Nutritional impacts on beef cow reproduction

May 21st, 2024

UF UNIVERSITY of FLORIDA

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Introduction

Retrospective analyses of cow BCS vs. nutrition
- Analysis 1 = BCS at calving vs. post-calving BCS change
- Analysis 2 = BCS at weaning vs. precalving supplementation

Precalving supplementation strategies
- Probiotics

Nutrition of heat stressed heifers
- Stair-step strategy to offset heat stress

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Cow BCS vs. Reproduction

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Studies across United States

$^{abc}P < 0.05$

BCS at calving vs. Pregnancy Rate, %

	Body condition score at calving		
	4	5	6
Spitzer et al. (1995)	56[a]	80[b]	96[c]
Lake et al. (2005)	64[a]	-	89[b]
Lents et al (2008)	56[a]	88[b]	-
Bohnert et al (2013)	79[a]	92[b]	-
Average	**63.8**	**86.7**	**92.5**

BCS at calving	Days to resume estrus
3	89[a]
4	70[b]
5	59[b]
6	52[b]
7	31[c]

Houghton et al. (1990) JAS 68:1438

Item	Calving distribution			SEM	*P*-value
	First 21 days	Second 21 days	Third 21 days		
Weaning body weight, lb	482[a]	469[b]	434[c]	10.8	<0.01
Body weight start of breeding, lb	652[a]	643[b]	608[c]	9.2	<0.01
Pubertal at start of breeding, %	70[a]	58[b]	39[c]	9.35	<0.01
Pregnancy rate, %	90[a]	86[b]	78[c]	5.62	0.02

Funston et al. (2012; JAS 90:5118)

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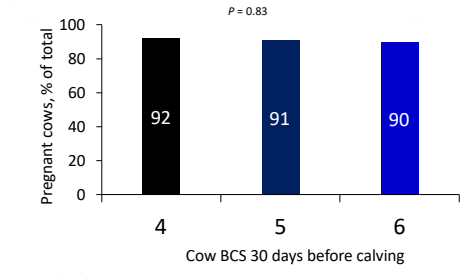
351 spring-calving, Angus & Angus x Hereford cows (2 and 3 years of age) in New Mexico



Mulliniks et al. (2012) J. Anim. Sci. 90:2811

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Retrospective data analyses

Moriel et al. (2024) Anim. Rep. Sci. *in press*

- 6 studies from 2017 to 2022
  - UF/IFAS Range Cattle Research & Education Center, Ona, FL
- 1,188 Brangus crossbred mature cows (8 ± 3 years of age)
- Day 0 = 2 weeks after weaning
  - 92 ± 37 days before calving
  - Received or not supplementation of protein and energy from day 0 until calving (90 ± 35 days of supplementation)

Palmer et al. (2020) Livest. Sci. doi:10.1016/j.livsci.2020.104176
Palmer et al. (2022b) J. Anim. Sci. doi:10.1093/jas/skac003
Izquierdo et al. (2022) Trans. Anim. Sci. doi:10.1093/tas/txac110
Palmer et al. (2022a) J. Anim. Sci. doi:10.1093/jas/skac022
Vedovatto et al. (2022) Trans. Anim. Sci. doi:10.1093/tas/txac105
Izquierdo et al. (2023) J. Anim. Sci. doi:10.1093/jas/skad244

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Retrospective data analyses

Moriel et al. (2024) Anim. Rep. Sci. 262:107433

2 statistical analyses:

Maternal BCS at calving and postpartum BCS change

- Calving: **BCS < 5** or **BCS ≥ 5**
- Within each calving BCS group, cows that lost (**LO**), maintained (**MA**), or gained (**GA**) BCS from calving until the start of the breeding season

Maternal initial BCS and prepartum supplementation

- Weaning: **BCS < 5** vs. **BCS ≥ 5**
- Within each initial BCS group, cows that received (**SUP**) or not (**NOSUP**) prepartum supplementation

