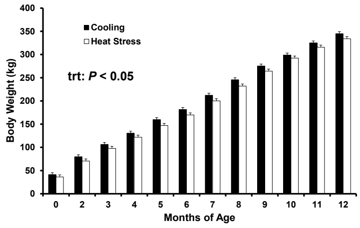
## *IN UTERO* HEAT STRESS DECREASES CALF BODYWEIGHT TO PUBERTY




Monteiro et al. , *J. Dairy Sci*. 99:8443-8450.

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## *IN UTERO* HS DECREASES CALF SURVIVAL

**Table 1.** Effect of maternal heat stress (HT) or cooling (CL) during late gestation on calf survival

| | CL | | | | HT | | | | *P* |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | AI | IVF[1] | Total | %[2] | AI | IVF | Total | % | Trt[3] |
| Bull calves, n | 30 | 1 | 31 | --- | 28 | 2 | 30 | --- | --- |
| Heifer calves, n | 29 | 12 | 41 | --- | 29 | 15 | 44 | --- | --- |
| DOA[4] | 0 | 0 | 0 | 0.0 | 2 | 1 | 3 | 4.1 | 0.25 |
| Males mortality by 4 mo of age | 1 | 0 | 1 | 3.2 | 3 | 0 | 3 | 10.0 | 0.35 |
| Heifers leaving herd before puberty | 1 | 4 | 5 | 12.2 | 3 | 7 | 10 | 22.7 | 0.26 |
| Due to sickness, malformation or growth retardation | 1 | 0 | 1 | 2.4 | 3 | 5 | 8 | 18.2 | 0.03 |
| Heifers leaving herd after puberty, before first lactation | 1 | 0 | 1 | 2.4 | 3 | 0 | 3 | 6.8 | 0.62 |
| Heifers completing first lactation | 27 | 8 | 35 | 85.4 | 22 | 7 | 29 | 65.9 | 0.05 |

[1] IVF = in vitro fertilization.
[2] Percentage of animals (AI + IVF) affected out of total animals (males or females) in the respective treatment.
[3] Treatment.
[4] Dead on arrival. Includes male and female calves.

Monteiro et al. , *J. Dairy Sci*. 99:8443-8450.

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## *IN UTERO* HEAT STRESS DECREASES REPRODUCTIVE PERFORMANCE

**Table 2.** Effect of maternal heat stress (HT) or cooling (CL) during late gestation on reproductive performance before first lactation of heifers born to HT or CL dams

| Parameter | CL | HT | SEM | *P* |
|---|---|---|---|---|
| N | 36 | 32 | --- | --- |
| Age at first AI, mo | 13.6 | 13.8 | 0.2 | 0.32 |
| Services per pregnancy d[1] 30 | 2.0 | 2.5 | 0.2 | 0.05 |
| Age at pregnancy d[1] 30, mo | 16.1 | 16.9 | 0.3 | 0.07 |
| Services per pregnancy d[1] 50 | 2.3 | 2.6 | 0.2 | 0.32 |
| Age at calving, mo | 24.8 | 25.0 | 0.4 | 0.72 |

[1] Days after insemination.

Monteiro et al. , *J. Dairy Sci*. 99:8443-8450.

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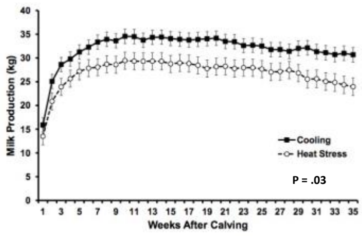
## *IN UTERO* HEAT STRESS REDUCES MILK PRODUCTION




Monteiro et al. , *J. Dairy Sci*. 99:8443-8450.

