HEAT STRESS IN LATE GESTATION: OFFSPRING OUTCOMES AND LONGEVITY

Selko DairyNutriVision 2024

11 September 2024

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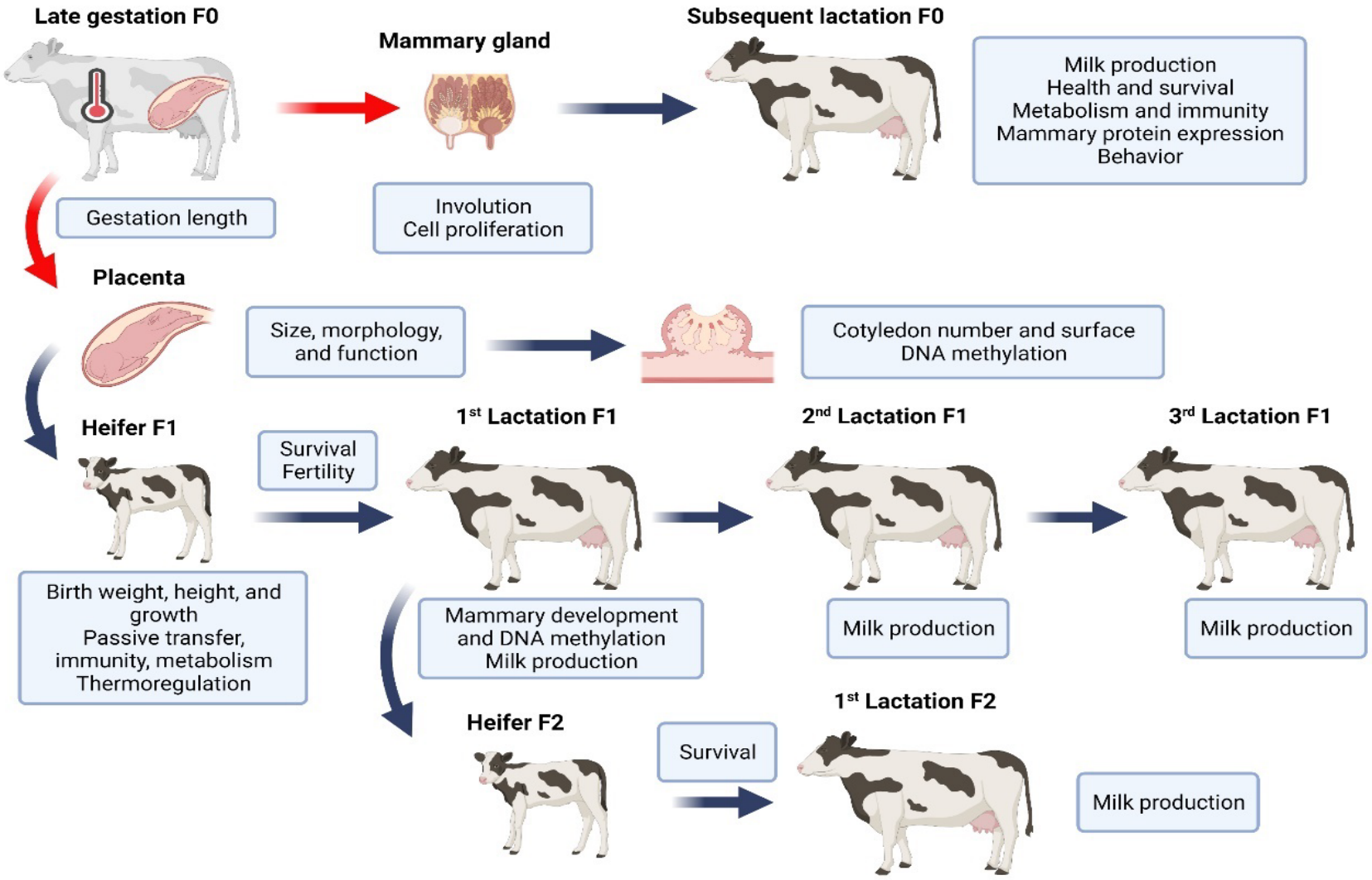
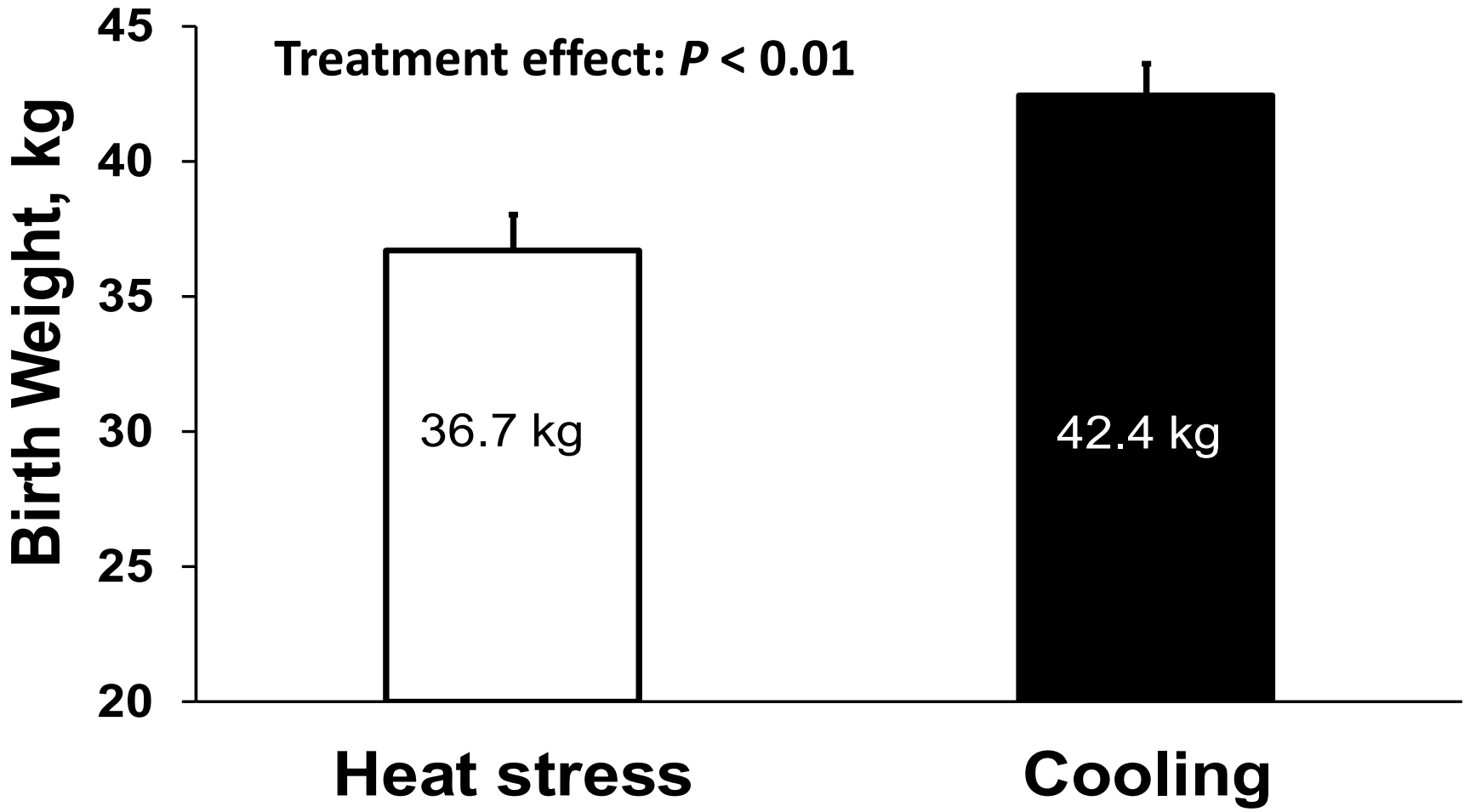
LATE GESTATION HEAT STRESS

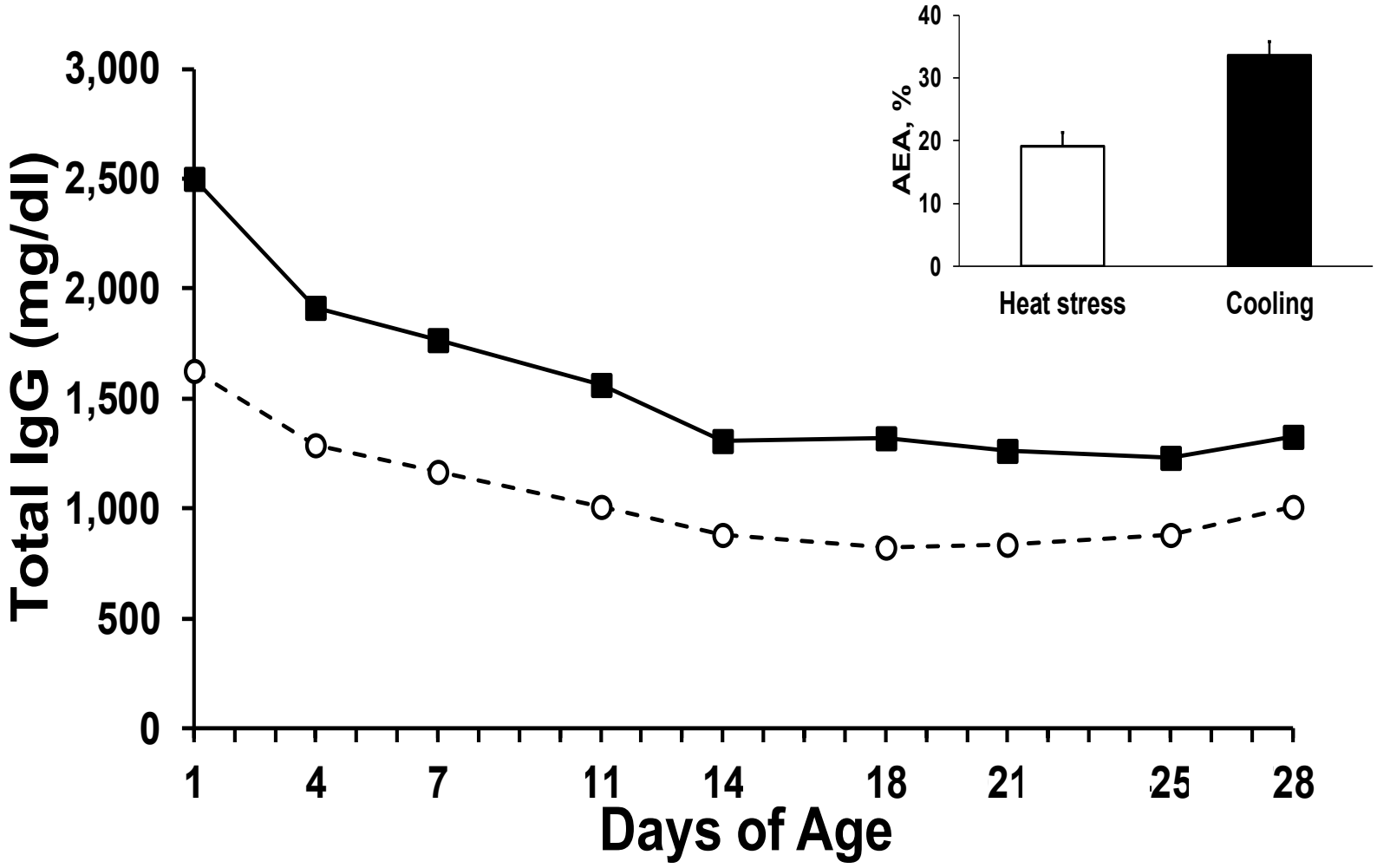


COOLING INCREASES CALF BIRTH WEIGHT



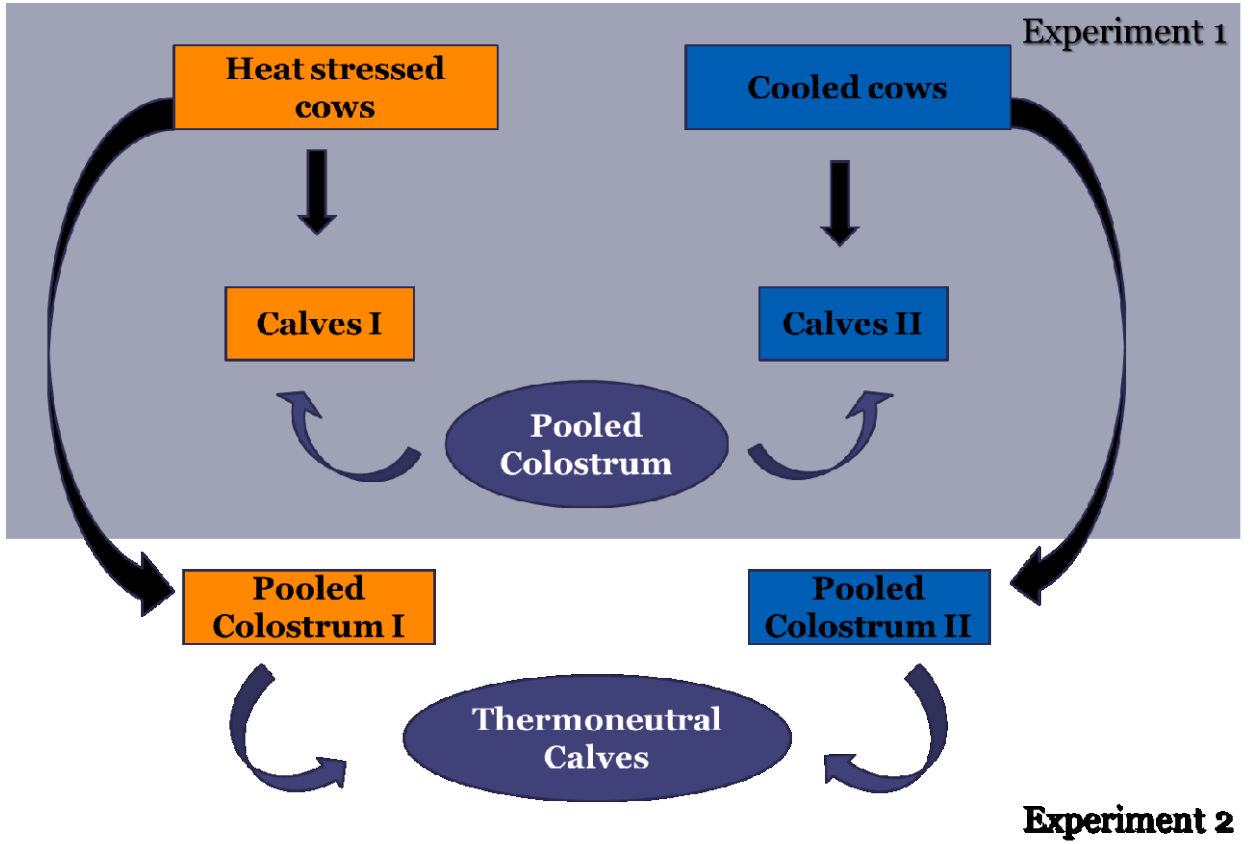
Tao et al., *J. Dairy Sci.* 95:7128-7136

