BEAT THE HEAT – OR IT WILL BEAT YOU!

HEAT STRESS EFFECTS ACROSS THE LACTATION CYCLE

Balchem

Real Science Lecture

1 April 2025

G. E. Dahl

Department of Animal Sciences

Institute of Food and Agricultural Sciences

gdahl@ufl.edu

HEAT STRESS AFFECTS ENTIRE LACTATION CYCLE

- Lactating cows
  - Impact on efficiency, CH_4
- Dry cows
  - Milk yield, placental fxn, nulliparous heifers
- In utero programming
  - Reproduction, mammary development
- Longevity effects of heat stress?

HEAT STRESS EFFECTS ON YIELD VARY WITH DIM

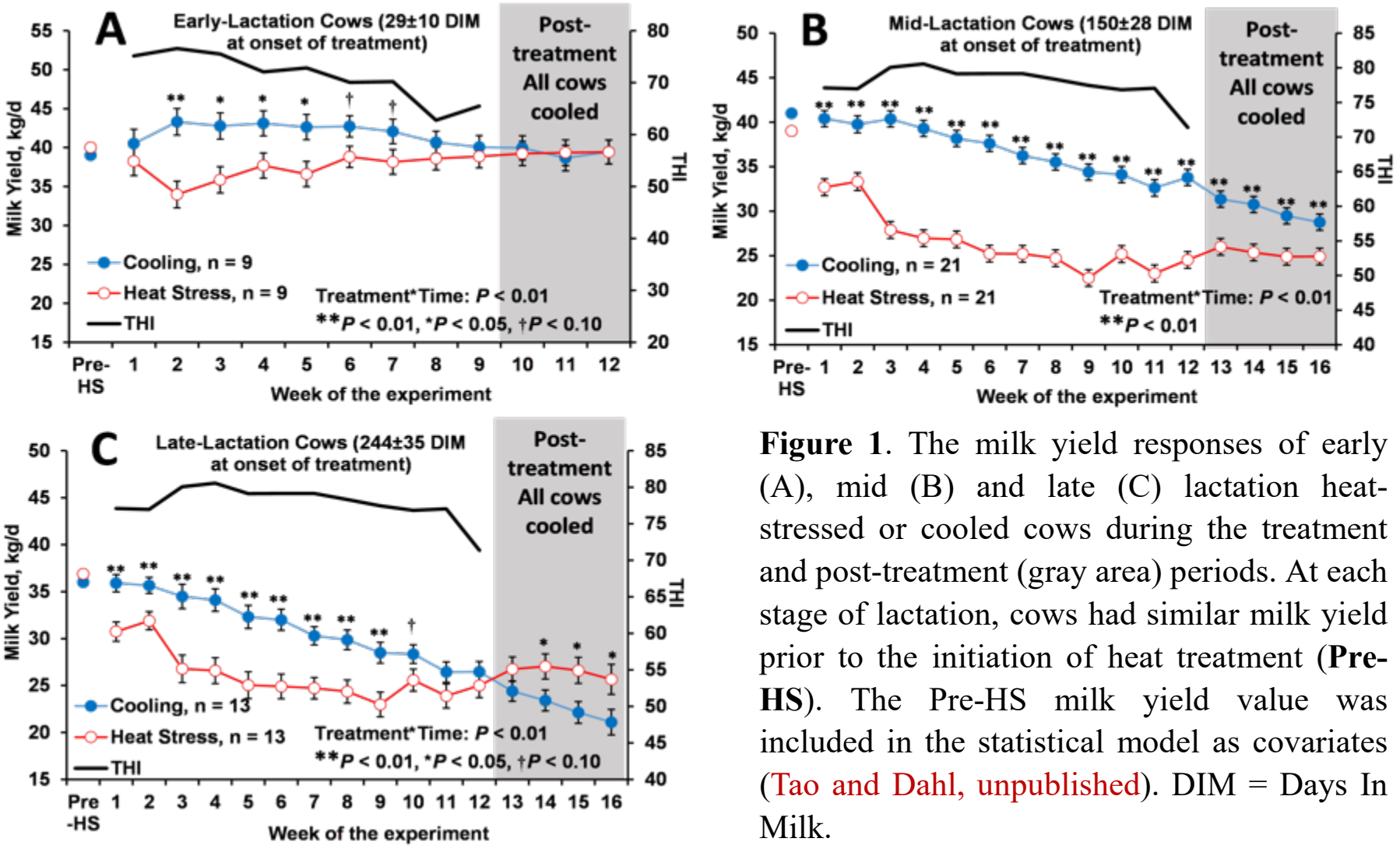


Figure 1. The milk yield responses of early (A), mid (B) and late (C) lactation heat-stressed or cooled cows during the treatment and post-treatment (gray area) periods. At each stage of lactation, cows had similar milk yield prior to the initiation of heat treatment (**Pre-HS**). The Pre-HS milk yield value was included in the statistical model as covariates (Tao and Dahl, unpublished). DIM = Days In Milk.

HEAT STRESS EFFECTS ON EFFICIENCY VARY WITH DIM

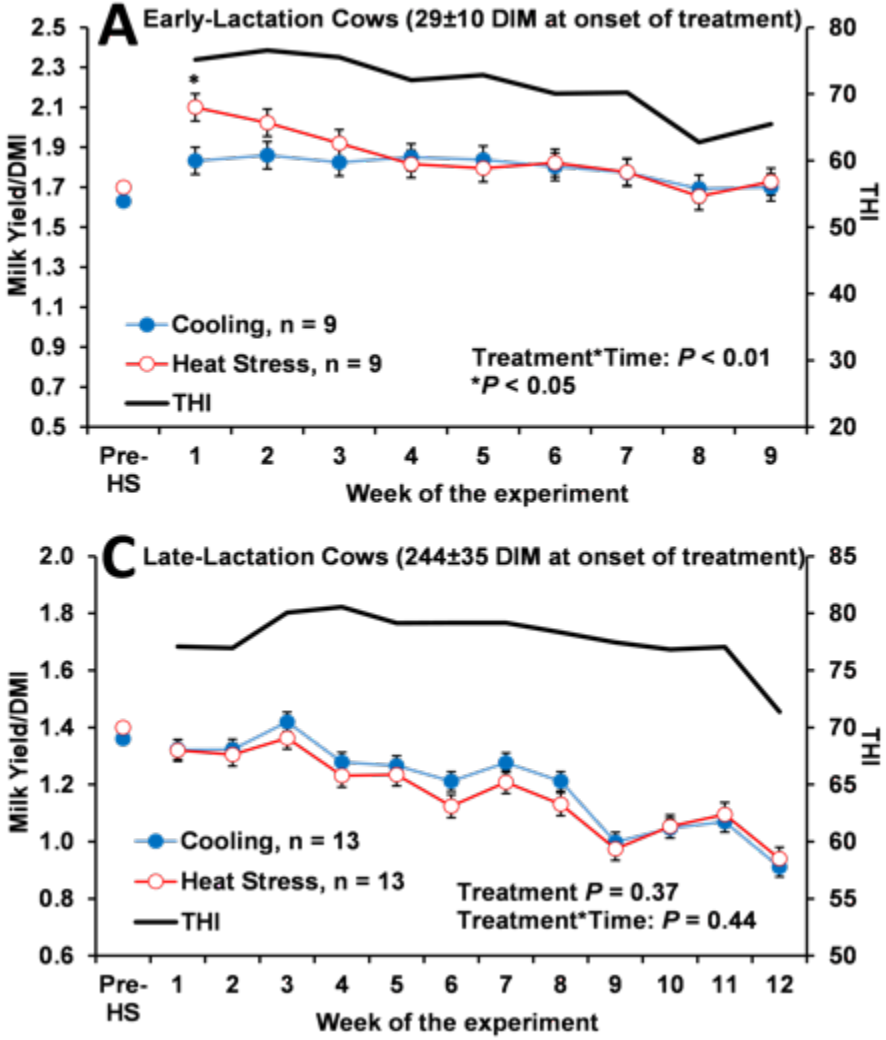
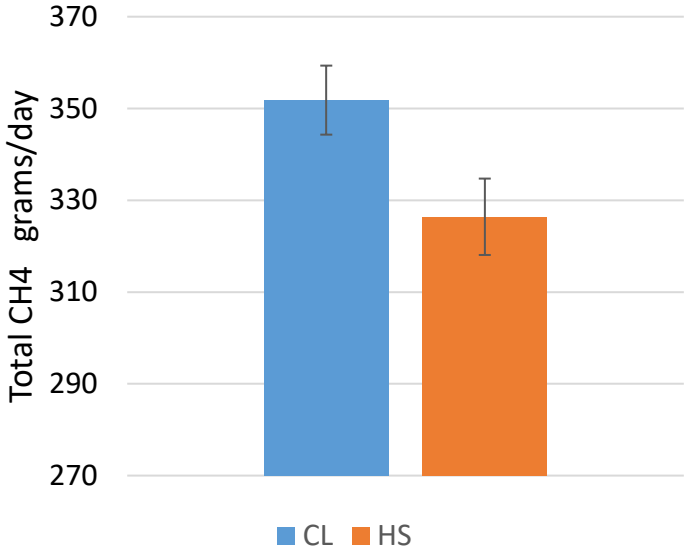
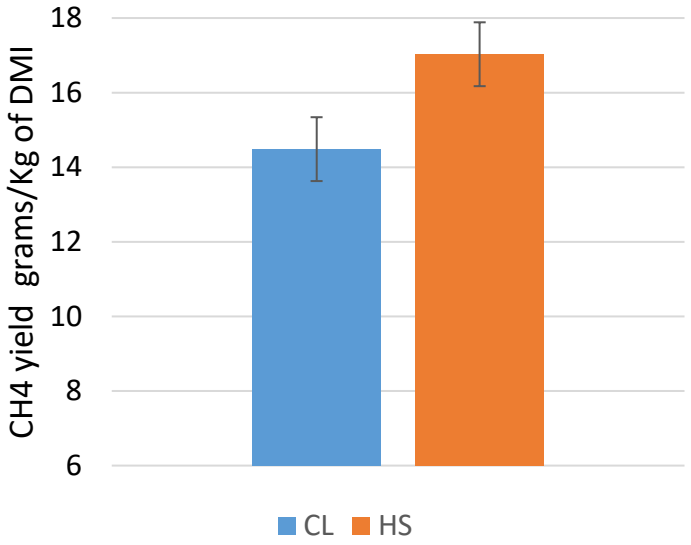


Figure 2. The milk yield/DMI ratio of early (A), mid (B) and late (C) lactation heat-stressed or cooled cows. At each stage of lactation, cows had similar milk yield/DMI ratio prior to the initiation of heat treatment (**Pre-HS**). The Pre-HS milk yield/DMI ratio was included in the statistical models as covariates (Tao and Dahl, unpublished). DIM = Days In Milk.

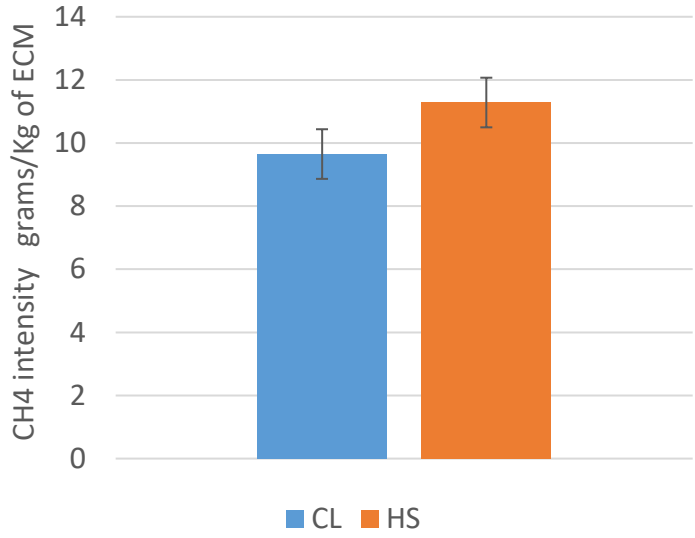
HEAT STRESS REDUCES TOTAL DAILY CH_4, INCREASES YIELD AND INTENSITY



Trt	0.0016
Period	0.0001
Trt*Period	0.0066

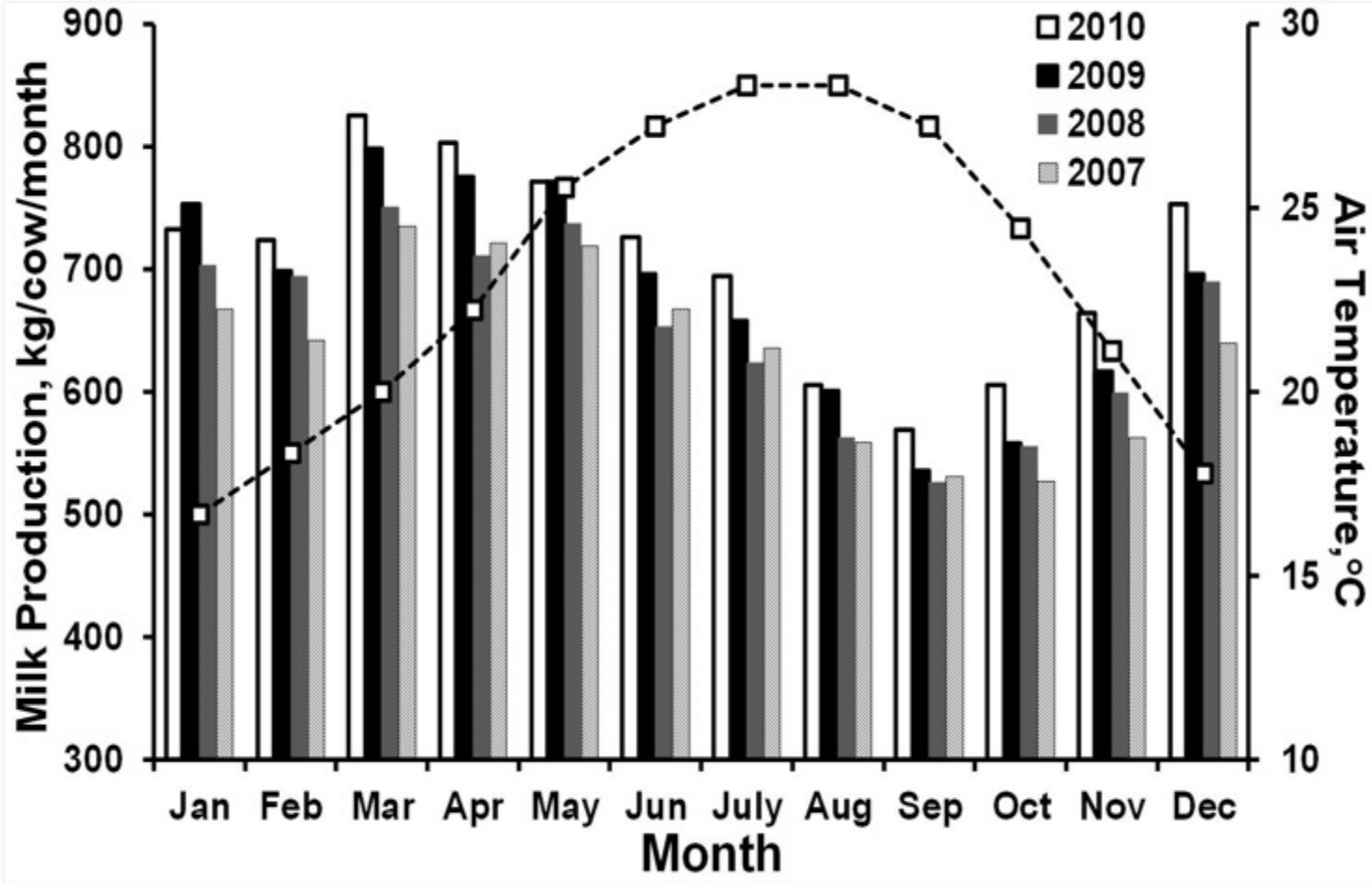


Trt	0.0001
Period	0.0754
Trt*period	0.1039



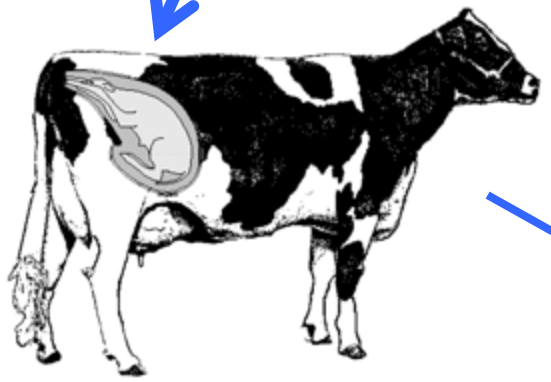
Trt	0.0039
Period	0.3472
Trt*period	0.151

HEAT STRESS EFFECTS ON YIELD PERSIST

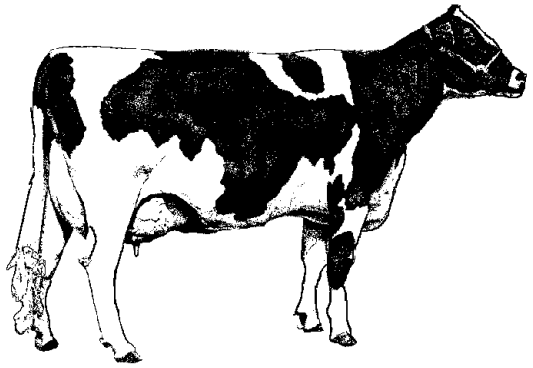


Tao & Dahl, *J. Dairy Sci.* 96:4079-4093

Late gestation



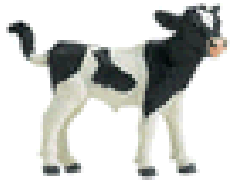
Milk yield?
Metabolism?
Immune function?
Placental Function?



