

Automated Monitoring of Health and Reproduction in Dairy Cows:

The Biosens Project

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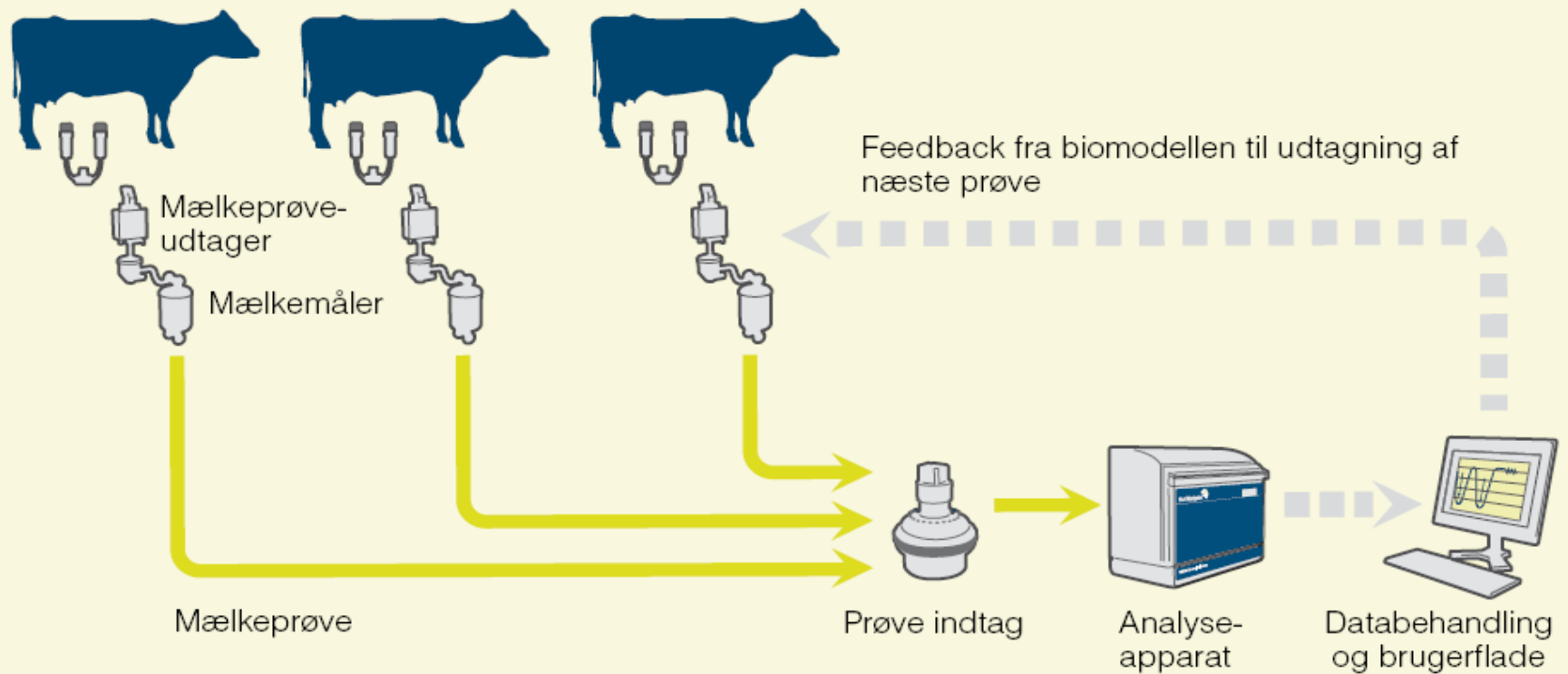
Biosens

- 5 year project (2002)
- 4.6 million Euros
- Consortium:
 - Danish Institute of Agricultural Sciences
 - Lattec (Foss Electric + DeLaval)
 - Danish Cattle Federation

