Objective

- To review current information on embryonic and early foetal losses in cattle
- Focus on some of the factors that affect it’s incidence
- To propose potential avenues to increase embryo and foetal survival rates

Definitions of Early Embryo / Foetal Mortality

Early Embryo Death:

Death of a fertilised ovum prior to implantation

Implantation ~ starts Day 21

Foetal Mortality:

Death of foetus from implantation stage onwards

Reported Fertilisation Rates in Heifers

Study	Fertilisation rate	
Beardon et al. (1956)	48/55	(87)
Henricks et al. (1971)	16/18	(89)
Wishart & Young (1974)	41/43	(95)
Spitzer et al. (1978)	18/22	(82)
Diskin & Sreenan (1980)	27/30	(90)
	37/41	(91)
Linares (1981)	31/32	(97)
Roche et al. (1981)	42/52	(81)
	46/55	(84)
Smith et al. (1982)	41/45	(91)
Maurer & Chenault (1983)	31/34	(91)
	24/32	(75)
Sartori et al 2002	32/32	(100)
Overall	434/491	(88)

Fertilisation Rates: Cows

Study	Fertilisation Rate (%)	
Boyd et al. (1969)	28/33	(85)
Ayalon (1972)	10/12	(83)
	22/25	(88)
Shelton et al. (1979)	26/30	(87)
Maurer & Chenault (1983)	19/19	(100
	17/17	(100)
All	122/136 (90)	

Fertilisation Rates in Dairy Cows Recent Studies

Study	Animals Conditions	**Fertilisation rate %**
Wiebold 1988	Lact. Cows	**92**
Ryan et al., 1993	High Temp (Lact. cows) Low Temp (Lact. cows)	**82.4** **79.5**
Sartori et al., 2002	High Temp (Lact. cows) High Temp (heifers)	**55.6** **100**
Sartori et al., 2002	Low Temp (Lact. cows) Low Temp (dry cows)	**87.8** **89.5**

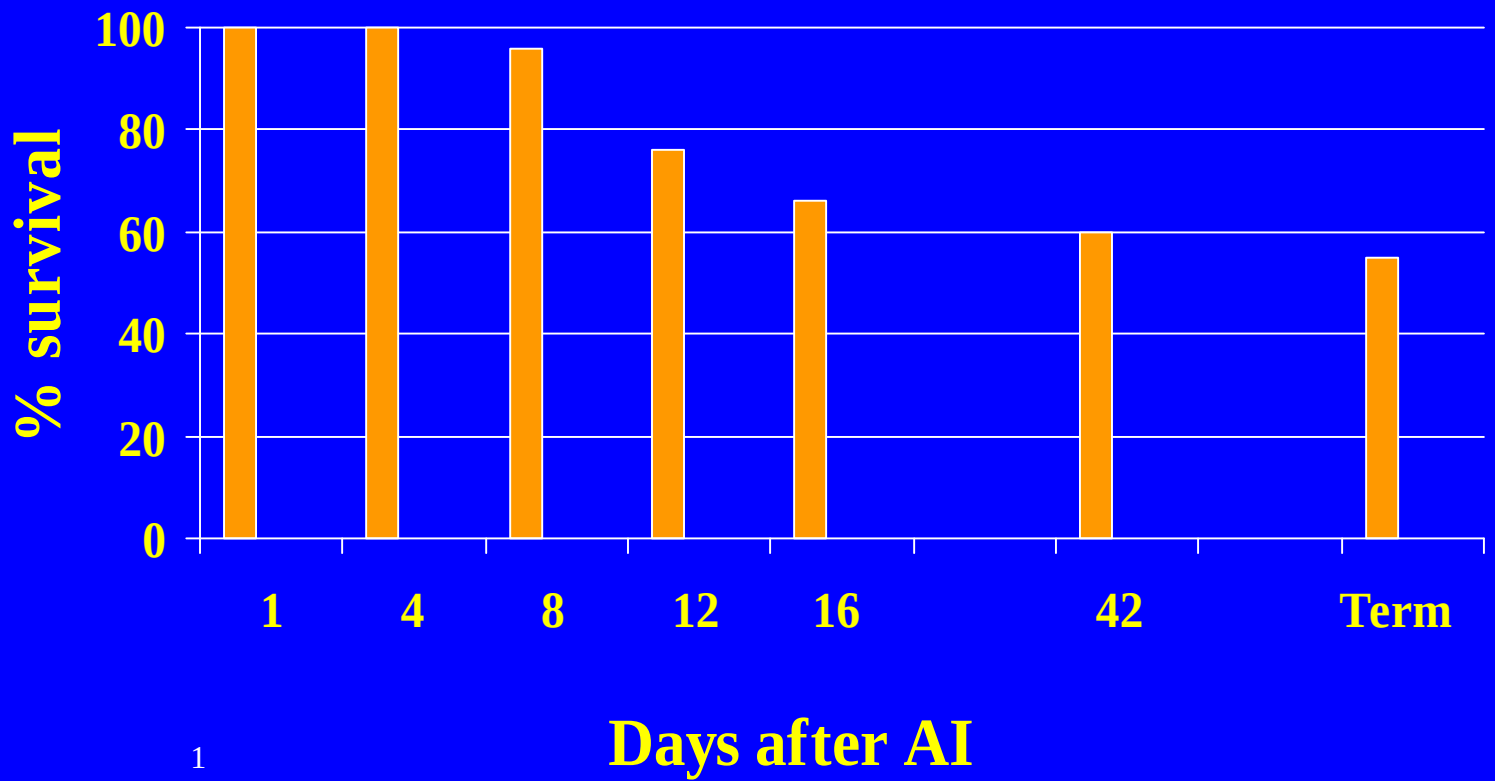
Summary: Fertilisation Rates

- **Heifers & Moderate-Yielding Cows ~ 90%**

- **High-Yielding Dairy Cows ~ <90%**

  more variable?

Embryo survival rate in heifers and moderate yielding cows



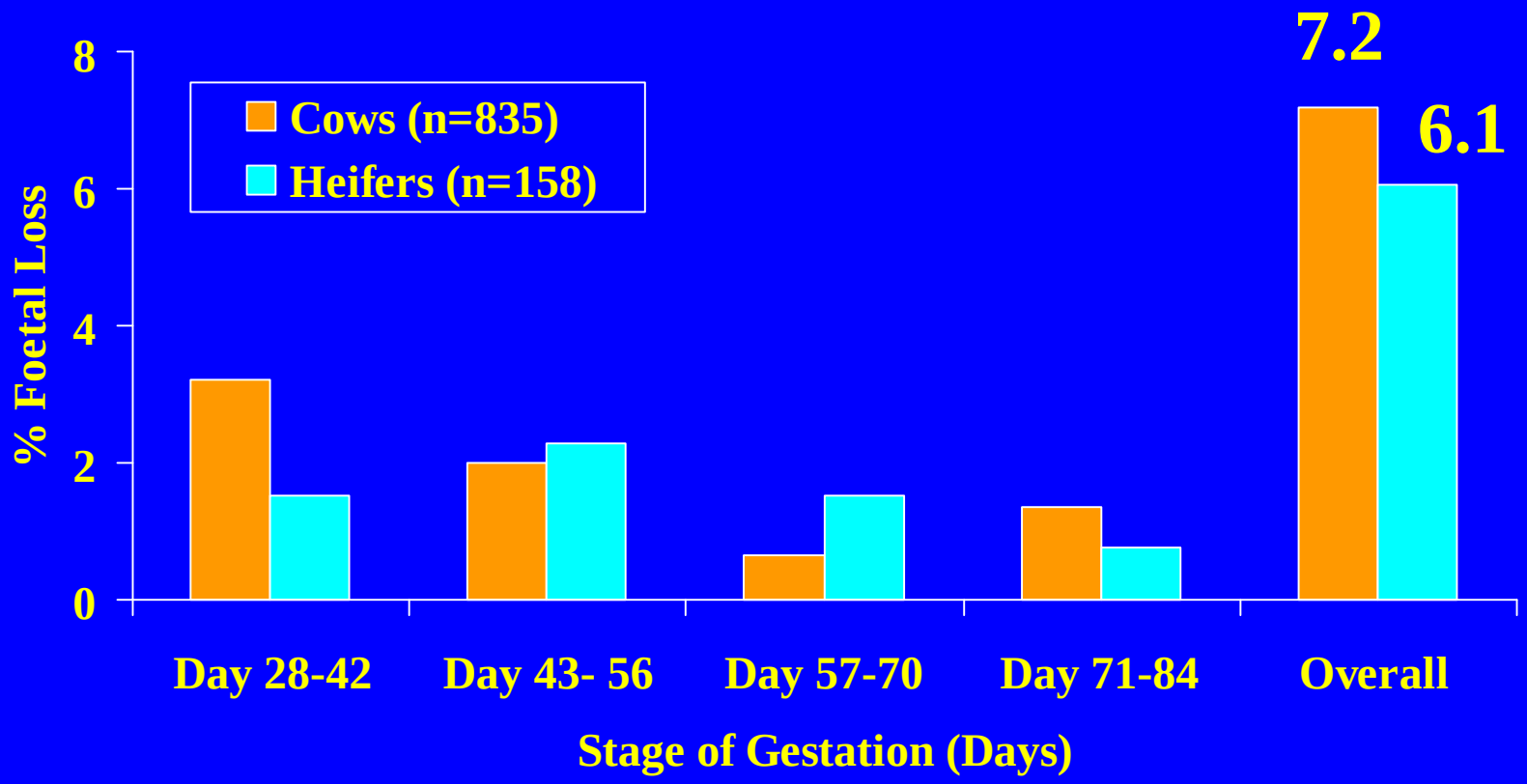
Fertilisation and Early Embryo Survival Rates in Dairy Cows Recent Studies