DAM

vs.

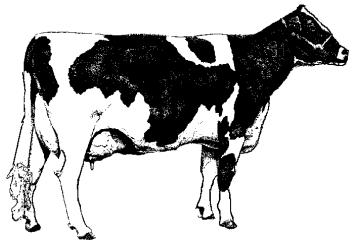
DAUGHTER



Calf health?
Calf growth?

Heifer growth?
Reproduction?

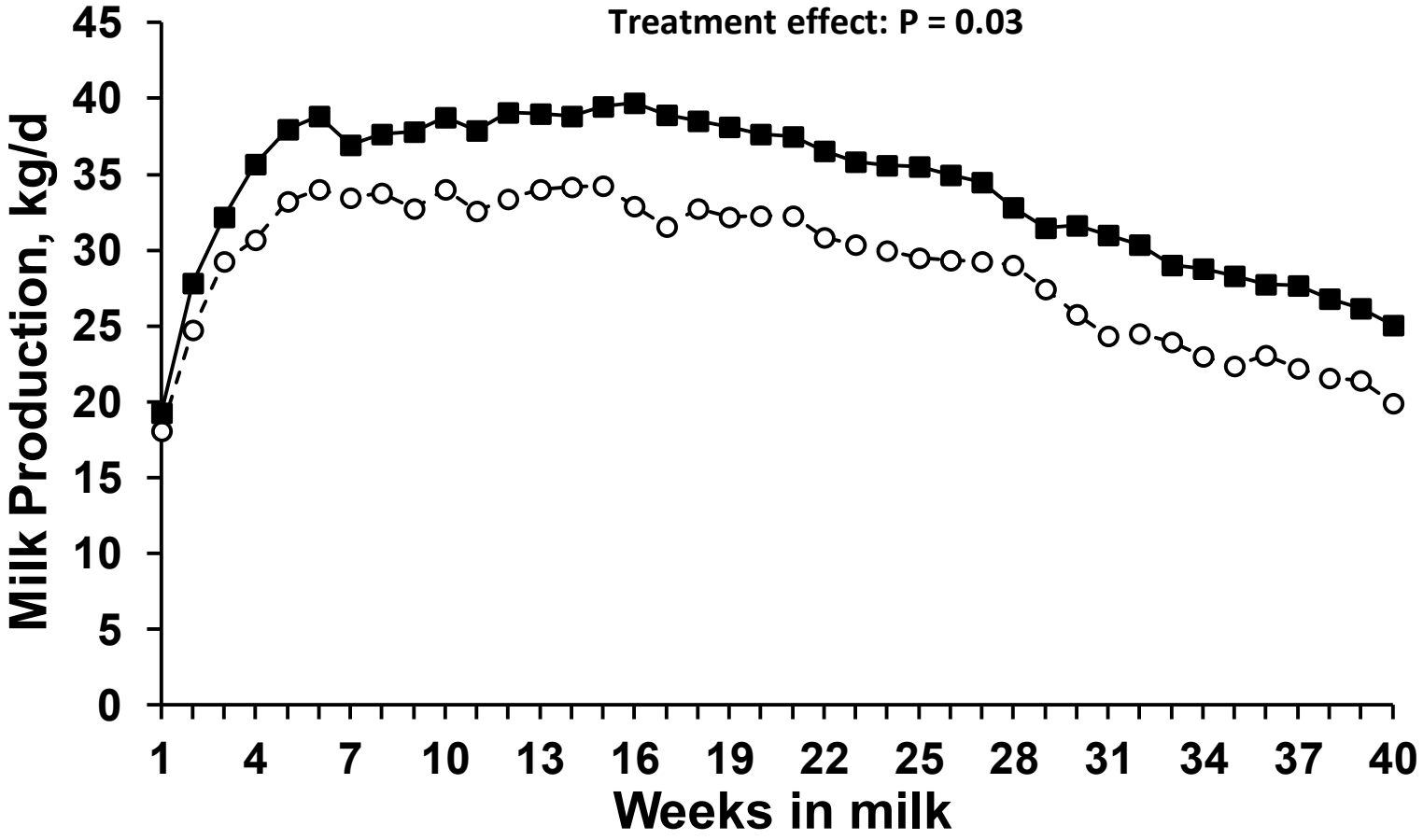
Cow performance?
Thermoregulation?
Survival?



Gainesville, Florida, USA

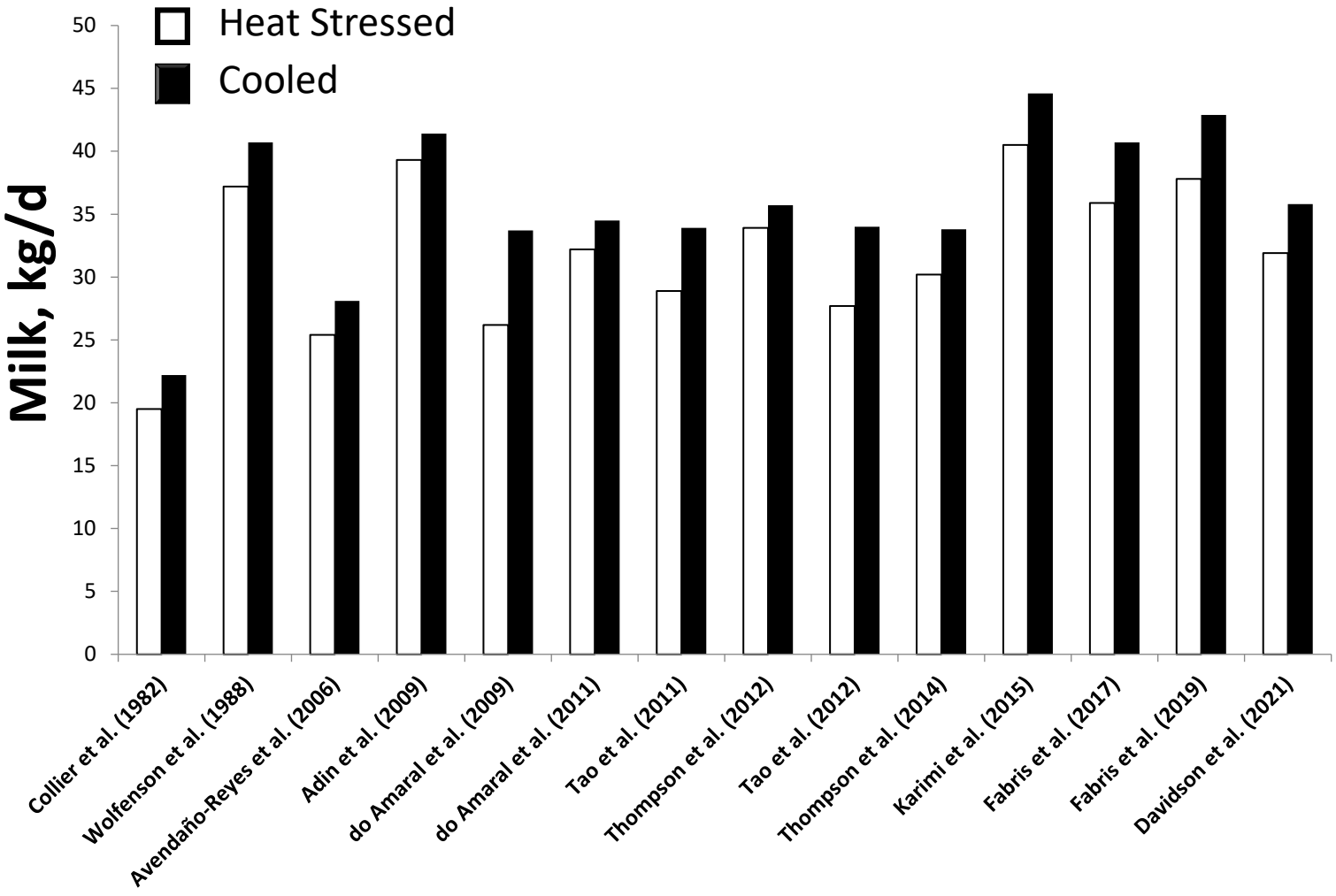
- Sand bedded free stalls
- Fans over stalls
- Soakers over feedline
- Fans on at 70° F (21.1°C)
- Soakers on 1 min every 5 min at 72° F

COOLING DRY COWS INCREASES MILK

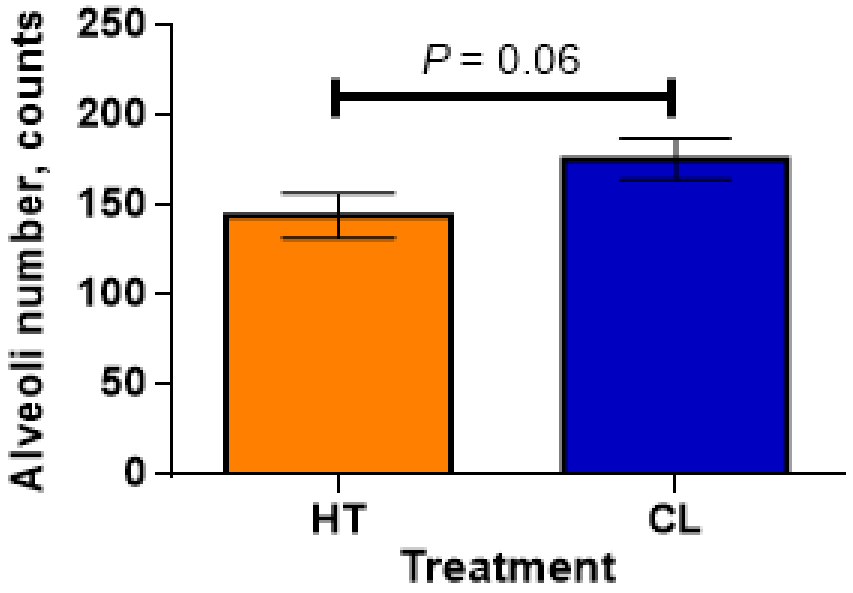


Tao et al., *J. Dairy Sci.* 94:5976–5986

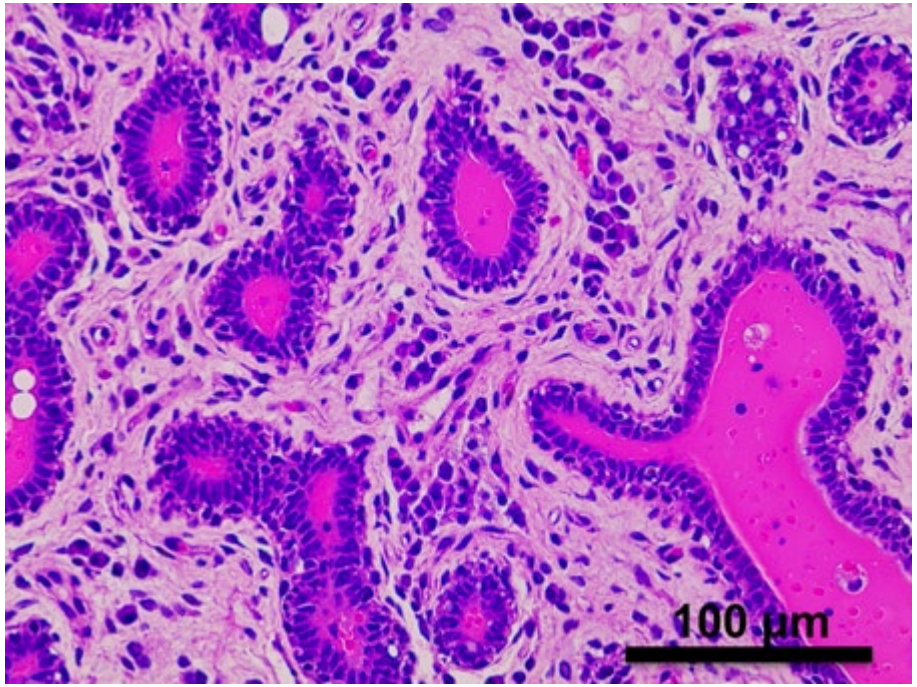
COOLING DRY COWS INCREASES MILK



HEAT STRESS DECREASES ALVEOLI NUMBER



H&E Stain



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

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

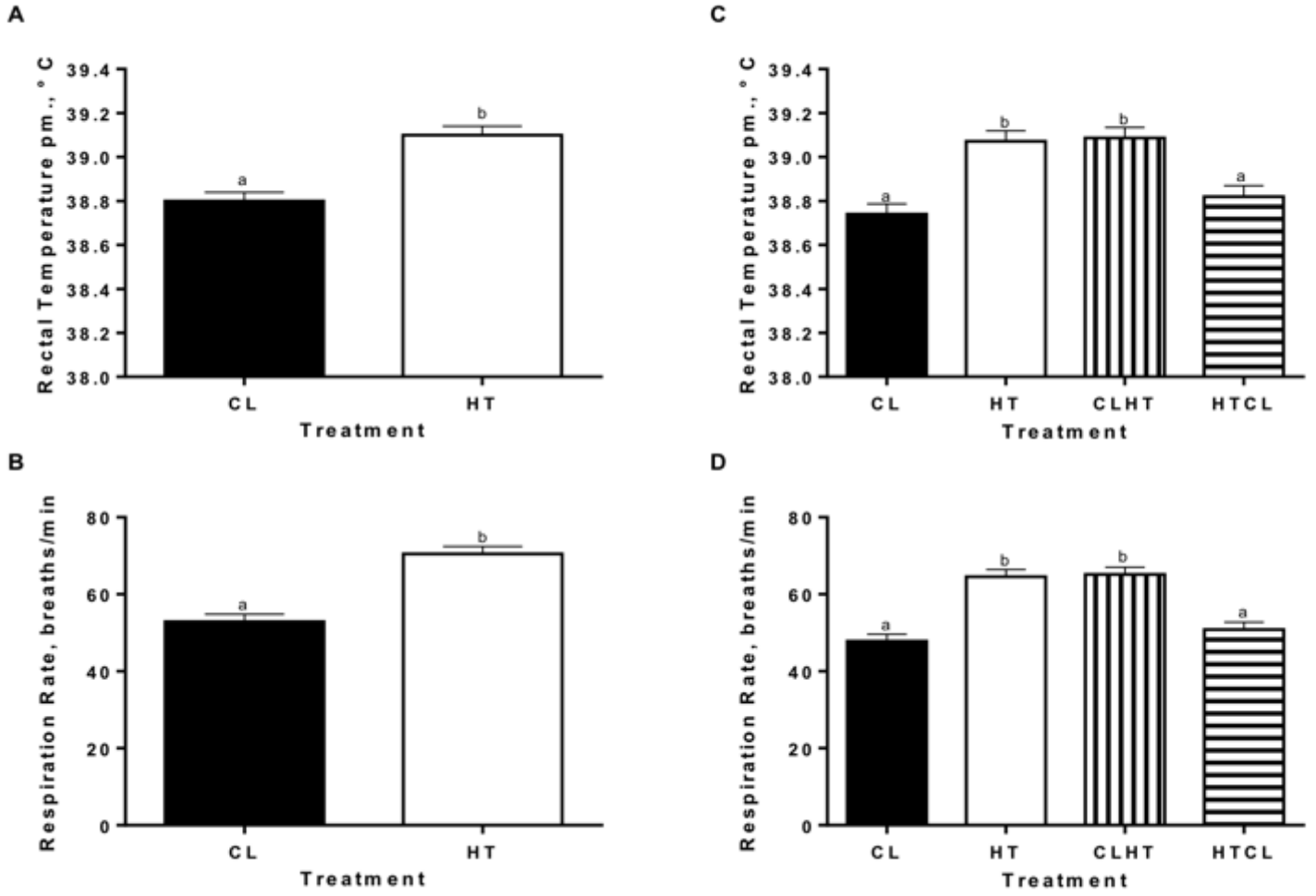
Item	Dry during HOT months (Jun, Jul, Aug)	Dry during COOL months (Dec, Jan, Feb)	*P*-value
Milk production (kg)	10,547 ± 67.0	11,005 ± 83.38	0.01
Number of breedings (n)	1,048	676	0.03
Mean (no.)	1.59 ± 0.02	1.51 ± 0.03	
DIM to breeding (n)	1,047	676	0.01
Mean (d)	97.0 ± 0.74	91.8 ± 0.92	
DIM to pregnancy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