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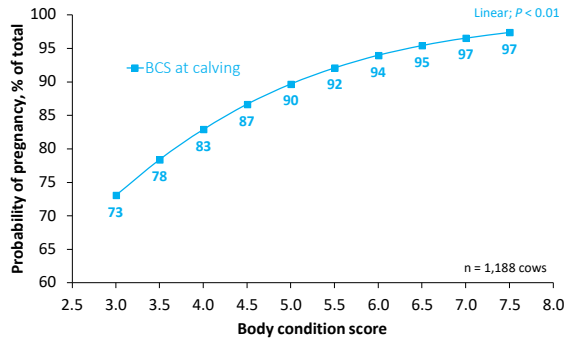
Body condition score at calving vs. Pregnancy %

Summary of 6 studies at the Range Cattle REC (2017 to 2022; Ona, FL)
1,188 Brangus mature cows grazing bahiagrass



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Body condition score at calving

Summary of 6 studies at the Range Cattle REC (2017 to 2022; Ona, FL)
1,188 Brangus mature cows grazing bahiagrass

	BCS at calving			
	BCS < 5	BCS > 5	SEM	*P*-value
n	208	980		
Cow BCS				
Calving	4.51	5.56	0.078	<0.01
Start of breeding season	4.51	5.51	0.082	<0.01
End of breeding season	4.27	5.15	0.105	<0.01
Weaning	4.77	5.59	0.065	<0.01
First calf crop				
Body weight at birth, lb	75.2	79.3	1.12	<0.01
Body weight at weaning, lb	524	541	14.4	0.04
Pregnant with 2nd calf, %	81	91	2.53	<0.01
Calved live 2nd calf, % of total	73	82	2.95	0.005
Calving interval, days	371	364	2.4	0.02
Calving distribution, % of total calves				
First 30 days	57	63	4.0	0.18
Second 30 days	34	29	4.8	0.23
Third 30 days	9	8	2.5	0.65

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Body condition score change post-calving

Summary of 6 studies at the Range Cattle REC (2017 to 2022; Ona, FL)
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	Post-calving BCS change				
	LOST	MAIN	GAIN	SEM	P-value
n	757	271	160		
BCS change from calving to breeding	-0.69	-0.02	0.51	0.05	<0.01
Cow BCS					
Start of breeding season	4.57[a]	4.96[b]	5.51[c]	0.08	<0.01
First calf crop					
Body weight at weaning, lb	536	529	533	15.7	0.47
Pregnant with 2nd calf, % of total	82[a]	87[b]	88[b]	2.8	0.07
Calving distribution, % of total calves					
First 30 days	52[a]	66[b]	63[b]	4.5	0.03
Second 30 days	39[b]	25[a]	31[ab]	4.9	0.03
Third 30 days	9	9	6.5	2.6	0.71

[ac]*P* < 0.05

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BCS at calving vs. Post-calving BCS change

Cow BCS at calving	Cow BCS change from calving to breeding	Pregnant, % of total	Calving within first 30 days of calving season, % of total
Below 5	Lost (n = 93)	74.5[a]	35.0[a]
	Maintained (n = 55)	84.8[b]	67.2[b]
	Gained (n = 60)	83.7[b]	68.4[b]
Above 5	Lost (n = 664)	88.3[bc]	64.2[b]
	Maintained (n = 216)	90.4[c]	68.1[b]
	Gained (n = 100)	93.2[c]	57.6[b]

BCS at calving determines the pregnancy rate and calving distribution.

Recover BCS after calving does not fully compensate for thin BCS at calving.

