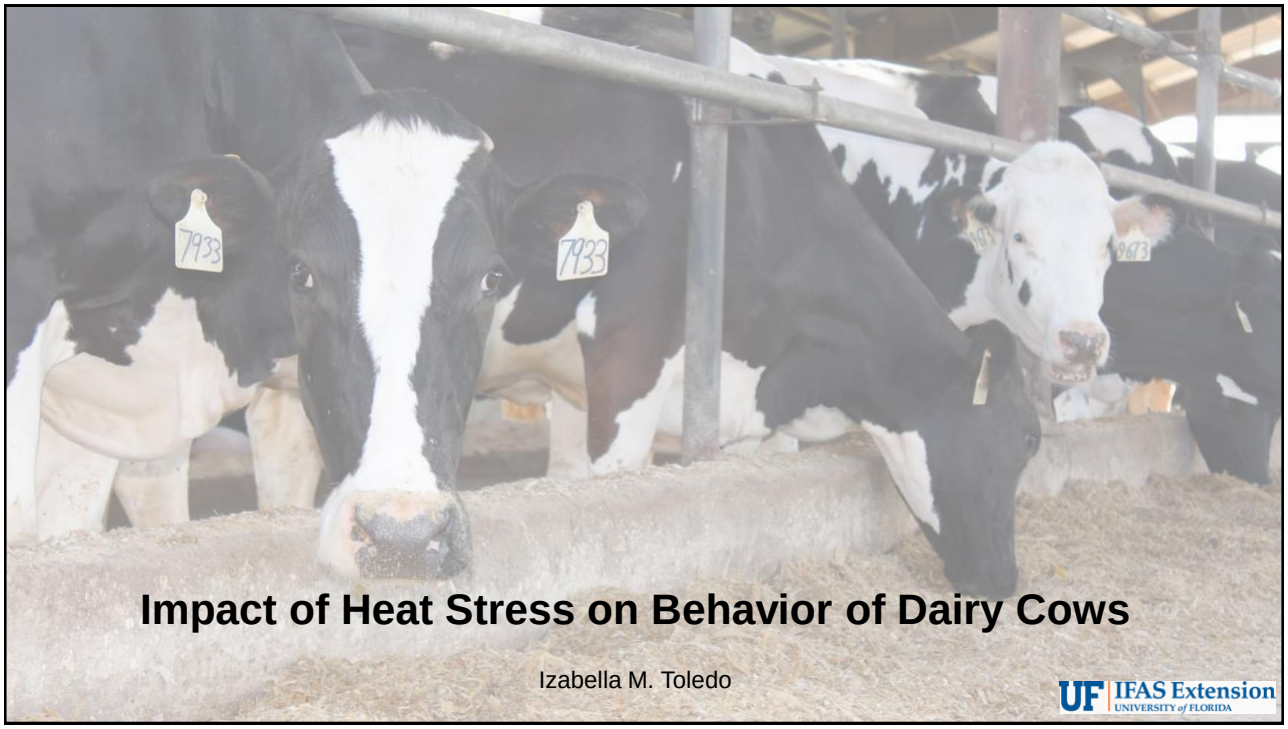

Impact of Heat Stress on Behavior of Dairy Cows

Izabella M. Toledo

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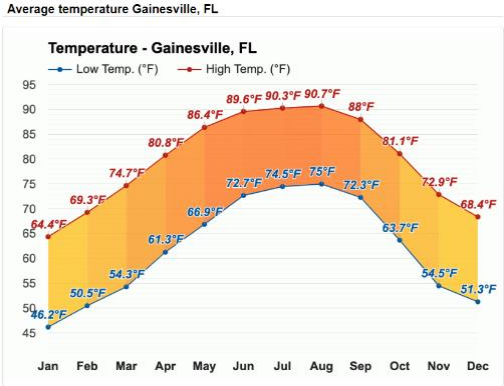
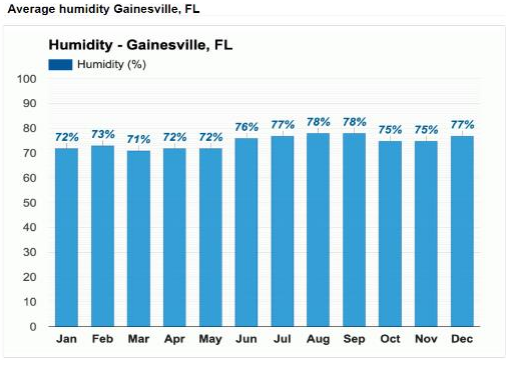
1

Florida is Hot!!

Average temperature Gainesville, FL



Average humidity Gainesville, FL



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Weather today - Gainesville, FL (weather-atlas.com)

2

Temperature-Humidity Index (THI)

Temperature		% Relative Humidity																				
°F	°C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
72	22.0	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71	72	72
73	23.0	65	65	66	66	66	67	67	68	68	68	69	69	70	70	71	71	71	72	72	73	73
74	23.5	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74
75	24.0	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
76	24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
77	25.0	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77
78	25.5	67	68	68	69	69	70	70	71	71	72	72	73	74	74	75	75	76	76	77	77	78
79	26.0	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78	78	79
80	26.5	68	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79	79	80
81	27.0	68	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	78	79	80	80	81
82	28.0	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
83	28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	82	83
84	29.0	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
85	29.5	70	71	72	73	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85
86	30.0	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
87	30.5	71	72	73	74	74	75	76	77	77	78	79	80	81	81	82	83	84	85	86	86	87
88	31.0	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
89	31.5	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87	88	89
90	32.0	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
91	33.0	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91
92	33.5	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
93	34.0	74	75	76	77	78	79	80	80	81	82	83	84	85	86	87	88	89	90	91	92	93
94	34.5	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	35.5	76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	95	96
97	36.0	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97
98	36.5	76	77	78	80	80	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	98
99	37.0	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	95	96	98	99
100	38.0	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	98	99	100
101	38.5	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	98	99	100	101
102	39.0	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100	101	102
103	39.5	78	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98	99	101	102	103
104	40.0	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101	103	104
105	40.5	80	80	82	83	84	86	87	88	89	91	92	93	95	96	97	98	100	101	102	104	105
106	41.0	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103	104	106
107	41.5	80	81	83	84	85	87	88	89	91	92	94	95	96	98	99	100	102	103	104	106	107
108	42.0	81	82	83	85	86	88	89	90	92	93	94	96	97	98	100	101	103	104	105	107	108
109	43.0	81	82	84	85	87	89	89	91	92	94	95	96	98	99	101	102	103	105	106	108	109
110	43.5	81	83	85	86	87	89	90	91	93	94	96	97	99	100	101	103	104	106	107	109	110
111	44.0	82	83	85	86	88	90	91	92	94	95	96	98	99	101	102	104	105	107	108	110	111
112	44.5	82	84	85	87	88	90	91	93	94	96	97	98	100	102	103	105	106	108	109	111	112
113	45.0	83	84	86	87	89	91	92	93	95	96	98	99	101	102	104	105	107	108	110	111	113
114	45.5	83	85	86	88	89	91	92	94	96	97	99	100	102	103	105	106	108	109	111	112	114
115	46.0	84	85	87	88	90	91	93	95	96	98	99	101	102	104	106	107	109	110	112	113	115
116	46.5	84	86	87	89	90	92	94	95	97	98	100	102	103	105	106	108	110	111	113	114	116
117	47.0	85	86	88	89	91	93	94	96	98	99	101	102	104	106	107	109	111	112	114	115	117
118	48.0	85	87	88	90	92	94	95	97	98	100	102	103	105	106	108	110	111	113	115	116	118
119	48.5	85	87	89	90	92	94	96	97	99	101	102	104	106	107	109	111	112	114	116	117	119
120	49.0	86	88	89	91	93	95	96	98	100	101	103	105	106	108	110	111	113	115	117	118	120

