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Heat stress in Beef Cattle

2022 Ona Highlight



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Presentation Overview

Introduction and current challenges

On-going studies:

- Nutritional strategy for replacement heifers
- Management of pregnant heifers
- Pre- and postnatal heat-stress mitigation



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Heat stress – Livestock production

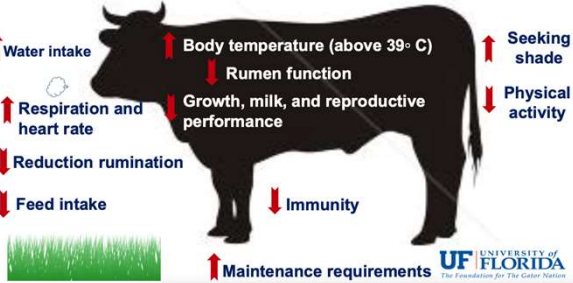
- Annual losses of \$900 million for dairy and \$300 million for beef and swine in the U.S. (St. Pierre et al., 2003; Pollman, 2010)
 - Large constraint to maximizing animal productivity
 - Compromises almost every metric of animal agriculture profitability

Develop strategies (genetic, management, nutritional, and pharmaceutical) to alleviate heat stress and optimize animal well-being, improving the sustainable production of high-quality protein for human consumption.

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Behavioral and Physiological Adaptations

Climatic variables that compromise heat dissipation: high air temperature, relative humidity, and solar radiation, associated with low wind speed



Slide from Drs. Silva & DiLorenzo – Marianna/NFREC

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Gestational heat stress – Dairy Cattle

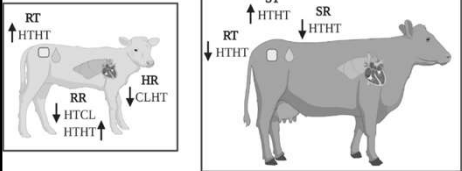
- Reduced fetal growth and birth weight by 9 lb (Tao et al., 2019)
- Reduced weaning weights by 18 lb (Tao et al., 2019)
 - Remained after 1 year of age (Monteiro et al., 2016ab)
- Reduced calf postnatal body weight, passive immunity
 - Reduced apparent efficiency of IgG absorption (Tao et al., 2012b)
 - Reduced cellular immunity and proliferation rate of peripheral blood mononuclear (Tao et al., 2012a)
 - Suggestive of underdeveloped immune organs due to maternal in utero heat stress
- Reduced milk production of dairy heifers by 8 lb/day during first and second lactations (Laporta et al., 2018)
 - Transgenerational effects reducing milk yield of the dam's granddaughters (Laporta et al., 2020)

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Gestational heat stress – Dairy Cattle

(A, Dado-Senn et al., 2020a) (B, Ahmed et al., 2017)




Heat stress during late gestation decreased heat tolerance immediately after birth, but increased heat tolerance at maturity by increasing capacity to dissipate heat and maintain core body temperature.

(A) Calves exposed to in-utero heat stress then postnatal heat stress (HTHT) had a higher rectal temperature (RT) and respiration rate (RR). Calves exposed to in-utero cooling then heat stressed postnatally had the lowest heart rate (HR).

(B) Heifers exposed to in-utero heat stress and then heat-stressed during lactation had a lower RT and sweating rate (SR) but a higher skin temperature (ST).

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Challenges – Heat Stress in grazing systems 

- Limited options to alleviate heat stress compared to feedlot system
- Heat stress effects vary among breeds
 - *B. indicus*-influenced cattle display different physiology, metabolism and growth compared to *B. taurus* cattle under similar management (Cooke et al., 2020; Ranches et al., 2021)
- No evidence of impacts of heat stress during gestation on beef progeny performance