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

LATE GESTATION COOLING

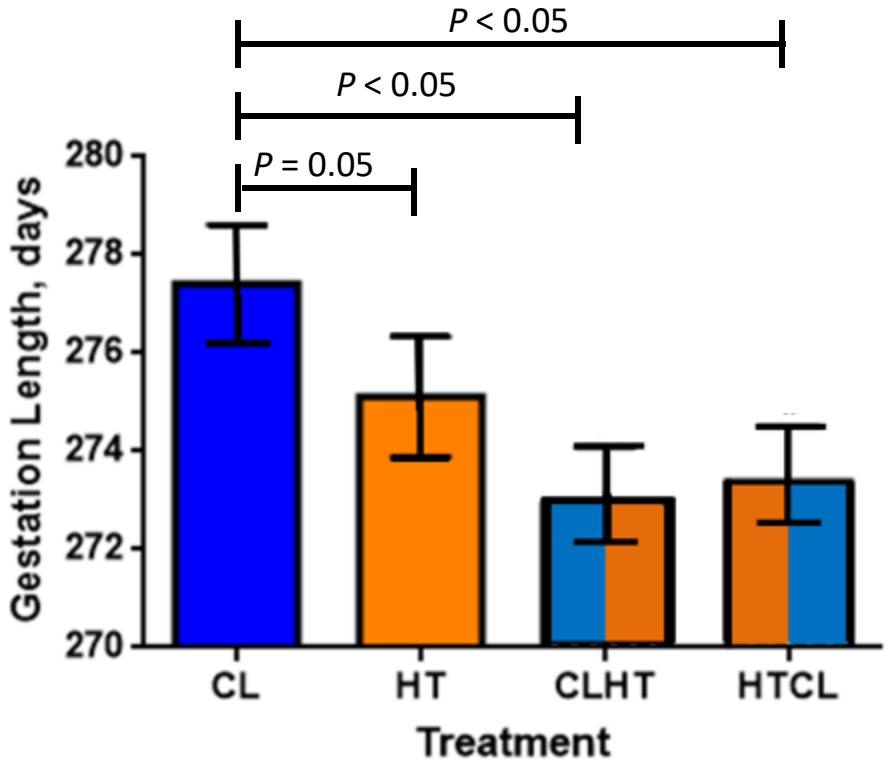
- Do I have to cool cows the entire dry period?
- Do heifers need to be cooled pre-partum?

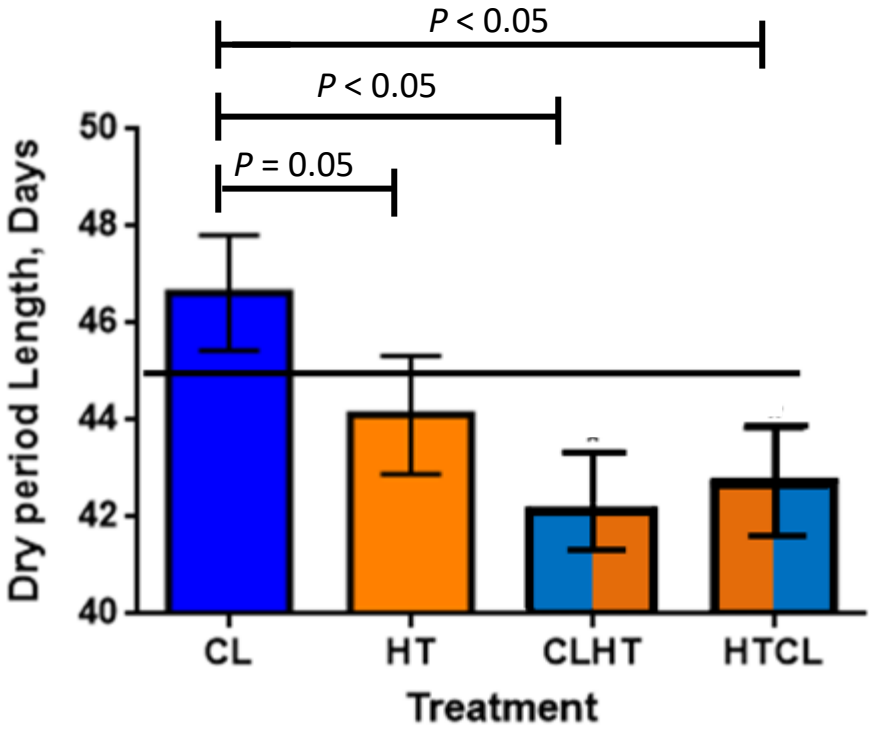
HEAT STRESS INCREASES RECTAL TEMPERATURE AND RESPIRATION



Fabris et al. , *J. Dairy Sci*. 102:5647-5656.

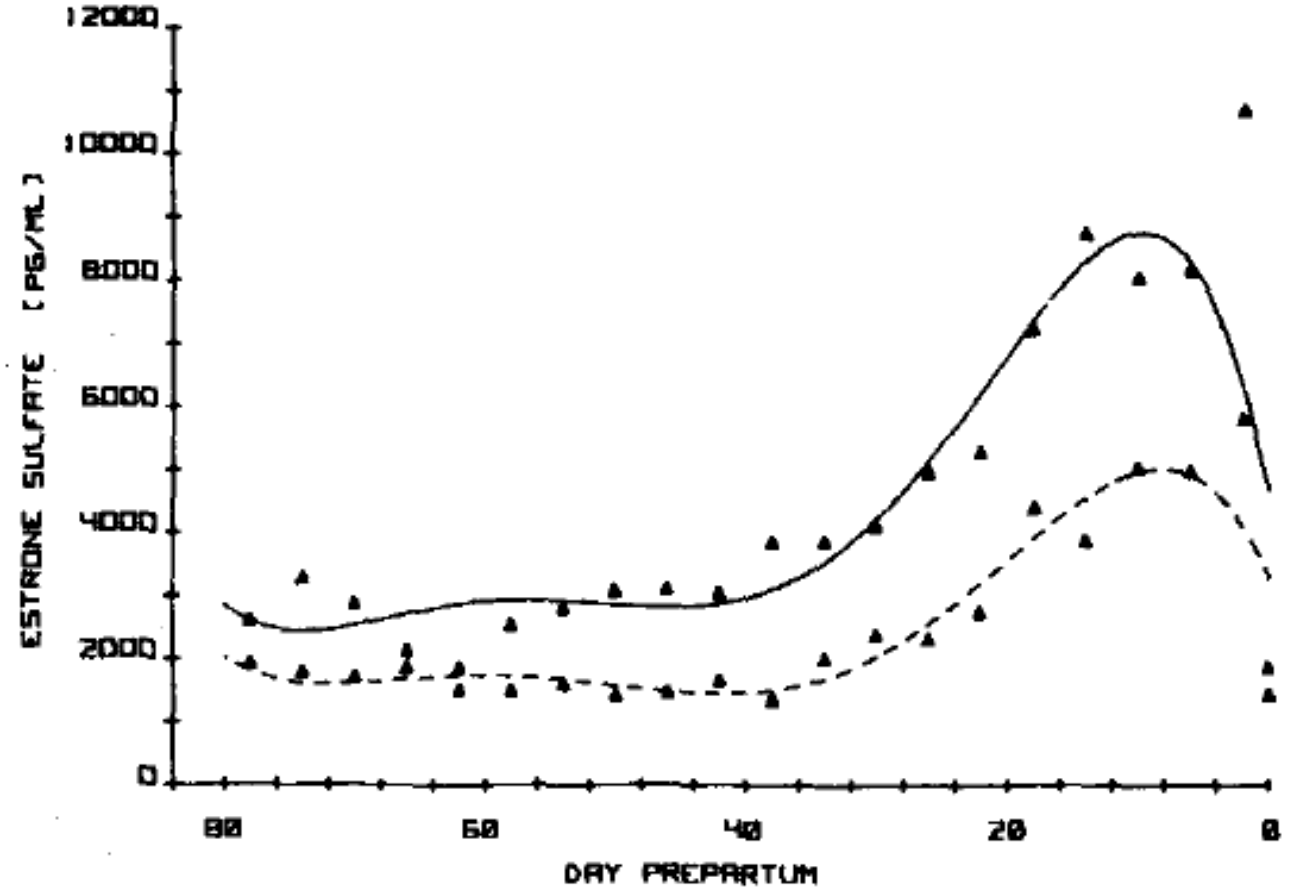
HEAT STRESS DECREASES GESTATION LENGTH AND DRY PERIOD LENGTH AT ANY TIME





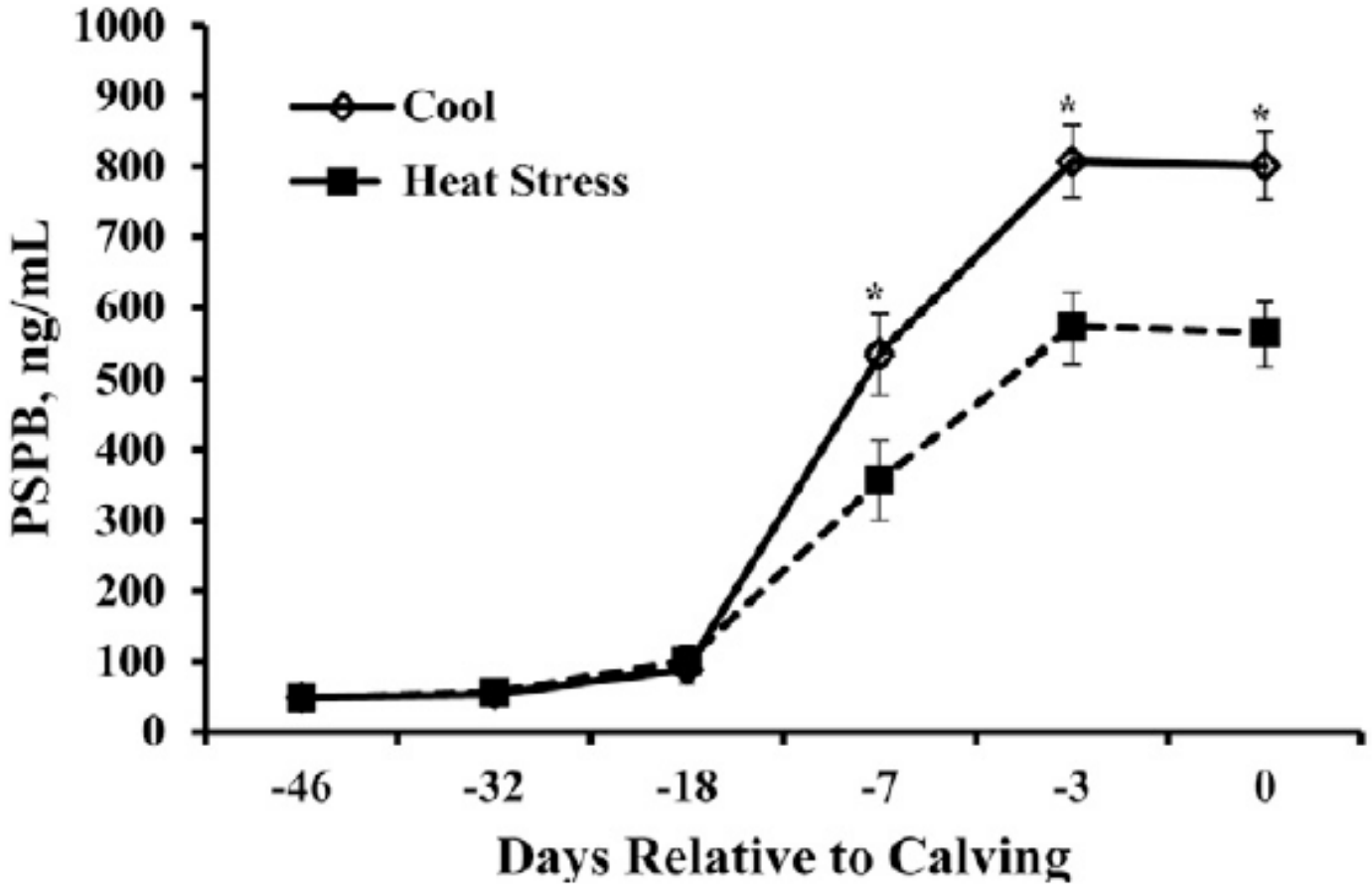
Fabris et al. , *J. Dairy Sci*. 102:5647-5656.