Study	Animals Conditions	Fertilisation rate %	% embryo survival at Day 7
Wiebold 1988	Lact. Cows	**92**	**52**
Ryan et al., 1993	High Temp (Lact. cows)	**82.4**	**71**
	Low Temp (Lact. cows)	**79.5**	**65**
Sartori et al., 2002	High Temp (Lact. cows)	**55.6**	**59**
	High Temp (heifers)	**100**	**72**
Sartori et al., 2002	Low Temp (Lact. cows)	**87.8**	**61**
	Low Temp (dry cows)	**89.5**	**93**

Summary: Early Embryo Survival (to Day 7-8 adjusted for Fertilisation failure rate)

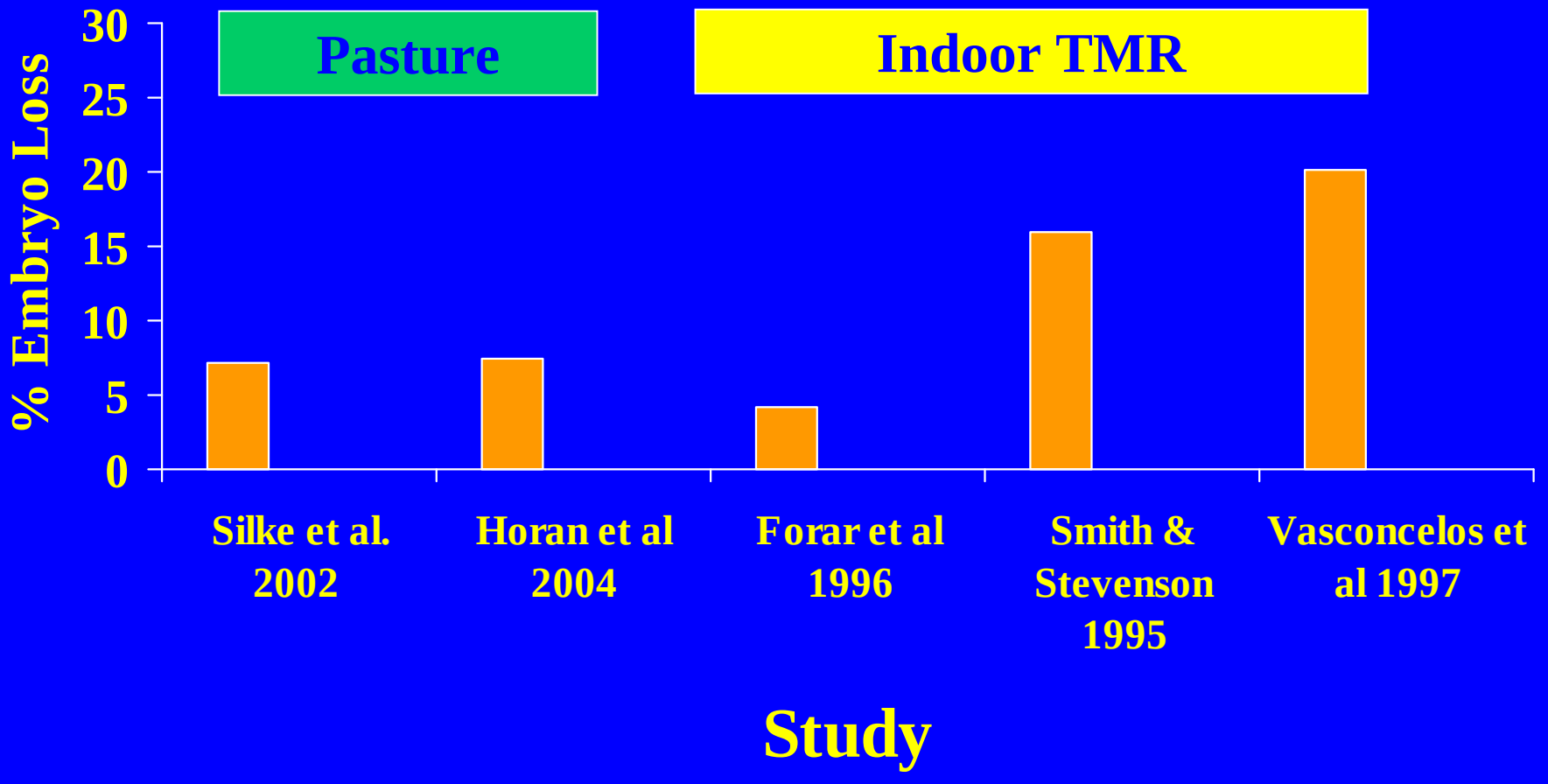
- Sreenan –Diskin 1986 (Heifers): 94%
- Recent heifer/ Dry cow studies: 83%
- High- yielding dairy cows: 62%

Timing of late embryo (foetal) mortality in lactating dairy cows and heifers on pasture

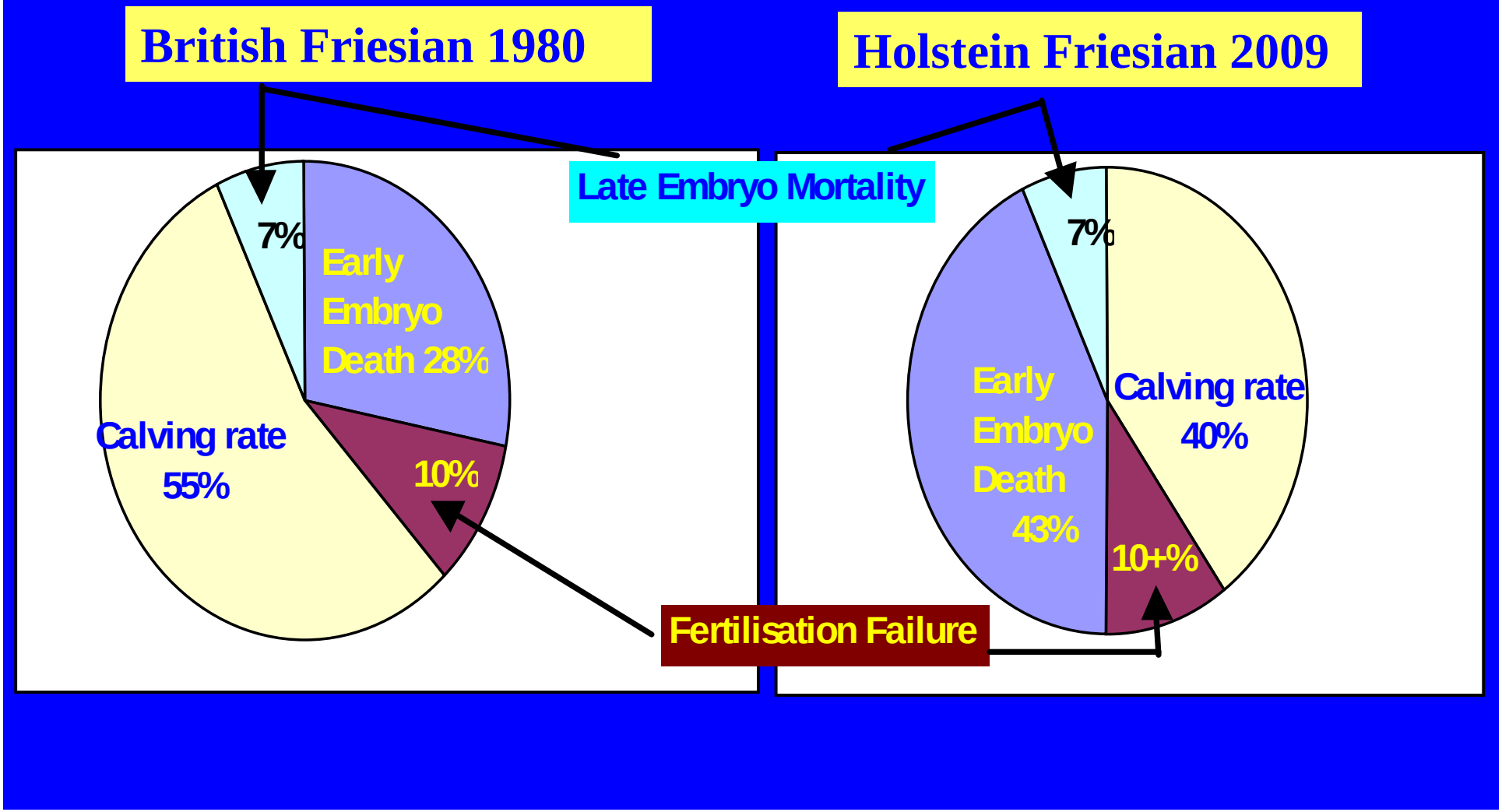


Silke et al., 2001

Extent of late embryo loss: comparison of studies



Reproductive Outcomes
British Friesian vs Holstein Friesian



Why do embryos die ?

Genetic: Chromosomal abnormalities

Genetic: Maternal/Paternal

Oocyte Quality: Aged follicle

Endocrine: Progesterone

Environmental: Disease/Nutrition

Genetic Causes

- **1/29 Robertsonian translocation (Swedish Red Cattle)**
- **Deficiency of Uridine Monophoshate Synthase (DUMPS) – homozygous recessive causing foetal death at 40-50 days**
- **Complex Vertebral Malformation (CVM), homozygous recessive and causes late embryo/ foetal death**

Inbreeding/Crossbreeding

- **Inbreeding of the Dam**

  Reduces 56-70 day non-return rates by 1-2% per 10% inbreeding

- **Inbreeding of the embryo**

  Reduces 70 day non-return rates by 1 per 10% inbreeding

- **Crossbreeding**

  Increases Embryo survival by ?

