Is it possible to alleviate the negative effects of heat stress on reproduction of dairy cows?

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Backbone of the presentation

- A brief introduction to heat stress
- When is heat stress reducing reproductive performance?
- Where is heat stress acting to affect reproductive performance?
- Why is heat stress reducing reproductive performance?
- What can we do to alleviate the heat stress effect?

1. During the heat stress period
2. During the carry over period

- Conclusions

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A brief introduction to heat stress

<u>How do the farmers see heat stress during the summer season?</u>

- Cows produce less milk
- Cows eat less
- Cows are quieter
- Cows express shorter estrus periods with reduced mounting activity
- Fertility of cows following AI at detected heat is very low

HEAT STRESS IN DAIRY COWS 611

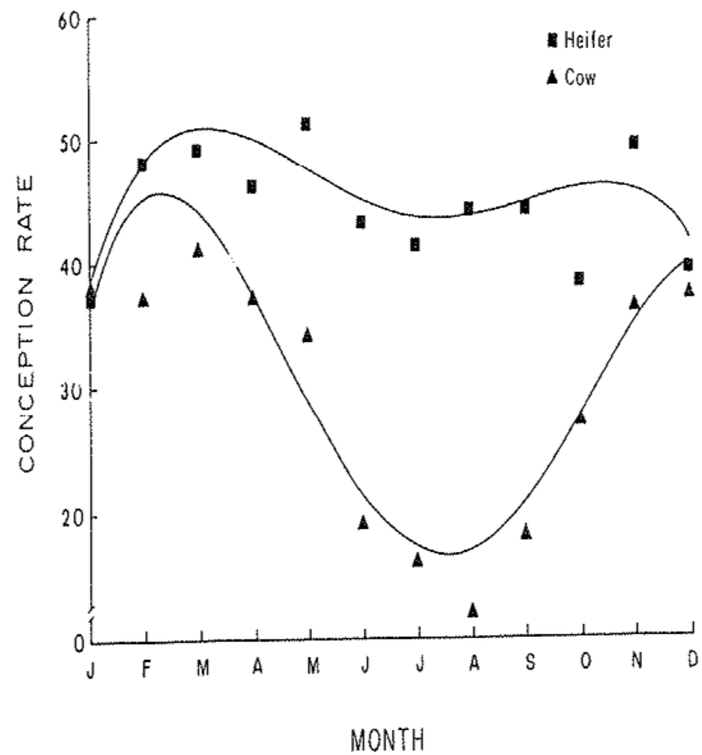

Figure 2. Least squares means for monthly pregnancy rates (%) in heifers and cows, unadjusted for environmental effects. (From Thatcher WW, Collier RJ: Effects of climate on bovine reproduction. In Morrow DA (ed): Current Therapy in Theriogenology. Edition 2. Philadelphia, WB Saunders Co, 1986, p 302; with permission.)

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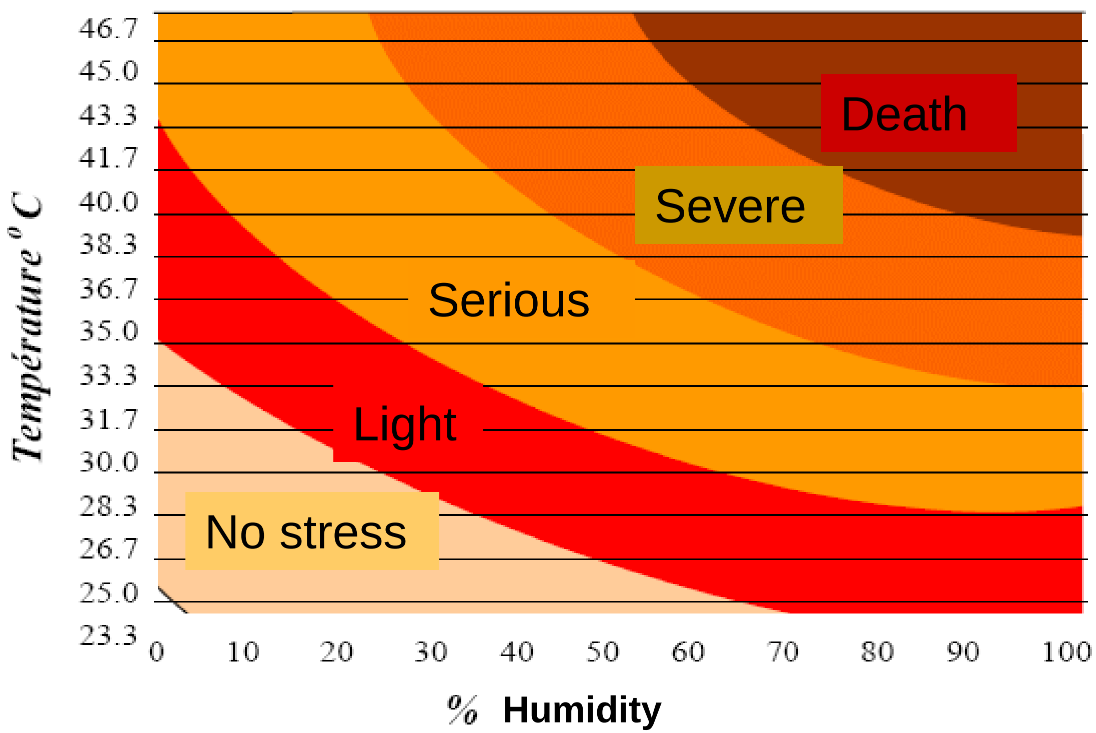
A brief introduction to heat stress

