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Breeding for improved dairy cow reproductive performance

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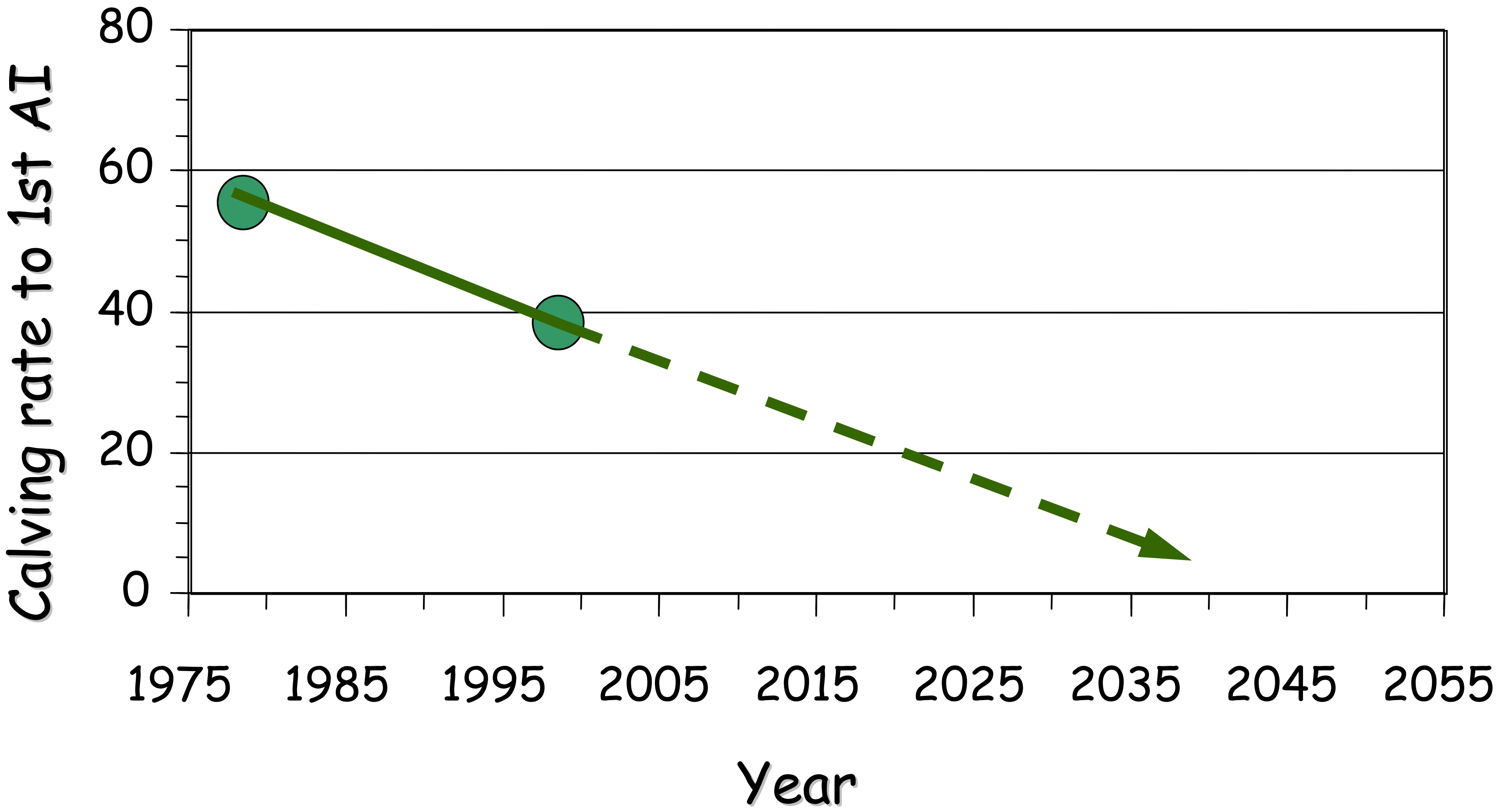
The presentation is a summary of the following recently published article:

Berglund, B. 2008. Genetic improvement of dairy cow reproductive performance. Reprod. Dom. Anim. 43 (Suppl. 2), 89-95; doi: 10.1111/j.1439-0531.2008.01147.x

Outline of presentation

- Declining reproductive performance
- Genetic improvement of reproductive performance (female fertility, calving traits)
- New traits in conventional breeding
- Genomic selection
- Concluding remarks