Stress threshold: Respiration rate exceeds 60 BPM. Milk yield losses begin. Repro losses detectable. Rectal temperature exceeds 38.5°C (101.3°F)

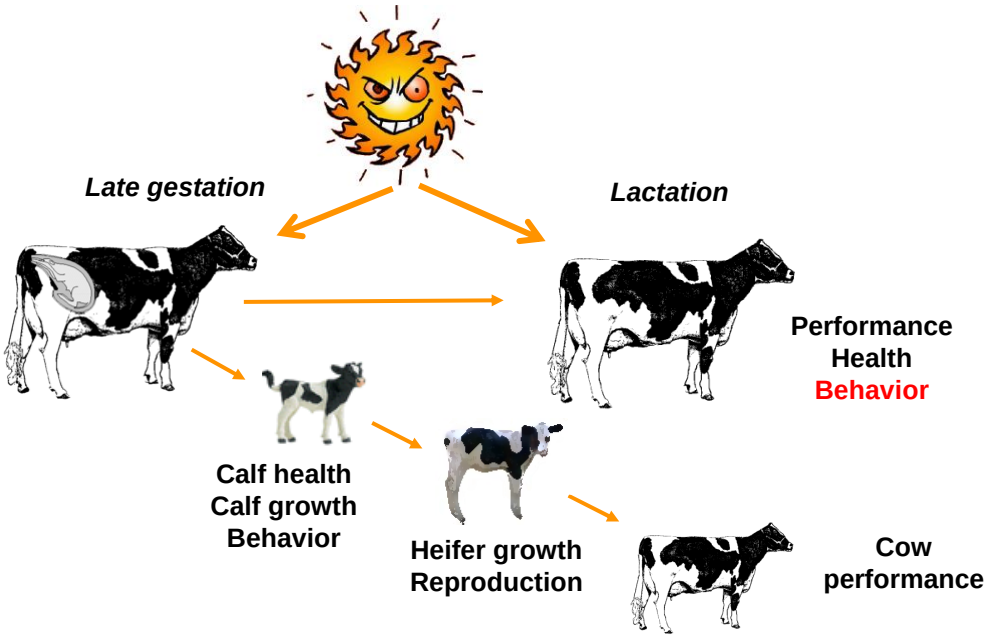
Mid-Moderate Stress: Respiration rate exceeds 75 BPM. Rectal temperature exceeds 39°C (102.2°F)

Moderate-Severe Stress: Respiration rate exceeds 85 BPM. Rectal temperature exceeds 40°C (104°F)

Severe Stress: Respiration rate 120-140 BPM. Rectal temperature exceeds 41°C (106°F)

Collier et al. (2012). Quantifying heat stress and its impact on metabolism and performance. UF-IFAS Ruminant Nutrition Symposium.

3



4

Typical Daily Time Budget of a Lactating Dairy Cow

Activity	Time devoted to activity per day
Eating	3 to 5 h (9 to 14 meals/d)
Lying/resting	12 to 14 h
Social interactions	2 to 3 h
Ruminating	7 to 10h
Drinking	30 min
Outside pen (milking, travel time)	2.5 to 3.5 h

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(Adapted from Grant and Albright, 2000).

5

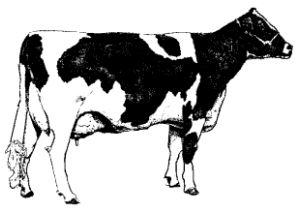
Behavioral Coping Strategies in Lactating Cows Exposed to Heat Stress

↓ Activity and Movement

Modified Drinking and Eating Behaviors

↓ Dry Matter Intake

↑ Standing time



↓ Rumination time

6

Behavior Measurements

- **Leg Tag:**
  Measure lying time, standing time, walking and standing events
- **Neck Tag:**
  Measure eating time and rumination time
- **Acclimation Period**

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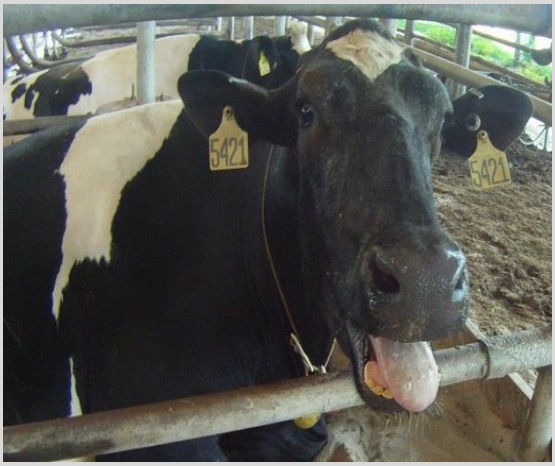
7

Effects of Exposure to Heat Stress During Late Gestation on the Daily Time Budget of Nulliparous Holstein Heifers



Toledo I.M., Ouellet V., Davidson B.D., Dahl G.E., and Laporta J. 2022. Effects of exposure to heat stress during late gestation on the daily time budget of nulliparous Holstein heifers. Front. Anim. https://doi.org/10.3389/fanim.2022.775272

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8

Hypothesis

Exposure of pregnant nulliparous Holstein heifers to hyperthermia during late gestation induces behavior modifications that have lingering effects during lactation.