Heat Stress Alters Placental Function
Estrone Sulfate: Shade vs. No Shade



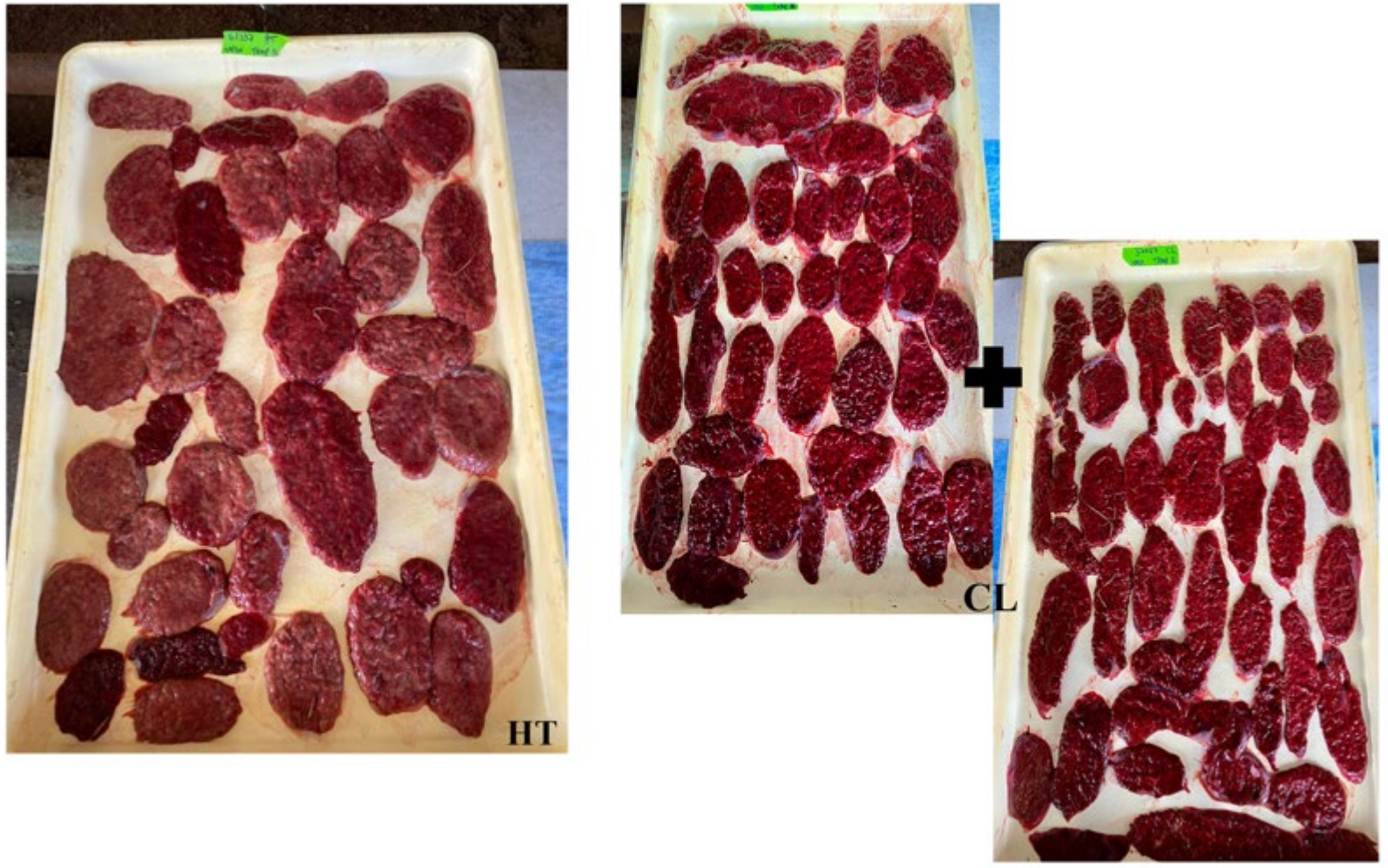
Collier et al., *J. Anim. Sci.*

Heat Stress Alters Placental Function Pregnancy Specific Protein B: HT vs. CL



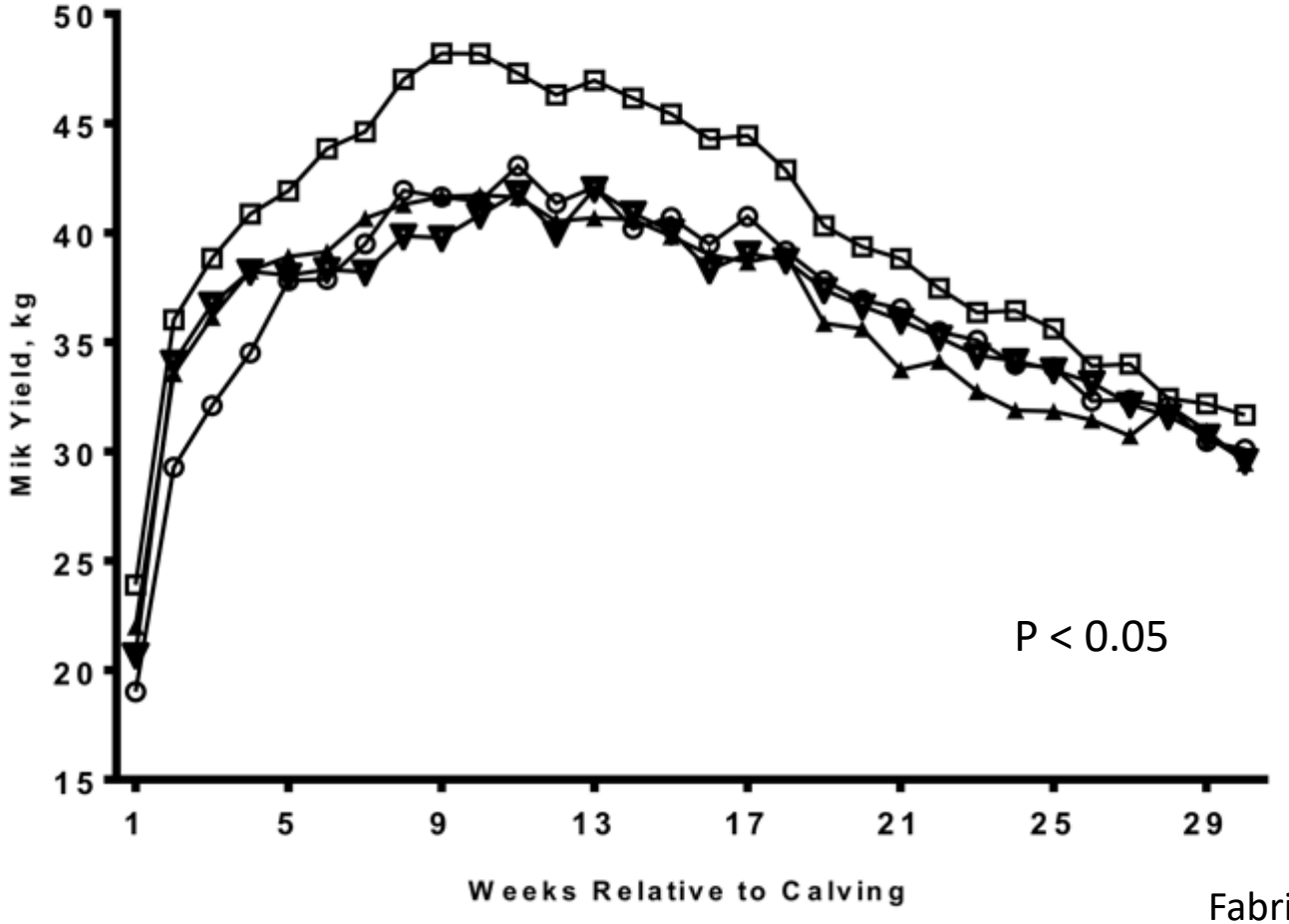
Thompson et al., *J. Anim. Sci.* 91:168–173

DRY PERIOD HEAT STRESS REDUCES PLACENTAL CAPACITY



Casarotto et al. , *J. Dairy Sci*. 108:1125-1137.

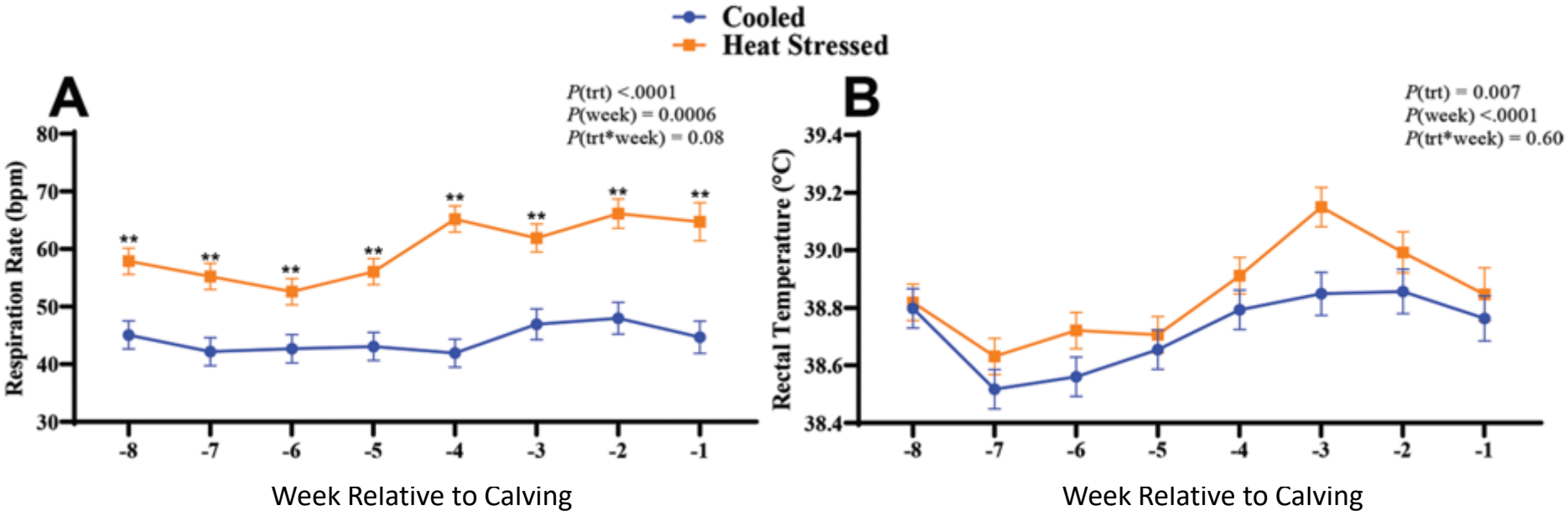
HEAT STRESS IMPOSED AT ANY TIME IN THE DRY PERIOD REDUCES MILK



$P < 0.05$

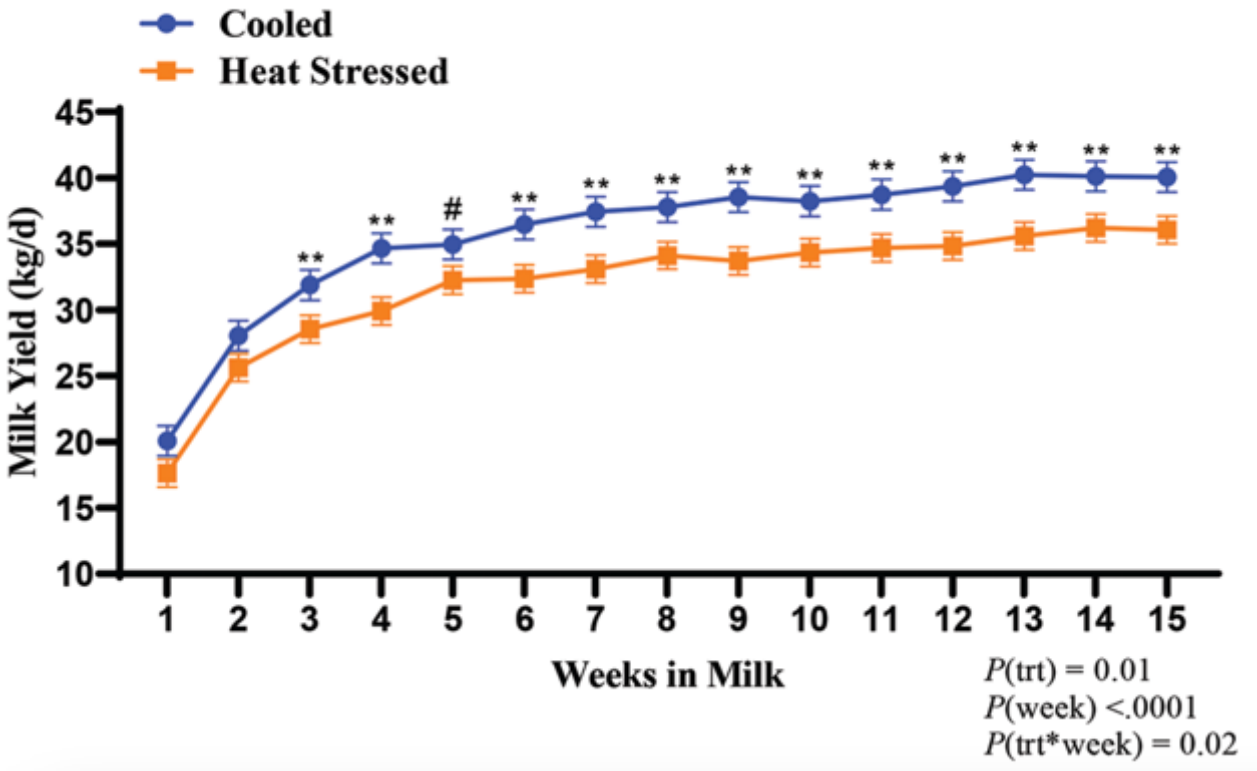
Fabris et al. , *J. Dairy Sci*. 102:5647-5656.

EFFECTS ON FIRST CALF HEIFERS: COOLING DECREASES RR AND RT



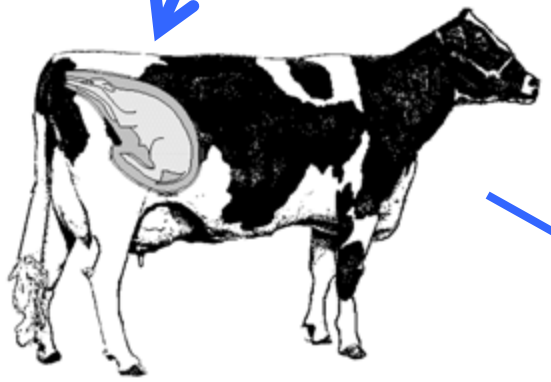
Davidson et al, *J. Dairy Sci.* 104:2357-2368

EFFECTS ON FIRST CALF HEIFERS: COOLING INCREASES YIELD

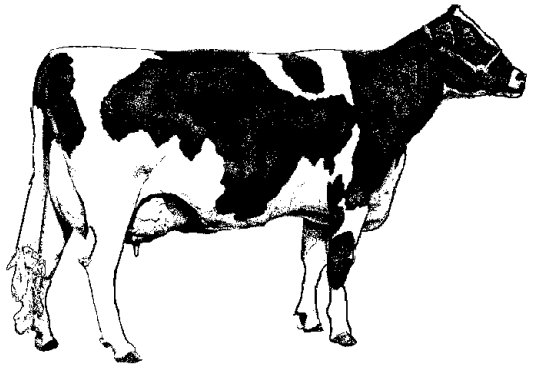


Davidson et al, *J. Dairy Sci.* 104:2357-2368

Late gestation



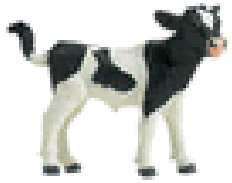
Milk yield?
Metabolism?
Immune function?
Placental Function?



DAM

vs.

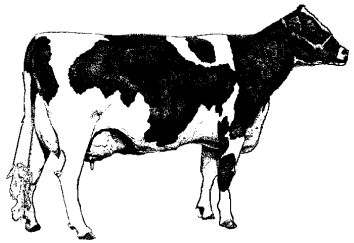
DAUGHTER



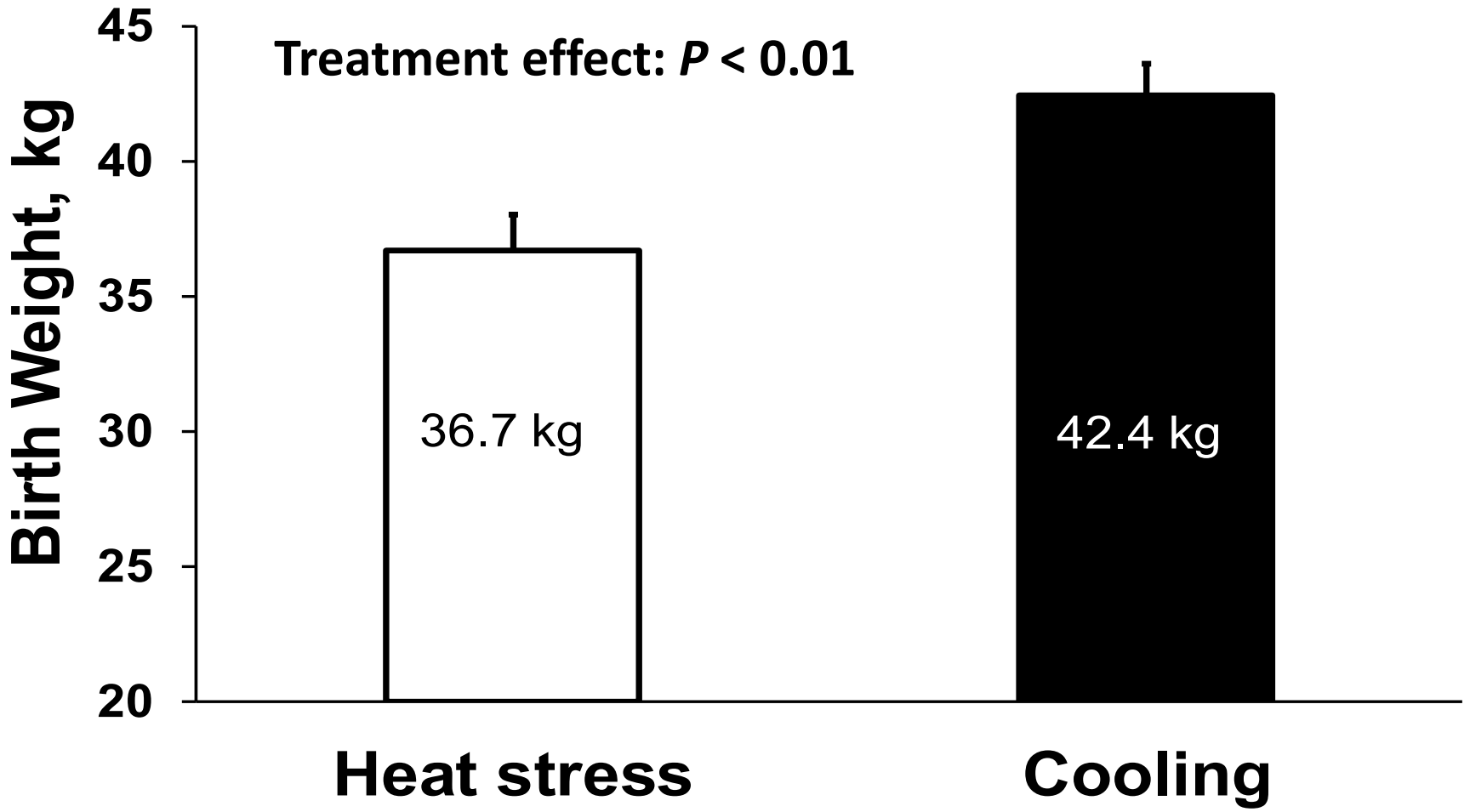
Calf health?
Calf growth?

Heifer growth?
Reproduction?

Cow performance?
Thermoregulation?
Survival?

