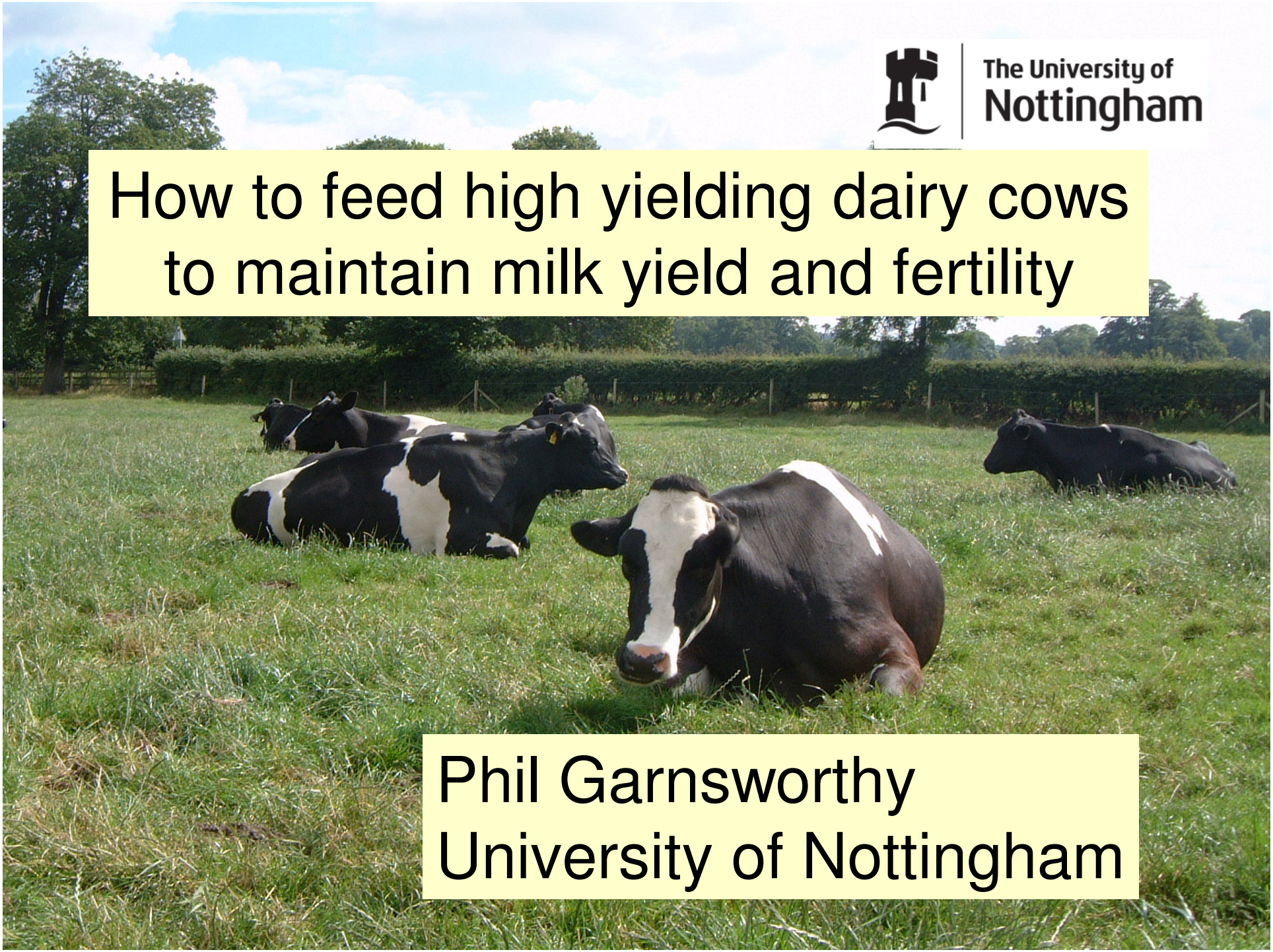

The University of
Nottingham
How to feed high yielding dairy cows to maintain milk yield and fertility
Phil Garnsworthy
University of Nottingham

Outline

- Feed Intake, Energy Balance and Body Condition Score
- Diet, Metabolic Hormones and Reproduction
- Optimal Nutrition for Fertility

High yielding cows can have good fertility

Is high milk yield a problem?

High milk yield can be associated with:

- Poor fertility
- Increased disease incidence
- More lameness

THESE ARE NOT INEVITABLE

- The challenge is to meet the nutritional needs of the cow!

Nutritional needs of the high-yielding cow

- High energy and nutrient intake
- A high energy diet fed *ad libitum*
- Managed body condition
  - Not too fat, avoid excessive loss
- Balanced diet
  - Avoid excesses as well as deficiencies
  - Maybe adjust to cow's physiological state?

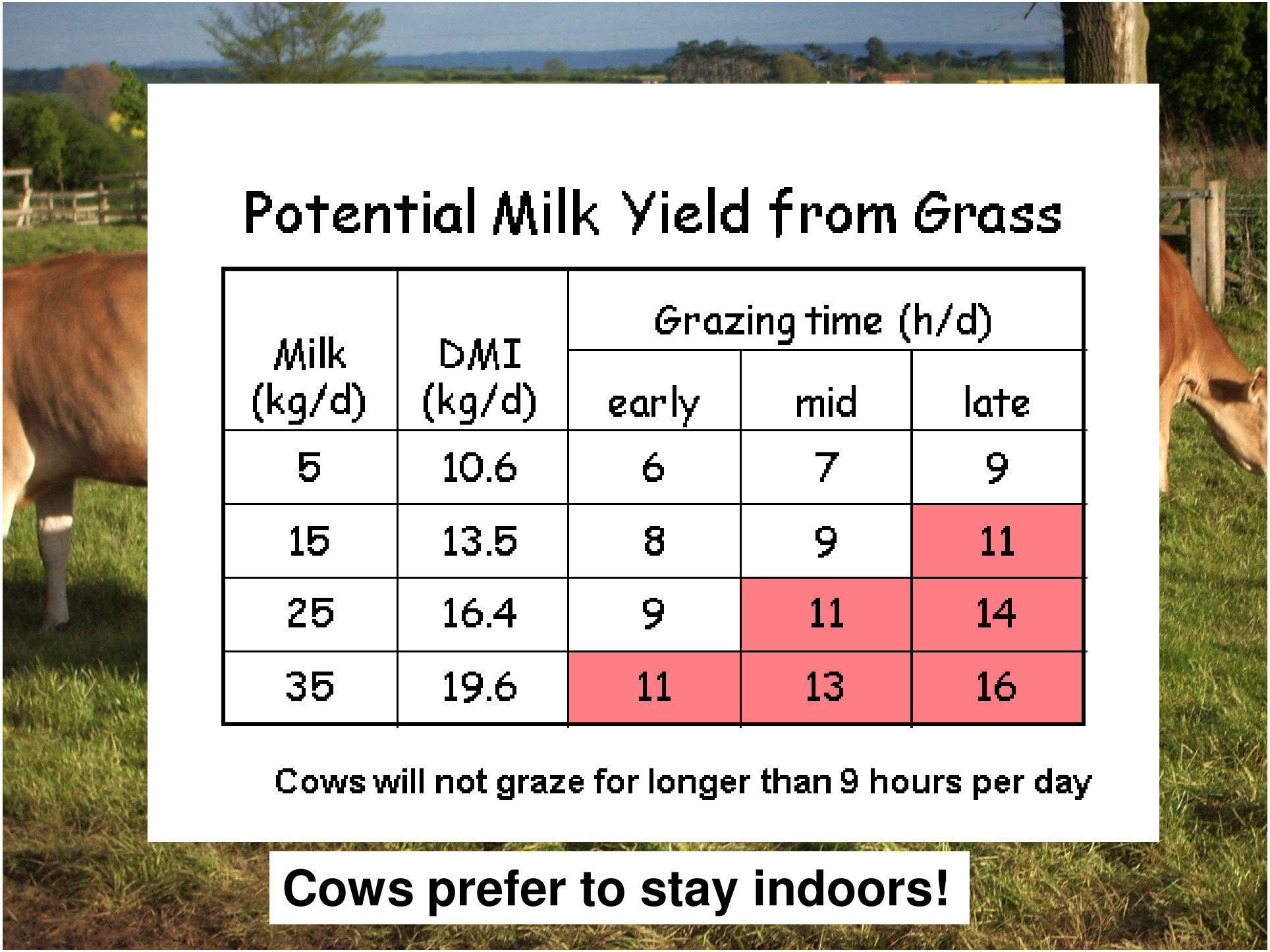
How much does a cow eat?

- Animal factors e.g. live weight, milk yield, condition score etc.
- Diet factors e.g.
- Dry Matter, Digestibility
- Forage Palatability
- Acid Loading of Forages
- Long fibre (saliva buffering)
- Total Mixed Rations

How much does a cow eat?

- Feed access (trough space 0.5-0.75 m/cow)
- Feed availability (ad-libitum is 110%)
- Ad-lib fresh clean water
- Number of feeds per day
- Remove old feed
- Comfortable bed for rumination


How much grass does a cow eat?