COOLING IMPROVES TOTAL IgG AND AEA



Tao et al., *J. Dairy Sci.* 95:7128-7136

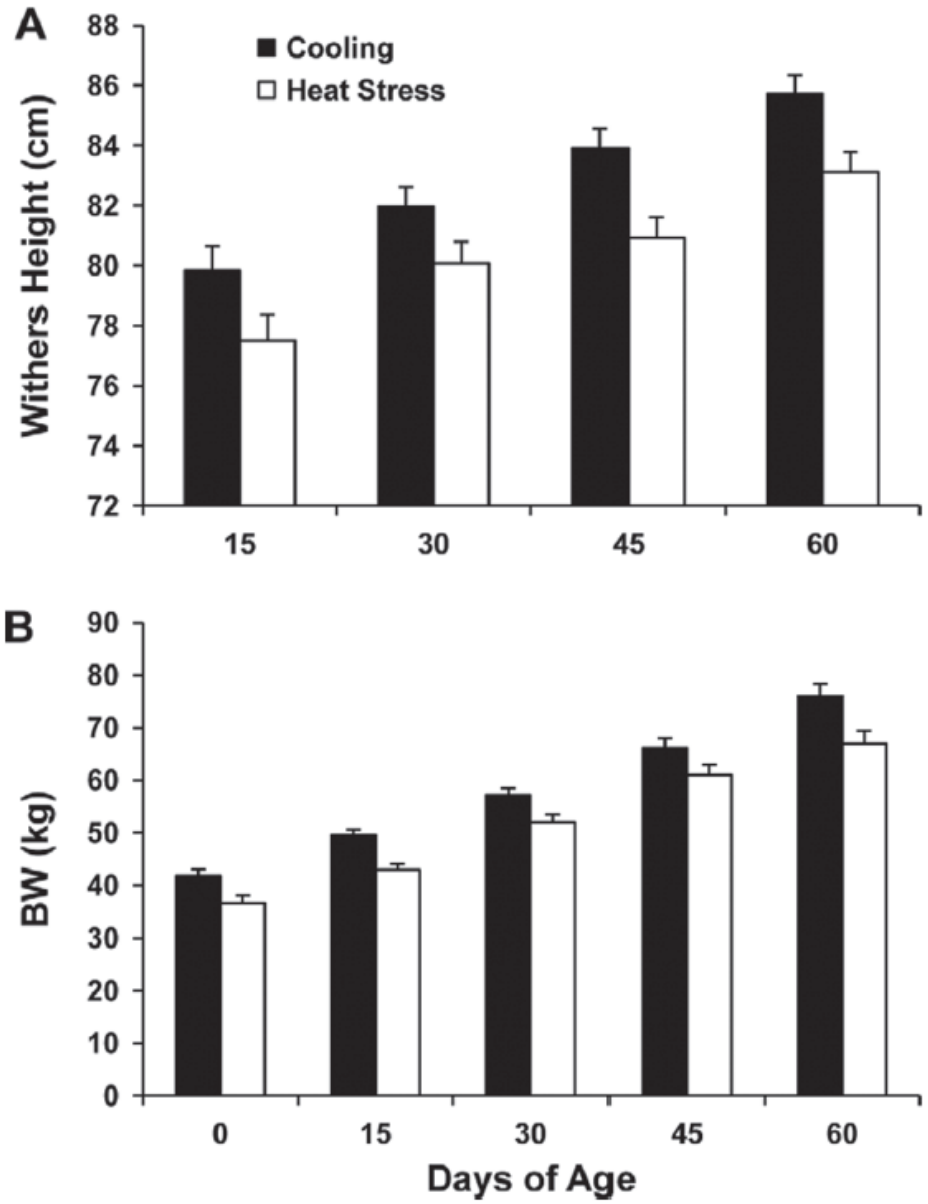
Why Does Cooling Affect AEA? Calf or Colostrum Effect?



Monteiro et al., *J. Dairy Sci.* 97:6426-6439

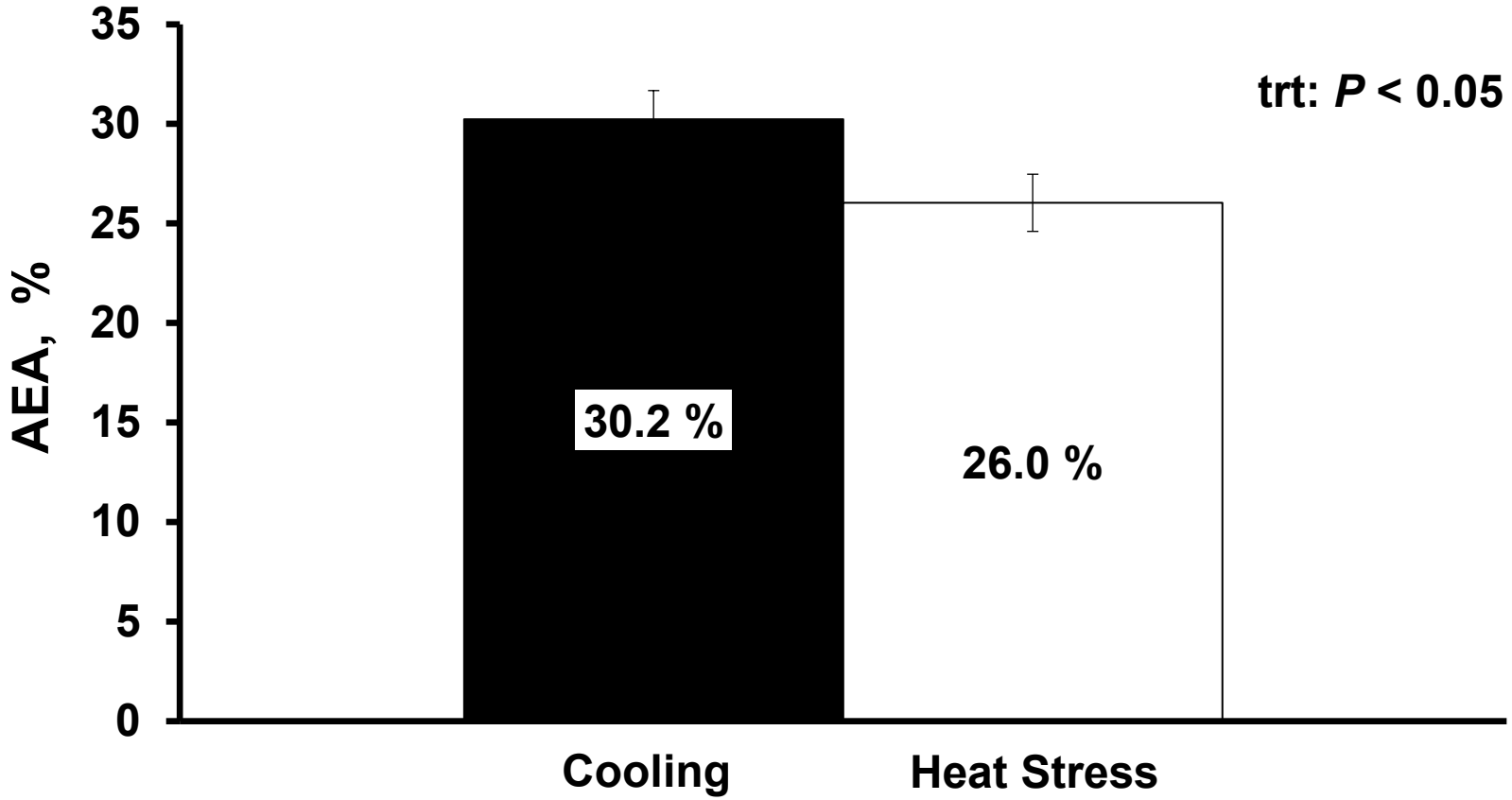
Experiment 1

In utero heat stress for ~6 weeks reduces body weight and height to weaning



Monteiro et al., *J. Dairy Sci.* 97:6426-6439

COOLING INCREASED APPARENT EFFICIENCY OF IGG ABSORPTION (AEA*)



* AEA = [Serum [IgG] (g/L) * birth weight (kg) * 0.091 / IgG fed (g)] x 100

Monteiro et al., *J. Dairy Sci.* 97:6426-6439

Experiment 2 – No Effect of Colostrum from Cooled or Heat Stressed Cows on Calf Performance

Growth performance of calves born to cows under thermoneutral conditions during the dry period and fed frozen colostrum from cows exposed to either heat stress or cooling during the dry period

Parameter	Heat Stress LSM ± SE	Cooling LSM ± SE	*P*-value
Birth Weight (kg)	38.8 ± 1.4	39.2 ± 1.5	0.8
Weaning Weight (kg)[1]	68.4 ± 2.5	64.8 ± 2.6	0.4
Preweaning BW Gain (kg)[2]	29.6 ± 2.3	25.6 ± 2.4	0.3
Avg. Daily Gain (kg/d)	0.49 ± 0.7	0.43 ± 0.8	0.2
Weaning Withers Height (cm)[1]	84.3 ± 0.8	83.0 ± 0.9	0.4
Preweaning Height Increase (cm)[2]	7.8 ± 1.1	6.2 ± 1.0	0.3

[1]Weaning weight and weaning height were measured at d 60 of age.
[2]Preweaning BW gain and height increase was calculated by individually subtracting data at d 60 of age by data at birth.

Monteiro et al., *J. Dairy Sci.* 97:6426-6439

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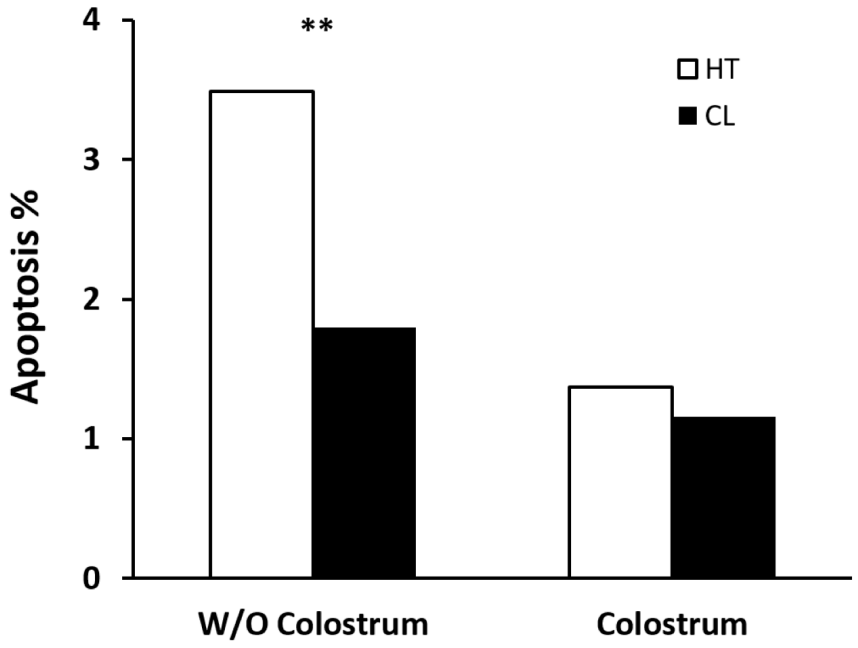
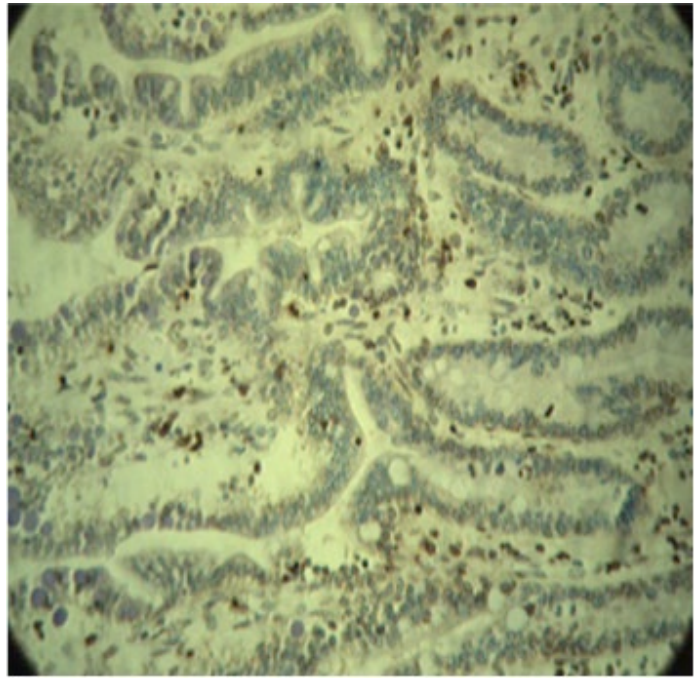
Experiment 2 – AEA Identical regardless of source

Monteiro et al., *J. Dairy Sci.* 97:6426-6439

IN UTERO HT ACCELERATES GUT CLOSURE





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

J. Dairy Sci. 92:5988–5999
doi:10.3168/jds.2009-2343

Heat-stress abatement during the dry period: Does cooling improve transition into lactation?