Heat stress is evaluated by the temperature-humidity index (THI), that combines temperature and humidity.

THI= (1.8T +32) ((0.55-0.0055RH) (1.8T-26))



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A brief introduction to heat stress

Conception rate starts declining when THI reaches 72, and collapses at higher THI values

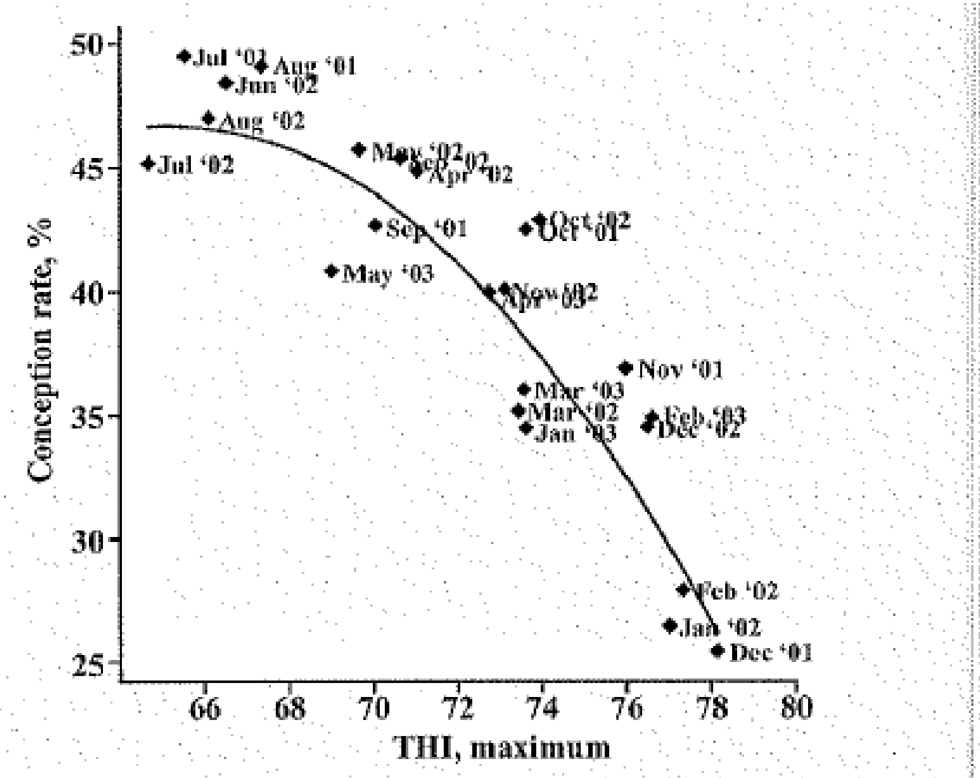

Figure 1. Association between monthly average of daily maximum temperature-humidity index (THI) and conception rate for services