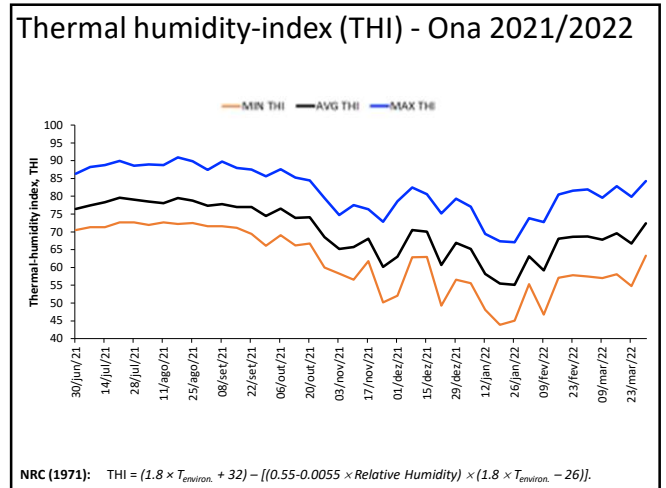
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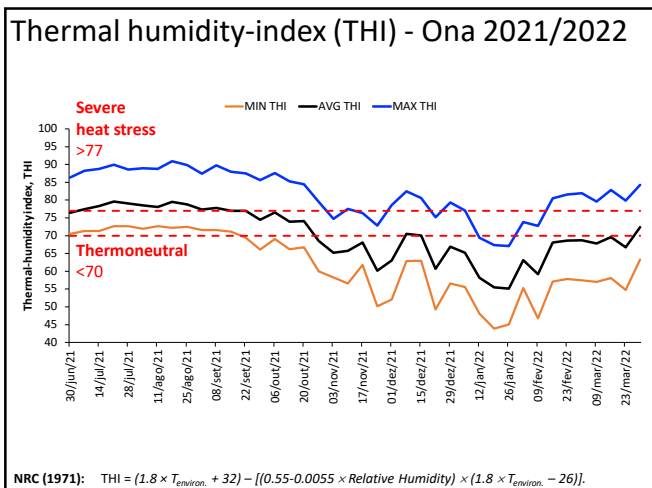
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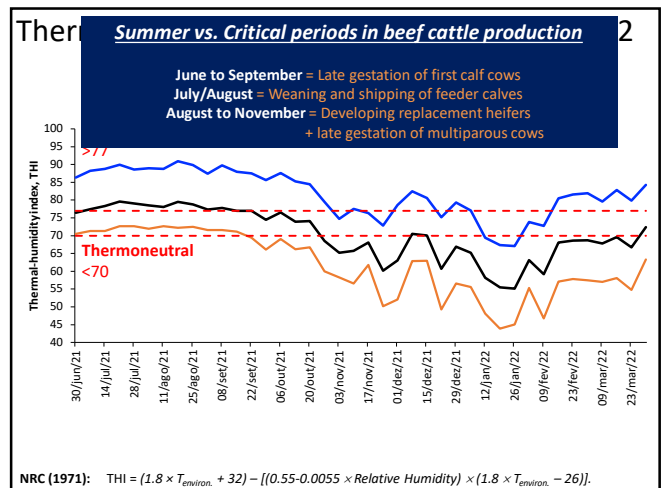
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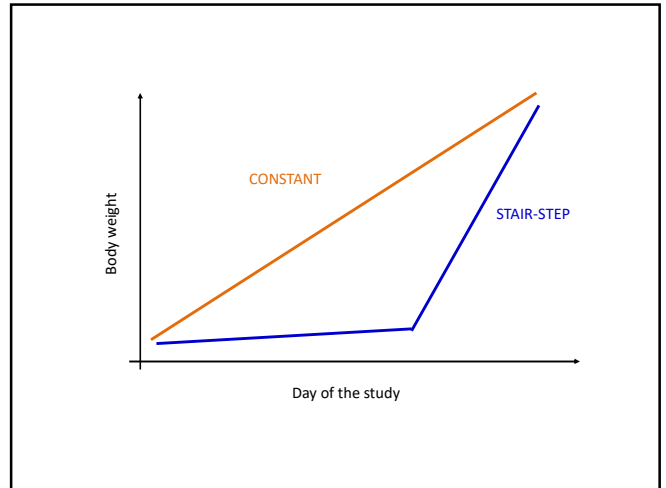
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STRATEGIES TO BOOST PUBERTY ATTAINMENT