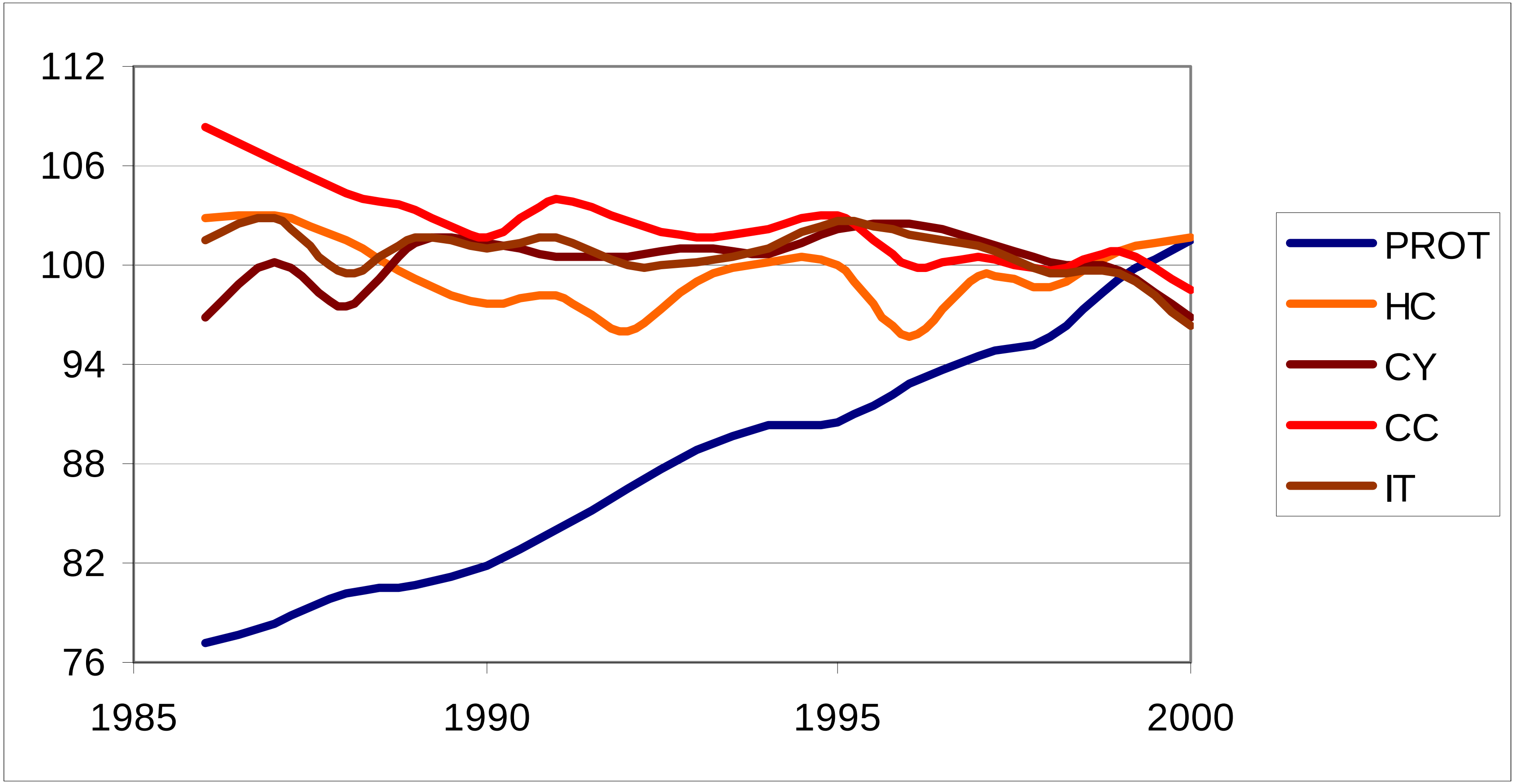
"Where is dairy cow fertility heading?"



Based on Royal et al., 2000.

Global genetic trends for Red dairy cattle

International breeding values, all bulls (10 000)
Mean=100, SD=10, Data from Sept. 2007

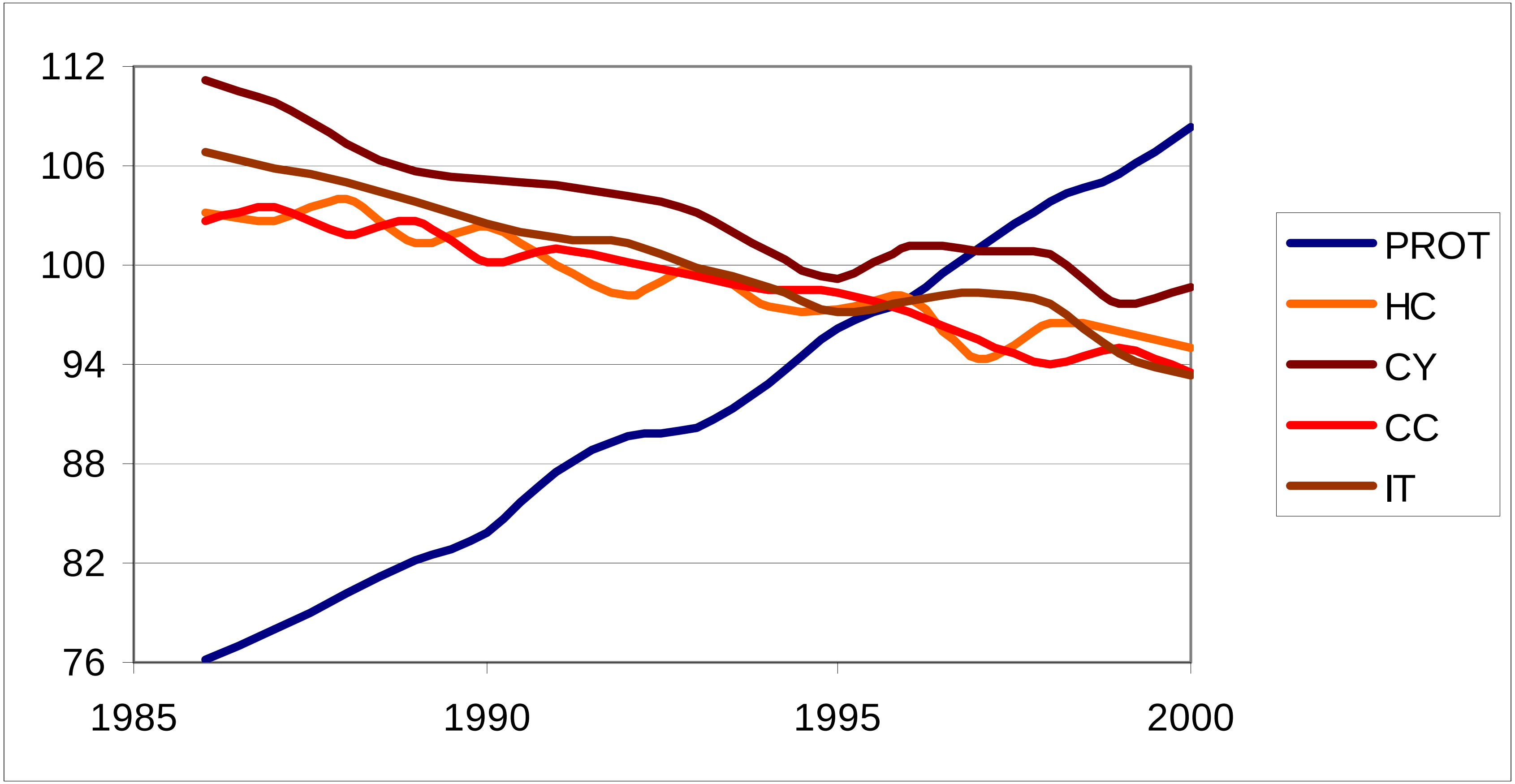


PROT= Protein yield, HC=Heifer conception, CY=Cow re-cycling ability, CC=Cow conception, IT=Interval traits (days open/calving interval)