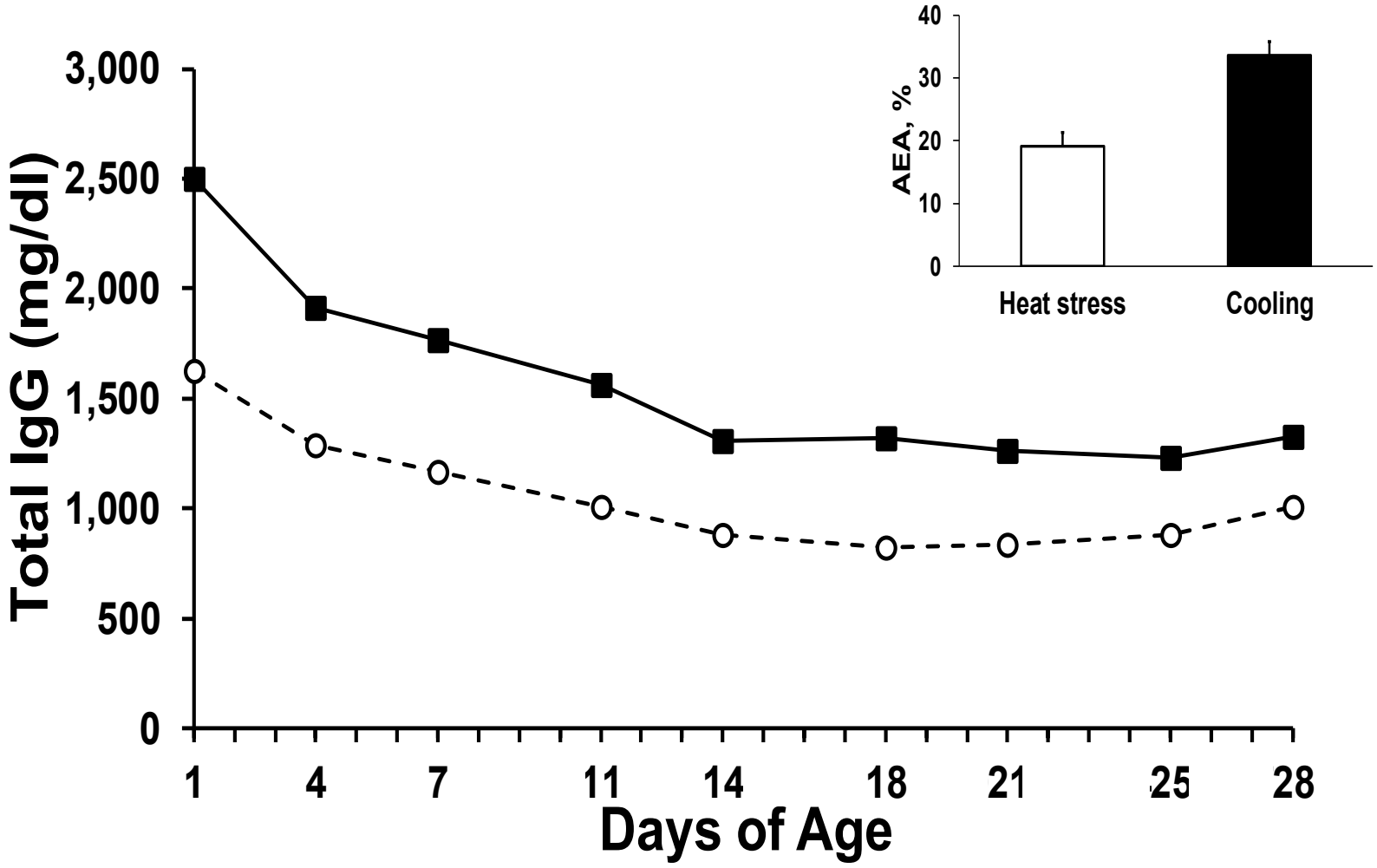


COOLING INCREASES CALF BIRTH WEIGHT



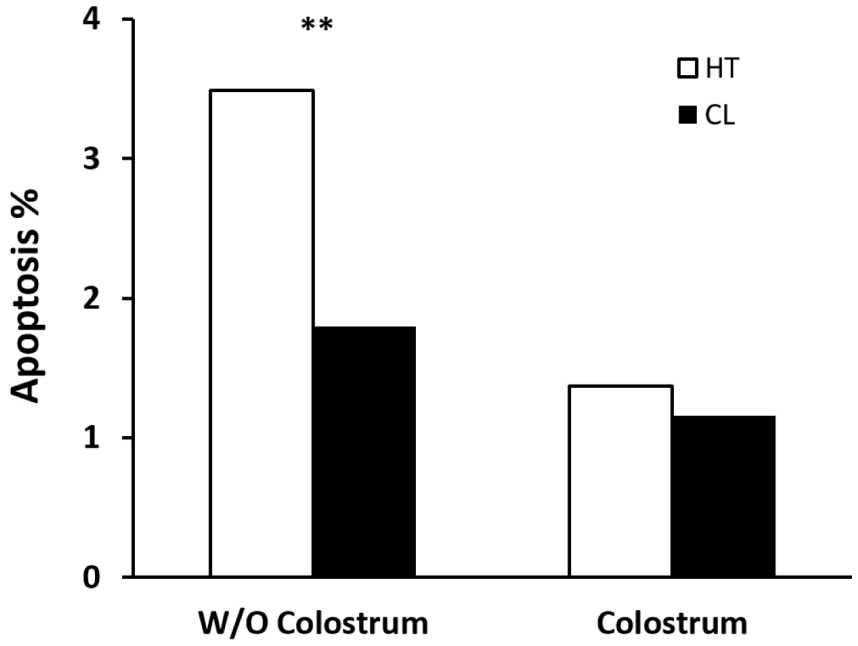
Tao et al., *J. Dairy Sci.* 95:7128-7136

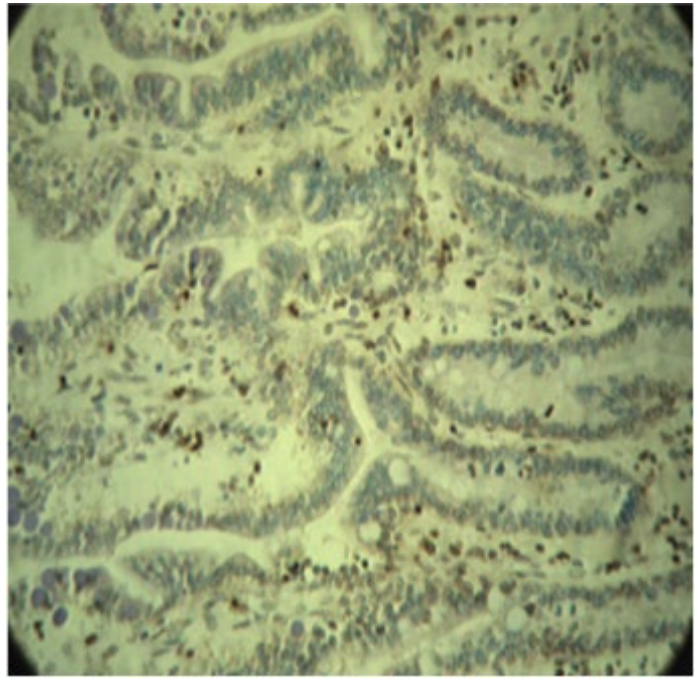
COOLING IMPROVES TOTAL IgG AND AEA



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

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?

B. C. do Amaral,* E. E. Connor,† S. Tao,* J. Hayen,* J. Bubolz,* and G. E. Dahl*[1]
*Department of Animal Sciences, University of Florida, Gainesville 32611
†Bovine Functional Genomics Laboratory, USDA-ARS, Beltsville Agricultural Research Center, Beltsville, MD 20705

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

B. C. do Amaral,*[1] E. E. Connor,† S. Tao,* M. J. Hayen,* J. W. Bubolz,* and G. E. Dahl*[2]
*Department of Animal Sciences, University of Florida, Gainesville 32611
†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
© American Dairy Science Association, 2009.

Heat-stress abatement during th
Does cooling improve transitior

B. C. do Amaral,* E. E. Connor,† S. Tao,* J. H
*Department of Animal Sciences, University of Florida, Gair
†Bovine Functional Genomics Laboratory, USDA-ARS, Belt

J. Dairy Sci. 94:86–96
doi:10.3168/jds.2009-3004
© American Dairy Science Association®, 20

Heat stress abatement during the dry
metabolic gene expression and impr
status in the transition period of dair

B. C. do Amaral,*[1] E. E. Connor,† S. Tao,* M. J. Haye
*Department of Animal Sciences, University of Florida, Gainesville 32
†Bovine Functional Genomics Laboratory, USDA-ARS, Beltsville Agri

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

Effect of heat stress during the

S. Tao, J. W. Bubolz, B. C. do Amaral,[1] I. M. Th
Department of Animal Sciences, University of Florida, Gaines

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

ring

oung,† and G. E. Dahl*[1]
la, Gainesville 32611

immune response after
ction challenge of dairy cows

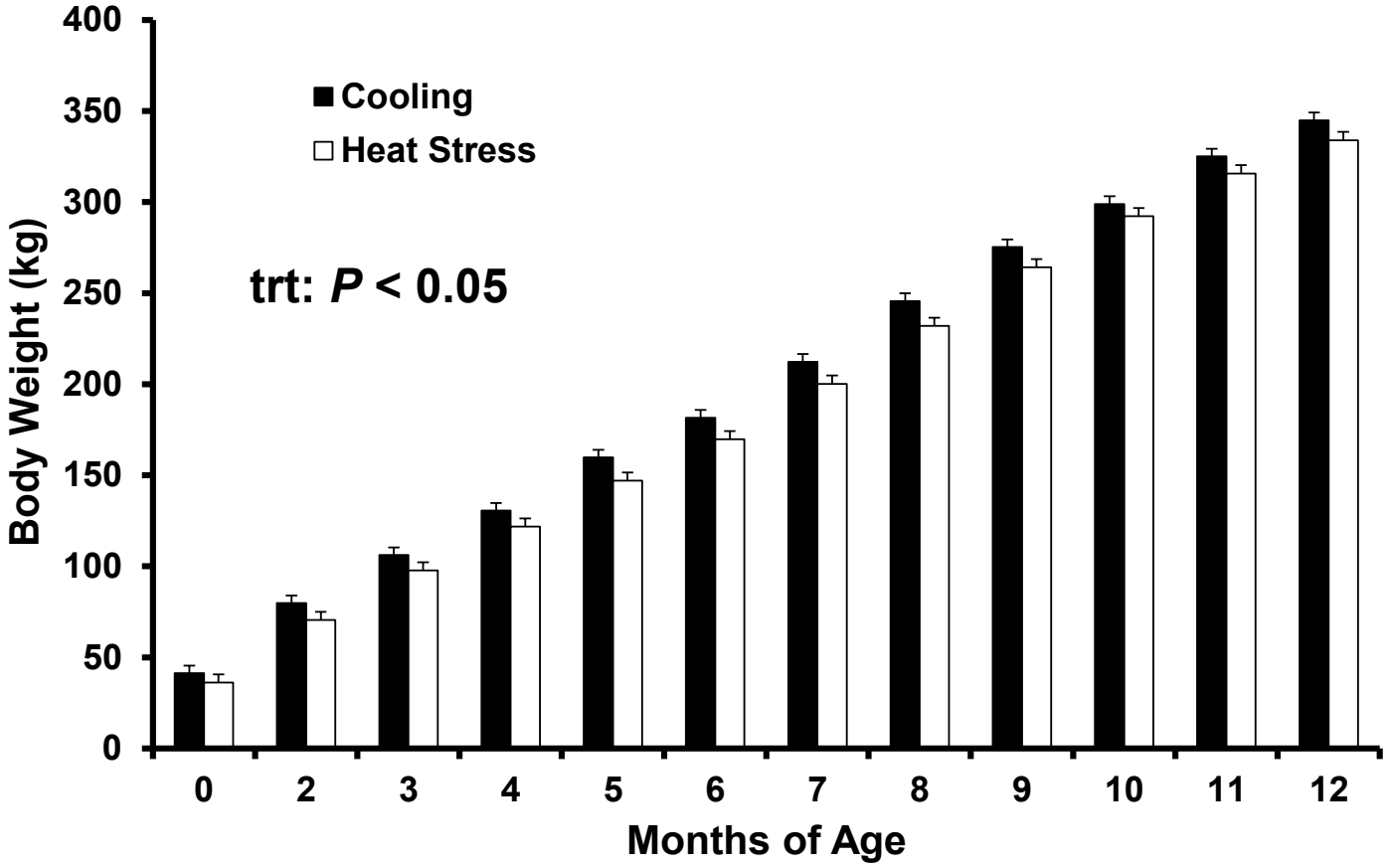
nd G. E. Dahl[1]

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 HS DECREASES REPRODUCTIVE PERFORMANCE

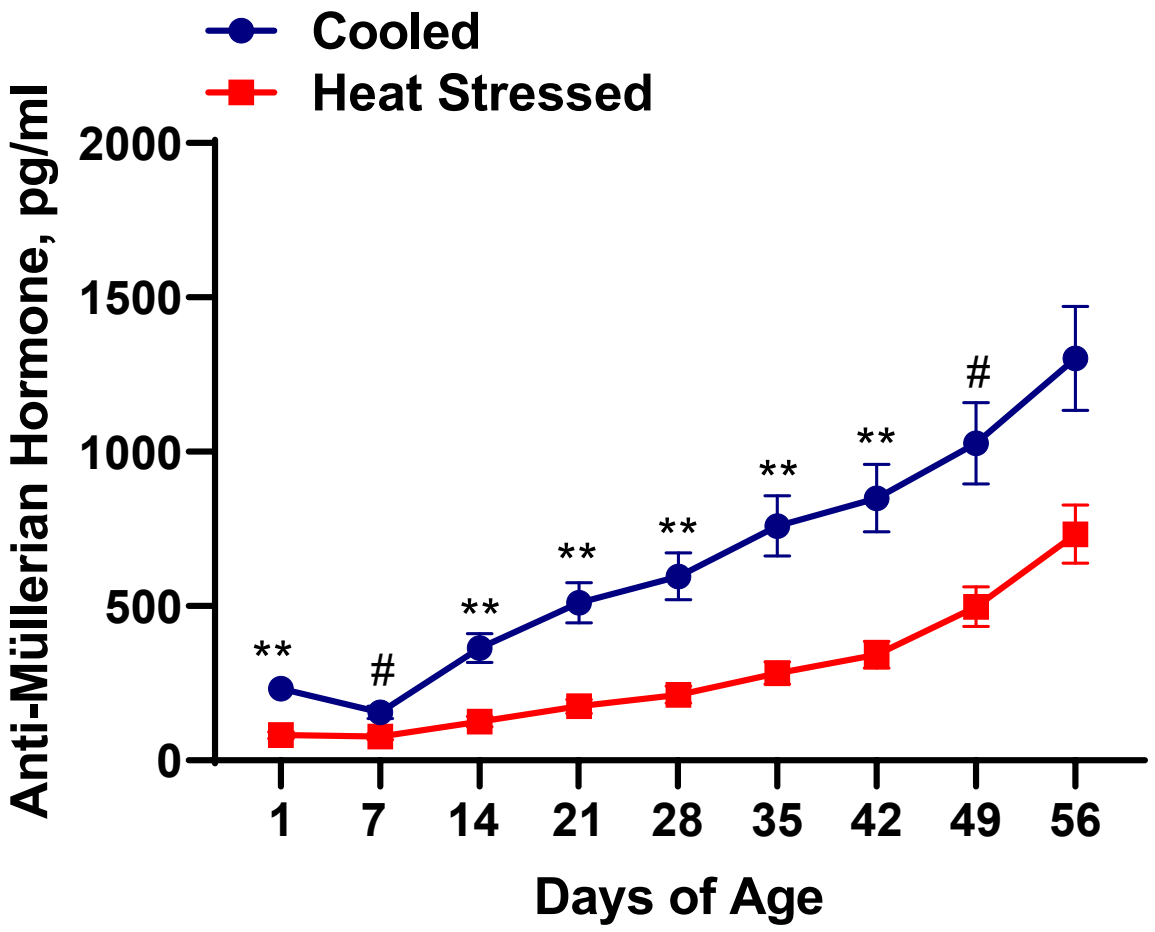
Table 2. Effect of maternal heat stress (HT) or cooling (CL) during late gestation on reproductive performance before first lactation of heifers born to HT or CL dams

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.