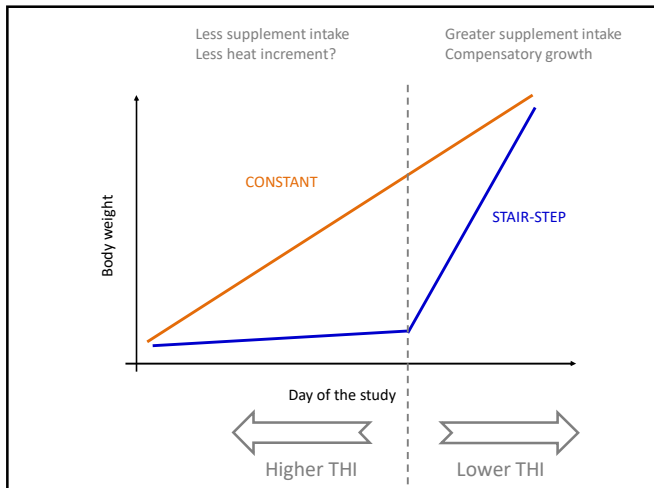
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Stair-step strategy

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Boosting reproduction without increasing feed costs of beef heifers in Florida
 Funded by Florida Cattlemen Enhancement Board - 2019/2020


Sep. 2019 to June 2020 (Yr 1) and Sep. 2020 to June 2021 (Yr 2)

- 64 Brangus heifers per year assigned to 16 bahiagrass pastures
- Treatments assigned to pastures (8 pastures/treatment/year):

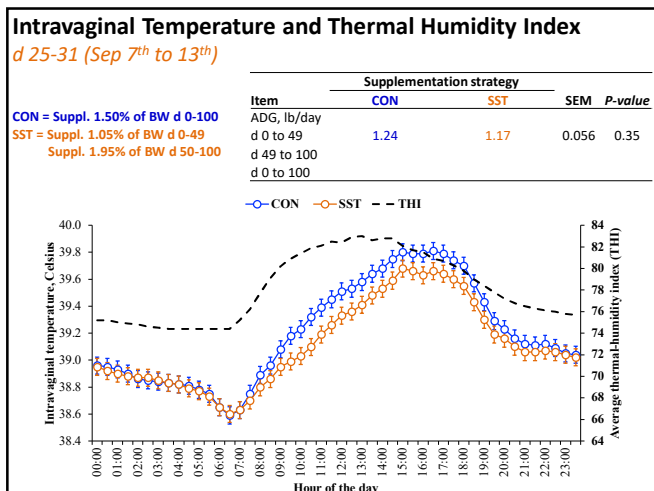
CONTROL = concentrate supplementation at **1.50% of body weight** from September until the start of the estrous synchronization (November; **d 0 to 100**)

STAIRSTEP = concentrate supplementation at **1.05% of body weight** from Aug. to Sep. (**d 0 to 49**) + **1.95% of body weight** until the start of the estrous synchr. (**d 50 to 100**).

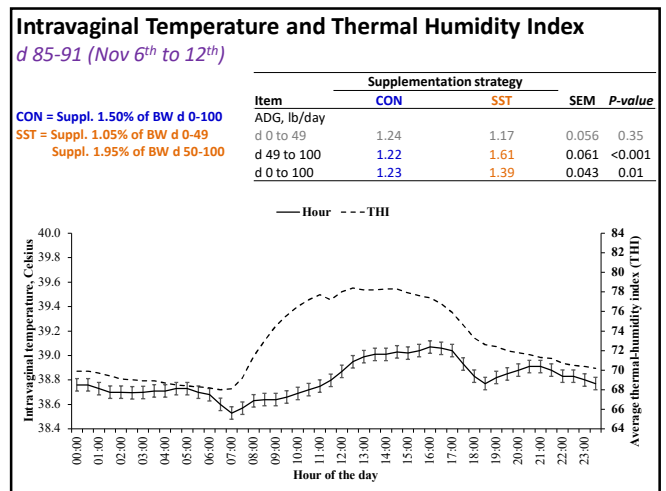
After d 100, all heifers were managed similarly:
 AI from d 113 to 115; Timed-AI on d 115
 Bulls from d 121-211
 Concentrate supp. at 1.50% of BW until d 211