Jorjani, 2008

Global genetic trends for Holsteins

International breeding values, all bulls (50 000)
Mean=100, SD=10, Data from Sept. 2007



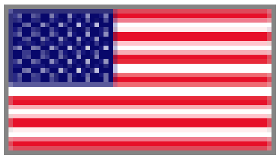
PROT= Protein yield, HC=Heifer conception, CY=Cow re-cycling ability, CC=Cow conception, IT=Interval traits (days open/calving interval)

Jorjani, 2008

Signs of declining cow fertility

- Later first ovulation
- Increasing ovulation rate without external heat signs
- Shorter oestrus
- Reduced conception rate
- Inferior calf vitality

Calving rate
- final reproductive sucess



Calving rate cows (live calves): 25.5 %

(Sartori et al. 2006)

Calving rate Swedish Holstein cows: 30.0 %

Calving rate Swedish Red cows: 35.2 %

(Petersson 2006)

Animal breeding

Basic principle: Selection of the best parents.

Aim: Improve the population mean according to the breeding goal.

Visible phenotypic variation ⇨ ranking (genetic evaluation) ⇨ selection ⇨ result

Selection index
$= b_1x_1 + b_2x_2 + \ldots + b_nx_n$
b_1 = weighting factor for trait 1
X_1 = recorded value for trait 1

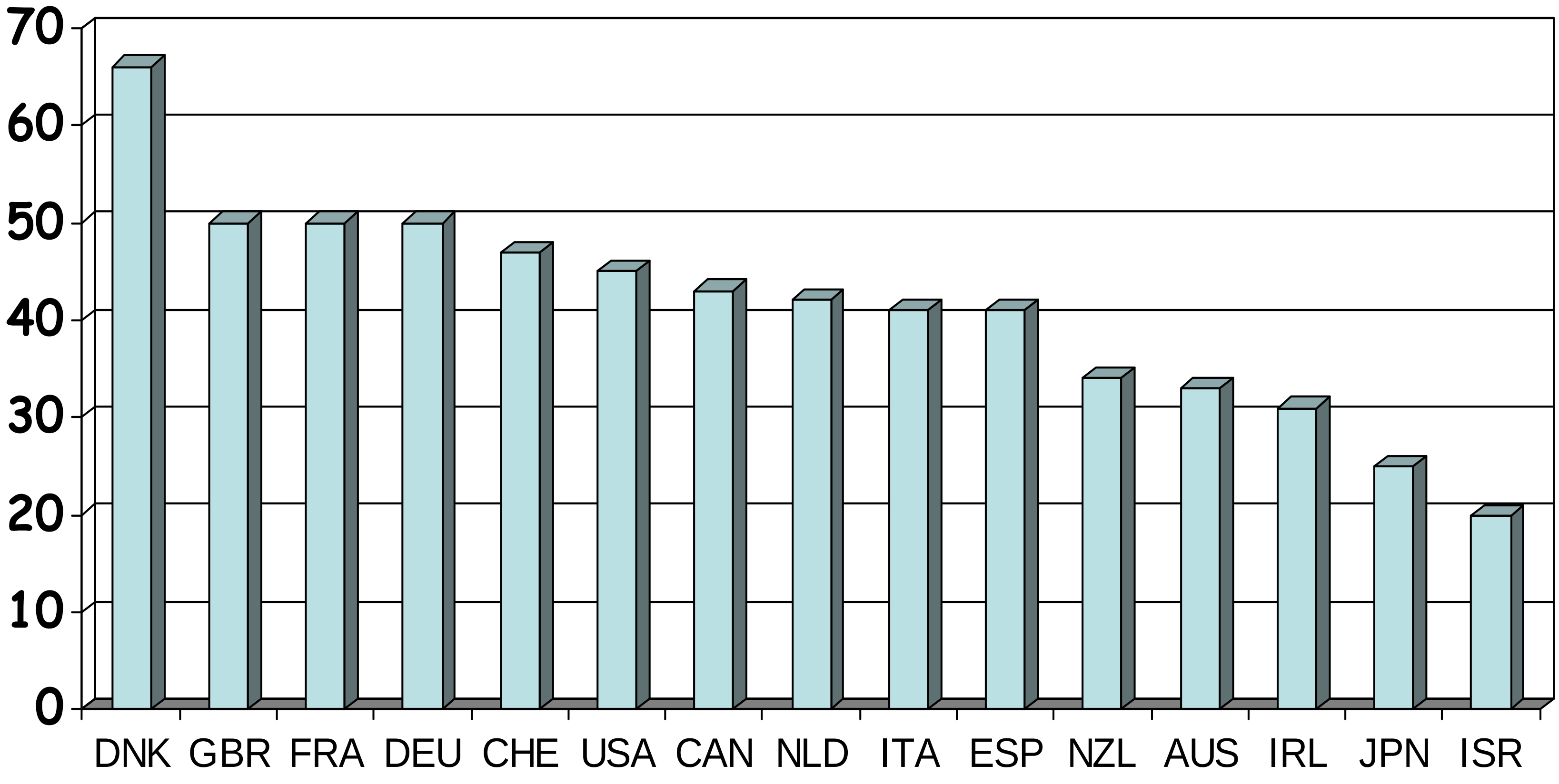
Breeding goal
$= v_1A_1 + v_2A_2 + \ldots + v_nA_n$
v_1 = economic weight for trait 1
A_1 = genotype for trait 1

Today's breeding

- Intensive
- Internationalised
- Broadening of the breeding goal even outside the Nordic countries
- New technologies; eg. reproductive, molecular genetic. Nucleus herds
- Integration of molecular data into conventional breeding programmes