Morton et al 2007

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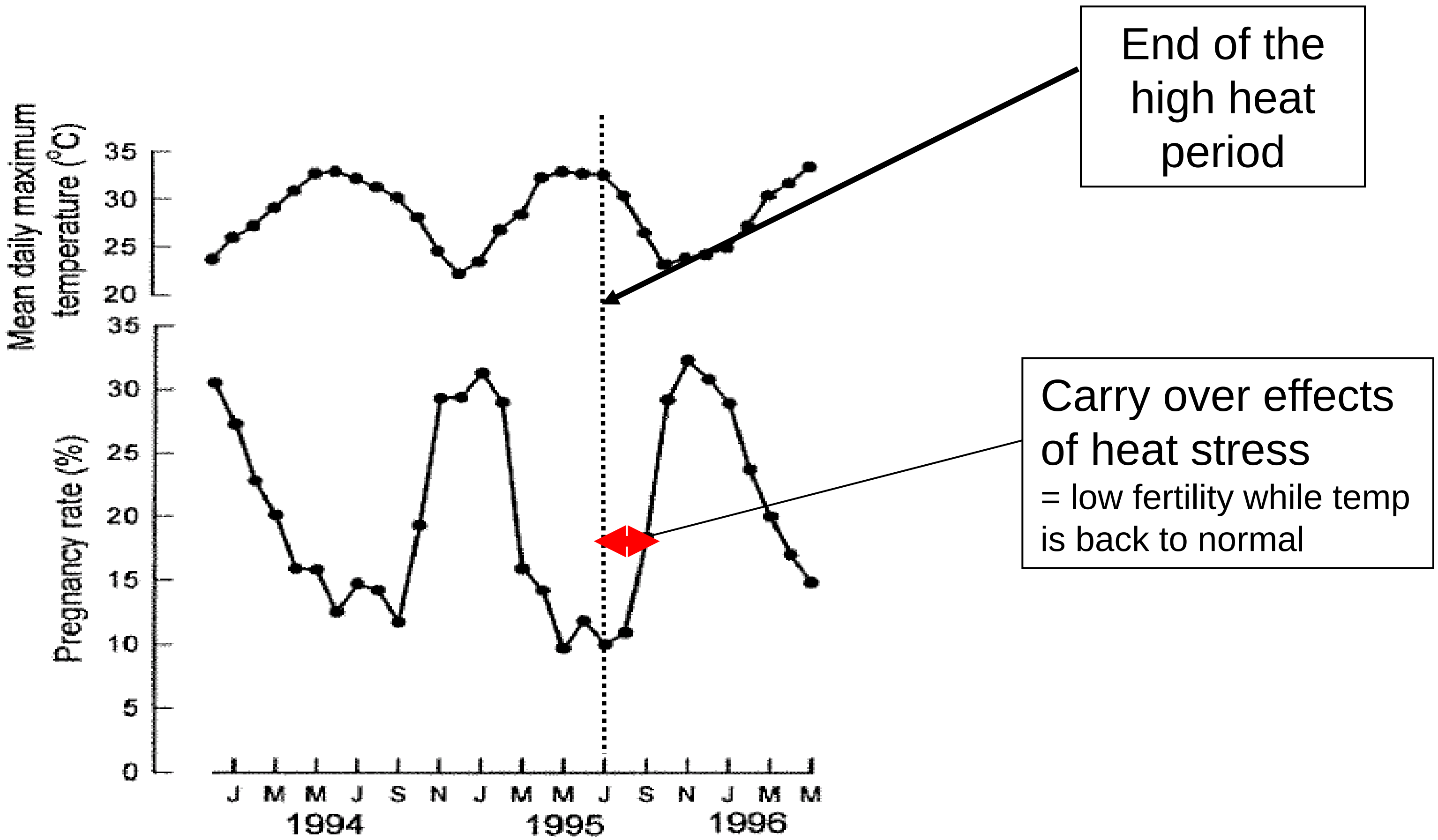
A brief introduction to heat stress

Heat stress reduces fertility not only during the period of high heat and humidity, but also in the 2-3 months following this period (carry over effect)