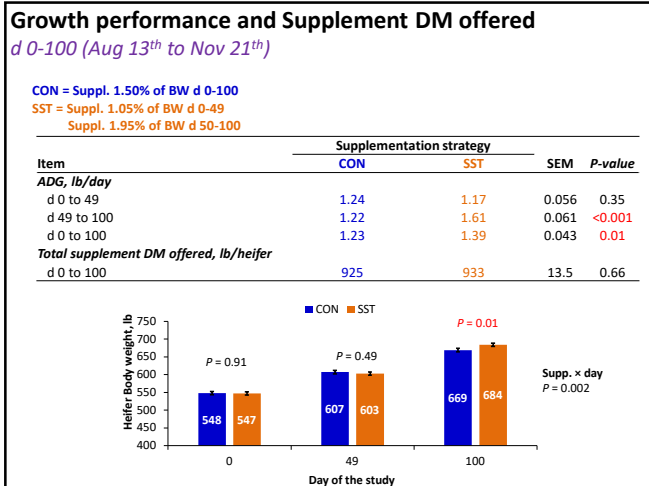
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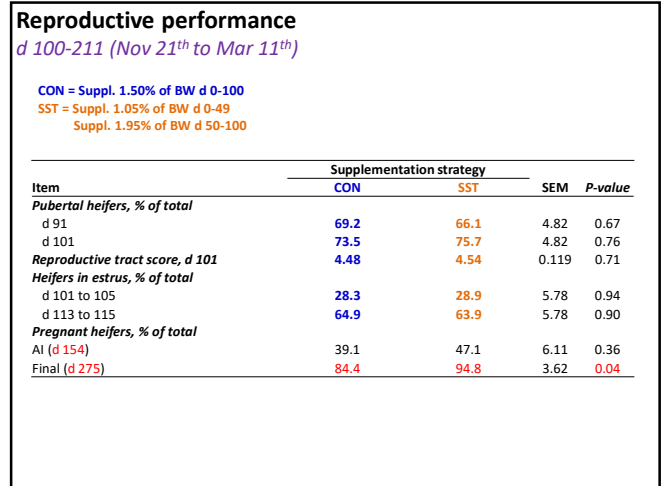
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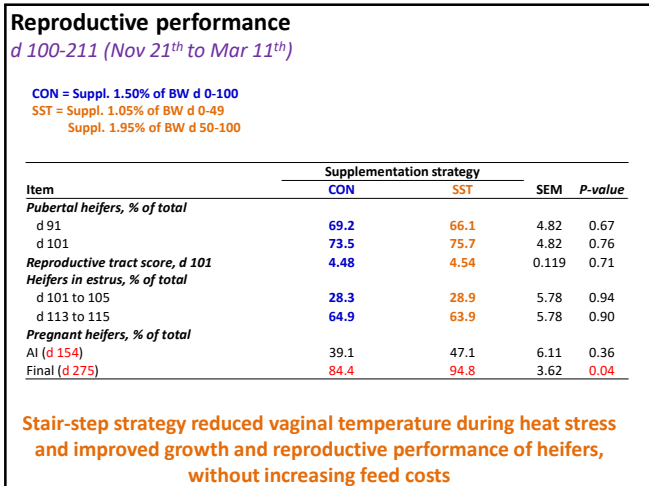
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Ongoing research studies

Management to alleviate heat stress and promote growth and reproductive performance of beef females in tropical/subtropical environments

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Artificial shade

- Protect cattle from direct solar radiation exposure using natural or artificial shade (Rovira and Velazco, 2010)
- Reduce total heat load by 30-50%, rectal temperatures (38.9 vs. 39.4°C) and respiratory rate (54 vs. 82 breaths/min) compared to a non-shaded environment (Collier et al., 2006)

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Study 1 - Effects pre- and post-partum access to shade on thermoregulation of Brangus heifers and growth and physiological responses of their offspring