Viking Genetics nucleus herd, Viken

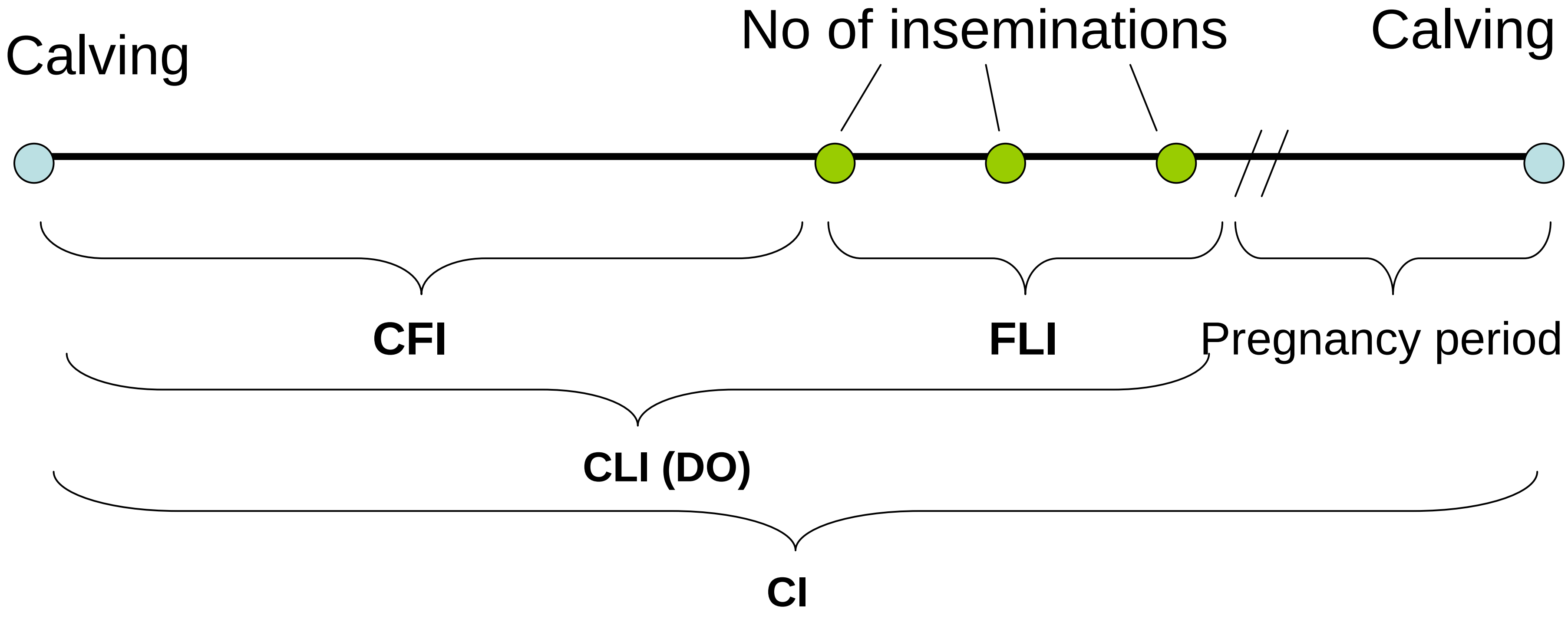
Relative emphasis on functional traits in Total Merit Indexes



Miglior et al., 2005

Female fertility has several important aspects

- Fast return to normal ovarian activity after calving
- Strong signs of oestrus
- High probability of conceiving when inseminated at correct time
- Ability to carry pregnancy to term



Mean heritability for fertility traits estimated from 17 studies

Fertility scores	Heritability (%)
Non-return after first insemination	1.9
Conception to first service	2.7
Number of services per conception	2.6
Interval traits	
Calving interval	3.4
Days open	2.4
Days to first service	5.0
Interval from first to last insemination	1.7

Pryce & Veerkamp, 2001

Female fertility;
Heritabilities and genetic correlations (SRB)

Fertility measure	Par-ity	Herita-bility (%)	r_g fertility parity 1	r_g fertility parity 2	r_g kg ECM_{23}^{b}
NINS	0	2.5	0.67		
	1	3.0		0.94	0.29
	2	3.1			0.31
	3	2.2		0.93	0.41
CFI	1	3.4		0.81	0.25
	2	2.5			0.30
	3	1.8		1.00	0.35

Roxström et al., 2001

Breeding for female fertility

- Low heritability,<5% (compare milk yield, 30%)
- Large genetic variation ⇨ Large possible change
- Heifer fertility differs from lactating cow fertility (genetic correlation, 0.7) ⇨ Use both categories
- Unfavourable genetic correlations with production, increasing with parity (0.2-0.4) ⇨ Consider both traits
- Several measures of fertility needed in genetic evaluations
- Large daughter groups and sufficient breeding goal weight

International Bull Evaluation Service - **Interbull**

www.interbull.org

Founded 1983. Main office in Uppsala. 42 member countries (2007)

Responsible for promoting the development and execution of international genetic evaluations for cattle.

- Milk production (fat, protein, milk yield)
- Conformation (18 traits)
- Udder health
- **Calving traits (2005)**
- Longevity
- **Female fertility (Feb. 2007)**

Female fertility International genetic evaluation (bulls)