9

Objectives

To characterize natural behaviors of nulliparous Holstein heifers 60 d pre-and postpartum and examine the effects of late gestation heat stress on those behaviors.

10

Design and Management

- 25 multiparous lactating Holstein heifers (~60 d before expected calving)
- Measurements recorded for each cow during 60 d pre and postpartum
- **Temperature and Humidity Index:** was assessed during the entire study period through HOBO devices.
- **Physiological measurements:** Davidson et al., J. Dairy Sci. 104:2357-2368.

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11

Design and Management

Cool Treatment (n=12) ← Sand bedded free stalls → Heat Stress Treatment (n=13)

12

Design and Management

- **Leg Tag:**
  Measure lying time, standing time, walking and standing events
- **Neck Tag:**
  Measure eating time and rumination time
- **Acclimation Period:** 7 days after leg and neck tags were placed

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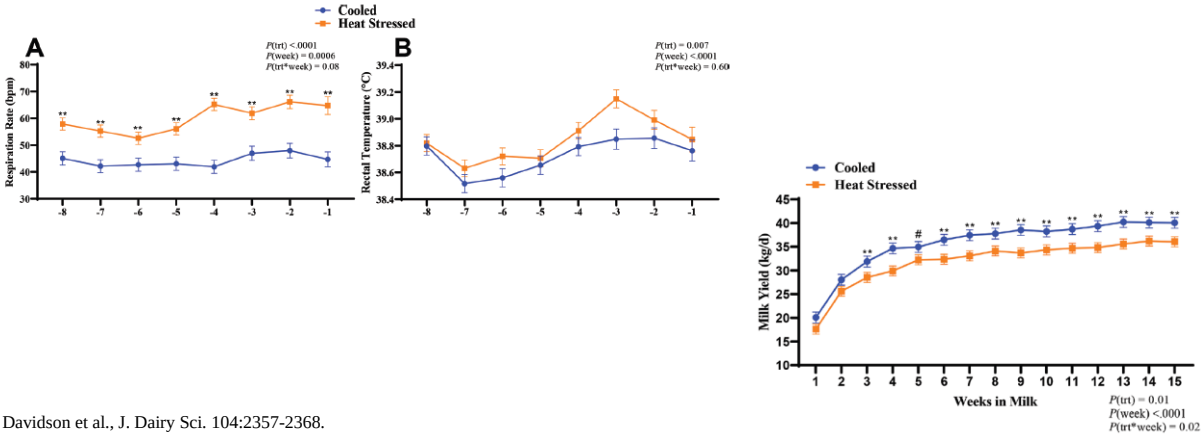
13

Results

14

Heat Stress Affects Respiration Rate, Rectal Temperature and Milk Yield

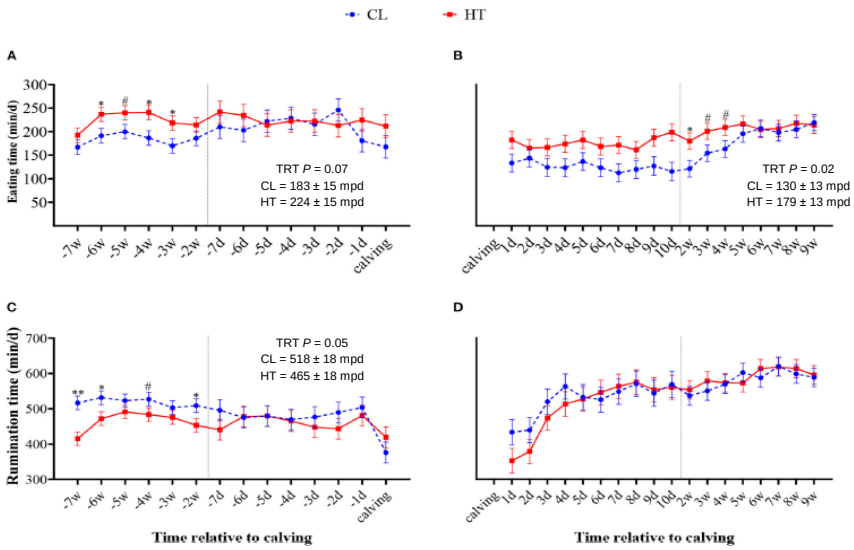
THI CL and HT = 77.3



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

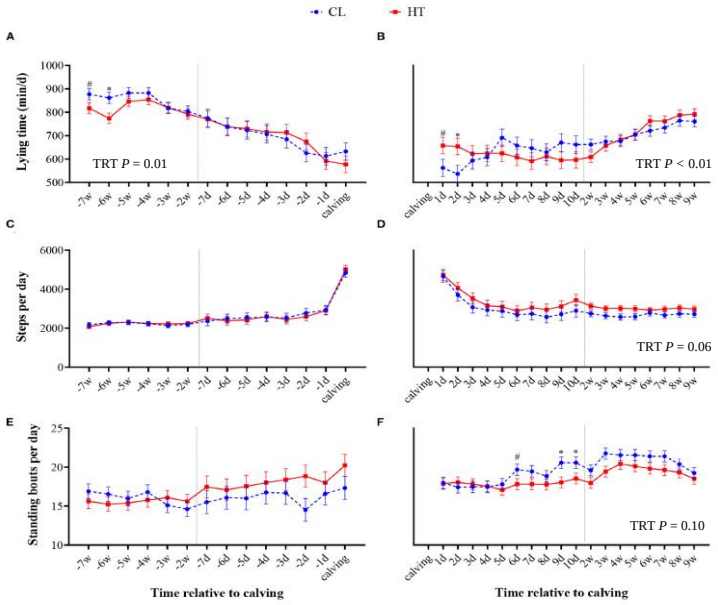
15

Heat Stress Affects Eating and Rumination Times During the Pre and Postpartum Periods



16

Lying Time, Steps by Day and Standing Bouts per Day During the Pre and Postpartum Periods



17

Heat Stress Affects Eating Frequency and Meal Sizes during the Pre and Postpartum Periods

- Eating frequency of HT and CL heifers was similar during pre- and postpartum.
- HT had larger meals at night during both the pre- and postpartum periods compared to CL heifers.

