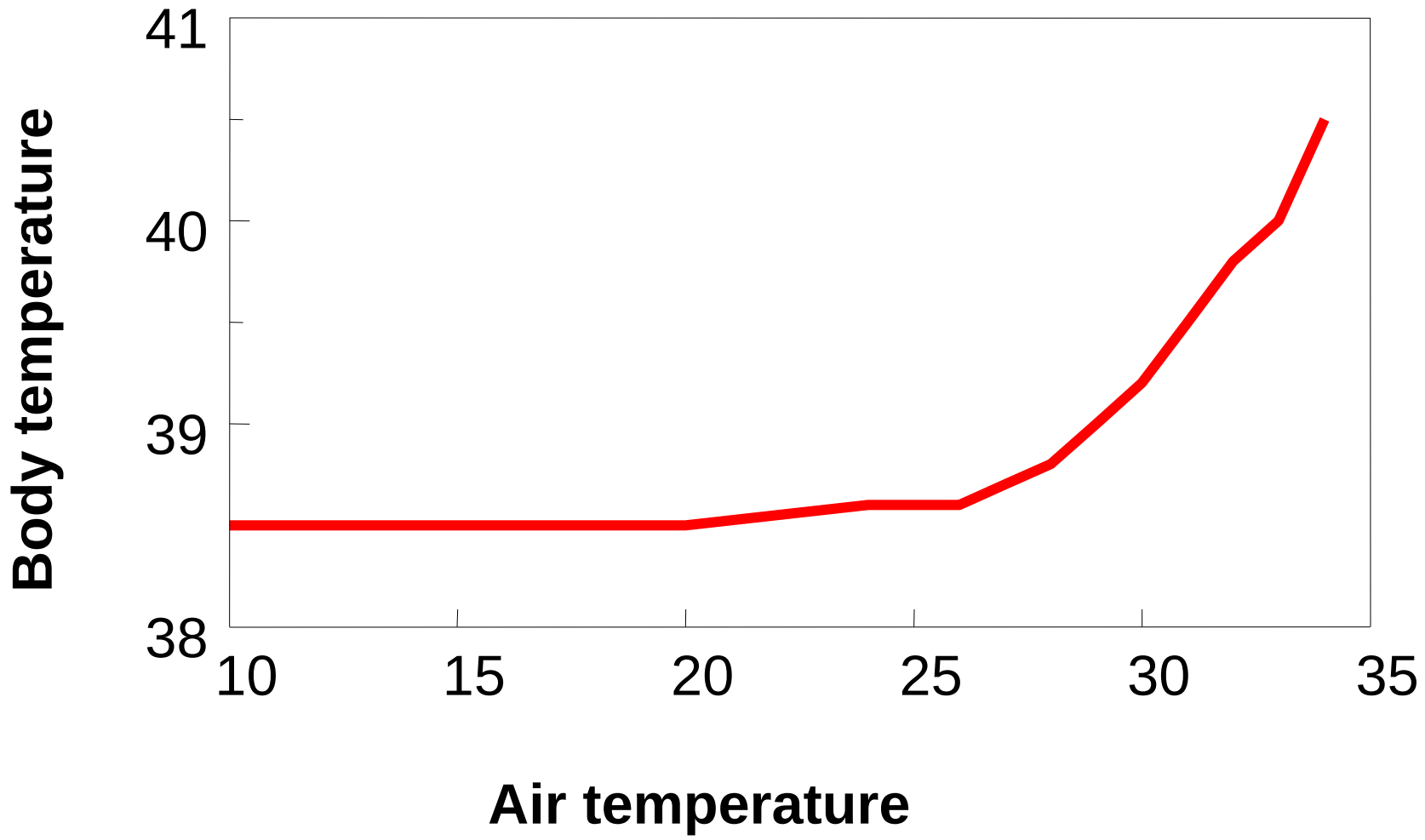
Effects of Heat Stress on Reproduction and Fertility of Dairy Cows

David Wolfenson

Department of Animal Sciences
Faculty of Agriculture, Food and Environment
The Hebrew University
Rehovot, Israel

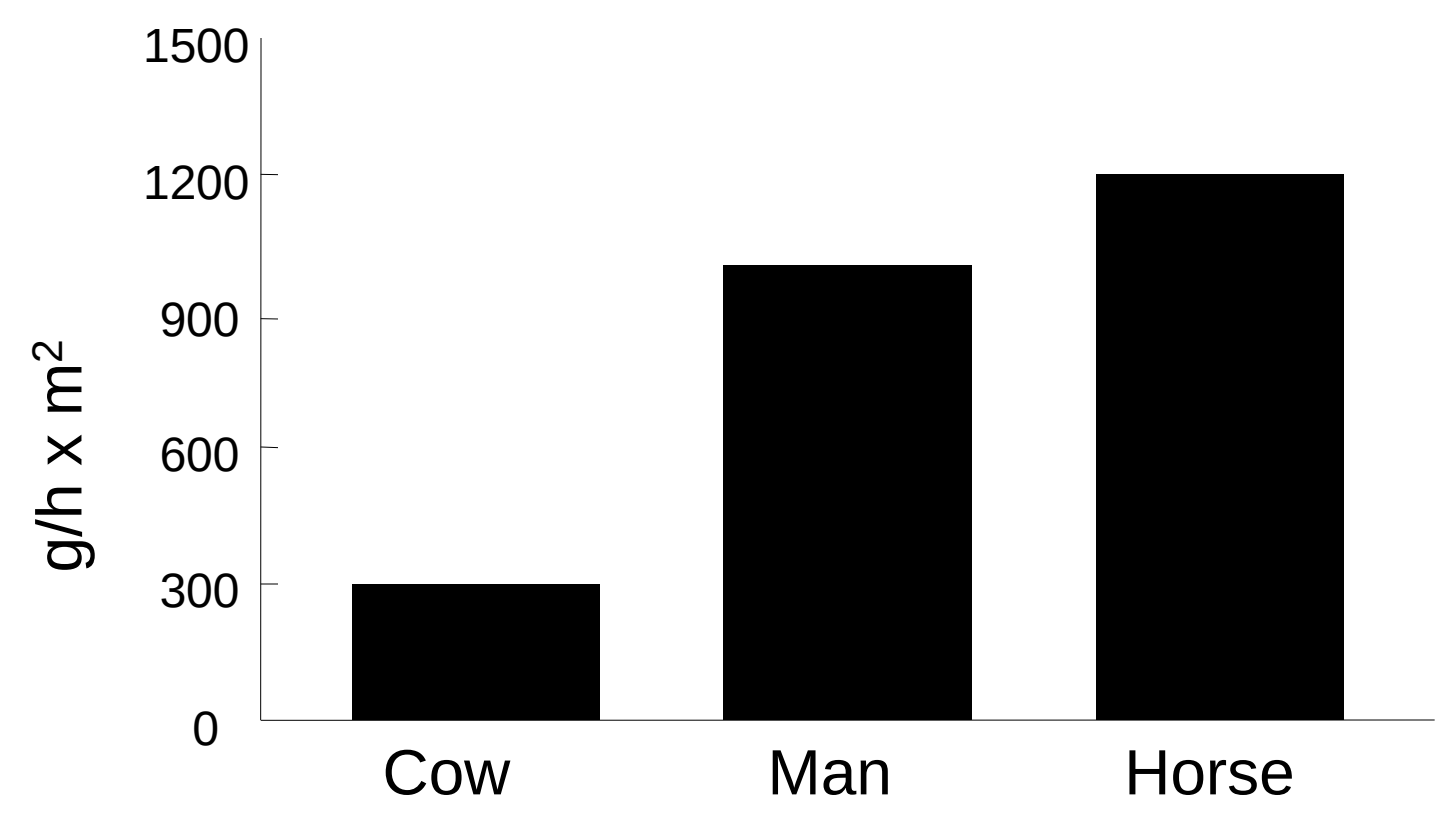
Introduction

- About 60% of the world cattle population is located in hot zones, 35° north and south of the equator.
- The problem of heat stress is on the rise because increases in milk yield are resulting in greater metabolic heat production and because of anticipated changes in the global climate.
- The problem is multifactorial in nature.



(Berman et al 1985)

Sweating rate in cattle is relatively low



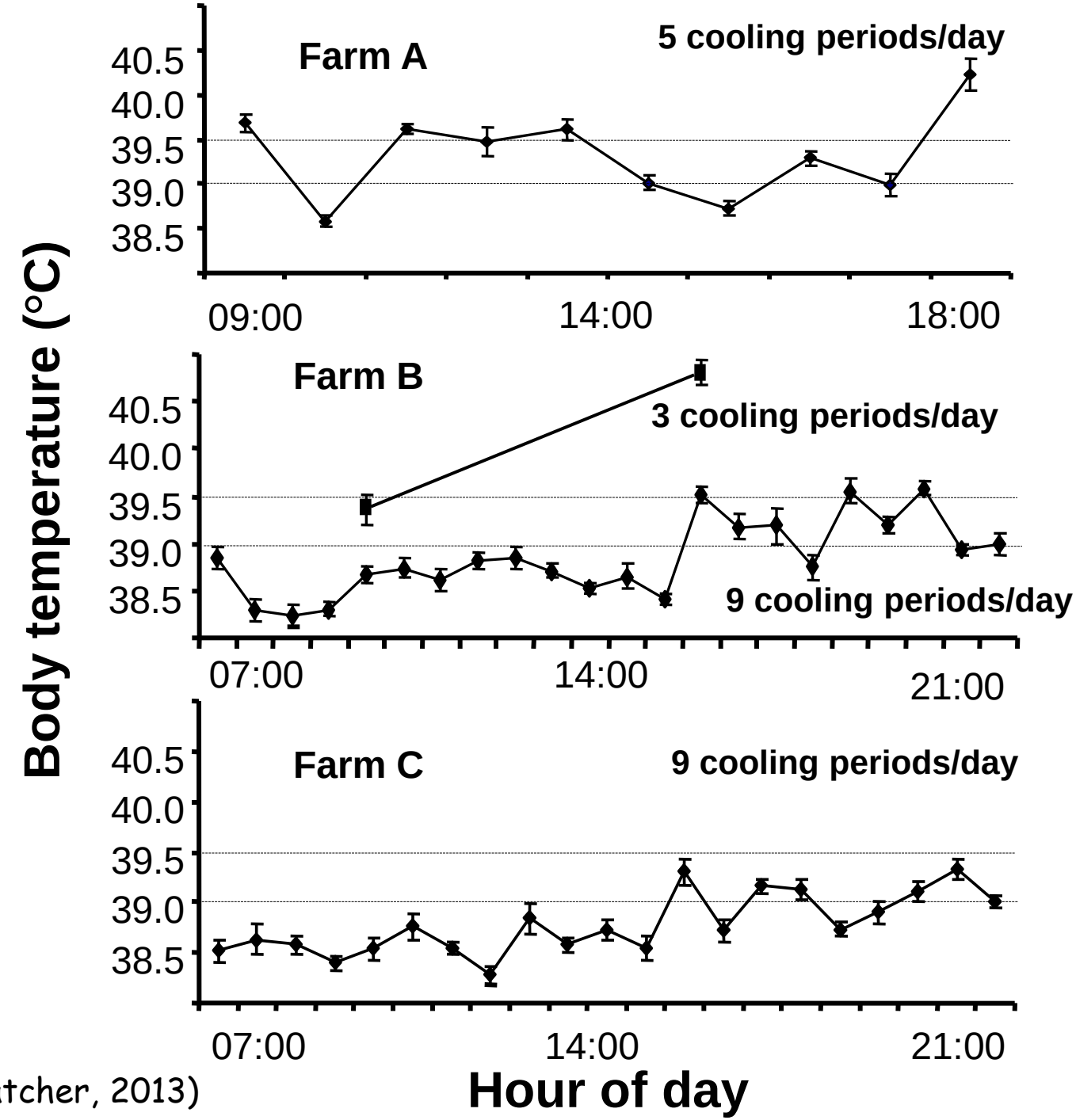
Cooling system: sprinkling & ventilation

In the holding area

Along the feeding line

Fans in the resting area

(Berman, Wolfenson & Flamenbaum)



(Wolfenson & Thatcher, 2013)

Milk production*

Cooling	minimal	intensive
Winter (kg/d)	39	41
Summer (kg/d)	35	40
Diff. (W-S; kg)	4	1
Ratio (S/W)	90%	98%

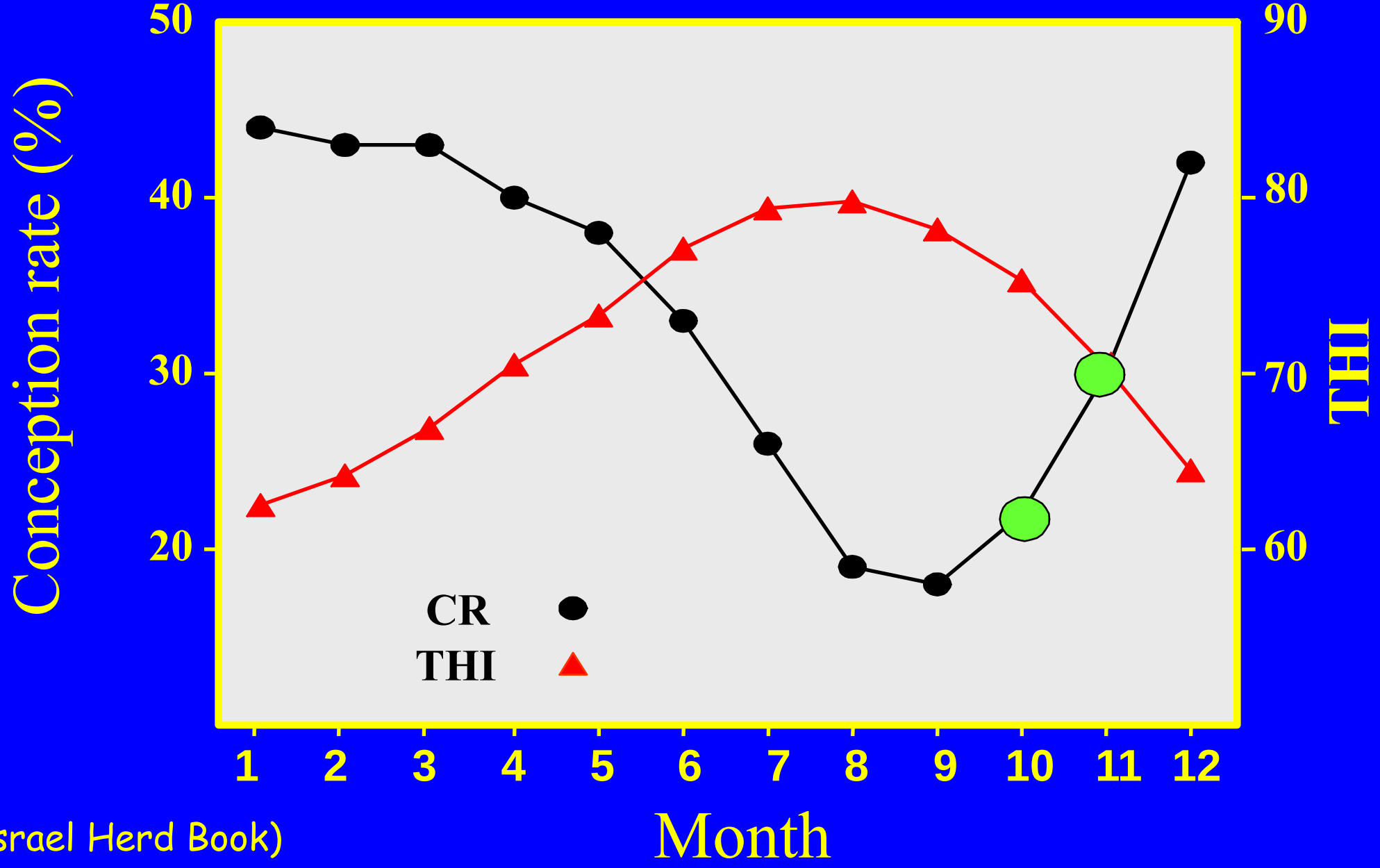
Conception rates*

Cooling	minimal	intensive
Winter (%)	43.5	46.6
Summer (%)	16.7	33.8
Difference (W-S)	26.8	12.8

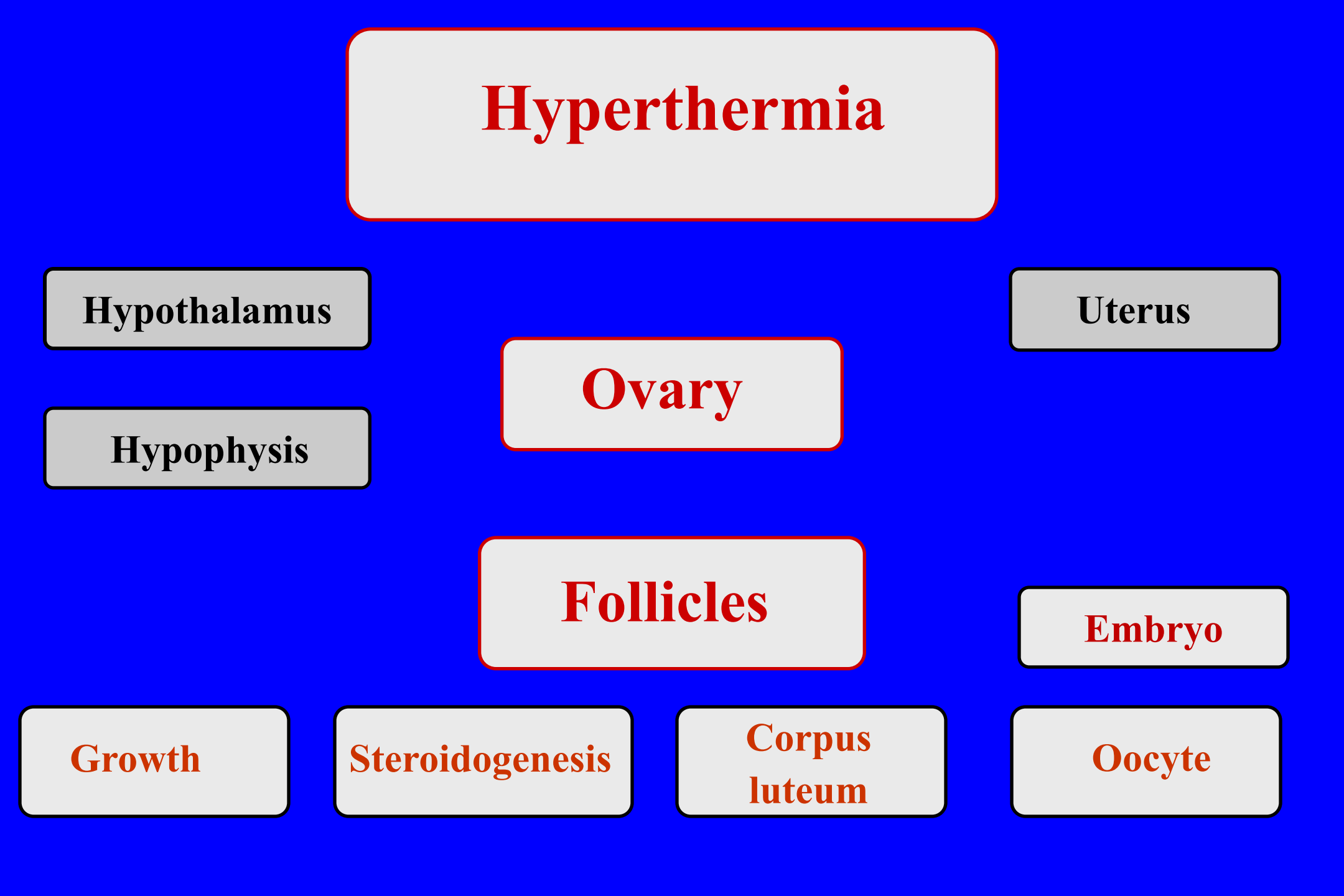
*mature cows

(Flamenbaum et al ; Israel Herd Book)