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Body condition score change post-calving vs. Pregnancy %

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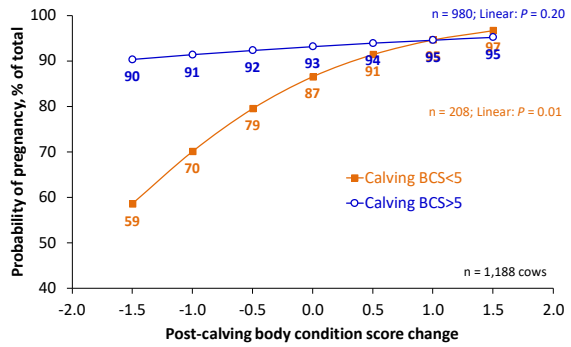
Brangus mature cows grazing bahiagrass



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https://doi.org/10.3389/fanim.2021.728635

Improving Beef Progeny Performance Through Developmental Programming

Philipe Moriel[1*], Elizabeth A. Palmer[1], Kelsey M. Harvey[2] and R. F. Cooke[3]

Maternal nutritional management during gestation appears to modulate fetal development and imprint offspring postnatal health and performance, via altered organ and tissue development and tissue-specific epigenetics. This review highlighted the studies demonstrating how developmental programming could be explored by beef producers to enhance offspring performance (growth, immune function, and reproduction), including altering cow body condition score (BCS) during pregnancy and maternal supplementation of protein and energy, polyunsaturated fatty acids (PUFA), trace minerals, frequency of supplementation, specific amino acids, and vitamins. However, this review also highlighted that programming effects on offspring performance reported in the literature were highly variable and depended on level, duration, timing, and type of nutrient restriction during gestation. It is suggested that maternal BCS gain during gestation, rather than BCS *per se*, enhances offspring preweaning growth. Opportunities for boosting offspring productive responses through maternal supplementation of protein and energy were identified more consistently for pre- vs. post-weaning phases. Maternal supplementation of specific nutrients (i.e.,

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Precalving supplementation of protein/energy in Florida

Summary of 6 studies at the Range Cattle REC (2017 to 2022; Ona, FL)
Brangus mature cows on bahiagrass and supplemented ***on average at 2.5 lb/day for 70 days before calving***

n = 1,188 cow-calf pairs

BCS at weaning (July/August) ✕ ***Precalving supplementation***
BCS > or < 5 *NOSUP vs SUP*

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BCS at weaning (July/August) ✕ ***Precalving supplementation***
BCS > or < 5 *NOSUP vs SUP*

	BCS < 5		BCS ≥ 5			
Item	**NOSUP**	**SUP**	**NOSUP**	**SUP**	**SEM**	**P-value**
n	106	125	557	400		
Cow BCS						
Weaning (July/August)	4.59[a]	4.64[a]	5.81[c]	5.72[b]	0.075	<0.01
Calving	4.51[a]	5.29[b]	5.37[b]	5.97[c]	0.172	
Start of breeding season	4.18[a]	4.82[b]	5.02[c]	5.35[d]	0.108	
End of breeding season	4.11[a]	4.54[b]	4.84[c]	5.08[d]	0.104	
Weaning (Following year)	4.56[a]	4.79[b]	5.37[c]	5.45[c]	0.087	

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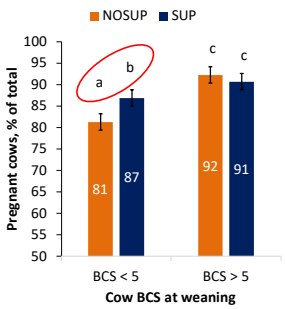

$^{ac}P < 0.05$

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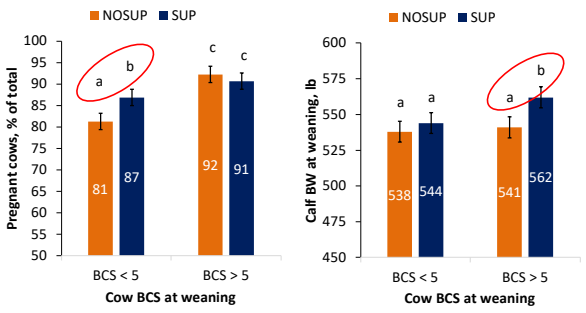