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J. Dairy Sci. 94:86–96
doi:10.3168/jds.2009-3004

Heat stress abatement during the dry period influences metabolic gene expression and improves immune status in the transition period of dairy cows

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†Bovine Functional Genomics Laboratory, USDA-ARS, Beltsville Agricultural Research Center, Beltsville, MD 20705

J. Dairy Sci. 94:5976–5986
doi:10.3168/jds.2011-4329

Effect of heat stress during the dry period on mammary gland development

S. Tao, J. W. Bubolz, B. C. do Amaral,[1] I. M. Thompson, M. J. Hayen, S. E. Johnson, and G. E. Dahl[2]
Department of Animal Sciences, University of Florida, Gainesville 32611

J. Dairy Sci. 95:5035–5046
http://dx.doi.org/10.3168/jds.2012-5405

Effect of cooling heat-stressed dairy cows during the dry period on insulin response

S. Tao,* I. M. Thompson,* A. P. A. Monteiro,* M. J. Hayen,* L. J. Young,† and G. E. Dahl*[1]
*Department of Animal Sciences, and
†Department of Statistics, Institute of Food & Agricultural Sciences, University of Florida, Gainesville 32611

J. Dairy Sci. 97:7426–7436
http://dx.doi.org/10.3168/jds.2013-7621

Effect of cooling during the dry period on immune response after *Streptococcus uberis* intramammary infection challenge of dairy cows

I. M. T. Thompson, S. Tao, A. P. A. Monteiro, K. C. Jeong, and G. E. Dahl[1]
Department of Animal Sciences, University of Florida, Gainesville 32611

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

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

J. Dairy Sci. 92:5988–5999
doi:10.3168/jds.2009-2343
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Heat-stress abatement during th
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Heat stress abatement during the dry
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la, Gainesville 32611

immune response after
ction challenge of dairy cows

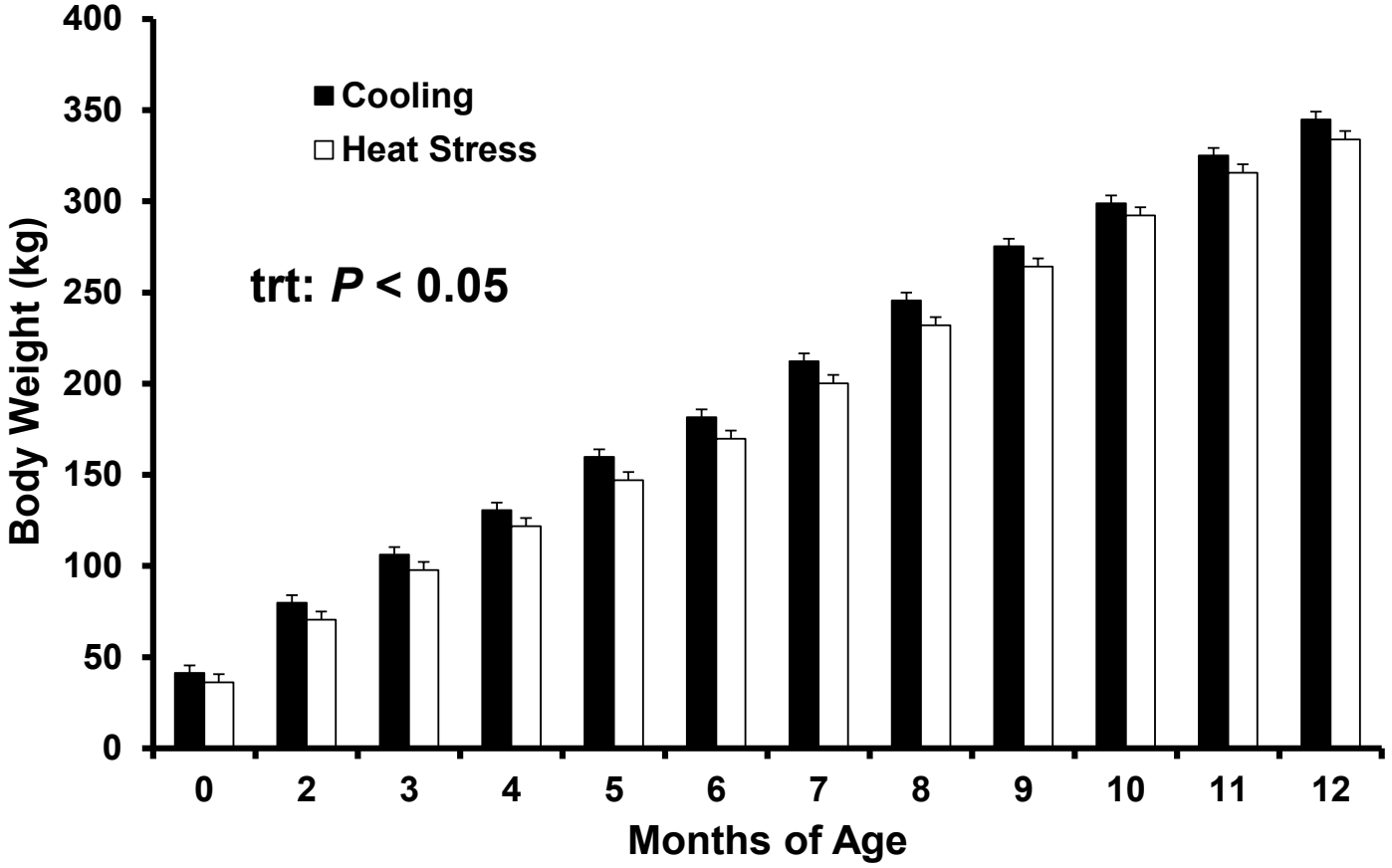
nd G. E. Dahl[1]

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.

IN UTERO HEAT STRESS DECREASES CALF BODYWEIGHT TO PUBERTY



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

IN UTERO HS DECREASES CALF SURVIVAL

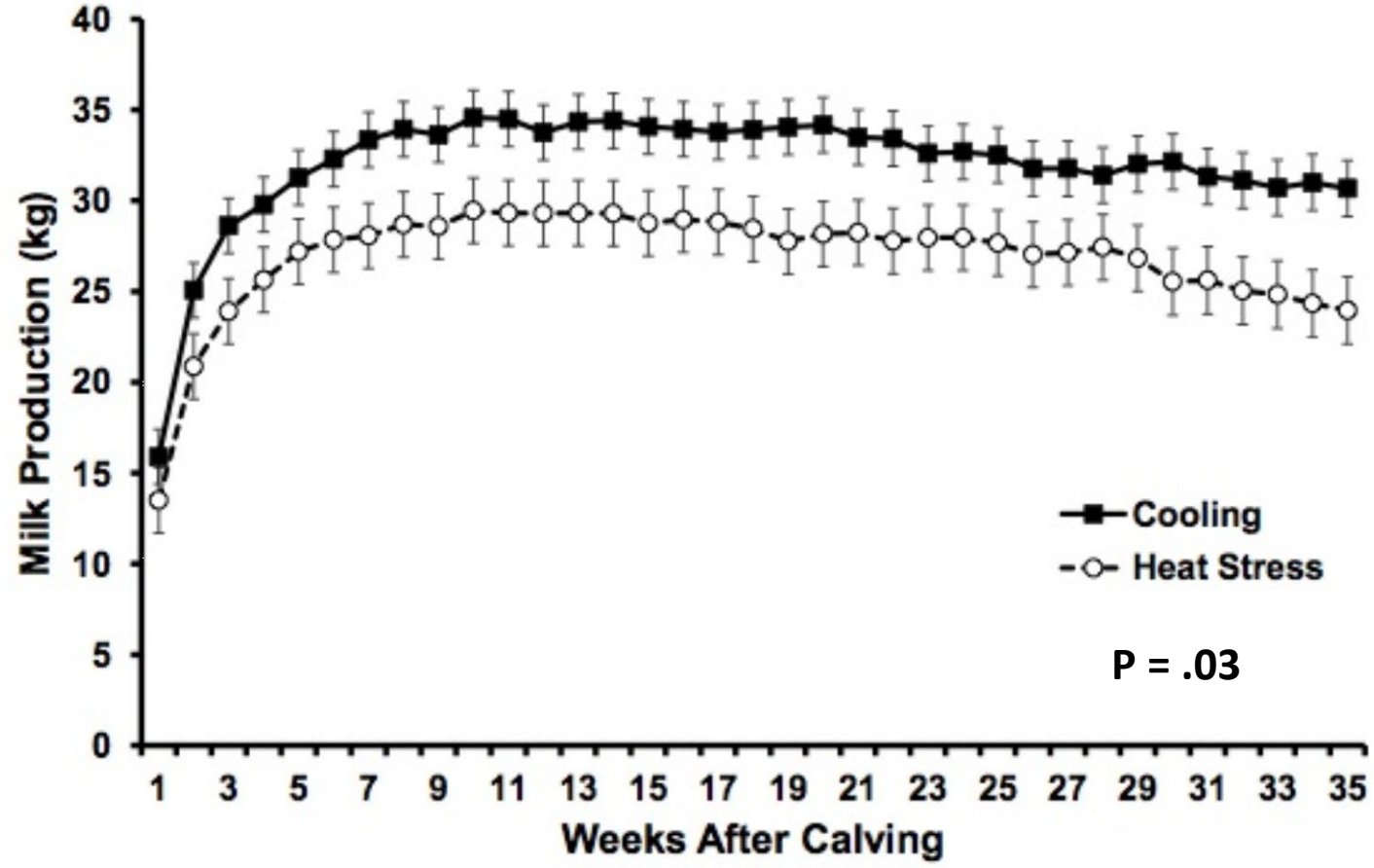
Table 1. Effect of maternal heat stress (HT) or cooling (CL) during late gestation on calf survival

	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.

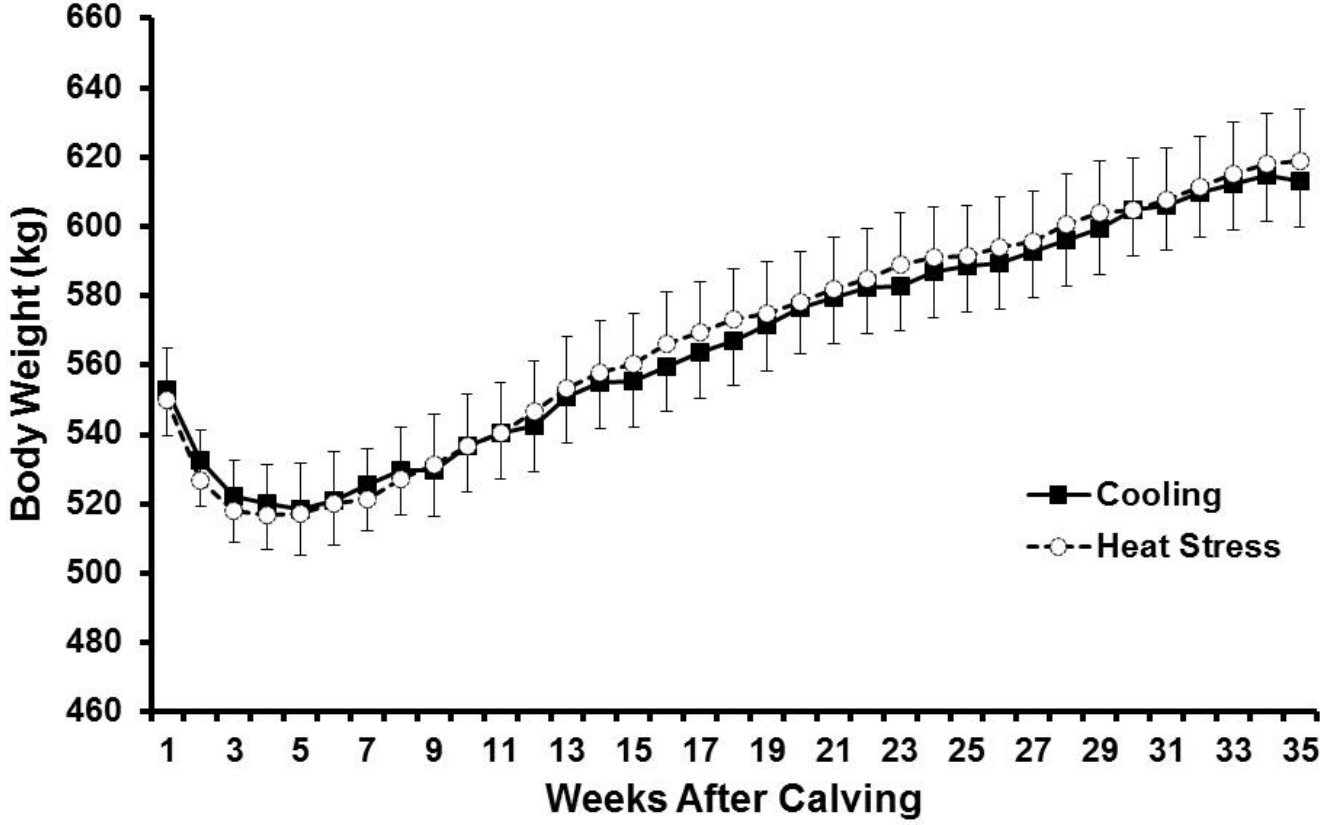
Monteiro et al. , *J. Dairy Sci*. 99:8443-8450.

IN UTERO HEAT STRESS REDUCES MILK PRODUCTION



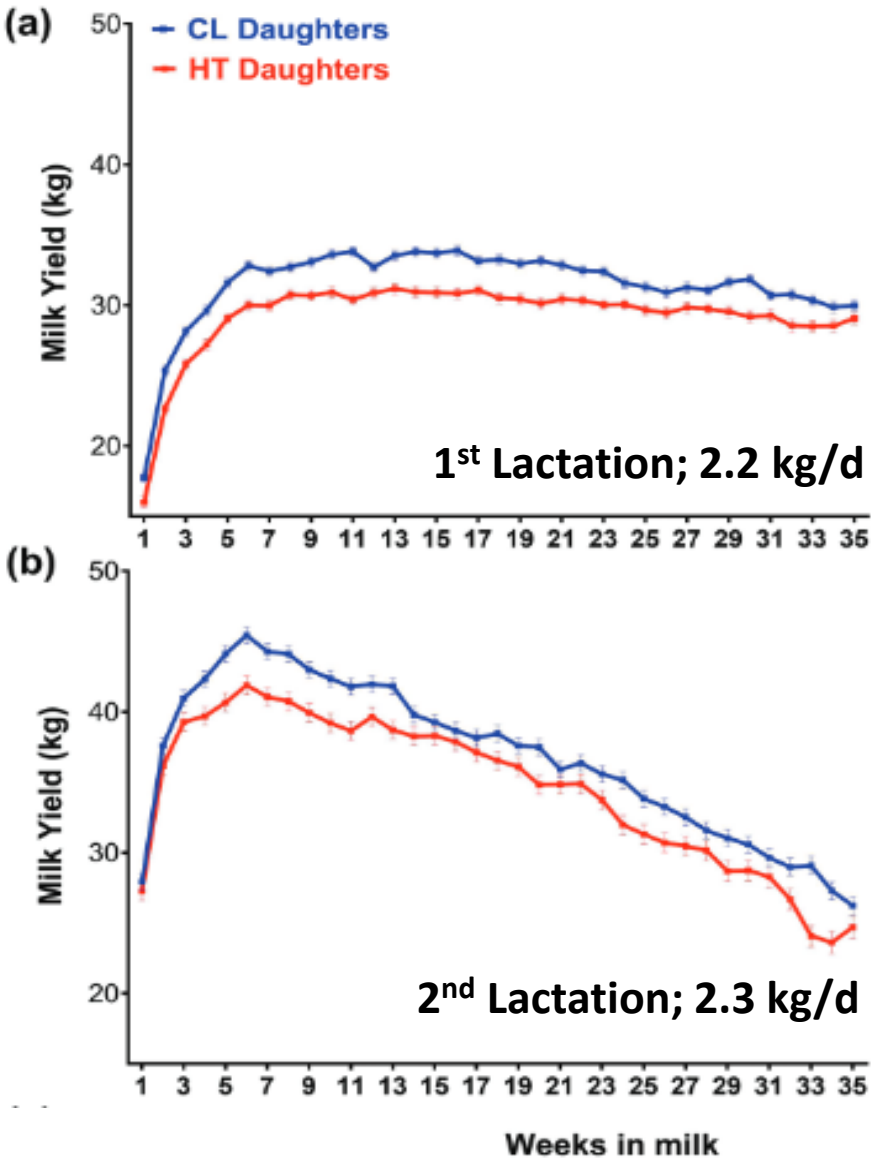
Monteiro et al. , *J. Dairy Sci*. 99:8443-8450.