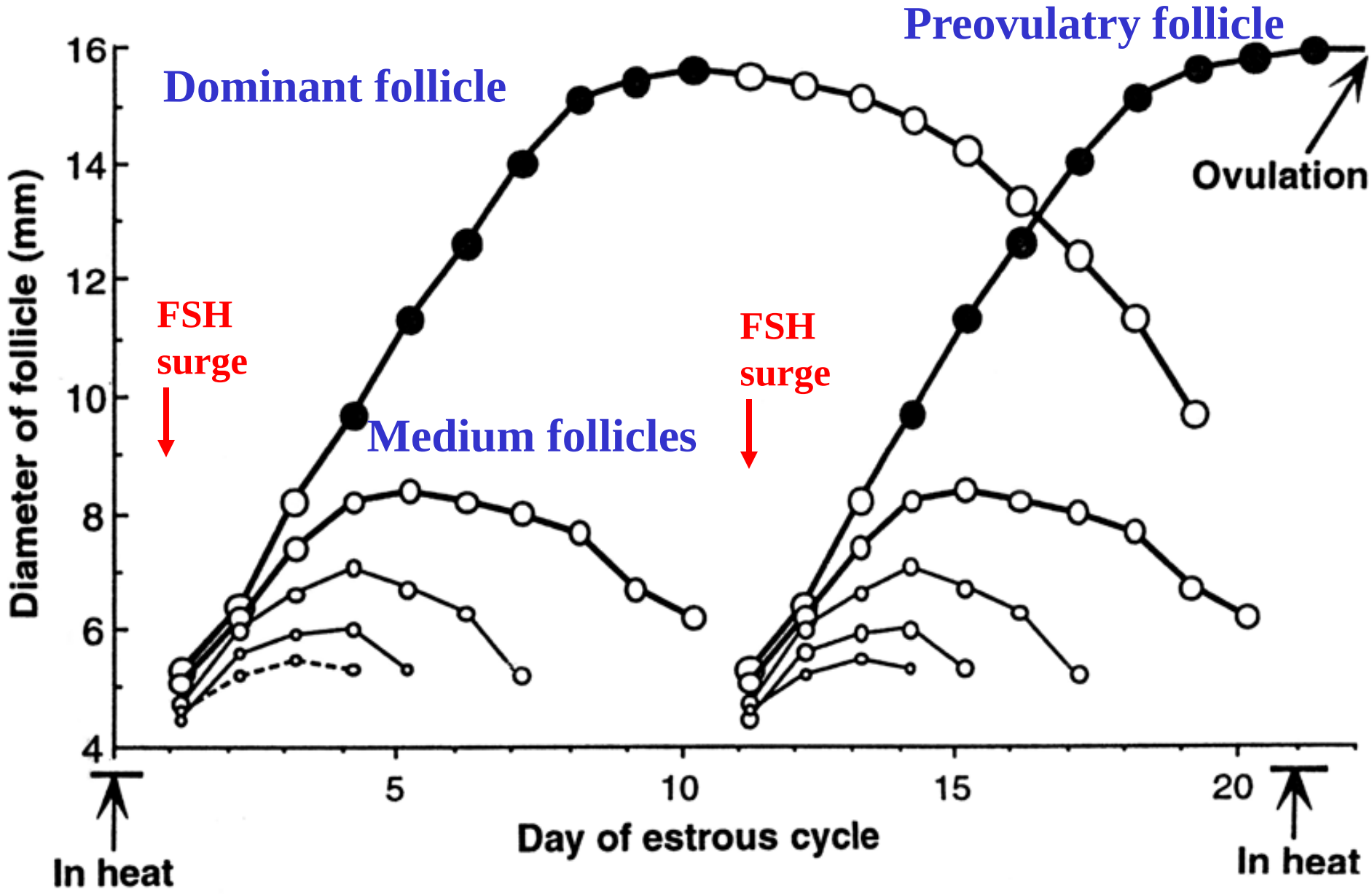
Conception rate and THI



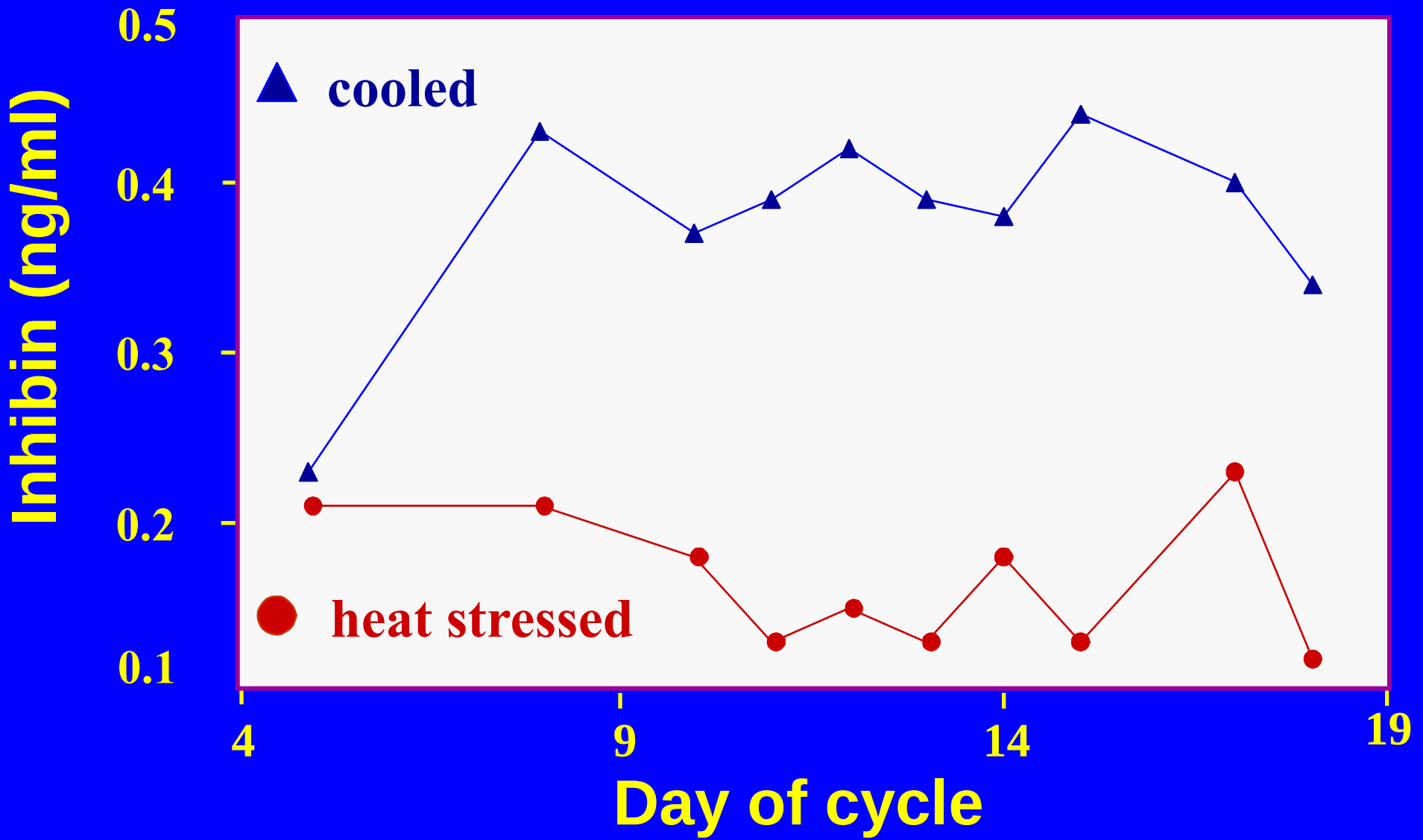
(Israel Herd Book)

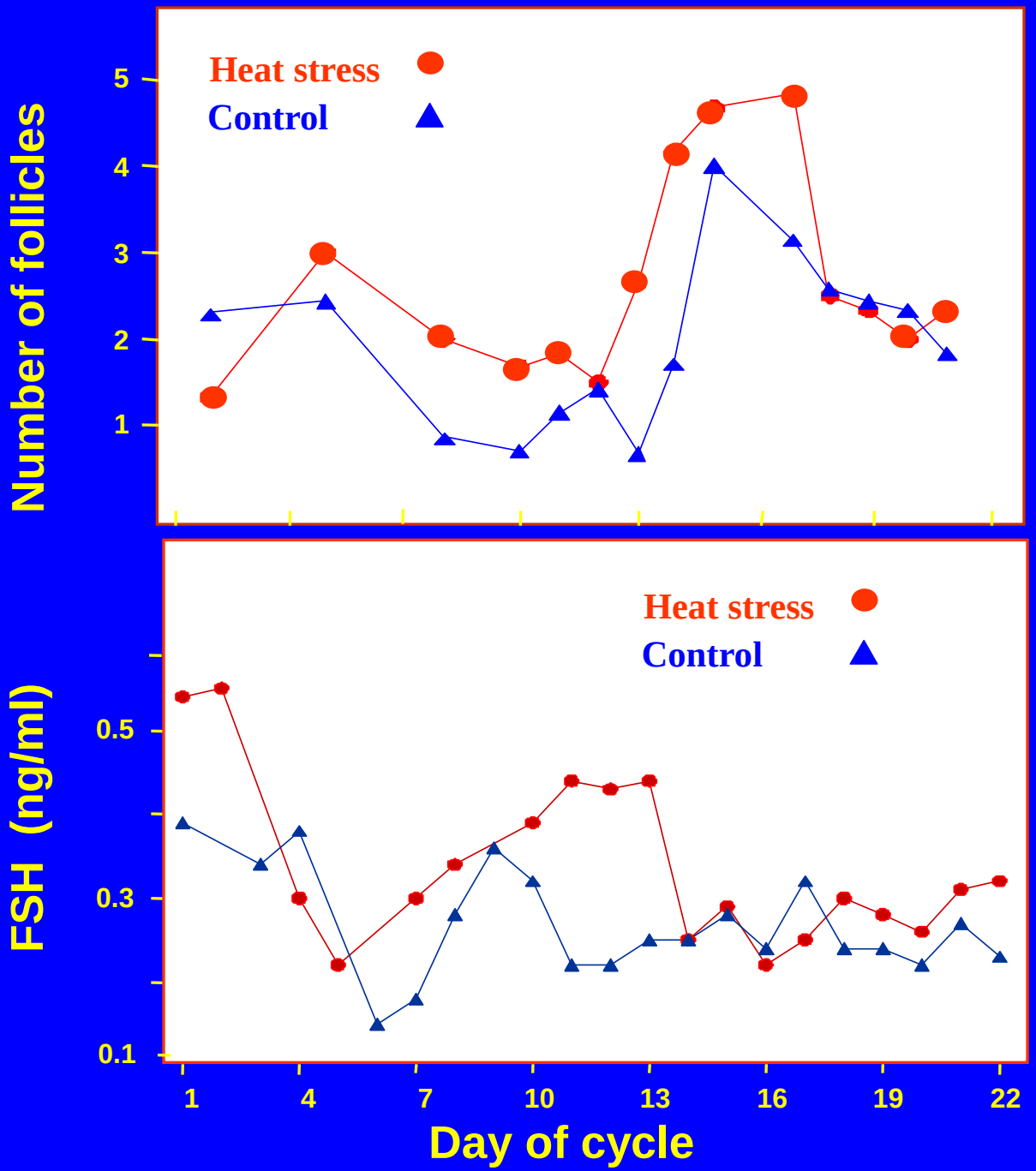

Hyperthermia
Hypothalamus
Hypophysis
Ovary
Uterus
Follicles
Embryo
Growth
Steroidogenesis
Corpus luteum
Oocyte

Follicular dynamics during the estrous cycle



Inhibin concentration in plasma is lowered by heat stress



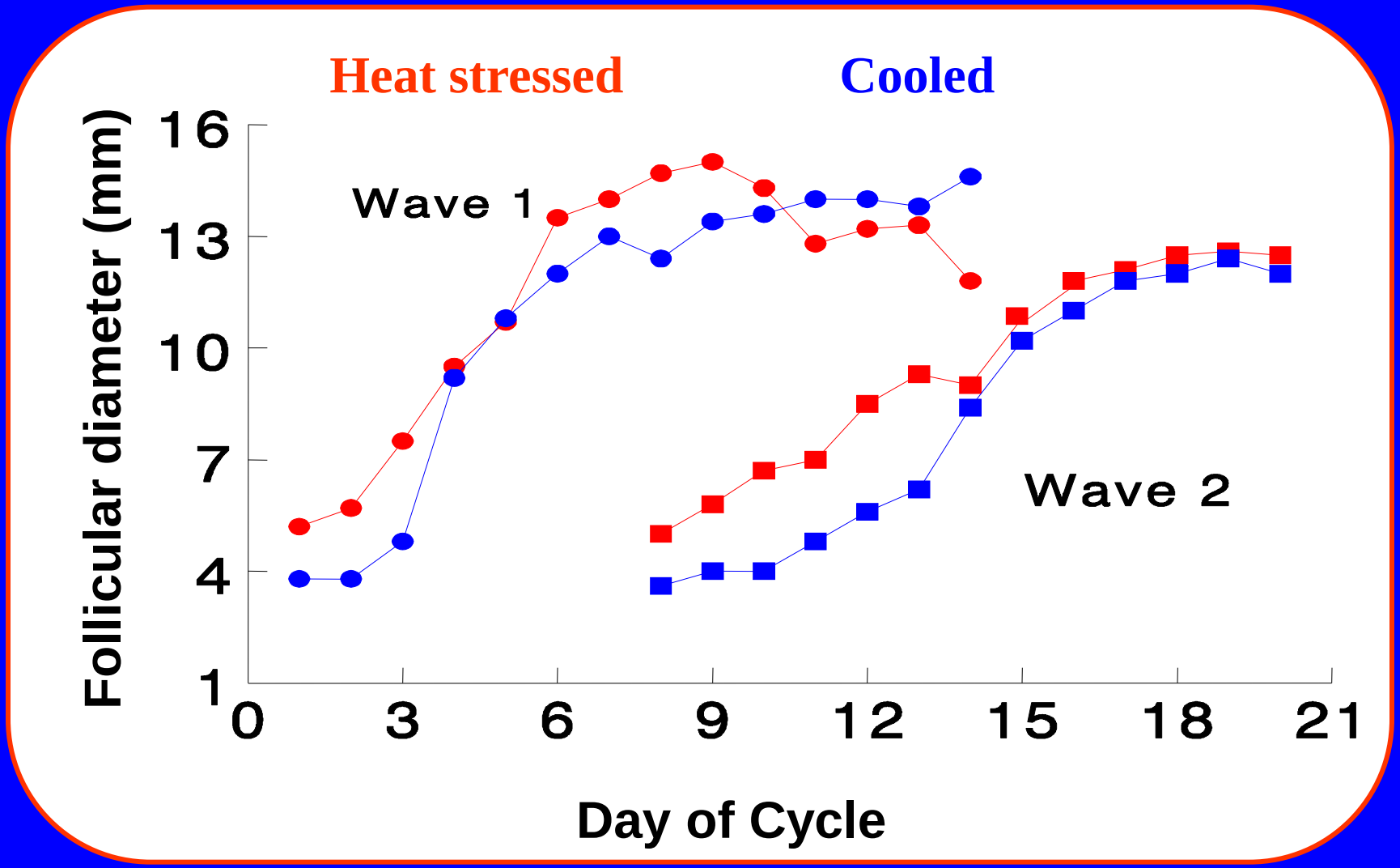


Medium-size follicles

FSH in plasma

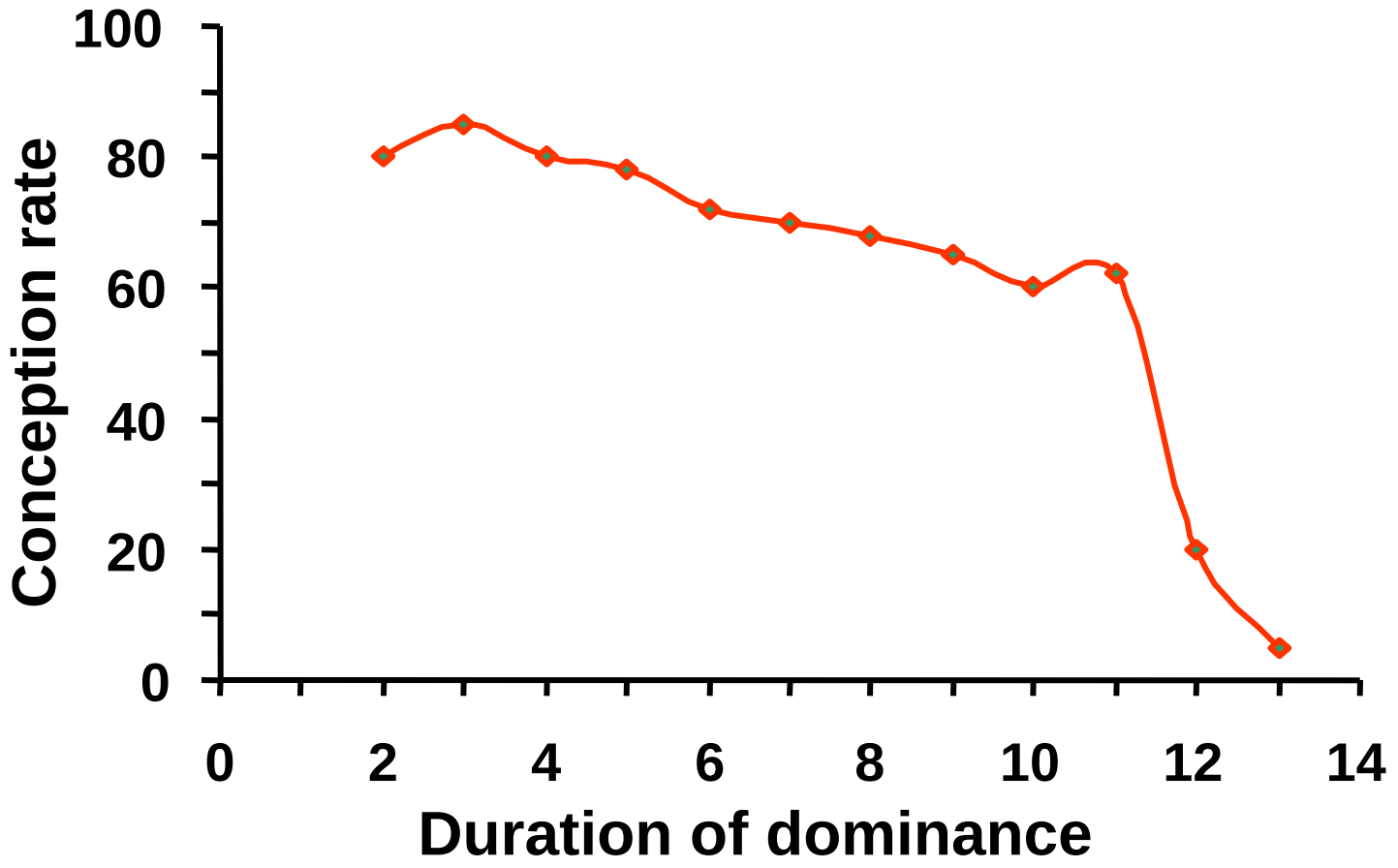
(Roth et al)