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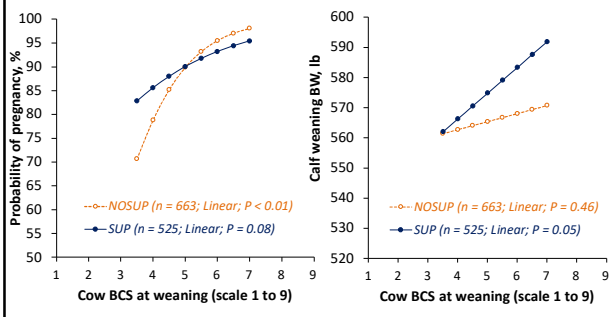

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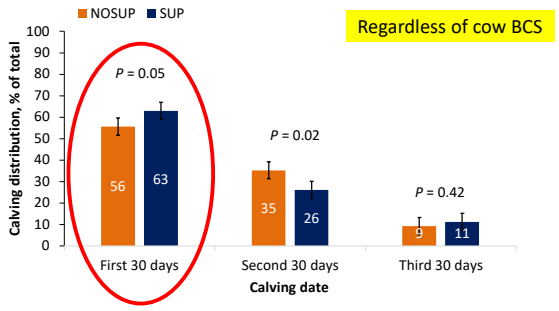

[a,c]$P < 0.05$

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FETAL PROGRAMMING

Probiotics

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Introduction

- Direct-fed Microbials
  - *Modulate rumen fermentation characteristics*
  - *Promote establishment of beneficial rumen microflora*
  - *Enhance fiber and overall nutrient digestibility* (Krehbiel et al., 2003; Pan et al., 2022; Cappellozza et al., 2023)
- *Bacillus* spp.
  - *Inhibition of harmful pathogens*
  - *Biofilm and mucin formation*
  - *Enhance production of wide variety of fibrolytic, amylolytic, proteolytic, and lipolytic enzymes* (Copani et al., 2020; Segura et al., 2020; Santano et al., 2020; Elshaghabee et al., 2017; Luise et al., 2022)

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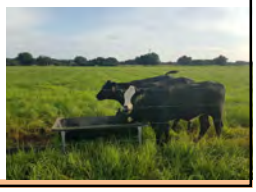
Experimental Design

- Range Cattle Research and Education Center
  - May 2022 to March 2023
- 72 pregnant Brangus heifers (21 months)
  BW = 431 ± 31 kg
  BCS = 6.0 ± 0.36
- 1 of 12 bahiagrass pastures (6 heifers/pasture)
- Treatments (6 pastures/treatment)



Izquierdo et al. (2024). J. Anim. Sci. 102:skae110. doi:10.1093/jas/skae110

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Experimental Design

Maternal Treatment

Start Breeding Season

May day 0 — August day 90 — November day 190 — January day 242

CALVING SEASON

Early weaning

CON: 2.2 lb/day of soybean hulls DM

BAC: 2.2 lb/day of soybean hulls DM added with 3g of a *Bacillus*-based DFM mixture (Bovacillus™; Chr. Hansen A/S, Hørsholm, Denmark)

Bacillus subtilis and *Bacillus licheniformis*
Target: 6.6 × 10^9 CFU

Izquierdo et al. (2024). J. Anim. Sci. 102:skae110. doi:10.1093/jas/skae110

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Experimental Design

Offspring Management

January day 242 — day 258 — day 271 — day 287 — March day 319

Early Weaning — Drylot Entry — Drylot Exit

- 60 Calves (96 ± 30 d of age)
- 1 of 12 drylot pens (4 to 6 calves/pen)
  - Same distribution of the maternal treatment
- Soybean hulls-based diet (3.25% DM of BW)
  - CP = 21%
  - TDN = 73%

Vaccinated against pathogens associated with respiratory disease and *Clostridium*

Izquierdo et al. (2024). J. Anim. Sci. 102:skae110. doi:10.1093/jas/skae110

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Maternal Results

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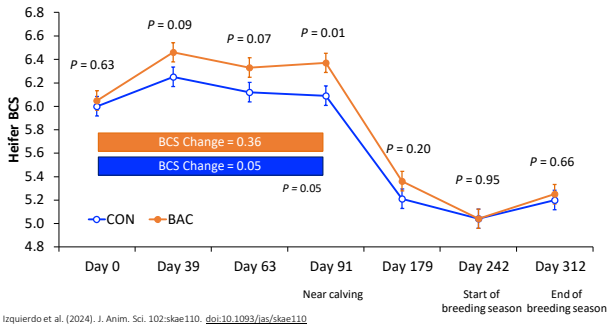
Maternal BW and BCS