Hansen & Arechiga 1999

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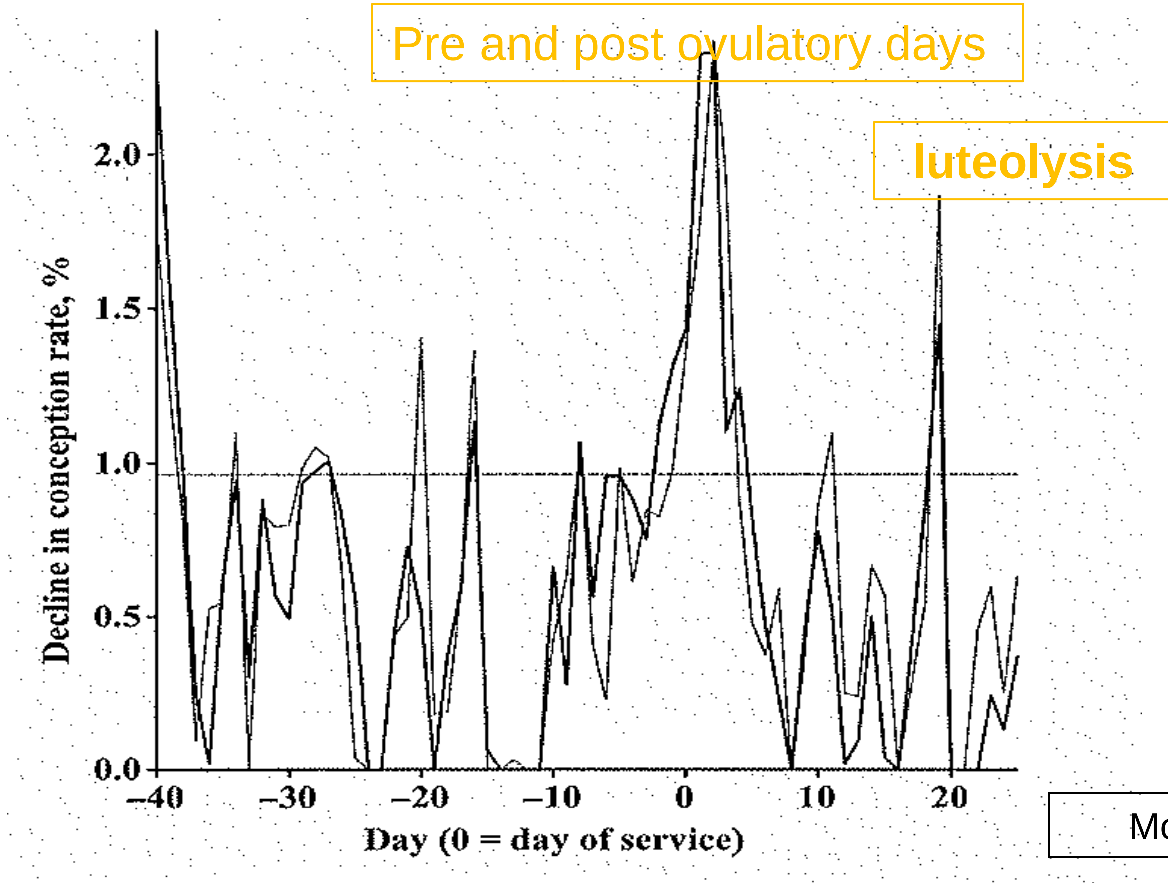
When is heat stress reducing reproductive performance?

There are 2 periods in the cycle when heat stress has clear detrimental effects: the peri-ovulatory period and around luteolysis



Morton et al 2007

Figure 3. Fitted effects with adjustment for autocorrelation in heat load between days (using ridge regression) of 2 measures of heat load on conception rates in lactating dairy cows. The solid line is

Where is heat stress interfering with reproduction?

- Hypothalamo-pituitary axis

a. Altered amplitude of LH pulses (Gilad et al 1993)
b. Reduced pituitary sensitivity to GnRH (blunted LH surge)(Gilad et al 1993)

- Ovarian function

a. Altered follicular dominance (Wolfenson et al 1995)
b. Reduced ability to convert androgens to estrogens (Wolfenson et al 1997)
c. Reduced progesterone production by the CL (Wolfenson et al 2002)

- Young embryo

a. Increased apoptosis (Roth & Hansen 2004)
b. Impaired resumption of meiosis (Roth & Hansen 2005)
c. Impaired oocyte cytoplasmic maturation, resulting in fewer blastocysts formed (Payton et al 2004)

- Reproductive tract

a. Heat shock increases prostaglandin output by cultured endometrium collected on day 17 of the cycle (Malayer et al 1990) and increases uterine production of PGF2 alpha in response to oxytocin (Wolfenson et al 1993)
b. Exposure of cultured day 17 conceptuses to 43°C reduces production of interferon tau, the embryonic signal that prevents luteolysis (Putney et al 1988)