AMH CONCENTRATIONS WERE HIGHER IN CL CALVES FROM D1 TO D56



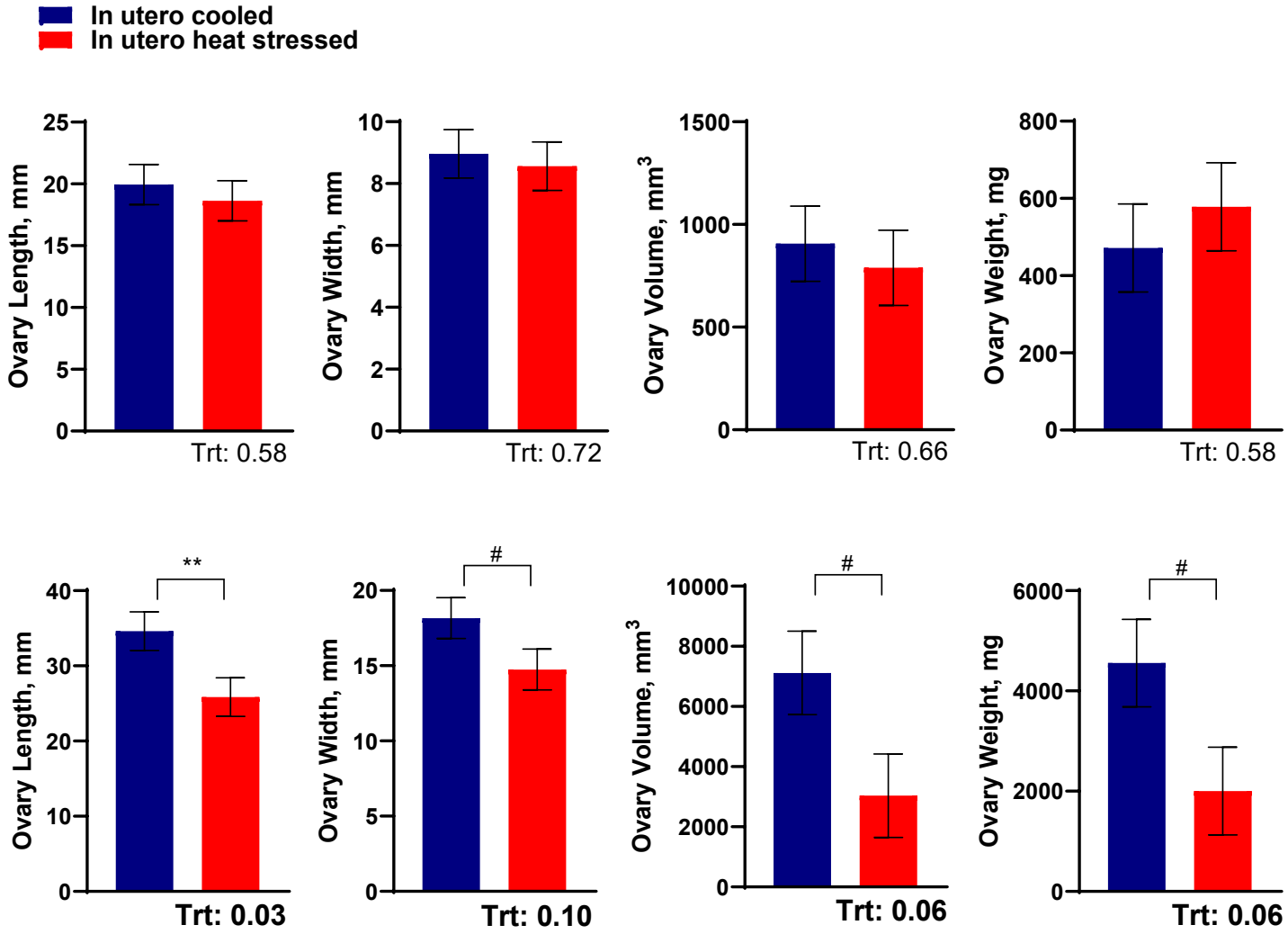
Trt: 0.03
Day: <0.0001
Trt*Day: 0.02

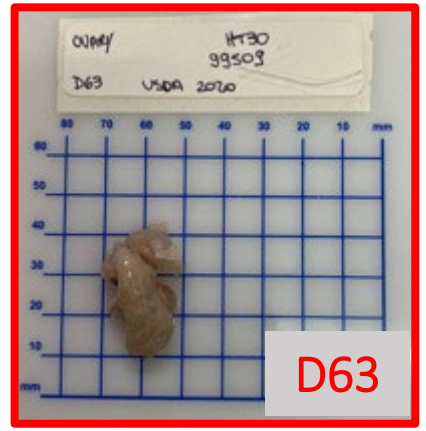
Davidson et al. , *J. Dairy Sci*. 104:Abstract.

CL HEIFERS: INCREASED OVARIAN SIZE AT D63

Birth

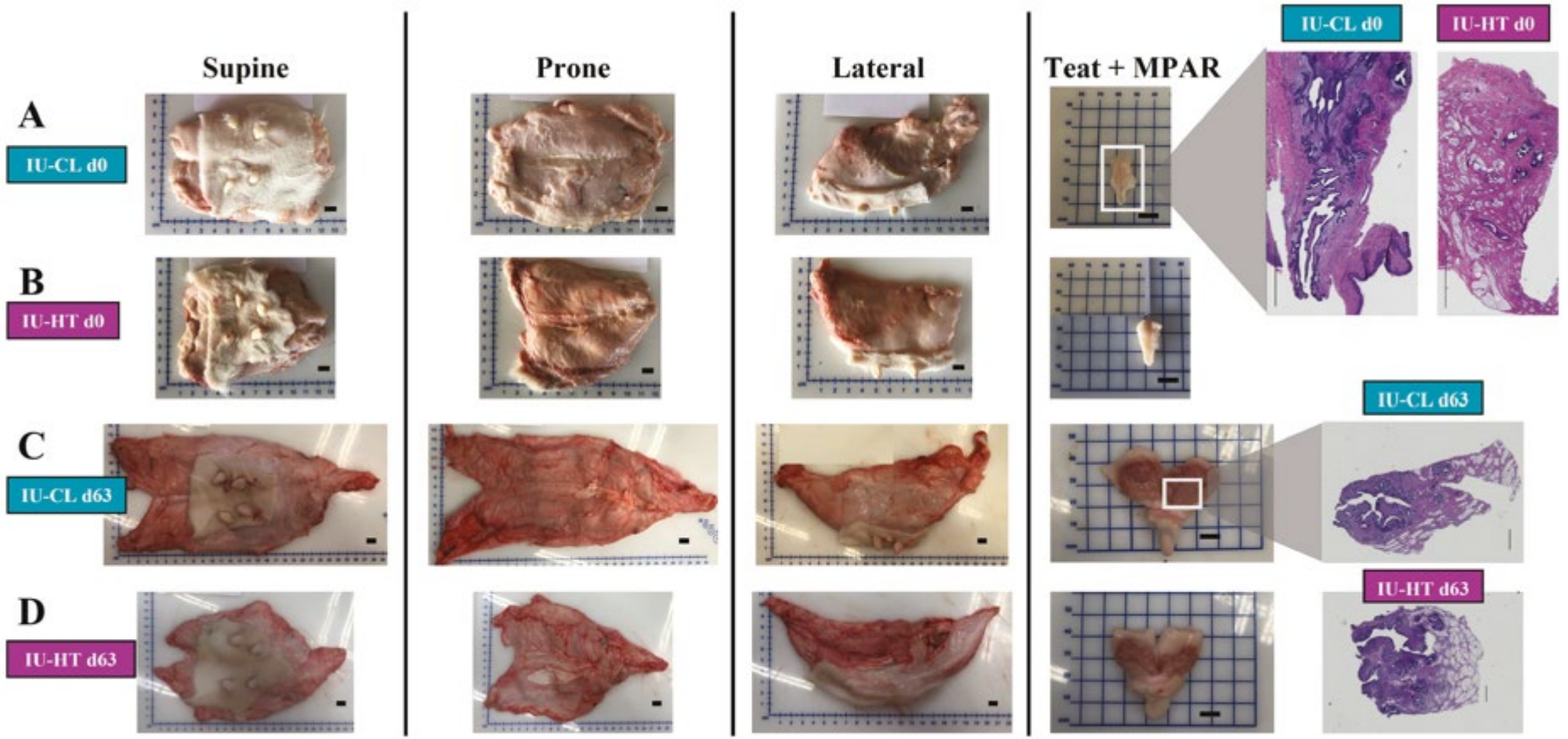
D63





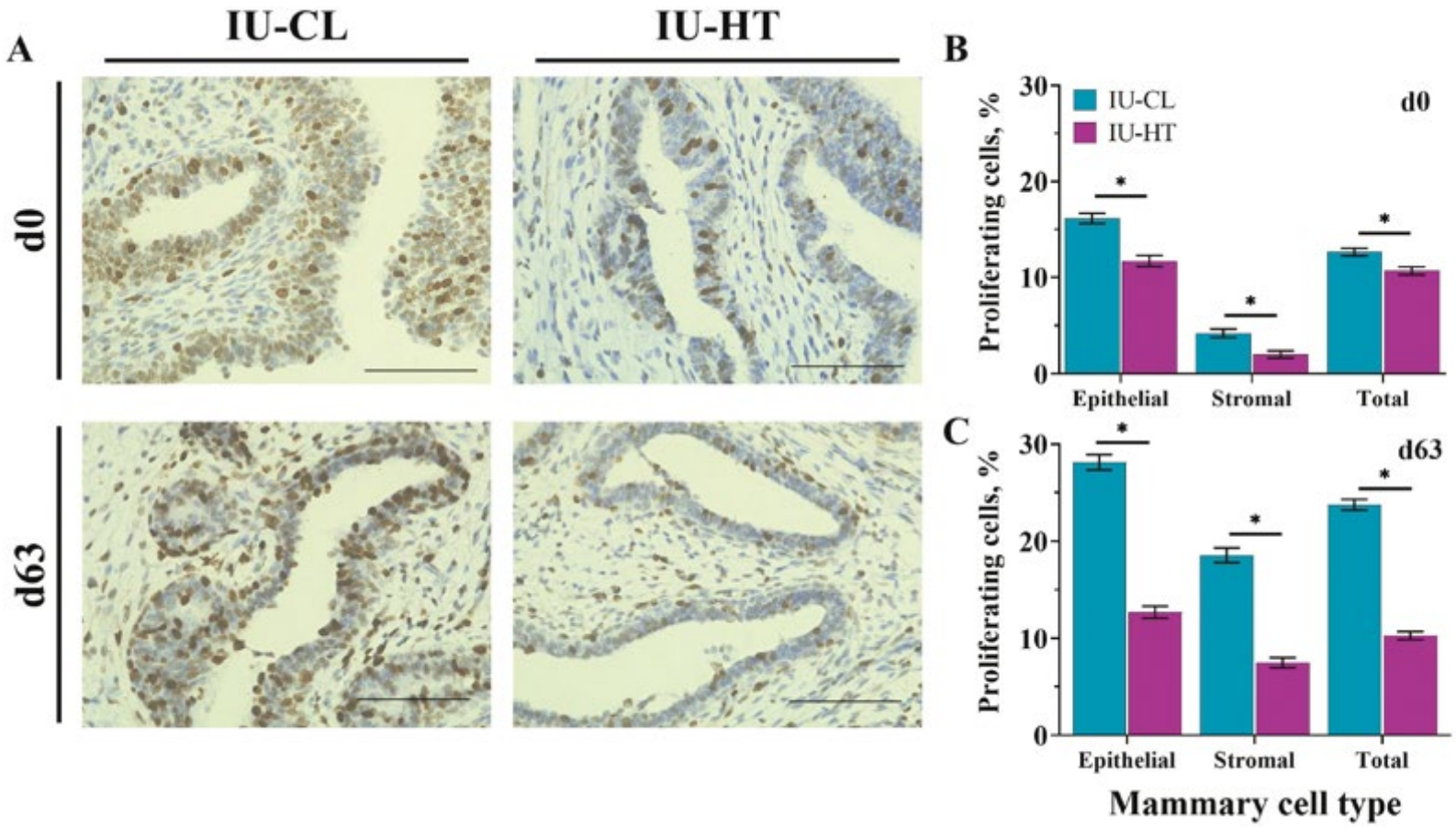
Davidson et al. , *J. Dairy Sci*. 104:Abstract.

IN UTERO HEAT STRESS REDUCES MAMMARY DEVELOPMENT



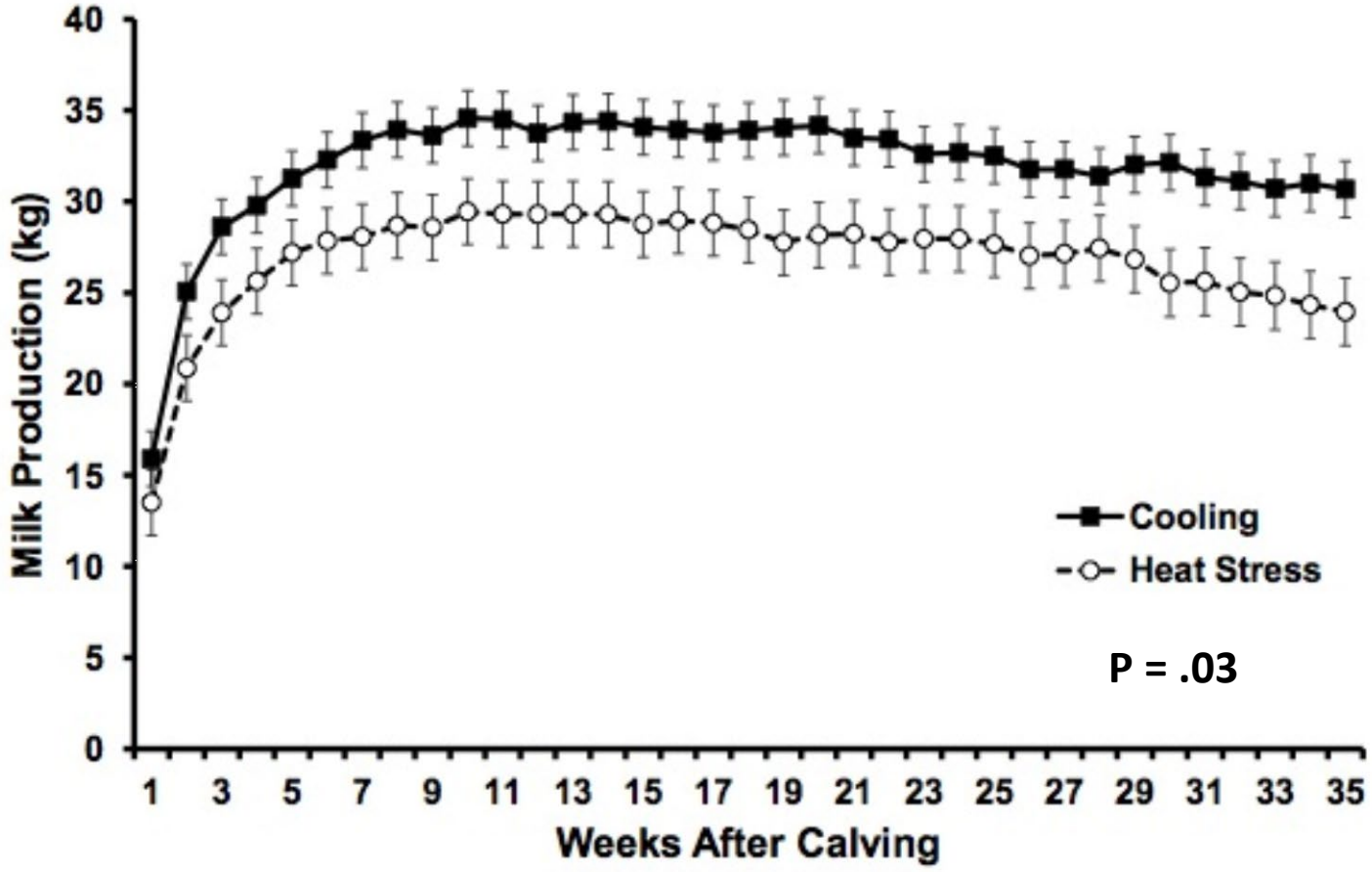
Dado-Senn et al. , *J. Anim. Sci*. 100:1-11.

