Effects of heat stress in dairy cattle on the performance of their offspring

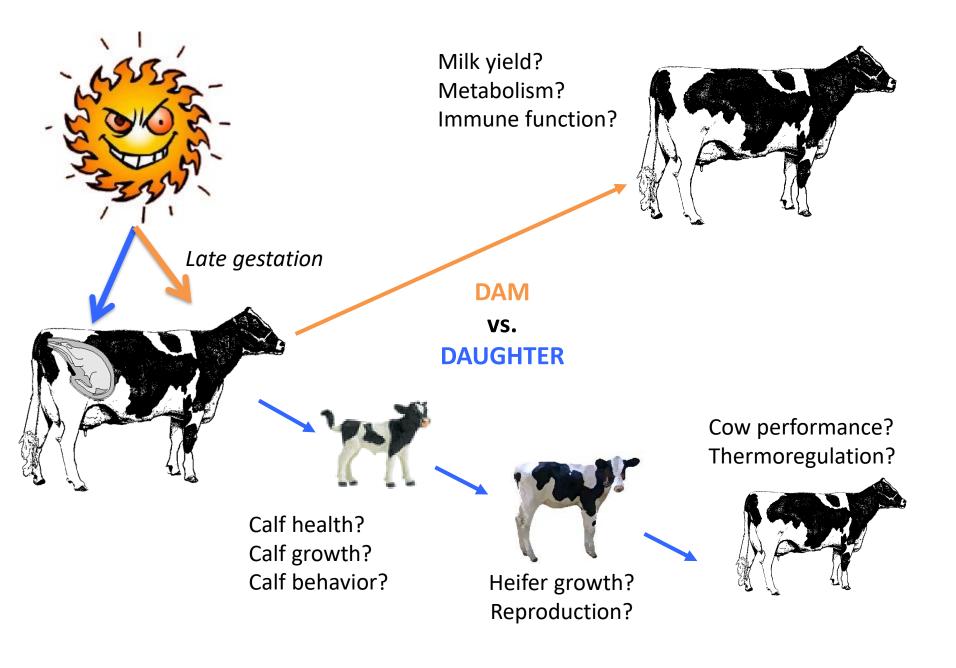
Albert De Vries, Jimena Laporta, Fernanda Ferreira, Geoff Dahl Department of Animal Sciences, University of Florida, USA

Sha Tao

Department of Animal and Dairy Science, University of Georgia, USA







Agenda

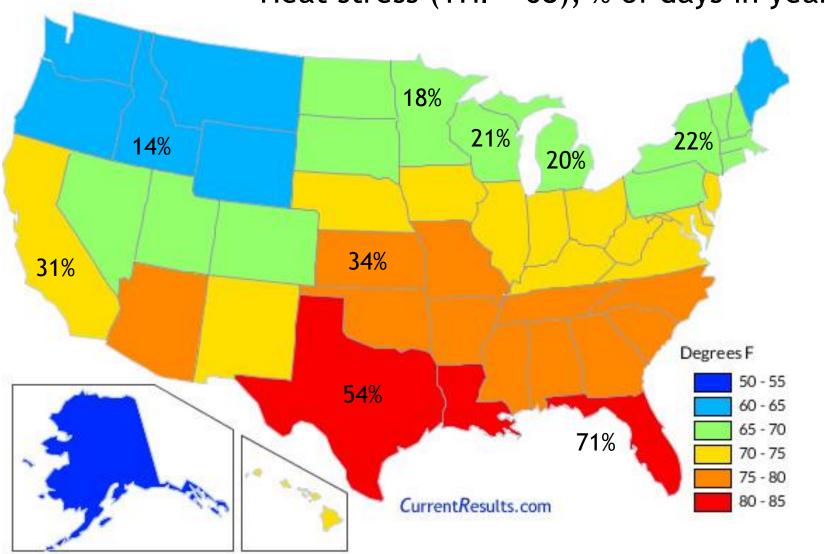
- 1. Heat stress and lactating cows
- 2. Dry cows: Heat stress during her own dry period
- 3. Calves: Heat stress during mom's dry period
- 4. Offspring: Effect on milk production, survival
- 5. Cows: Heat stress when she was conceived
- 6. Summary