Early emergence of the preovulatory follicle



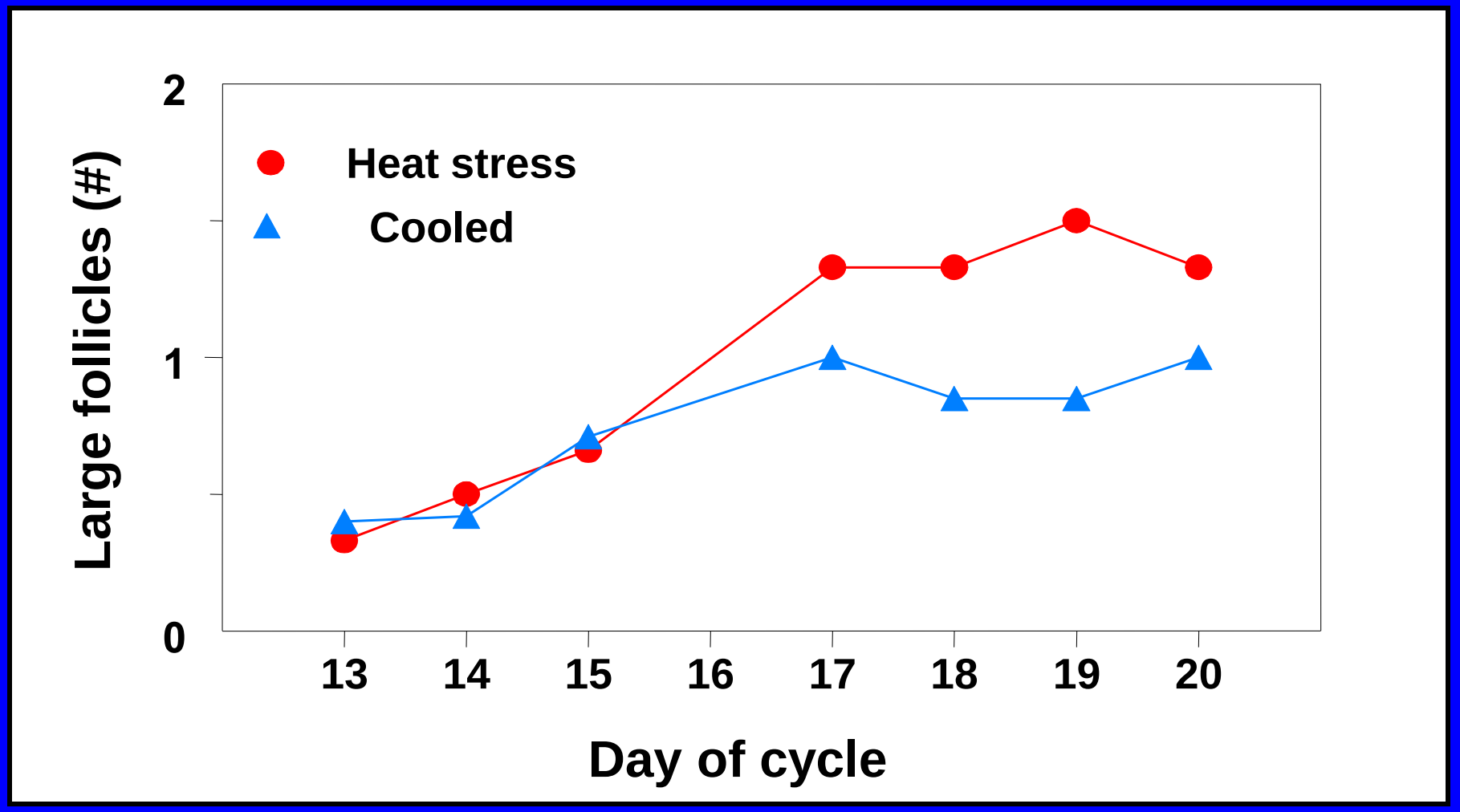
(Wolfenson et al)

Long duration of dominance is associated with low conception rate

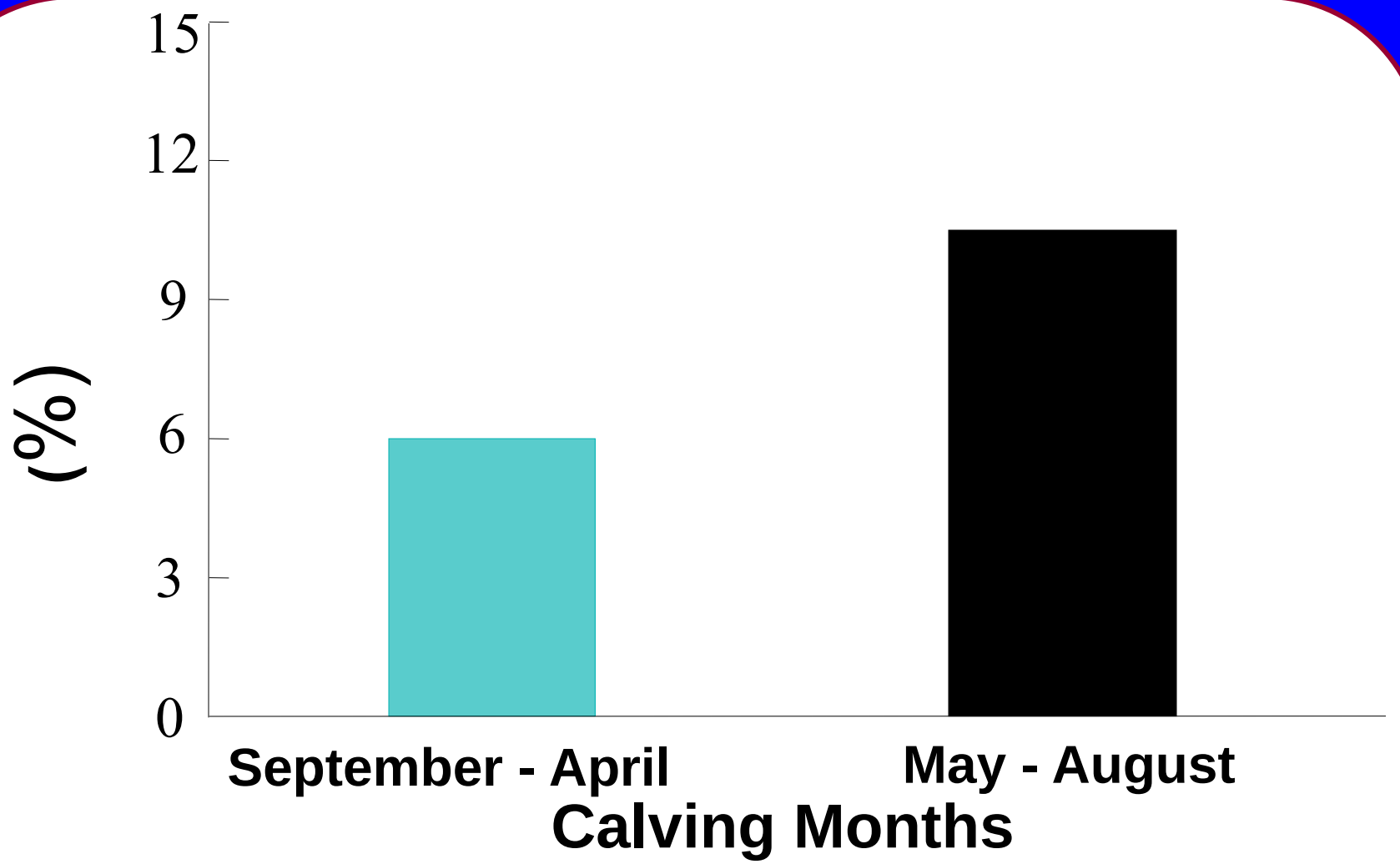


Austin et al., 1999

Heat stress increases number of large follicles

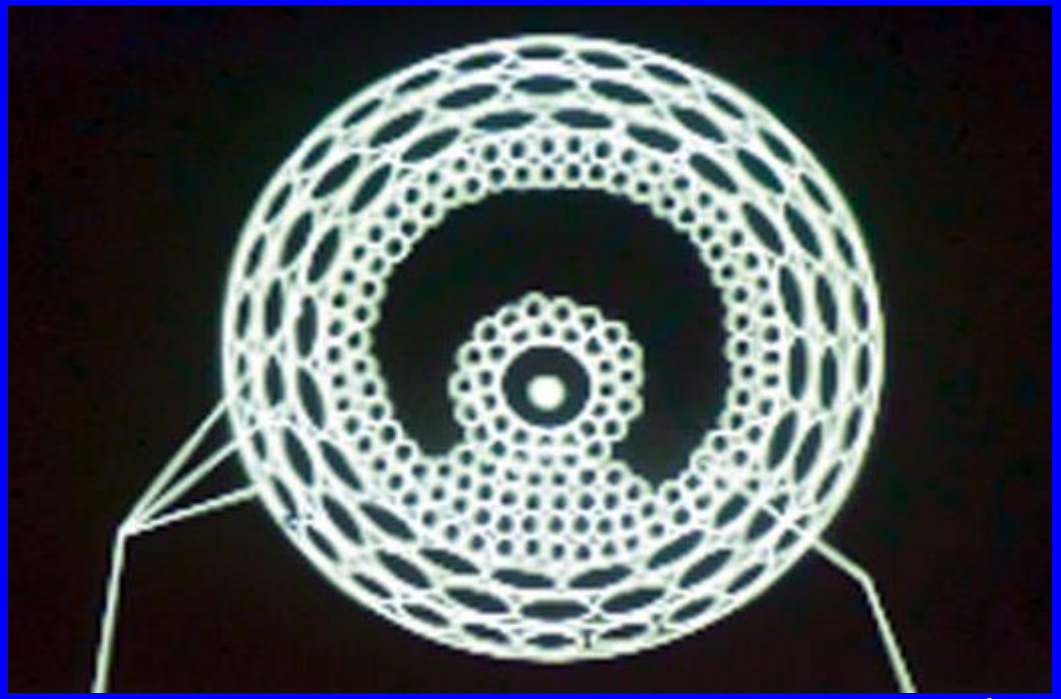


Twining rate in mature lactating cows



(Ryan & Boland (1991), and Israel Herd Book)

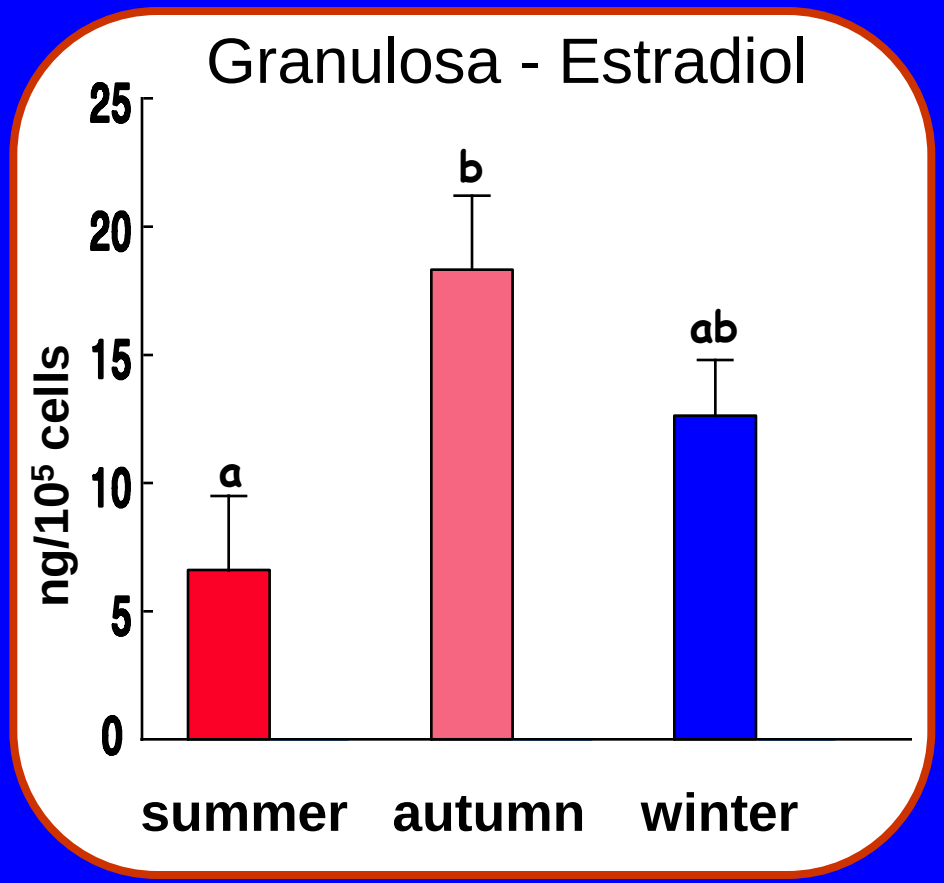
Follicular Steroidogenic Capacity

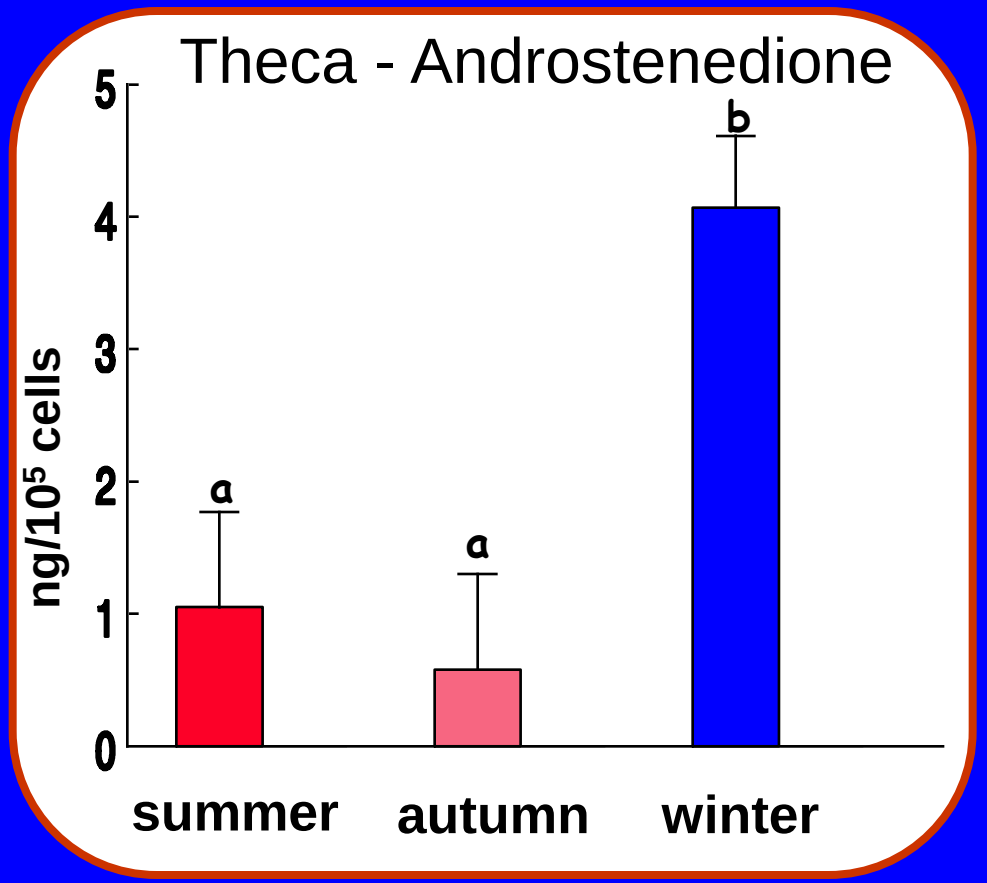


Theca cells

Granulosa cells

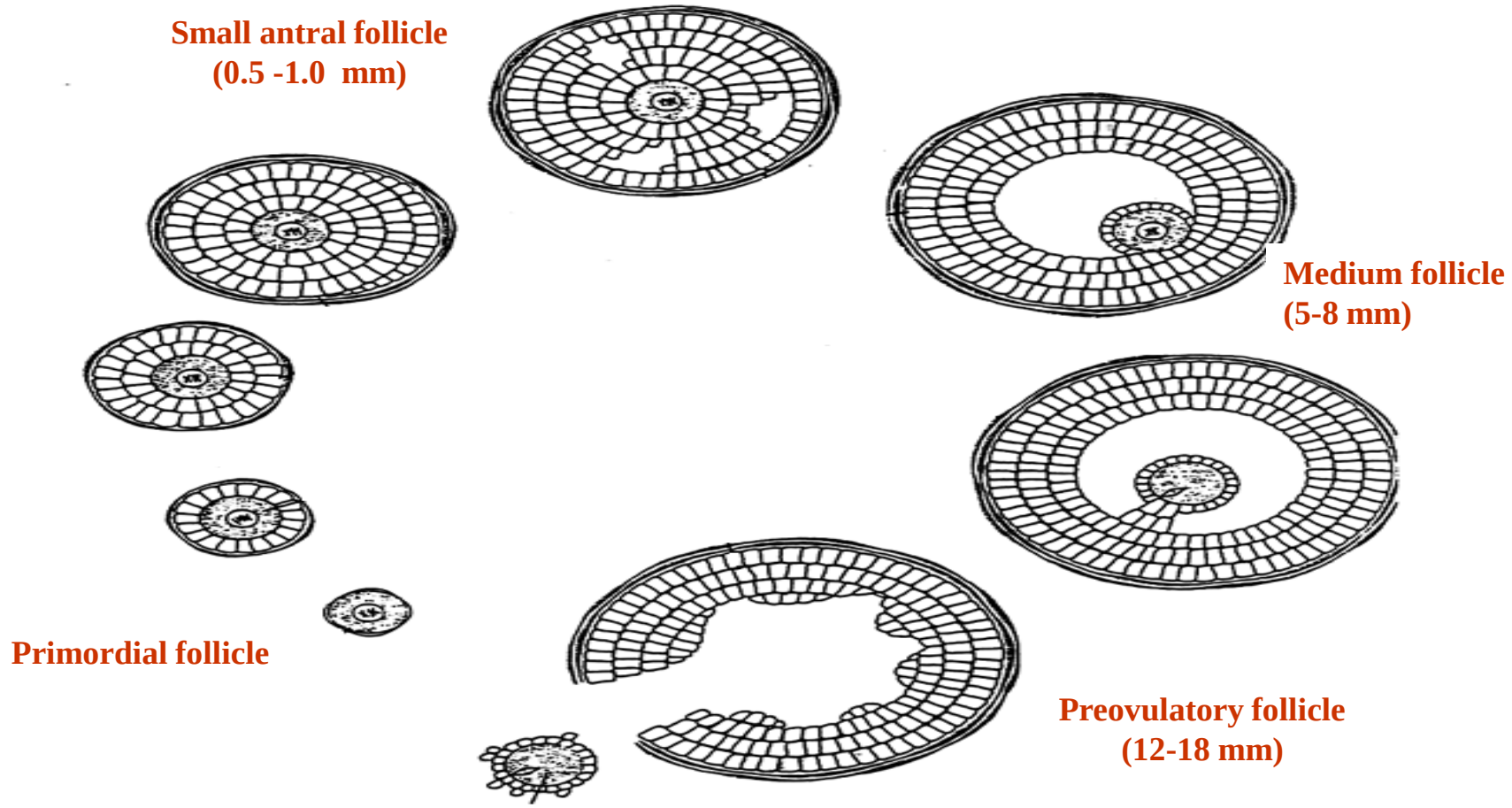
Steroid production by the preovulatory follicle during different seasons