BAC = 3g of *Bacillus*-based DFM from day 0 to 242
CON = No *Bacillus* supplementation from day 0 to 242



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Reproductive Data

BAC = 3g of *Bacillus*-based DFM from day 0 to 242
CON = No *Bacillus* supplementation from day 0 to 242

	Maternal treatment			*P*-value
	CON	BAC	SEM	Treatment
First offspring (Calves in utero when treatments were provided)				
Calving, % of total	96	91	4.22	0.45
Calving date, day of the study	142	135	4.10	0.22
Male calves at birth, % of total	48	54	9.21	0.63
Calf birth BW, lb	62	65	0.99	0.34
Second offspring (Calves conceived from day 242 to 312)				
Pregnant, % of total	89	89	5.35	0.97
Calving, % of total	84	88	7.83	0.76
Calving date, day of the study	554	556	4.60	0.61
Male calves, % of total	52	52	12.00	0.94

Izquierdo et al. (2024). J. Anim. Sci. 102:skae110. doi:10.1093/jas/skae110

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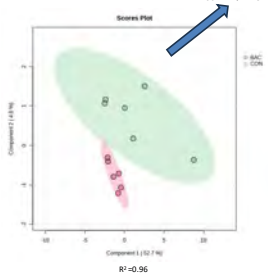
Heifers
63 days of supplementation

100 VIP → ANOVA $P \leq 0.05$ and Fold Change ≥ 1.2 or ≤ 0.8 Oyebade et al., 2023



Class	Metabolite	Fold Change BAC/CON	*P*-value
Diglycerides	DG(16:0_20:3)	0.50	0.02
Triglycerides	TG(16:0_35:1)	0.66	0.00
Triglycerides	TG(18:0_32:1)	0.69	0.02
Triglycerides	TG(18:1_33:0)	0.74	0.02
Phosphatidylcholines	PC aa C34:2	1.20	0.02
Phosphatidylcholines	PC aa C34:3	1.20	0.00
Aminoacids Related	Kynurenine	1.21	0.02
Phosphatidylcholines	PC aa C36:3	1.21	0.00
Lysophosphatidylcholines	lysoPC a C16:0	1.21	0.03
Phosphatidylcholines	PC aa C36:4	1.22	0.01
Aminoacids Related	Carnosine	1.22	0.02
Phosphatidylcholines	PC aa C38:5	1.22	0.00
Phosphatidylcholines	PC aa C40:5	1.23	0.01
Aminoacids	Met	1.25	0.05
Phosphatidylcholines	PC aa C36:5	1.27	0.00
Phosphatidylcholines	PC aa C32:1	1.41	0.00
Aminoacids Related	Cit	1.50	0.03
Dihexosylceramides	Hex2Cer(d18:1/14:0)	1.63	0.01
Triglycerides	TG(16:1_34:0)	1.67	0.01
Trihexosylceramides	Hex3Cer(d18:1/16:0)	1.68	0.03
Hormones	Cortisol	2.60	0.03

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Offspring Results

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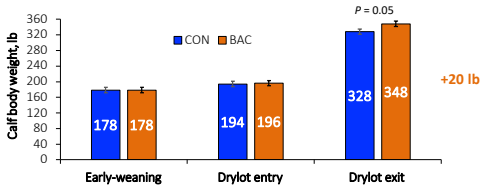
Offspring Performance



	Maternal treatment			*P*-value
	CON	BAC	SEM	Treatment
Calf ADG, lb/day				
Drylot entry to exit (61 days)	2.22	2.44	0.077	0.04
Total DMI, % of BW	3.24	3.27	0.038	0.73
Gain:Feed	0.25	0.27	0.004	0.05