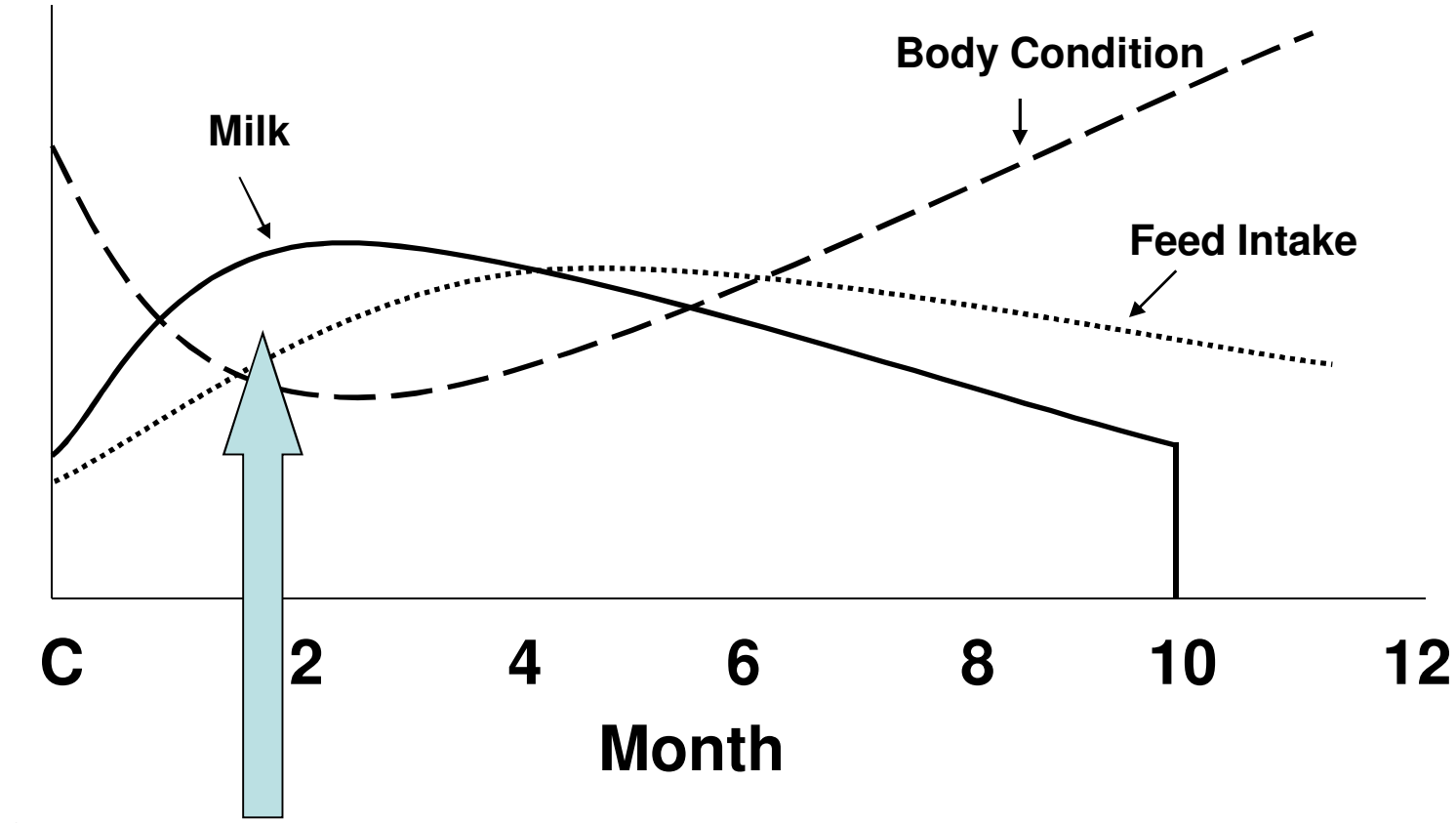
Potential Milk Yield from Grass

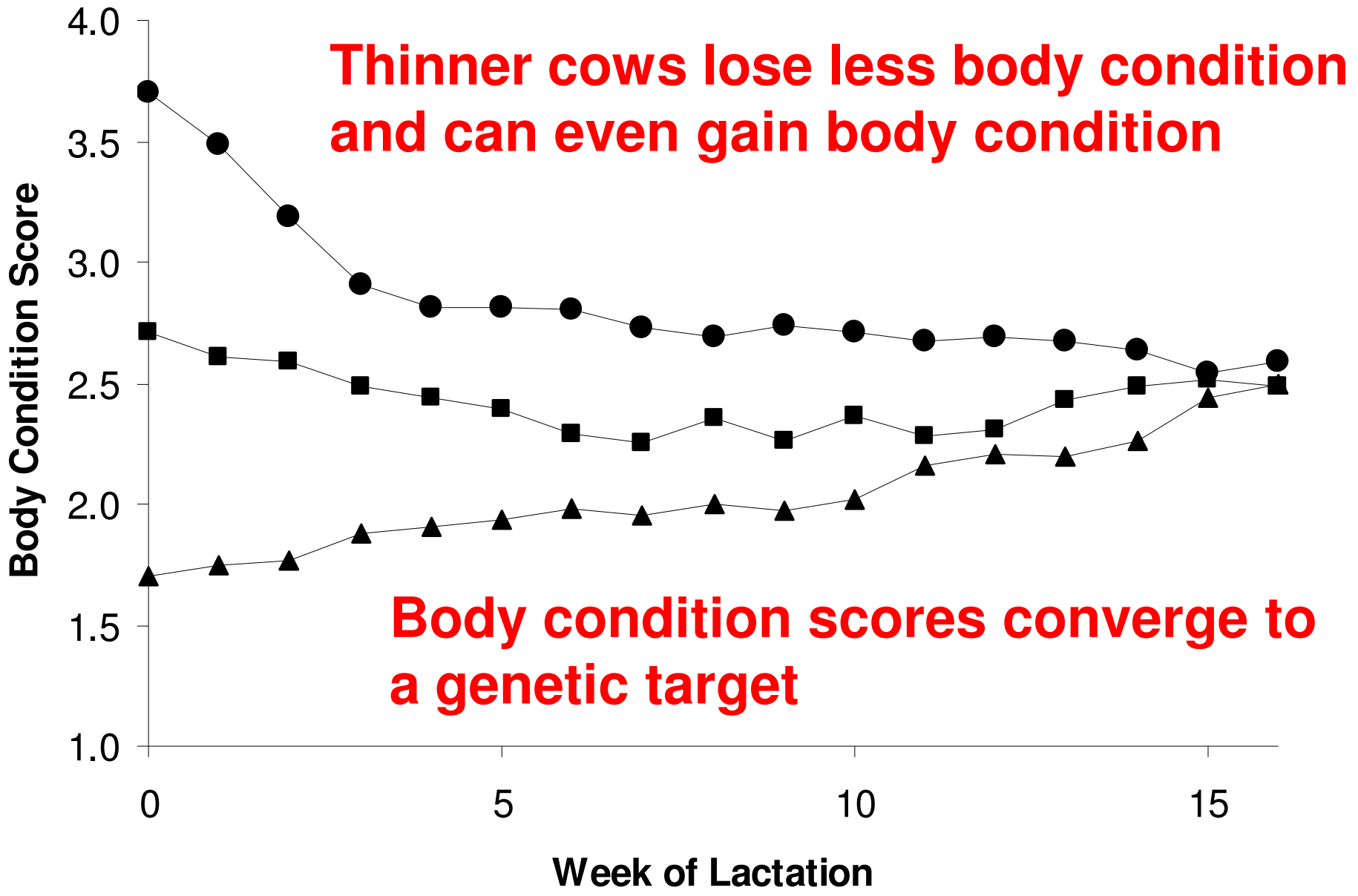
Milk (kg/d)	DMI (kg/d)	Grazing time (h/d)		
		early	mid	late
5	10.6	6	7	9
15	13.5	8	9	11
25	16.4	9	11	14
35	19.6	11	13	16

Cows will not graze for longer than 9 hours per day

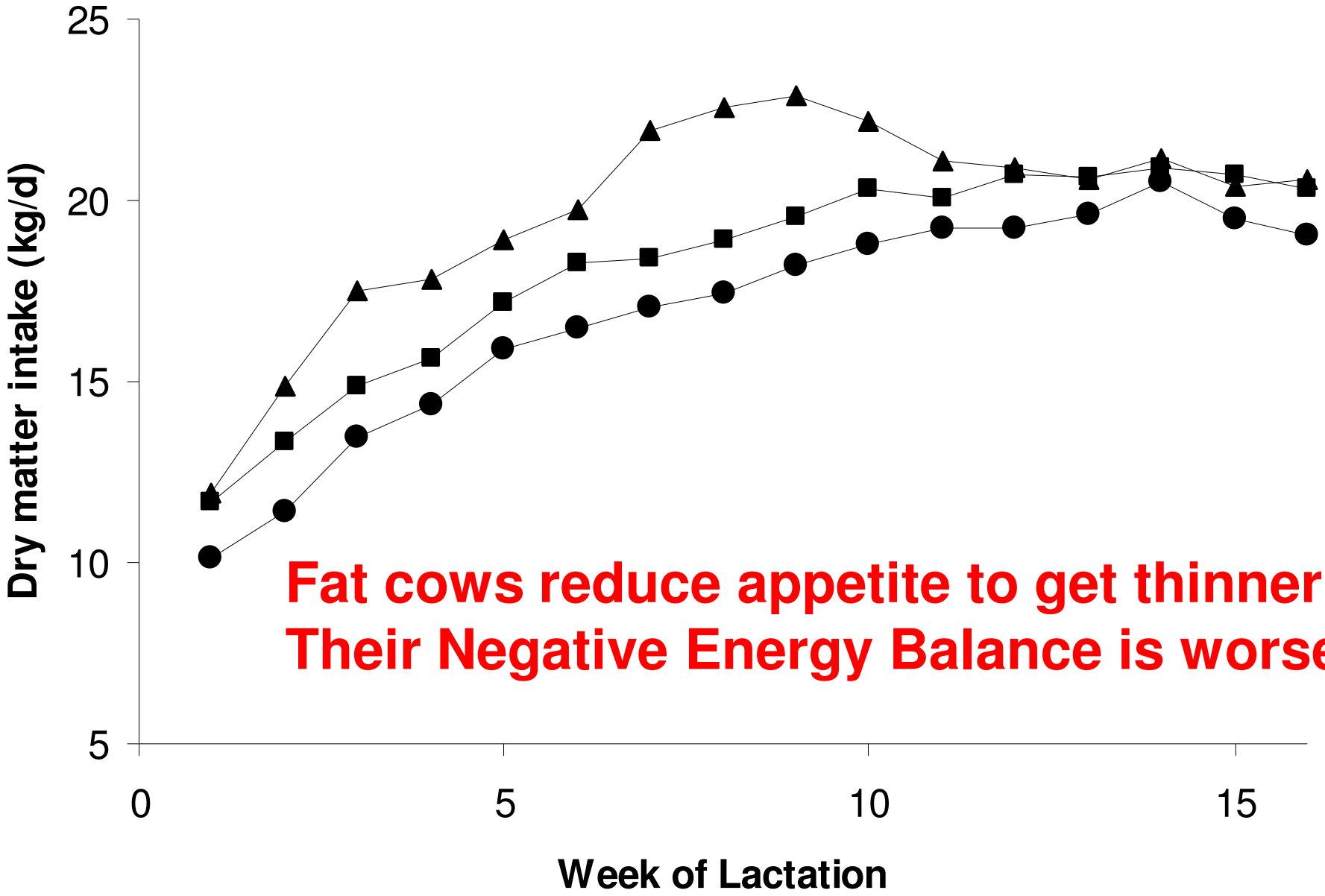
Cows prefer to stay indoors!