18

Eating, Rumination, and Lying times (min/d) of Late Gestation Nulliparous Heifers and Late Gestation Dry Cows

	Late-gestation Nulliparous Heifers[1]		Calving week Nulliparous Heifers[2]		Late-gestation cows[3]		
Behavior/Treatments[4]	CL/TN	HT	CL/TN	HT	CL/TN	HT	References
Eating, min/d							
	183	224	209	223	166	147	Karimi et al., 2015
					205	–	Schirmann et al., 2013
Rumination, min/d							
	518	465	471	456	655	–	Ouellet et al., 2016
					283	243	Karimi et al., 2015
Lying, min/d							
	854	817	687	689	962	–	Jensen et al., 2012
					1050	966	Karimi et al., 2015
					768	–	Ouellet et al., 2016

[1]Behaviors automatically recorded from 7 to 2 weeks before calving in the present study
[2]Behaviors automatically recorded during the last 7 days before calving in the present study
[3]Behaviors automatically recorded during the 3 weeks before calving or last 7 days before calving retrieved in different studies
[4]CL/TN = animals exposed to active cooling by fans and soakers or housed in thermoneutral conditions; HT = animals deprived of cooling or exposed to high temperature-humidity index

19

Eating, Rumination, and Lying Times (min/d) in Postpartum Nulliparous Heifers and Lactating Cows

	Postpartum Nulliparous Heifers[1]		Calving week Nulliparous Heifers[2]		Lactating cows[3]		
Behavior/Treatments[4]	CL/TN	HT	CL/TN	HT	CL/TN	HT	References
Eating, min/d							
	130	179	180	209	224	–	King et al., 2016
Rumination, min/d							
	511	496	588	593	340–410	–	Pahl et al., 2015
					535–545	493–520	Müschner-Siemens et al., 2020
Lying, min/d							
	637	604	666	638	660–720	–	Cook et al., 2004b
					600	480	Cook et al., 2007
					540	360	Nordlund et al., 2019

[1]Behaviors automatically recorded from 0 to 10 days postpartum in the present study
[2]Behaviors automatically recorded from 2 to 9 weeks postpartum in the present study
[3]Behaviors automatically recorded during in lactating multiparous cows
[4]CL/TN = animals exposed to active cooling by fans and soakers or housed in thermoneutral conditions during the last 60 days of gestation; HT = animals deprived of cooling or exposed to high temperature-humidity index during last 60 days of gestation

20

Summary

- Heat stress during the last 60 d of gestation altered the behavior of nulliparous heifers and had lingering effects after parturition.

- Heat-stressed heifers adapted their behavior by increasing feeding time and meal size at night and by reducing rumination and lying during the *prepartum* period.

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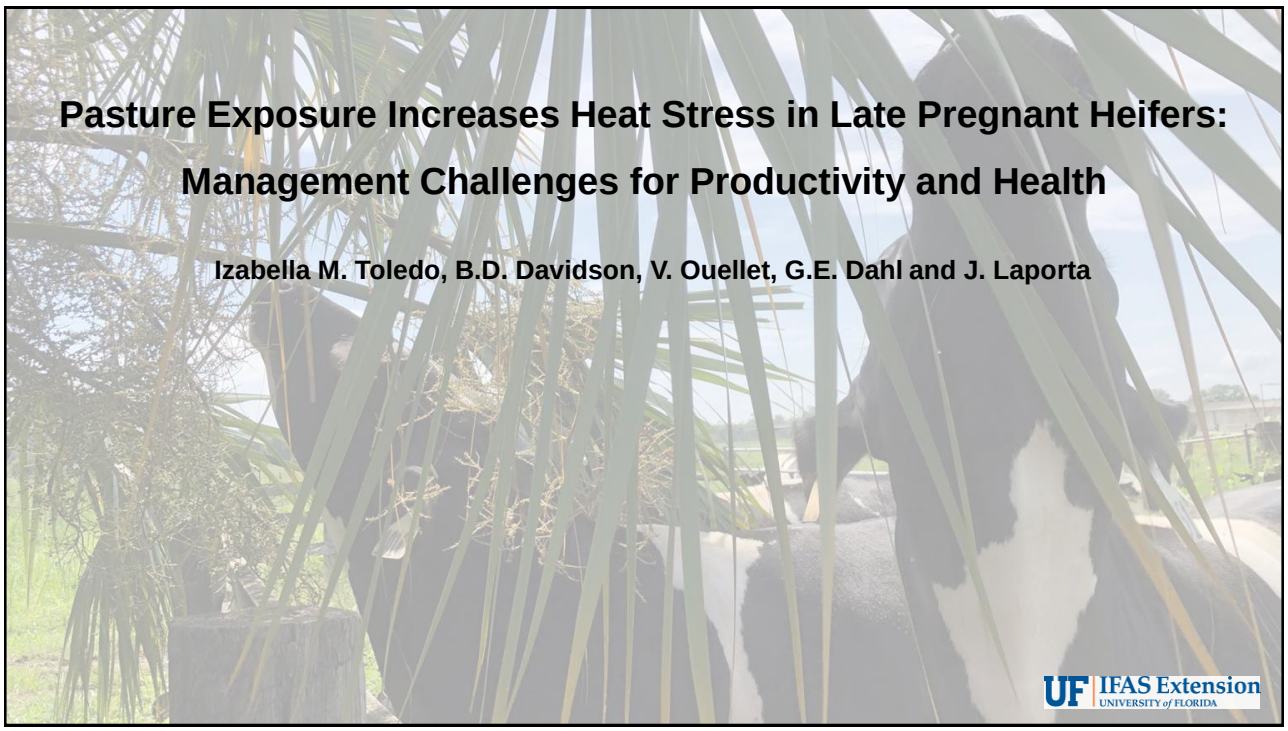
21



22

Objective

To have a better understanding of how heat stress affects the daily time budget of late gestation dairy heifers in order to adapt management practices in adverse conditions.

23

Design and Management

- 17 Holstein dairy heifers
- Treatments:
  - Pasture (PA; n= 6)
  - Heat Stress (HT; n=6)
  - Cooling (CL; n=5)
- **Study Period:** measurements were recorded for each cow for 14 days
- **Respiration Rate (**breaths/min) were recorded thrice weekly
- **Temperature and Humidity Index** was measured during the entire study through HOBO devices.
- **Black Globe Temperature** was measured during the entire study period by using a black globe temperature sensor.