Maternal Age

Heifer: conception rate is at maximum at 15-16 months. (Kuhn et al., 2006)

13 percentage higher CR at 15-16 vs 26 months

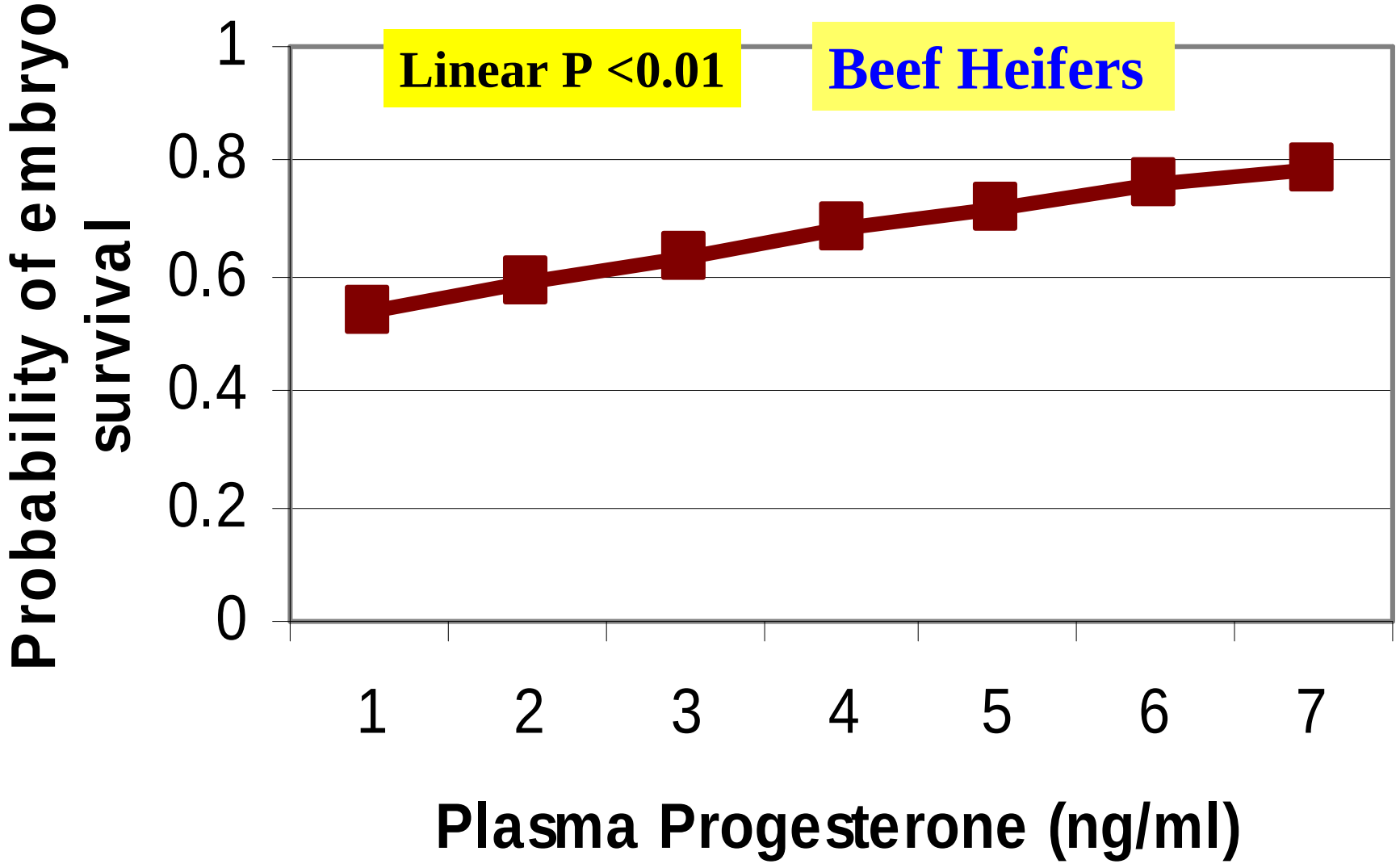
Older dairy cows: lower CR than heifers and 1st Parity cows (- production-related)