Negative Energy Balance



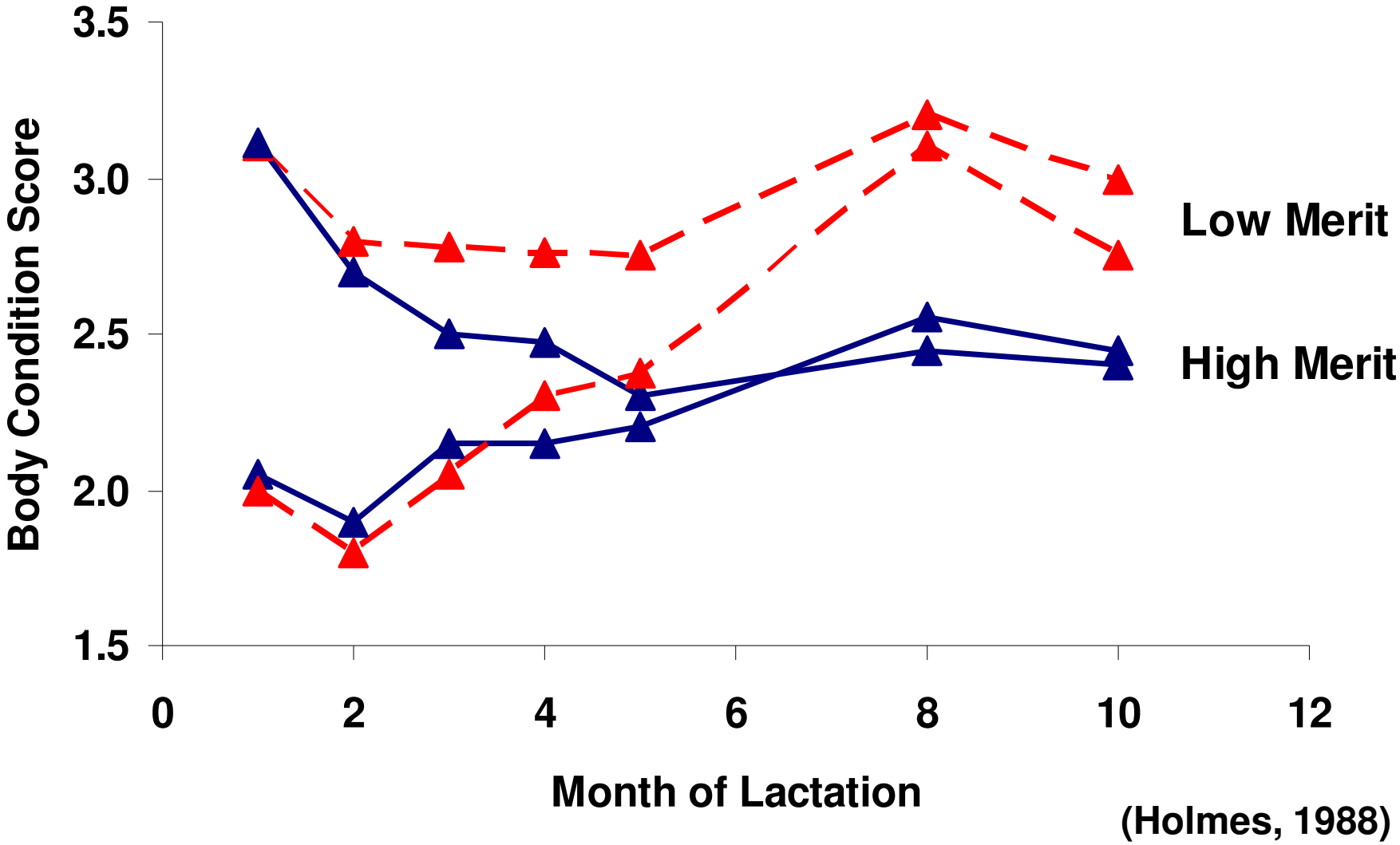


Garnsworthy and Topps, 1982



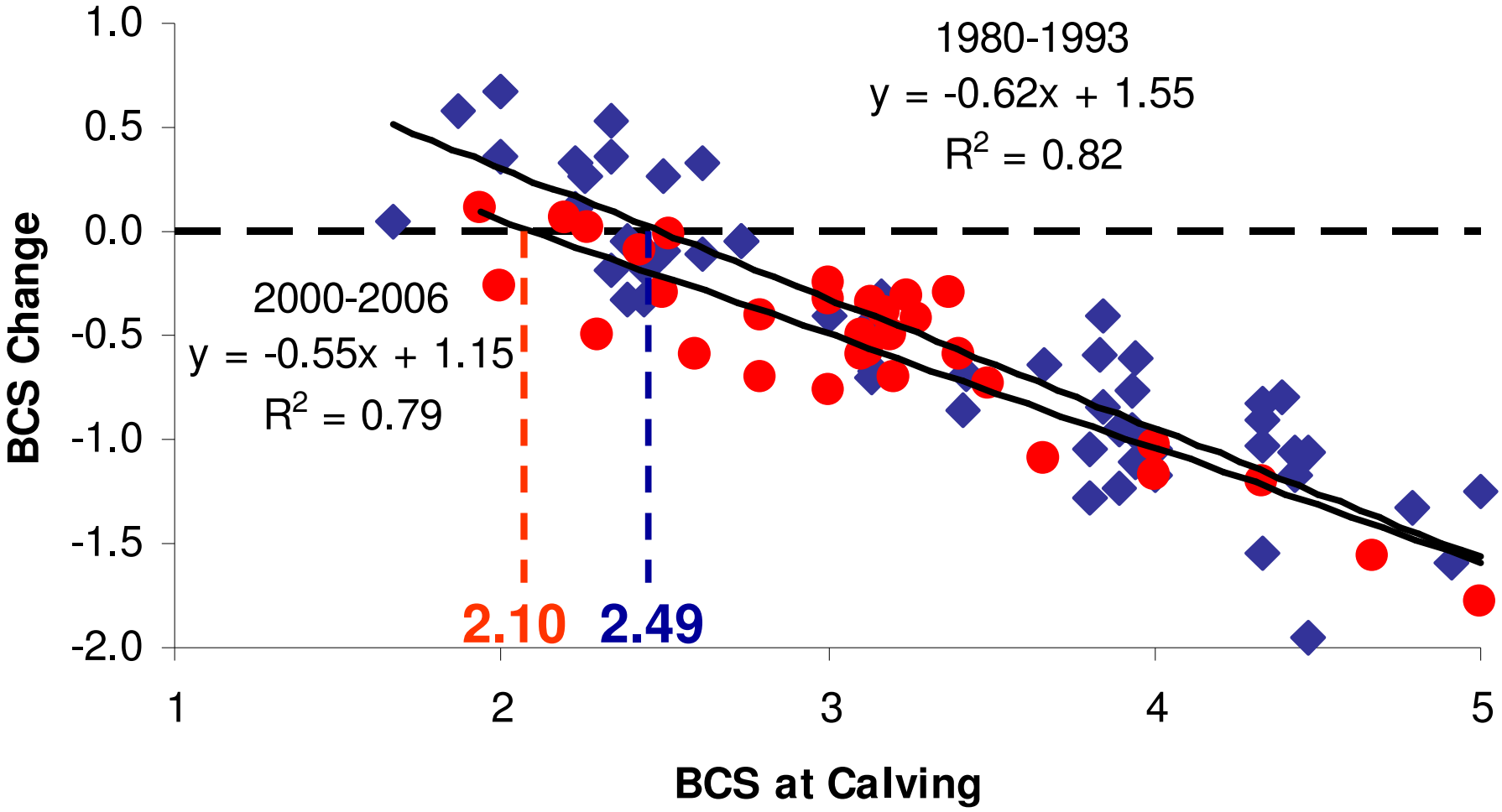
Garnsworthy and Topps, 1982

Change in Condition Score with Genetic Merit



(Holmes, 1988)

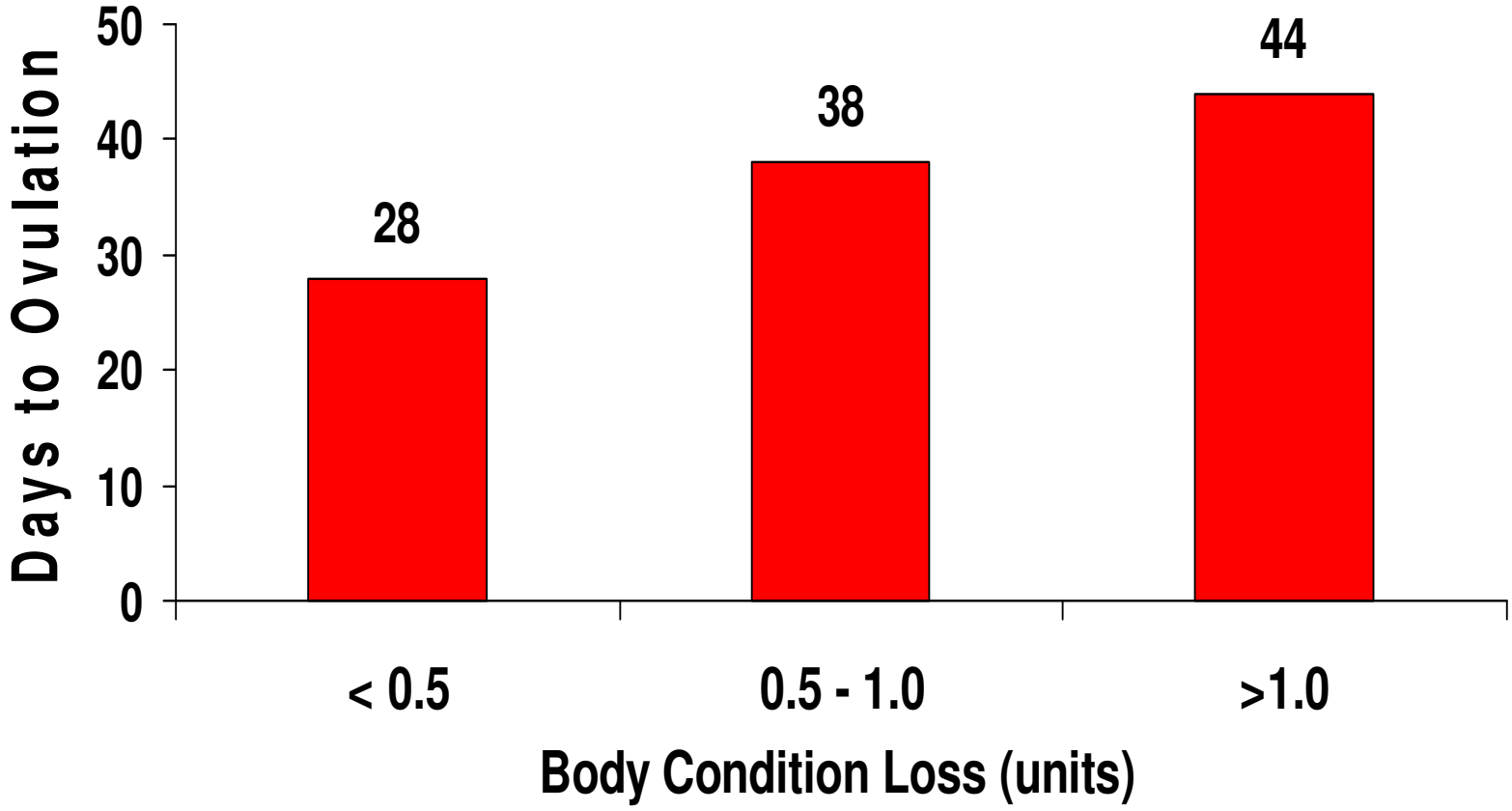
Effect of BCS at Calving on change in BCS (0-10 wks)



23 studies, 81 treatment groups, >5,000 cows

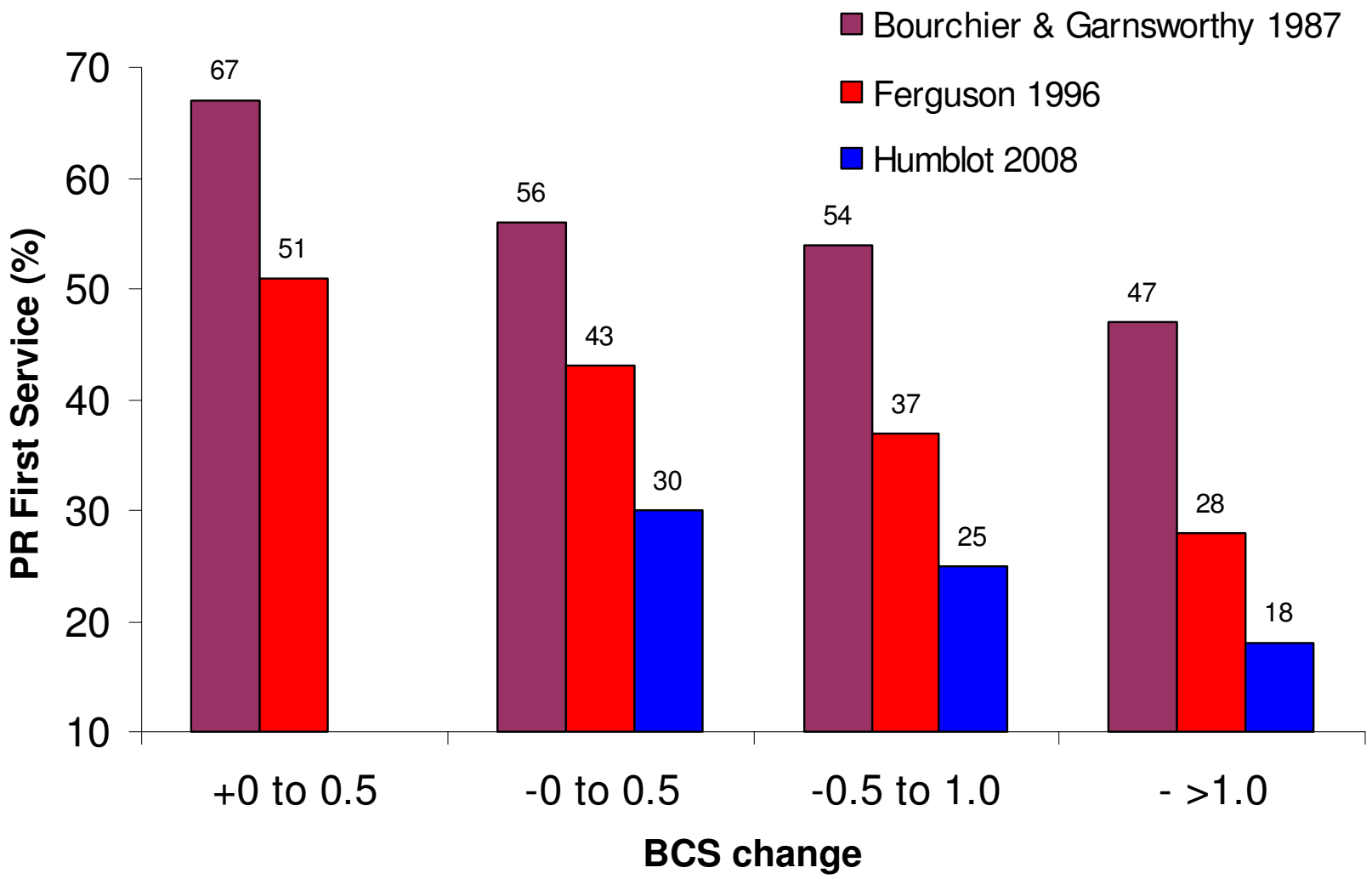
Garnsworthy, 2006

Negative Energy Balance and Resumption of Oestrous Cycles



Butler, 2004

Effect of BCS change on Pregnancy Rate to 1st service



BCS and ketosis

BCS at calving	Odds ratio for ketosis
<=3.25	1.0
3.5-3.75	2.4
4.0-4.25	2.3
>=4.5	2.8