0	Themperature				% 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	7	70	71	71	72	73	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	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	3	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	5	76	77	78	78	79	80	80	81	82	83	83	84
85	29.5	70	71	72	72	73	74	75	75	7 6	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	73	No	r75	76	37/	dr	$-\lambda$	79	hô	3 1+	c °t r	20	23	84	85	85	86	87
88	31.0	72	72	73	74	/HQ	re	D (C ₇ V	er	7 9	80		al	str	G 3	9	85	86	86	87	88
89	31.5	72	73	74	75	75	76	77	78	79	80	- 4	81	82	83	84	85	86	86	87	88	89
90	32.0	72	73	74	75	76	77	78	79	79	90	0.4	02	83	84	85	96	0.0	~-		-00	90
91								,	, ,	75	80	81	82	3	0	3	86	86	87	88	89	30
91	33.0	73	74	75	76	76	77	78	79	80	81	81	2	84	85	86	86	87	87	88	90	91
92	33.0 33.5	73 73		75 75	76 76				 				84									
_			74			76	77	78	79	80	81	82	1	84	85	86	86	87	88	89	90	91
92	33.5	73	74 74	75	76	76 77	77 78	78 79	79 80	80 81	81 82	82 83	84	84 85	85 85	86 86	86 87	87 88	88 89	89 90	90 91	91 92
92 93	33.5 34.0	73 74	74 74 75	75 76	76 77	76 77 78	77 78 79	78 79 80	79 80 80	80 81 81	81 82 82	82 83 83	84 85	84 85 5	85 85 86	86 86 87	86 87 88	87 88 89	88 89 90	89 90 91	90 91 92	91 92 93
92 93 94	33.5 34.0 34.5	73 74 74	74 74 75 75	75 76 76	76 77 77	76 77 78 78	77 78 79 79	78 79 80 80	79 80 80 81	80 81 81 82	81 82 82 83	82 83 83 84	84 85 86	84 85 5 86	85 85 86 87	86 86 87 88	86 87 88 89	87 88 89 90	88 89 90 91	90 91 92	90 91 92 93	91 92 93 94
92 93 94 95	33.5 34.0 34.5 35.0	73 74 74 75	74 74 75 75 76	75 76 76 77	76 77 77 78	76 77 78 78 79	77 78 79 79 80	78 79 80 80 81	79 80 80 81 82	80 81 81 82 83	81 82 82 83 84	82 83 83 84 85	84 85 86 86	84 85 5 86 87	85 85 86 87	86 86 87 88 89	86 87 88 89 90	87 88 89 90 91	88 89 90 91 92	89 90 91 92 93	90 91 92 93 94	91 92 93 94 95
92 93 94 95 96	33.5 34.0 34.5 35.0 35.5	73 74 74 75 75	74 74 75 75 76 76	75 76 76 77 77	76 77 77 78 78	76 77 78 78 79 79	77 78 79 79 80 80	78 79 80 80 81 81	79 80 80 81 82 82	80 81 81 82 83 83	81 82 82 83 84 85	82 83 83 84 85 86	84 85 86 86 87	84 85 5 86 87 88	85 85 86 87 38	86 86 87 88 89 90	86 87 88 89 90	87 88 89 90 91	88 89 90 91 92 93	90 91 92 93 94	90 91 92 93 94 95	91 92 93 94 95 96
92 93 94 95 96 97	33.5 34.0 34.5 35.0 35.5 36.0	73 74 74 75 75 76	74 74 75 75 76 76 77	75 76 76 77 77 78	76 77 77 78 78 79	76 77 78 78 79 79	77 78 79 79 80 80 81	78 79 80 80 81 81 82	79 80 80 81 82 82 83	80 81 81 82 83 83	81 82 82 83 84 85 85	82 83 83 84 85 86	84 85 86 86 87 87	84 85 5 86 87 88 88	85 85 86 87 38 8	86 86 87 88 89 90	86 87 88 89 90 91	87 88 89 90 91 92 93	88 89 90 91 92 93	89 90 91 92 93 94 95	90 91 92 93 94 95	91 92 93 94 95 96
92 93 94 95 96 97	33.5 34.0 34.5 35.0 35.5 36.0 36.5 37.0 38.0	73 74 74 75 75 76 76	74 74 75 75 76 76 77	75 76 76 77 77 78 78	76 77 77 78 78 79	76 77 78 78 79 79 80 80	77 78 79 79 80 80 81	78 79 80 80 81 81 82 83	79 80 80 81 82 82 83	80 81 81 82 83 83 84 85	81 82 82 83 84 85 85	82 83 83 84 85 86 86	84 85 86 86 87 87	84 85 5 86 87 88 88 89	85 85 86 87 28 8. 89	86 86 87 88 89 90	86 87 88 89 90 91 92	87 88 89 90 91 92 93	88 89 90 91 92 93 94	89 90 91 92 93 94 95	90 91 92 93 94 95 96 96	91 92 93 94 95 96 97 98 99
92 93 94 95 96 97 98 99	33.5 34.0 34.5 35.0 35.5 36.0 36.5 37.0	73 74 74 75 75 76 76 76	74 74 75 75 76 76 77 77	75 76 76 77 77 78 78 79	76 77 77 78 78 79 80	76 77 78 78 79 79 80 80	77 78 79 79 80 80 81 82	78 79 80 80 81 81 82 83	79 80 80 81 82 82 83 83	80 81 81 82 83 83 84 85	81 82 82 83 84 85 85 86	82 83 83 84 85 86 86 87	84 85 86 86 87 87 88 89	84 85 5 88 87 88 88 89 90	85 85 86 87 38 8 89 90	86 86 87 88 89 90 91	86 87 88 89 90 91 92	87 88 89 90 91 92 93 93	88 89 90 91 92 93 94 94	89 90 91 92 93 94 95 95	90 91 92 93 94 95 96 96	91 92 93 94 95 96 97 98 99