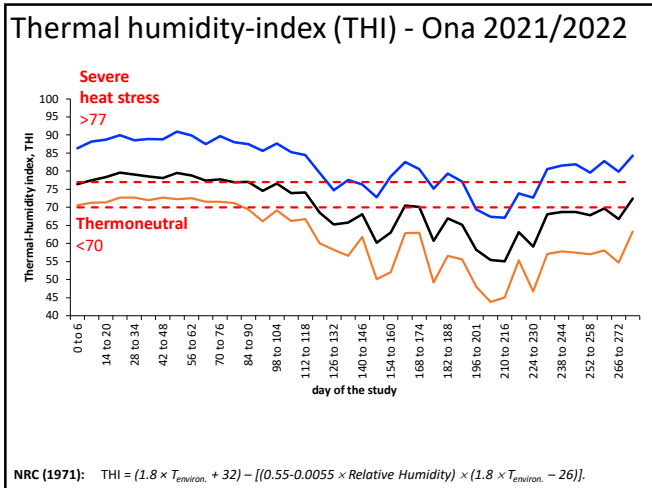
- 64 Brangus, pregnant beef heifers on bahiagrass pastures
- Treatments (July until end of the calving season):
 - No access to shade (NS);
 - Access to shade (SH);

Treatment Period	Access to Shade	Management
Day 0 to 133	NS = No Shade SH = Access to artificial Shade	8 pastures; 4 heifers per pasture
Day 133 to 200	NS = No Shade SH = Access to artificial Shade	8 pastures; 4 heifers per pasture
Day 200 to 270	NS = No Shade SH = Access to artificial Shade	8 pastures; 4 heifers per pasture

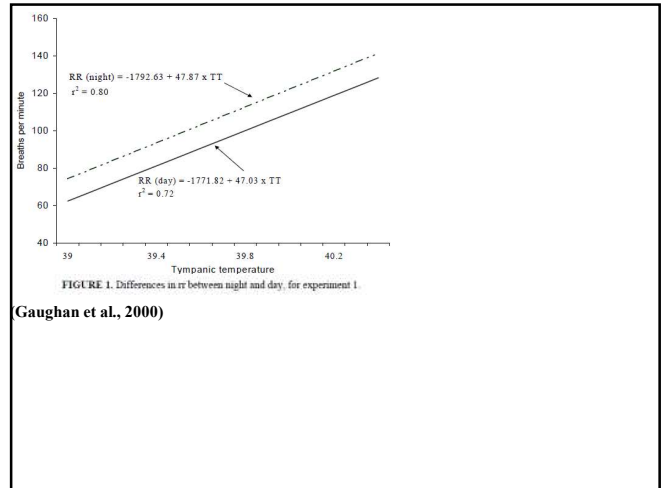
Day 210 to 270

- Calves sorted by previous group distribution and randomly allocated into 1 of 16 drylot pens (3 to 4 calves/pen).
- All calves provided a soybean hulls-based diet at 3.3% of body weight (Dry matter basis).
- All calves vaccinated against pathogens associated with bovine respiratory disease using a standard vaccination protocol (2 mL s.c. Bovishield Gold One Shot on day 225, and then 2 mL s.c. Bovishield Gold 5 on day 240).

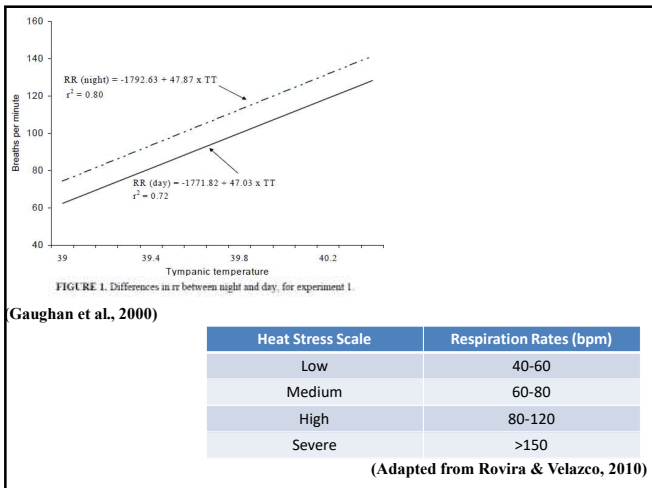
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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).