Progesterone and Embryo Survival rate

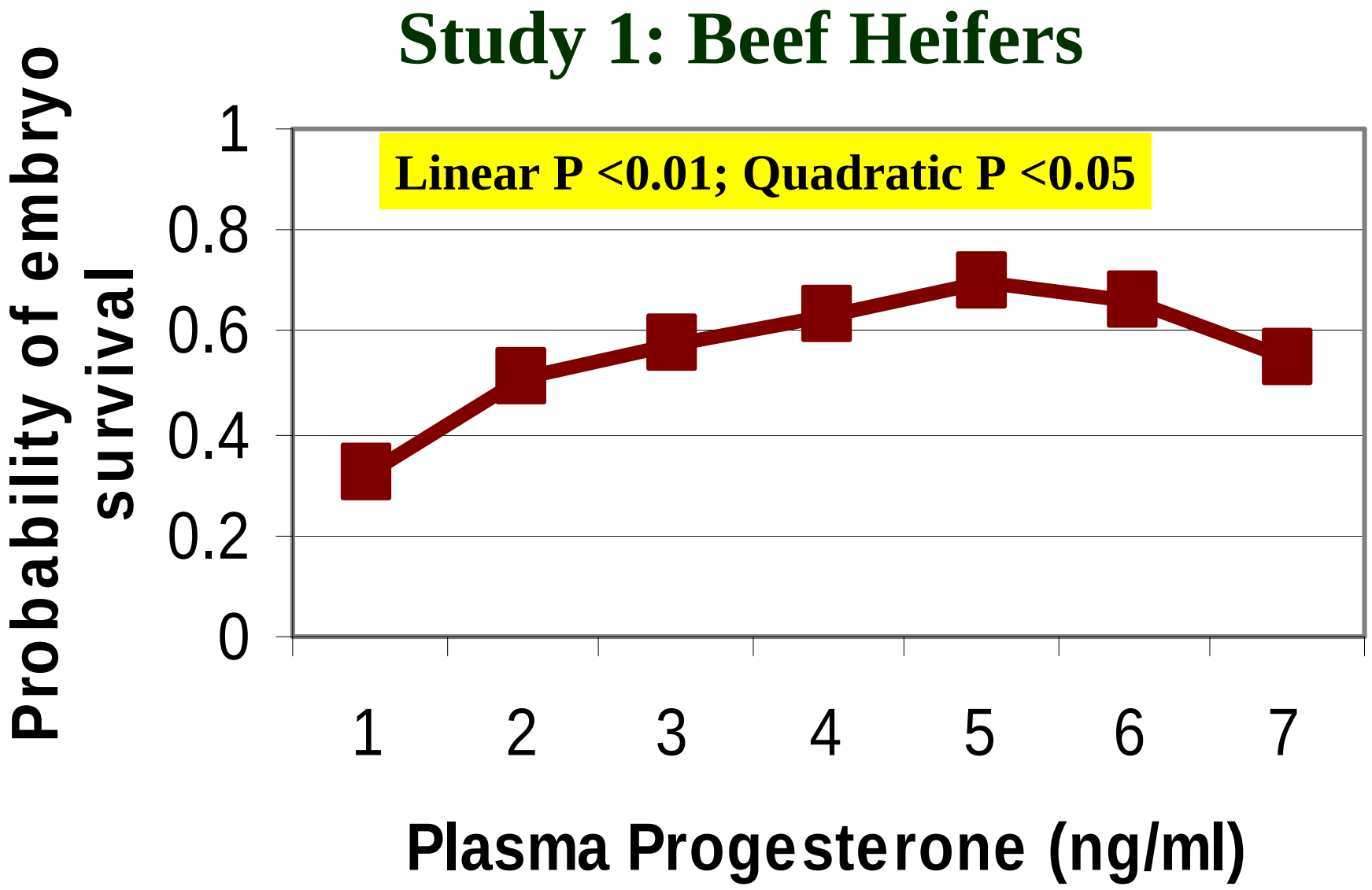
Background

Progesterone

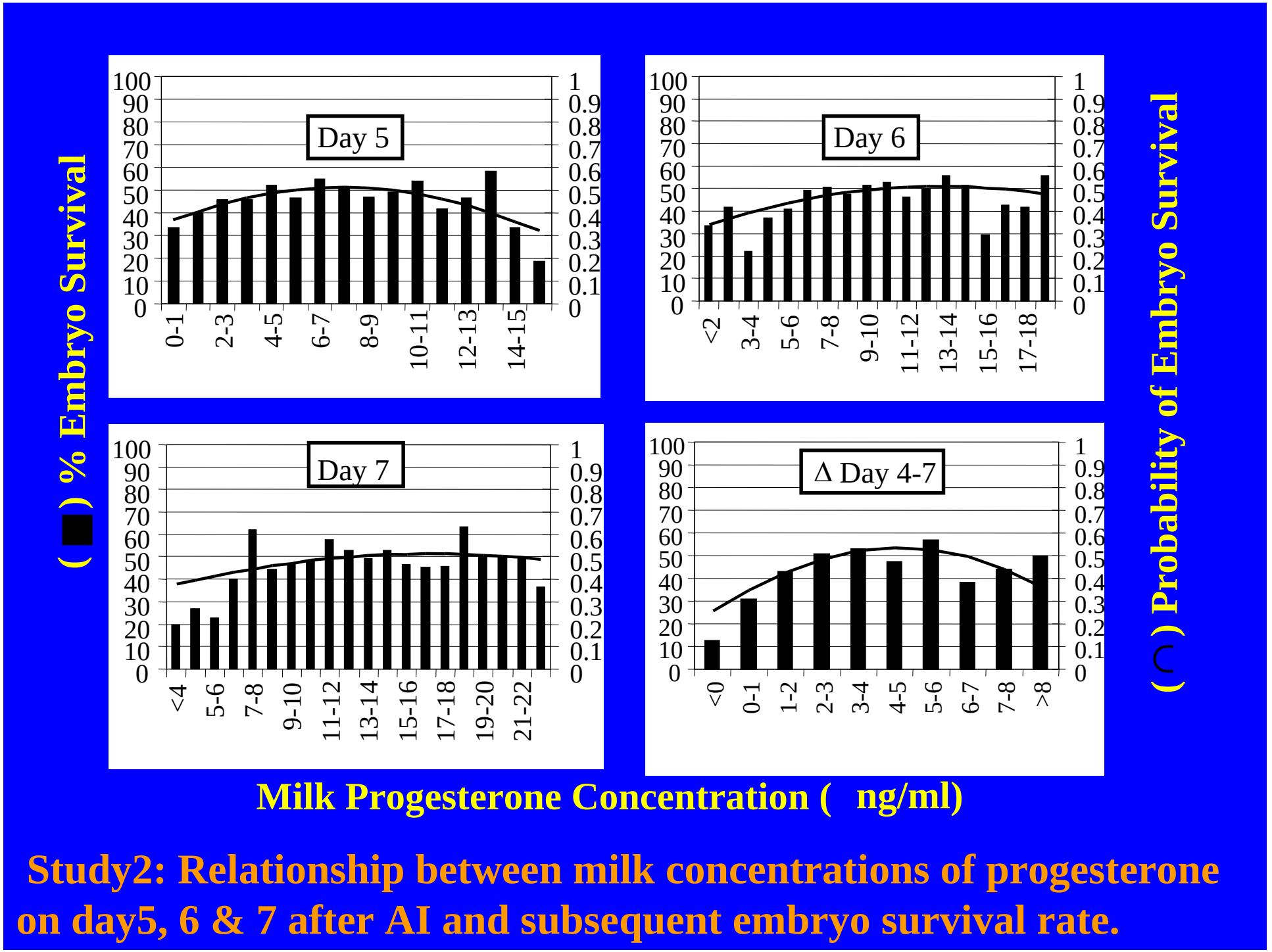
- Is essential for establishment & maintenance of pregnancy
- Affects uterine fluid protein composition
- Affects embryo size → Interferon tau → pregnancy recognition



Relationship between plasma concentrations of progesterone on the day of induced luteolysis and subsequent embryo survival rate.



Relationship between plasma concentrations of progesterone on day 7 after insemination and subsequent embryo survival rate.



Study2: Relationship between milk concentrations of progesterone on day5, 6 & 7 after AI and subsequent embryo survival rate.

Conclusions

- For dairy cows and beef heifers there are optimal ranges in progesterone concentration during the early luteal phases within which embryo survival is maximised

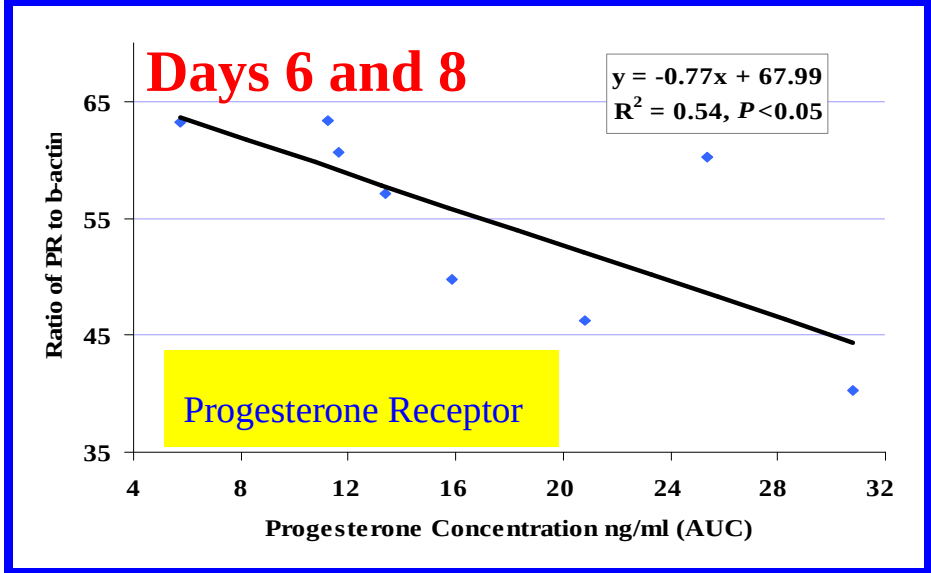
- From the current study it would appear that between 60 and 75% of dairy cows have a concentration of progesterone that is optimal for embryo survival rate

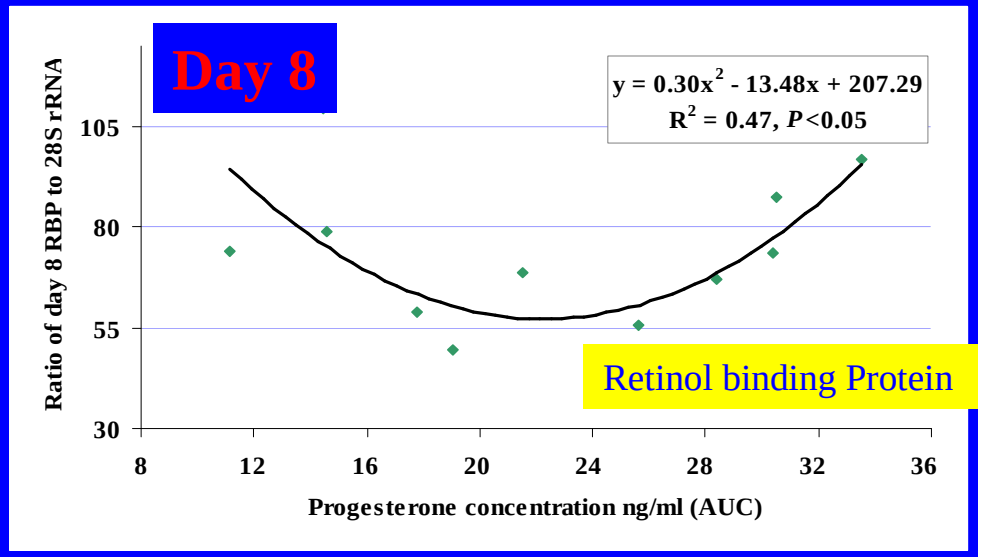
- Progesterone insufficiency rather than excess, particularly in dairy cows, appears to be the main problem on these days.

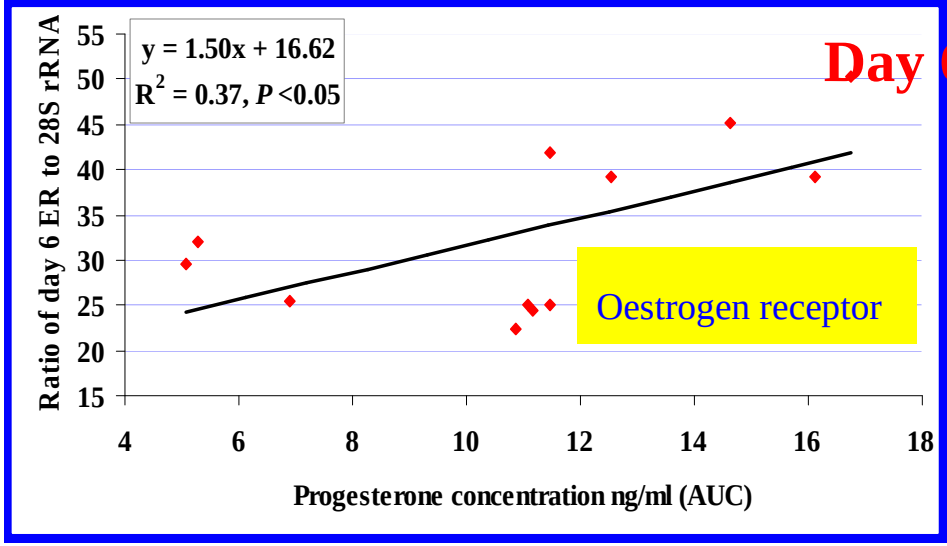
Summary: Published Progesterone Supplementation Studies