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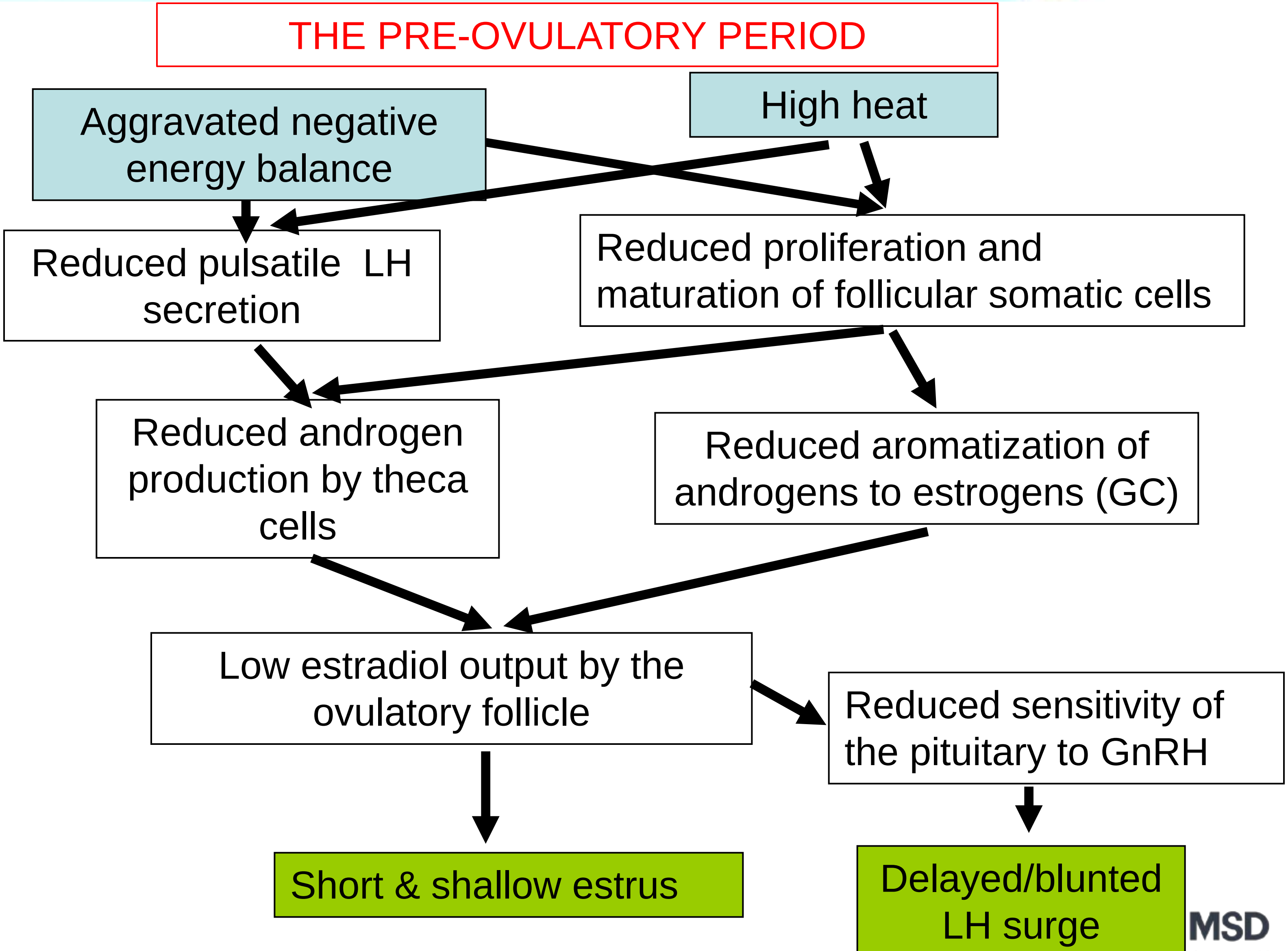
Why is heat stress reducing reproductive performance?



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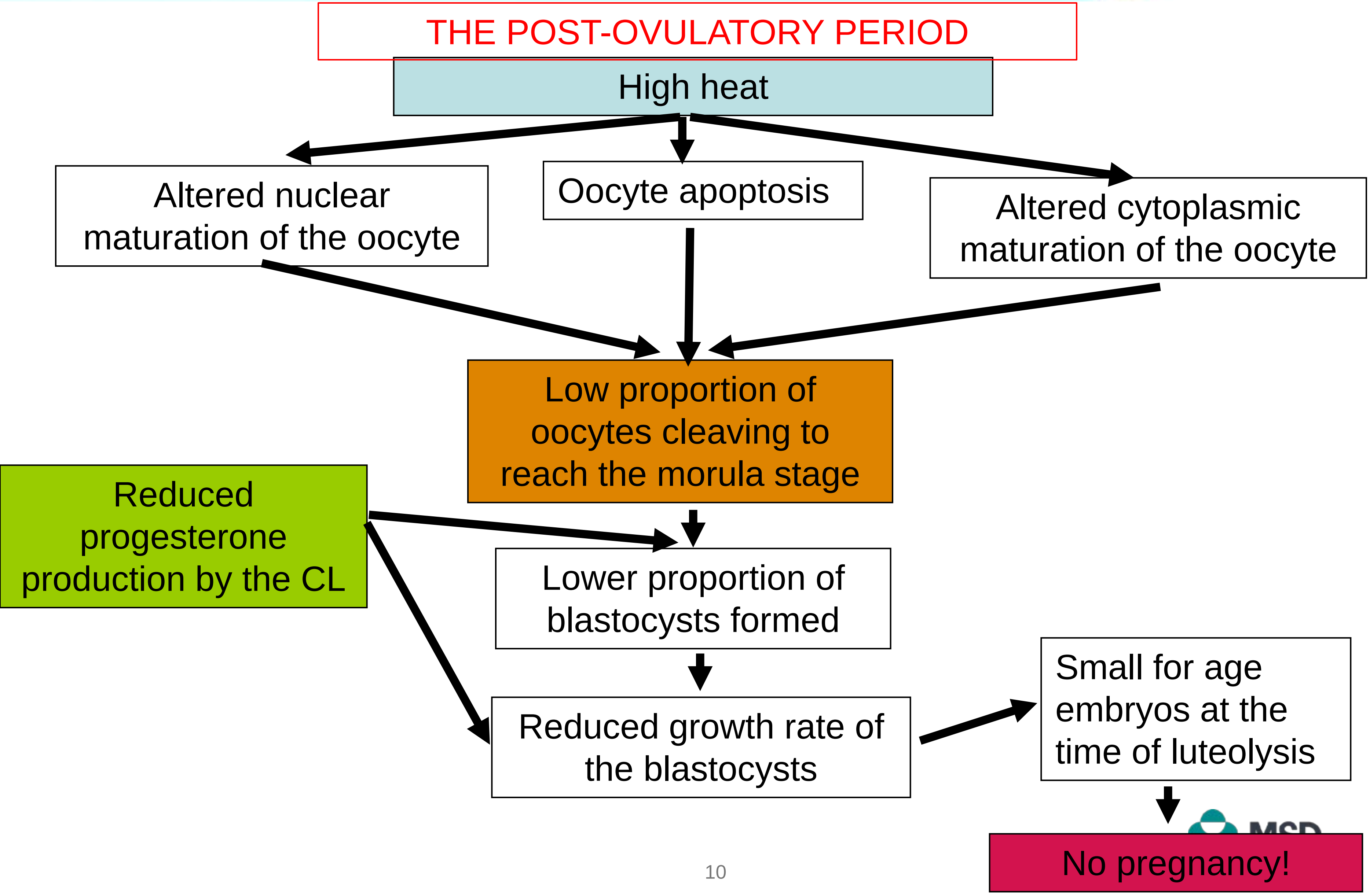
Why is heat stress reducing reproductive performance?