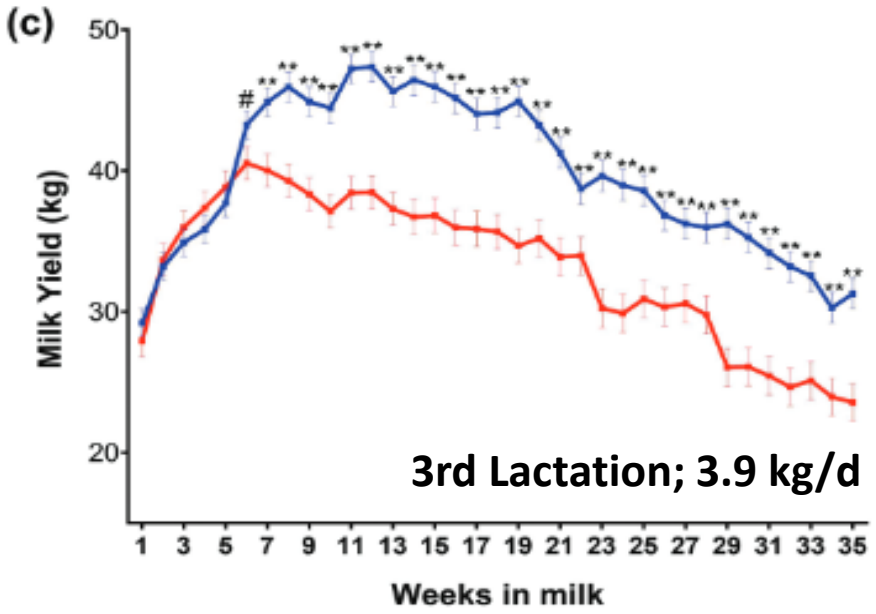
IN UTERO HEAT STRESS DOES NOT AFFECT MATURE BODYWEIGHT



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

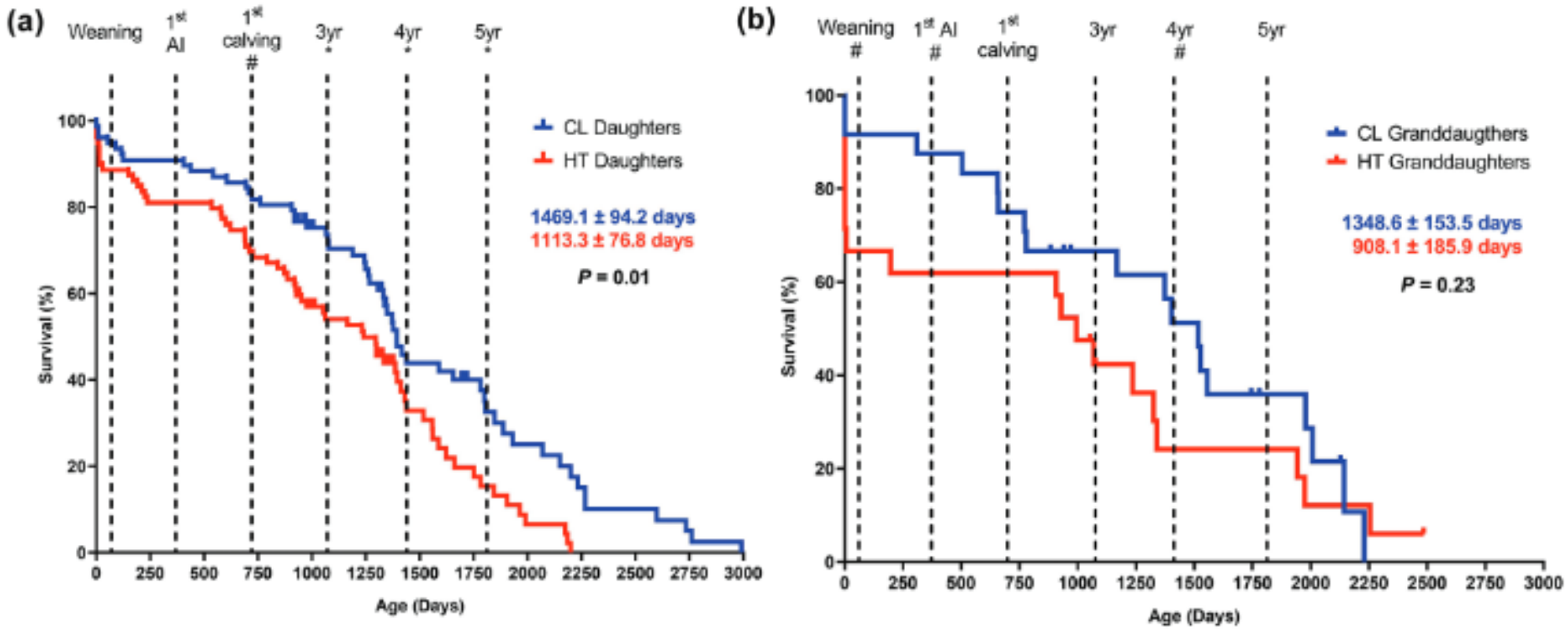
In Utero Heat Stress Alters Lifetime Yield





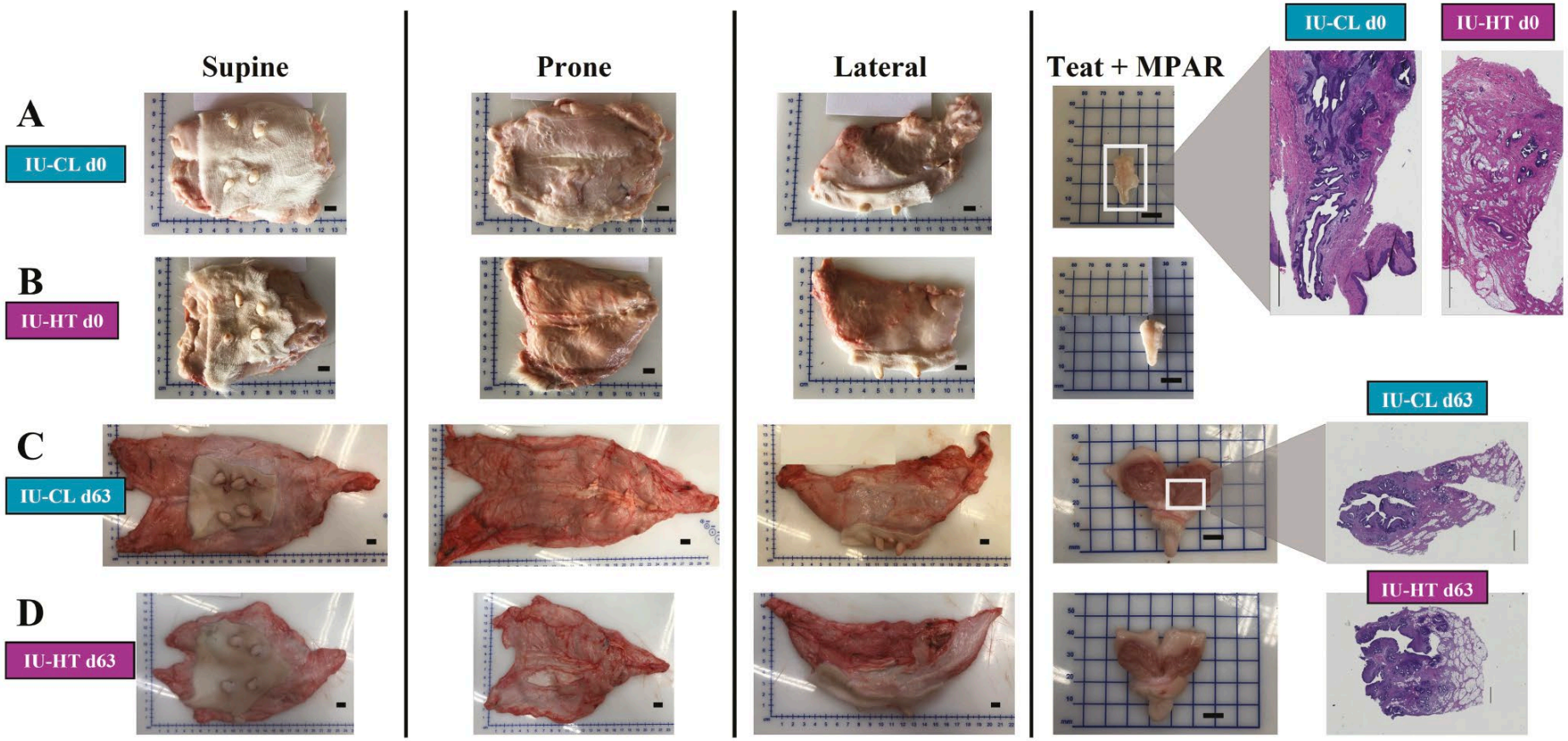
Laporta et al. , *J. Dairy Sci*. 103:7555-7568.

IN UTERO HEAT STRESS REDUCES SURVIVAL IN HERD



Laporta et al. , *J. Dairy Sci*. 103:7555-7568.

IN UTERO HEAT STRESS REDUCES MAMMARY DEVELOPMENT



Dado-Senn et al. , *J. Anim. Sci*. 100:1-11.

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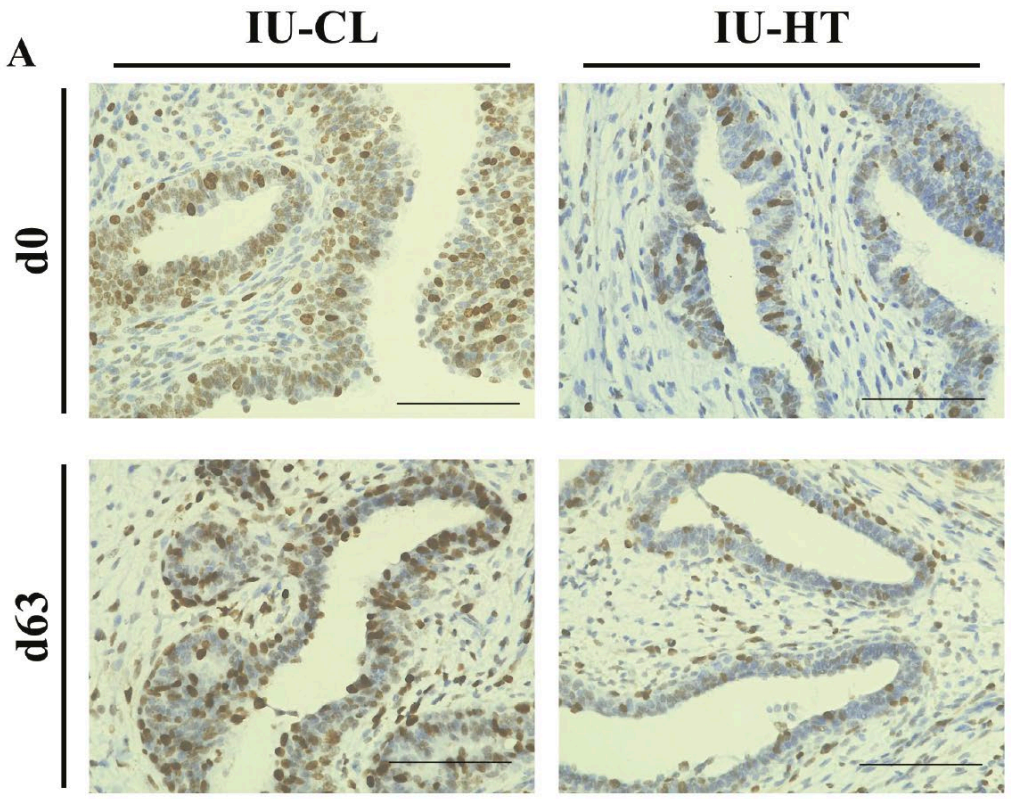
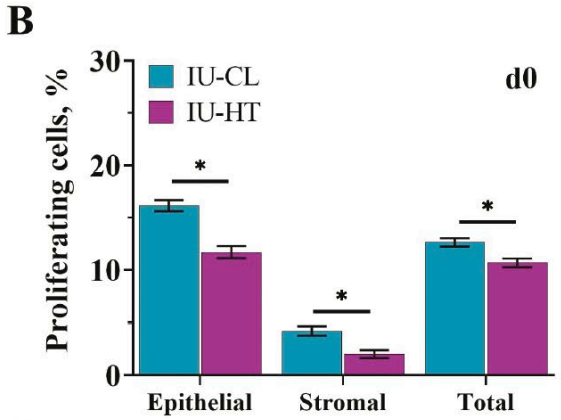
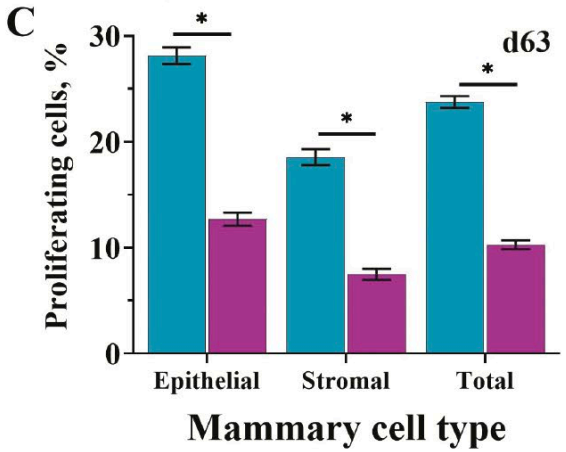


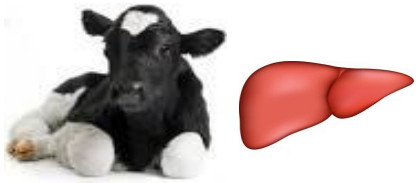


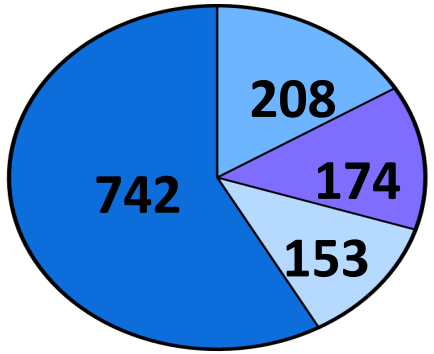


Dado-Senn et al. , *J. Anim. Sci*. 100:1-11.