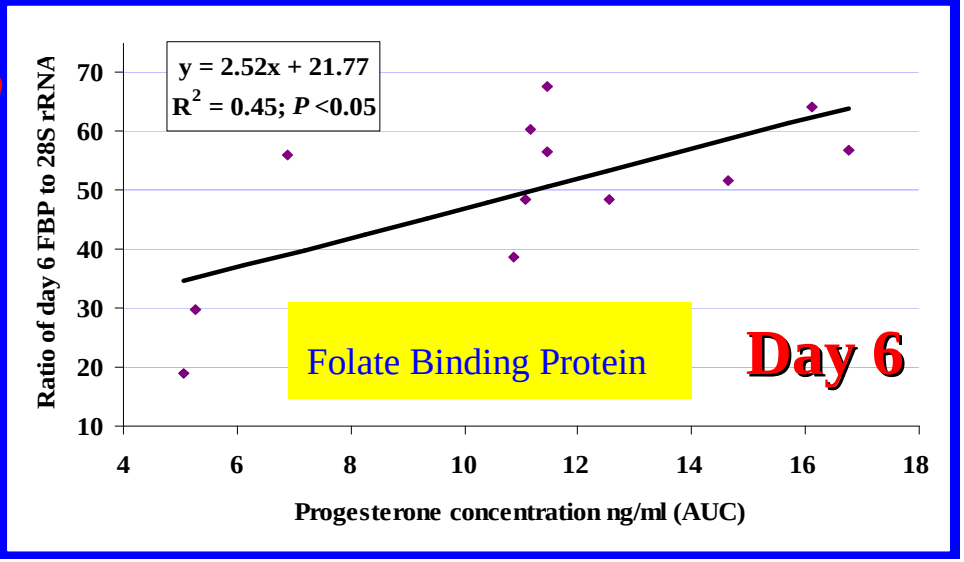
Cow Type	No Studies	No Cows	CR Controls	CR +P4	TRT X Study	Study	TRT
Cows / Heifers	6	1078	56.1%	69.3%	NS (P=0.09)	***	***
Repeat Breeders	4	239	23%	43%	NS	NS	**

Relationship between Temporal Progesterone and Uterine Gene Expression (McNeill et al. 2004)



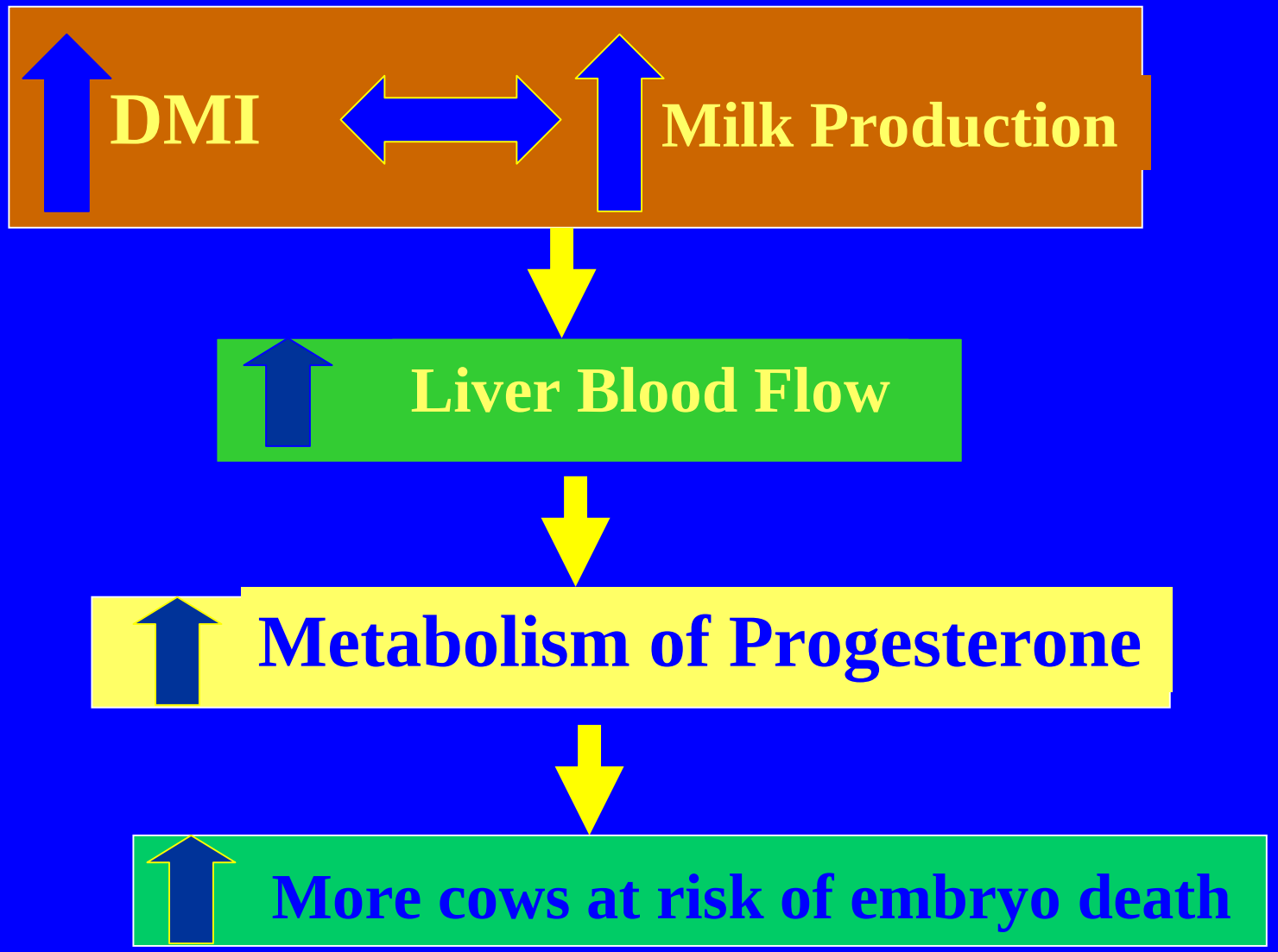






Fate of Progesterone in the High Producing cows

Consequences for Embryo Survival Rate

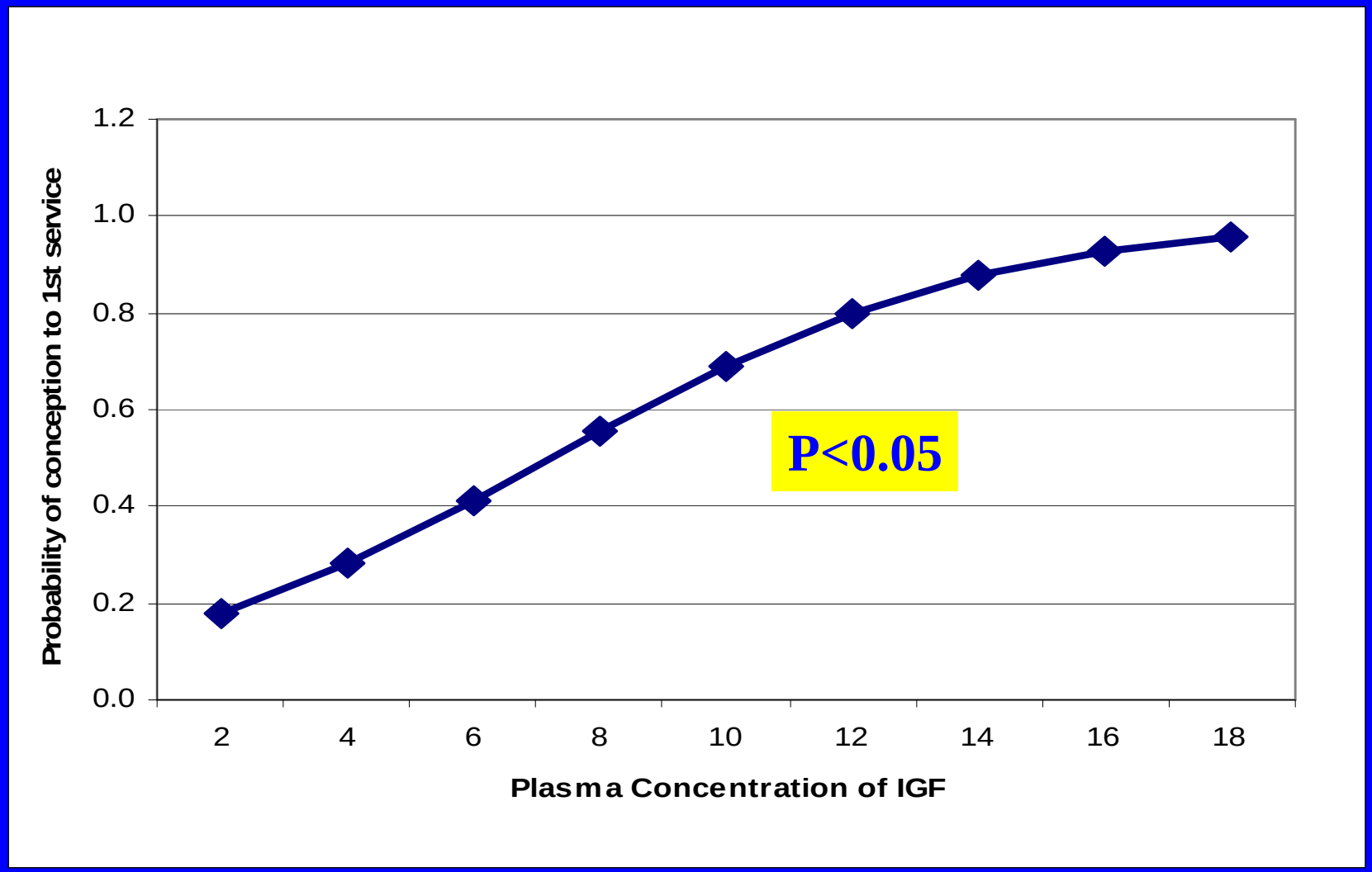


Energy Balance: Early post Partum period (Calving-Day 28 postpartum).