IN UTERO HEAT STRESS REDUCES MAMMARY DEVELOPMENT



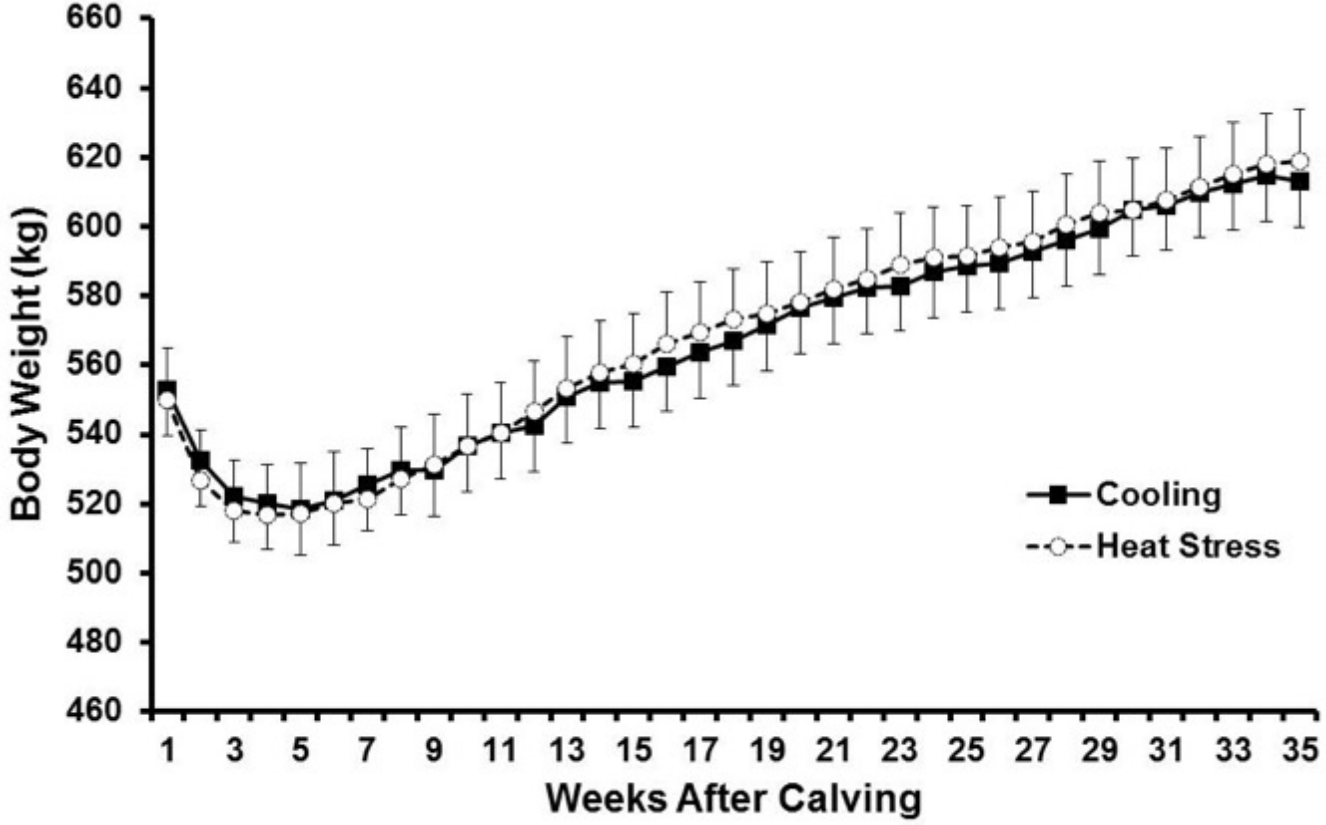
Dado-Senn et al. , *J. Anim. Sci*. 100:1-11.

IN UTERO HEAT STRESS REDUCES MILK PRODUCTION



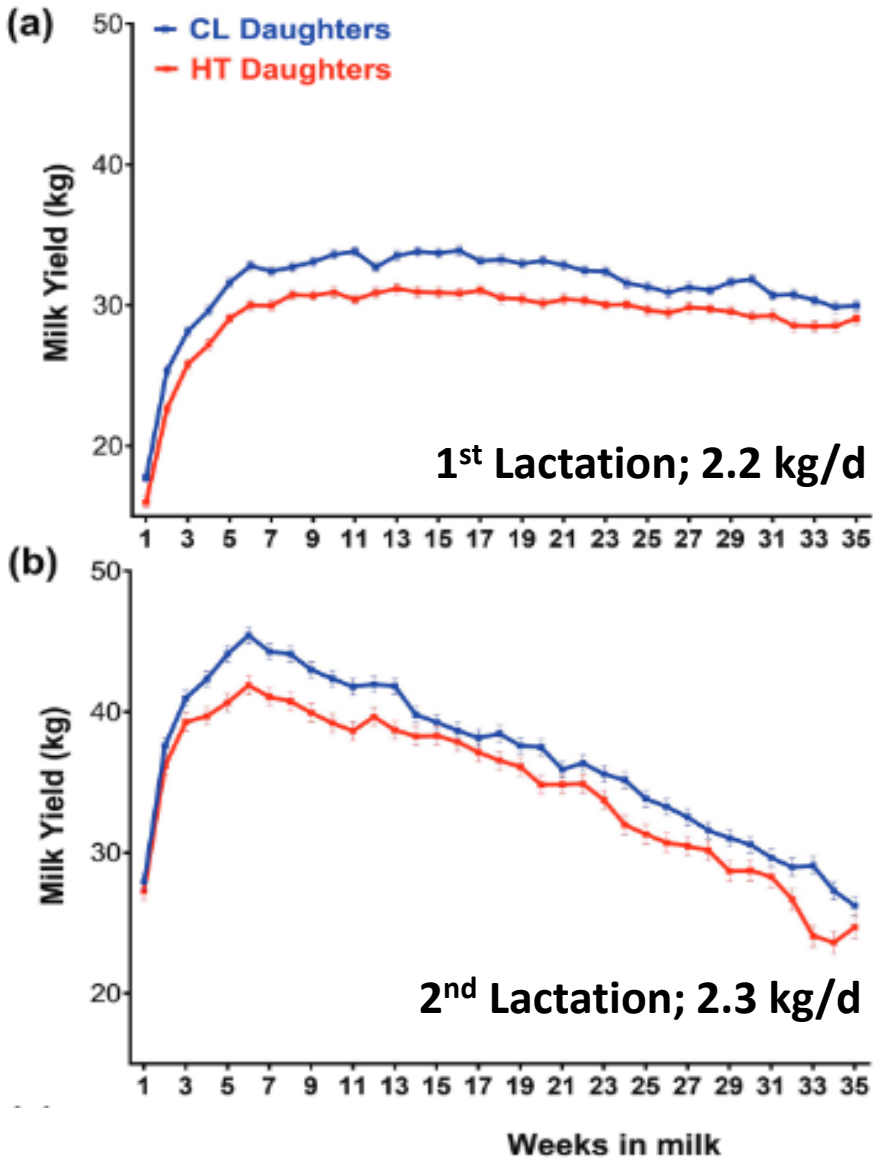
Monteiro et al. , *J. Dairy Sci*. 99:8443-8450.

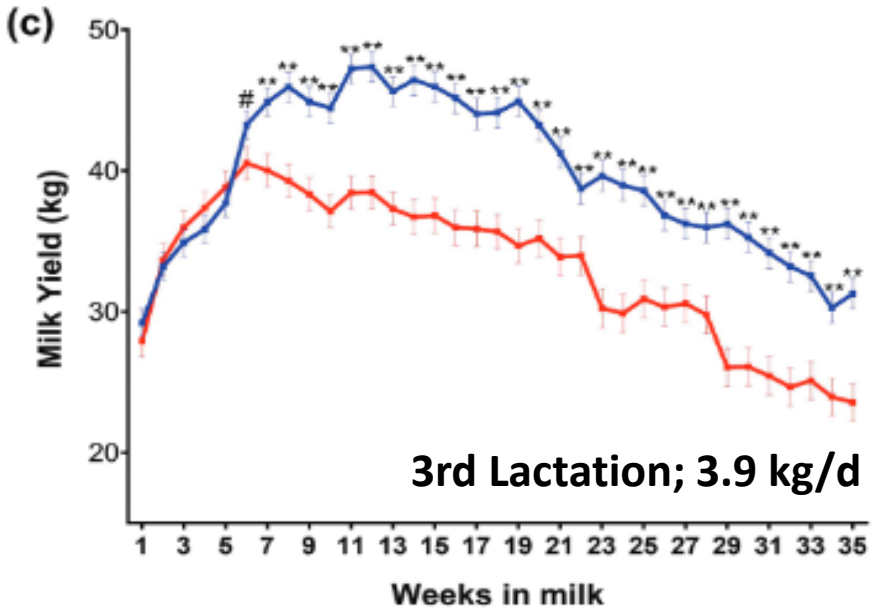
IN UTERO HEAT STRESS DOES NOT AFFECT MATURE BODYWEIGHT



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

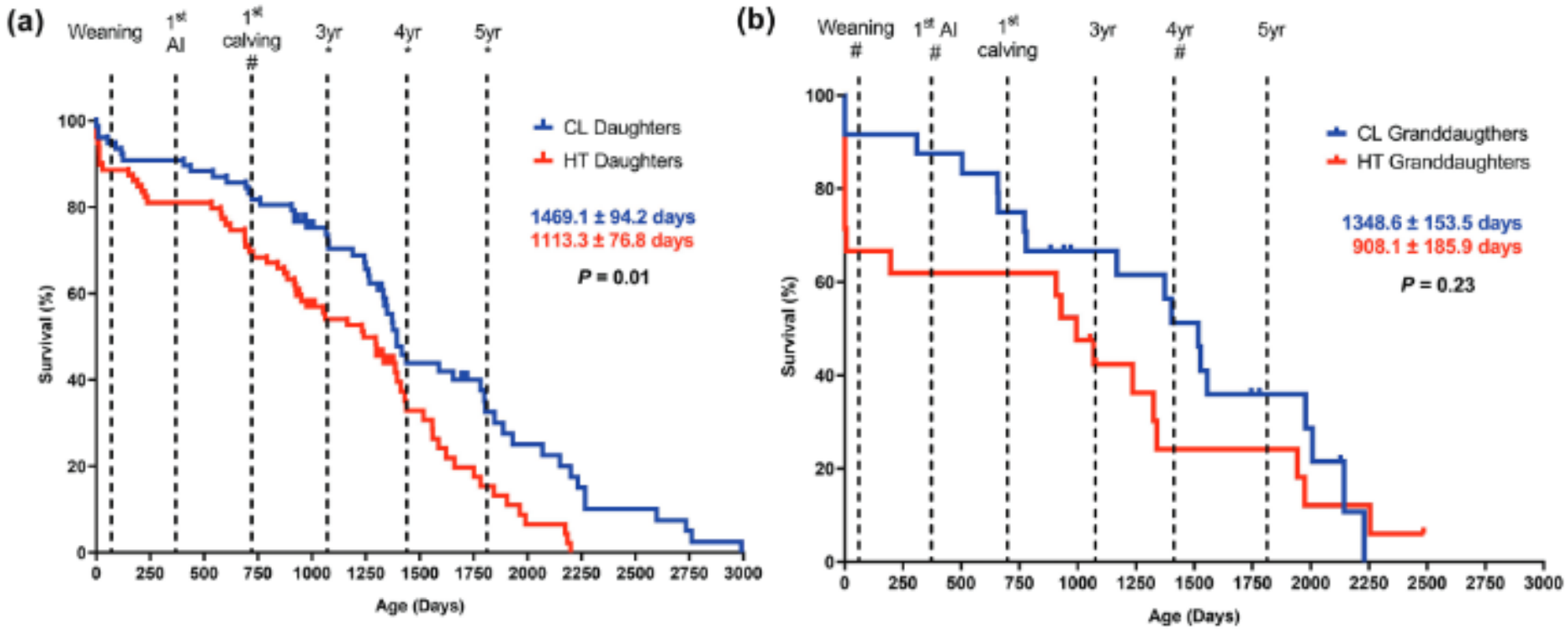
In Utero Heat Stress Alters Lifetime Yield





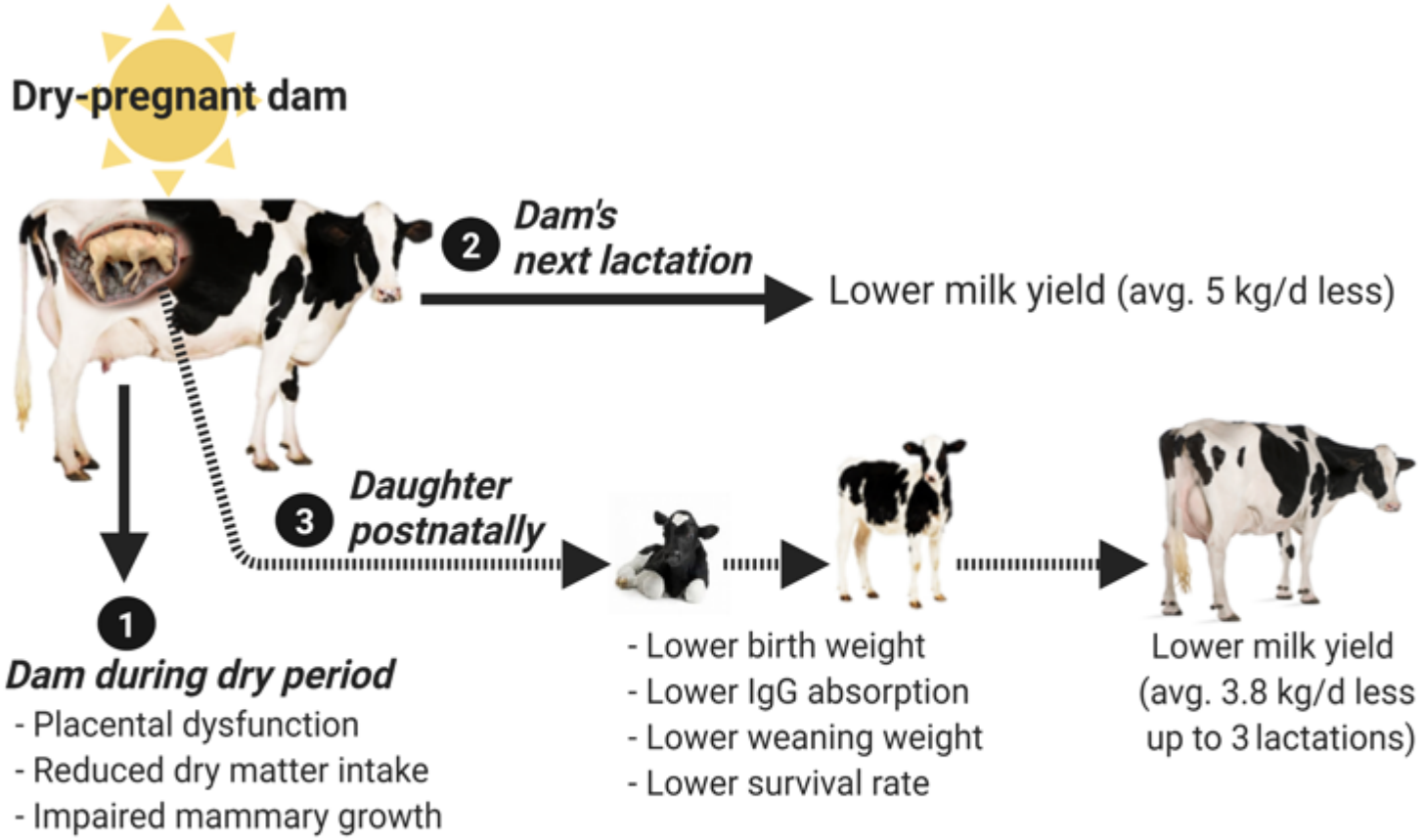
Laporta et al. , *J. Dairy Sci*. 103:7555-7568.

IN UTERO HEAT STRESS REDUCES SURVIVAL IN HERD



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

IMPACT ON LONGEVITY?



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

Birth Season Impacts Cow Longevity in Florida

Cool Season THI= 58.4 ± 0.5
Hot Season THI= 77.0 ± 0.2

Lactation Number	Cow Number	Birth Season	
		Cool Season	Hot Season
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**

Toledo et al., 2024 *JDS Communications*. 5:674-678.