732 cows; P<0.01

Gillund et al. 2001

BCS and Fatty Liver

BCS at calving (1-5 scale)	**2.82**	**3.93**
BCS change 0-8 weeks	-0.52	-1.20
Liver fat week 1 (% liver volume)	15.2	30.8
Liver fat week 4 (% liver volume)	5.2	23.9
Dry matter intake (kg/d)	17.2	15.8
Milk yield (kg/d)	30.9	26.5
Mastitis	3	11
Lameness	4	7
Other disease incidents	6	12

Treacher et al. (1986); Reid et al. (1986)

BCS and oxidative stress

Cows calving with BCS >3.0 had:

Higher:

- Lipid mobilization
- NEFA, BHBA
- Reactive oxygen metabolites (ROM)
- Thiobarbituric acid-reactive substances (TBARS)
- Plasma thiol groups (SH)

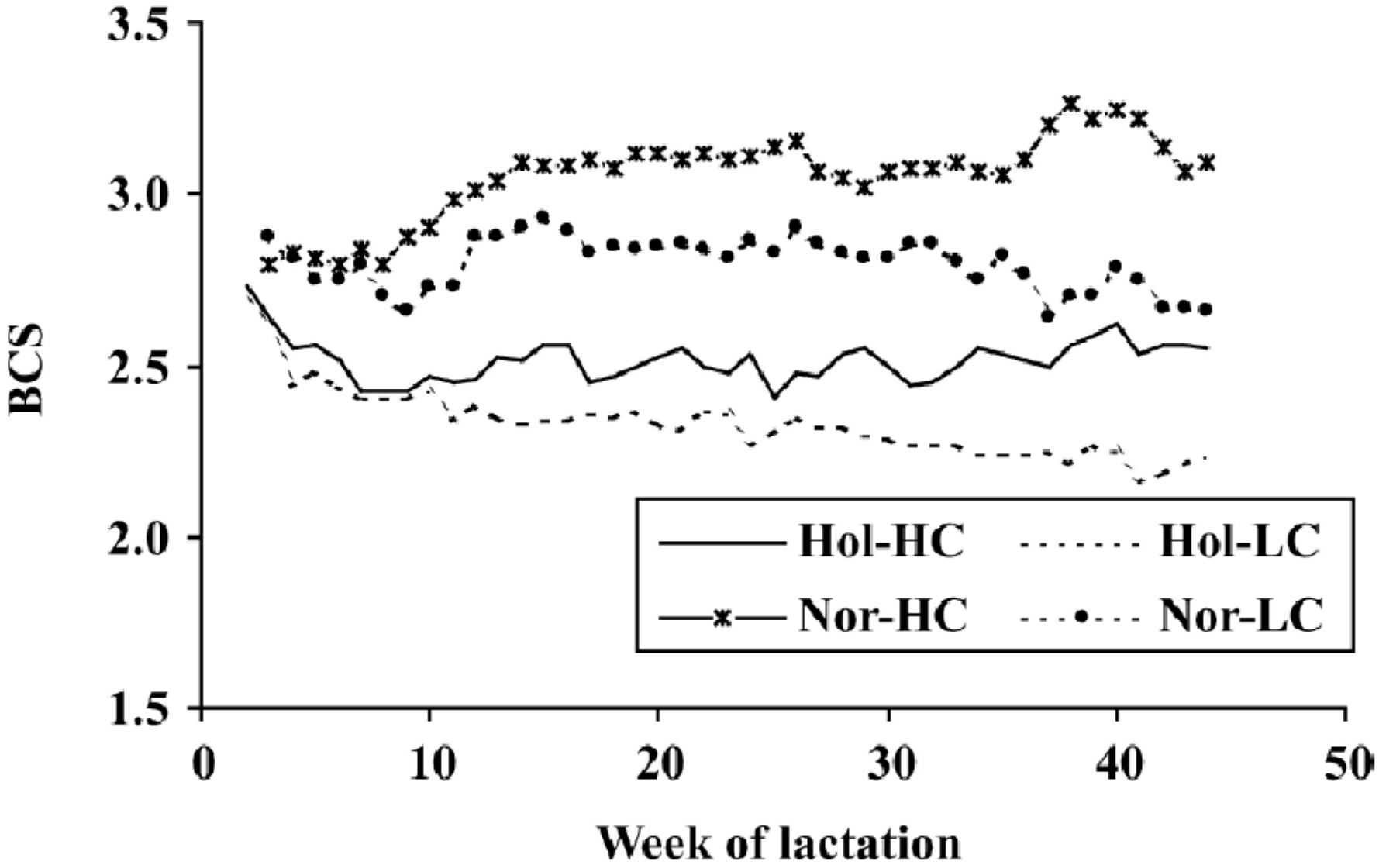
Lower:

- Superoxide dismutase

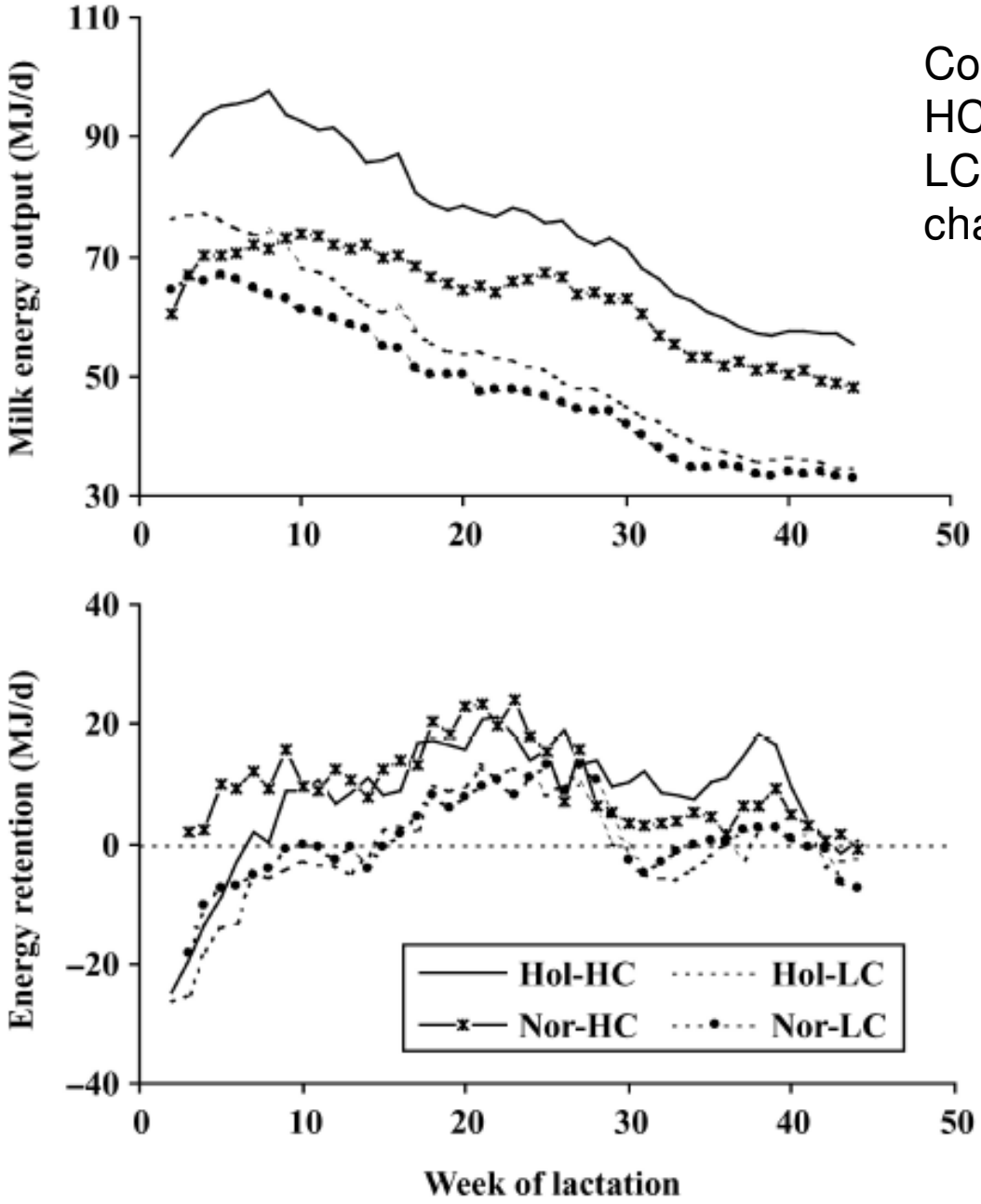
Conclusion: BCS >3 = greater oxidative stress

Bernabucci et al. (2005)

Modern Holsteins do not have to lose BCS



Yan, Mayne, Keady, and Agnew (2006)



Concentrates
HC 60 – 50 – 40%
LC 30 – 20 – 10%
change at 100 & 200d

Energy Balance Summary

- **Prolonged periods of severe negative energy balance must be avoided**
- **The main factor affecting loss of body condition is Body Condition Score at calving NOT nutrition**
- **Modern Holsteins are genetically thinner, so cows with BCS >3.0 at calving will lose ≥1.0 BCS units and be at risk from poor health and fertility**

Outline

- Feed Intake, Energy Balance and Body Condition Score
- Diet, Metabolic Hormones and Reproduction
- Optimal Nutrition for Fertility

High and Low genetic merit dairy cows
Days to first ovulation, Growth Hormone and Insulin

	First ovulation	GH	Insulin
	days	ng/ml	ng/ml
High merit	28.2	14.2	0.35
Low merit	20.1	10.0	0.46