What to do to alleviate the effects of heat stress?

During the heat stress period

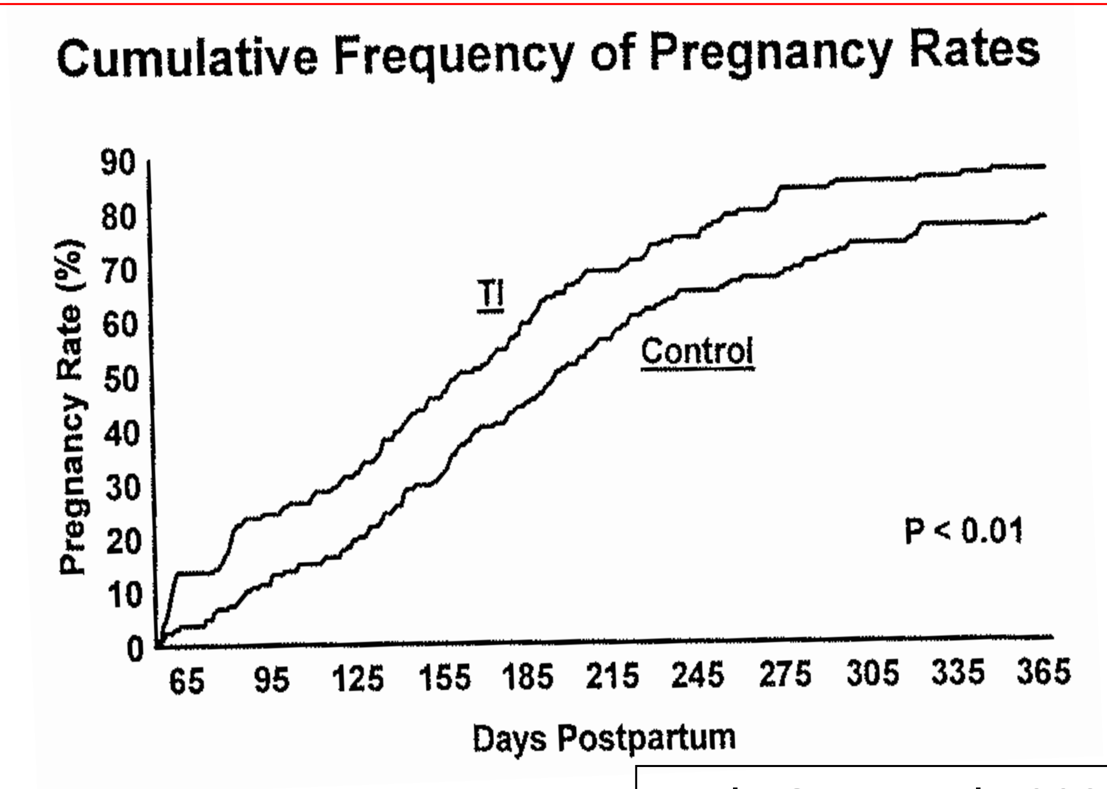
Cool and provide shade to the cows during the two periods when they are most sensitive to heat stress

What to do to alleviate the effects of heat stress?

