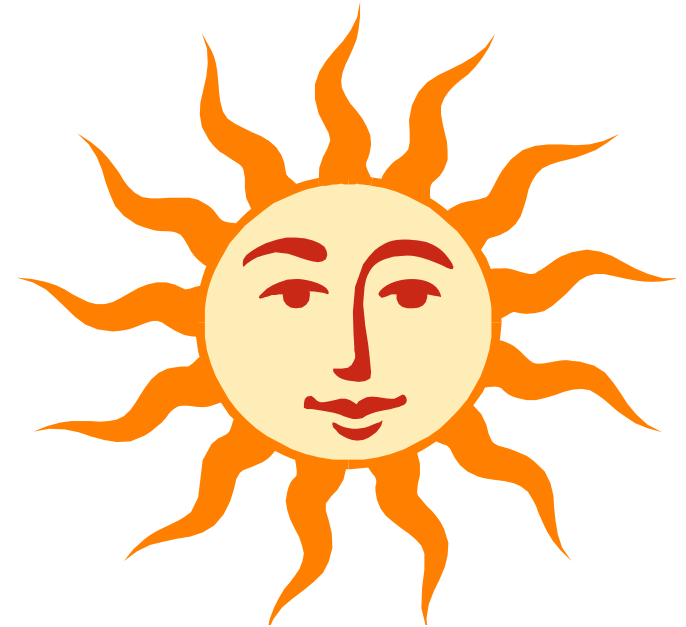


Effects of Heat Stress on Reproduction in Dairy Cows

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Maintenance of Body Temperature in Dairy Cattle

Homeothermy:

$$HP + EH = HL$$

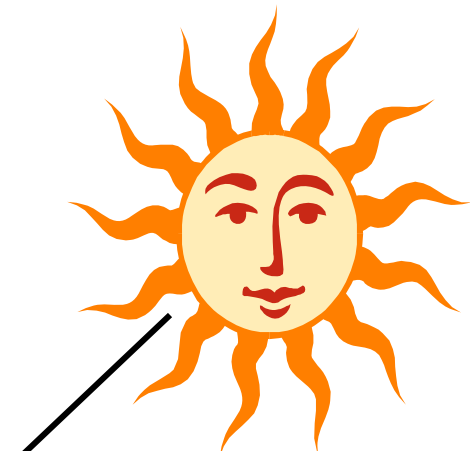
Hyperthermia:

$$HP + EH > HL$$

Internal Heat Production (HP)

Metabolism:

- 1) Growth
- 2) Lactation



Environmental Heat (EH)

Heat Loss to Environment (HL)

4 methods:

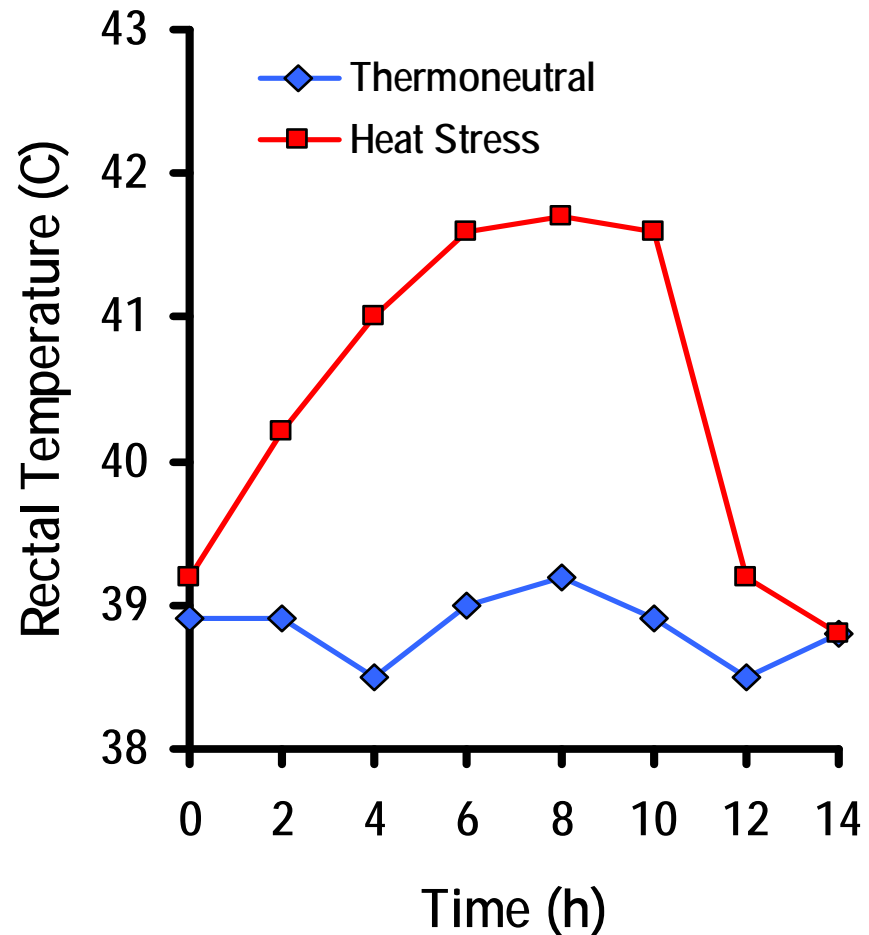
- 1) Conduction
- 2) Convection
- 3) Radiation
- 4) Evaporation

Effects of Heat Stress

Body Temperature

Mean rectal temperature of a heifer throughout the imposition of thermoneutral or heat environmental temperatures