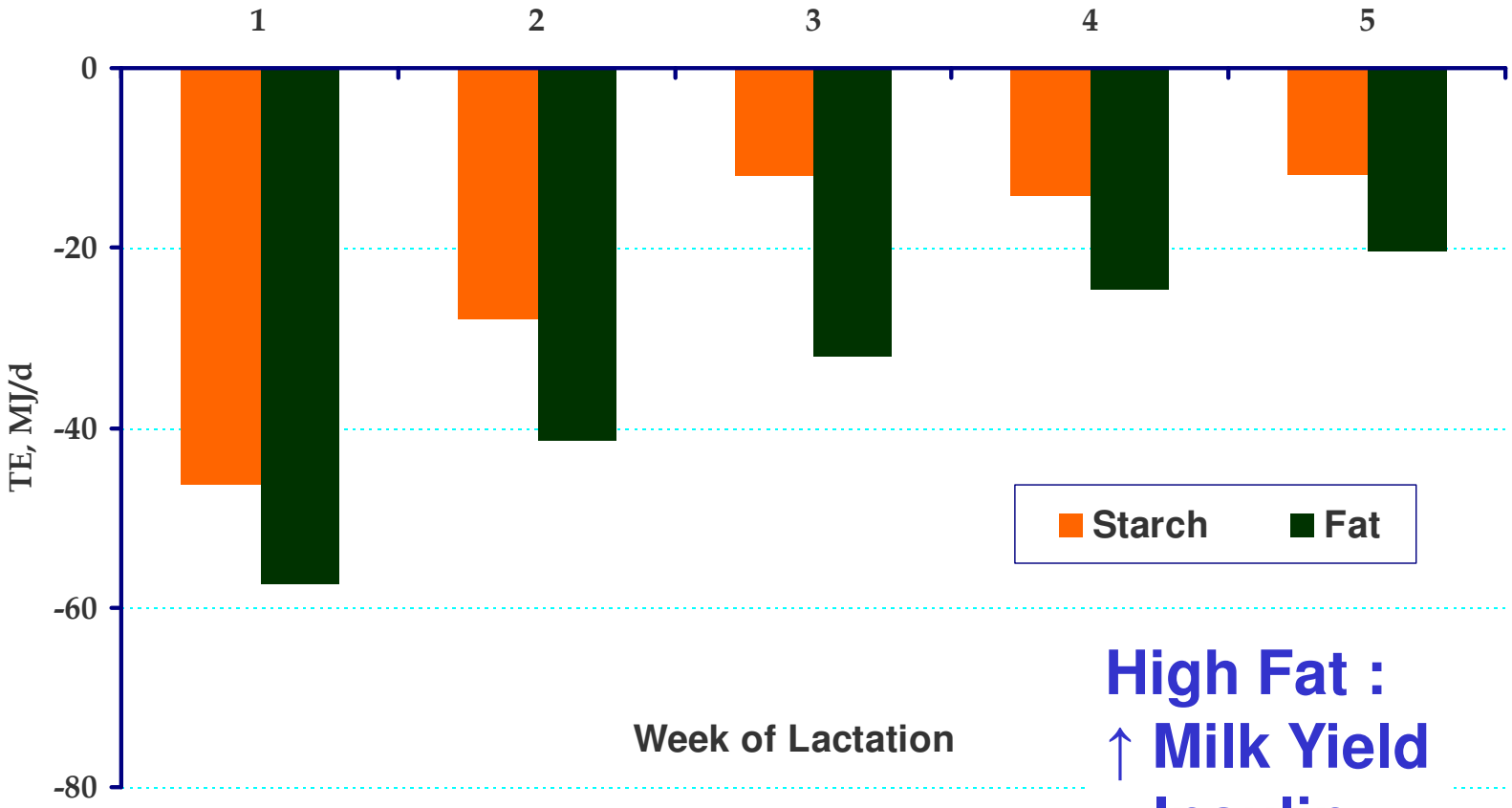
(Gutierrez *et al*., 1999; 2006)

Can we increase insulin by nutrition?

Fat and Starch

Can a high fat or high starch diet overcome the problems of negative energy balance?

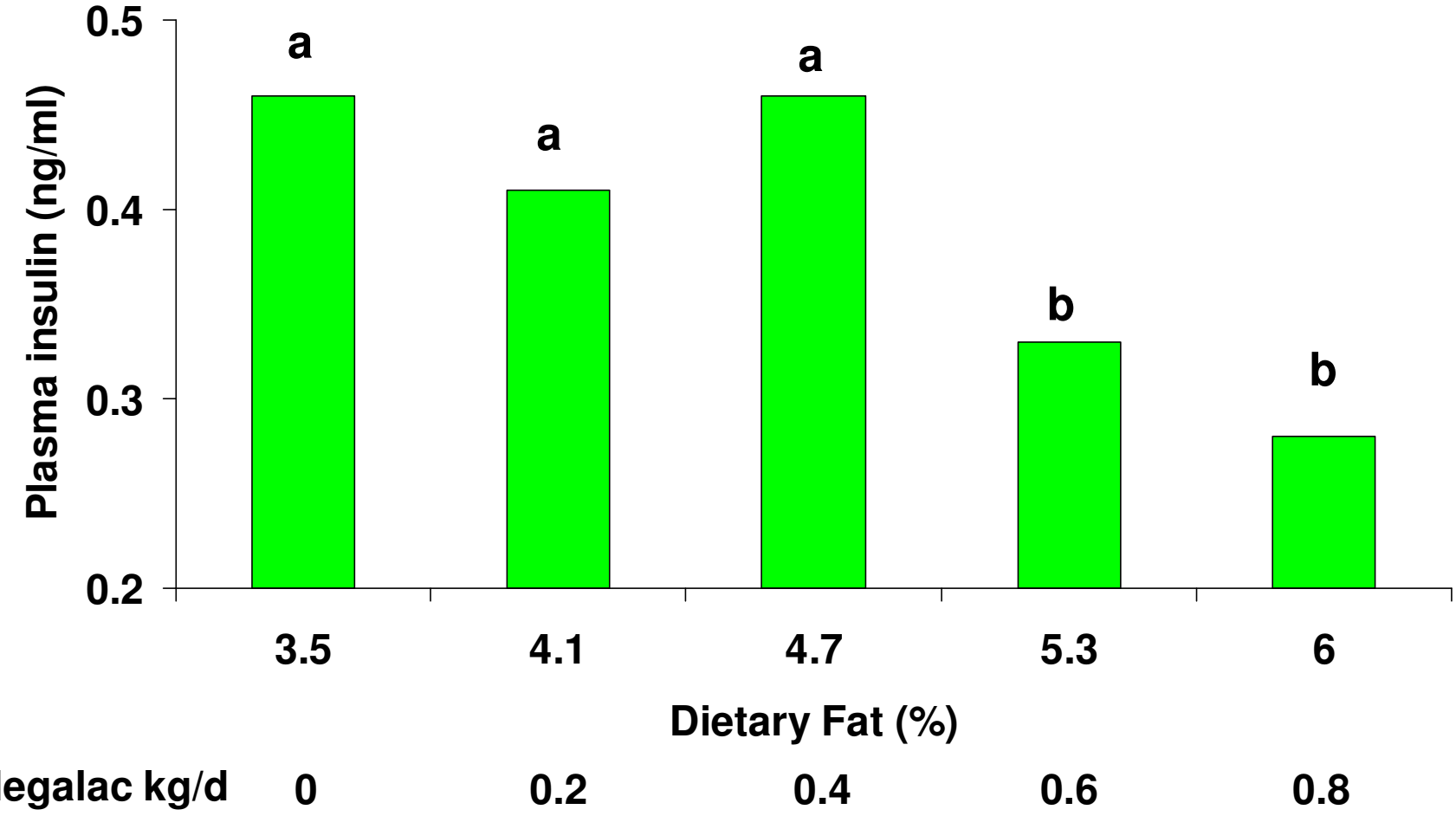
Energy Status: Effect of high dietary starch or fat on body tissue energy balance