DIFFERENTIALLY METHYLATED CYTOSINES (DMC'S)

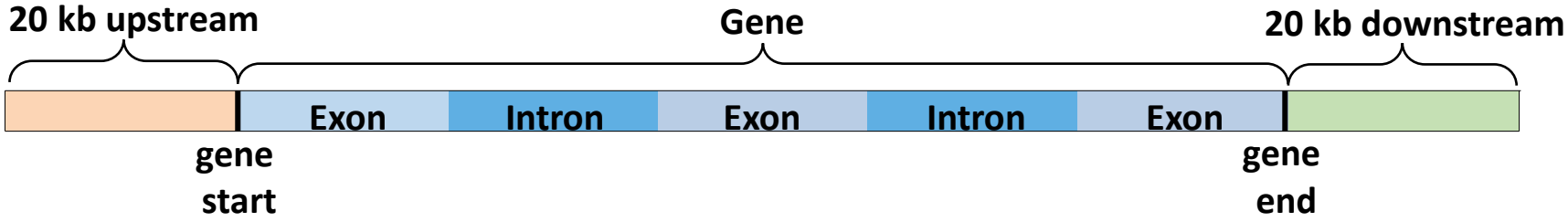
Bull calves



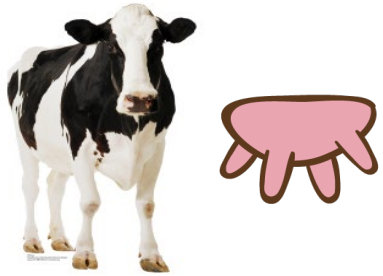


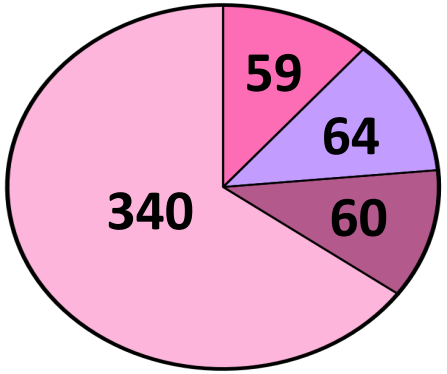
Within 20 kb downstream
Within gene
Within 20 kb upstream
Outside genic region

1277 DMC's



Cows



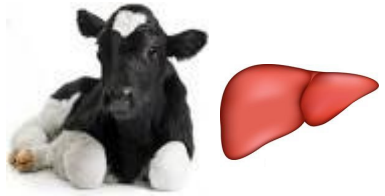


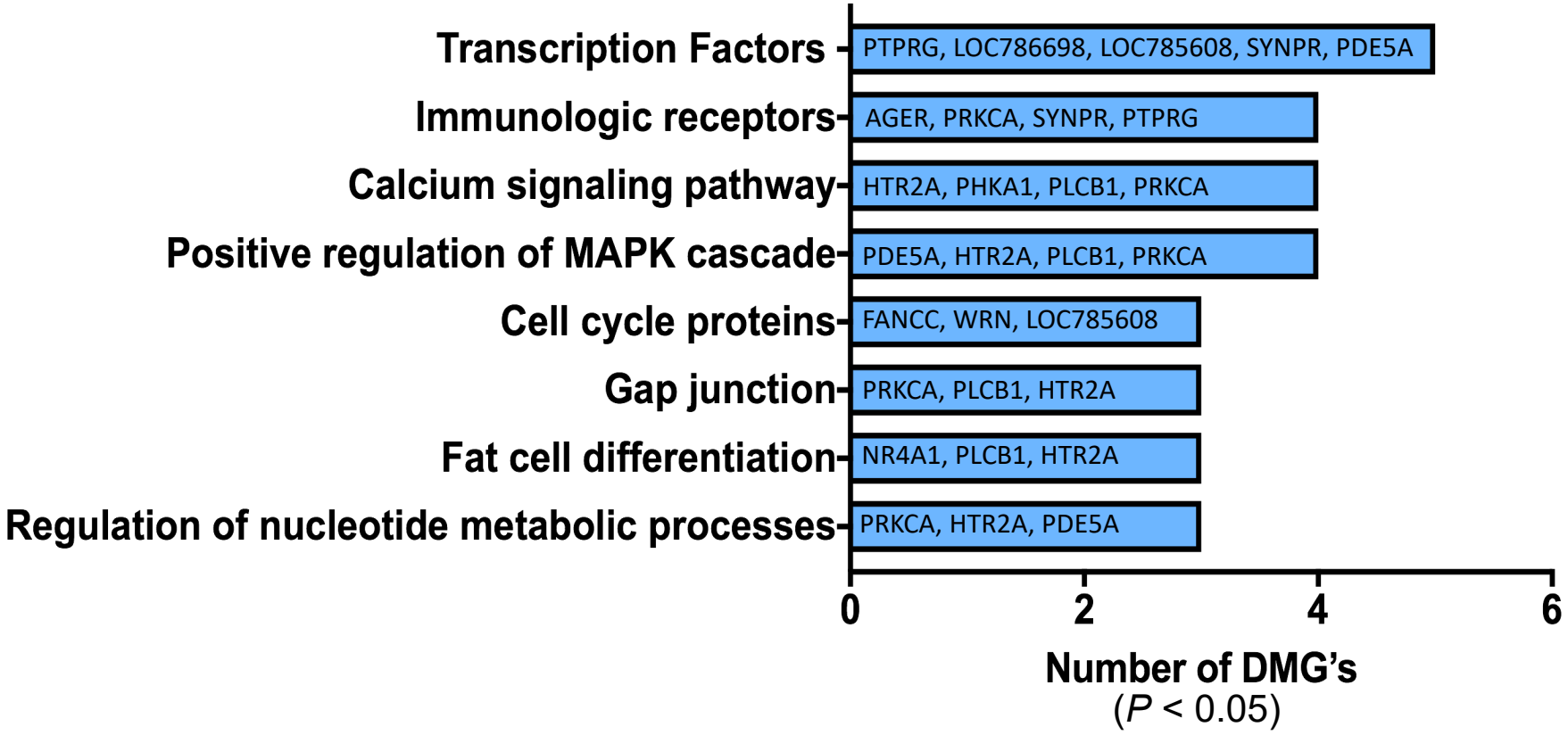
Within 20 kb downstream
Within gene
Within 20 kb upstream
Outside genic region

523 DMC's

Skibiel et al., *Sci. Reports* 8(1):146

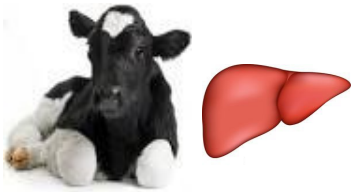
BIOLOGICAL PATHWAYS AND FUNCTIONS





Skibiel et al., *Sci. Reports* 8(1):14609.

AGER GENE



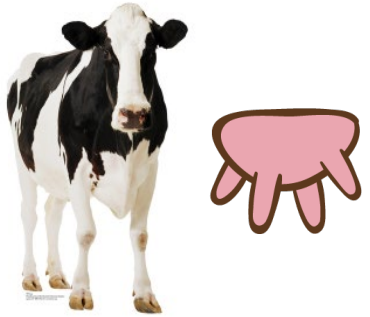
- ***In utero* HT - hypomethylation of C's upstream of gene**

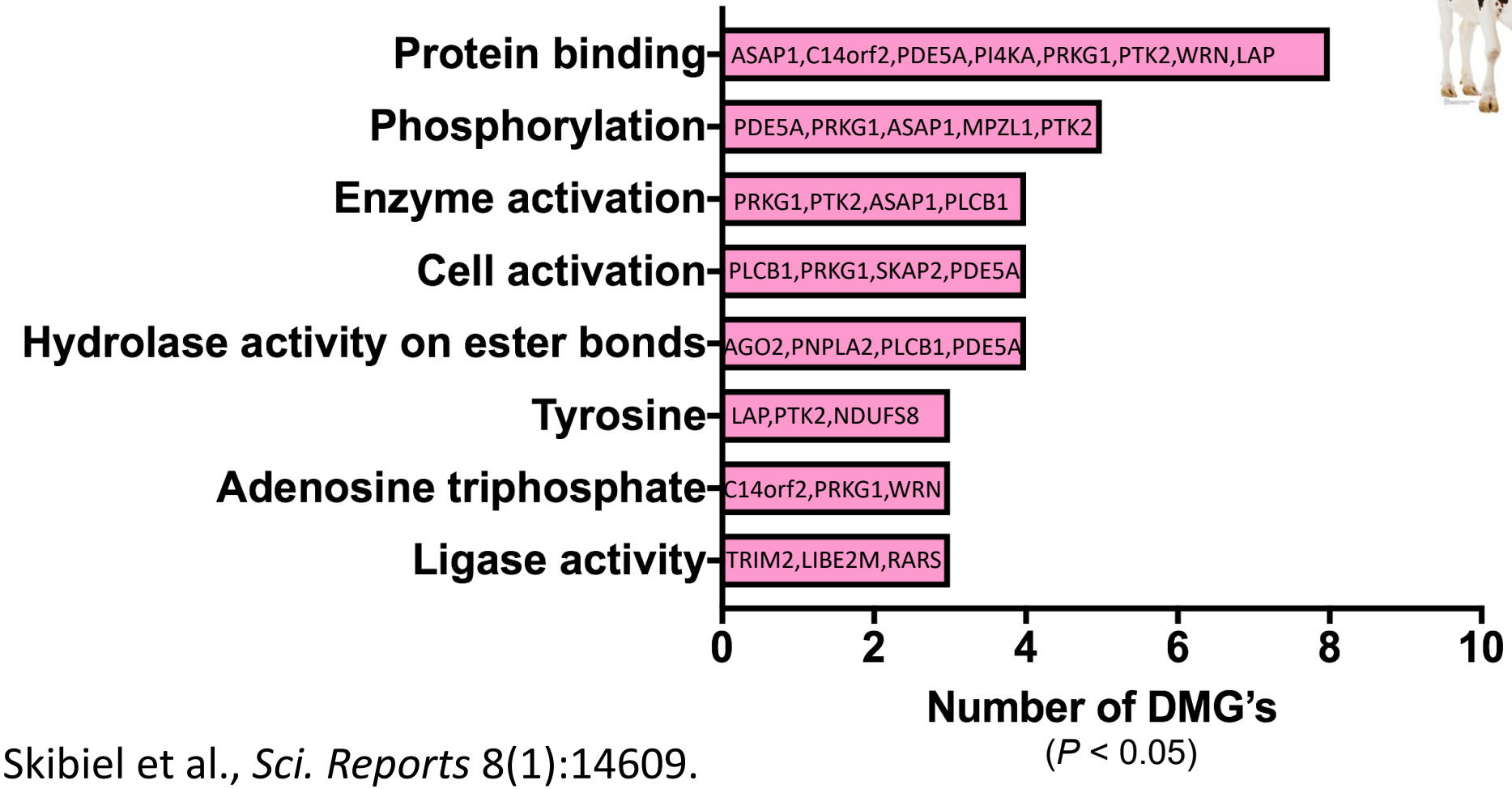
- **Innate immune function and inflammation**
  - Production of pro-inflammatory cytokines
  - Leukocyte recruitment

- **Oxidative stress**
  - ROS production
  - Depress glutathionine and ascorbic acid levels

Chavakis et al., 2004; Bierhaus et al., 2005; Lin et al., 2009

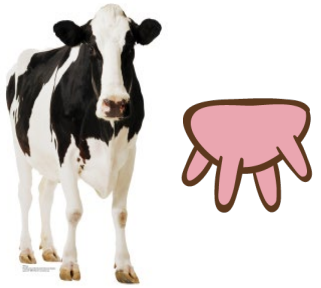
BIOLOGICAL PATHWAYS AND FUNCTIONS



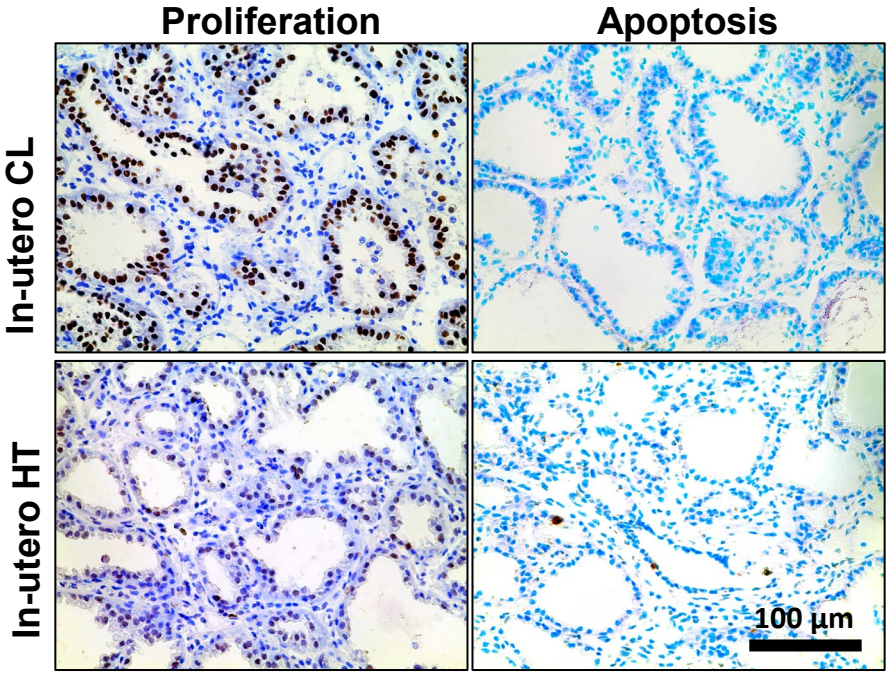


Skibiel et al., *Sci. Reports* 8(1):14609.