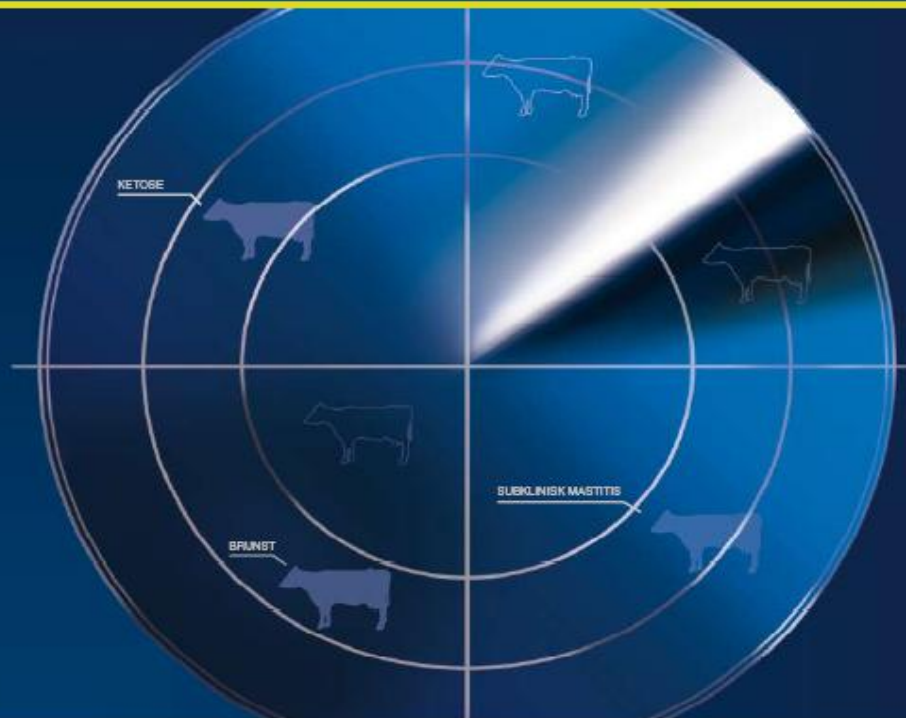
- Herd Navigator (2008)
- 20 Scientific papers
- Patent



Herd Navigator systematiske fremgangsmåde



Herd Navigator 



Proaktiv herd management

www.herdnavigator.com

Plan of talk

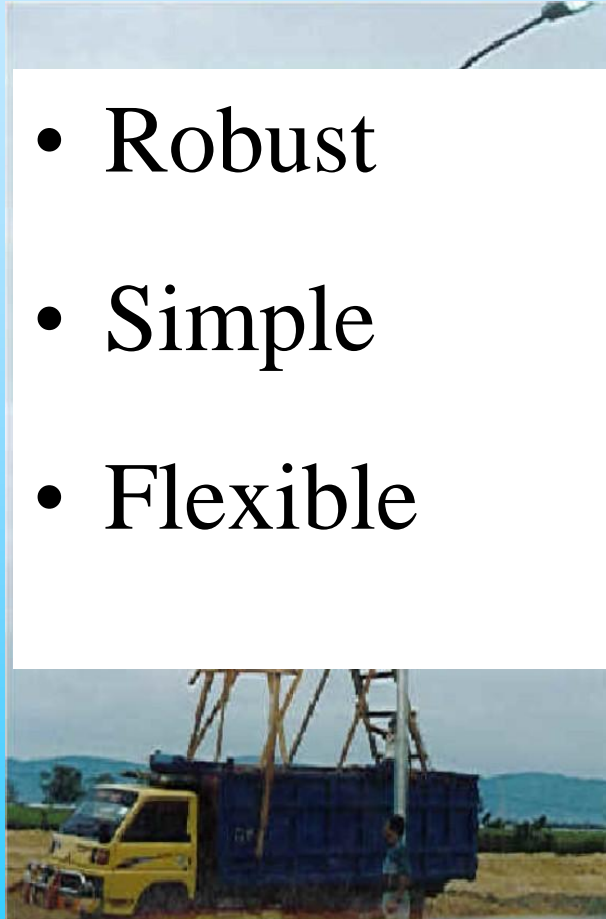
- Biological Models
 - General approach
- Reproduction Model
 - Combining application and science
- Key Project features
 - Consortium with industry