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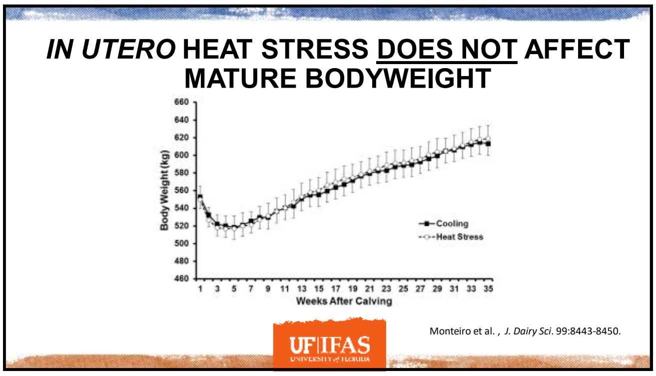
IN UTERO HEAT STRESS DOES NOT AFFECT MATURE BODYWEIGHT
Body Weight (kg)
Weeks After Calving
Cooling
Heat Stress
Monteiro et al. , J. Dairy Sci. 99:8443-8450.
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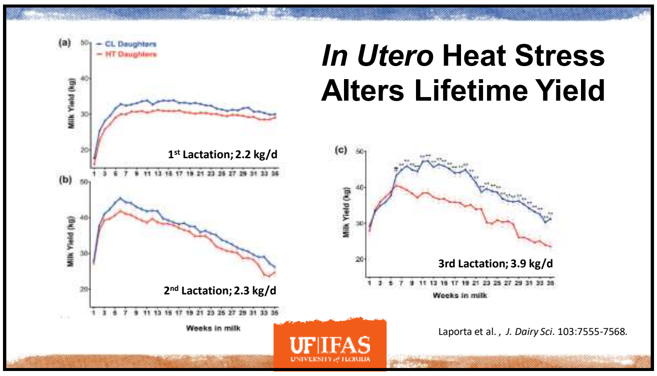
In Utero Heat Stress Alters Lifetime Yield
CL Daughters
HT Daughters
Milk Yield (kg)
1st Lactation; 2.2 kg/d
2nd Lactation; 2.3 kg/d
3rd Lactation; 3.9 kg/d
Weeks in milk
Laporta et al. , J. Dairy Sci. 103:7555-7568.
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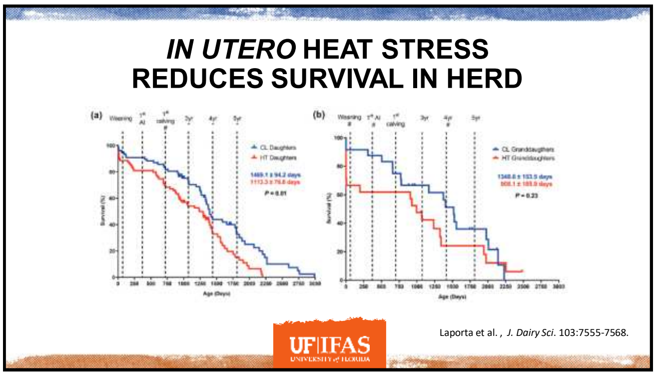
IN UTERO HEAT STRESS REDUCES SURVIVAL IN HERD
Weaning
CL Daughters
HT Daughters
CL Granddaughters
HT Granddaughters
Survival (%)
Age (Days)
Laporta et al. , J. Dairy Sci. 103:7555-7568.
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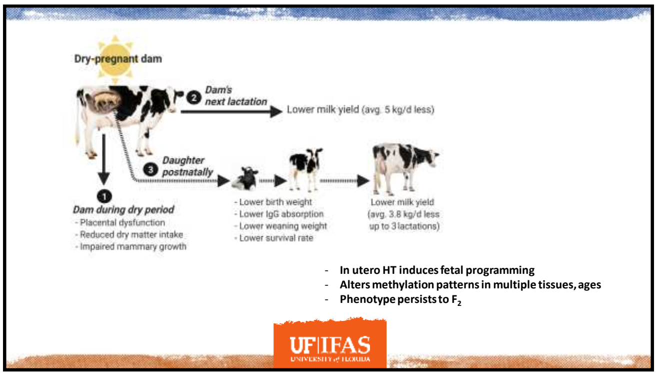
Dry-pregnant dam
Dam's next lactation
Lower milk yield (avg. 5 kg/d less)
Daughter postnatally
Dam during dry period
- Placental dysfunction
- Reduced dry matter intake
- Impaired mammary growth
- Lower birth weight
- Lower IgG absorption
- Lower weaning weight
- Lower survival rate
Lower milk yield (avg. 3.8 kg/d less up to 3 lactations)
- In utero HT induces fetal programming
- Alters methylation patterns in multiple tissues, ages
- Phenotype persists to F2
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## TAKE HOME MESSAGES

- Cooling needed for all mature cows – lactating and dry
- Heifers need to be cooled pre-partum to improve yield, protect calf
- Water conservation – esp. “Blue water” - increasingly important consideration for cooling

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