PRKG1 GENE



- **In-utero HT - hypomethylation of C's within gene**
- **Cell signal transduction**
  - Major intracellular receptor for cGMP
  - Catalyzes substrate phosphorylation
- **Decrease intracellular Ca**
- **Apoptotic effect**

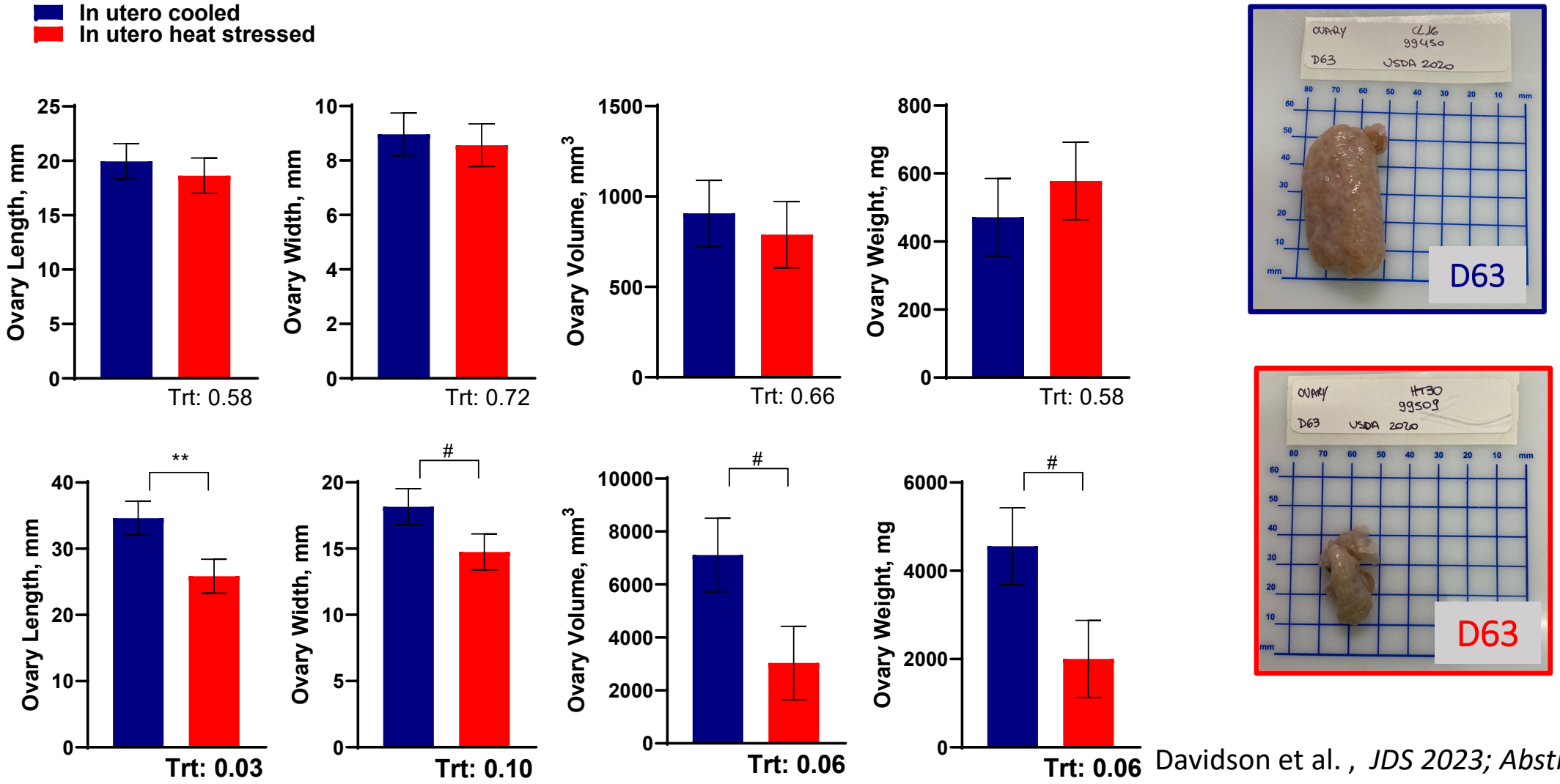


Francis et al., 1999, Schlossman et al., 2000 Hou et al., 2006, Jackson and Ceresa 2016

In Utero Cooling Increases Ovarian Size at D63

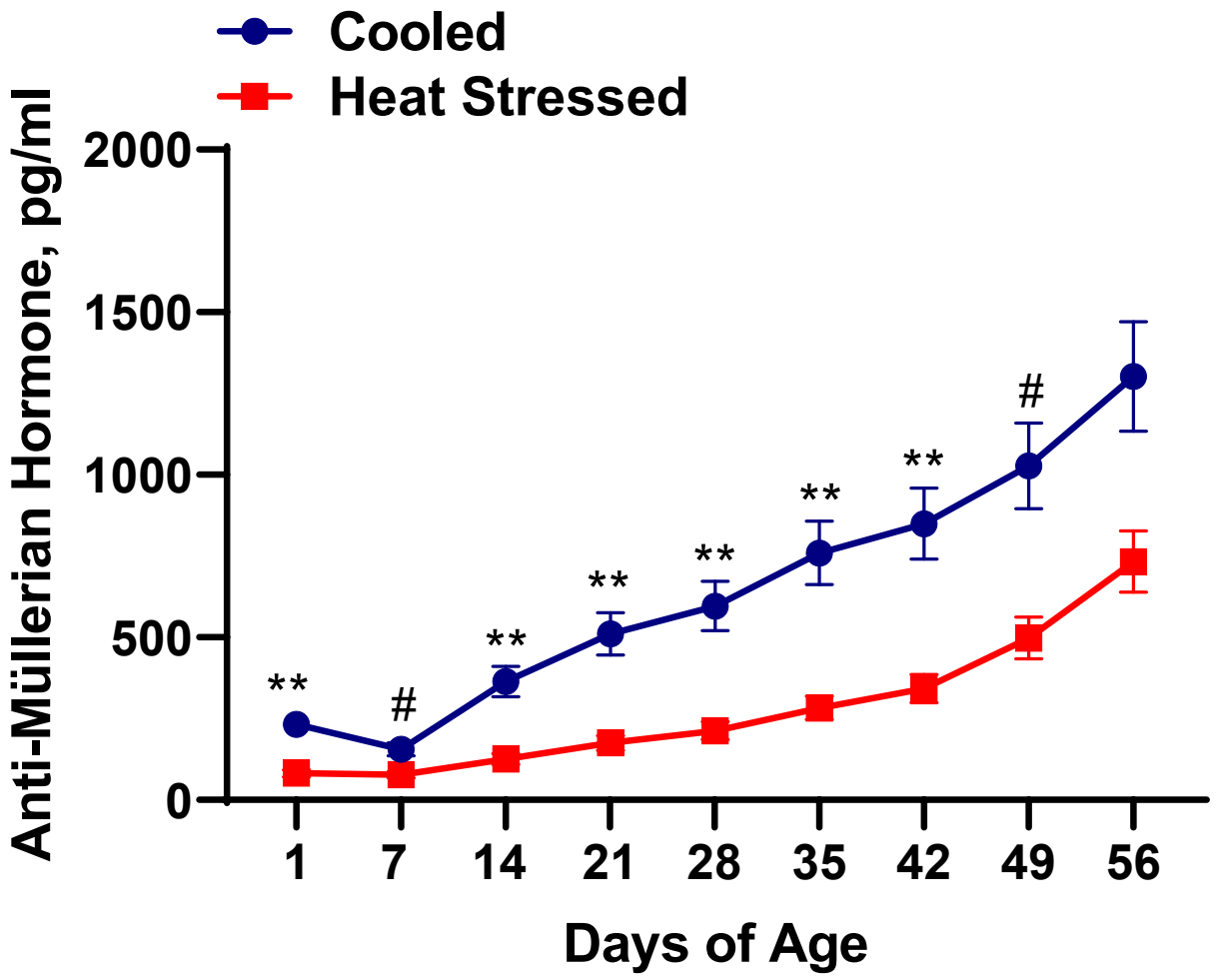
Birth

D63



Davidson et al. , *JDS 2023; Abstract*

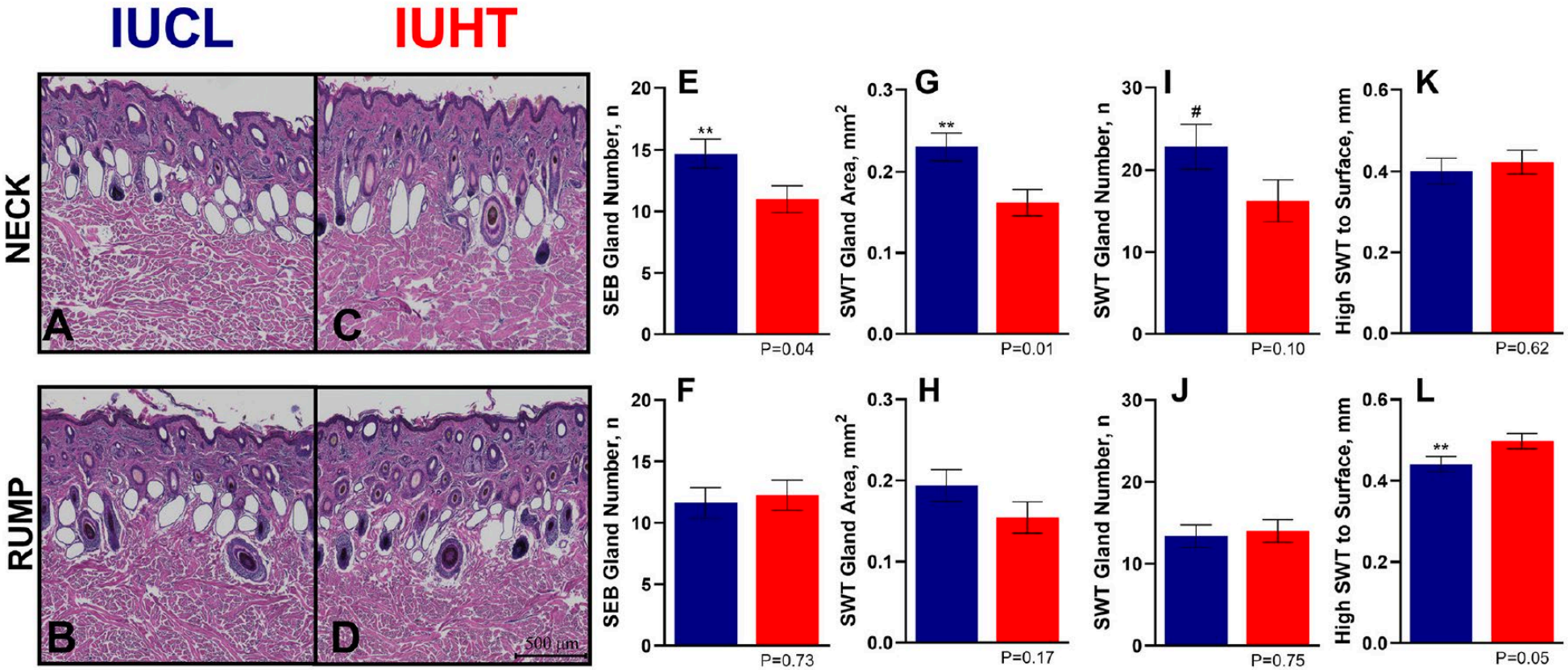
AMH CONCENTRATIONS WERE HIGHER IN IUCL CALVES FROM D1 TO D56



Trt: 0.03
Day: <0.0001
Trt*Day: 0.02

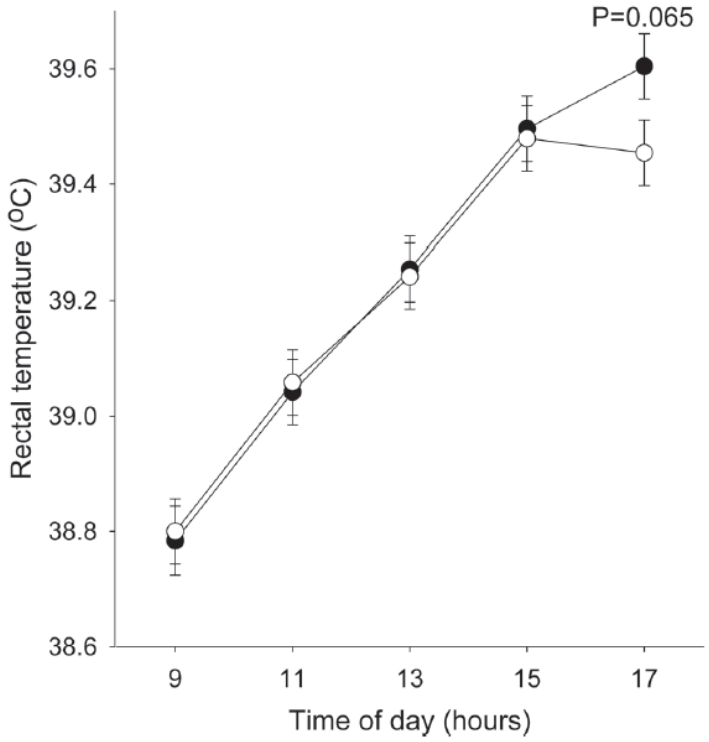
Davidson et al. , *JDS 2023; Abstract*

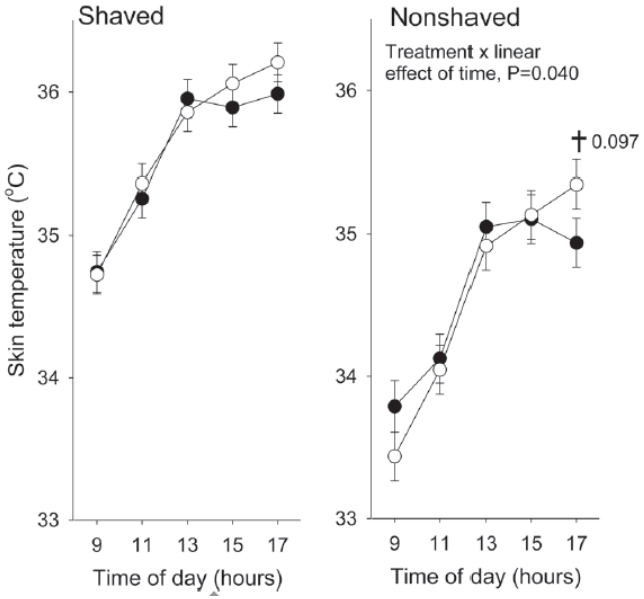
IN UTERO HEAT STRESS ALTERS SKIN MORPHOLOGY

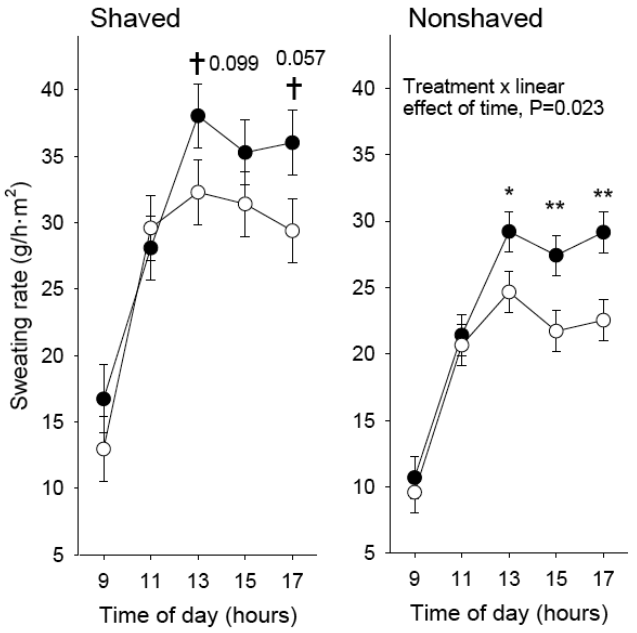


Davidson et al. , *J. Dairy Sci*. 105:8898-8910.