Izquierdo et al. (2024) J. Anim. Sci. 102:skae110 doi:10.1093/jas/skae110

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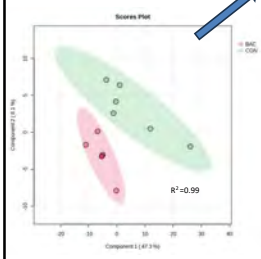
Calves:
30 days after drylot entry

100 VIP → ANOVA



$P \leq 0.05$ and Fold Change $\geq$ **1.2** or $\leq$ **0.8**

Oyebade et al., 2023

Class	Metabolite	Fold Change BAC/CON	*P*-value
Aminoacids Related	3-Met-His	1.20	0.02
Phosphatidylcholines	PC aa C40:5	1.20	0.05
Aminoacids Related	t4-OH-Pro	1.22	0.05
Lysophosphatidylcholines	lysoPC a C28:1	1.22	0.04
Phosphatidylcholines	PC aa C42:2	1.22	0.01
Phosphatidylcholines	PC aa C34:1	1.23	0.05
Triglycerides	TG(16:0_34:3)	1.23	0.03
Phosphatidylcholines	PC aa C42:2	1.25	0.05
Aminoacids Related	1-Met-His	1.25	0.05
Carboxylic Acids	AconAcid	1.25	0.05
Triglycerides	TG(16:0_35:1)	1.25	0.05
FattyAcids	AA	1.26	0.05
Ceramides	Cer(d18:1/16:0)	1.26	0.01
Lysophosphatidylcholines	lysoPC a C26:1	1.29	0.05
Triglycerides	TG(18:2_34:1)	1.29	0.05
Triglycerides	TG(18:1_34:2)	1.30	0.05
FattyAcids	DHA	1.31	0.05
Triglycerides	TG(16:0_34:2)	1.34	0.04
Triglycerides	TG(16:1_34:2)	1.37	0.03
Dihydroceramides	Cer(d18:0/24:0)	1.38	0.04
Triglycerides	TG(16:0_34:1)	1.40	0.01
Triglycerides	TG(16:0_32:0)	1.48	0.00
Triglycerides	TG(16:1_34:1)	1.52	0.04
Aminoacids Related	HCys	1.58	0.03
Triglycerides	TG(16:0_32:2)	1.58	0.05
Triglycerides	TG(22:5_34:1)	1.72	0.05
Triglycerides	TG(20:2_32:0)	1.77	0.05
Triglycerides	TG(16:1_32:1)	2.14	0.01

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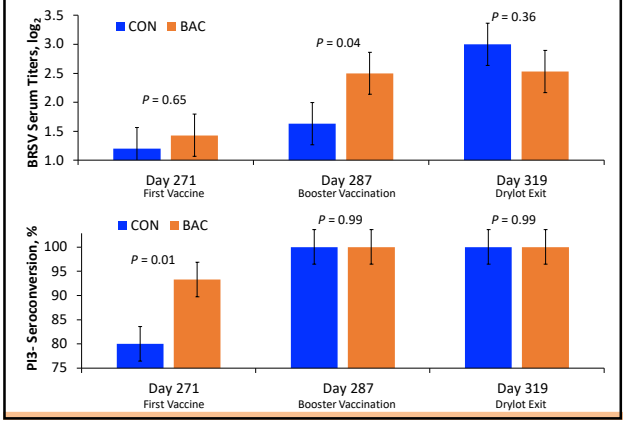
Offspring Performance



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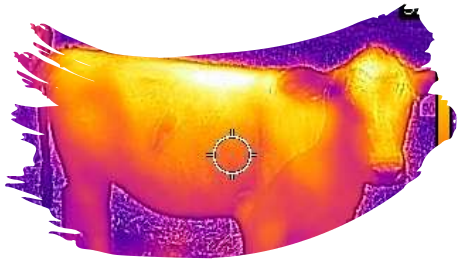