During the heat stress period

1. Use estrus synchronization to get around the estrus detection problems

GPG synchronisation treatments are useful as they increase submission rates



De la Sota et al 1998

What to do to alleviate the effects of heat stress?

During the heat stress period

2. Inject GnRH at estrus to ensure a “normal” LH surge

	Location and treatments	Group size	Fertility untreated group	Fertility treated group
Ullah et al (1996)	USA (MS), 100µg GnRH at estrus synchonized by a prostaglandin vs neg control	49 treated & 45 controls	17.9%	28.6%
Kaim et al (2003)	Israel 10µg Buserelin vs neg control in PG synchronized cows	157 control & 157 treated	35.1%	51.6%
Lopez-Gatius et al (2006)	Spain 100µg GnRH at estrus vs neg control (all presynchronized	429 treated & 431 controls	20.6%	30.8%

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What to do to alleviate the effects of heat stress?

During the heat stress period

3. Inject GnRH to alter follicular turn over (days 5 and 11)and possibly postpone initiation of the luteolytic cascade (day 11) (Willard et al 2003)

Treatment Location	USA (MS & NC)	N=	Fertility
Control	Ovsynch synchronized	37	19%
GnRH Day 5	As above+ 100µg GnRH	34	32%
GnRH Day 11	As above +100µg GnRH	34	38%

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What to do to alleviate the effects of heat stress?

During the heat stress period

4. Inject GnRH on days 0 and again around day 12 to combine the benefits of the two previous approaches

F. López-Gatius et al. / Theriogenology 65 (2006) 820–830 825

Table 1
Conception rates and odds ratios of the variables included in the final logistic regression model

Independent (explanatory) variables	Class	*n*	(%)	Odds ratio	95% Confidence interval	*P*
Milk production	Continuous	1289		0.98[a]	0.96–0.99	0.007
Repeat breeding	<4 AI	953	30.6			
	≥4 AI	336	24.1	0.64[b]	0.48–0.87	0.004
Treatment	GnRH-0 + 12[c]	429	35.4	Reference		
	GnRH-0[d]	429	30.8	0.80[e]	0.56–0.97	0.044
	0	431	20.6	0.46[e]	0.34–0.63	<0.0001
AI technician	9 classes					0.005
	Technician 8	262	19	0.45[f]	0.30–0.69	<0.0001

Likelihood ratio test = 1490.9, 11 d.f., $P = 0.0001$. Hosmer and Lemeshow goodness of fit statistics = 7.5, 8 d.f., $P = 0.48$ (the model fits).

[a] Odds of a cow becoming pregnant, compared to cows producing 1 kg less milk.

[b] Odds of a cow becoming pregnant in response to the fourth or more AI, compared to the first to third AI.

[c] GnRH at AI and 12 days later.

[d] GnRH at AI.

[e] Odds of a cow receiving GnRH at AI or no treatment, respectively, becoming pregnant, compared to cows receiving GnRH at AI and 12 days later (reference).

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What to do to alleviate the effects of heat stress?

During the heat stress period

PROVIDE MAXIMAL SHADE, COOL & TRY TO BE SMART…

1. Selectively breed the heifers during the heat stress period
2. Use embryo transfer to breed the lactating cows

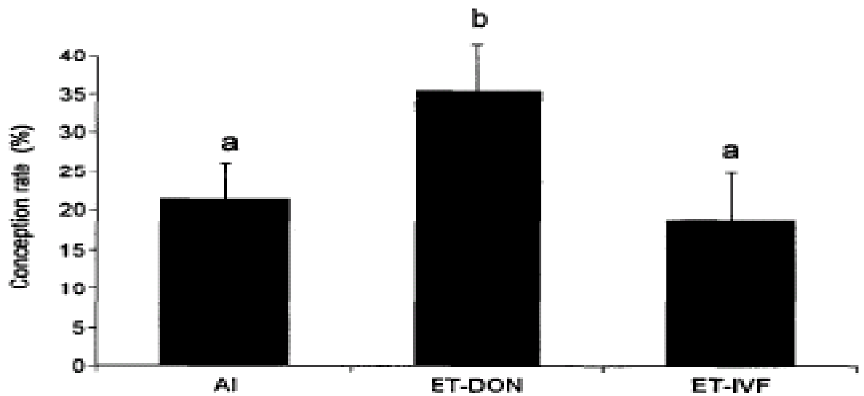

Figure 1. Conception rate of cows in AI, ET-DON, and ET-IVF groups determined by palpation per rectum at 42 days after estrus. The conception rate at 42 days was higher (P<0.05) in cows in the ET-DON group than those in ET-IVF. Conception rates of the AI versus ET- (DON and IVF) did not differ (P>0.10). AI = artificial insemination, ET-DON = embryo transfer (embryos collected from superovulated donors); ET-IVF = embryo transfer (embryos produced in vitro).