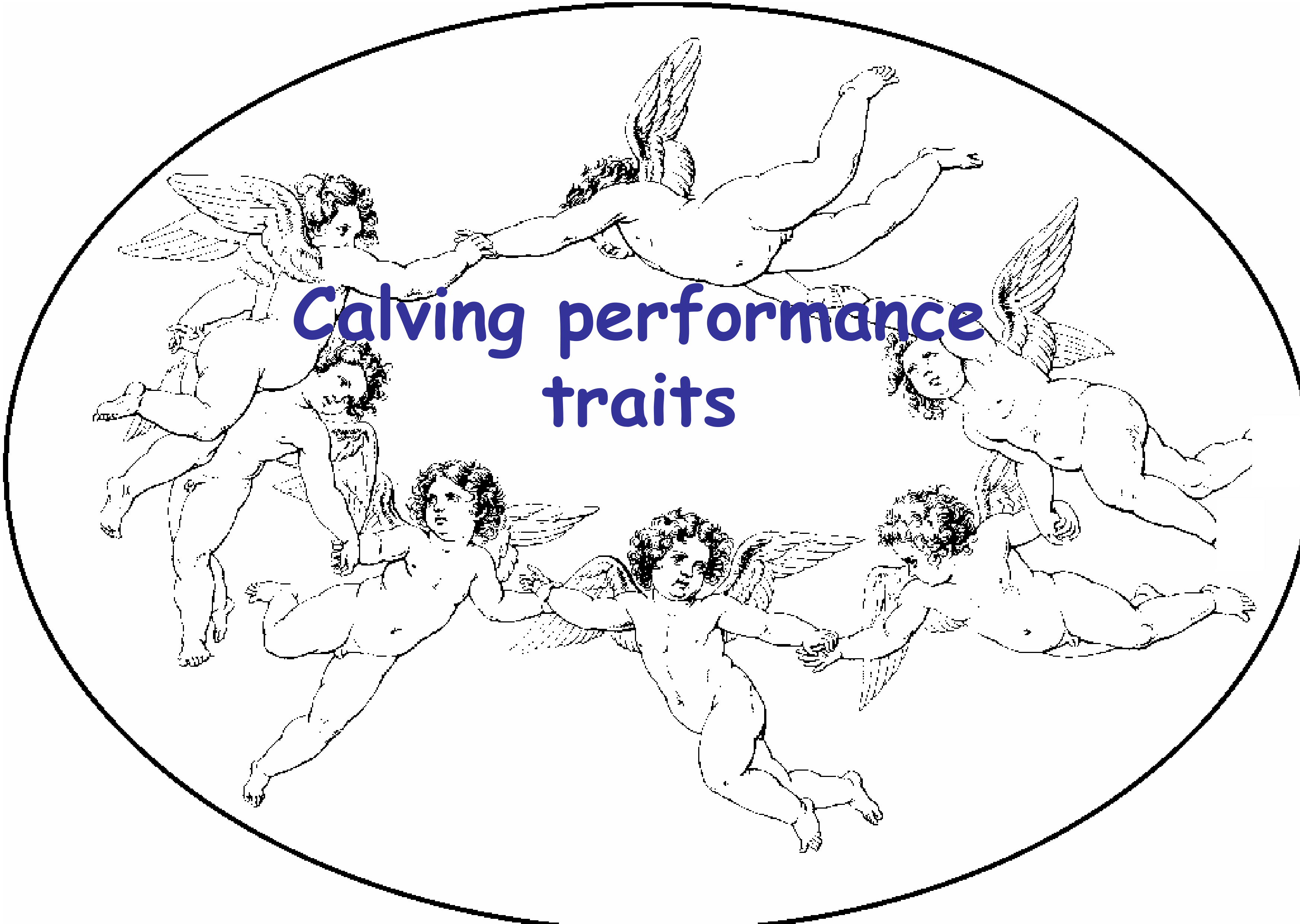
- Maiden heifers' ability to concieve (HC) (eg. a measure of confirmed conception rate).
- Lactating cow's ability to recycle after calving (CY). (eg. days to 1st AI).
- Lactating cow's ability to concieve (1) expressed as a rate trait (eg. conception rate).
- Lactating cow's ability to concieve (2) expressed as an interval trait.
- Lactating cow's measurements of interval calving conception (eg. days open and calving interval).

Nordic fertility index (2005-)
(bulls and cows)

www.nordicebv.info

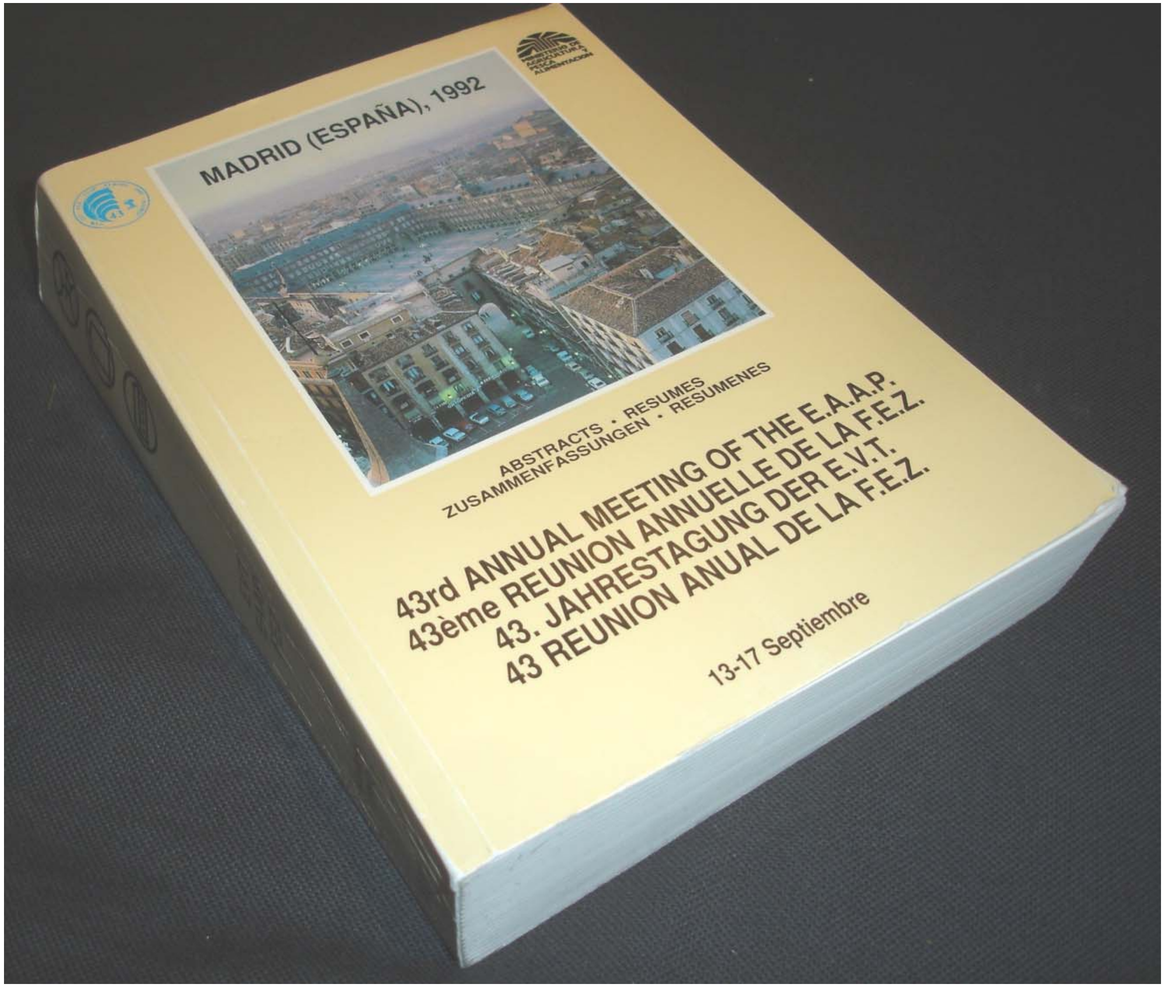
- NINS: No of ins. (h=heifers, c=cows 1-3 parity)
- ICF: Interval from calving to first ins. (c)
- IFL: Interval from first to last ins. (h, c)
- REPT: Reproductive treatments (c)