Rectal temperatures can approach 107 F during severe heat stress

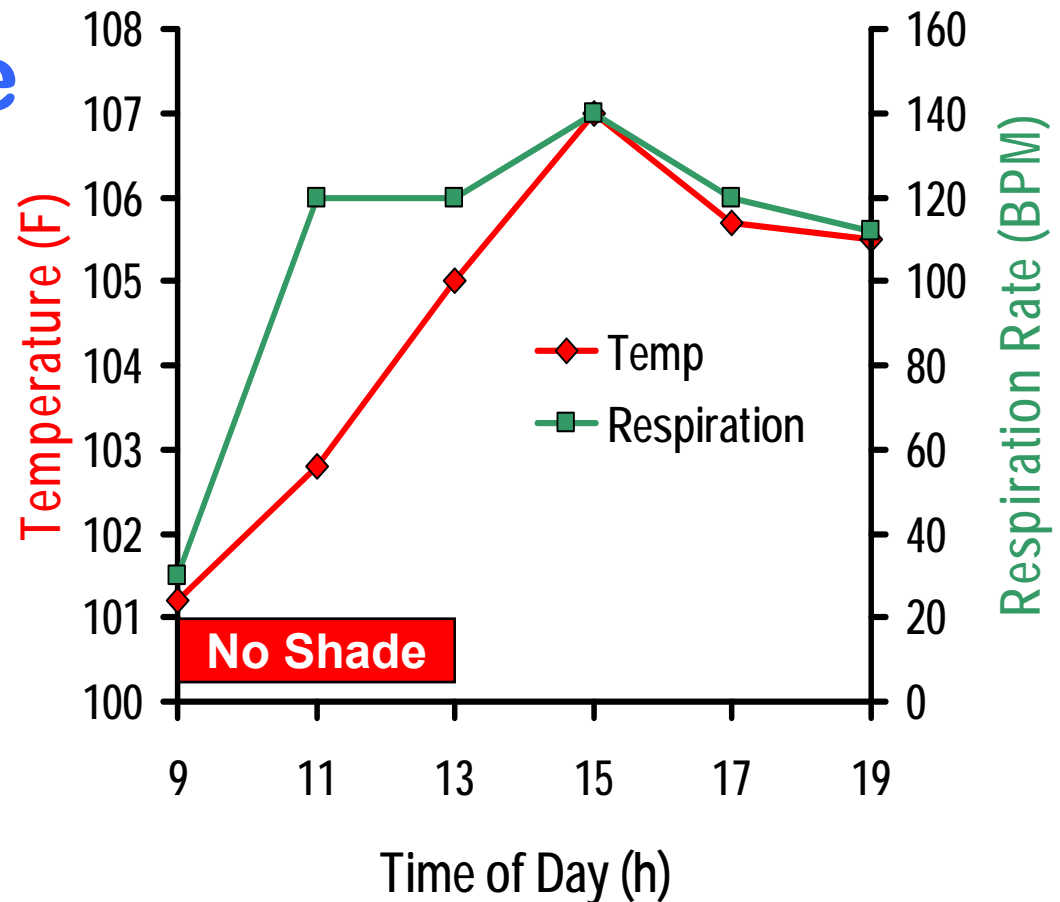


Data from Putney et al., 1989

Effects of Heat Stress

Respiration Rate

Rectal temperature and respiration rates from a lactating dairy cow that was heat stressed by placing her in direct sunlight without access to shade in Florida



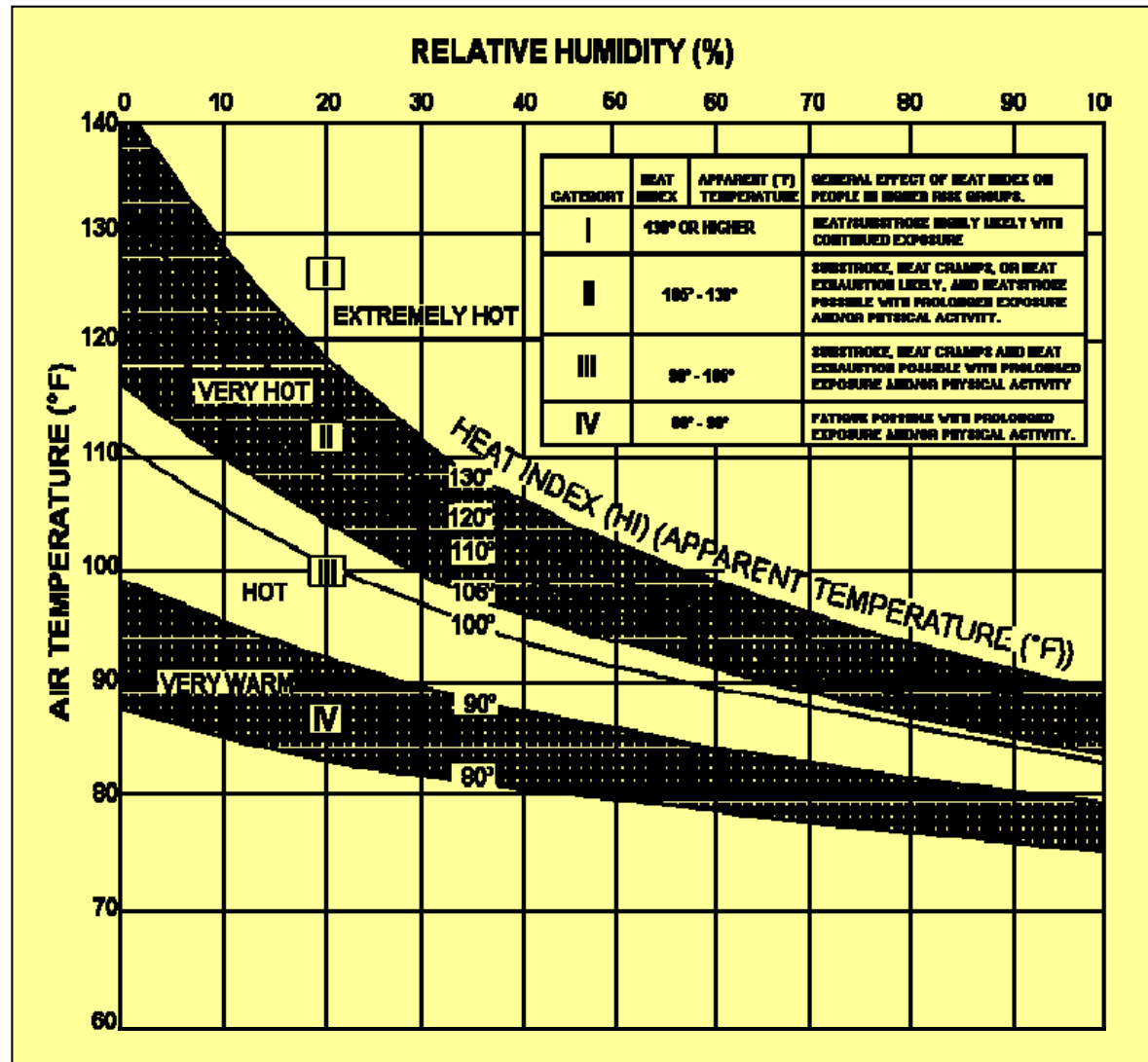
Cole and Hansen, Unpublished

Temperature Humidity Index

When ambient temperature = body temperature, evaporation becomes the only route for heat loss