92 93 94 95 96 97 98 99	33.5 34.0 34.5 35.0 35.5 36.0 36.5 37.0 38.0	73 74 74 75 75 76 76 76	74 74 75 75 76 76 77 77 78	75 76 76 77 77 78 78 79	76 77 77 78 78 79 80 80	76 77 78 78 79 79 80 80 81	77 78 79 79 80 80 81 82 82	78 79 80 80 81 81 82 83 83	79 80 80 81 82 82 83 83 84	80 81 81 82 83 83 84 85 85	81 82 82 83 84 85 85 86 87	82 83 84 85 86 86 87 88	84 85 86 86 87 87 88 89	84 85 5 86 87 88 88 89 90	85 85 86 87 88 89 90 91	86 86 87 88 89 90 91 92 93	86 87 88 89 90 91 92 92	87 88 89 90 91 92 93 93 94	88 89 90 91 92 93 94 94 95	89 90 91 92 93 94 95 95 96	90 91 92 93 94 95 96 96	91 92 93 94 95 96 97 98 99
92 93 94 95 96 97 98 99 100	33.5 34.0 34.5 35.0 35.5 36.0 36.5 37.0 38.0 38.5	73 74 74 75 75 76 76 76 77	74 74 75 75 76 76 77 77 78 78 79	75 76 76 77 77 78 78 79 79	76 77 77 78 78 79 80 80 81	76 77 78 78 79 79 80 80 81 82	77 78 79 79 80 80 81 82 82 83	78 79 80 80 81 81 82 83 83 84	79 80 80 81 82 82 83 83 84 85	80 81 81 82 83 84 85 85 86 87	81 82 82 83 84 85 85 86 87 87	82 83 84 85 86 86 87 88 88	84 85 86 86 87 87 88 89 90	84 85 5 80 87 88 88 89 90 91	85 85 86 87 88 89 90 91 92	86 86 87 88 89 90 91 92 93 94	86 87 88 89 90 91 92 92 93	87 88 89 90 91 92 93 93 94 95	88 89 90 91 92 93 94 94 95 96	89 90 91 92 93 94 95 95 96 98	90 91 92 93 94 95 96 98 99	91 92 93 94 95 96 97 98 99 100
92 93 94 95 96 97 98 99 100 101	33.5 34.0 34.5 35.0 35.5 36.0 36.5 37.0 38.0 38.5 39.0	73 74 74 75 75 76 76 76 77 77	74 74 75 75 76 76 77 77 78 78 79	75 76 76 77 77 78 78 79 79 80	76 77 77 78 78 79 80 80 81 81	76 77 78 78 79 79 80 80 81 82 82	77 78 79 79 80 80 81 82 82 83 83	78 79 80 81 81 82 83 83 84 84	79 80 80 81 82 82 83 84 85 86	80 81 81 82 83 83 84 85 85 86 87	81 82 82 83 84 85 85 86 87 87 88	82 83 84 85 86 86 87 88 88 89	84 85 86 86 87 87 88 89 90 90	84 85 5 86 87 88 88 89 90 91 92	85 85 86 87 38 8 89 90 91 92 93	86 86 87 88 89 90 91 92 93 94 95	86 87 88 89 90 91 92 92 93	87 88 89 90 91 92 93 94 95 96	88 89 90 91 92 93 94 94 95 96 98	89 90 91 92 93 94 95 96 98 99	90 91 92 93 94 95 96 98 99 100	91 92 93 94 95 96 97 98 99 100 101
92 93 94 95 96 97 98 99 100 101 102	33.5 34.0 34.5 35.0 35.5 36.0 36.5 37.0 38.0 38.5 39.0	73 74 74 75 75 76 76 77 77 78 78	74 74 75 75 76 76 77 77 78 78 79 79	75 76 76 77 77 78 78 79 79 80 80	76 77 77 78 78 79 80 80 81 81 82	76 77 78 78 79 79 80 80 81 82 82 83	77 78 79 79 80 80 81 82 82 83 83 84	78 79 80 81 81 82 83 84 84 85	79 80 80 81 82 82 83 83 84 85 86 86	80 81 81 82 83 83 84 85 85 86 87 87	81 82 82 83 84 85 85 86 87 87 88 89	82 83 84 85 86 86 87 88 88 89 90	84 85 86 86 87 87 88 89 90 90 91	84 85 5 88 87 88 88 89 90 91 92 92	85 85 86 87 88 89 90 91 92 93 94	86 86 87 88 89 90 91 92 93 94 95 96	86 87 88 89 90 91 92 92 93 95 96	87 88 89 90 91 92 93 93 94 95 96 97	88 89 90 91 92 93 94 95 96 98 99	89 90 91 92 93 94 95 96 98 99 100	90 91 92 93 94 95 96 98 99 100 101	91 92 93 94 95 96 97 98 99 100 101 102
92 93 94 95 96 97 98 99 100 101 102 103	33.5 34.0 34.5 35.0 35.5 36.0 36.5 37.0 38.0 38.5 39.0 39.5 40.0	73 74 74 75 75 76 76 76 77 77 78 78	74 74 75 75 76 76 77 77 78 78 79 79 79	75 76 76 77 77 78 78 79 79 80 80 81	76 77 77 78 78 79 80 80 81 81 82 82	76 77 78 78 79 79 80 81 82 82 83 83	77 78 79 79 80 80 81 82 82 83 83 84 84	78 79 80 81 81 82 83 84 84 85 86	79 80 80 81 82 82 83 84 85 86 86	80 81 81 82 83 84 85 85 86 87 87 88	81 82 82 83 84 85 85 86 87 87 88 89	82 83 84 85 86 86 87 88 88 89 90 91	84 85 86 86 87 87 88 89 90 91 92	84 85 5 88 87 88 88 89 90 91 92 92 93	85 85 86 87 88 89 90 91 92 93 94 94	86 86 87 88 89 90 91 92 93 94 95 96	86 87 88 89 90 91 92 92 93 95 96 97	87 88 89 90 91 92 93 93 94 95 96 97	88 89 90 91 92 93 94 95 96 98 98 99 100	89 90 91 92 93 94 95 96 98 99 100 101	90 91 92 93 94 95 96 98 99 100 101 102	91 92 93 94 95 96 97 98 99 100 101 102 103 104