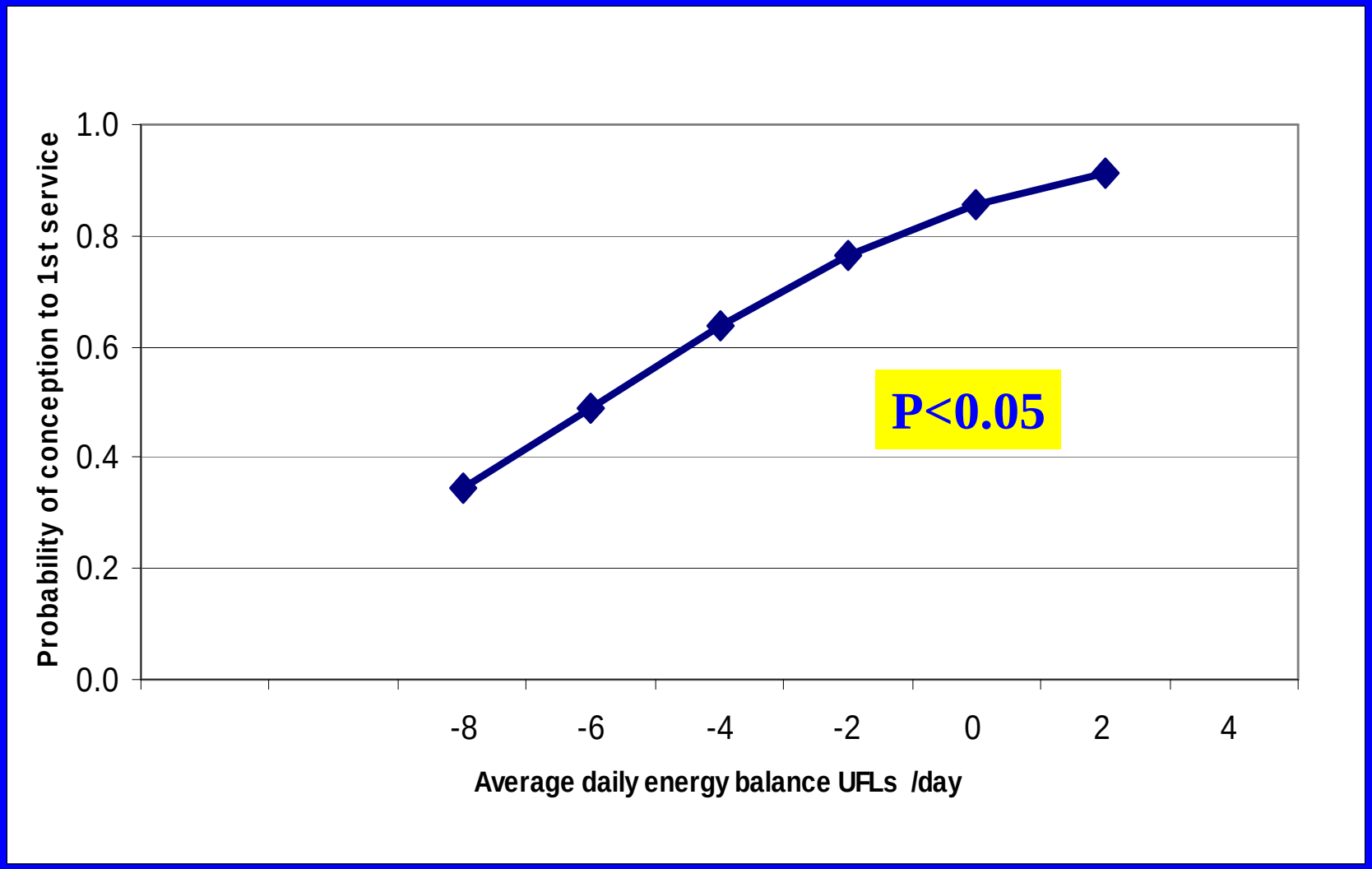
(Patton et al., 2006)

Measurements

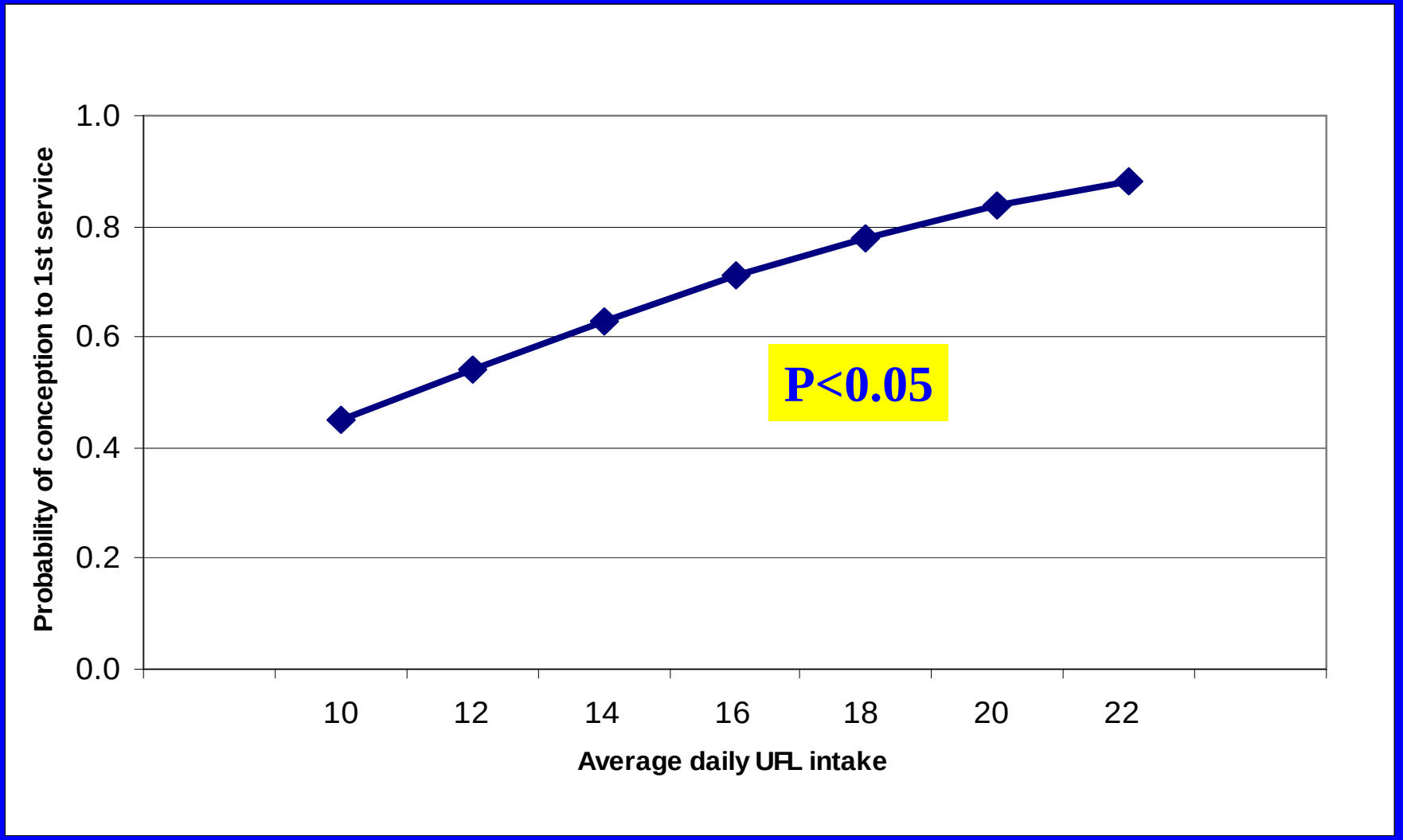
- Intake
- Milk production & composition
- Plasma IGF-I
- Post partum interval & Conception / Pregnancy rate



Relationship between plasma concentrations of IGF-I during first 2 weeks of lactation and probability of pregnancy to first service in dairy cows



Relationship between average daily EB during first 28 days of lactation and conception to first service in dairy cows