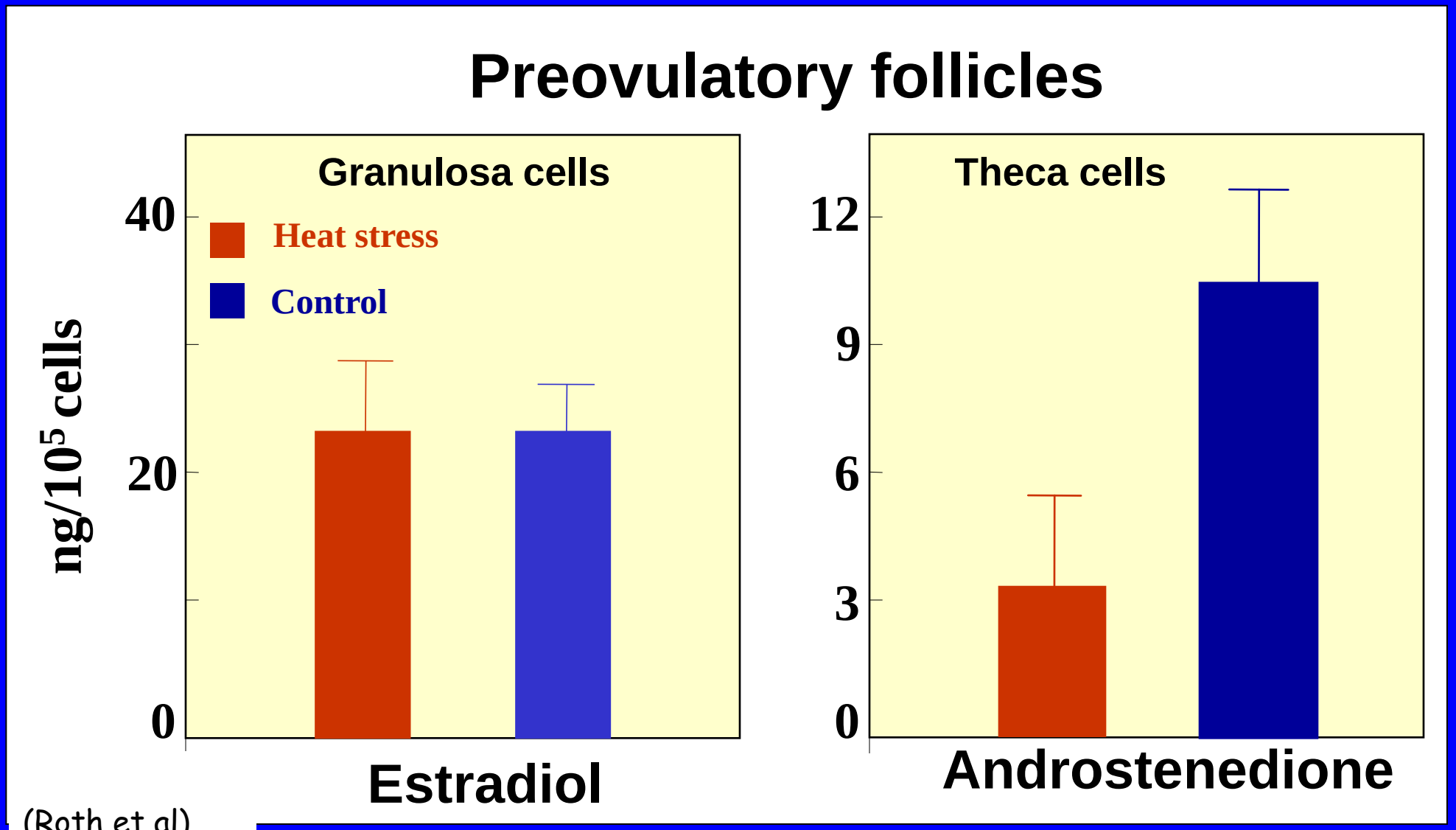


(Wolfenson et al)

Follicular growth is a quite long process



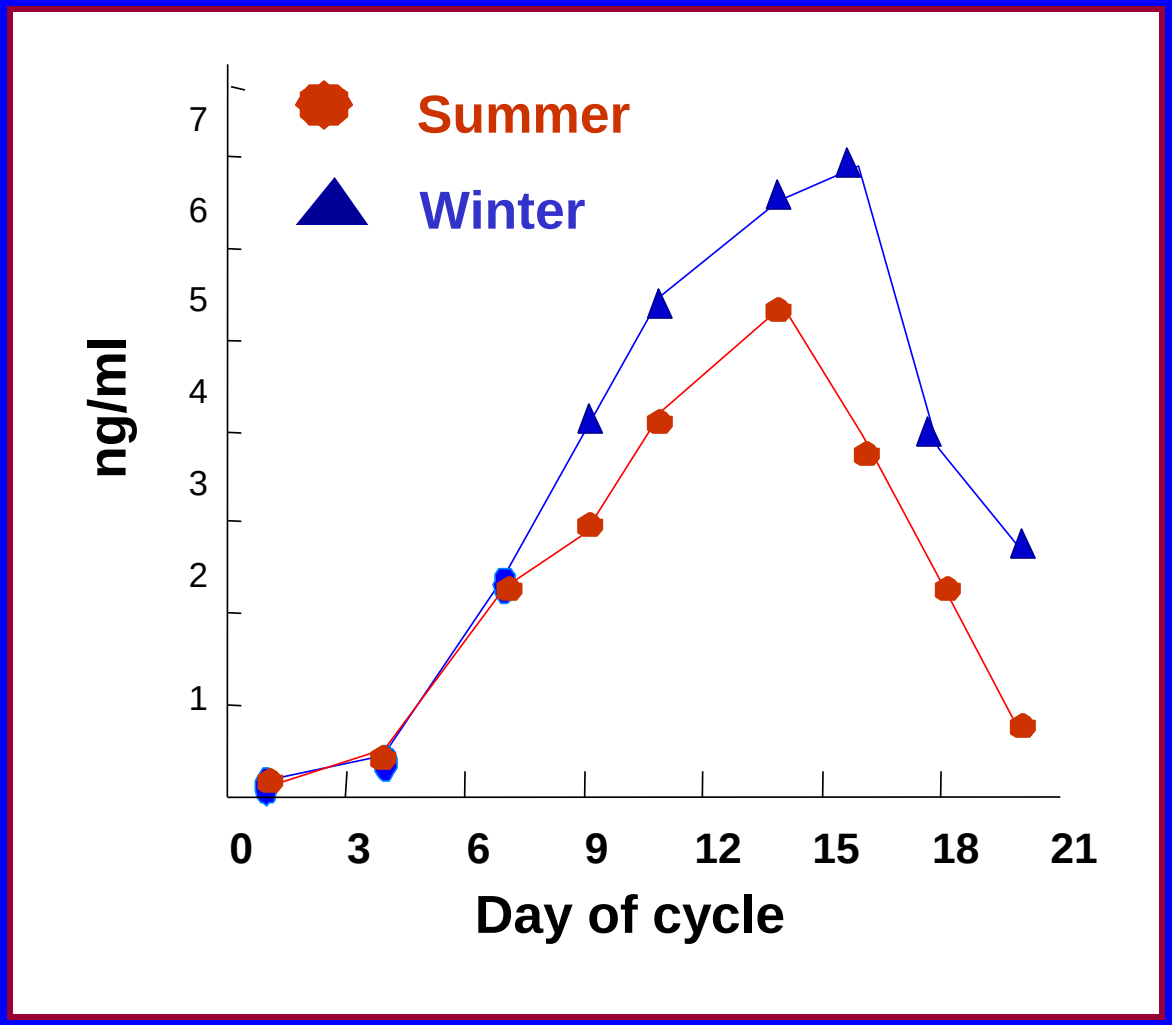
Carryover effect: Estradiol & Androgen production
26 days after induction of acute heat stress (5 days)



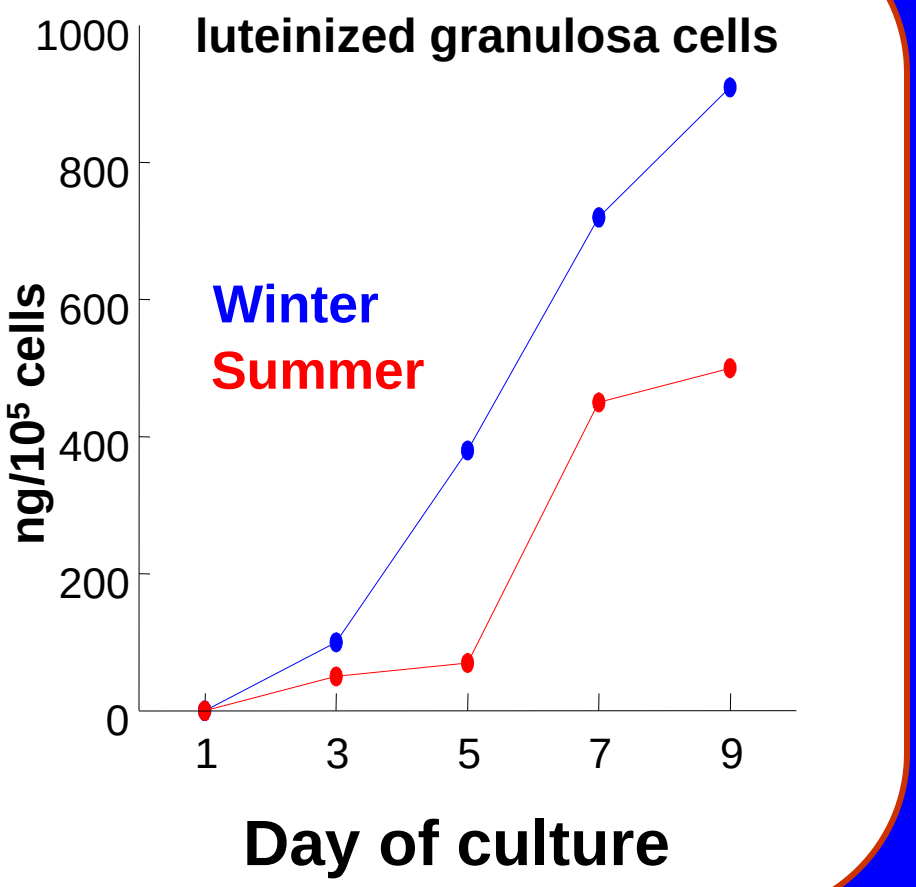
(Roth et al)

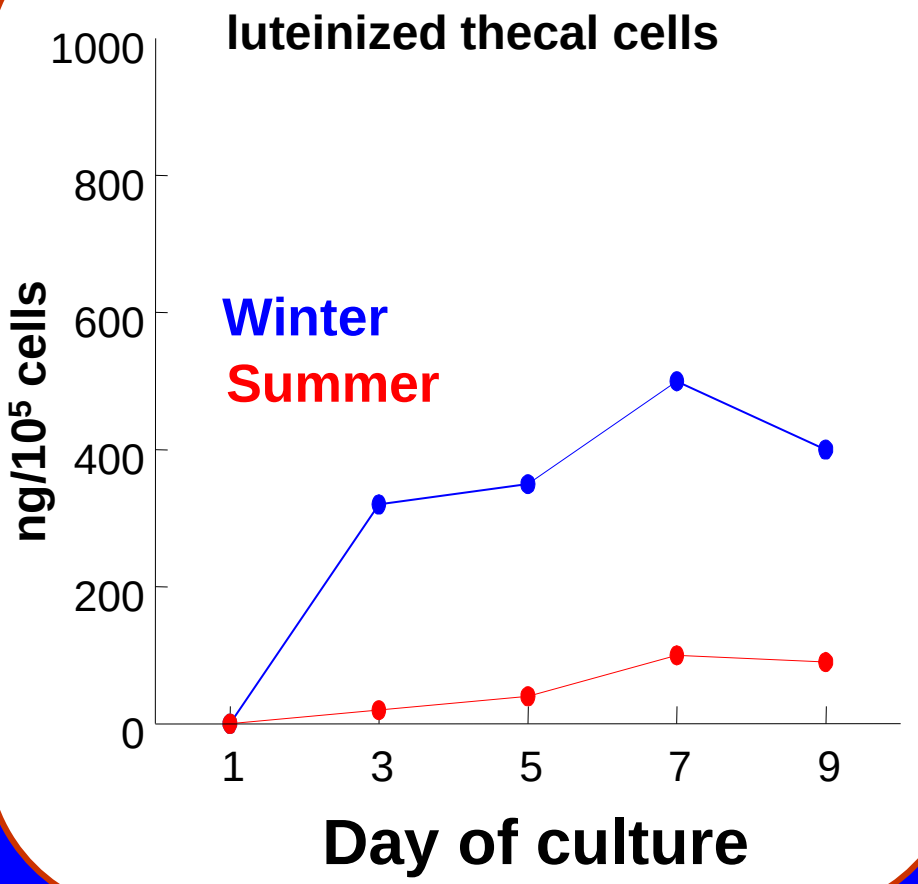
The corpus luteum

Plasma progesterone is lower during the summer



Progesterone production during winter and summer by luteinized granulosa and theca cells

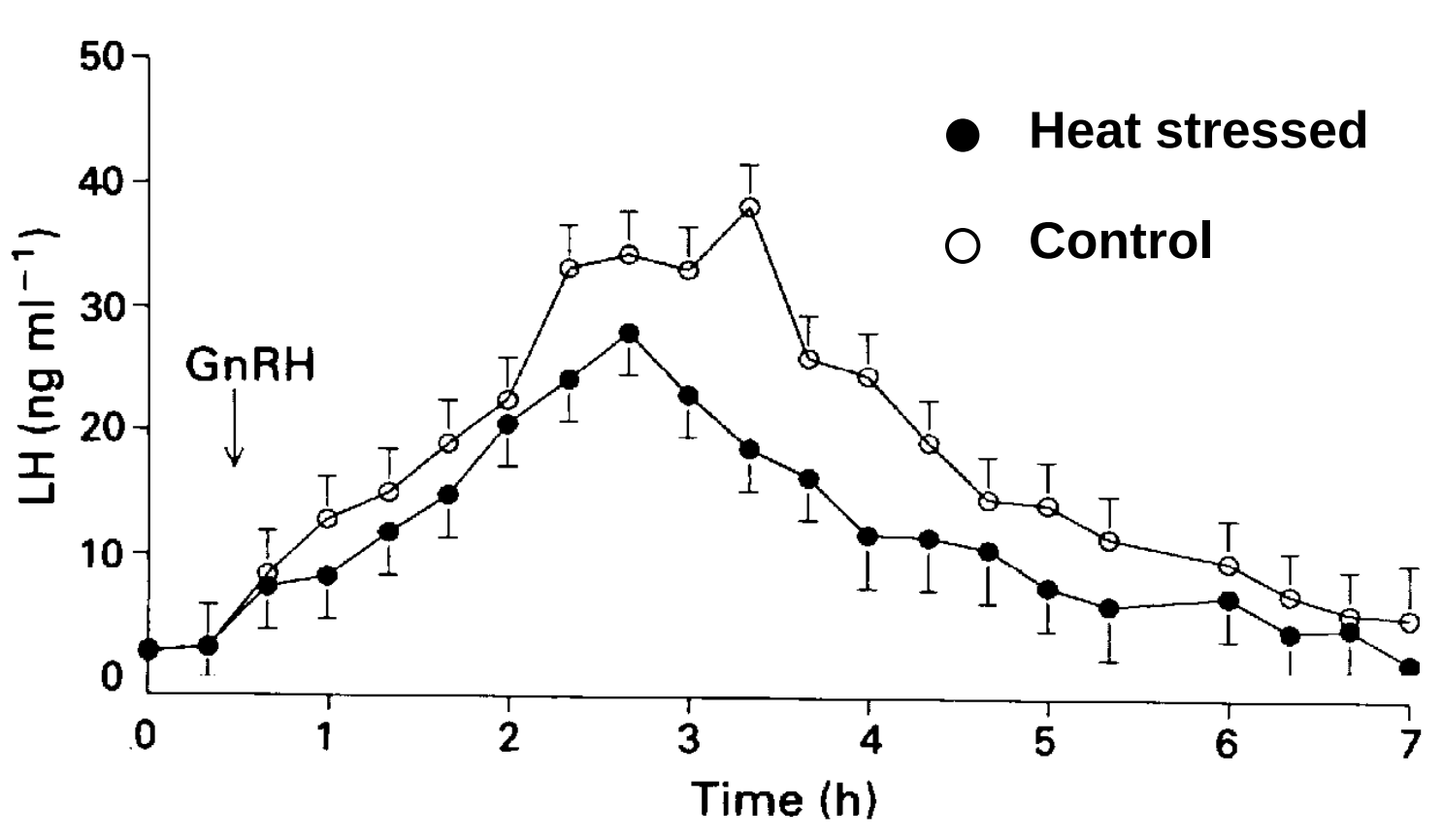




(Sonego et al)

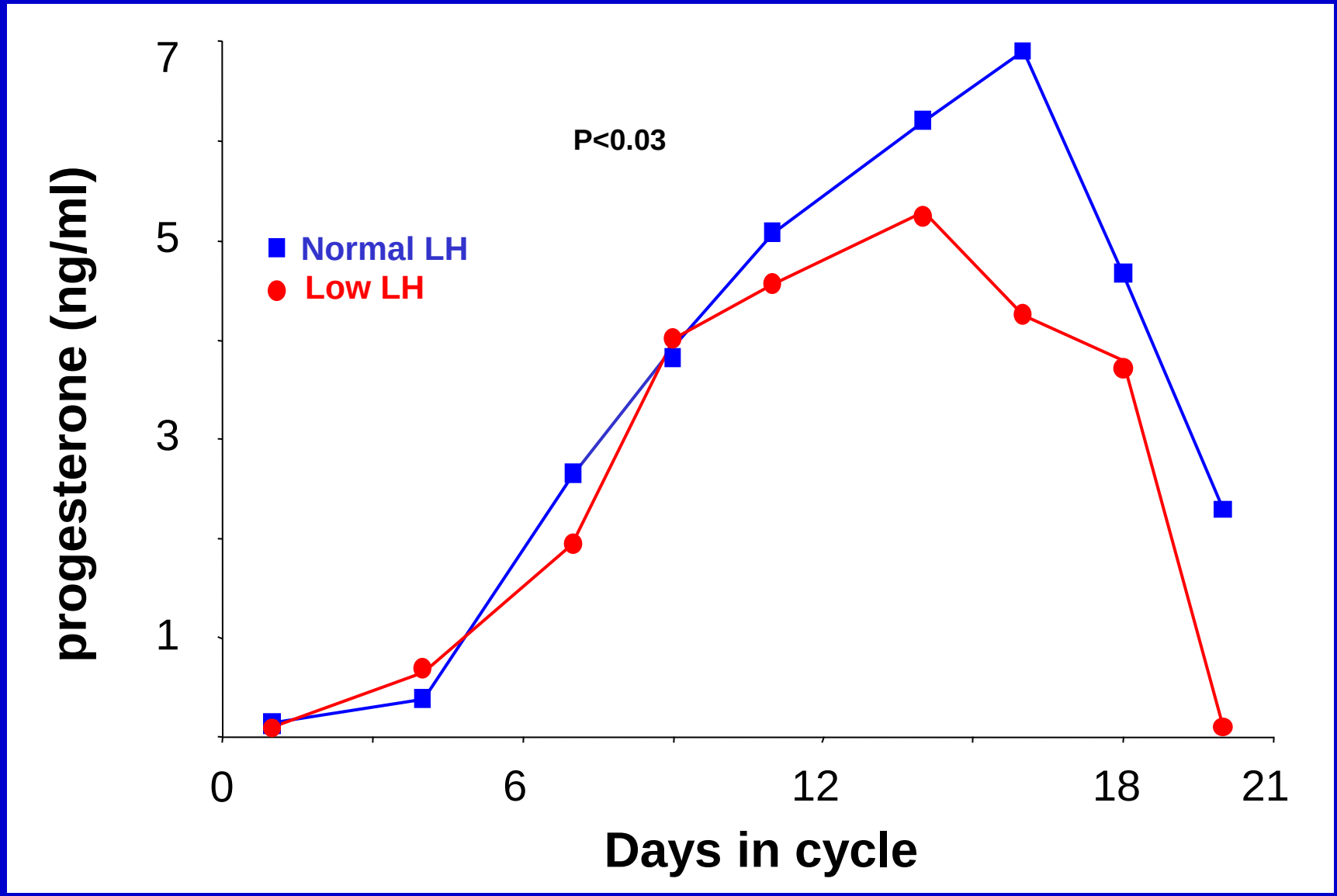
The formation of a sub-optimal corpus luteum in summer is determined to a great extent by the ‘quality’ of the ovulatory follicle from which it originated.