Temperature Humidity Index for lactating dairy cows

Average summer temperatures (Fahrenheit)

Heat stress (THI > 68), % of days in year



Heat stress during lactation

- Depresses dry matter intake
- Reduces milk yield
- Additional metabolic effects beyond dry matter intake
- Lower reproduction
- Recovery dependent on duration



Typical housing for lactating cows Fans and soakers



Traditional dry cow housing

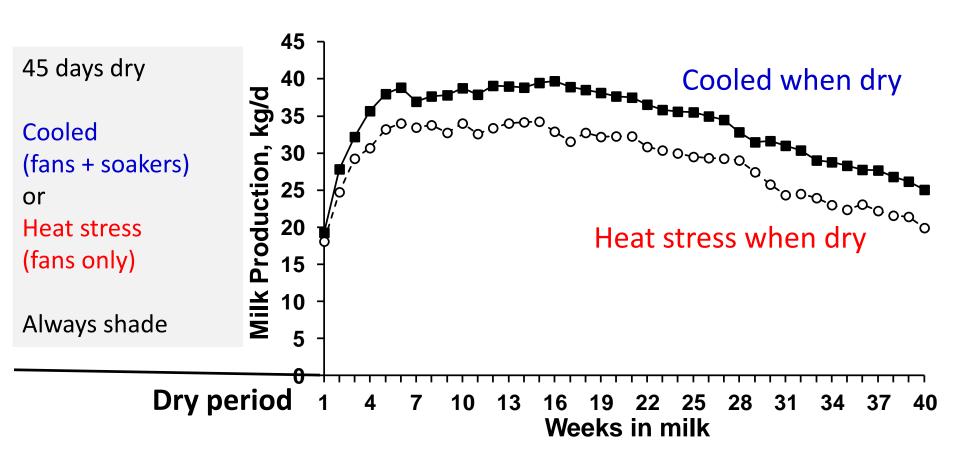
→ heat stress in the summer



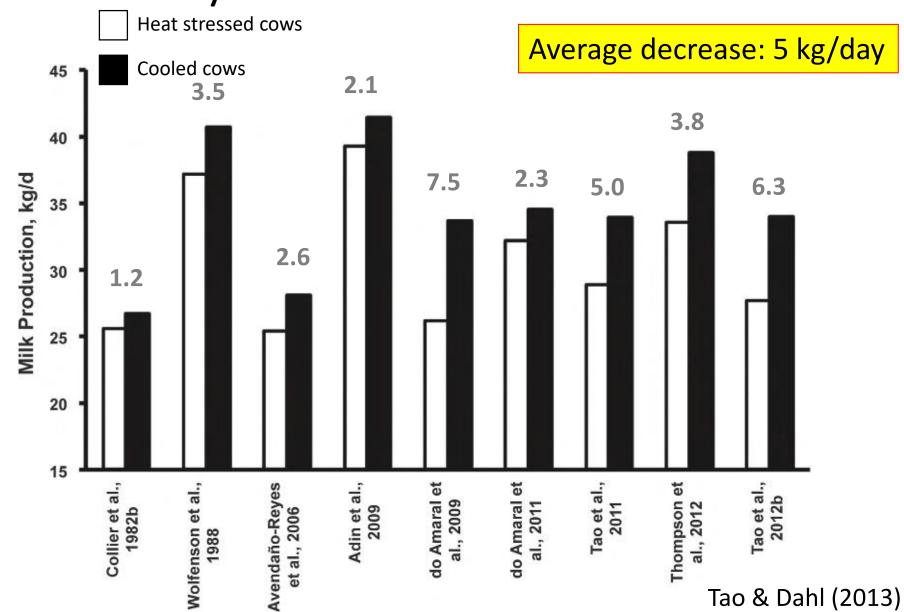
Agenda

- 1. Heat stress and lactating cows
- 2. Dry cows: Heat stress during her own dry period
- 3. Calves: Heat stress during mom's dry period
- 4. Offspring: Effect on milk production, survival
- 5. Cows: Heat stress when she was conceived
- 6. Summary

Cooling dry cows increases milk yield after calving



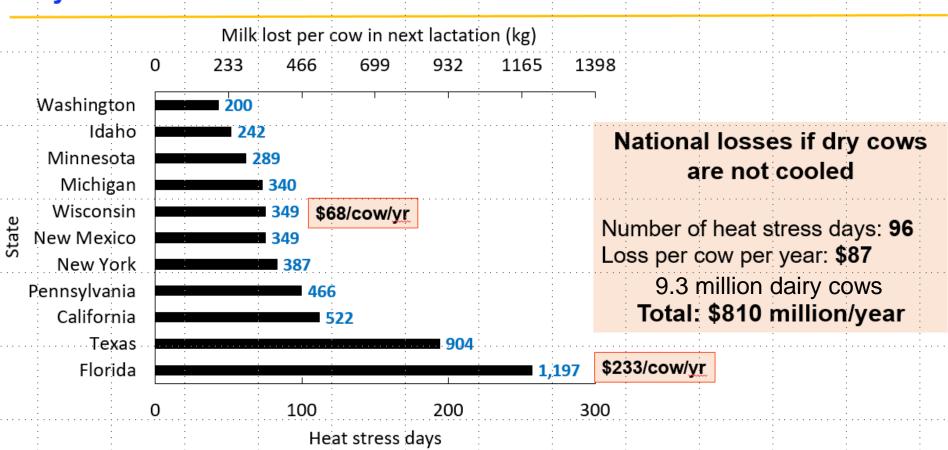
Heat stress during the dry period decreases milk yield in the next lactation