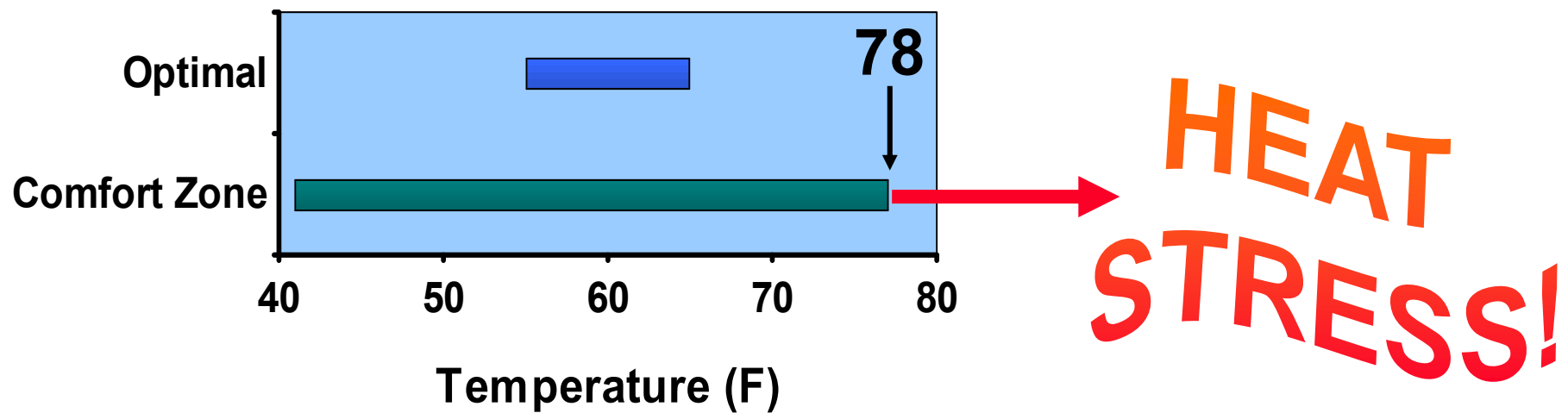
Efficiency of evaporation decreases as relative humidity increases

THI > 72 = Heat Stress



Thermoneutral Zone

- ✓ 55 – 65 F = optimal environmental temperature range for dairy cattle
- ✓ 41 – 77 F = comfort zone for dairy cattle
 - ✓ Usually significant changes in DMI and other adverse effects of heat stress do not occur within the comfort zone



How Hot is Too Hot?

- ✓ Rectal temperatures are above 102.5 F
- ✓ Panting in excess of 80 breaths per minute
- ✓ Dry matter intake drop of 10% or more associated with hot weather
- ✓ Milk production drop of 10% or more associated with hot weather

You need to consider cooling strategies for your cows if any of these conditions exist!

Effects of Heat Stress

Milk Production

Direct effects of heat stress on milk yield are due primarily to decreased dry matter intake

Cows under severe heat stress ($THI > 80$) may decrease milk production by 25 – 35% if no intervention is used