Heat stress lowers the preovulatory LH surge



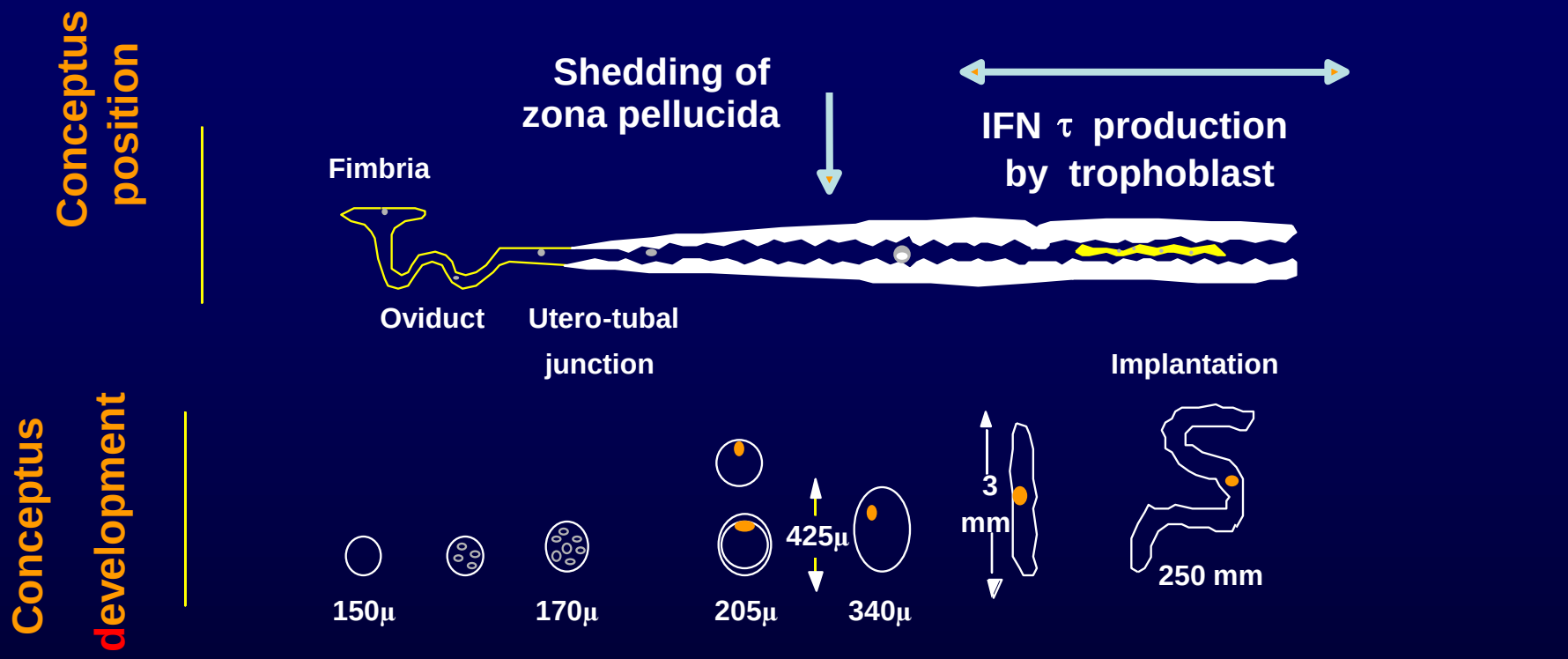
(Gilad et al)

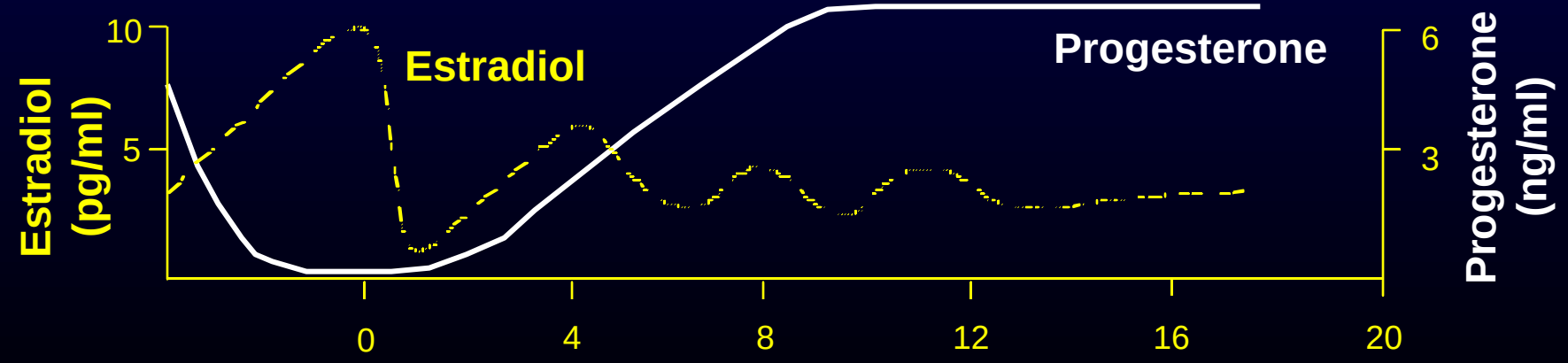
Low LH surge is associated with low progesterone



(Bloch et al)

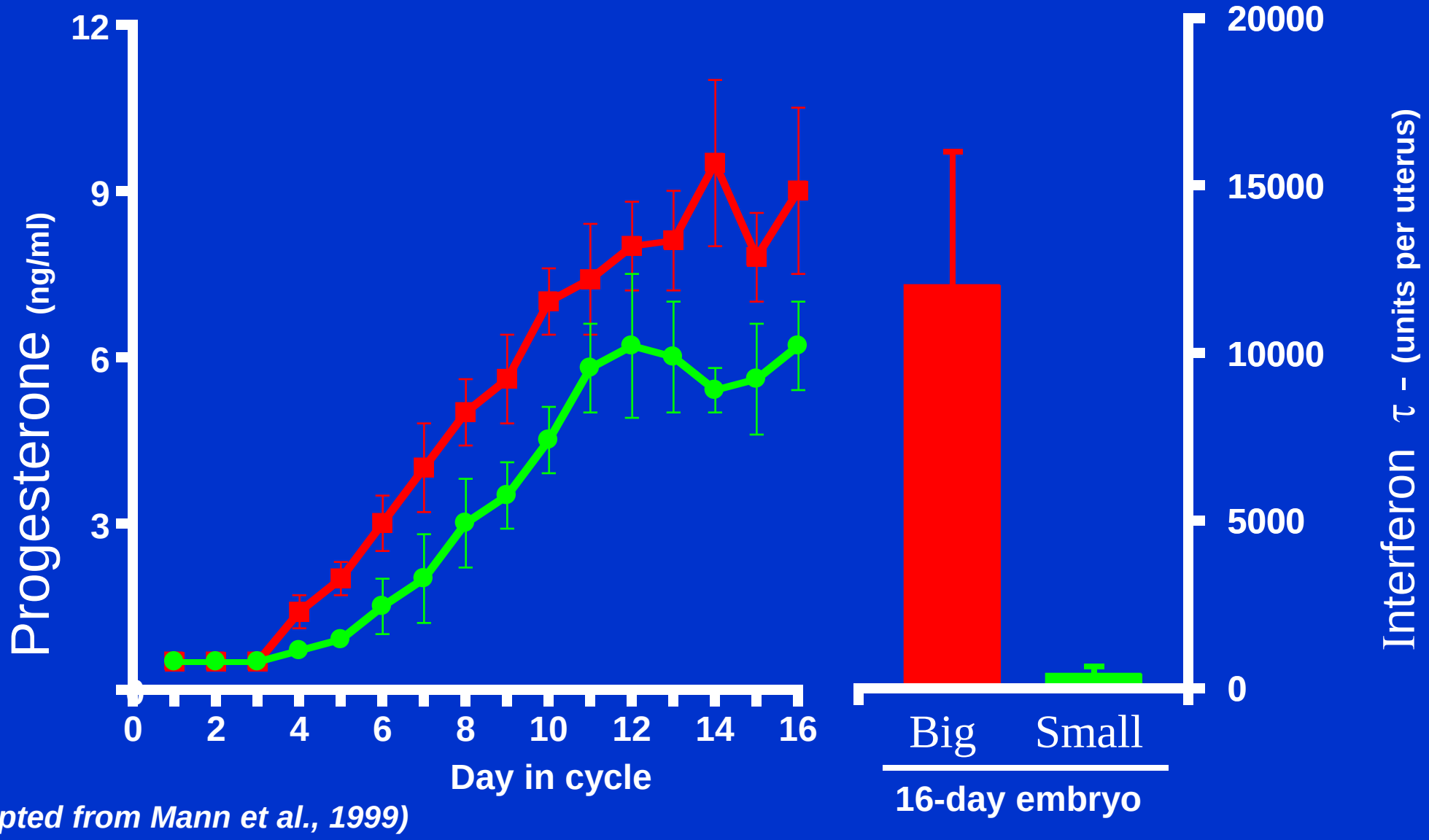
Bovine peri-implantation events





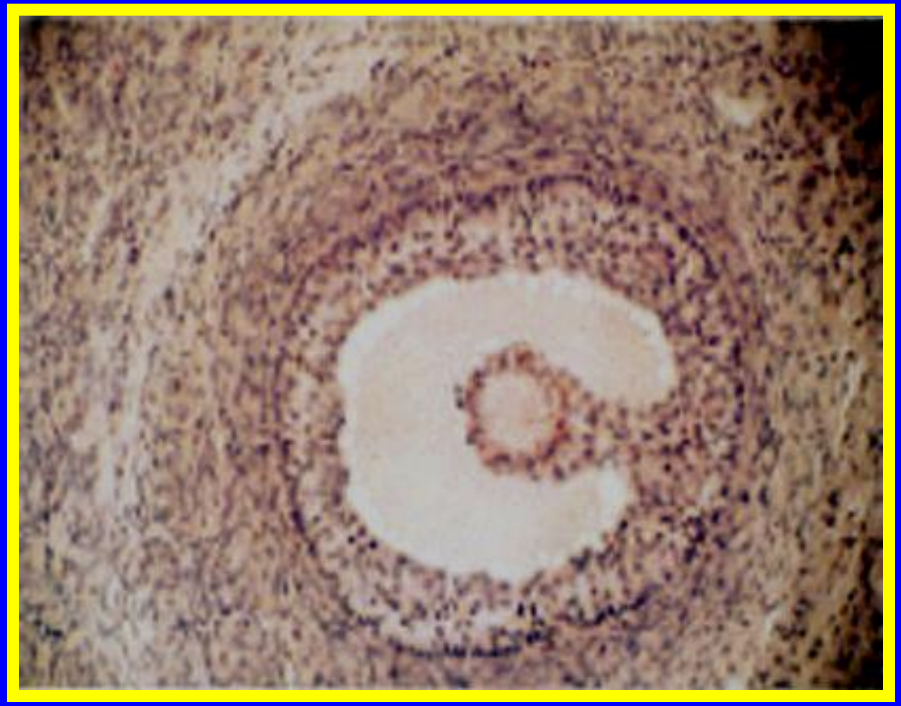
(W. Thatcher)

Association between progesterone level and embryonic development

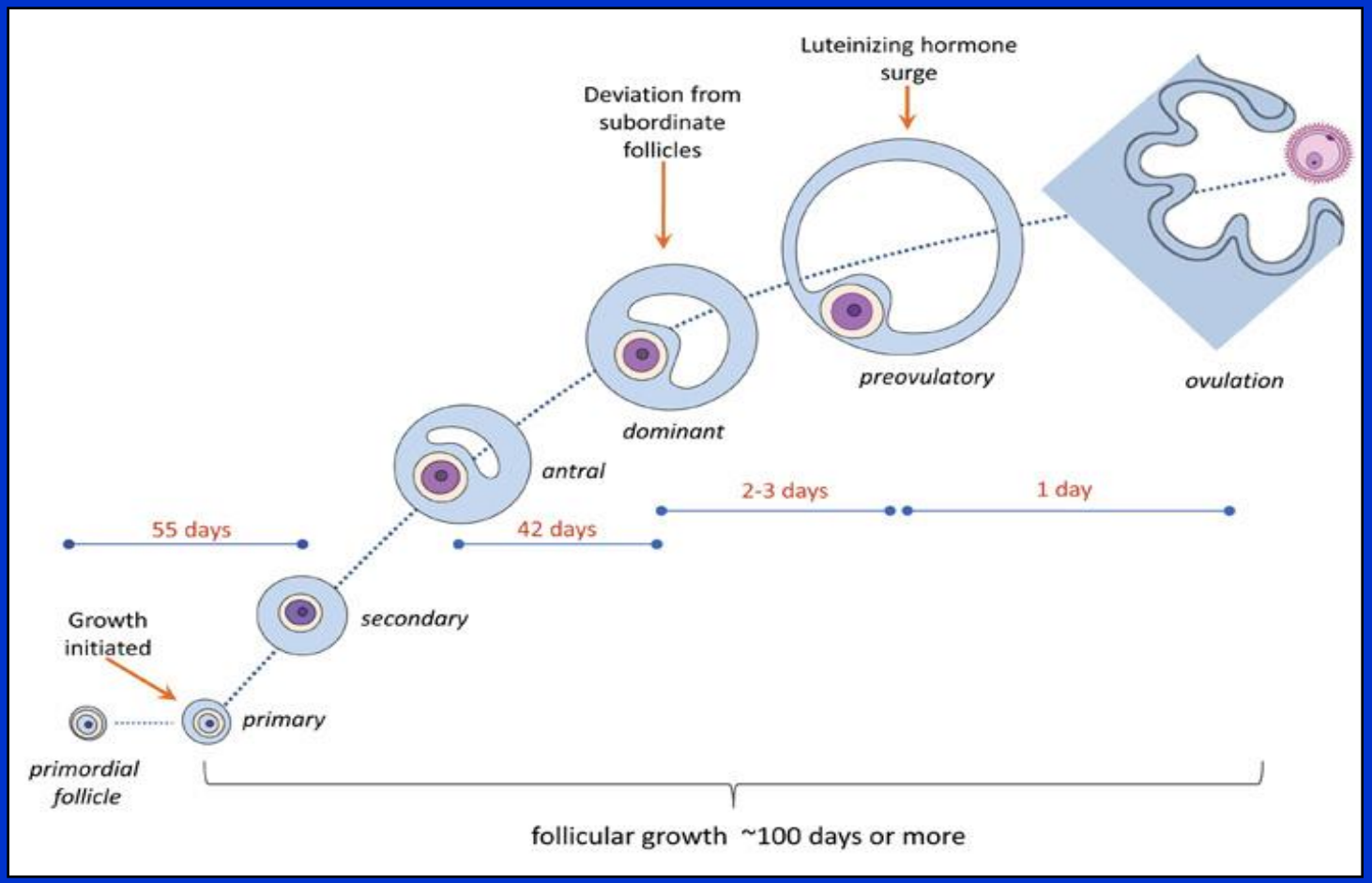


(Adopted from Mann et al., 1999)

OOCYTE QUALITY



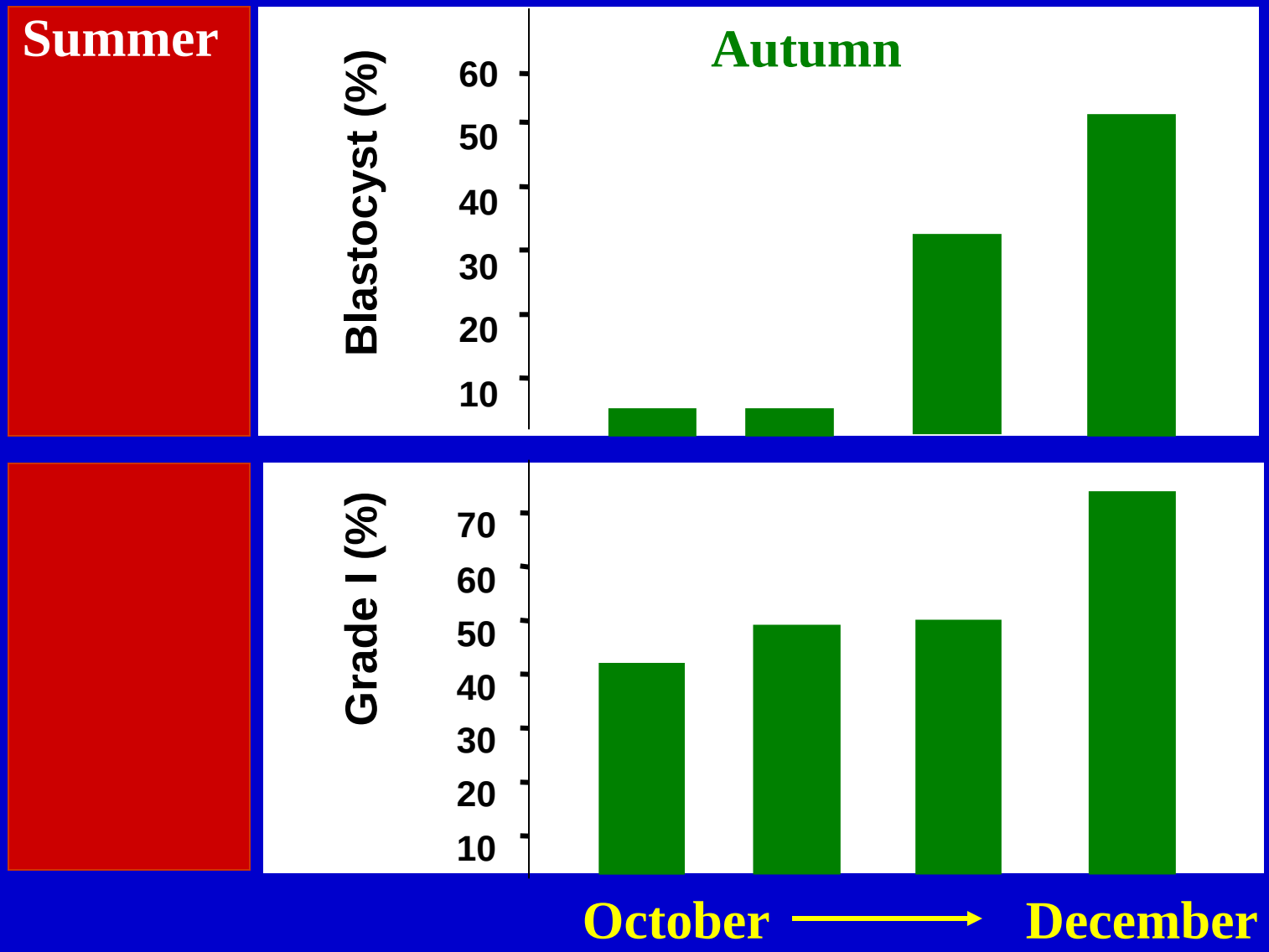
Effect of heat stress on OOCYTE COMPETENCE



(adapted from: P.J. Hansen, 2013)

The process of oocyte and follicle formation is quite long and therefore, impairment early in the process can lead to reduced fertility many days later.