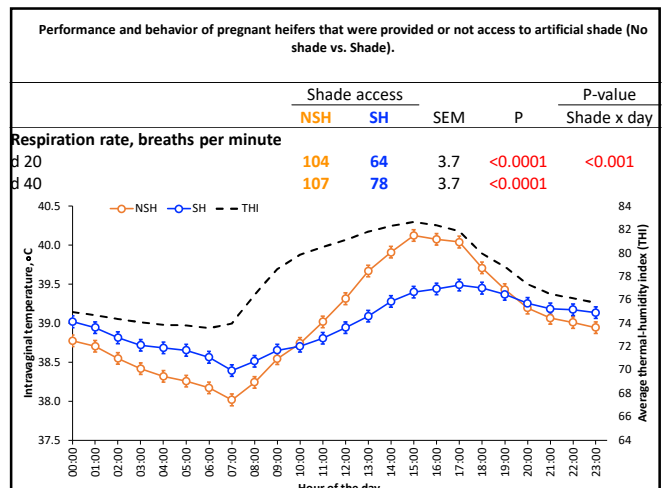
	Shade access		SEM	P	P-value Shade x day
	NSH	SH			
Respiration rate, breaths per minute					
d 20	104	64	3.7	<0.0001	<0.001
d 40	107	78	3.7	<0.0001	
d 56					
d 76					
d 96					
d 126					

Heat Stress Scale	Respiration Rates (bpm)
Low	40-60
Medium	60-80
High	80-120
Severe	>150

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access		SEM	P	P-value
	NSH	SH			Shade x day
Rectal temperature, C					
d 0 (start of the study)	39.7	39.7	0.07	0.96	0.05
d 34	39.4	39.6	0.07	0.02	
d 55 (near calving)					
d 125 (after calving)					
Body surface temperature, C					
d 0 (start of the study)					
d 34					
d 55 (near calving)					
d 125 (after calving)					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access		SEM	P	P-value
	NSH	SH			Shade x day
Rectal temperature, C					
d 0 (start of the study)	39.7	39.7	0.07	0.96	0.05
d 34	39.4	39.6	0.07	0.02	
d 55 (near calving)					
d 125 (after calving)					
Body surface temperature, C					
d 0 (start of the study)	34.2	33.9	0.20	0.30	0.006
d 34	31.8	32.4	0.20	0.07	
d 55 (near calving)					
d 125 (after calving)					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access		SEM	P	P-value
	NSH	SH			Shade x day
Heifer BCS					
d 0 (start of the study)	6.34	6.35	0.077	0.98	0.0001
d 34	6.06	6.05	0.077	0.93	
d 55 (near calving)					
d 125 (after calving)					
d 202 (start of the breeding season)					
d 281 (end of the breeding season)					
Heifer BW, lb					
d 0 (start of the study)					
d 34					
d 55 (near calving)					
d 125 (after calving)					
d 202 (start of the breeding season)					
d 281 (end of the breeding season)					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access		SEM	P	P-value
	NSH	SH			Shade x day
Heifer BCS					
d 0 (start of the study)	6.34	6.35	0.077	0.98	0.0001
d 34	6.06	6.05	0.077	0.93	
d 55 (near calving)					
d 125 (after calving)					
d 202 (start of the breeding season)					
d 281 (end of the breeding season)					
Heifer BW, lb					
d 0 (start of the study)	998	998	12.3	0.99	0.08
d 34	1017	1033	12.3	0.38	
d 55 (near calving)					
d 125 (after calving)					
d 202 (start of the breeding season)					
d 281 (end of the breeding season)					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access		SEM	P	P-value
	NSH	SH			Shade x day
Respiration rate, breaths per minute					
d 20	104	64	3.7	<0.0001	<0.001
d 40	107	78	3.7	<0.0001	
d 56	101	72	3.7	<0.0001	
d 76	89	65	3.7	0.0001	
d 96	67	46	3.7	0.0007	
d 126	49	43	3.7	0.30	