Effects of Heat Stress

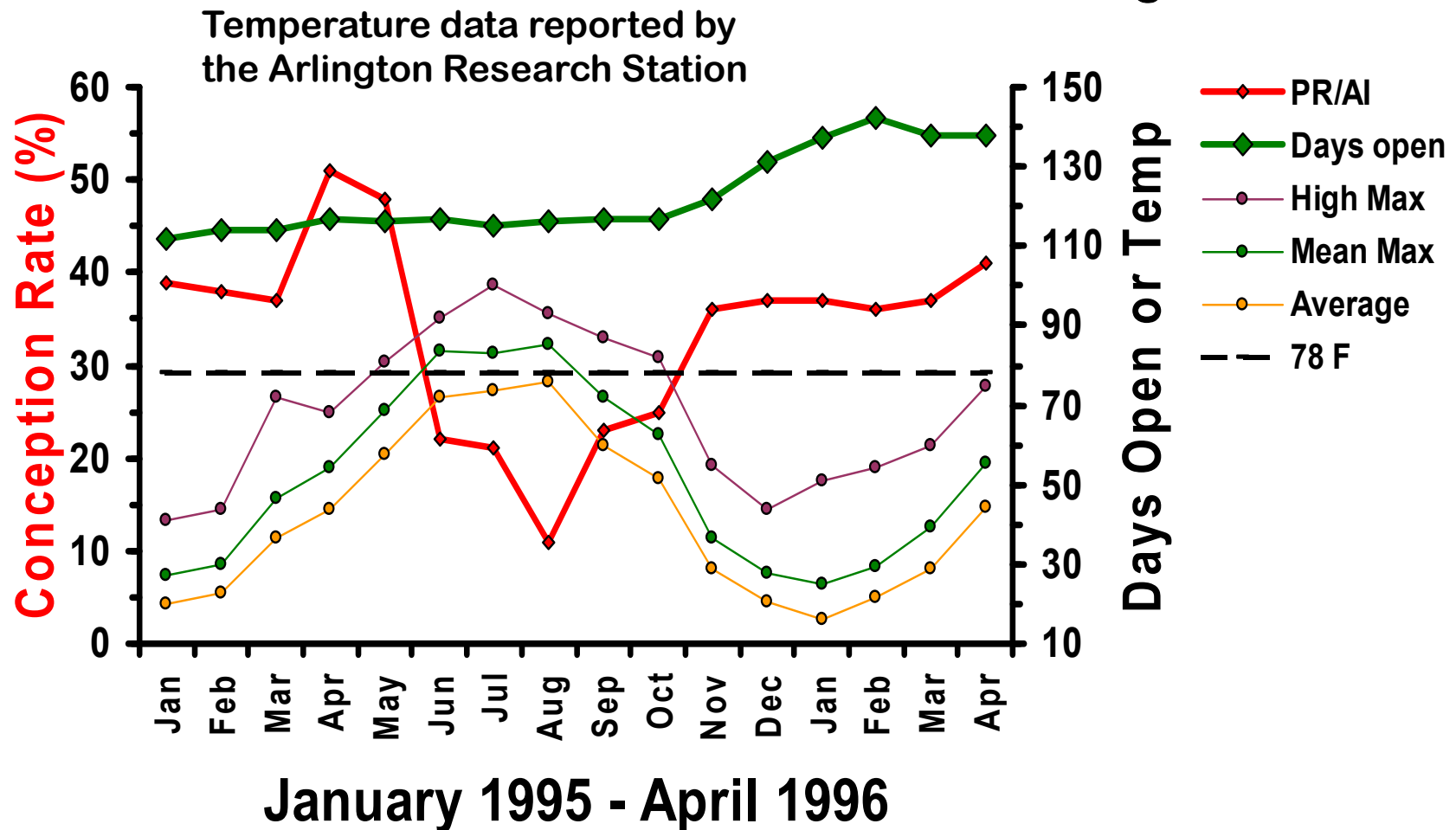
Conception Rate – UW Dairy Herd, 95-96

Days Max Temp ≥ 90

June = 9

July = 6

August = 4



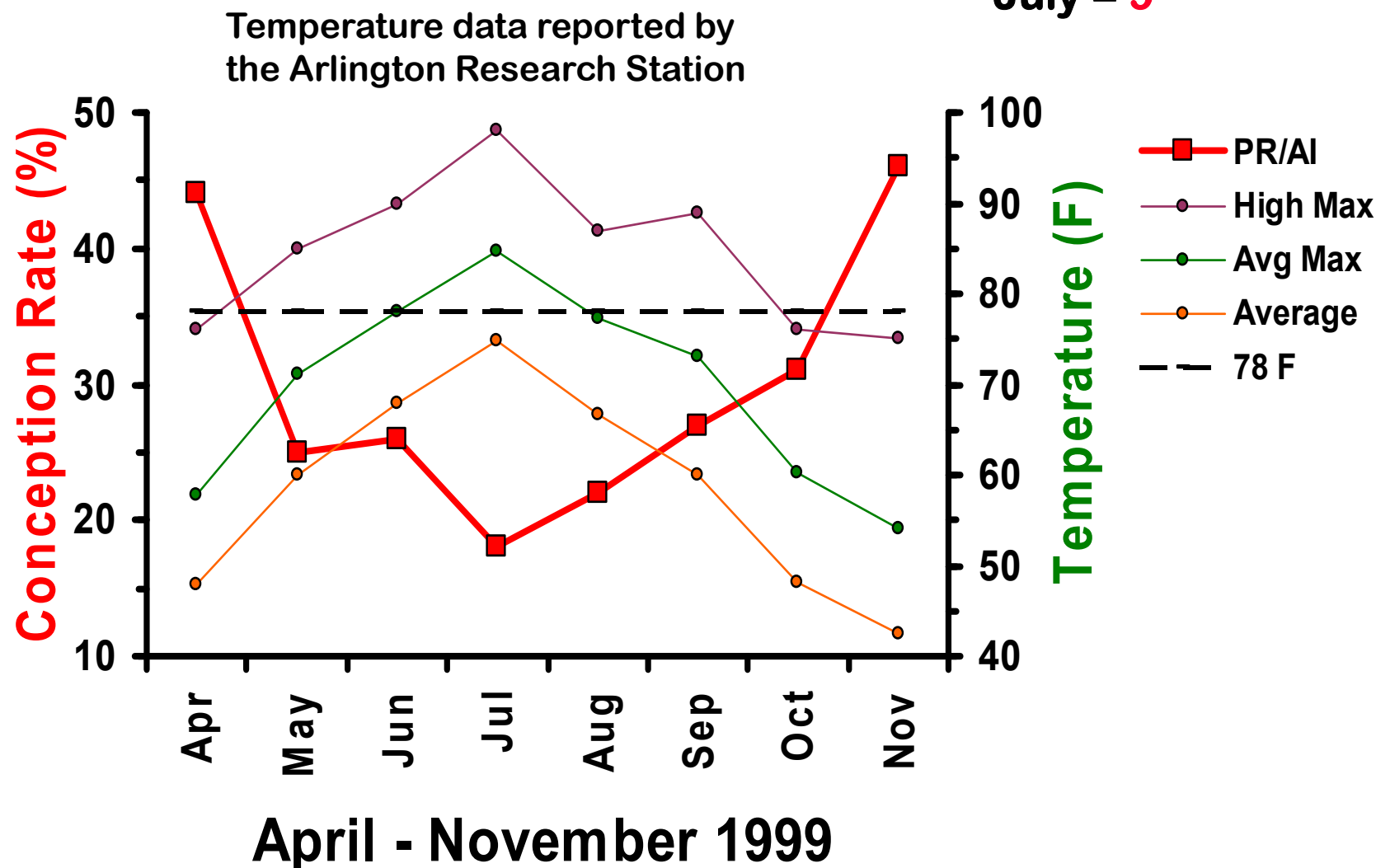
Effects of Heat Stress

Conception Rate – UW Dairy Herd, 1999

Days Max Temp ≥ 90

June = 1

July = 9



Fertility of Dairy Cows after Resynchronization of Ovulation at Three Intervals Following First Timed Insemination