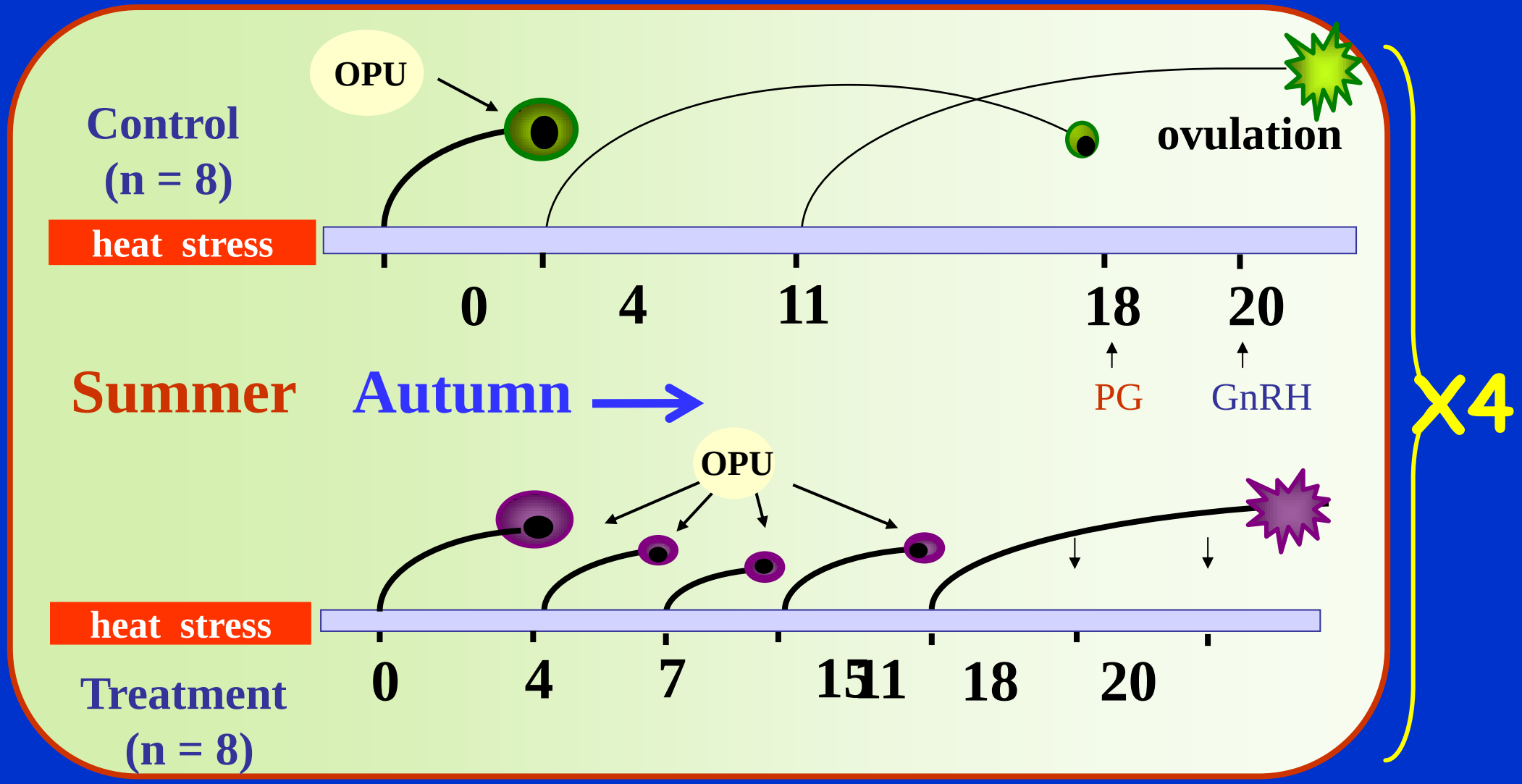
Quality of oocytes and % blastocysts aspirated during the autumn following summer heat stress



Hypothesis:

Enhanced removal of the pool of impaired follicles, that had been damaged during the preceding summer, could induce an earlier emergence of healthy follicles in the autumn.

Frequent aspiration to enhance follicular turnover

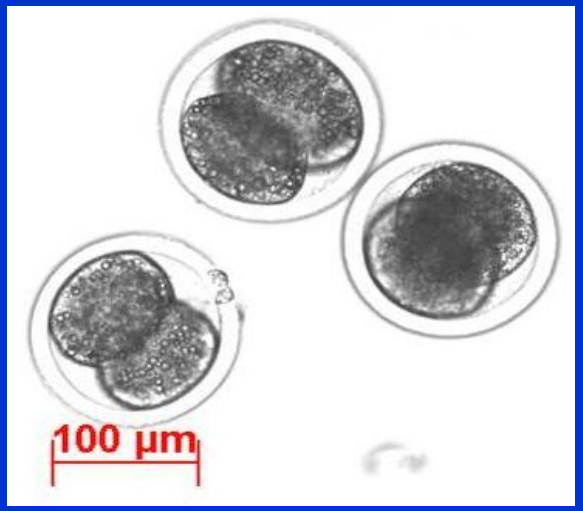


Day of cycle

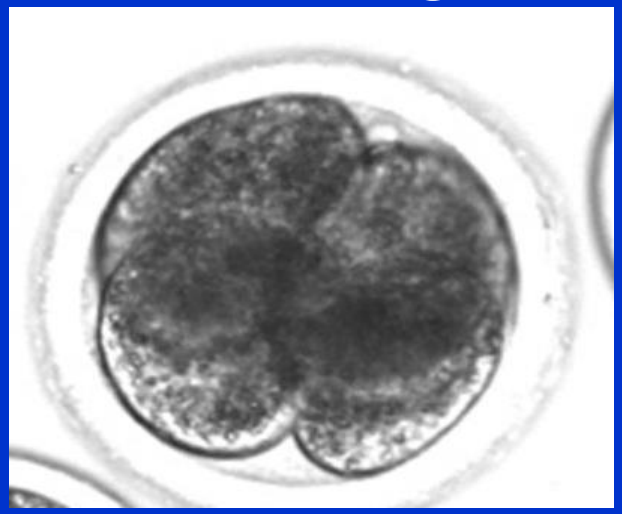
Roth et al.

In vitro culture

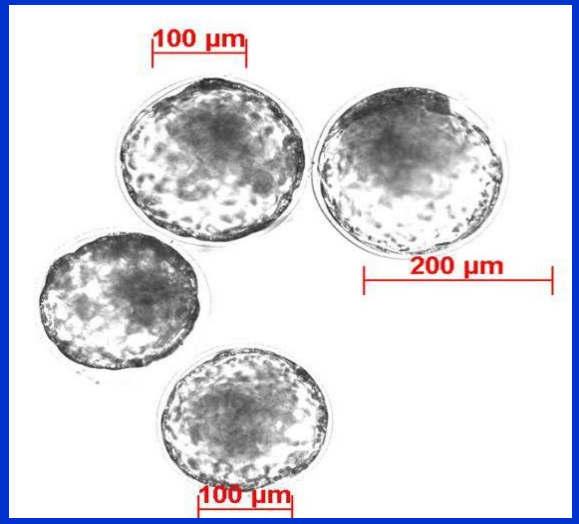
2-cell stage



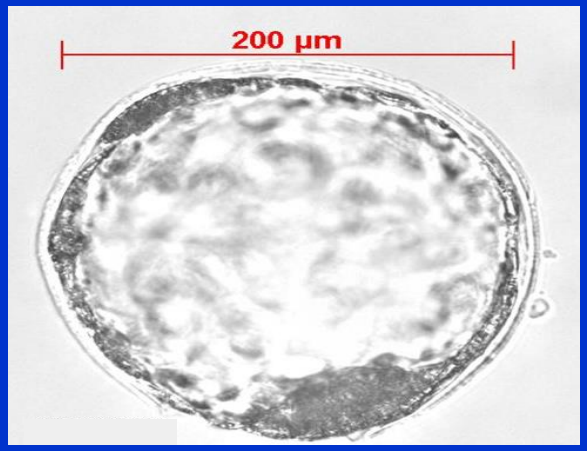
4-cell stage

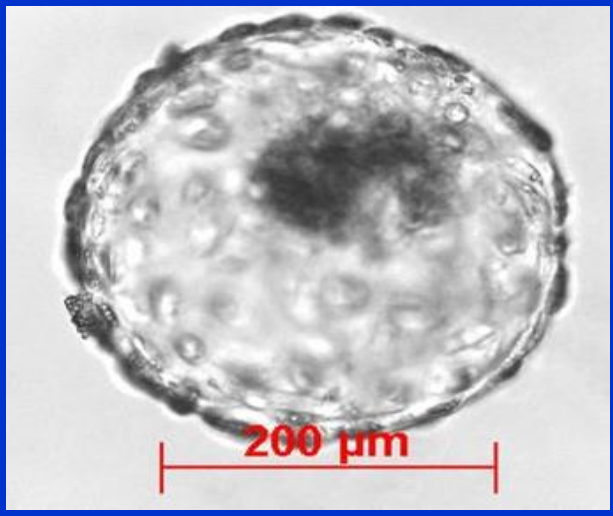


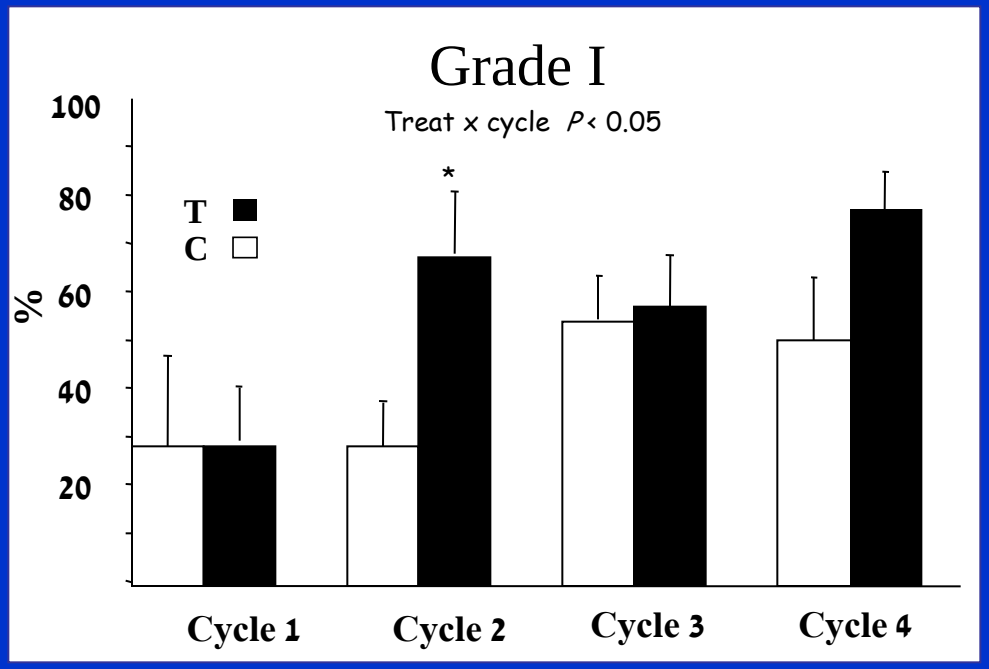
8-cell stage

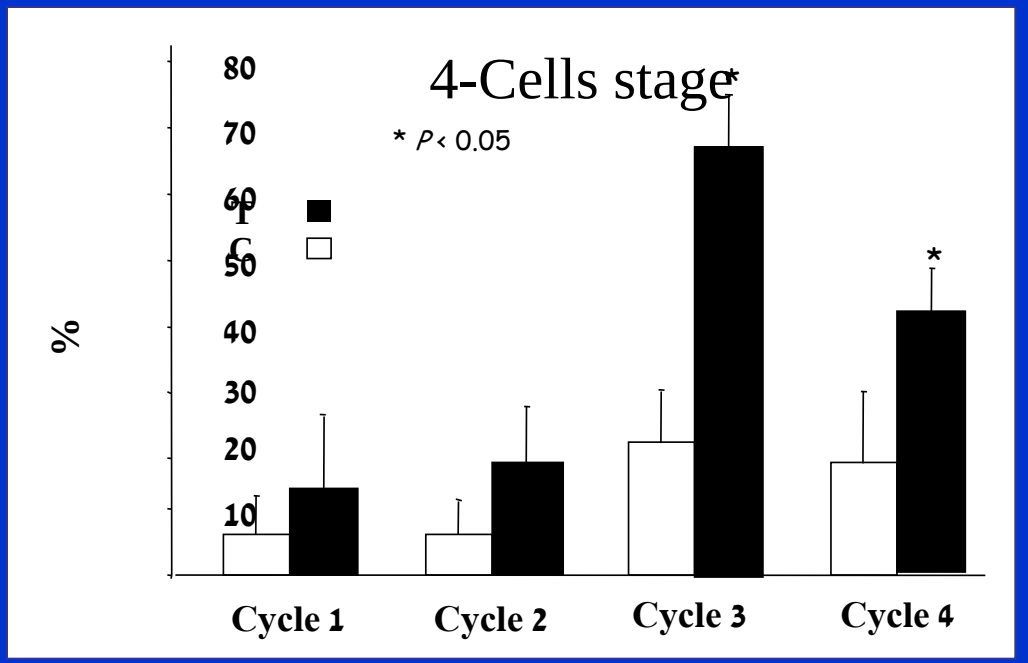


8-day blastocyst






Grade I
Treat x cycle P< 0.05
100
80
60
40
20
%
T
C
*
Cycle 1
Cycle 2
Cycle 3
Cycle 4


4-Cells stage
* P< 0.05
80
70
60
50
40
30
20
10
%
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*
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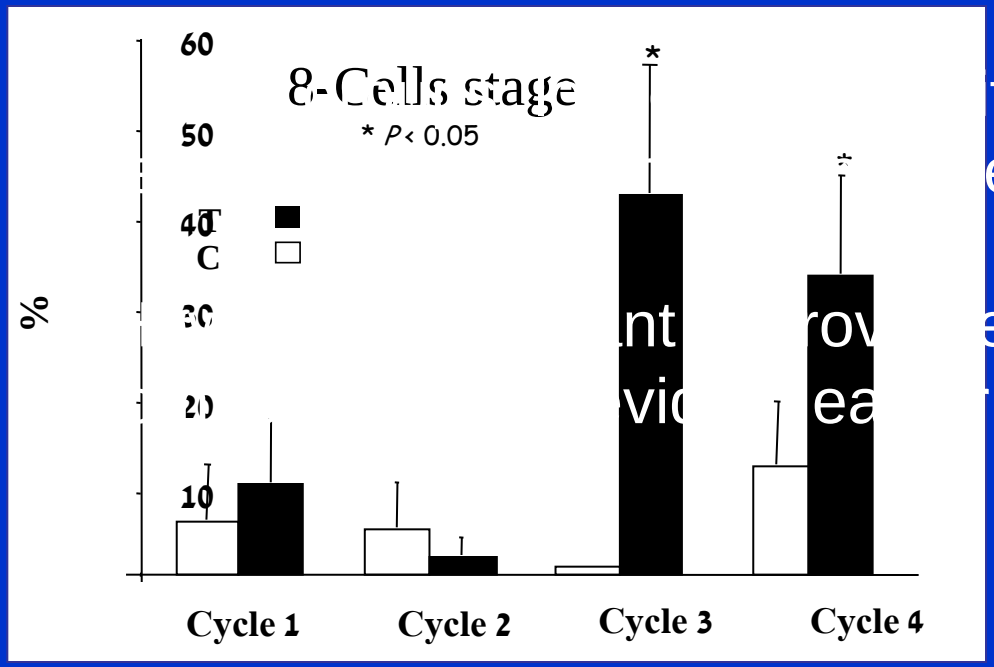
Cycle 1
Cycle 2
Cycle 3
Cycle 4


8-Cells stage
* P< 0.05
60
50
40
30
20
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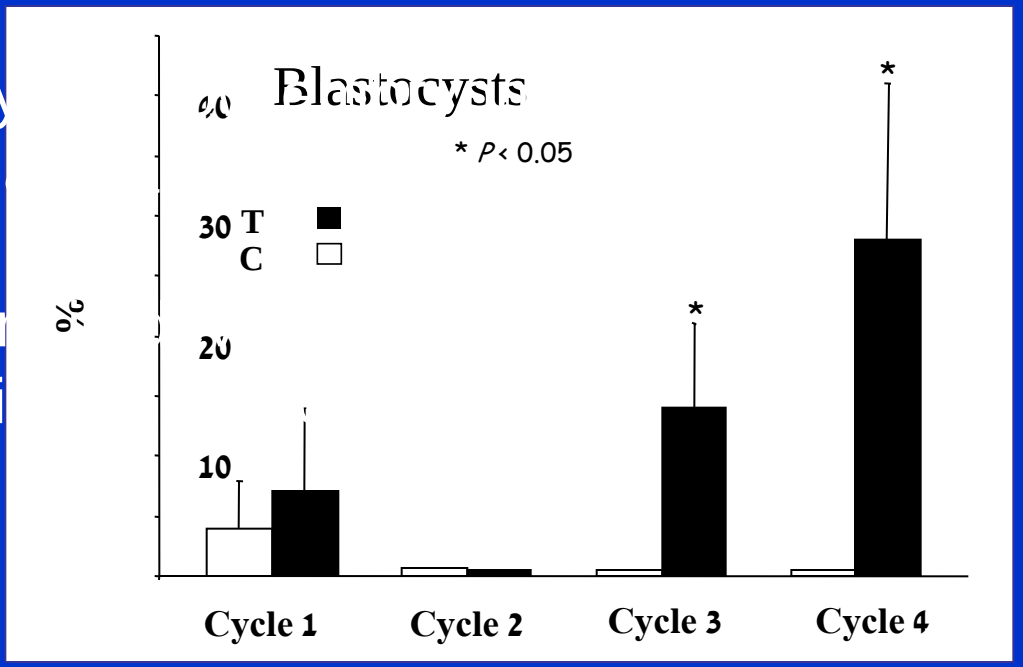
%
T
C
*
Cycle 1
Cycle 2
Cycle 3
Cycle 4