High Fat :
↑ Milk Yield
↓ Insulin
↑ NEBAL

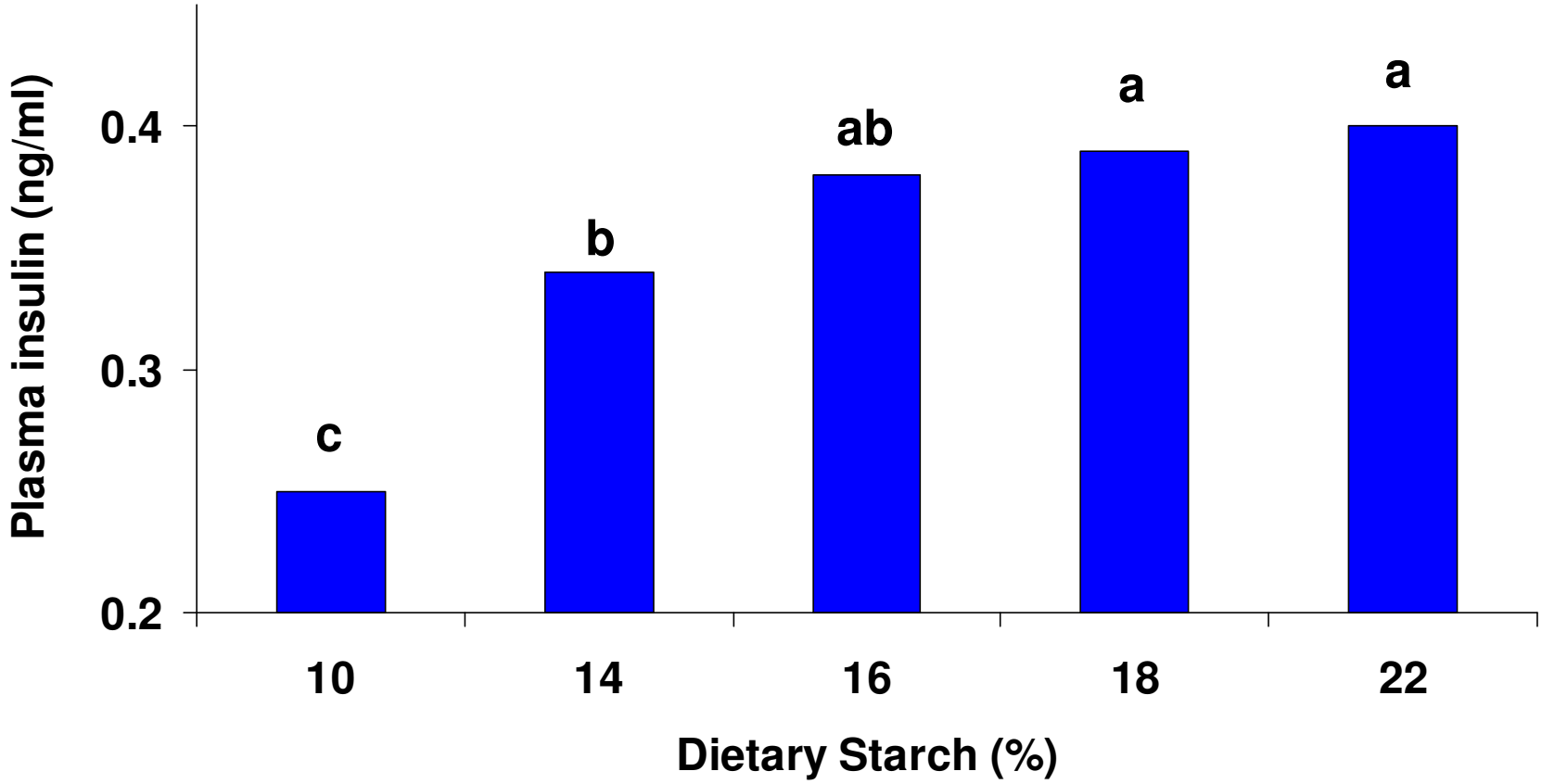
Beever, 2004

Effect of dietary fat content on plasma insulin



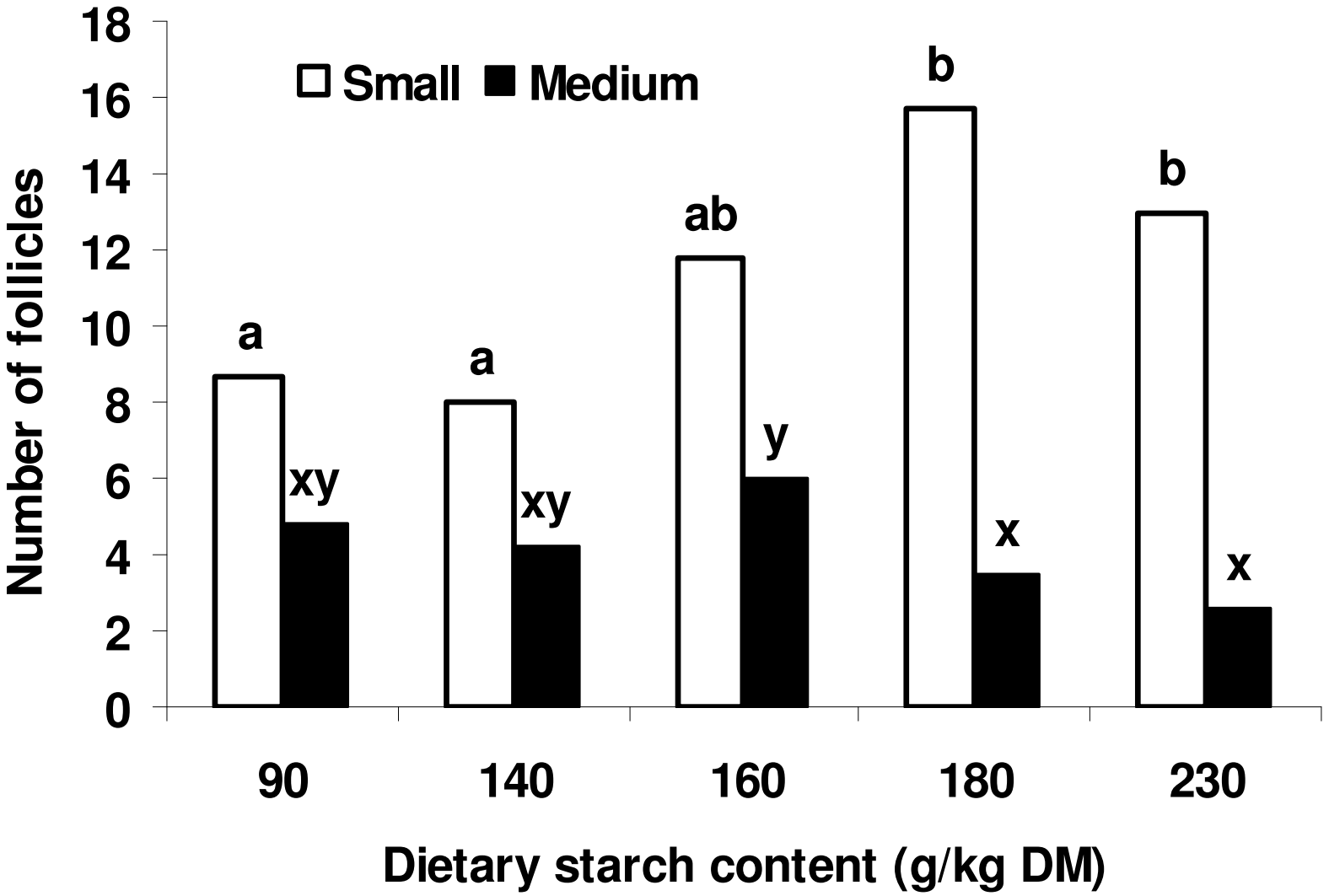
Garnsworthy et al. 2008 *J Dairy Sci* **91:**3824-3833.

Effect of dietary starch content on plasma insulin

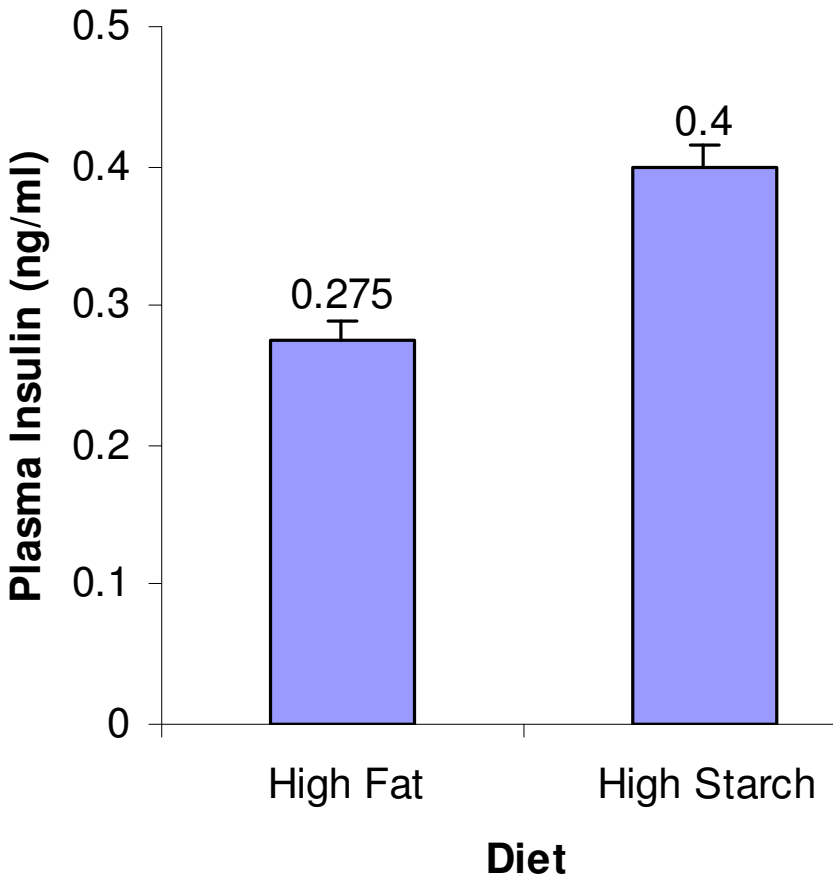


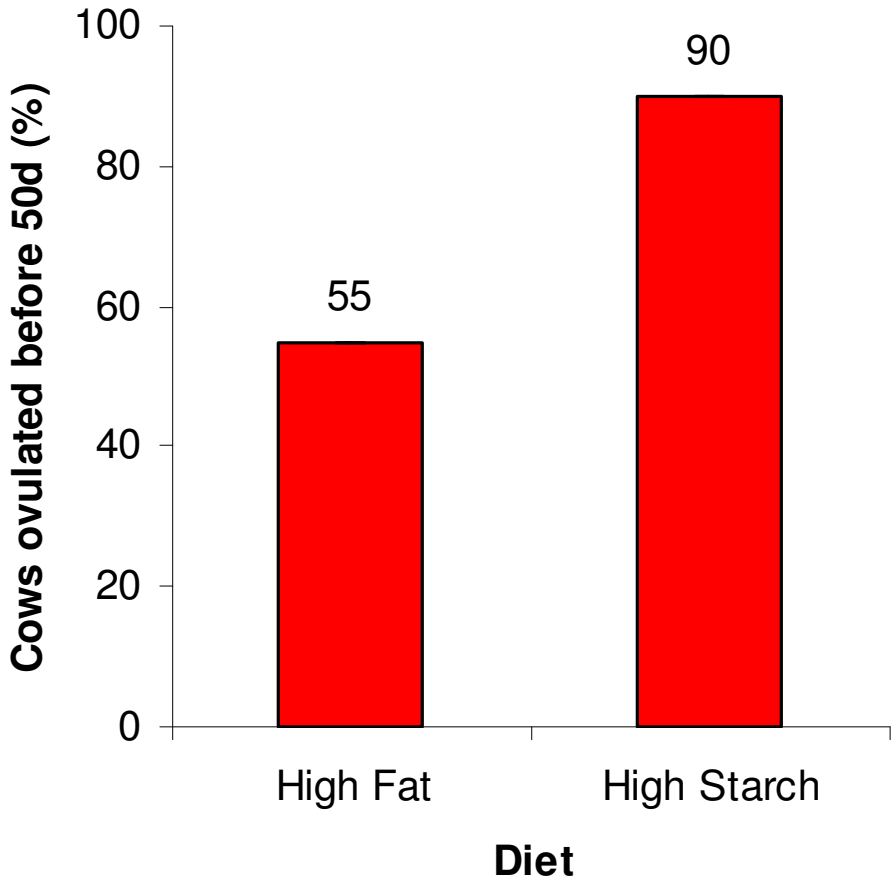
Garnsworthy et al. 2008 *J Dairy Sci* **91:**3814-3823.

Effect of dietary starch content on ovarian follicles



High starch increases plasma insulin and ovulation rate





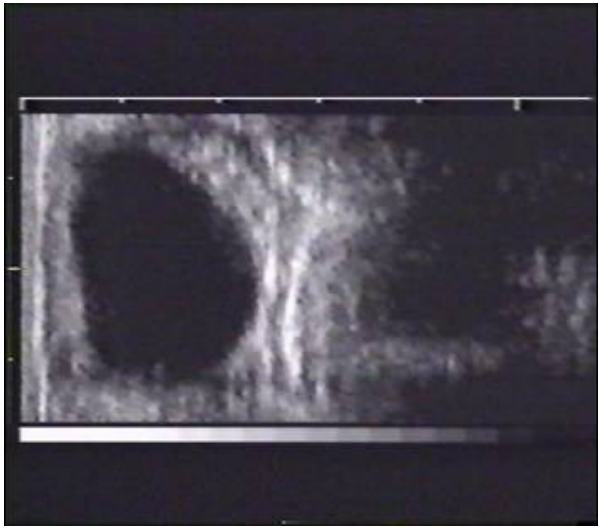
Gong, Lee, Garnsworthy, and Webb (2002) *Reproduction*, **123**, 419-427.

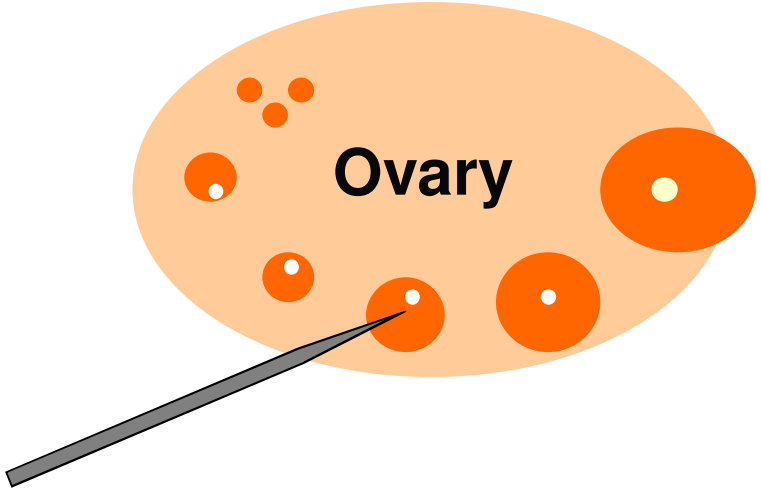
Insulin Conclusions

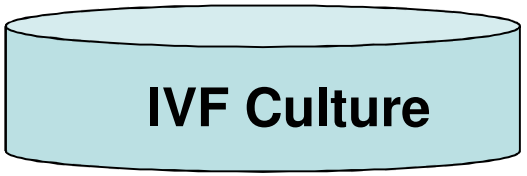
- **Improving insulin status of dairy cows encourages resumption of oestrous cycles**
- **Insulin status can be improved by high starch / low fat diets – but not too high starch or too low fat**
- **A note of caution …**

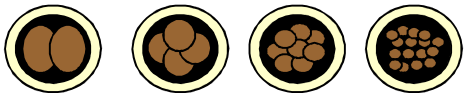
… beware oocyte quality!