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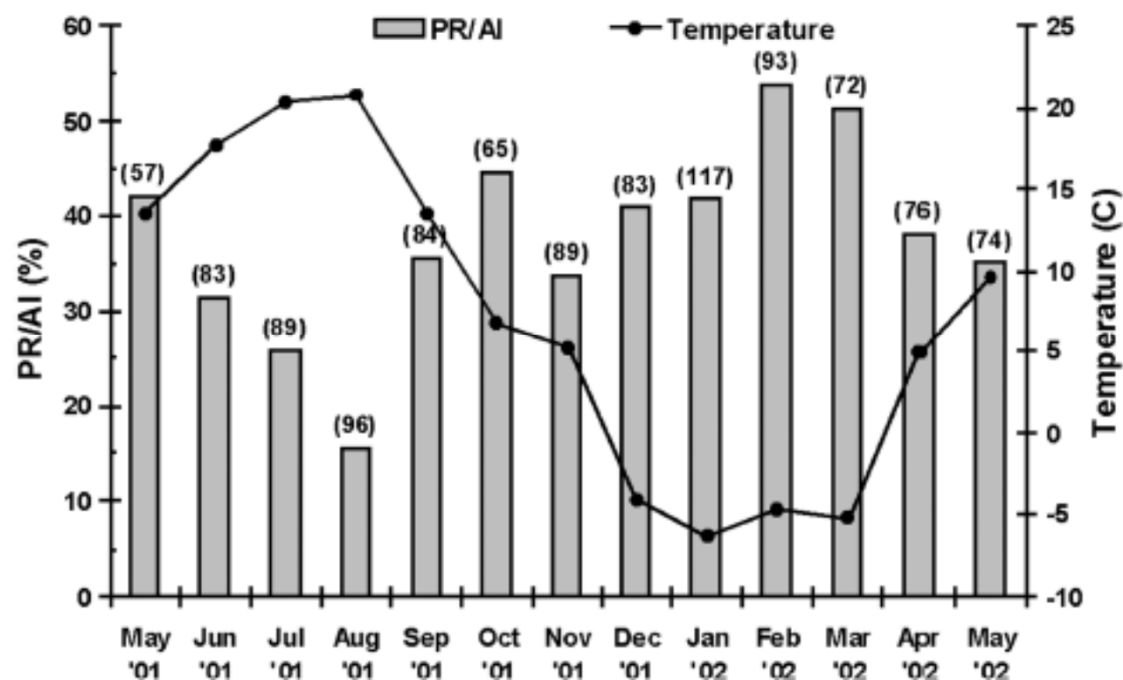
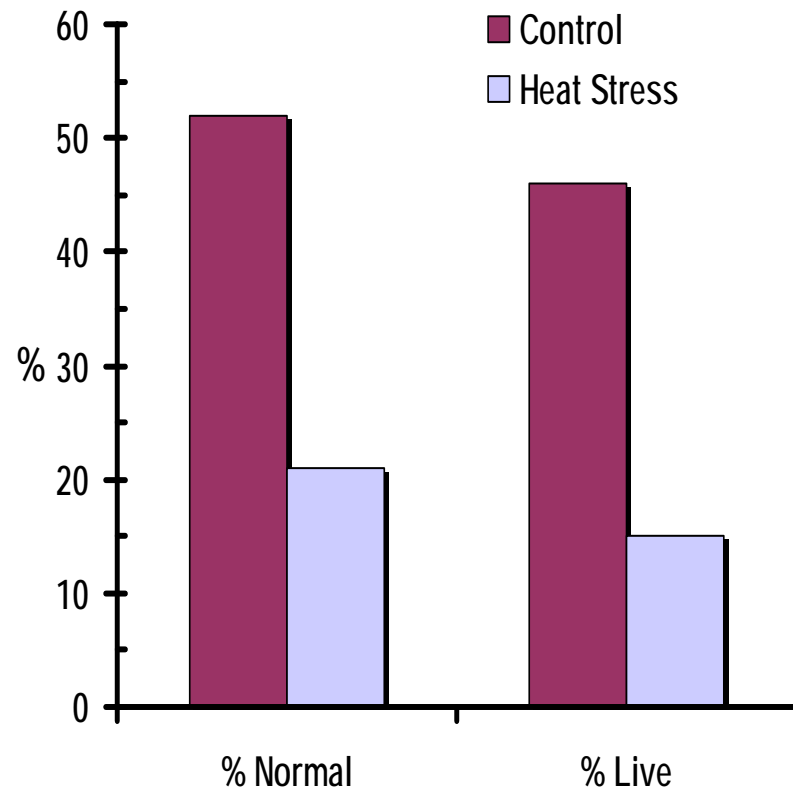


Figure 1. Effect of mean high ambient temperature on pregnancy rates to timed AI (TAI) by month. Pregnancy rate per artificial insemination (PR/AI) represents all Ovsynch and Resynch TAI services during each respective month. Numbers above bars are the total number of TAI services for each month. Temperature data represents the mean high daily temperature at the time of TAI for all TAI services occurring each month. Cows had greater ($P = 0.05$) pregnancy rates during fall and winter months compared to summer months.

Effects of Heat Stress

Embryonic Development

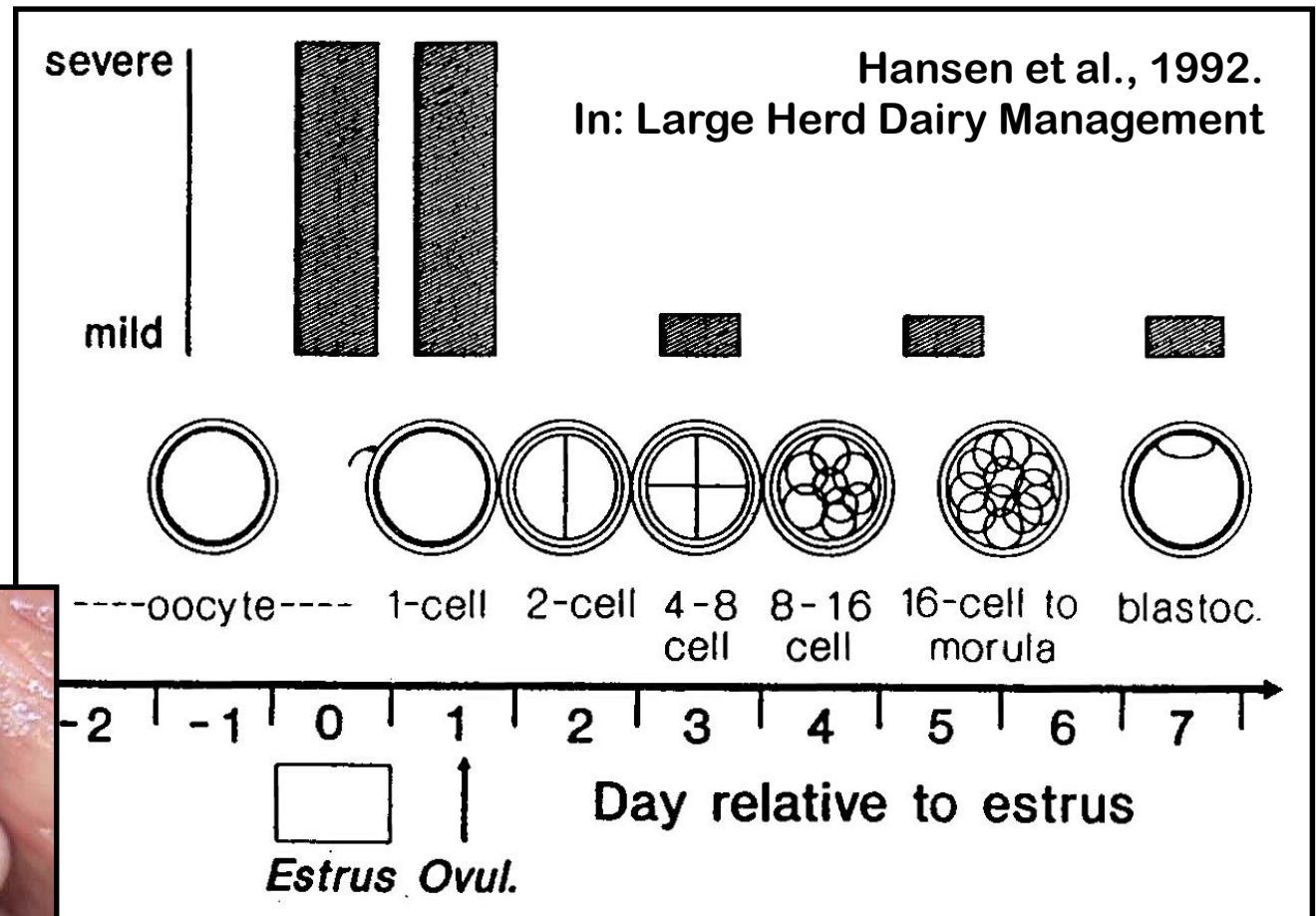
Embryonic development in superovulated cows placed in environmental chambers from day 1-7 after estrus