Calving performance traits



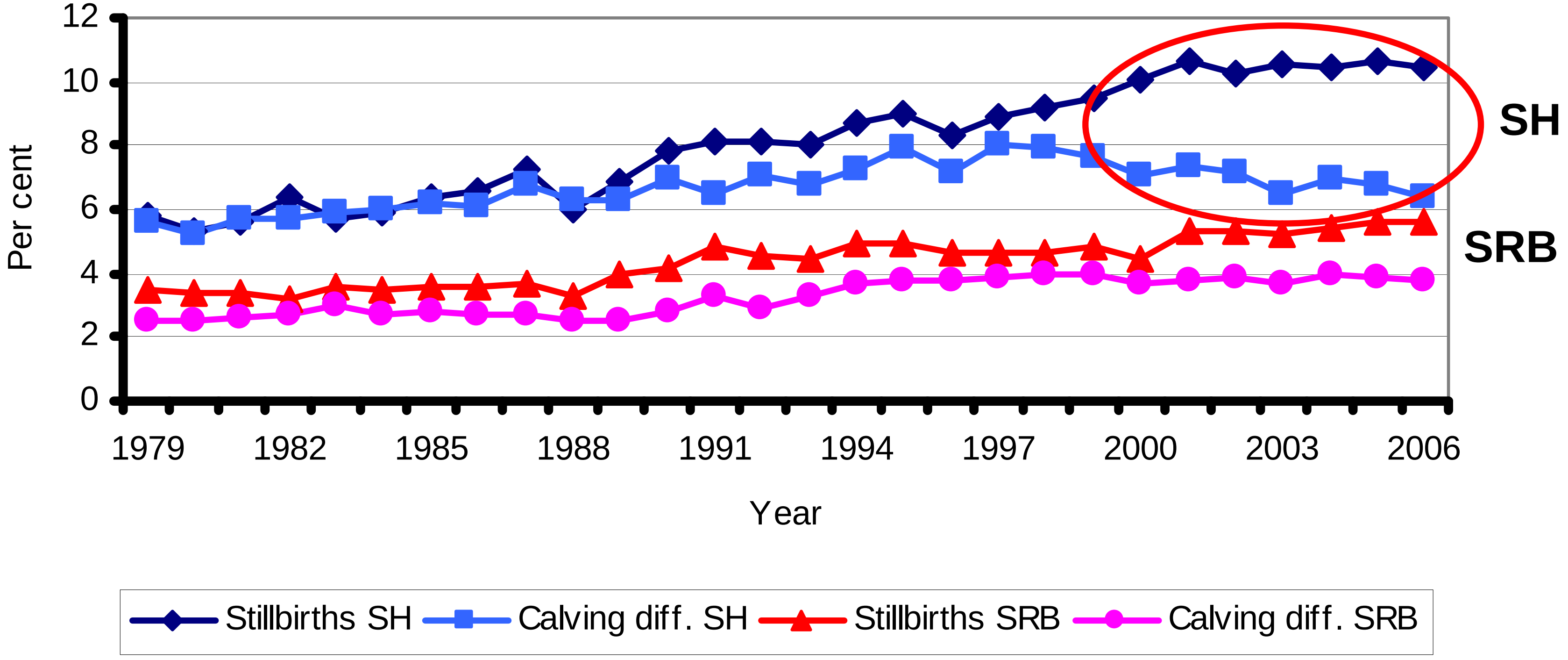
Calf survival

Too high mortality of calves from Holstein heifers



Berglund & Philipsson, 1992

Stillbirth rate and calving difficulty for first calvers of SLB/Swedish Holsteins (SH) and Swedish Red (SRB)



Swedish milk recording statistics

Heritabilities (%) for calving traits

	SH		SRB	
Calving no	**1**	**2**	**1**	**2**
Calving diff., direct	6.2	0.4	2.6	0.6
maternal	4.8	0.2	1.8	0.3
Stillbirth, direct	3.8	0.7	0.7	0.7
maternal	2.8	0.3	0.5	0.2

Steinbock et al., 2003 and 2006

Genetic correlations for calving traits

	SH	SRB
Calving diff., calving no 1-2, direct	0.61	0.85
maternal	0.71	0.76
Stillbirth, calving no 1-2, direct	0.45	0.83
maternal	0.48	0.85
Stillbirth x Calving diff., 1, direct	0.80	0.83
maternal	0.74	0.85

Steinbock et al., 2003

Breeding for good calving performance

- Priority first calvers
- Stillbirth and calving difficulty
- Direct and maternal effects
- Low heritabilities ⇨ Large daughter groups needed
- Breeds differ ⇨ Different strategies might be needed
- Control program for congenital defects

Effects of Complex Vertebral Malformation (CVM) on fertility

CVM calf with multiple malformations. Notice short neck and contraction of the distal joints.

Fig. 1 A case of complex vertebral malformation in a Holstein calf. Notice short neck and contration of the distal joints.

Photo: Agerholm

DNA-test available in 2001. (Marker test in 1999)

Retrospective study;

- All Holstein bulls used by the Swedish AI-org. Birth years 1995-1999.

Berglund et al., 2004

Cross breeding as a tool to enhance fertility

Fitness traits such as reproduction traits are to a relatively large extent affected by heterosis (dominance and epistasis) i.e. non-addive genetic variation. **Cross-breeding** is one method used to **increase heterozygocity** and thus decrease inbreeding depression.