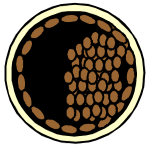
Ultrasound-guided ovum pickup (OPU)



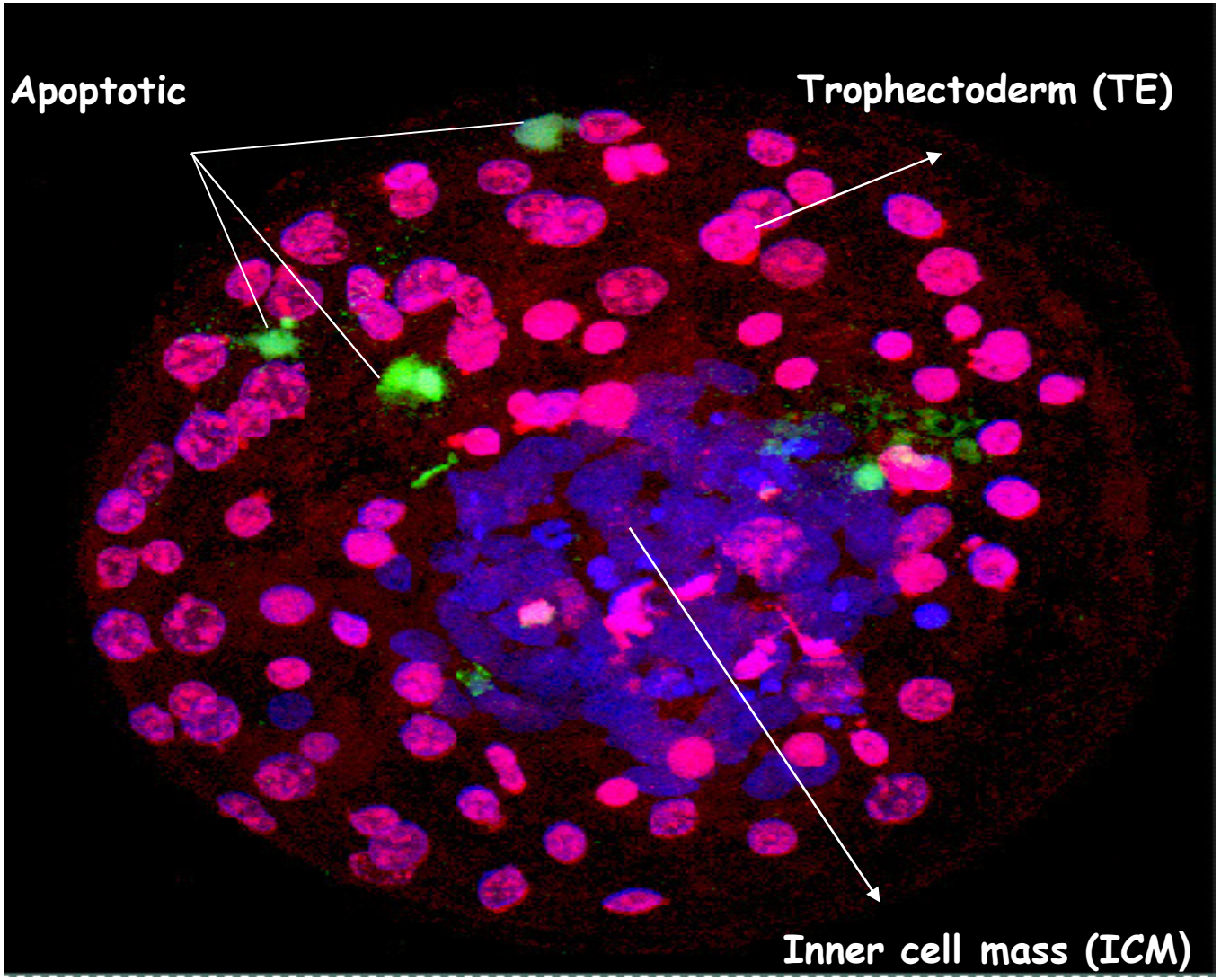




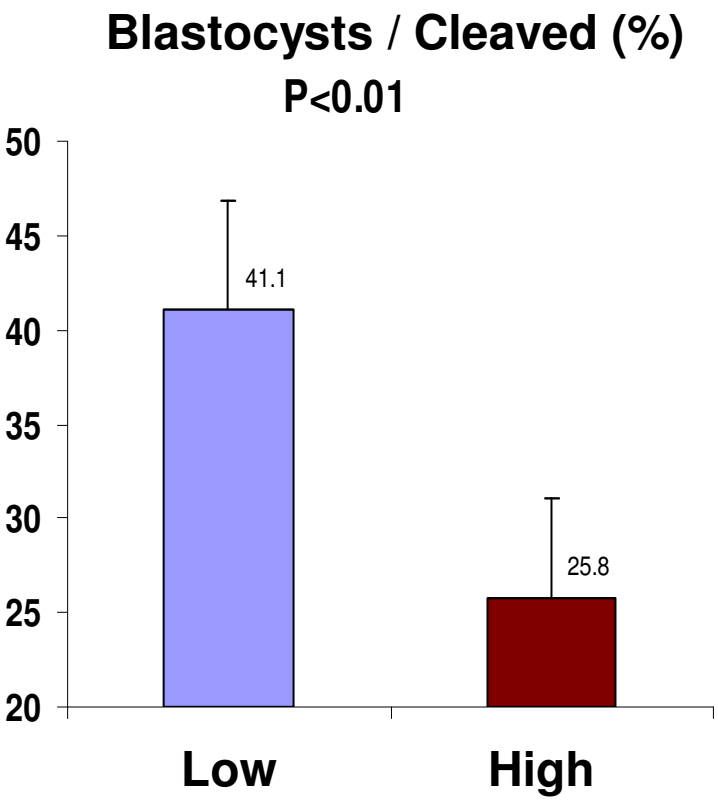


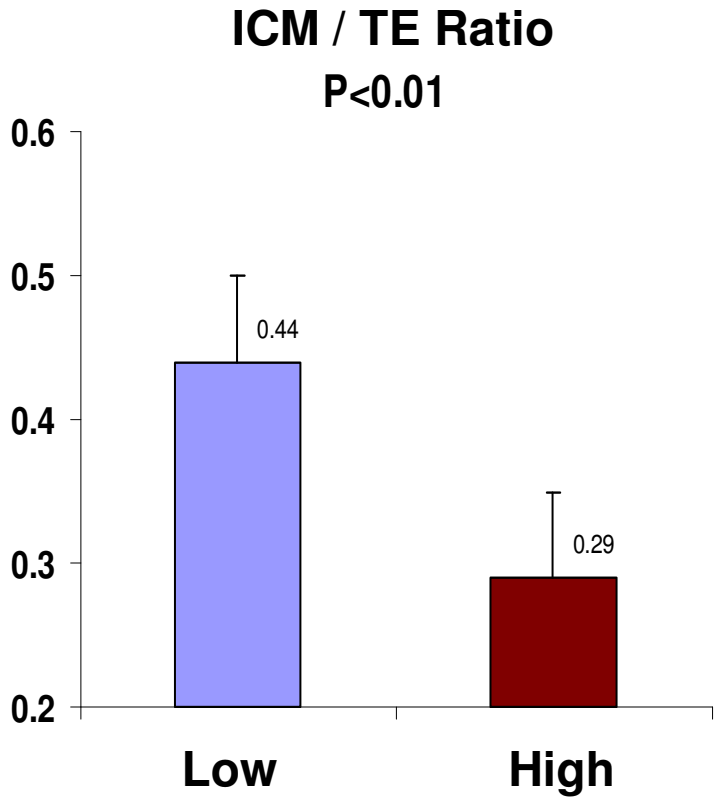


Day 8 blastocysts used for differential staining



High Insulin reduces oocyte quality in dairy cows

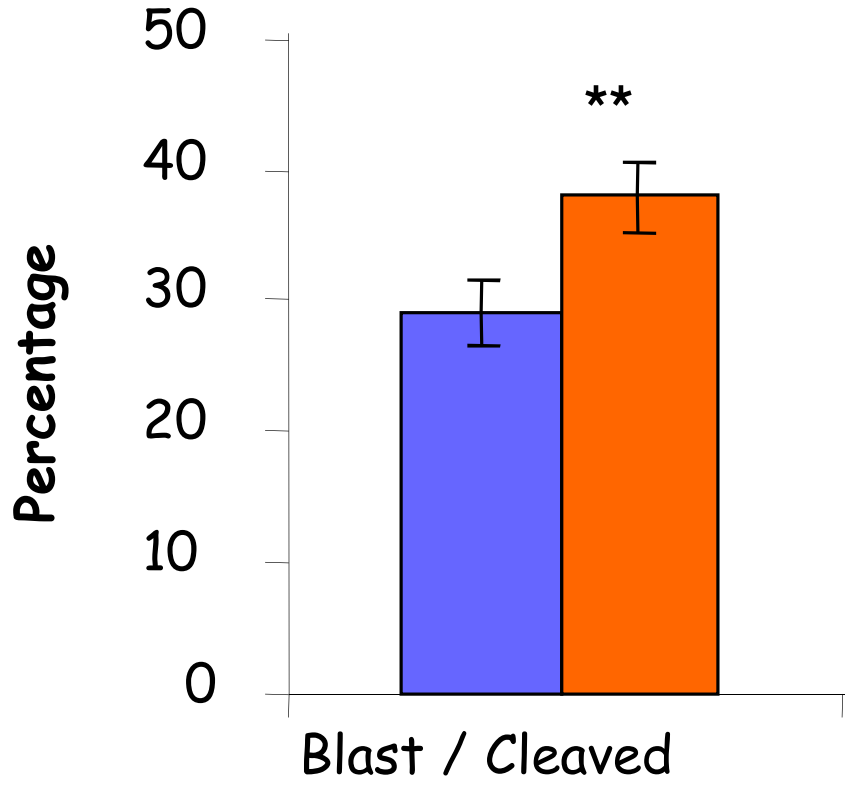




56 OPU, 243 oocytes

Fouladi et al. (2005)