Data adapted from Putney et al.,
Theriogenology 30:195; 1988

Effects of Heat Stress

Effects on
Late Follicular
and Early
Embryonic
Development



Effect of dietary organic zinc, manganese, copper, and cobalt supplementation on milk production, follicular growth, embryo quality, and tissue mineral concentrations in dairy cows

K. S. Hackbart, R. M. Ferreira, A. A. Dietsche, M. T. Socha, R. D. Shaver, M. C. Wiltbank and P. M. Fricke

J Anim Sci 2010.88:3856-3870.

doi: 10.2527/jas.2010-3055 originally published online Sep 3, 2010;

Table 11. Flushing and embryo measures for lactating dairy cows classified as heat stressed or thermoneutral

Measure	Heat stress ¹	Thermoneutral	P-value
	————— % (n/n) —————		
Fertilized (based on staining)	36.8 (7/19)	83.1 (54/65)	<0.001
% Viable (1 to 2)	20.0 (4/20)	42.2 (27/64)	0.110
	————— mean ± SEM —————		
Embryo stage ²	3.14 ± 0.46	3.19 ± 0.30	0.981
Embryo quality	2.75 ± 0.49	2.62 ± 0.18	0.766
Nuclei/embryo	37.20 ± 12.17	49.48 ± 4.96	0.548
Accessory sperm/embryo	99.20 ± 56.80	43.10 ± 9.10	0.463
Accessory sperm/entity	42.93 ± 22.46	38.05 ± 7.82	0.783
Accessory sperm/UFO ³	11.67 ± 6.04	11.8 ± 6.28	0.280

¹Cows were classified as heat-stressed if rectal temperatures were $\geq 39^{\circ}\text{C}$ at the time of breeding.

²For all measures, embryo indicates a fertilized structure in which signs of cleavage (2 or more cells) were observed; entity refers to all structures, regardless of cell number.

³UFO = unfertilized oocyte.

Effects of Heat Stress

Seasonal Effects on Estrus Expression



Breed	Standing Events	
	Winter	Summer
Holstein	8.6	4.5
Jersey	12.1	5.3

Nebel et al., J Dairy Sci 80(Suppl 1); 1997

Strategies for Managing Heat Stress

General Considerations

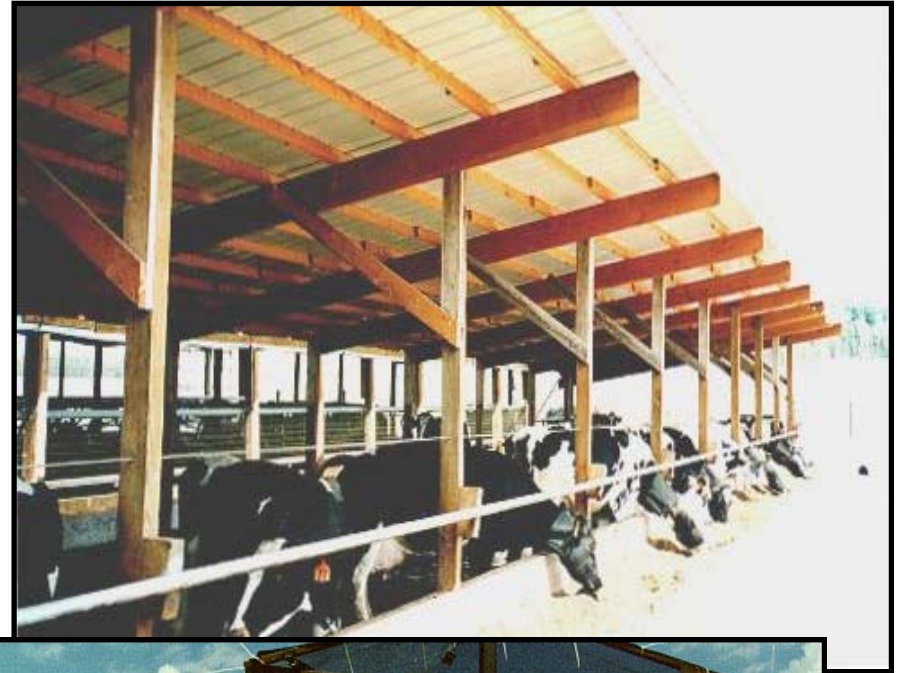
Water

- ❑ Water intake can increase by nearly 50% during severe heat stress
- ❑ Keep water fresh and clean
- ❑ Make water available immediately to cows after returning from the parlor after milking



Shade

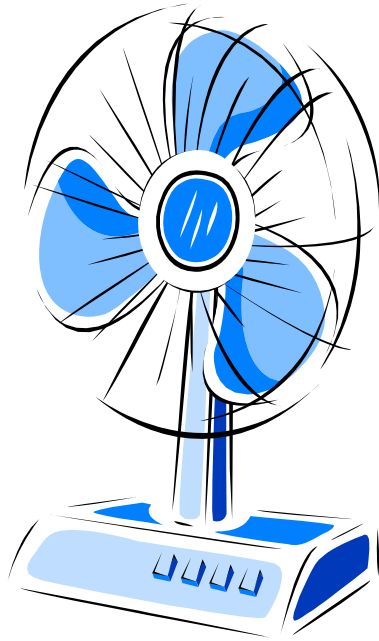
- ✓ Shade is a physical barrier against solar radiation
- ✓ Shade should be provided over resting areas, parlors, and over feed and water stations
- ✓ Pregnancy rates were 44% for cows maintained in shade in the summer in Florida versus 25% for cows not given access to shade (Roman-Ponce et al., 1977)