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24

Design and Management

Heat Stressed Heifers:
- Sand bedded free stalls

Cooled Heifers:
- Sand bedded free stalls
- Fans over stalls
- Soakers over feedline
- Fans on at 70º F (21.1ºC)
- Soakers on 1 min every 5 min at 72º F

Pastured Heifers:
- Portable shade shelters

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25

Design and Management

- **Leg Tag:**

Measure lying time, standing time, walking and standing events

- **Neck Tag:**

Measure eating time and rumination time

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26

27

Temperature-Humidity Index, Black Globe Temperature and Respiration Rate During the Study Period

- Temperature-Humidity Index averaged 78.0 in the pasture and 77.3 in the free-stall barn
- Black Globe Temperature averaged 29 °C
- Respiration Rates ($P < 0.01$)
  - Cooled Heifers: 48 ± 2.11 bpm
  - Heat Stressed Heifers: 61 ± 8.69 bpm
  - Pastured Heifers: 96 ± 2.14 bpm

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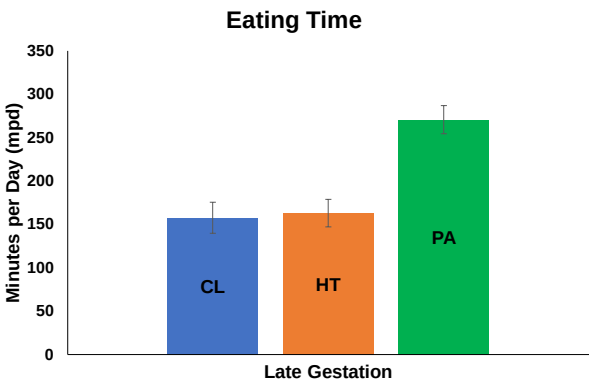
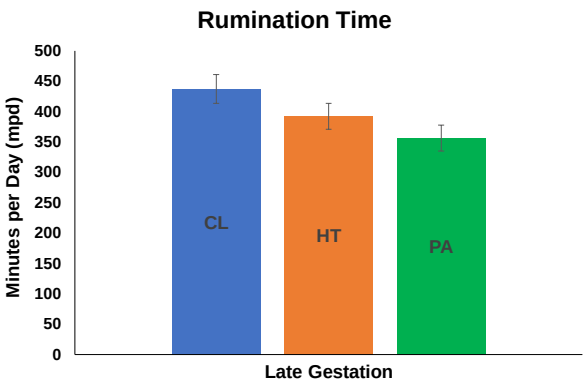
28





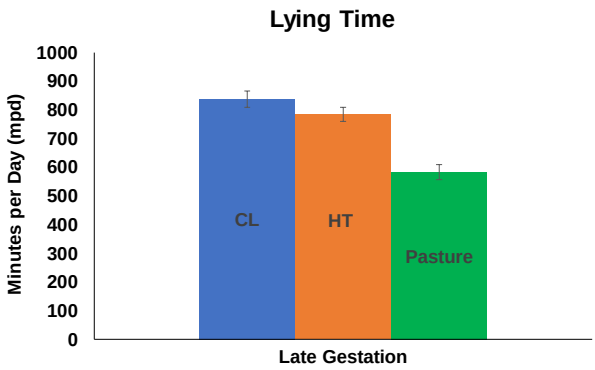
CL vs HT $P = 0.97$
CL vs PA $P < 0.01$
HT vs PA $P < 0.01$

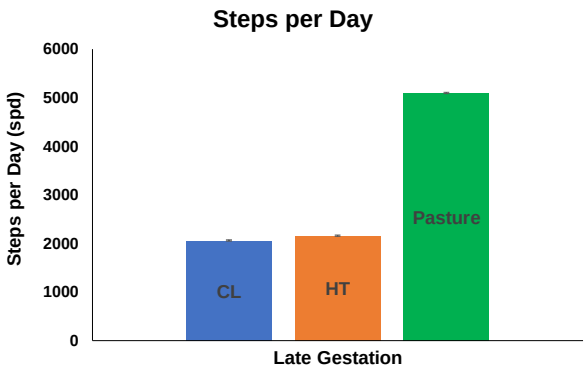
CL = 158 ± 18 mpd
HT = 163 ± 16 mpd
PA = 270 ± 16 mpd

CL vs HT $P = 0.36$
CL vs PA $P = 0.05$
HT vs PA $P = 0.48$

CL = 438 ± 24 mpd
HT = 392 ± 22 mpd
PA = 357 ± 21 mpd

29





CL vs HT $P = 0.35$
CL vs PA $P < 0.01$
HT vs PA $P < 0.01$

CL = 877 ± 28 mpd
HT = 784 ± 24 mpd
PA = 583 ± 26 mpd

CL vs HT $P = 0.92$
CL vs PA $P < 0.01$
HT vs PA $P < 0.01$

CL = 2060 ± 200 spd
HT = 2159 ± 179 spd
PA = 5097 ± 184 spd

30

Summary

- Exposure to heat stress during late gestation affects the daily time budget of first lactation heifers, especially if they are kept in pasture conditions.

- Insights onto heat stress effects in the daily time budget of late gestation heifers may contribute to the development of more effective management strategies to decrease the possible negative effects of heat exposure.

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31

Seasonal Effects on Multiparous Lactating Dairy Cow Behavior

Izabella M. Toledo, L.T. Casarotto and G.E. Dahl

JDS Communications, accepted.

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32

Hypothesis

Seasonal changes will affect the behavior of multiparous lactating dairy cows housed in free-stall facilities and exposed to active cooling.

33

Objectives

To have a better understanding of how seasonal changes affect the daily activities and the behavior of multiparous dairy cows.

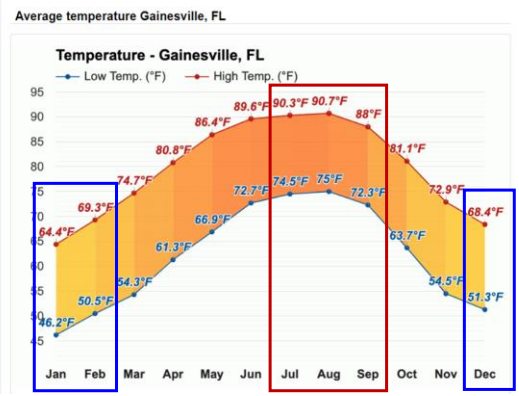
34

Design and Management

- **34 multiparous lactating Holstein cows**
- **2 Treatments:**

Hot Season:
HS; July, August and September; n=19

Cool Season
CS; December, January and February; n=15



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35

Design and Management

- **Study Period:** measurements were recorded for each cow during the first 9 weeks of lactation during the hot and cool seasons.
- **Temperature and Humidity Index,** was assessed during the entire study period.