Heat stress in dry period:

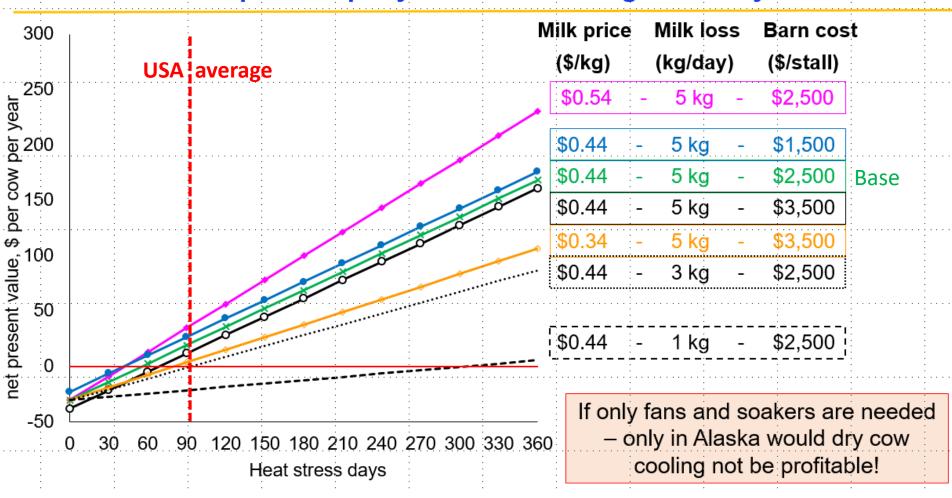
- Increases mean rectal temperature
- Decreases proliferation of mammary cells before calving
- Has no effect on mammary epithelial cell apoptosis
- Reduces dry matter intake before calving but not after calving
- Decreases loss of body weight after calving
- Decreases lymphocyte proliferation

Milk and profitability losses in next lactation in the 10 states with the most dairy cows and Florida