Heat Stress Scale	Respiration Rates (bpm)
Low	40-60
Medium	60-80
High	80-120
Severe	>150

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access		SEM	P	P-value
	NSH	SH			Shade x day
Rectal temperature, C					
d 0 (start of the study)	39.7	39.7	0.07	0.96	0.05
d 34	39.4	39.6	0.07	0.02	
d 55 (near calving)	40.1	40.4	0.07	0.0006	
d 125 (after calving)	39.3	39.3	0.07	0.50	
Body surface temperature, C					
d 0 (start of the study)	34.2	33.9	0.20	0.30	0.006
d 34	31.8	32.4	0.20	0.07	
d 55 (near calving)					
d 125 (after calving)					

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	NSH	SH	SEM		Shade x day
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d 34	39.4	39.6	0.07	0.02	
d 55 (near calving)	40.1	40.4	0.07	0.0006	
d 125 (after calving)	39.3	39.3	0.07	0.50	
Body surface temperature, C					
d 0 (start of the study)	34.2	33.9	0.20	0.30	0.006
d 34	31.8	32.4	0.20	0.07	
d 55 (near calving)	35.4	35.9	0.20	0.10	
d 125 (after calving)	33.5	34.7	0.20	<0.0001	

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access			P	P-value
	NSH	SH	SEM		Shade x day
Heifer BCS					
d 0 (start of the study)	6.34	6.35	0.077	0.98	0.0001
d 34	6.06	6.05	0.077	0.93	
d 55 (near calving)	6.15	6.43	0.077	0.01	
d 125 (after calving)	5.52	6.03	0.077	<0.0001	
d 202 (start of the breeding season)	5.39	5.75	0.077	0.001	
d 281 (end of the breeding season)	6.01	6.07	0.077	0.62	
Heifer BW, lb					
d 0 (start of the study)	998	998	12.3	0.99	0.08
d 34	1017	1033	12.3	0.38	
d 55 (near calving)					
d 125 (after calving)					
d 202 (start of the breeding season)					
d 281 (end of the breeding season)					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
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	NSH	SH	SEM		Shade x day
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d 34	6.06	6.05	0.077	0.93	
d 55 (near calving)	6.15	6.43	0.077	0.01	
d 125 (after calving)	5.52	6.03	0.077	<0.0001	
d 202 (start of the breeding season)	5.39	5.75	0.077	0.001	
d 281 (end of the breeding season)	6.01	6.07	0.077	0.62	
Heifer BW, lb					
d 0 (start of the study)	998	998	12.3	0.99	0.08
d 34	1017	1033	12.3	0.38	
d 55 (near calving)	996	988	12.3	0.67	
d 125 (after calving)	934	983	12.3	0.009	
d 202 (start of the breeding season)	912	926	12.3	0.43	
d 281 (end of the breeding season)	1011	1020	12.3	0.61	

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
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	NSH	SH	SEM		Shade x day
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d 34	6.06	6.05	0.077	0.93	
d 55 (near calving)	6.15	6.43	0.077	0.01	
d 125 (after calving)	5.52	6.03	0.077	<0.0001	
d 202 (start of the breeding season)	5.39	5.75	0.077	0.001	
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Heifer BW, lb					
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d 34	1017	1033	12.3	0.38	
d 55 (near calving)	996	988	12.3	0.67	
d 125 (after calving)	934	983	12.3	0.009	
d 202 (start of the breeding season)	912	926	12.3	0.43	
d 281 (end of the breeding season)	1011	1020	12.3	0.61	
Calf birth BW, lb					
	62	67	1.7		0.05
Calves born alive, % of total					
Calving date, day of the study					
Calf BW, lb					
d 202 (early-weaning)					
d 209 (drylot entry)					
d 268 (drylot exit)					
Calf ADG, lb/day					
birth to d 202					
d 209 to 268					
birth to d 268					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access			P	P-value
	NSH	SH	SEM		Shade x day
Calf birth BW, lb					
	62	67	1.7		0.05
Calves born alive, % of total					
	97	100	2.6	0.40	
Calving date, day of the study					
	80	88	4.1	0.17	
Calf BW, lb					
d 202 (early-weaning)					
d 209 (drylot entry)					
d 268 (drylot exit)					
Calf ADG, lb/day					
birth to d 202					
d 209 to 268					
birth to d 268					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).					
Item	Shade access			P	P-value
	NSH	SH	SEM		Shade x day
Calf birth BW, lb					
	62	67	1.7		0.05
Calves born alive, % of total					
	97	100	2.6	0.40	
Calving date, day of the study					
	80	88	4.1	0.17	
Calf BW, lb					
d 202 (early-weaning)	255	247	9.9	0.55	0.12
d 209 (drylot entry)	257	245	9.9	0.43	
d 268 (drylot exit)					
Calf ADG, lb/day					
birth to d 202	1.58	1.61	0.072	0.79	
d 209 to 268					
birth to d 268					