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36

Design and Management

- Sand bedded free stalls
- Fans over stalls
- Soakers over feedline
- Fans on at 70º F (21.1ºC)
- Soakers on 1 min every 5 min at 72º F
- Lights were on for 14h/day

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37

Design and Management

- **Leg Tag:**
  Measure lying time, standing time, walking and standing events
- **Neck Tag:**
  Measure eating time and rumination time
- **Acclimation Period**

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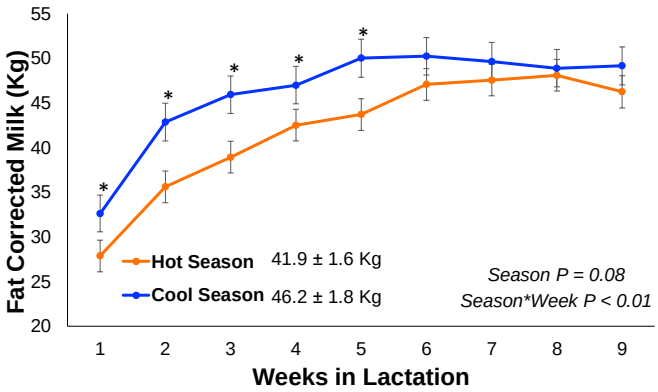
38

39

Seasonal Changes Affect Milk Production of Lactating Dairy Cows

- THI Cool Season: 54.4
- THI Hot Season: 78.2



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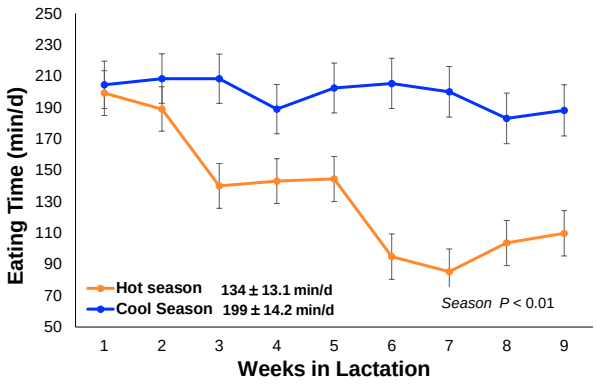
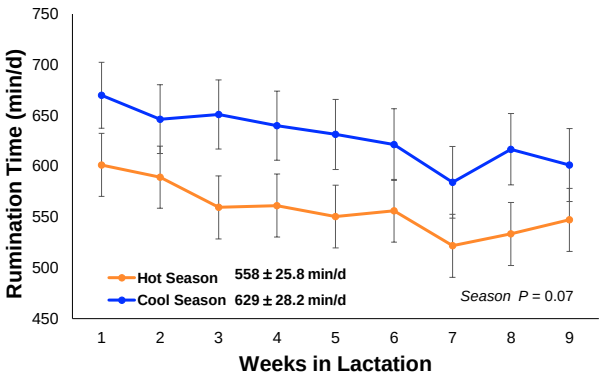
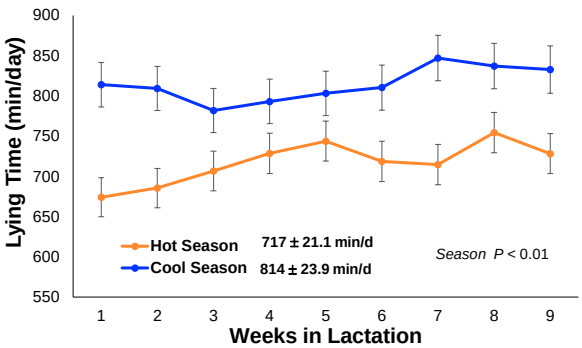
Eating and Rumination During the Cool and Hot Seasons

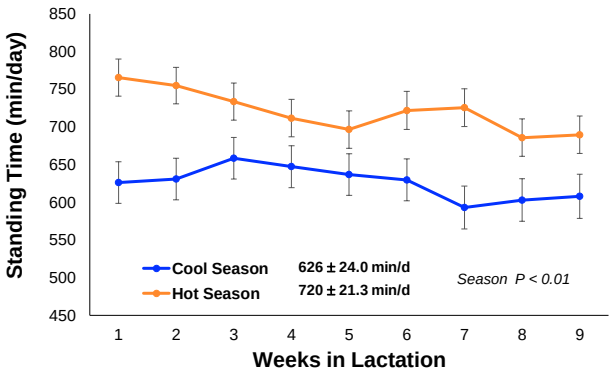




41

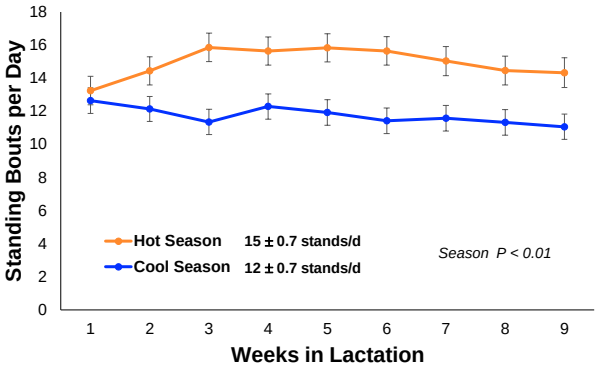
Lying Time and Standing Time During the Cool and Hot Seasons

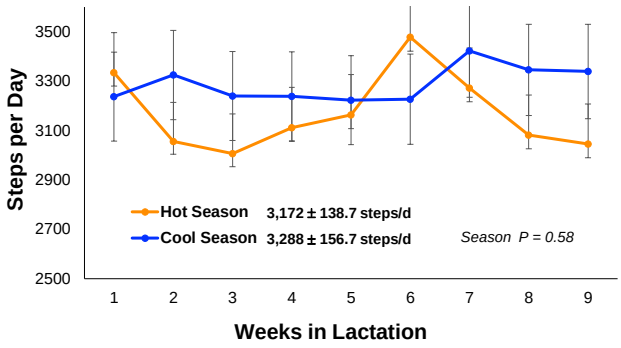




42

Standing Bouts and Standing Time per Day During the Cool and Hot Seasons





43

Summary

- Seasonal changes affect milk production of multiparous dairy cows.
- Exposure to heat during lactation seems to negatively affect the behavior and the daily time budget of lactating Holstein cows even in free-stall facilities with active cooling.
- A better understanding on how different seasons affect the daily time budget of lactating dairy cows may contribute to the development of more effective management strategies to decrease the negative effects of heat exposure.