But pure breeding is needed for genetic improvement

Results from crossbreeding experiment in California

	First service CR	Days open	Stillbirths heifers	Stillbirths cows
Holstein	22	150	14.0	3.7
Normande x H	35*	123**	9.9	4.7
Montbeliarde x H	31**	131**	6.2**	5.9
Scand. Red x H	30	129**	5.1**	2.3

Heins et al., 2006

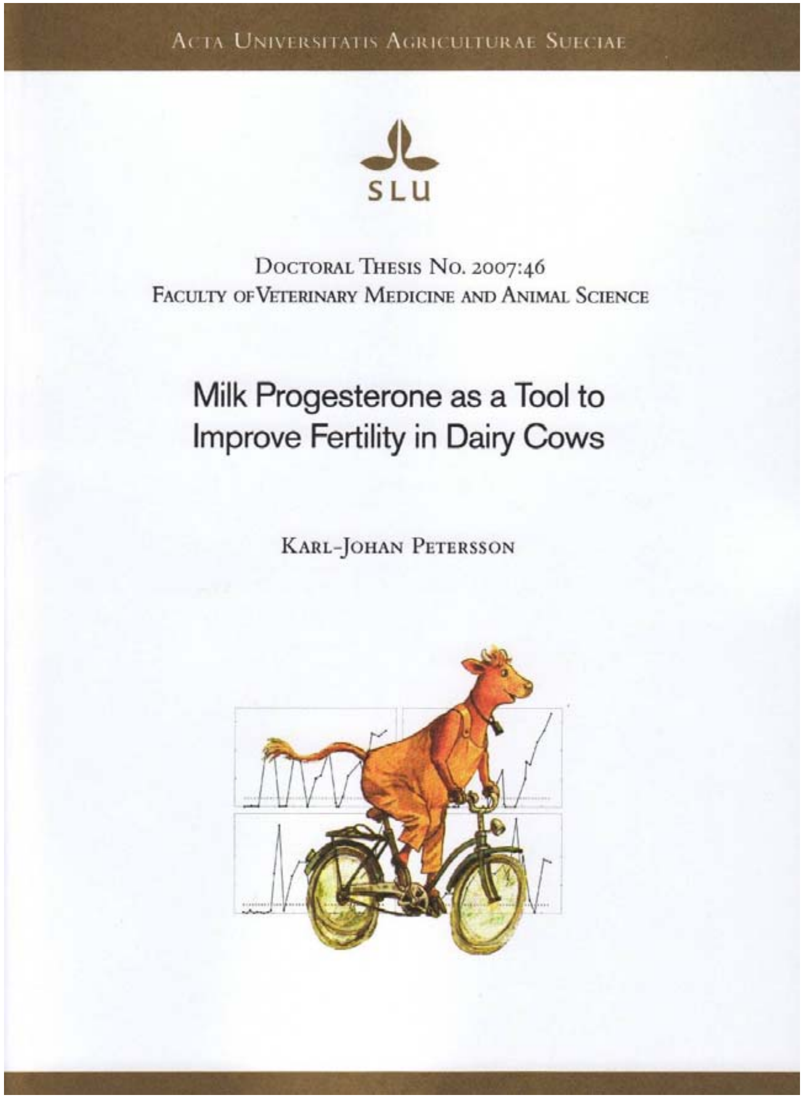
To increase the accuracy in genetic evaluations and to enable identification of genetic mechanisms underlying low heritability traits, it is important to have accurate trait definitions and reliable registrations of phenotypes on a large number of animals. Measures with a more direct association to *the inherent physiological capacity of the cow* may capture more of the genetic variation.

New traits/tools for reproductive functions in conventional breeding

- Nutrient/energy balance e.g. body condition score (BCS)
- Endocrinological measures e.g. progesterone
- Juvenile predictors (metabolic, endocrine)
- Behavioural traits (pedometers for oestrus)
- Increased knowledge of genes

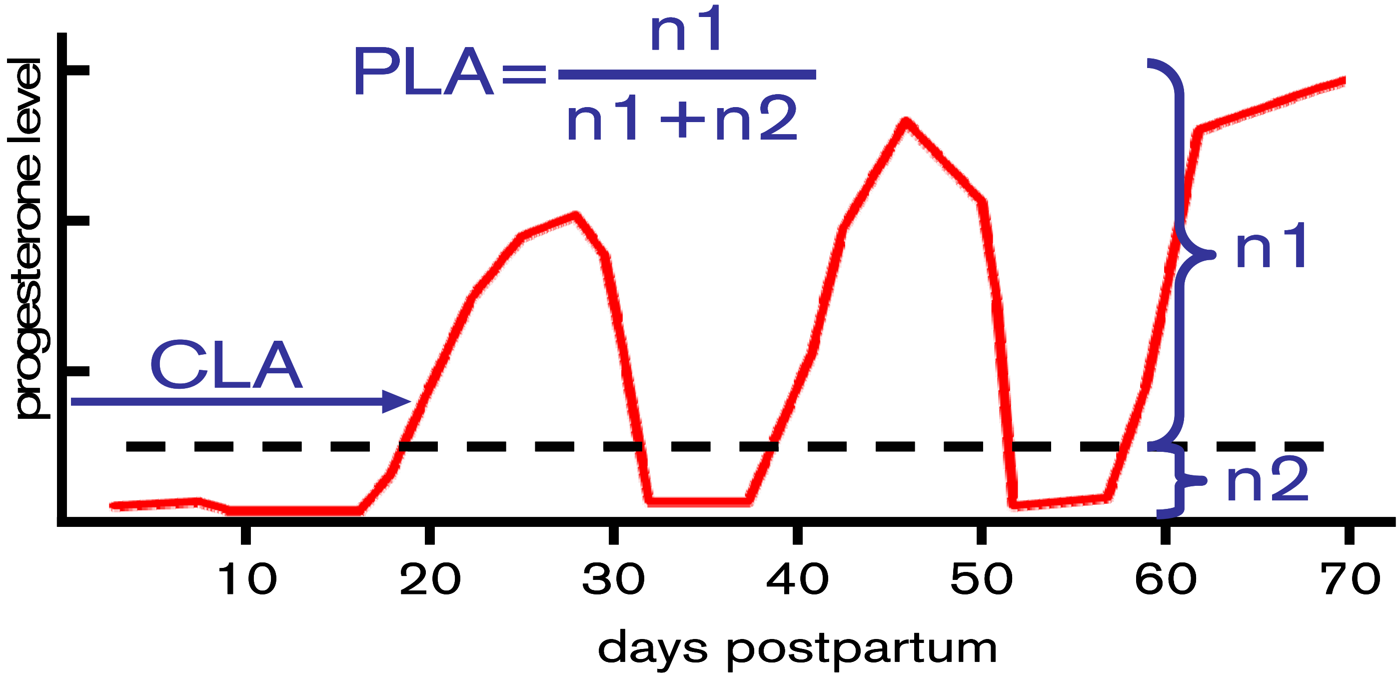
Milk progesterone to improve fertility

Can milk progesterone measures based on monthly milk sampling be used in breeding for improved fertility and as a diagnostic tool for disturbed ovarian function in dairy cows?