High Fat produces better oocytes in dairy cows



No effect on ICM/TE ratio

Fouladi-Nashta et al. 2007

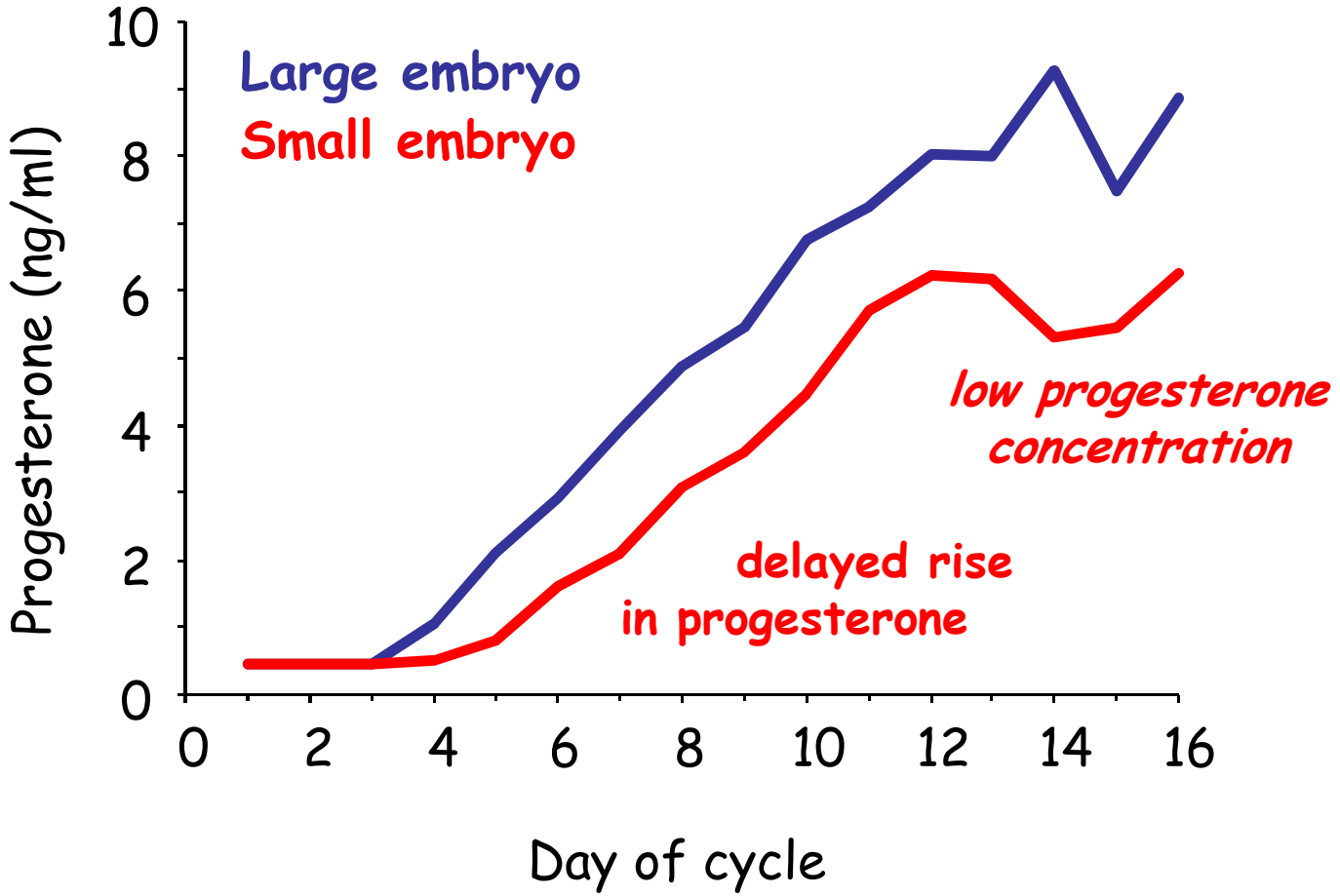
144 OPU, 1051 oocytes

Another Insulin Conclusion

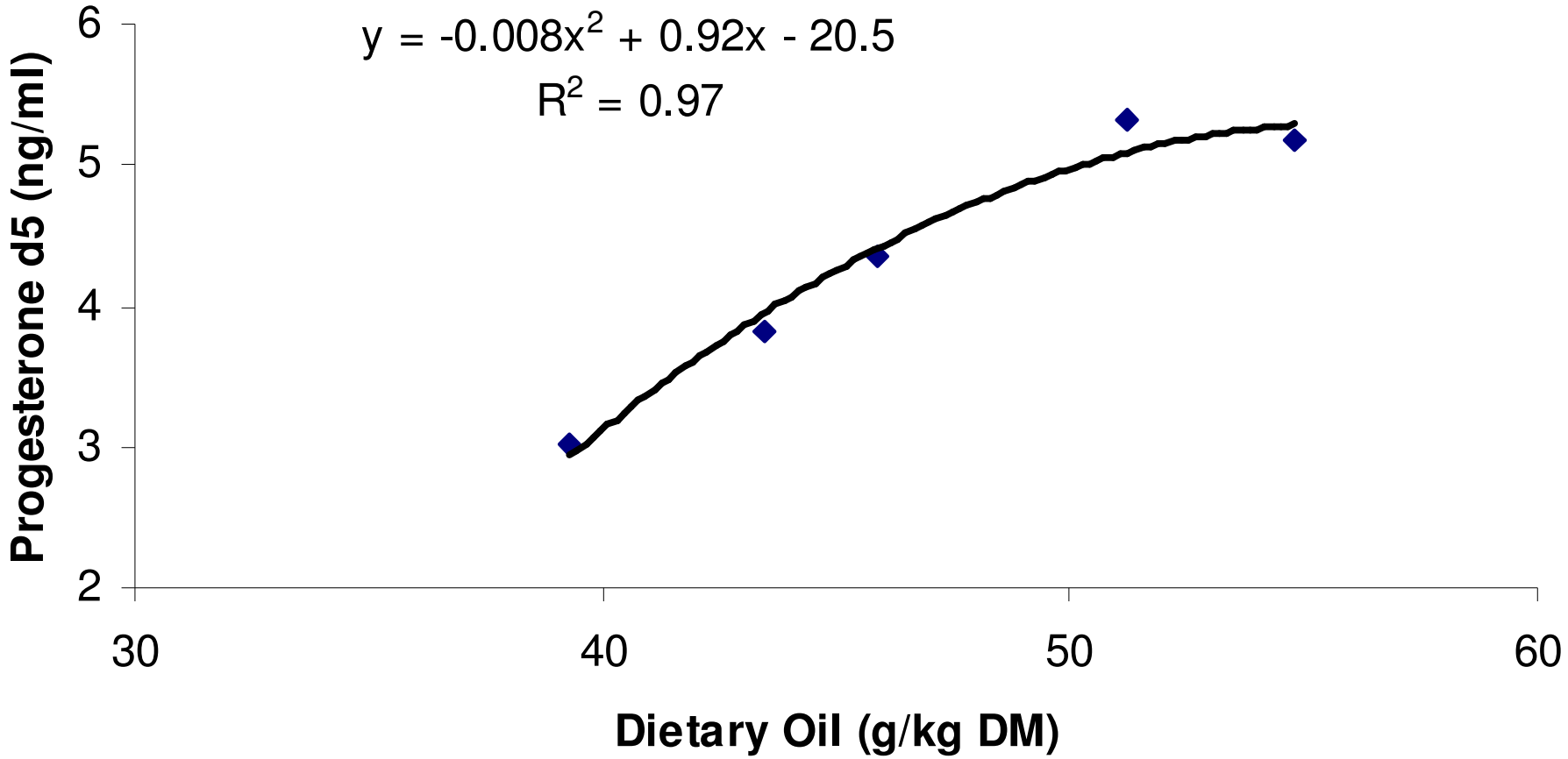
For good oocyte quality and blastocyst development we need low starch and/or high fat

i.e. a LOW insulin diet !!

Progesterone and embryo development



Effect of dietary fat concentration on Progesterone at Day 5 of the Oestrous Cycle



Garnsworthy et al. 2008

Summary: Fertility and Insulin

Early resumption of oestrous cycles

High insulin

Good follicular development

High insulin

Good quality oocyte

Low insulin – High fat

Establishment of pregnancy (High Day-5 P4)

Low insulin – High fat

A conundrum!

Outline

- Feed Intake, Energy Balance and Body Condition Score
- Diet, Metabolic Hormones and Reproduction
- Optimal Nutrition for Fertility

Nottingham Pregnancy study

High insulin cycling diet (18% starch, 3.9% fat)

Low insulin mating diet (10% starch, 5.3% fat)

4 dietary treatments, 60 cows (n = 15)

Diets changed after cows started to cycle (≈50 d)

Days 0 to 120 of lactation

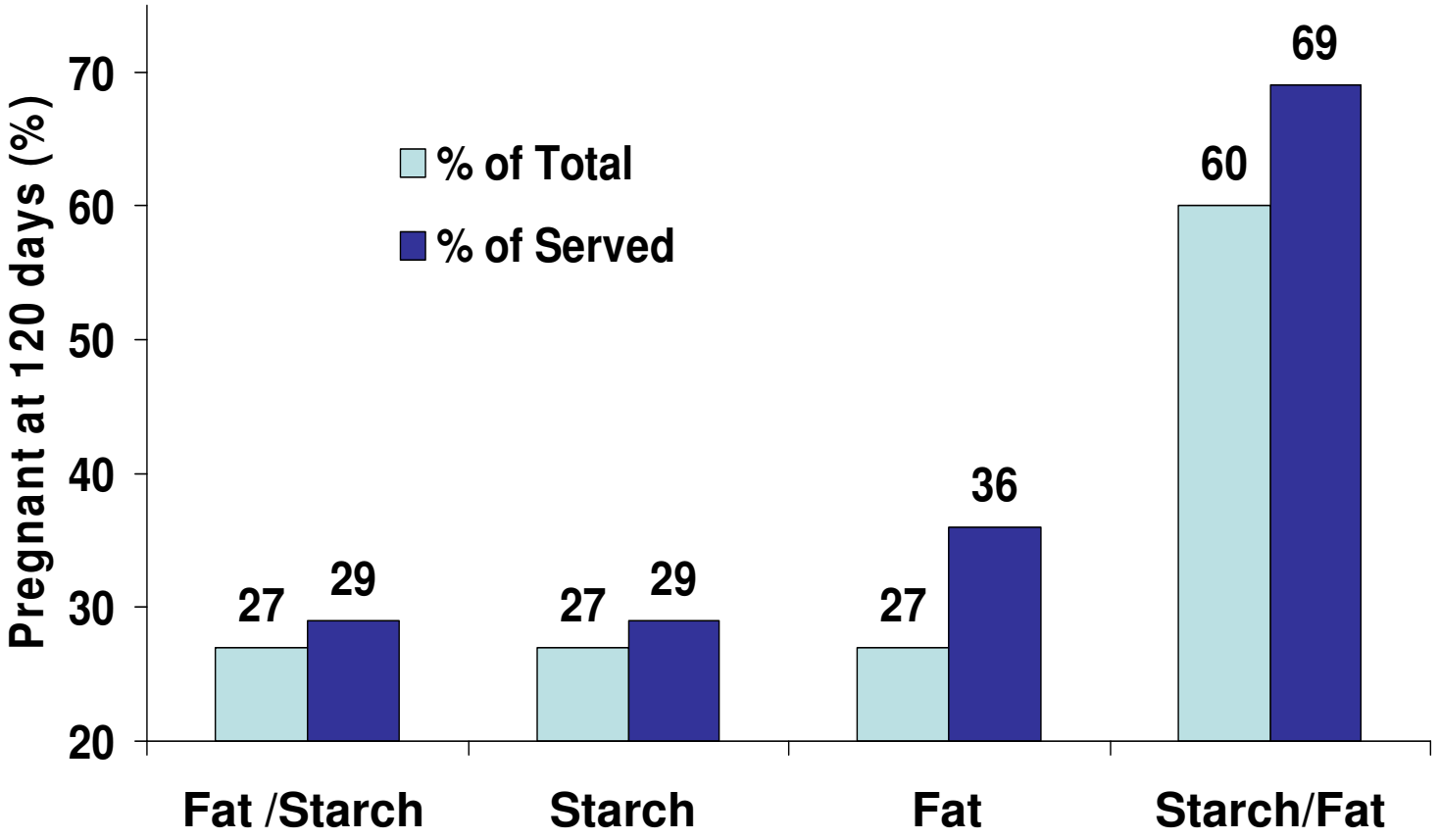
1. Worst for reproduction (LH)
2. Intermediate A (H)
3. Intermediate B (L)
4. Best for reproduction (HL)

Garnsworthy et al. (2009) *Reproduction* **137**, 759-768

No treatment effect on:

- Milk yield, energy balance, BCS
- Days to first progesterone rise (29 +/- 5.4)
- Days to first insemination (74 +/- 7.6)
- Proportion of cows served (87%)
- Days to conception (78 +/- 12.2)
  (for cows pregnant at 120 DIM)

Pregnancy rate at 120 days with diets designed to improve cycling (High Starch) or oocytes (High Fat)



Garnsworthy et al. (2009) *Reproduction* **137**, 759-768

Overall Fertility Conclusions

A high insulin diet improves follicular development in early lactation

A low insulin diet improves oocyte quality

For best results, feed the right diet at the right time

(Or MAYBE avoid extremes?)

Conclusions

- Nutrition can have profound effects on all aspects of production, health and reproduction
- Negative energy balance must be minimised by controlling body condition in late lactation
- Avoid extremes of fat, starch [and protein] – an excess can be as bad as a deficiency
- Resumption of oestrous cycles is encouraged by high insulin, oocyte quality by low insulin
- Optimum nutrition at each stage of the lactation cycle significantly improves health and fertility

Thank you for your attention