Blastocysts
* P< 0.05
30
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10
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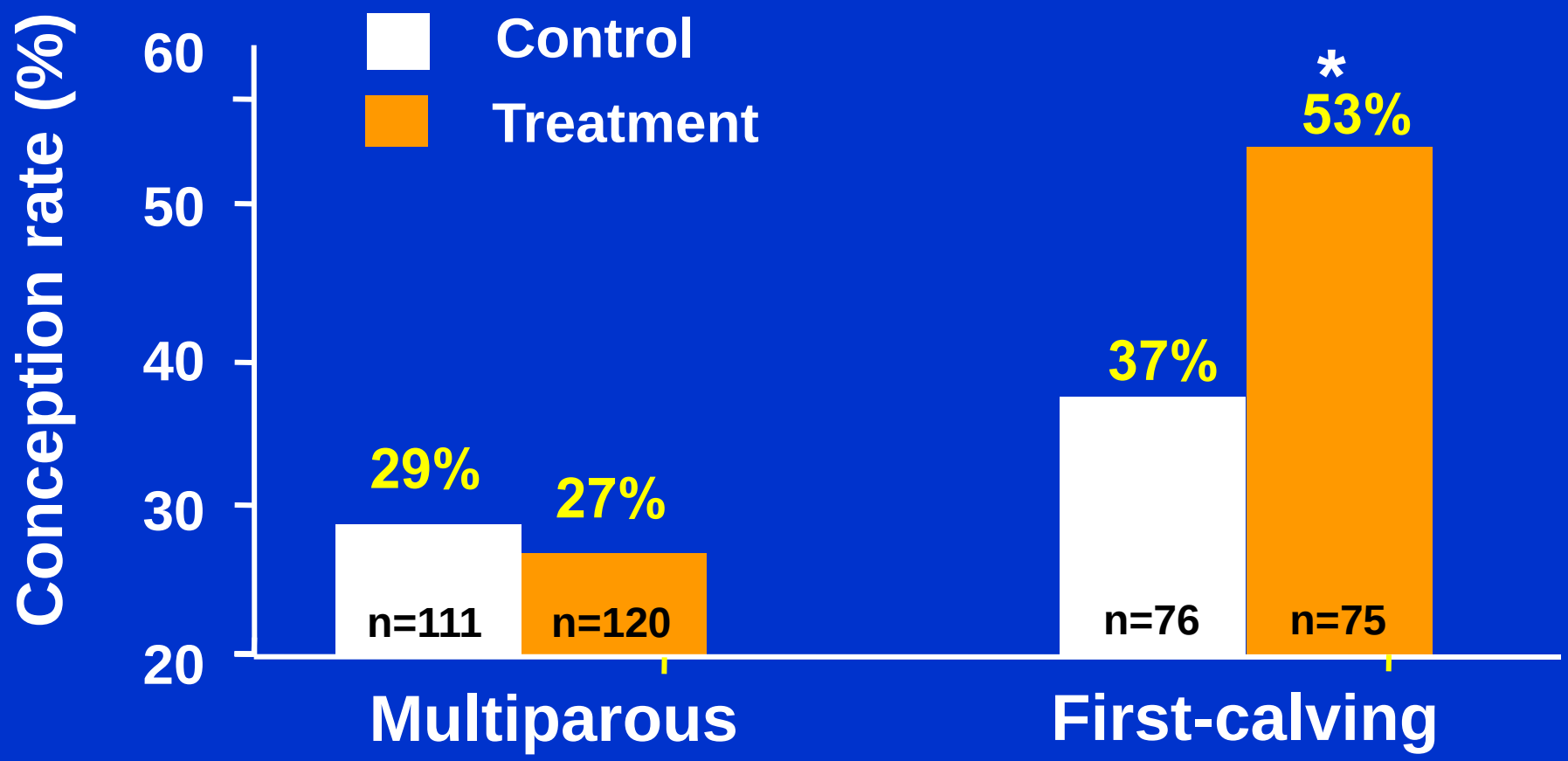
C
*
*
Cycle 1
Cycle 2
Cycle 3
Cycle 4

Roth et al.

Fertility study (1)

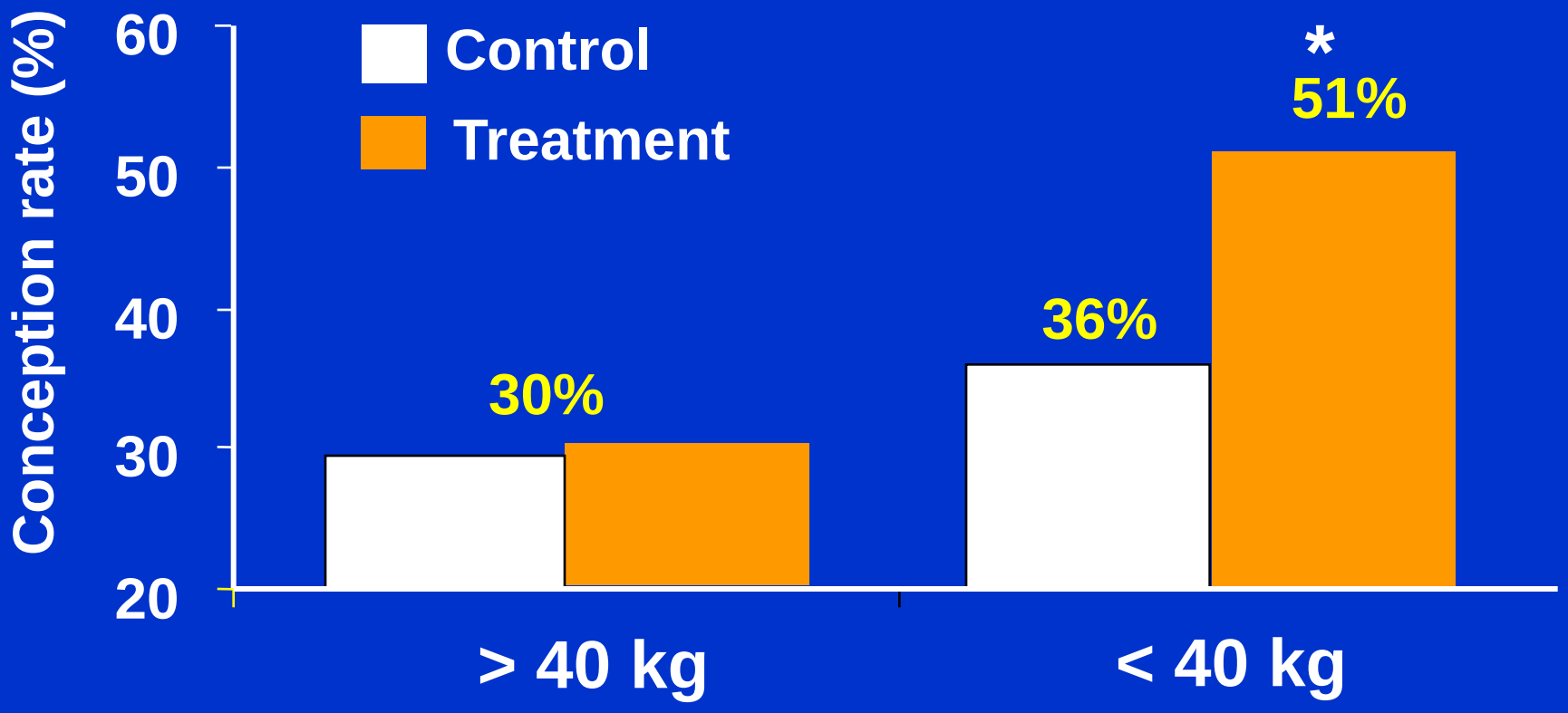
Three induced 9-day cycles with GnRH + PGF2α improves conception rate in first-calving cows



Friedman et al., 2011

** P<0.06*

Treatment with GnRH + PGF2α improves conception rate in cows with low milk production

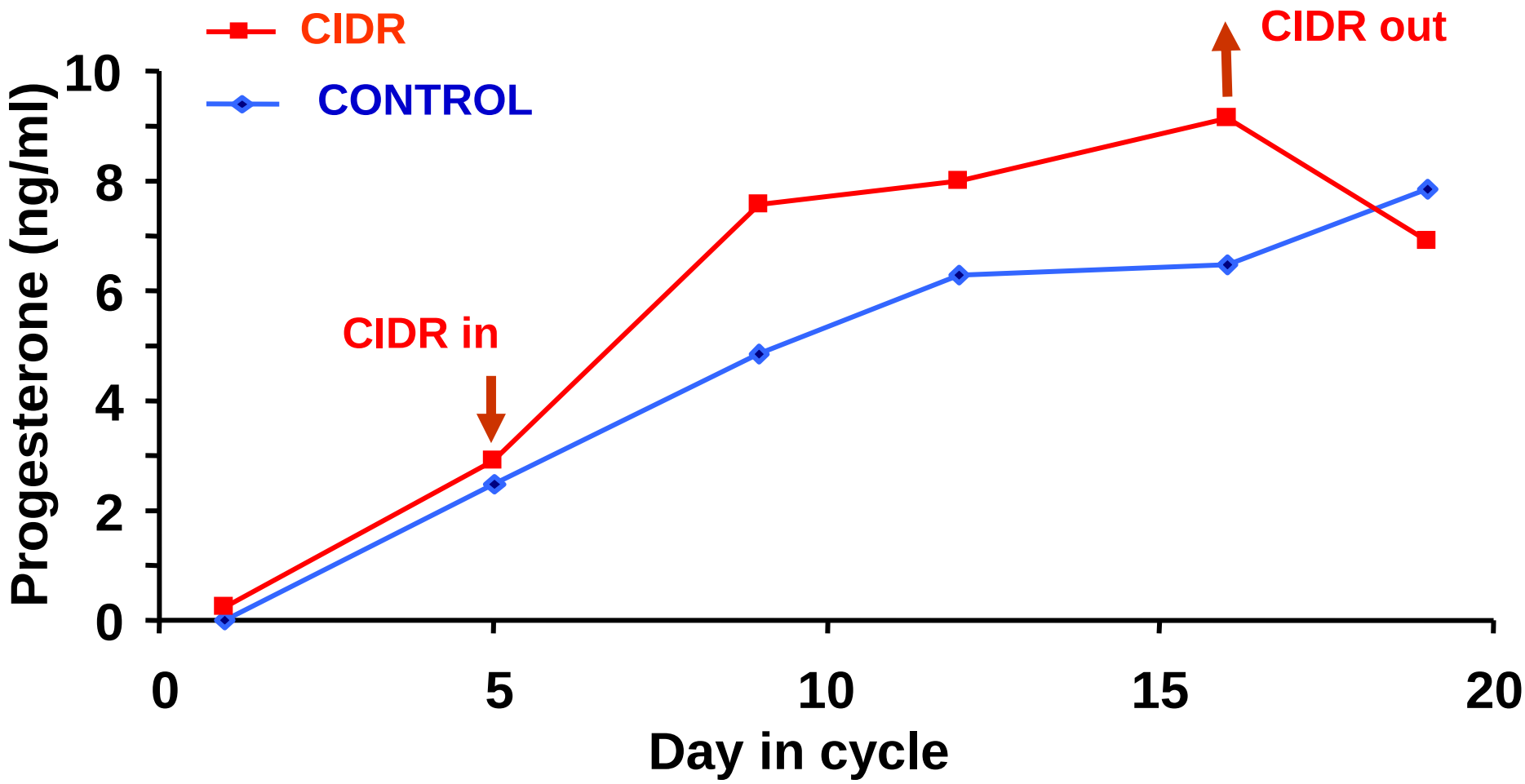


Friedman et al., 2011

** P<0.05*

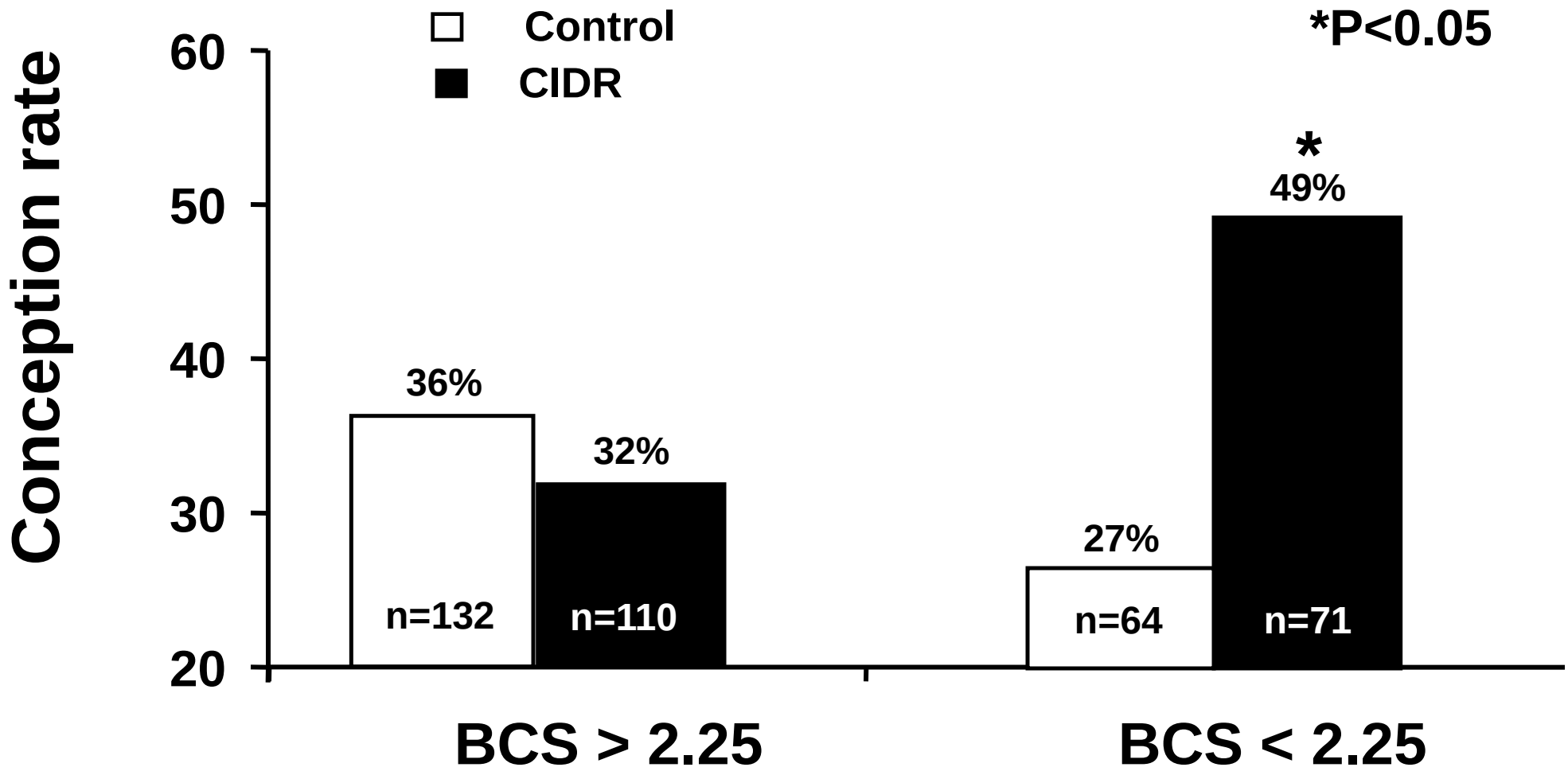
Fertility study (2): exogenous progesterone