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).

Item	Shade access		SEM	P	Shade x day	P-value
	NSH	SH				
Calf birth BW, lb	62	67	1.7	0.05		
Calves born alive, % of total	97	100	2.6	0.40		
Calving date, day of the study	80	88	4.1	0.17		
Calf BW, lb						
d 202 (early-weaning)	255	247	9.9	0.55	0.12	
d 209 (drylot entry)	257	245	9.9	0.43		
d 268 (drylot exit)	408	385	9.9	0.12		
Calf ADG, lb/day						
birth to d 202	1.58	1.61	0.072	0.79		
d 209 to 268	2.56	2.41	0.081	0.17		

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Performance and behavior of pregnant heifers that were provided or not access to artificial shade (No shade vs. Shade).

Item	Shade access		SEM	P	Shade x day	P-value
	NSH	SH				
Calf birth BW, lb	62	67	1.7	0.05		
Calves born alive, % of total	97	100	2.6	0.40		
Calving date, day of the study	80	88	4.1	0.17		
Calf BW, lb						
d 202 (early-weaning)	255	247	9.9	0.55	0.12	
d 209 (drylot entry)	257	245	9.9	0.43		
d 268 (drylot exit)	408	385	9.9	0.12		
Calf ADG, lb/day						
birth to d 202	1.58	1.61	0.072	0.79		
d 209 to 268	2.56	2.41	0.081	0.17		
birth to d 268	1.84	1.79	0.053	0.50		

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Study 2 - Combining heat stress mitigation strategies during pre- and postnatal phases: Impacts on cow and heifer offspring performance

The study is being conducted at the Range Cattle REC from August 2021 to April 2025

160 Brangus, pregnant mature beef cows on bahiagrass pastures

Treatments (2 x 2 factorial design): Applied during gestation and then heifer development

(1) **No heat abatement (CONTROL)** = No access to artificial shade

(2) **Heat abatement strategy (HAST)** = Unlimited access to artificial shade (40 sq ft per animal)

July Calf weaning	November Calving	March End of cow breeding season	July Calf weaning at 8-9 mo of age	November Heifer estrus synchronization
Cow Gestational Treatments			Heifer Post-weaning	
CONTROL 4 pastures per year, 10 cows per pasture	Bahiagrass grazing + 2.3 kg/day molasses	Bahiagrass grazing + no concentrate	CONTROL 4 pastures per year, 4-5 heifers per pasture	
CONTROL 4 pastures per year, 10 cows per pasture	Bahiagrass grazing + 2.3 kg/day molasses	Bahiagrass grazing + no concentrate	HEAT STRESS ABATEMENT 4 pastures per year, 4-5 heifers per pasture	
HEAT STRESS ABATEMENT 4 pastures per year, 10 cows per pasture	Bahiagrass grazing + 2.3 kg/day molasses	Bahiagrass grazing + no concentrate	CONTROL 4 pastures per year, 4-5 heifers per pasture	
HEAT STRESS ABATEMENT 4 pastures per year, 10 cows per pasture	Bahiagrass grazing + 2.3 kg/day molasses	Bahiagrass grazing + no concentrate	HEAT STRESS ABATEMENT 4 pastures per year, 4-5 heifers per pasture	

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