Petersson et al 2006, 2007, 2008

Progesterone measures



- CLA - commencement of luteal activity
- PLA - percentage of samples above the limit for luteal activity within the first 60 days postpartum
- CLA_m or PLA_m - CLA or PLA based on monthly sampling

Genetic analysis

	h^2 (%)	SE
PLA_m	11.3	5.0
CLA_m	9.2	4.9
PLA (Petersson et al., 2007)	29.5	5.8
CLA (Royal et al., 2002)	16.1	5.0

Genetic correlations between PLA_m or CLA_m and CLA had on average an absolute value of 0.85 (SE 0.18)

Selection index calculations with PLA_m or CLA_m predicted breeding values for CLA with high accuracy (0.64-0.72 with 50 daughters/bull)

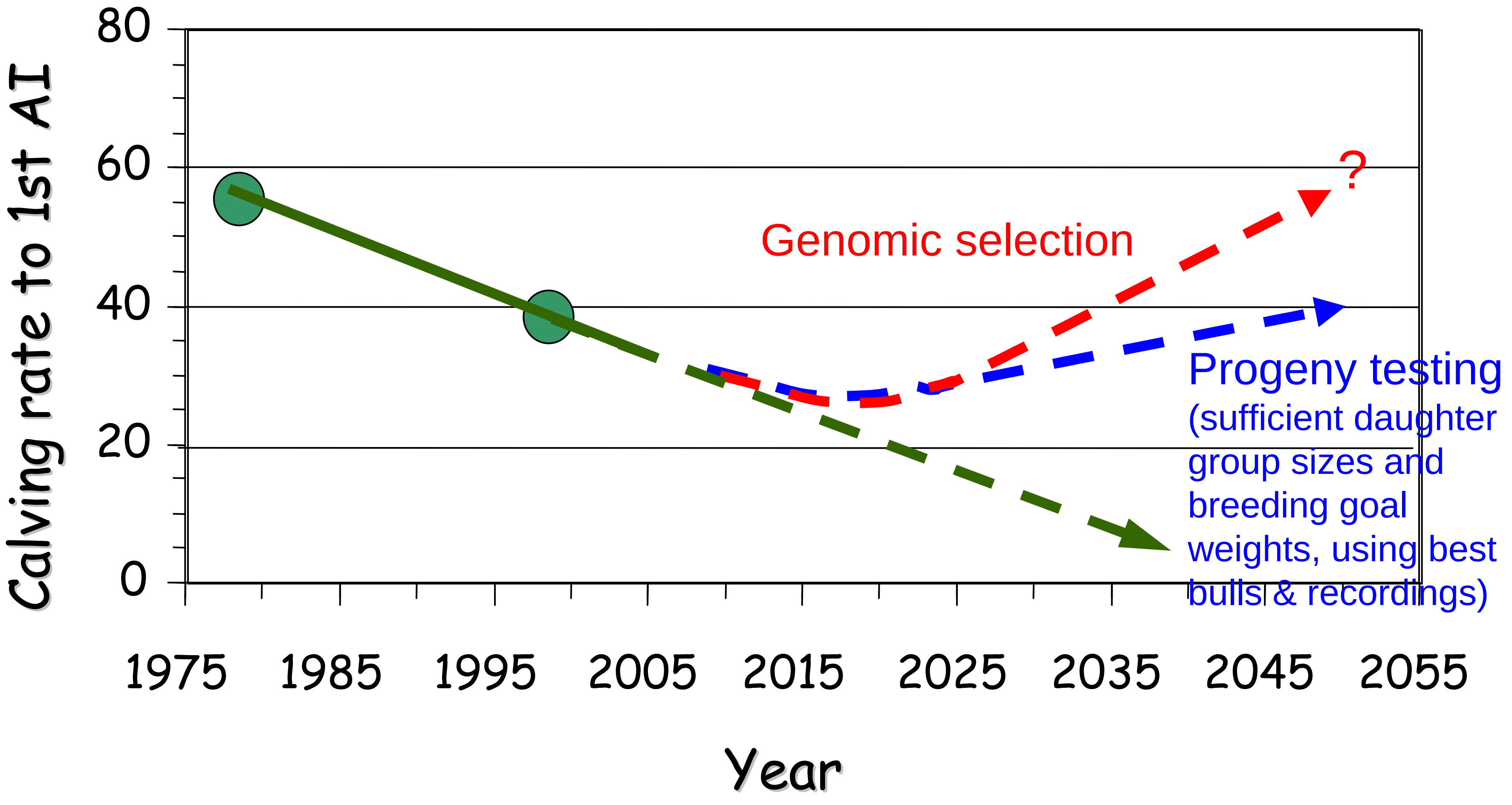
Genomic selection

- Genomic selection is now possible with availability of reasonably high density SNP panels (>50 000 SNPs for cattle), which may be sufficient to capture most genetic variation.
- By summing all marker haplotype effects in the genome a breeding value can be obtained directly at birth.
- Adding marker info to breeding evaluation procedures → Increased accuracy and shorter generation interval → Increased response.
- Genomic selection provide opportunities to enhance breeding programmes.
- Most beneficial for low heritability traits such as reproduction.

Concluding remarks

- Selection is dependent upon good integrated data-bases (pedigree, phenotypic and genotypic recordings)
- Positive response by a joint consideration of all important traits in a ”Total merit index”
- Conventional selection can be improved by more accurate measures, early indicator traits, reproductive and molecular genetic tools
- Increased knowledge of genes and their regulation may improve the genetic selection strtegies and have large impact on genetic evluation programmes

"Where is dairy cow fertility heading ?"



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