4 Modes of Heat Transfer

- ❑ **Evaporation** – vaporization of water
 - ❑ Primary means by which cows cool themselves
 - ❑ Panting & Sweating
- ❑ **Radiation** – radiant energy from the sun
 - ❑ Major cause of increased heat load in lactating COWS
- ❑ **Convection** – exchange of heat with moving air
 - ❑ Only effective when air temperature < body temperature
- ❑ **Conduction** – flow of heat from a hotter to a cooler surface via physical contact
 - ❑ Least important factor for cow cooling

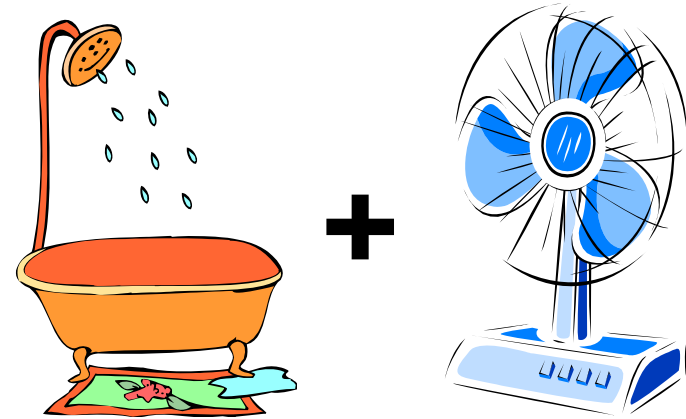
Fans



- ✓ Increase cooling by convection
- ✓ However, air temperature must be lower than the cows body temperature for effective cooling to take place



Sprinklers and Fans



Sprinkling systems in combination with fans improve evaporative and convective cooling of cows



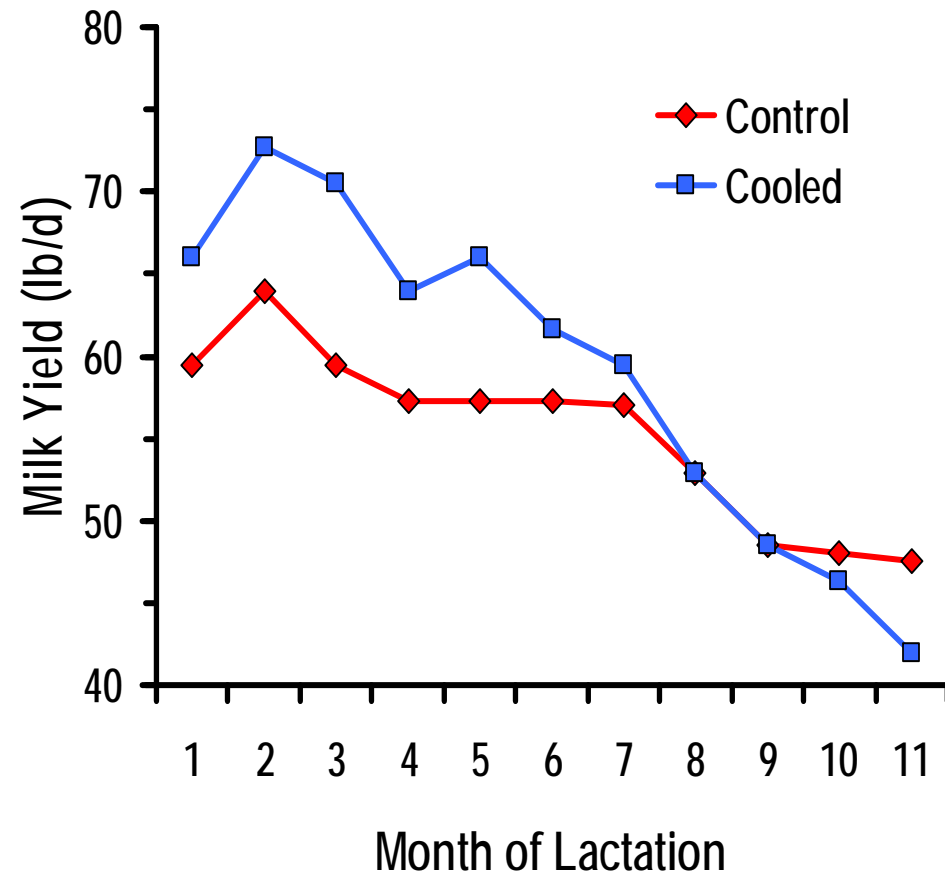
Managing Heat Stress

Cooling & Milk Production

Daily milk yield during summer (Israel) for cows offered a voluntary cooling facility (4X/day, 1h each)

Control = shade only

Cooled = shade + sprinkling



Data from Berman & Wolfenson, 1992.
In Large Herd Dairy Management

Reproductive Management Strategies during Heat Stress

Timed AI and Heat Stress

De la Sota et al., Theriogenology 49:761;1998

Dynamic Economic Modeling Program

- A decision not to breed cows during the summer months decreased net revenue per cow by \$30.00
- Timed AI at first service increased net revenue per cow \$17.24 compared with controls
- Greatest increase in net revenue (\$55.27) was for use of timed AI for all cows open in April