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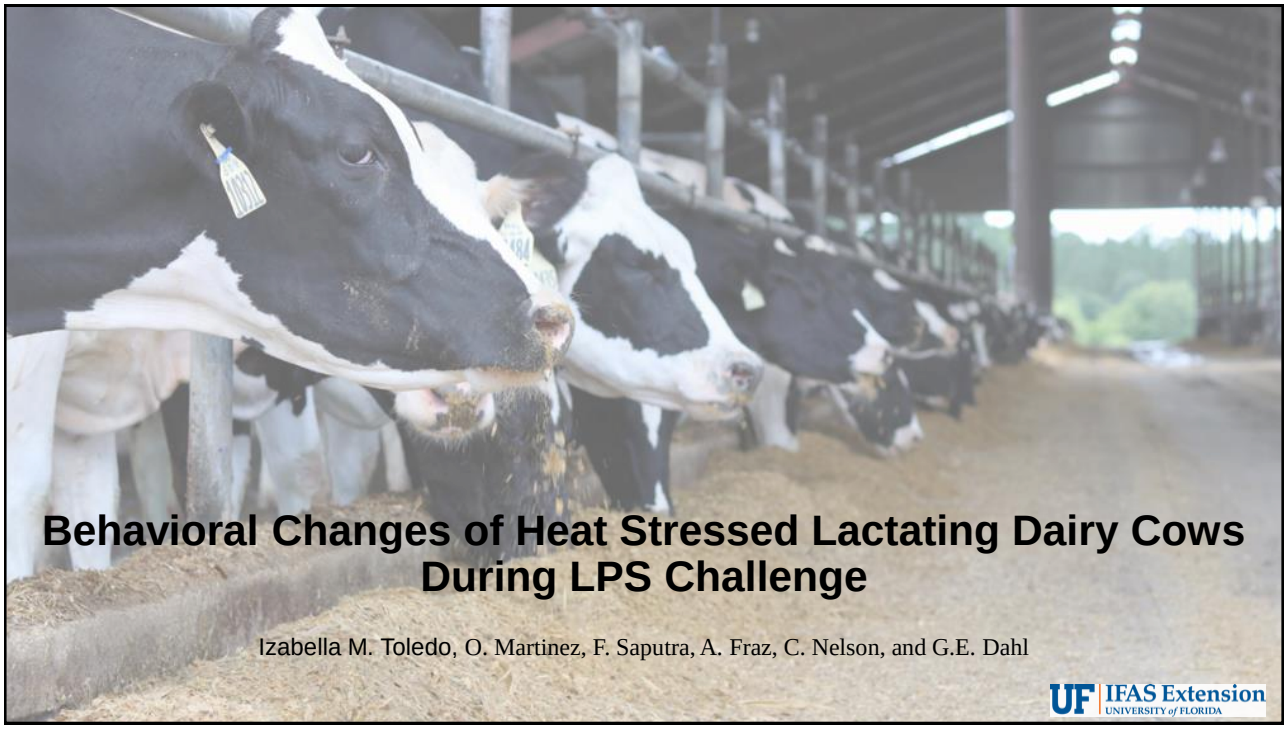
44



Behavioral Changes of Heat Stressed Lactating Dairy Cows During LPS Challenge

Izabella M. Toledo, O. Martinez, F. Saputra, A. Fraz, C. Nelson, and G.E. Dahl

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45

Hypothesis

Heat stress will affect the behavior of multiparous lactating dairy cows challenged with LPS.

46

Objective

To have a better understanding of how the development of intramammary infections affect the behavior of lactating dairy cows in heat stress conditions .

47

Design and Management

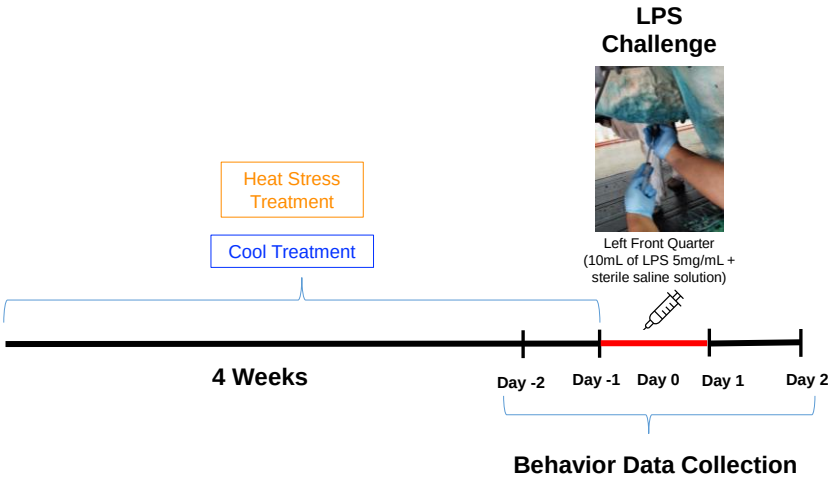
- 12 multiparous lactating Holstein cows
- Sand bedded free stalls
- **Temperature and Humidity Index,** was assessed during the entire study period

Cool Treatment (n=6)

Heat Stress Treatment (n=6)

48

Design and Management



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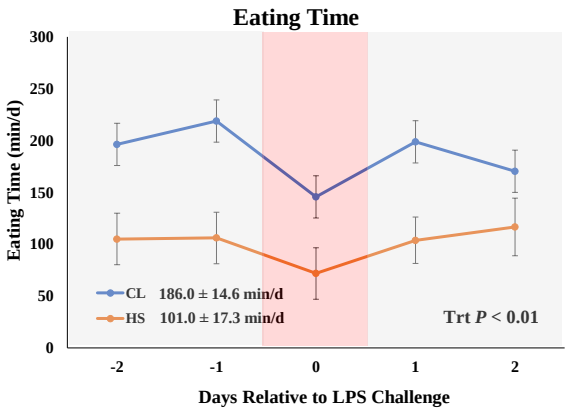
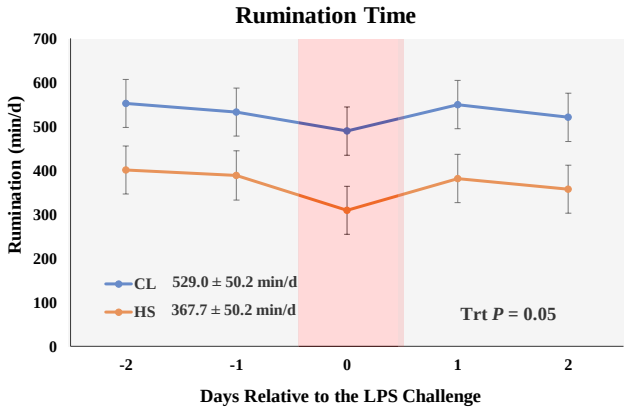
49