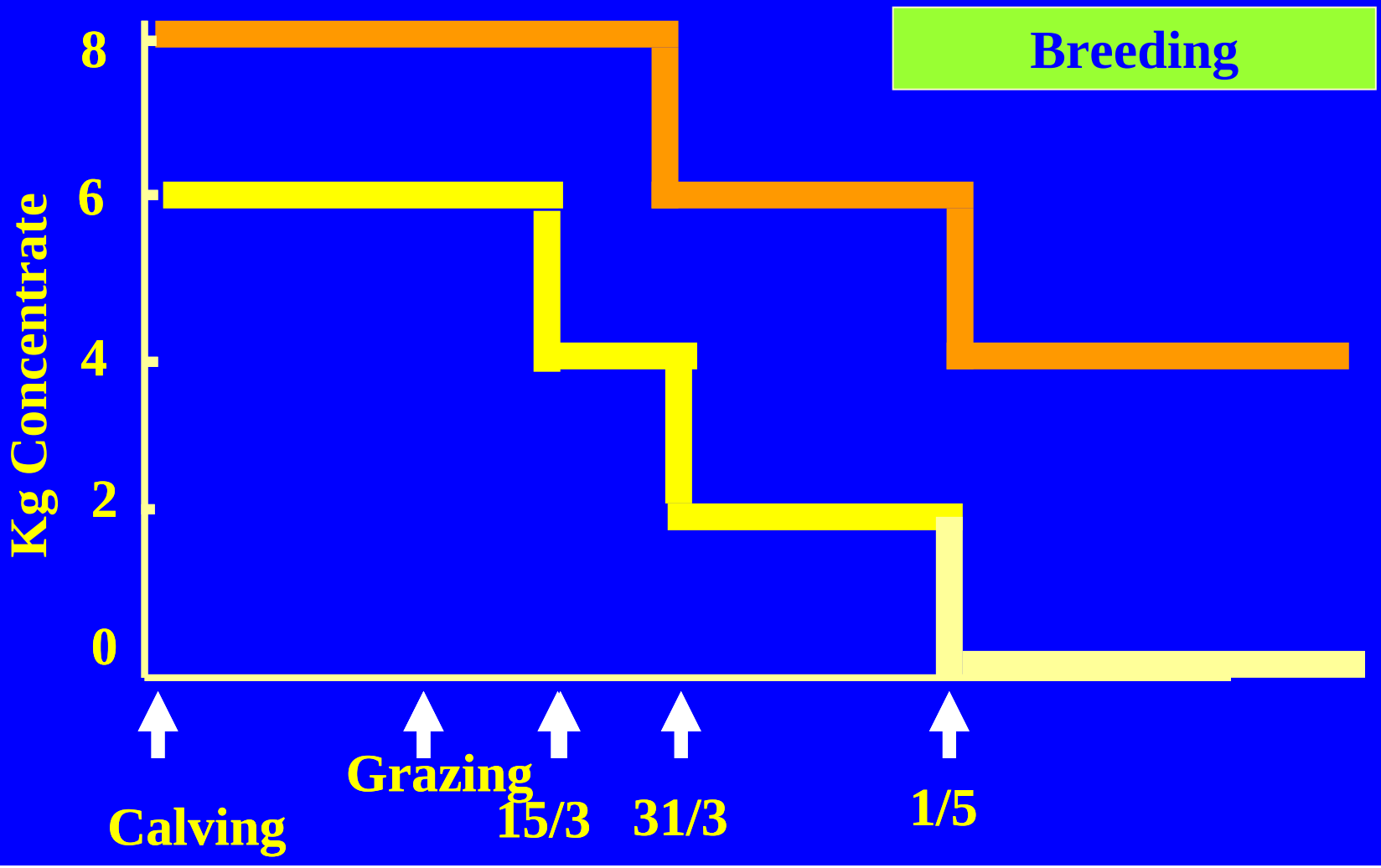
Relationship between average daily average UFL intake during first 28 days of lactation and conception rate to first service in dairy cows

Repeatability estimates (r_e) for DM intake, energy balance (EB) and plasma IGF-I during the 1st 4 weeks post-partum in dairy cows

Variable	*Repeatability (r_e)*	*Variance*
Intake	0.71	1.0883
Energy Balance	0.48	0.4252
IGF-I	0.42	0.015

Nutrition during the breeding season and embryo survival /pregnancy rate

Dairy cows concentrate supplementation regimen (Horan et al, 2004)



Effect of cow genetic merit and concentrate supplementation during the breeding season on pregnancy rates

	Cow Strain				*Supplementation*		
	HP	HD	NZ		LC	HC	Sig
1st Service	47	56	60	NS	59	54	NS
2nd Service	39[a]	40[a]	59[b]	*	40	57	NS
1ST + 2nd Service	69[a]	77[b]	84[b]	*	76	75	NS
Overall Pregnant	79[a]	85[b]	91[b]	*	86	86	NS
%late EM	8	7	7	NS	10	9	NS

Source: Horan et al. 2004

Association between cow genotype and BCS loss between calving and 90 days post calving and pregnancy rate to 1st and 2nd service

Pregnancy rate 1st & 2nd Service

Variable	*OR*	*95% CI*	*Significance*
New Zealand Genotype	2.451	1.067-5.628	P<0.05
BCS loss calving to AI	0.256	0.075-0.873	P<0.05

Source: Horan et al 2004

Summary /conclusions

- **NZ strains had significantly higher pregnancy rates than HP Holstein strains**
- **No clear beneficial effect of higher concentrate supplementation rate on conception and pregnancy rates**
- **Loss of BCS between calving and AI associated with lower pregnancy rates**

1st & 2nd service pregnancy rate: Data from Kennedy et al. 2003 and Horan et al. 2004 (n~480 cow records)

		Rate of supplementation		
		Low	High	
1st Service	Kennedy et al. 2003	50	52	P>0.10
	Horan et al 2004	59	54	P>0.10
	Overall	56	53	P>0.10
2nd Service	Kennedy et al. 2003	40	57	P>0.10
	Horan et al. 2004	39	58	P>0.10
	Overall	**39**	**58**	**P<0.05**

Conclusions on Concentrate Supplementation

- Large effects on DM intake
- Little effects on EB
- No effect on 1st service pregnancy rate
- Improved cow liveweight and BCS from calving
- Inconsistent effects on Δ LW and BCS
- No effect on 1st service pregnancy rate
- Evidence of lower 2nd service CR in both studies

Does changes in dietary intake around the time of AI affect embryo survival rate ?

Experimental

Pre-AI dietary intake

- 2.0 M
- 0.8 M

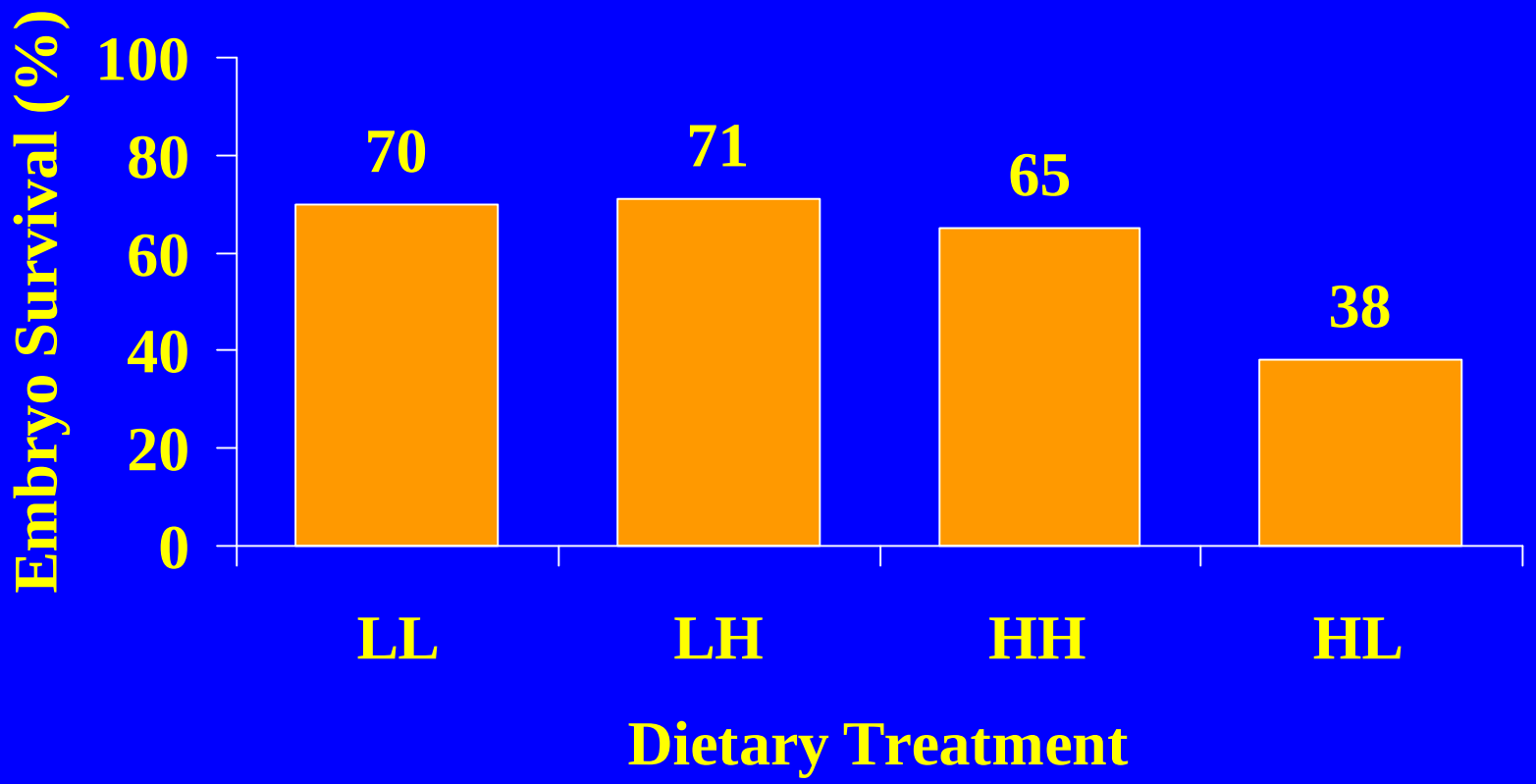
Post AI dietary intake

- 2.0 M
- 0.8 M

2x 2 Factorial

The effect of pre and post-insemination dietary intake on embryo survival rate in heifers (n=296)