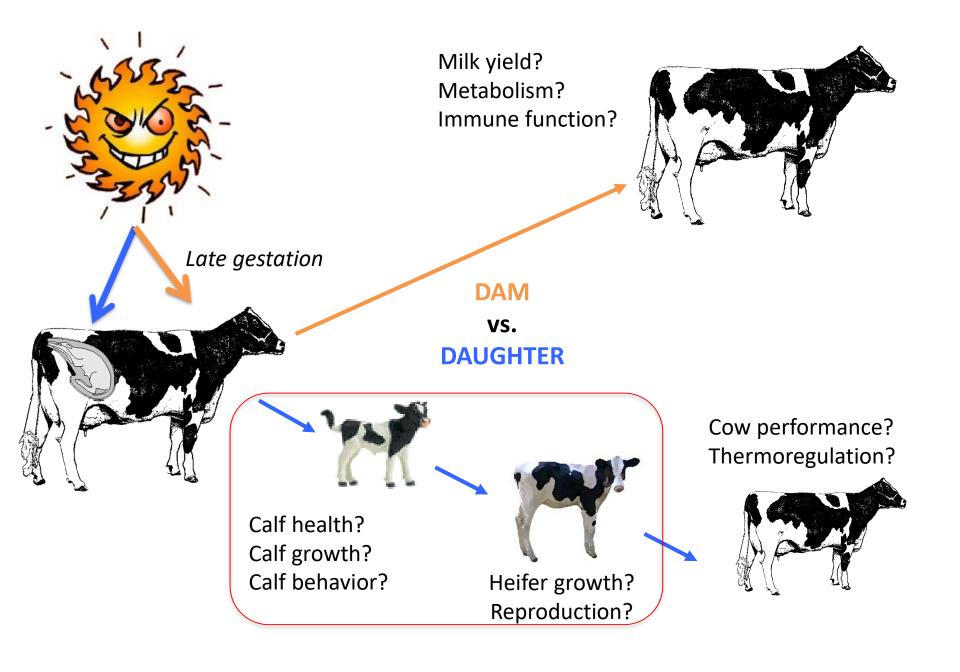
It almost always pays to cool dry cows

Net Present Value per cow per year when building a new dry cow barn

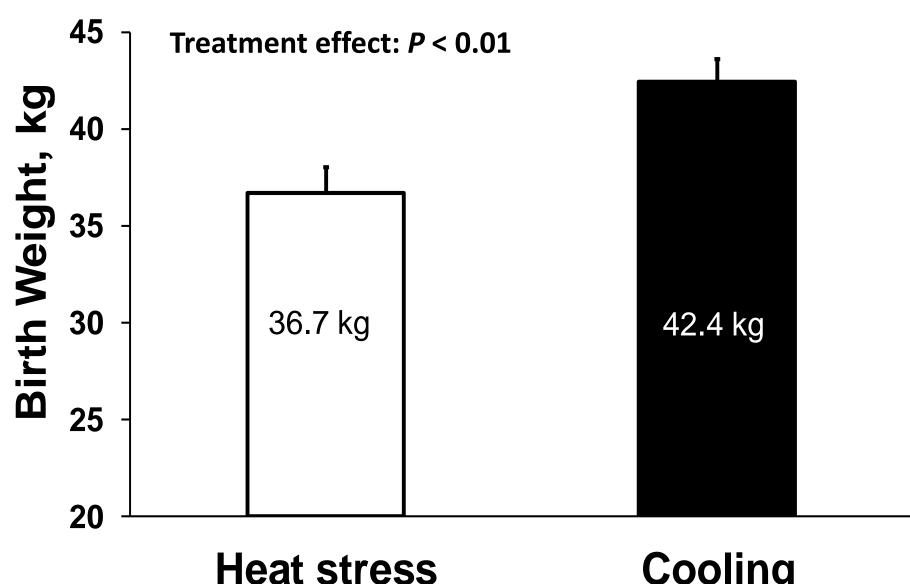


Agenda

- 1. Heat stress and lactating cows
- 2. Dry cows: Heat stress during her own dry period
- 3. Calves: Heat stress during mom's dry period
- 4. Offspring: Effect on milk production, survival
- 5. Cows: Heat stress when she was conceived
- 6. Summary



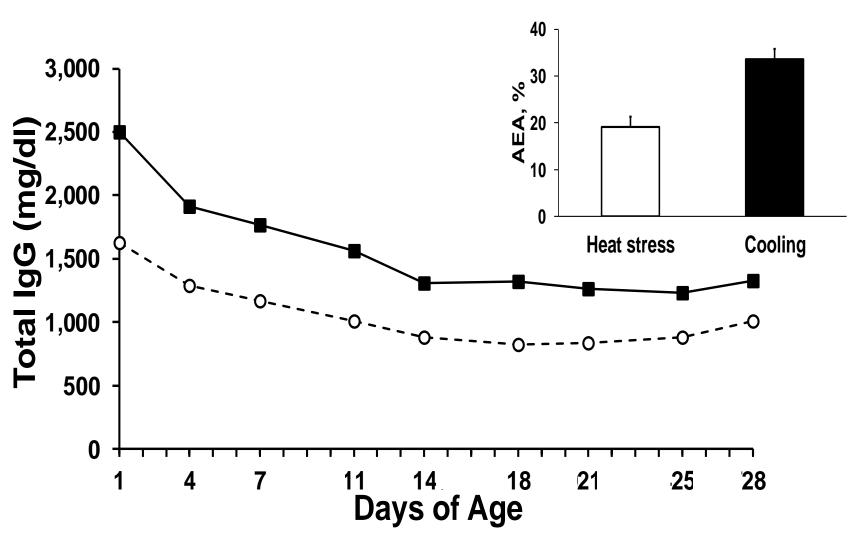
Cooling dry dam increases calf birth weight



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

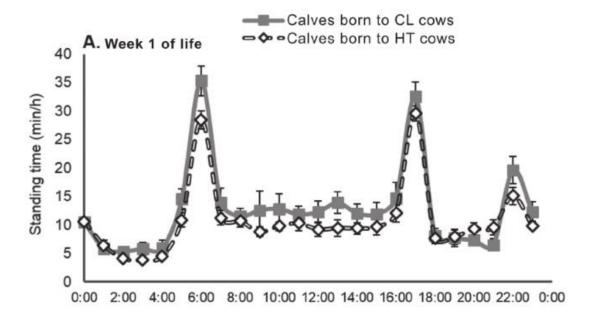
Cooling

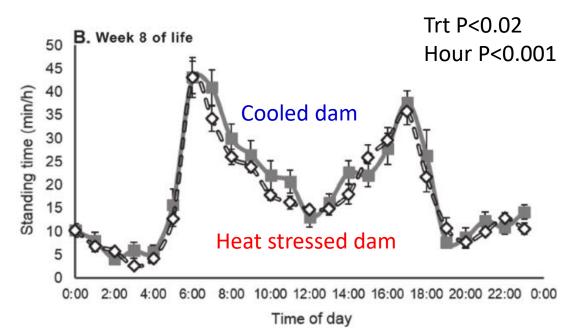
Cooling improves total IgG and apparent efficiency of absorption (AEA)



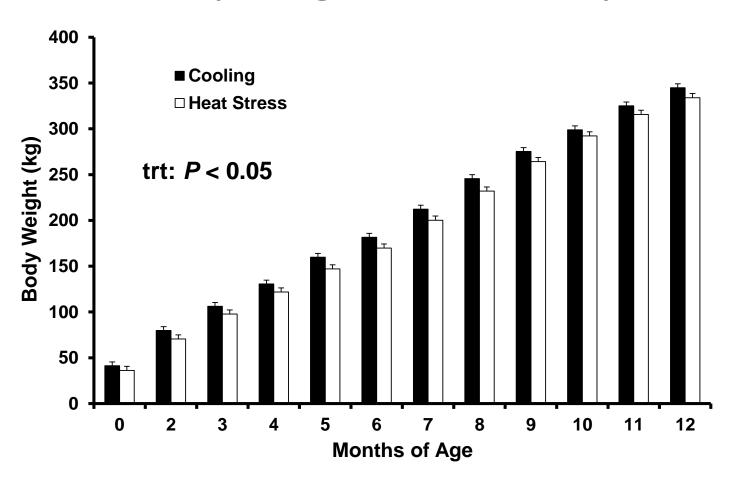
Tao et al., J. Dairy Sci. 95:7128-7136

In-utero heat stress decreases amount of standing in calves





In Utero Heat Stress Decreases Calf Bodyweight to Puberty



Summary – Short term effects of dry dam's heat stress on their calves

- Lower weight at birth and weaning
- Reduced apparent efficiency of IgG absorption, but not an effect on colostrum quality
- Altered carbohydrate metabolism, consistent with greater fat deposition
- Decreases standing activity in calves