Shifting heifer nutrition to cope with heat stress

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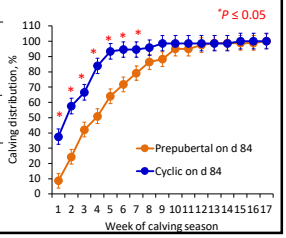
Not pubertal vs. pubertal Brangus heifers at start of breeding season

Pregnant heifers, % of total	Puberty status at the start of the breeding season: Prepubertal	Pubertal	SEM	*P-value*
Year 1	33.9	78.2	12.2	0.001
Year 2	39.4	85.0	6.1	0.005
Average	36.2	81.6	10.3	<0.0001

Moriel et al. (2020) J. Anim. Sci. https://doi.org/10.1093/jas/skaa236

Item	Puberty status at the start of the breeding season: Prepubertal	Pubertal	SEM	P
Pregnancy %	55.4	87.4	11.7	<0.001
Calving %	51.0	72.2	11.6	0.009

Moriel et al. (2017) J. Anim. Sci. 95:3523–3531 https://doi.org/10.2527/jas.2017.1666



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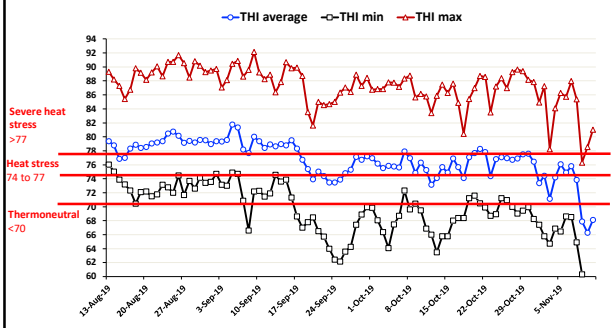
Thermal humidity-index (THI) - Ona 2019



NRC (1971): THI = $(1.8 \times T_{environ.} + 32) - [(0.55\text{-}0.0055 \times \text{Relative Humidity}) \times (1.8 \times T_{environ.} - 26)]$.

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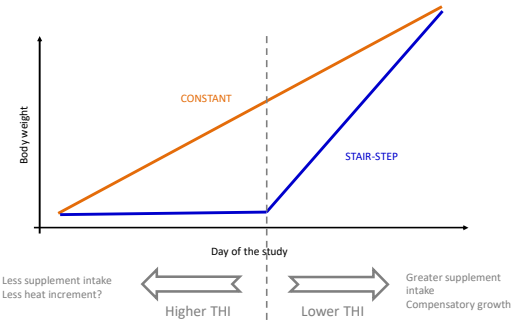
Constant vs. stair-step supplementation



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Boosting reproduction without increasing feed costs of beef heifers in Florida

Funded by Florida Cattlemen Enhancement Board

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 (6 pastures/treatment/year):

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

STAIRSTEP = concentrate supplementation at **1.0% of body weight** from Aug. to Sep. (day 0 to 49) + **2% of body weight** until the start of the estrous synchr. (day 50 to 100).

After day 100, all heifers were managed similarly:

AI from day 113 to 115; Timed-AI on day 115

Bulls from day 121-211

Concentrate supp. at 1.50% of BW until day 211

Moriel et al. (2022). J. Anim. Sci. 100(4):skac107. doi:10.1093/jas/skac107

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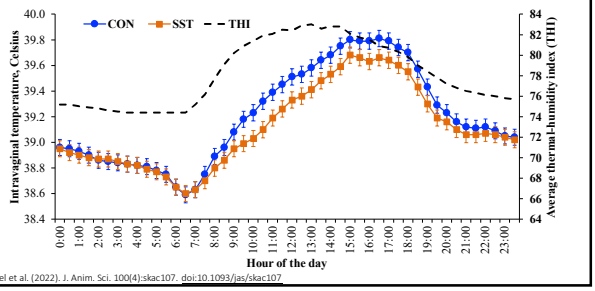
Intravaginal Temperature and Thermal Humidity Index

d 25-31 (Sep 7th to 13th)