Interaction between Pre and Post AI



Dunne et al 1999

Summary

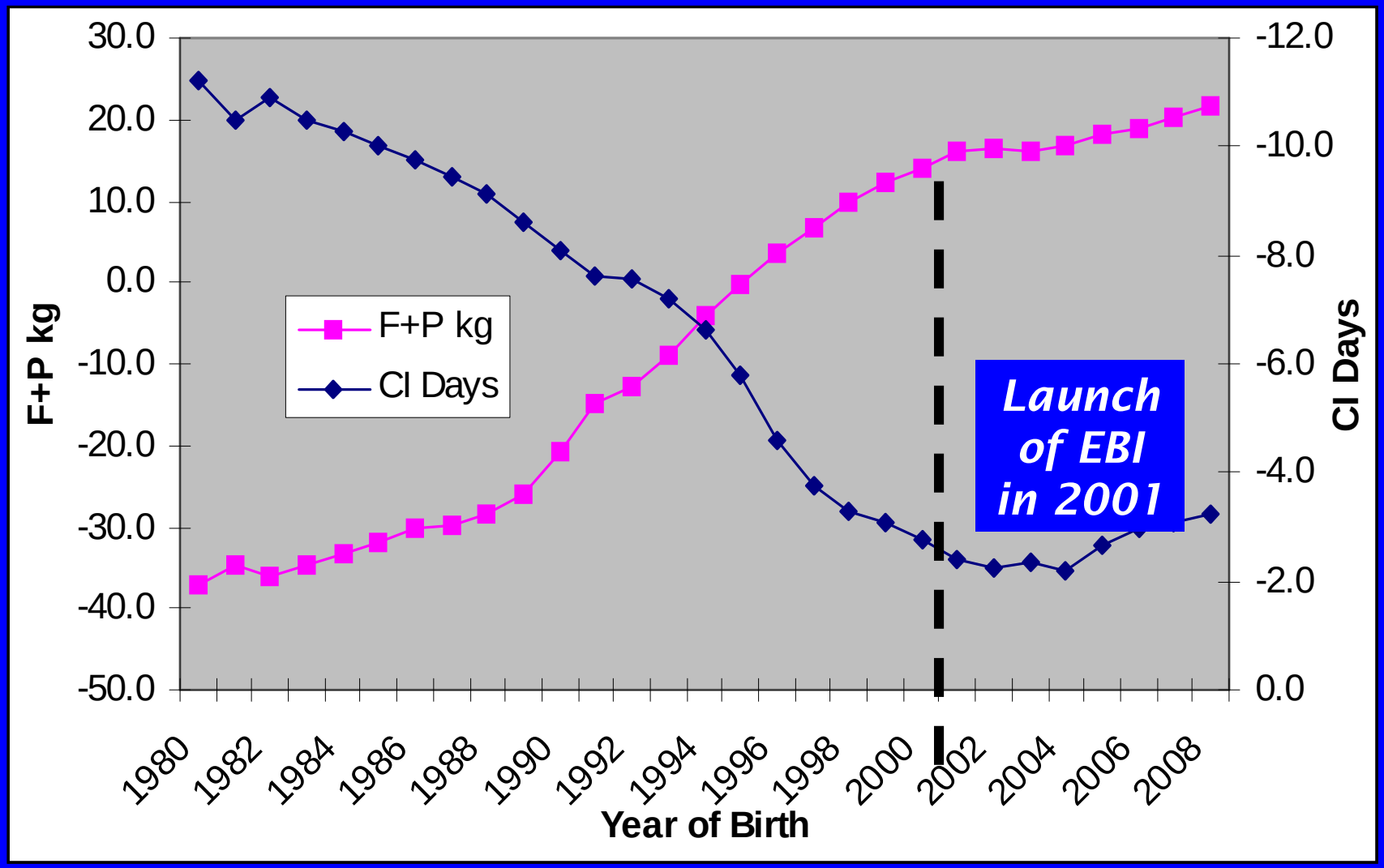
- Acute reduction in dietary intake immediately post AI reduces embryo survival rate
- Some evidence is apparent by Day 8 post AI.
- Effect not mediated through P4, live weight or BCS changes

Genetic Selection for Female Fertility

- Scandinavian countries 1st to incorporate measures of "fertility" into selection indices.
- Ameliorated decline in fertility

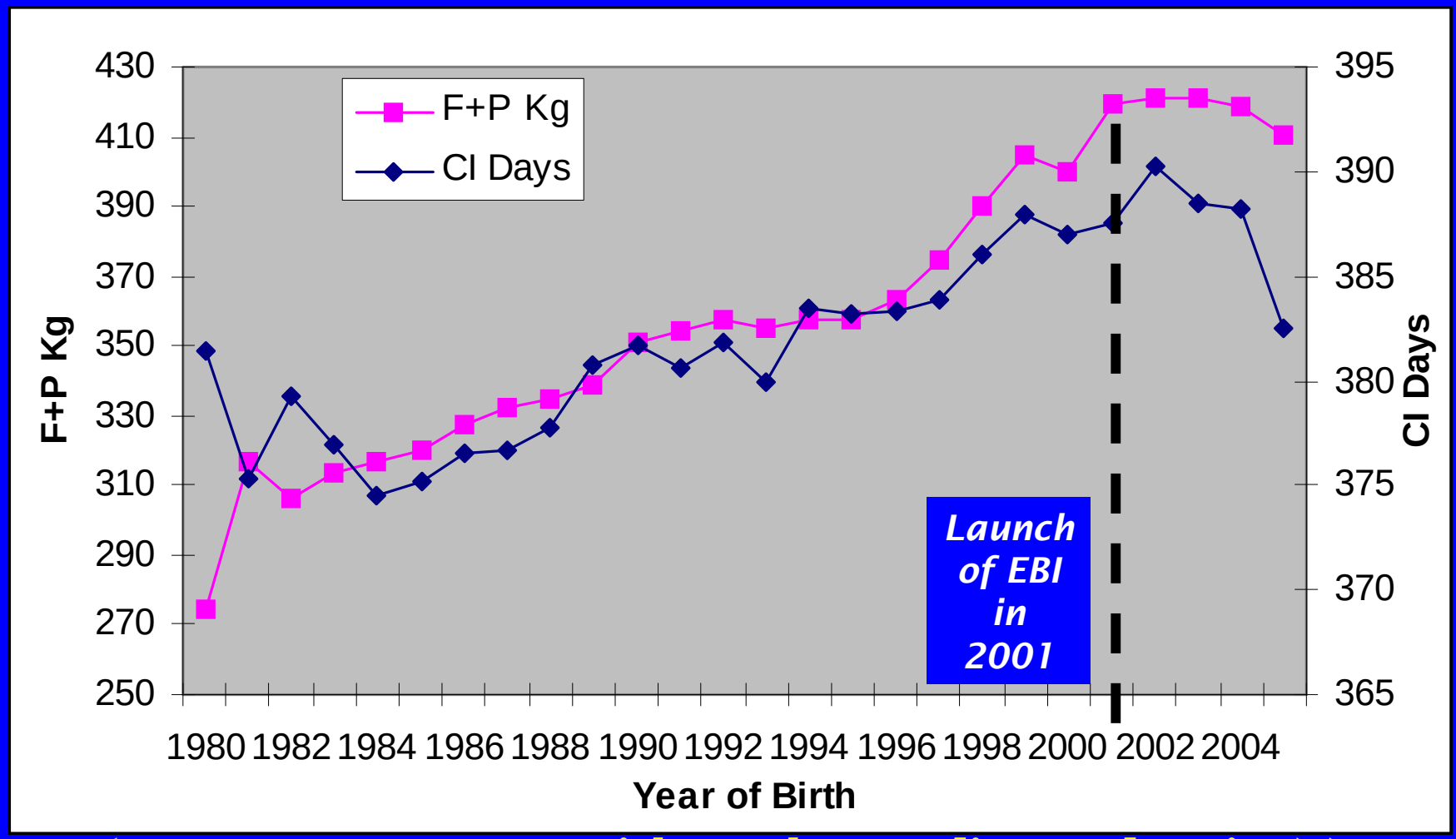
- Recently many other countries have incorporated measures of "fertility" into selection indices

The up to date picture. *Female Genetic Trends for F+P & CI Days*



Source: F. Kearney, Irish Cattle Breeding Federation).

Phenotypic Trends; *F+P kg & CI Days (Heifer Data)*



(Source: F. Kearney, Irish Cattle Breeding Federation)).

Cross-breeding: Holstein & Norwegian Red - Cow Fertility

	HO	NR	NR×HO	*P*-value
1st Service CR (%)	50[a]	59[b]	60[b]	<0.001
6 week in-calf (%)	62[a]	70[b]	75[b]	<0.001
13 week in-calf (%)	85[a]	90[b]	92[b]	<0.001
CCI (days)	92[a]	88[b]	87[b]	<0.05
No. services per cow	1.69[a]	1.56[b]	1.52[b]	<0.001
Fat +Prot (kg)	459	429	449	<0.01

Source: Begley and Buckley, 2009

Cross-breeding: Holstein & Jersey – Fertility

Trait	HF	J	F_1	P-value
Yield of milk solids (kg)	352[ab]	344[a]	365[b]	<0.01
CSI (days)	79	73	75	<0.05
1st Service CR (%)	42[a]	53[ab]	68[b]	<0.01
6 week in-calf rate (%)	57	67	73	NS
13 week in-calf rate (%)	85	88	96	NS
CCI (days)	98	90	87	0.058
No. of services per cow	2.07[a]	1.90 [a]	1.53[b]	<0.05

Source: Begley and Buckley, 2009

Summary

- **Include measures of fertility in selection indices**
- **Cross breeding**
  - **Production Maintained**
  - **Significant Improvement in Fertility**

Future Possibilities

- Gain a better understanding of underlying biology – molecular biology
- Select for increase dry matter intake
- Include measures of fertility in selection indices
- Exploit genetic variation within breeds
- Cross-breeding
- Use of genomic technologies


Thank You