Drost et al 1999

What to do to alleviate the effects of heat stress?

During the heat stress period

As none of these treatments will stop the effects of heat on the oocytes, do not expect miracles from such treatments

Further research is needed to identify strategies whereby the young embryos (before genome activation) may be made tolerant to heat!

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What to do to alleviate the effects of heat stress?

During the carry over period

1. Remove the heat damaged follicles by follicle aspiration (Wolfenson et al 2001)

2. Accelerate follicle turn over by injection FSH to deplete the ovary from heat stressed follicles (Roth et al 2002)

However, none of these approaches is easy and has gained acceptance in field conditions…

AND

Further research is needed to understand the delayed effects of heat on oocyte and follicle quality

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Conclusion (1)

Heat stress is a very complex problem that warrants further research

1144 F.D. Rensis, R.J. Scaramuzzi / Theriogenology 60 (2003) 1139–1151

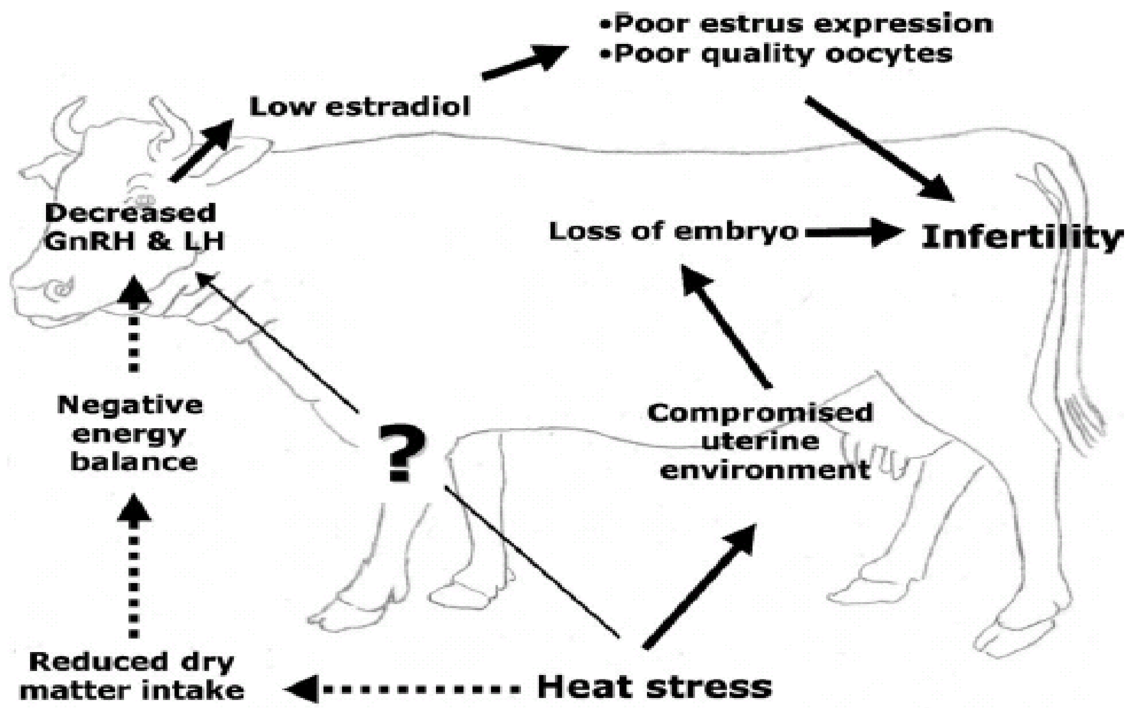

Fig. 1. A schematic description of the possible mechanisms for the effect of heat stress on reproduction in the lactating dairy cow. Heat stress can act in more than one way to reduce fertility in lactating dairy cows. Heat Stress can reduce dry matter intake to indirectly inhibit GnRH and LH secretion from the hypothalamo-pituitary system (dashed lines). However, it is not clear if heat stress can also directly influence the hypothalamo-pituitary system (thin solid line) to reduce GnRH and LH secretion. Heat stress can directly compromise the uterine environment (solid lines) to cause embryo loss and infertility.

Rensis & Scaramuzzi 2003

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Conclusion (2)

Multi-disciplinary research is needed to devise improved solutions

Understanding of the appetite-metabolic balance-heat stress interactions

Understanding of the lactation-heat stress interactions

Understanding of reproduction –heat stress interactions

Understanding of the effects of heat stress of pregnant cows on their progeny

Understanding of the genetics-reproduction interactions in breeds tolerant to heat stress

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