CIDR device increases plasma progesterone

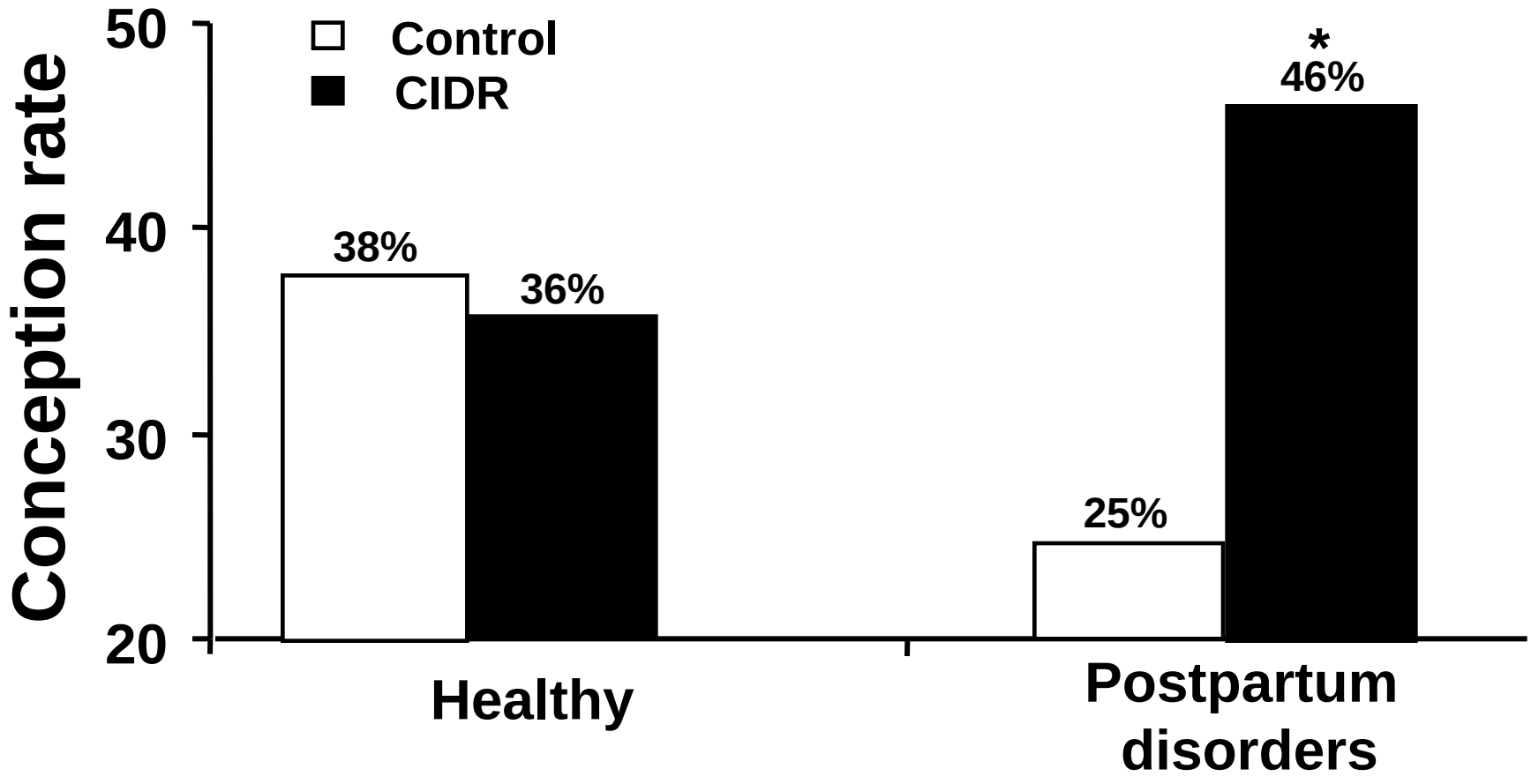


Friedman et al., 2011

Progesterone improves conception rate in cows with low body condition



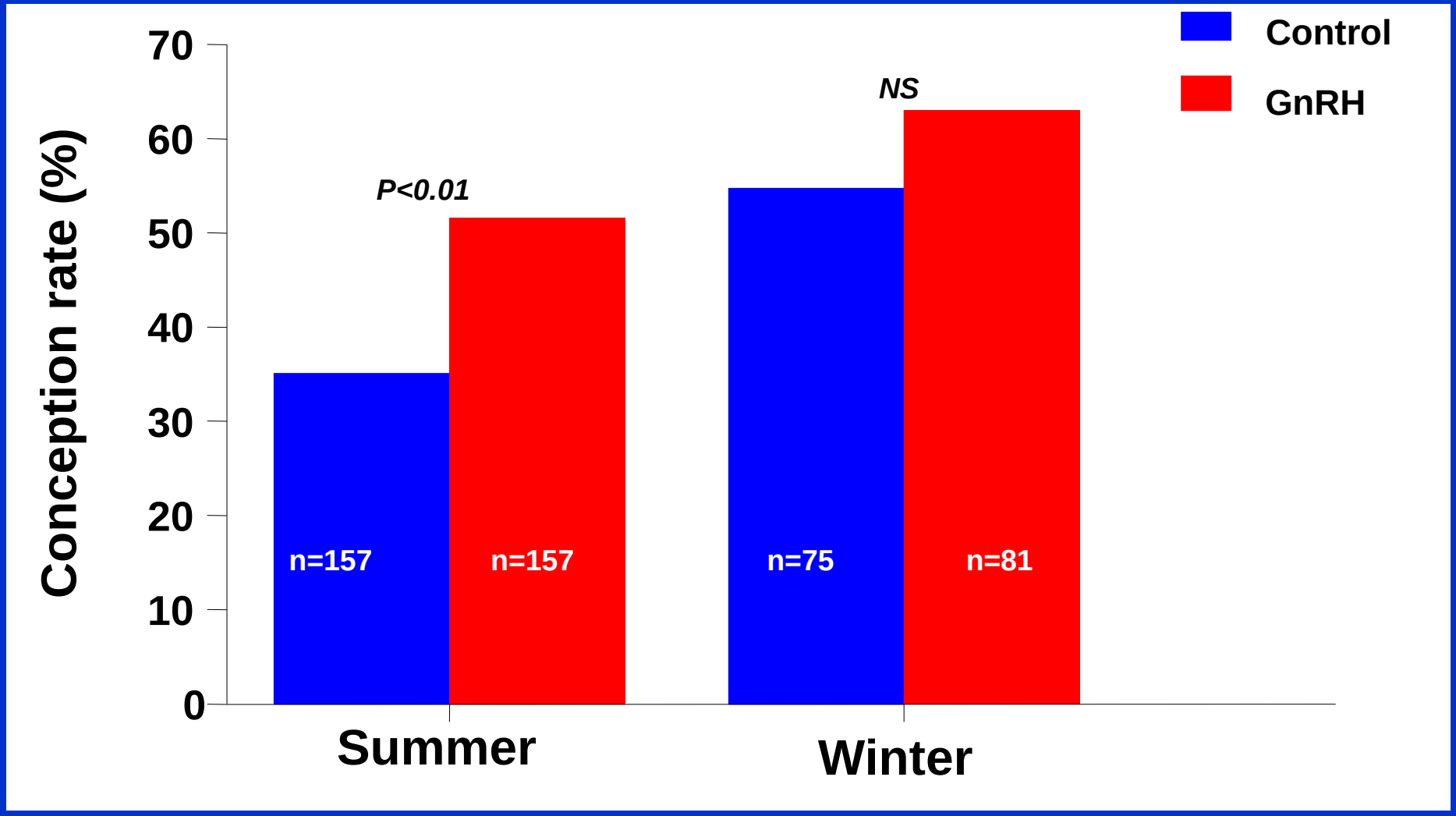
Progesterone improves conception rate in cows with postpartum disorders



Friedman et al., 2011

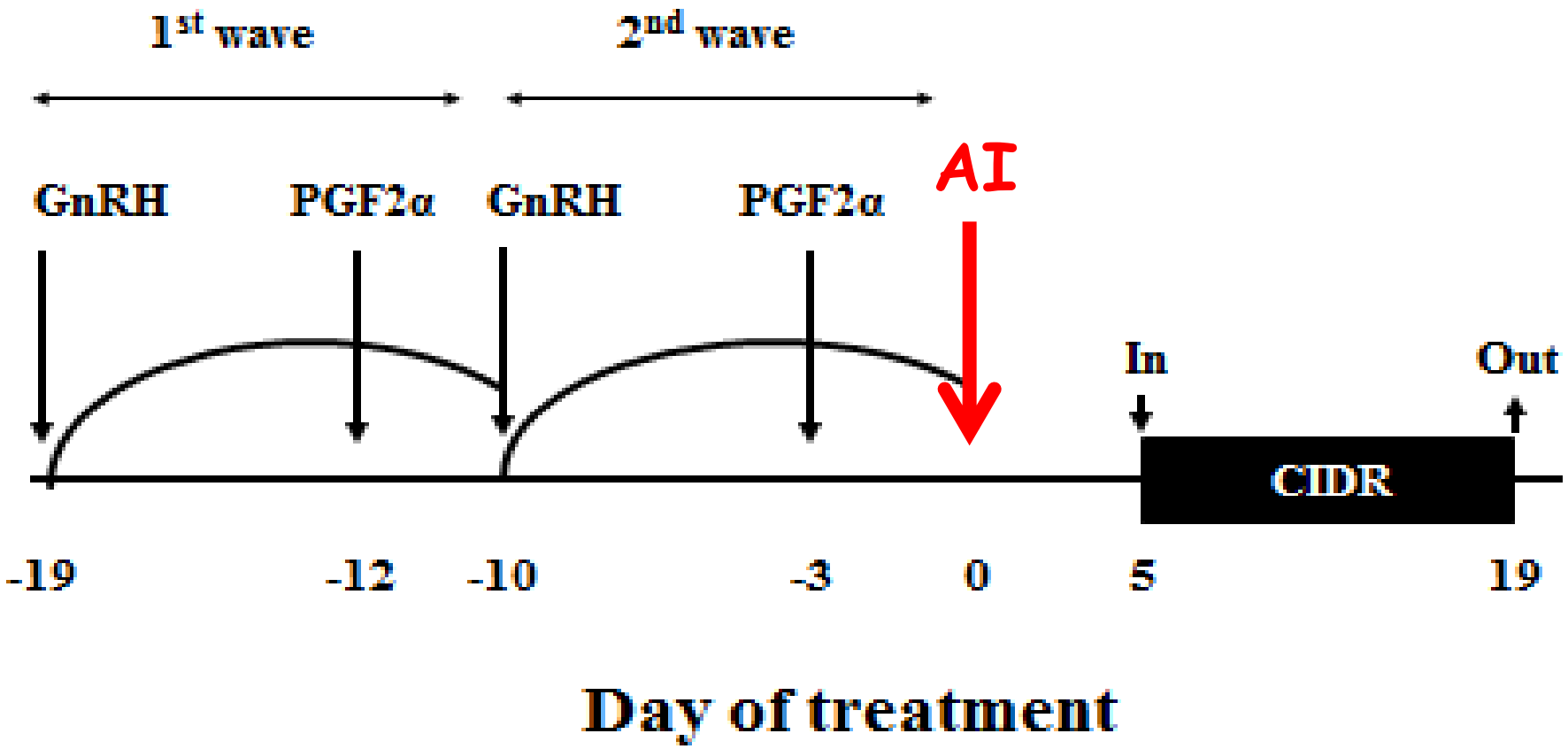
**P<0.09*

Fertility study (3): GnRH injection at onset of estrus*



Kaim et al., 2003

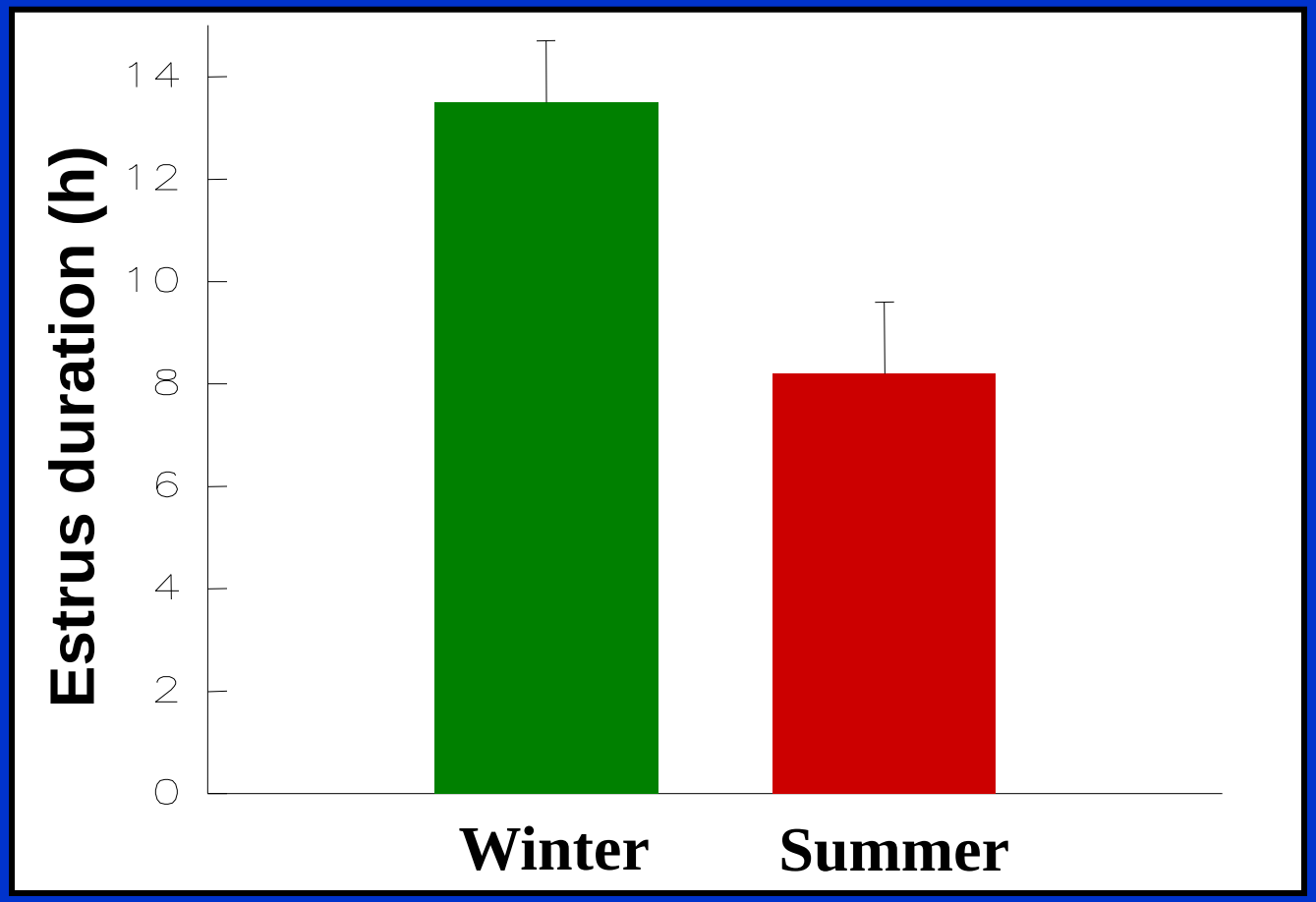
Fertility study (4): Combined Treatment



(Friedman, Wolfenson & Roth, In Press, JDS 2015)

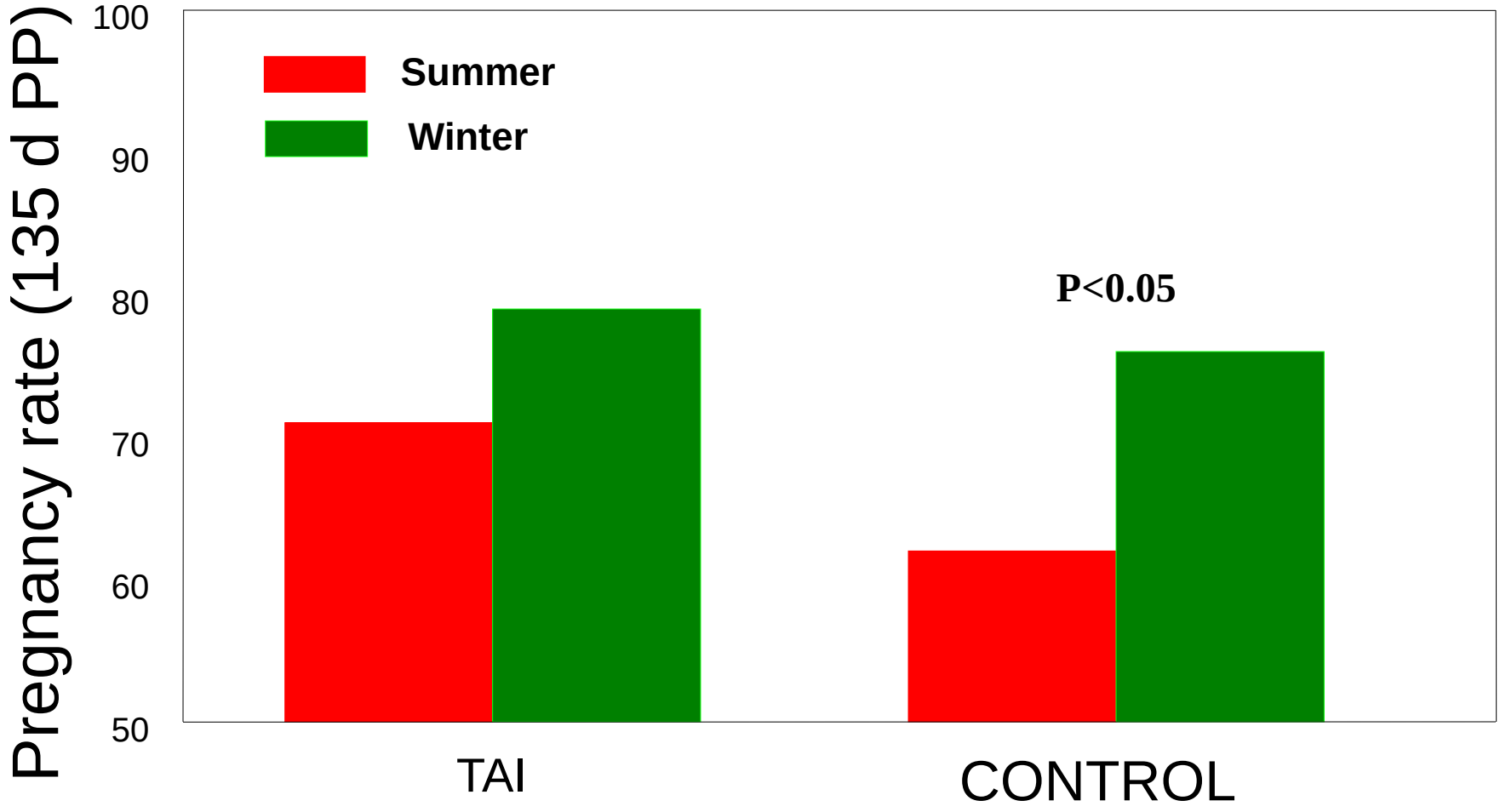
Fertility study (5): Timed AI

Duration and intensity of estrus



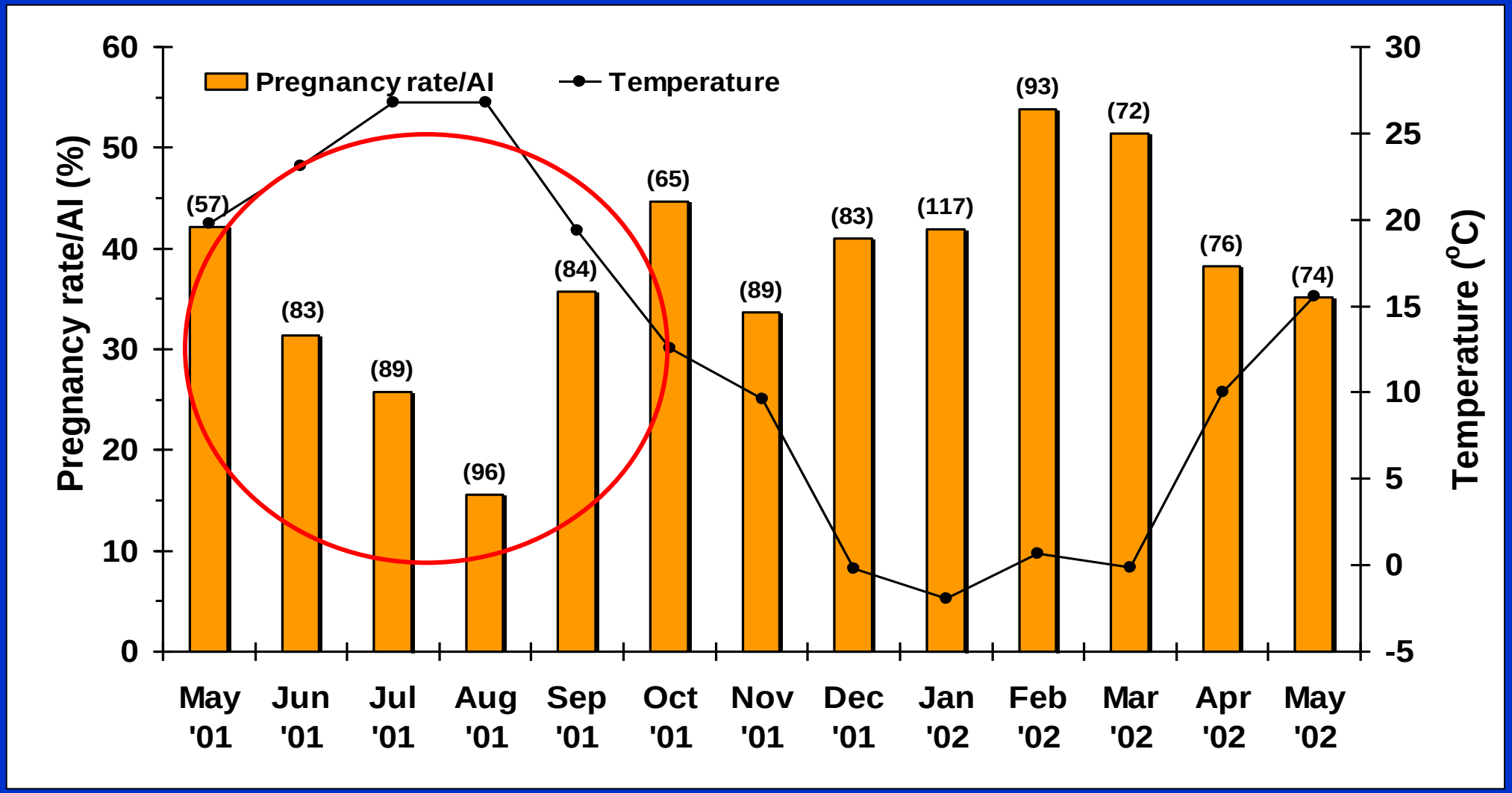
Monty and Wolff, 1974

Pregnancy rate increased by Ovsynch - TAI in the summer



(de Rensis et al 2002)

Conception rate per timed AI by month



Fricke et al., 2003

CONCLUSIONS

- Hyperthermia impairs several ovarian functions in lactating dairy cows.
- The knowledge gained enables to examine hormonal strategies to optimize reproductive function and to improve fertility of heat-stressed cattle.
- Efficient cooling management is a prerequisite for other strategies to improve fertility.
- Specific treatments for specific designated subpopulations of cows are suggested.

Collaboration

Z. Roth, R. Braw-Tal, R. Meidan, W.W. Thatcher, I. Flamenbaum, A. Arav, A. Bor, Y. Folman, M. Kaim, H. Sonego, B. Lew, A. Bloch, E. Friedman, Y. Lavon, Y. Graber, M. Maman

Thank you