IN UTERO HS ALTERS BODY TEMPERATURE REGULATION AT MATURITY

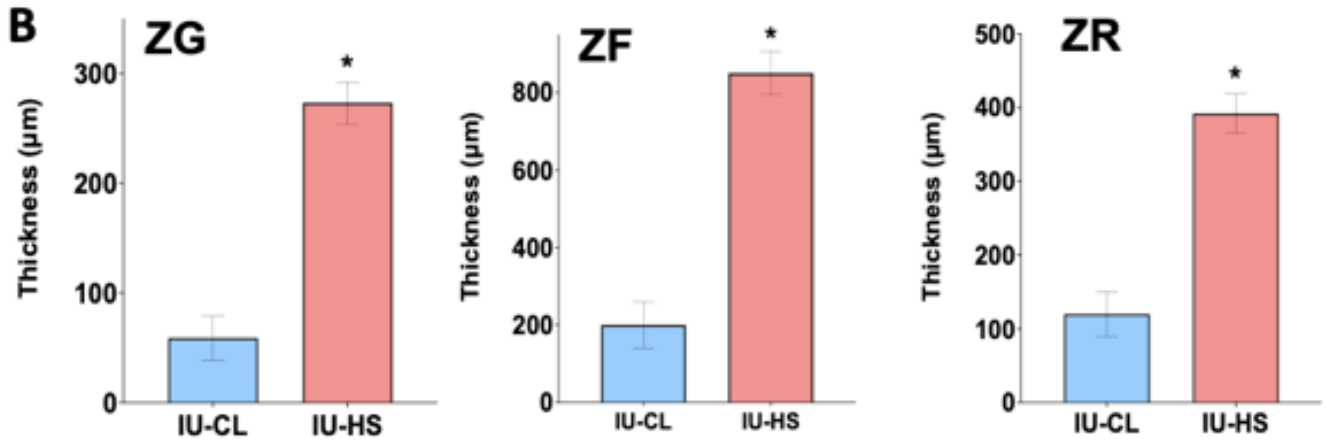


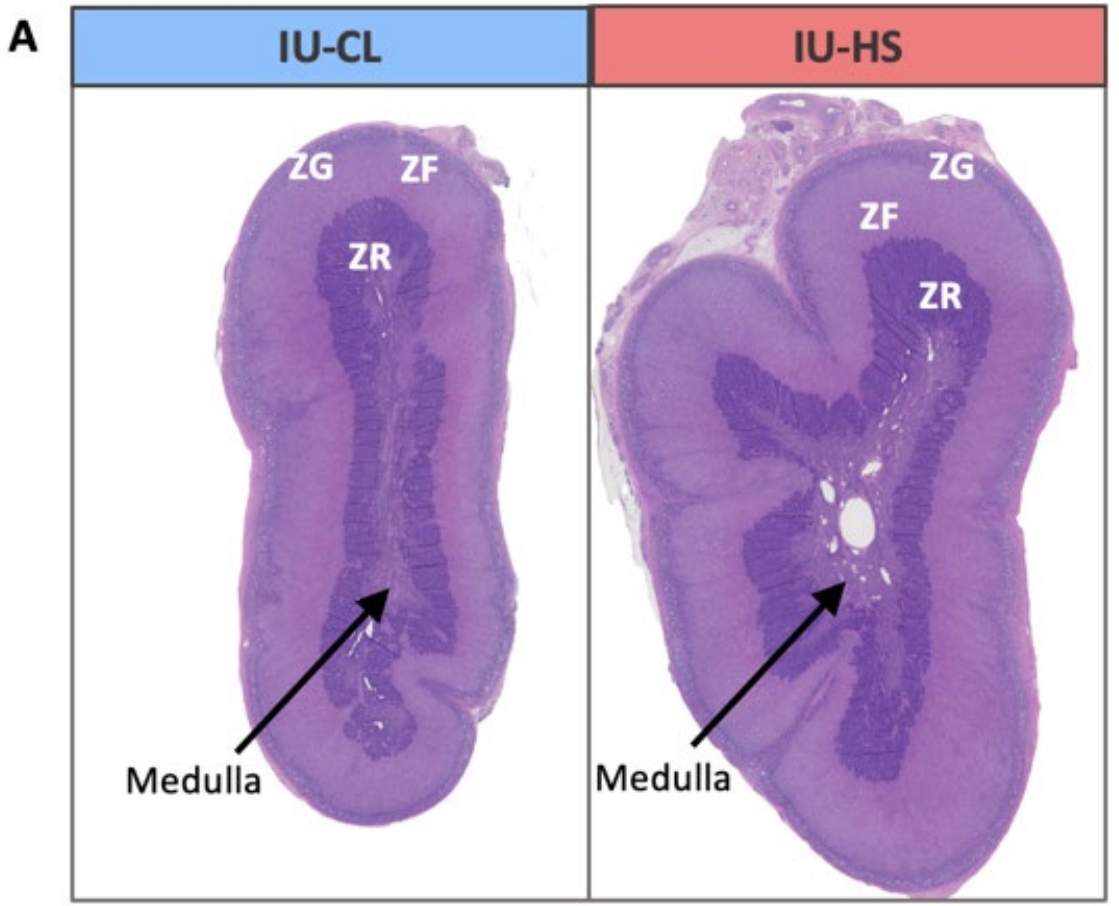




Ahmed et al. , *J. Anim. Sci*. 95:3497-3503.

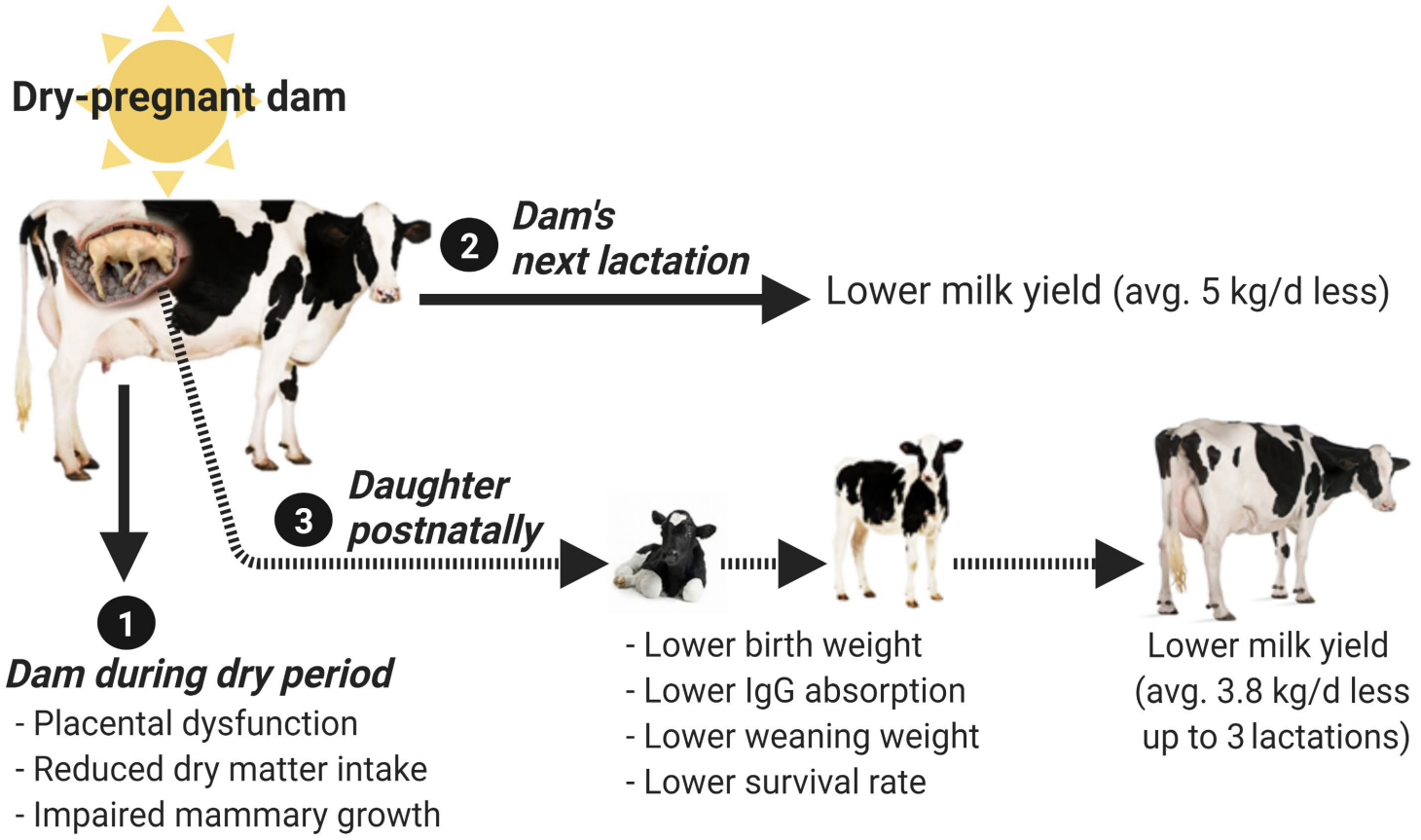
IN UTERO HS ALTERS ADRENAL DEVELOPMENT AT WEANING





Guadagnin et al. , *JDS 2024:In Press*

IMPACT ON LONGEVITY?



- **In utero HT induces fetal programming**
- **Alters methylation patterns in multiple tissues, ages**
- **Phenotype persists to F_2**

FLORIDA: LONGEVITY AND BIRTH SEASON

Lactation Number	Cow Number	Birth Season	
		"Cool Season" (Dec., Jan., Feb., Mar)	"Hot Season" (Jun., Jul., Aug., Sept.)
5	968	686	282
6	423	321	102
7	129	96	33
8	47	26	21
Total Cows	**1,567**	1,129 (72%)**	438 (28%)**

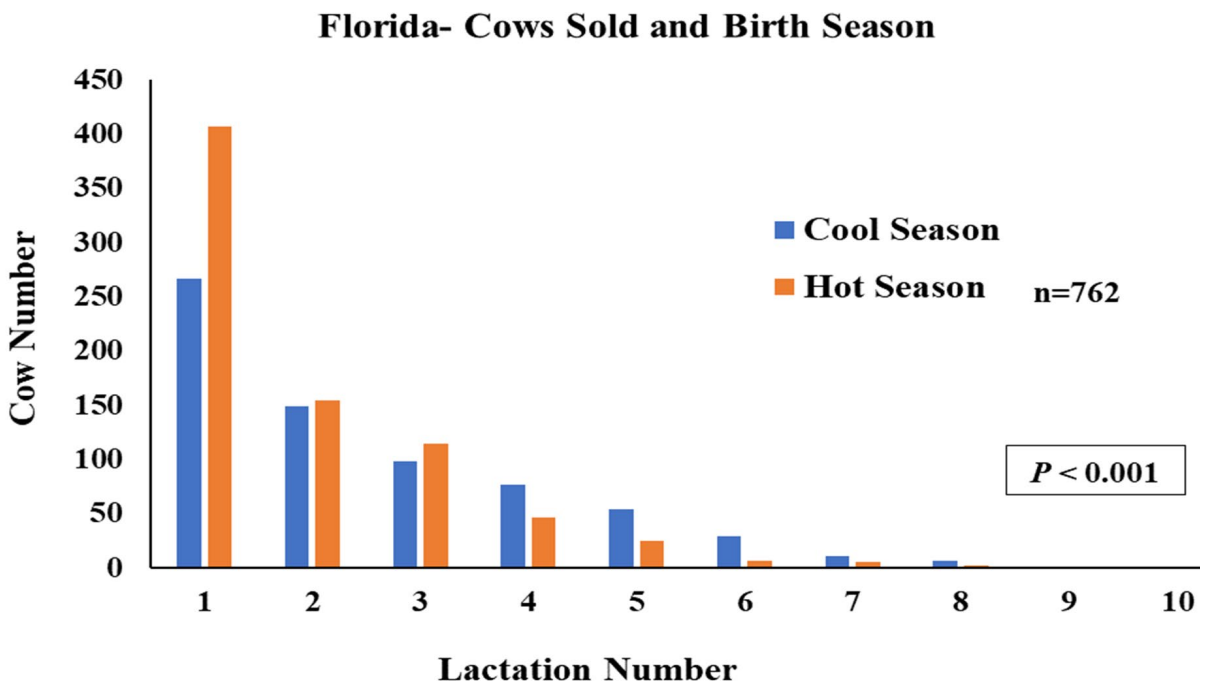
$^{**}P < 0.01$

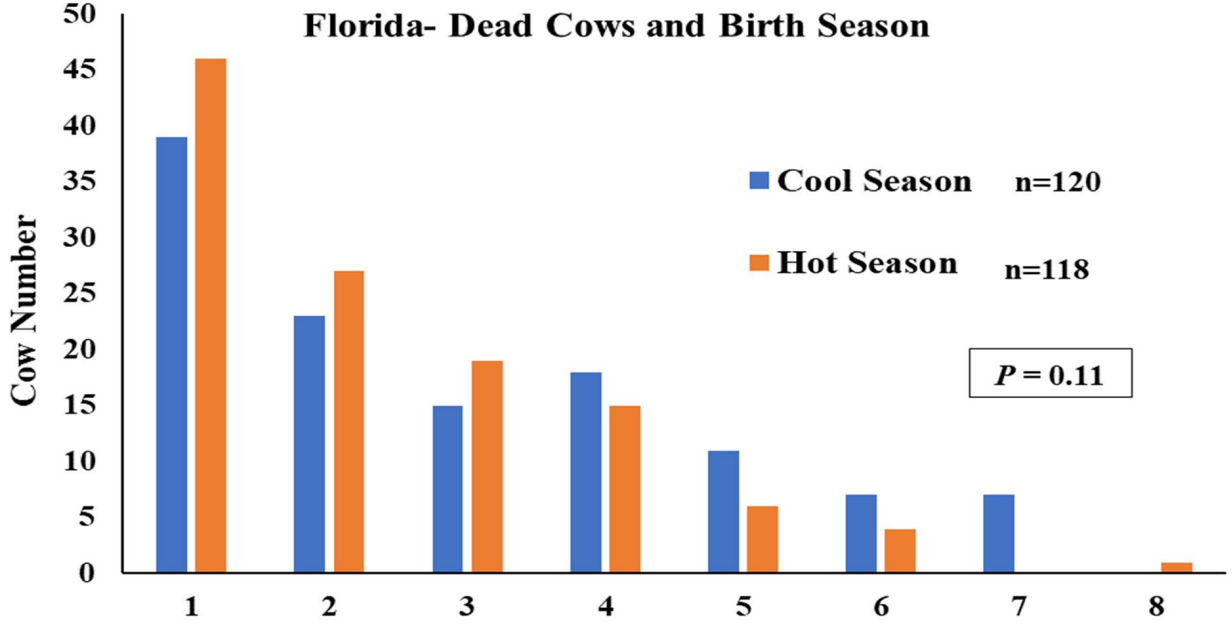
CALIFORNIA: BIRTH SEASON IMPACTS LONGEVITY

Lactation Number	Cow Number	Birth Season	
		Cool Season (Dec, Jan, Feb, Mar)	Hot Season (Jun, Jul, Aug, Sept)
5	908	484	424
6	507	318	189
7	204	108	96
8	50	29	21
Total Cows	1,669	939 (56.3%) **	730 (43.7%) **