CON = Suppl. 1.5% of BW d 0-100
SST = Suppl. 1.0% of BW d 0-49
Suppl. 2.0% of BW d 50-100

Item	Supplementation strategy CON	SST	SEM	*P-value*
ADG, lb/day				
day 0 to 49	1.24	1.17	0.056	0.35
day 49 to 100				
day 0 to 100				



Moriel et al. (2022). J. Anim. Sci. 100(4):skac107. doi:10.1093/jas/skac107

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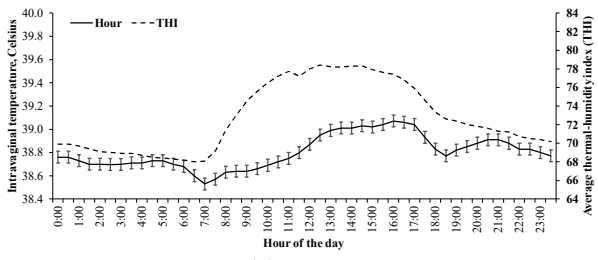
Intravaginal Temperature and Thermal Humidity Index

d 85-91 (Nov 6th to 12th)

CON = Suppl. 1.5% of BW d 0-100
SST = Suppl. 1.0% of BW d 0-49
Suppl. 2.0% of BW d 50-100

Item	Supplementation strategy CON	SST	SEM	*P-value*
ADG, lb/day				
day 0 to 49	1.24	1.17	0.056	0.35
day 49 to 100	1.22	1.61	0.061	<0.001
day 0 to 100	1.23	1.39	0.043	0.01



Moriel et al. (2022). J. Anim. Sci. 100(4):skac107. doi:10.1093/jas/skac107

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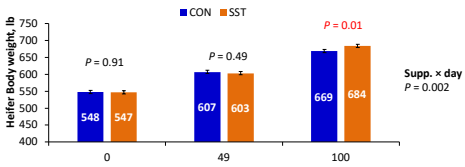
Growth performance and Supplement DM offered

d 0-100 (Aug 13th to Nov 21th)

CON = Suppl. 1.5% of BW d 0-100
SST = Suppl. 1.0% of BW d 0-49
Suppl. 2.0% of BW d 50-100

	Supplementation strategy			
Item	**CON**	**SST**	**SEM**	***P-value***
ADG, lb/day				
day 0 to 49 (Aug to Sep)	1.24	1.17	0.056	0.35
day 49 to 100 (Sep to Nov)	1.22	1.61	0.061	<0.001
day 0 to 100 (Aug to Nov)	1.23	1.39	0.043	0.01
Total supplement DM offered, lb/heifer				
day 0 to 100 (Aug to Nov)	925	933	13.5	0.66



Moriel et al. (2022). J. Anim. Sci. 100(4):skac107. doi:10.1093/jas/skac107

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Reproductive performance

d 100-211 (Nov 21th to Mar 11th)

CON = Suppl. 1.5% of BW d 0-100
SST = Suppl. 1.0% of BW d 0-49
Suppl. 2.0% of BW d 50-100

	Supplementation strategy			
Item	**CON**	**SST**	**SEM**	***P-value***
Pubertal heifers, % of total				
day 91	**69.2**	**66.1**	4.82	0.67
day 101	**73.5**	**75.7**	4.82	0.76
Reproductive tract score, day 101	**4.48**	**4.54**	0.119	0.71
Heifers in estrus, % of total				
day 101 to 105	**28.3**	**28.9**	5.78	0.94
day 113 to 115	**64.9**	**63.9**	5.78	0.90
Pregnant heifers, % of total				
AI (day 154; Dec)	39.1	47.1	6.11	0.36
Final (day 275; Apr)	84.4	94.8	3.62	0.04

Stair-step strategy reduced vaginal temperature during heat stress and improved growth and reproductive performance of heifers, without increasing feed costs

Moriel et al. (2022). J. Anim. Sci. 100(4):skac107. doi:10.1093/jas/skac107

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