50

Heat Stress Affects Eating and Rumination Pre, During and Post LPS Challenge





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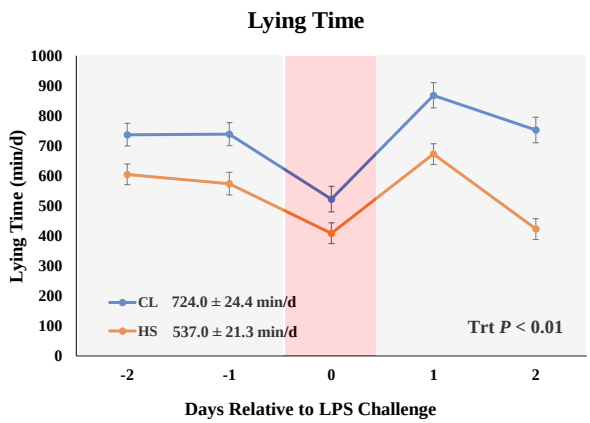
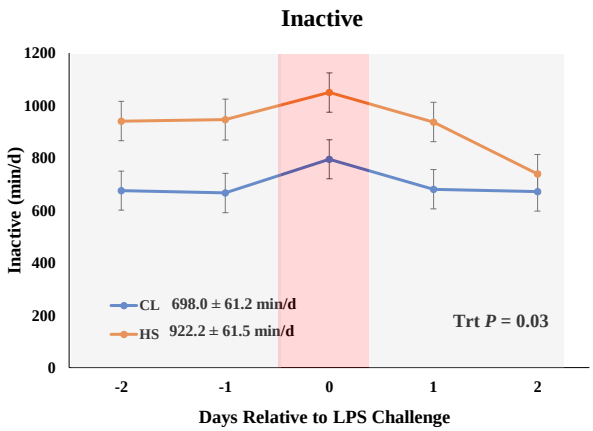
Heat Stress Affects Lying and Inactivity Pre, During and Post LPS Challenge





52

Heat Stress Does Not Affect Standing Bouts and Steps per Day

Behavior Activity	Cooled Cows	Heat Stressed Cows	*P*-value
Standing Bouts	13.5 ± 0.77	13 ± 0.65	0.61
Steps per Day	2,716 ± 142	2,524 ± 123	0.33

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53

Summary

- Exposure to heat affects the behavior of lactating dairy cows.
- Heat stress affects behavior of lactating dairy cows independently of the development of intramammary infections.
- Heat stress effects on behavior is not a good parameter to be used to monitor the development of intramammary infections.

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54

Take Home Message

- Exposure to heat stress affects the behavior of dairy cows at different stages of the lactation cycle
- Exposure to heat during lactation negatively affect the behavior and the daily time budget of lactating Holstein cows even in free-stall facilities with active cooling.
- Insights onto heat stress effects in the daily time budget of dairy cows during different seasons and stages of the lactation cycle may contribute to the development of more effective management strategies to decrease the possible negative effects of heat exposure.

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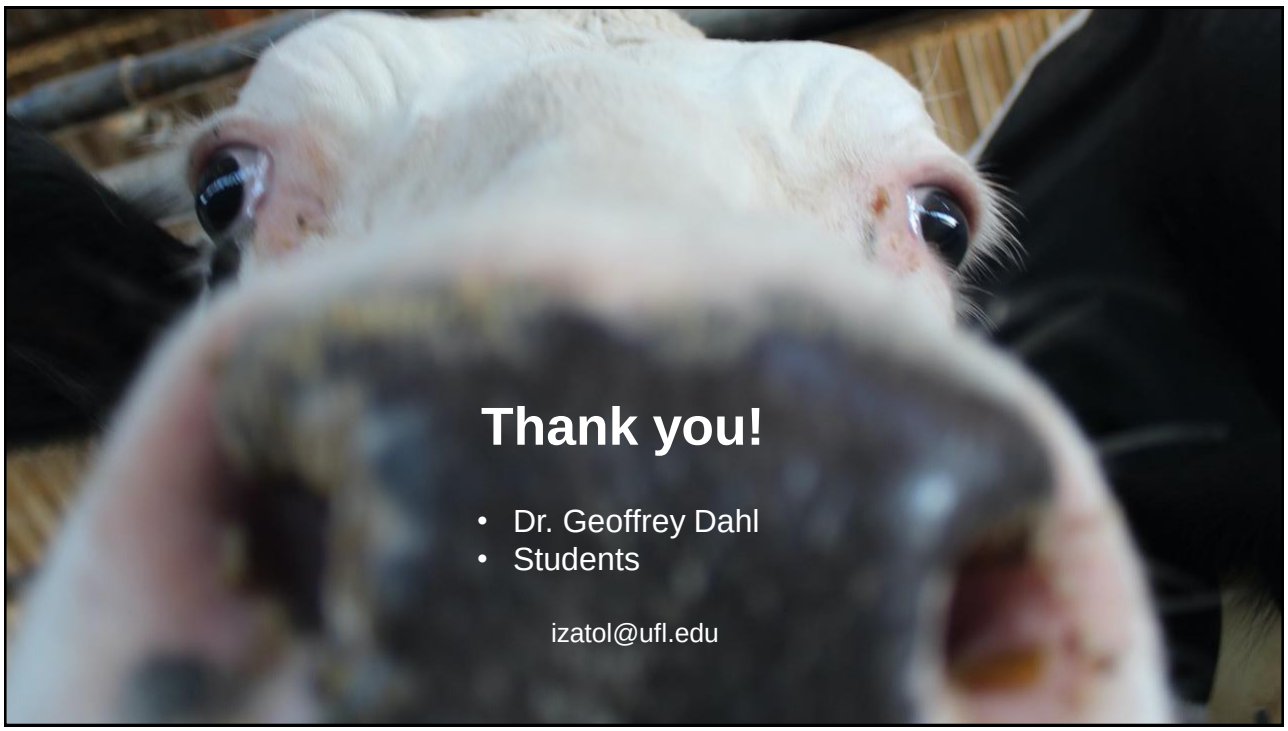
55



56