Birth Season Impacts Cow Longevity in California

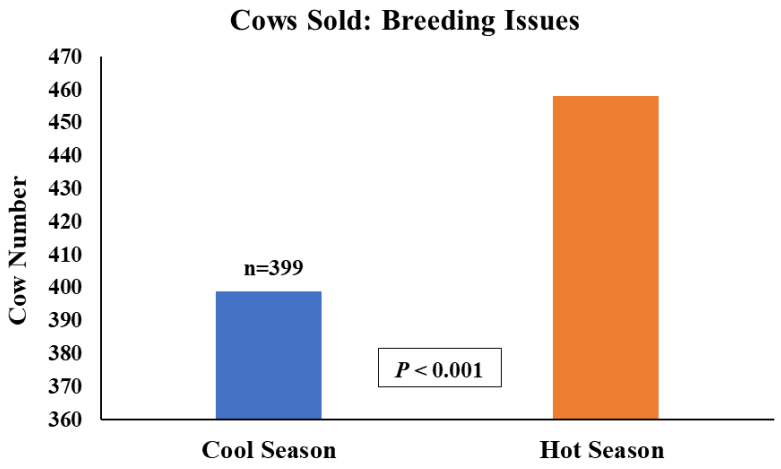
Cool Season THI= 52.7 ± 0.5
Hot Season THI= 73.5 ± 0.2

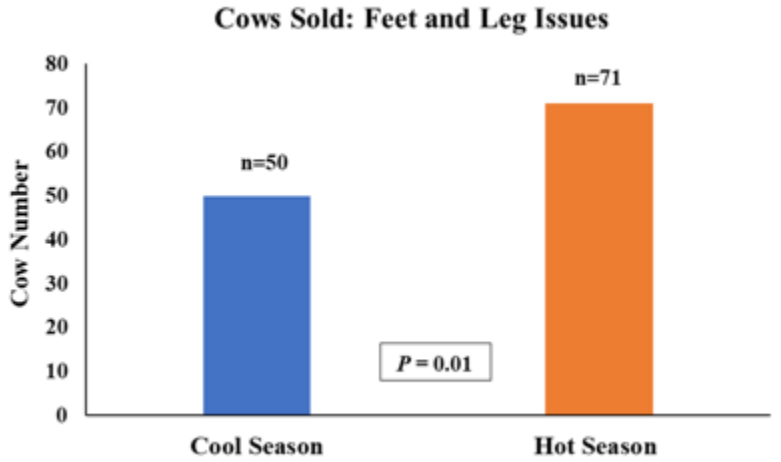
Lactation Number	Cow Number	Birth Season	
		Cool Season	**Hot Season**
5	908	484	424
6	507	318	189
7	204	108	96
8	50	29	21
Total Cows	1,669	**939 (56.3%) ****	**730 (43.7%) ****

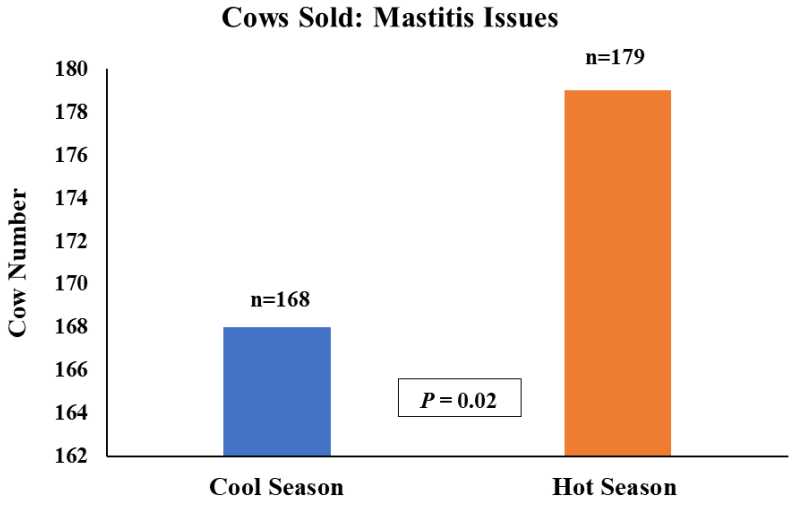
**** *P* < 0.01**

Toledo et al., 2024 *JDS Communications*. 5:674-678.

Hot Birth Season Increases Cows Sold for Reproductive, Feet and Leg Issues, Mastitis

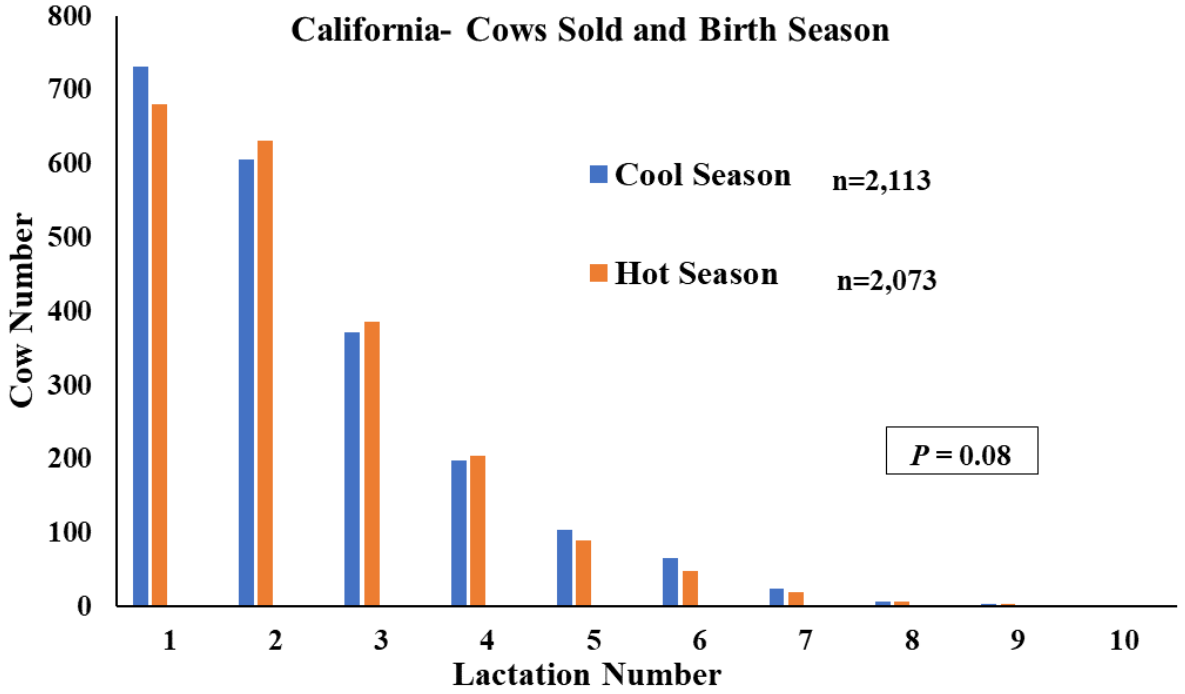


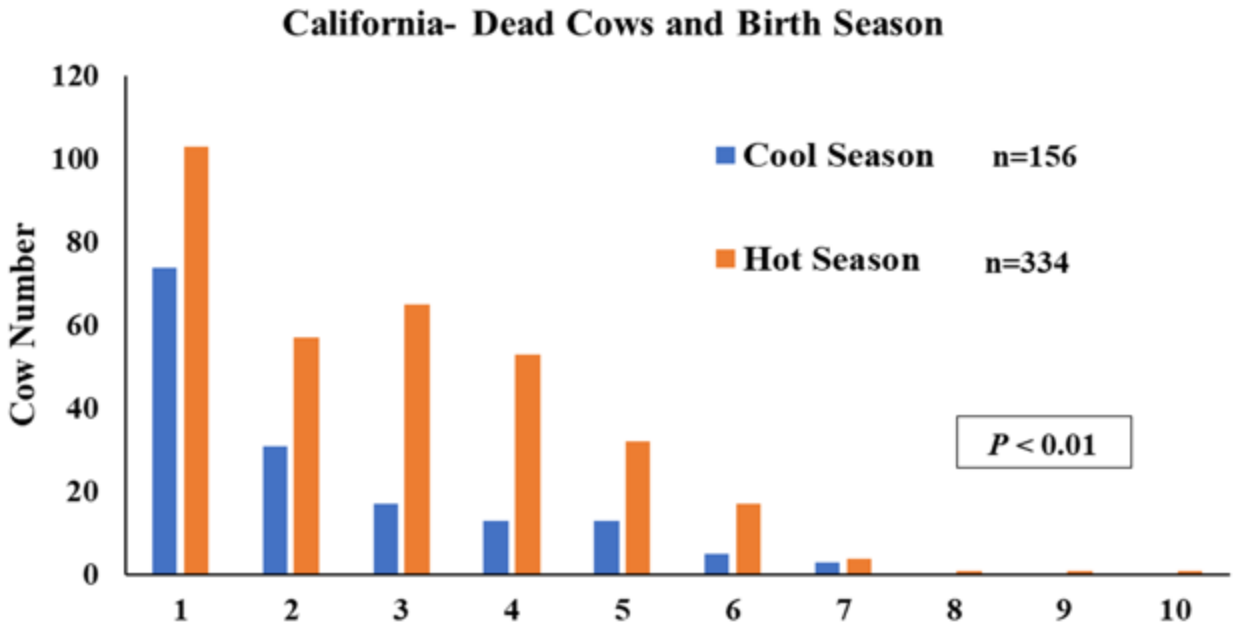




Toledo et al., 2024 *JDS Communications*. 5:674-678.

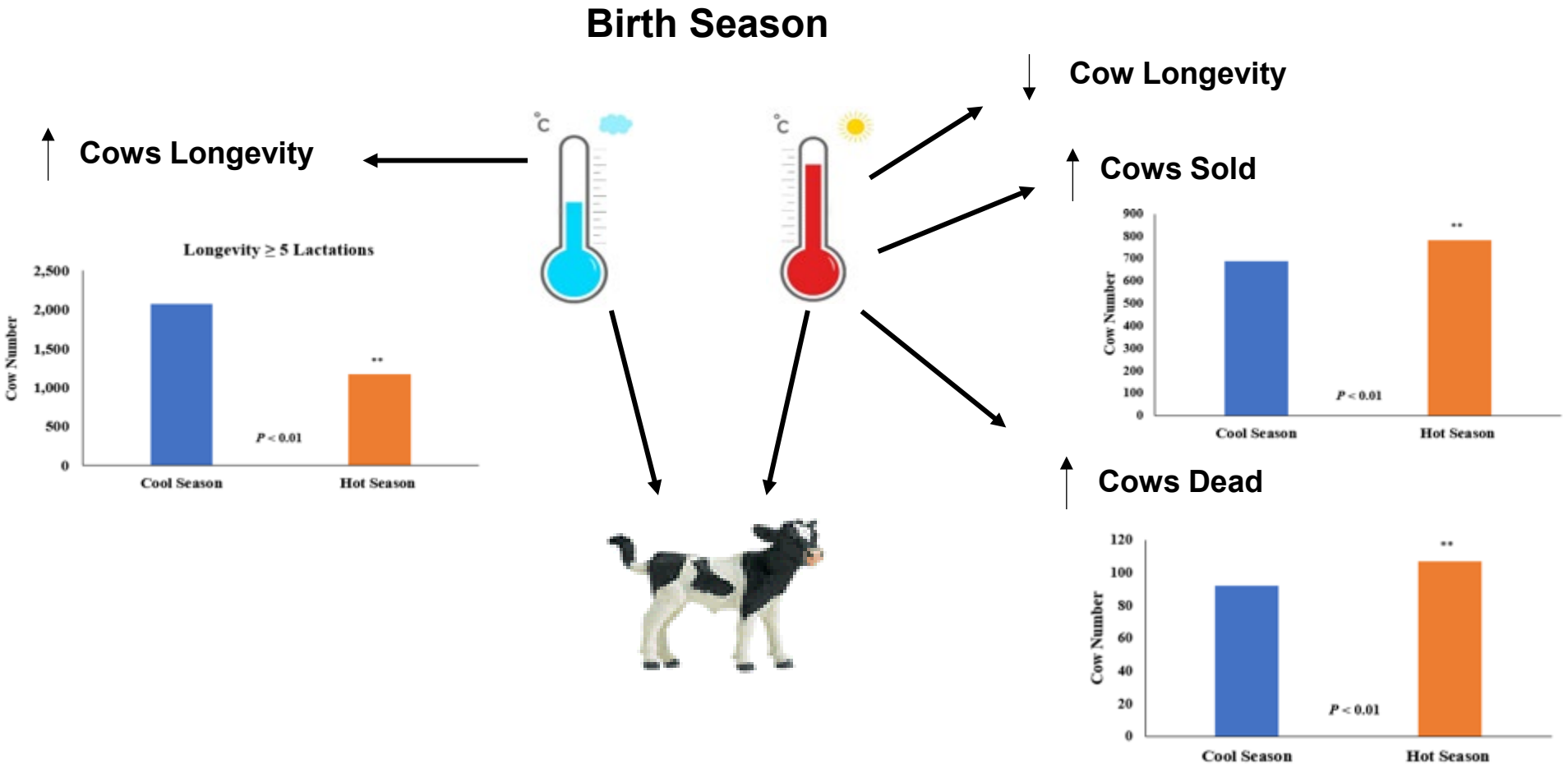
California: Birth Season Alters Death Loss



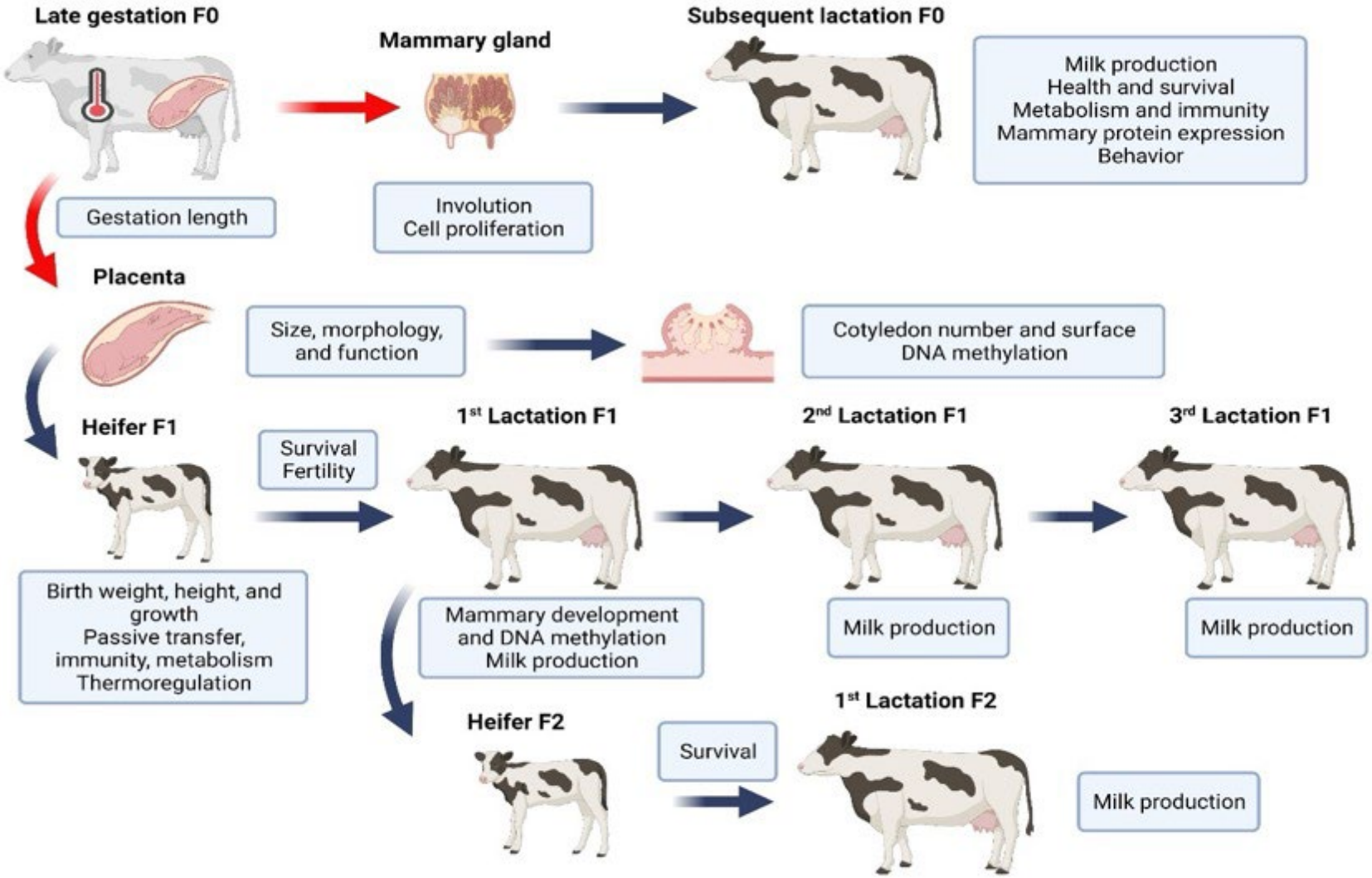


Toledo et al., 2024 *JDS Communications*. 5:674-678.

Birth Season Affects Dairy Cow Longevity



Toledo et al., 2024 *JDS Communications*. 5:674-678.


Late gestation F0
Mammary gland
Subsequent lactation F0
Milk production
Health and survival
Metabolism and immunity
Mammary protein expression
Behavior
Gestation length
Involution
Cell proliferation
Placenta
Size, morphology, and function
Cotyledon number and surface DNA methylation
Heifer F1
Survival
Fertility
1st Lactation F1
2nd Lactation F1
3rd Lactation F1
Birth weight, height, and growth
Passive transfer, immunity, metabolism
Thermoregulation
Mammary development and DNA methylation
Milk production
Milk production
Milk production
Heifer F2
Survival
1st Lactation F2
Milk production