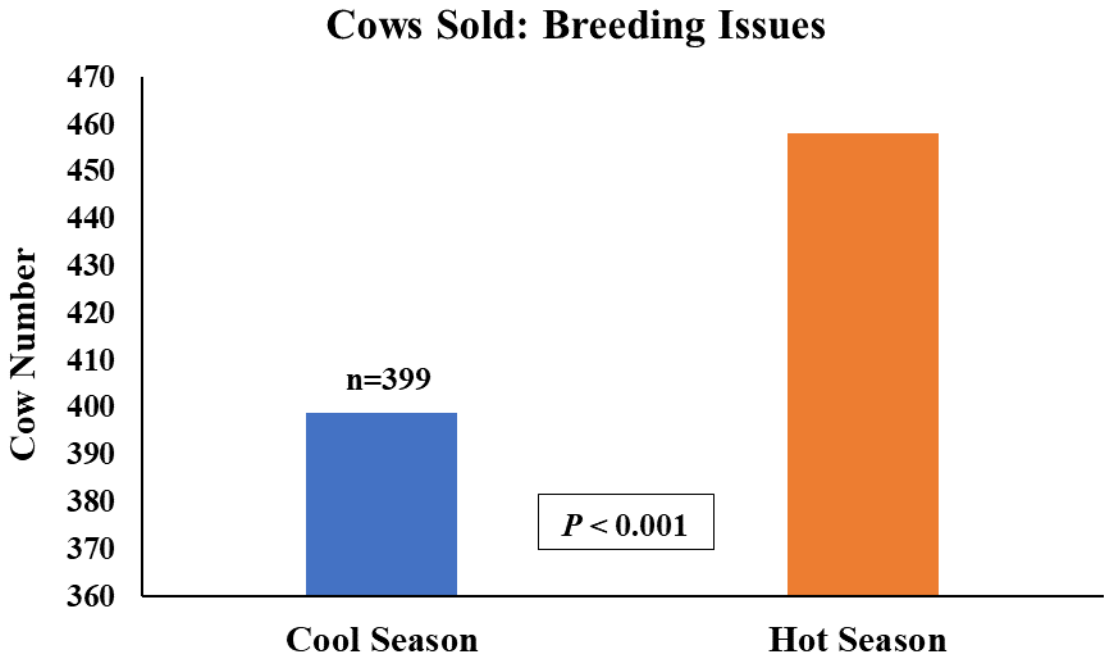
$^{**}P < 0.01$

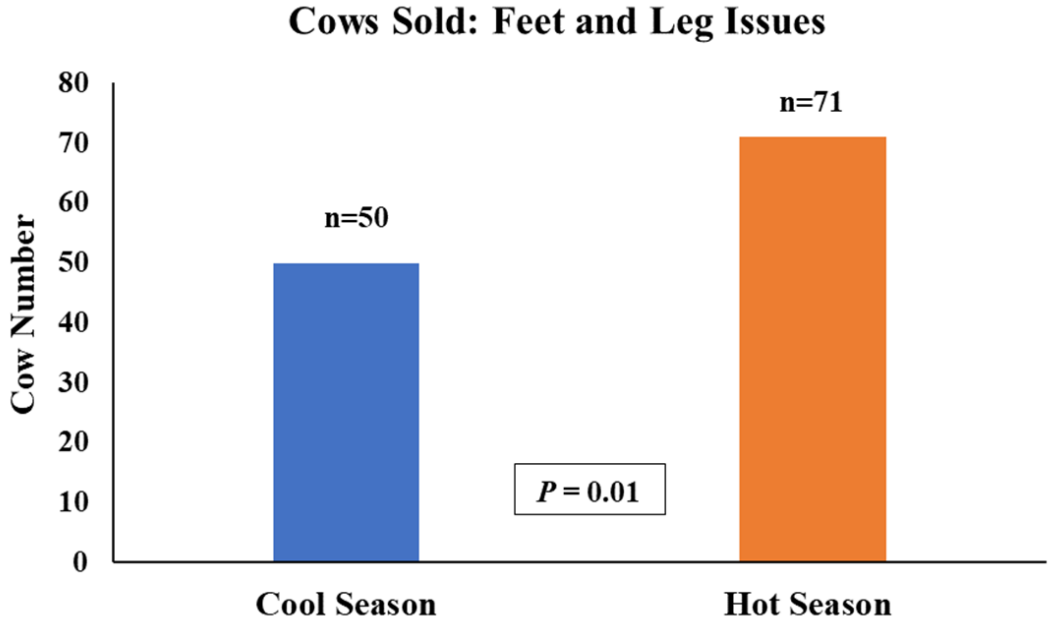
FLORIDA: COWS LEAVE DUE TO SALE



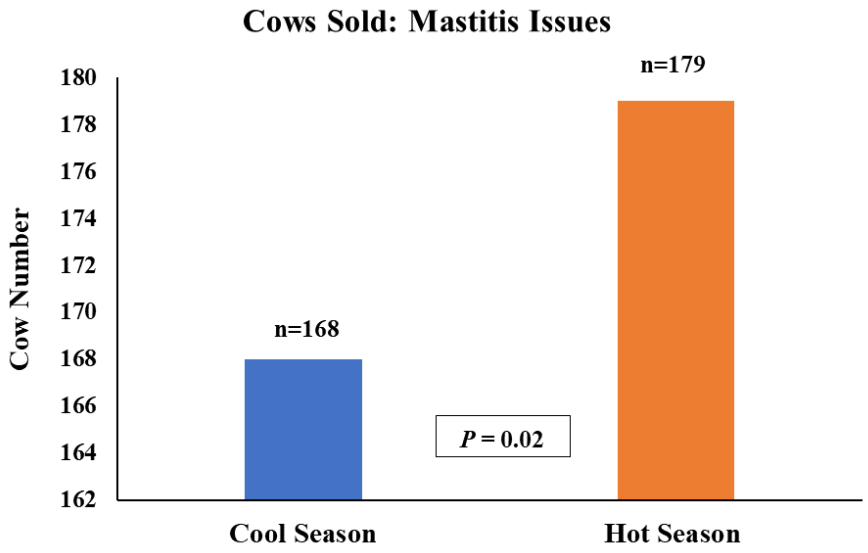


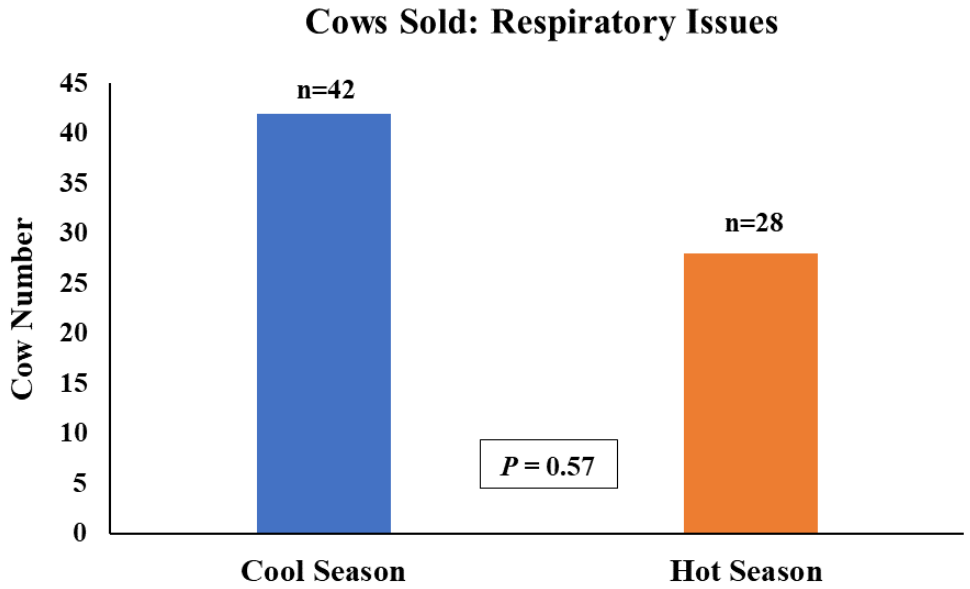
HOT BIRTH SEASON INCREASES COWS SOLD FOR REPRODUCTIVE, FEET AND LEG ISSUES

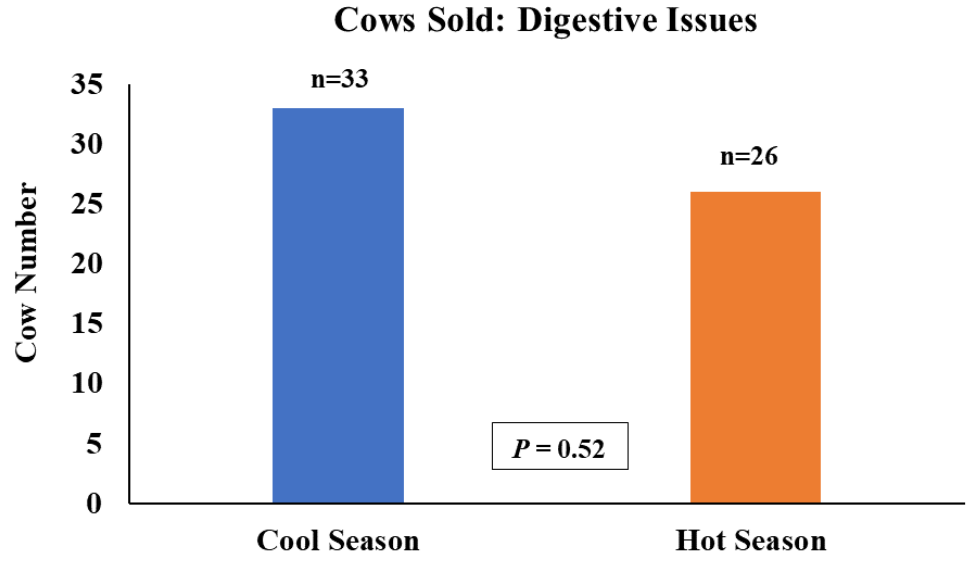




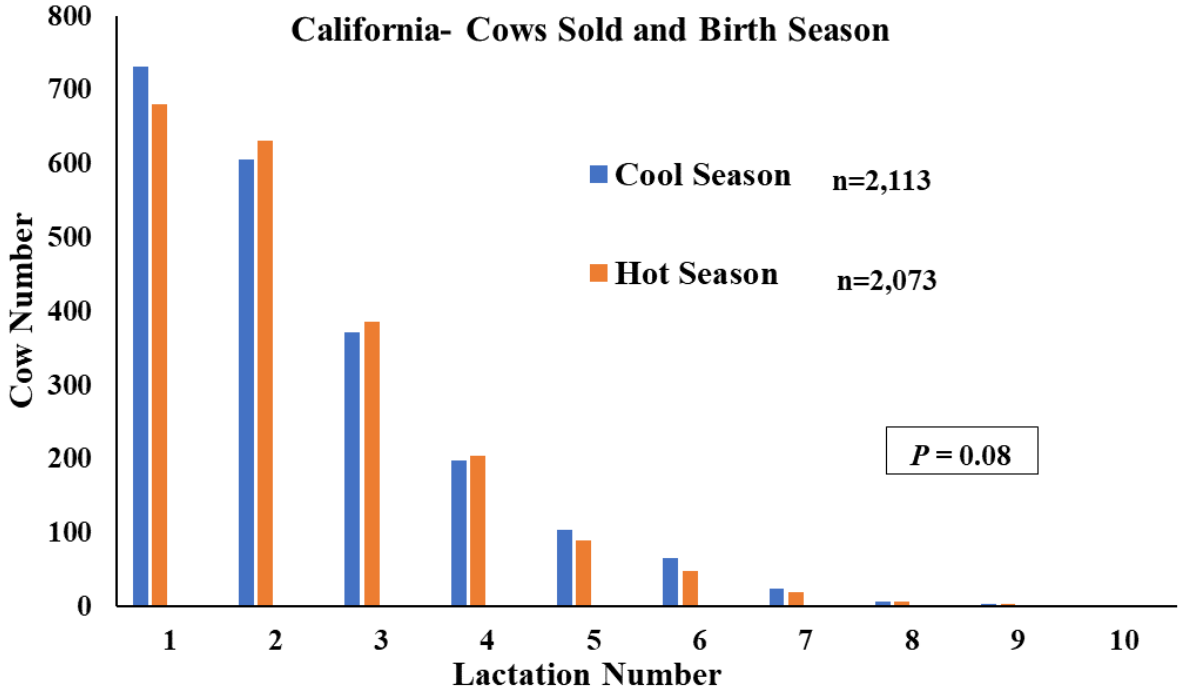
HOT BIRTH SEASON INCREASES COWS SOLD FOR MASTITIS

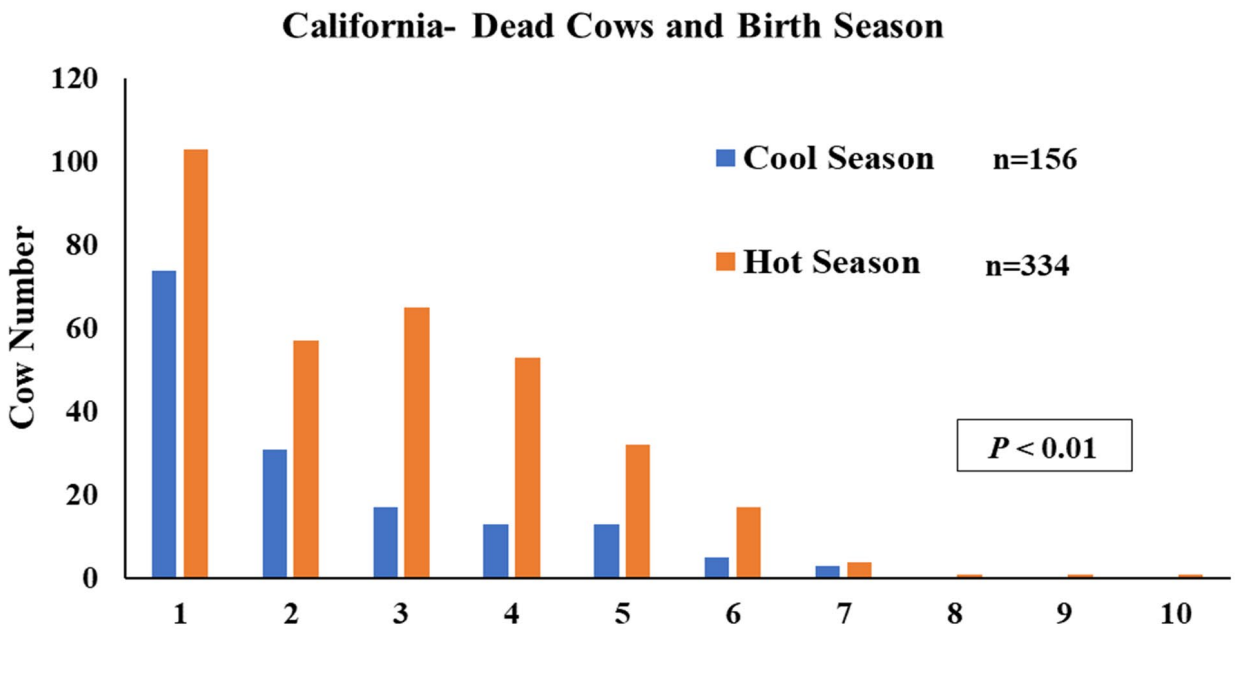






CALIFORNIA: BIRTH SEASON ALTERS DEATH LOSS





BIRTH IN HOT SEASON REDUCES HERD SURVIVAL

- Consistent with in utero heat stress effects
- Death and sale due to reproduction, mastitis and lameness drive early exits
- Longevity programmed by in utero and early events – esp. heat stress
- Consider in selection of heifers for future production herd

LATE GESTATION HEAT STRESS