Heat Stress Summary – Longer term effects on calves before calving

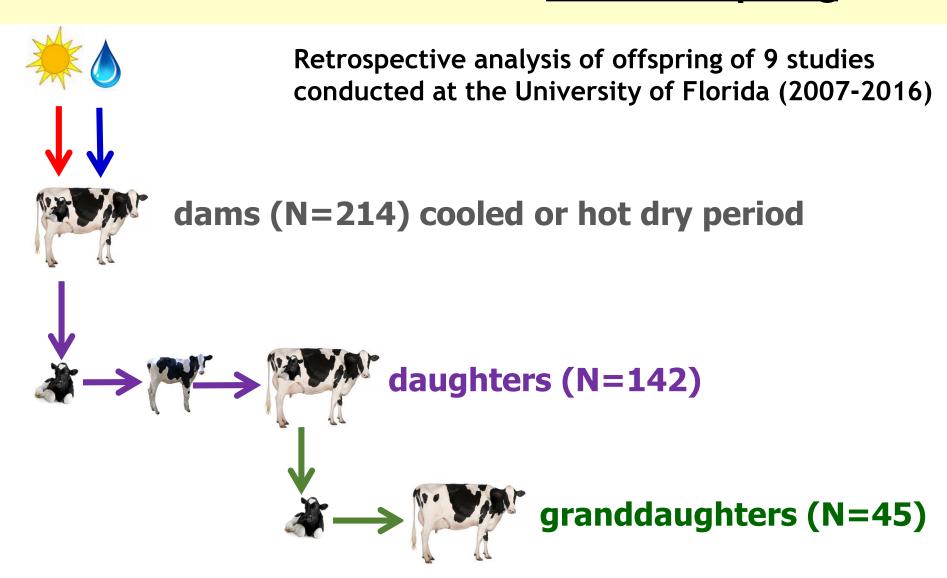
- Lower weight through first year of age
- Decreased survival
- Decreased reproduction older at first calving



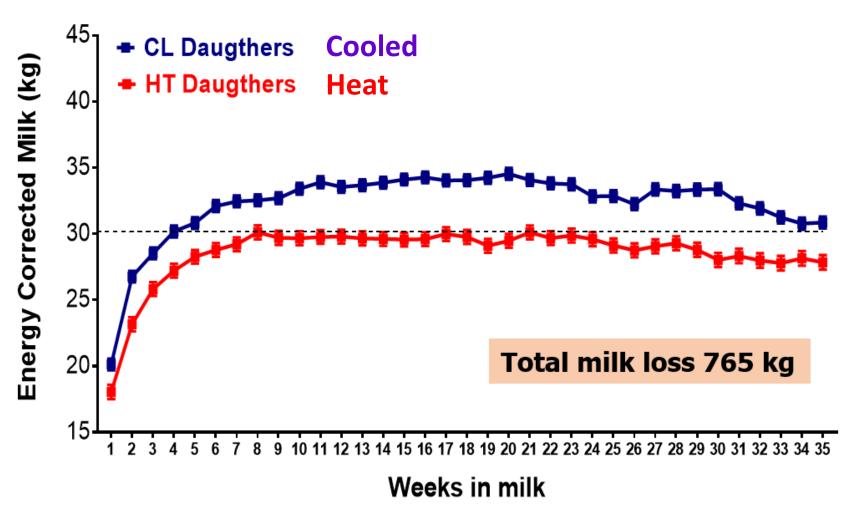
Agenda

- 1. Heat stress and lactating cows
- 2. Dry cows: Heat stress during her own dry period
- 3. Calves: Heat stress during mom's dry period
- 4. Offspring: Effect on milk production, survival
- 5. Cows: Heat stress when she was conceived
- 6. Summary

How does exposure of dry pregnant dams to heat stress affect their <u>adult offspring</u>?