Managing Heat Stress – Timed AI

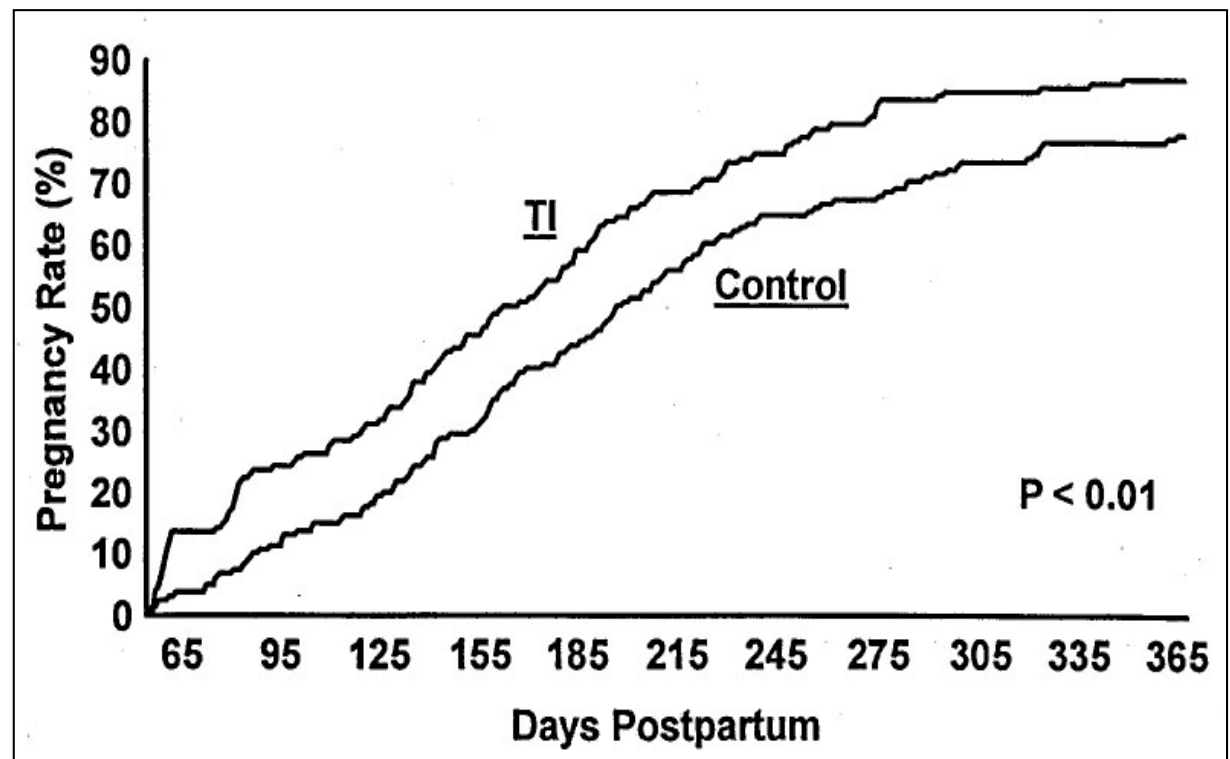
De la Sota et al., Theriogenology 49:761;1998

Response	Control AI	Timed AI	P <
Cows in study	156	148	0.05
Pregnancy rate (%)	4.8 ± 2.5	13.9 ± 2.6	0.05
Estrus detection or service rate (%)	18.1 ± 2.5	100.0 ± 0.0	0.05
Conception rate (%)	22.9 ± 6.4	13.2 ± 3.6	0.05
Overall pregnancy rate to 120 d (%)	16.5 ± 3.5	27.0 ± 3.6	0.05
Days open	90.0 ± 4.2	77.6 ± 3.8	0.05
Services per conception	1.27 ± 0.11	1.63 ± 0.10	0.05
Days to first AI	91.0 ± 1.9	58.7 ± 2.1	0.05

Timed AI and Heat Stress

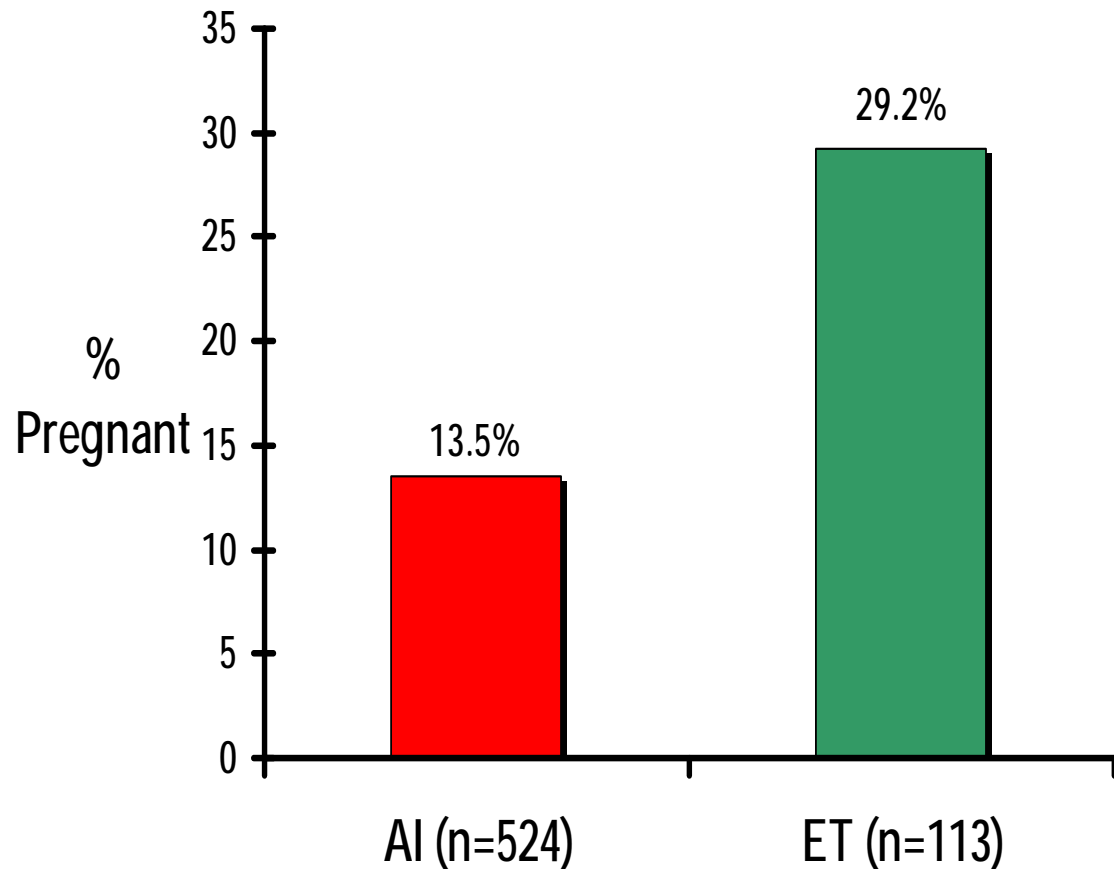
De la Sota et al., Theriogenology 49:761;1998

Cumulative pregnancy rates in lactating dairy cows receiving their first postpartum insemination in summer (Florida) as a timed AI or an AI to a detected estrus



Embryo Transfer

% of cows pregnant after artificial insemination or embryo transfer on day 7 during summer in Florida



Data adapted from Putney et al.,
Theriogenology 31:765; 1989

Heat Stress: ET vs. AI

Putney et al., Theriogenology 31:765; 1989

Environmental Temperature (C)	n	Conception rate (%)					
		Embryo Transfer			Artificial Insemination		
		d 21	d 40	(n)	d 21	d 40	(n)
Overall	637	47.6	29.2	(113)	18.0	13.5	(524)
< 32 C	350	35.5	22.9	(48)	15.6	13.9	(302)
≥ 32 C	287	54.7	33.8	(65)	20.7	13.1	(222)