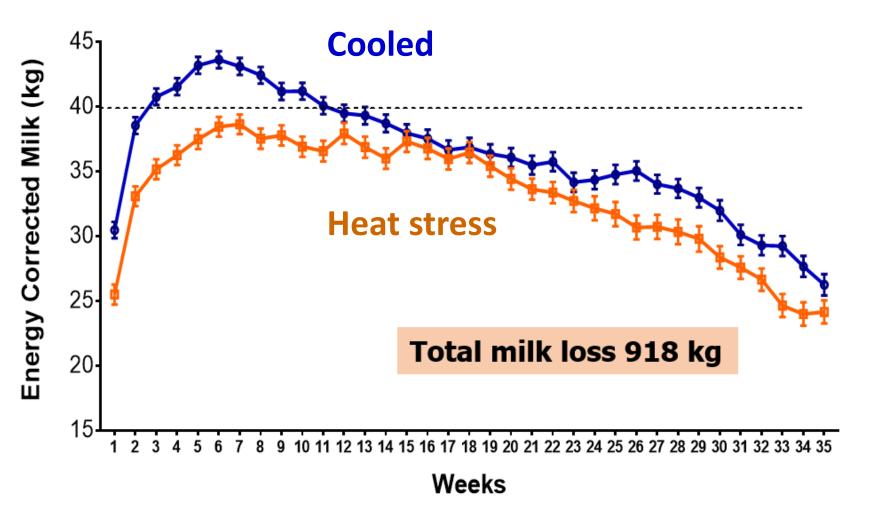


Daughters (in-utero HT or CL, >2 yrs ago), 1st lactation milk yield

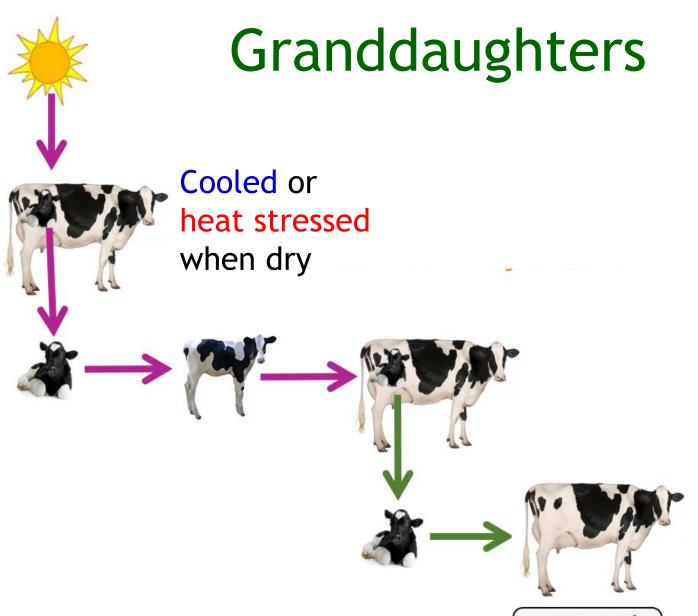


Laporta et al., 2018 (abstract)

Daughters (in-utero HT or CL, >3 yrs ago), 2nd lactation milk yield

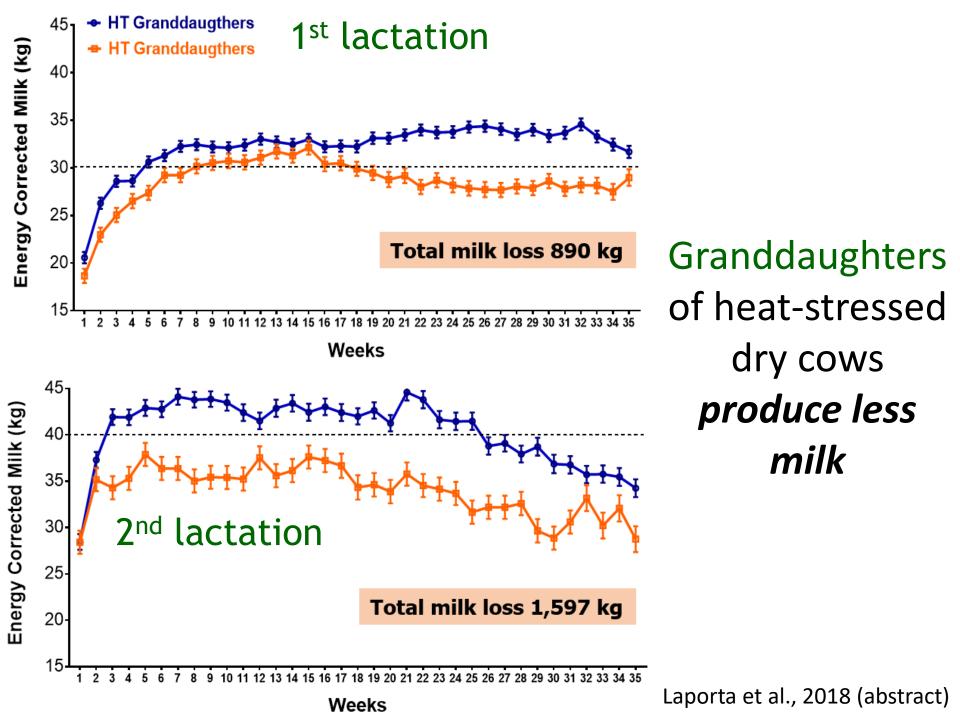


Laporta et al., 2018 (abstract)



Grand daughters

1st & 2nd lactation



Agenda

- 1. Heat stress and lactating cows
- 2. Dry cows: Heat stress during her own dry period
- 3. Calves: Heat stress during mom's dry period
- 4. Offspring: Effect on milk production, survival
- 5. Cows: Heat stress when she was conceived
- 6. Summary



Season of conception is associated with future survival, fertility, and milk yield of Holstein cows

P. J. Pinedo*1 and A. De Vries†

*Department of Animal Sciences, Colorado State University, Fort Collins 80523 †Department of Animal Sciences, University of Florida, Gainesville 32611

- Analysis of >300,000 Florida lactations
- Cows conceived during winter vs. summer (9 months before their birth, ≥30 months before first calving)
- Cows that were conceived in summer:
 - Greater age at first calving
 - More culling in first lactation
 - Lower reproduction
 - Lower milk production

Summary

- Dry cow heat stress affects the cow, her daughters and her granddaughters
- Limited data available on heat stress and offspring
- Dry cow cooling very profitable in most places