Biological models

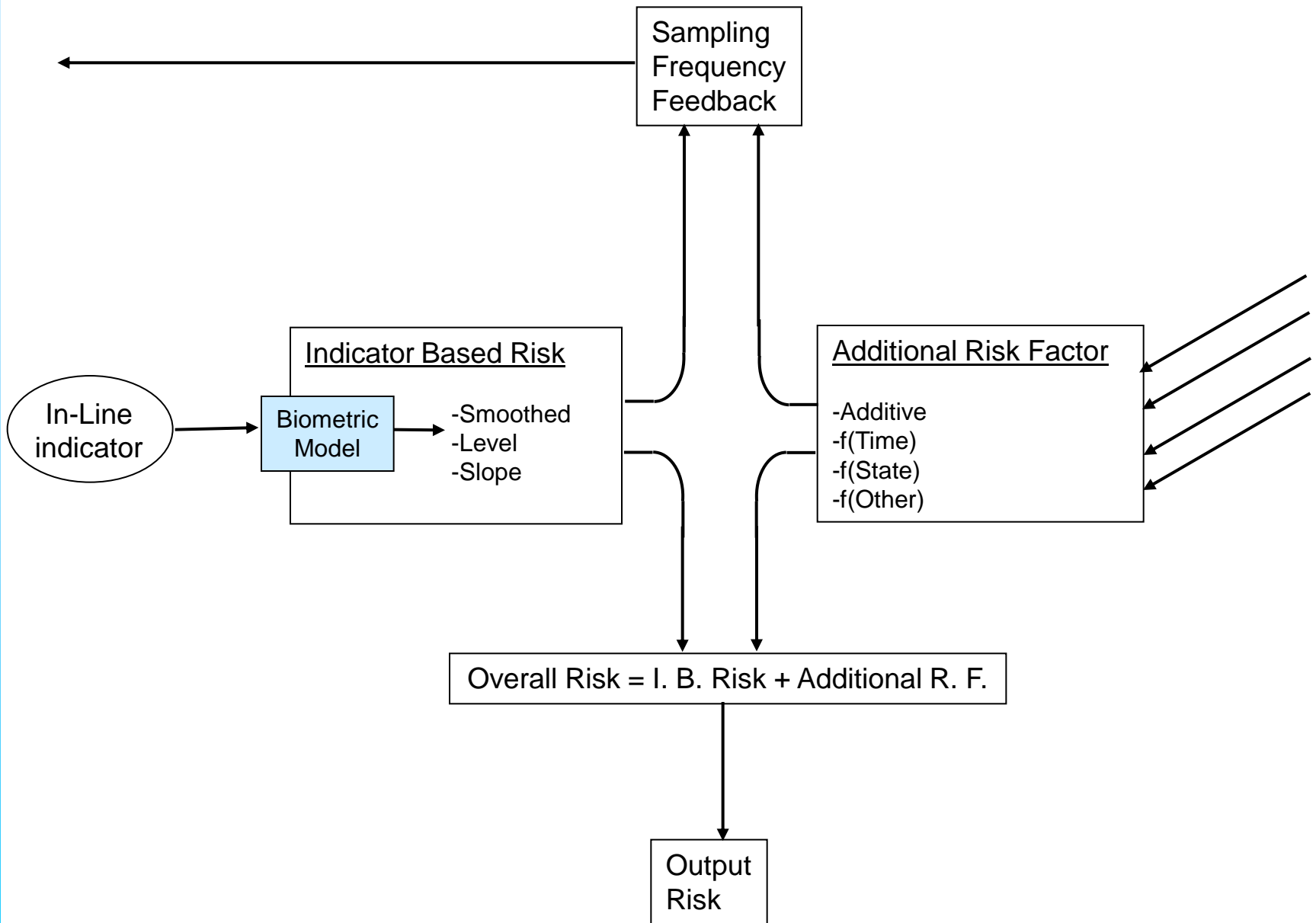
- Three models:
 - Ketose
 - Mastitis
 - Reproductive status
- Three indicators:
 - β -hydroxybutyrate (BOHB)
 - Lactate dehydrogenase (LDH)
 - Progesterone

Model Principles

- Robust
- Simple
- Flexible

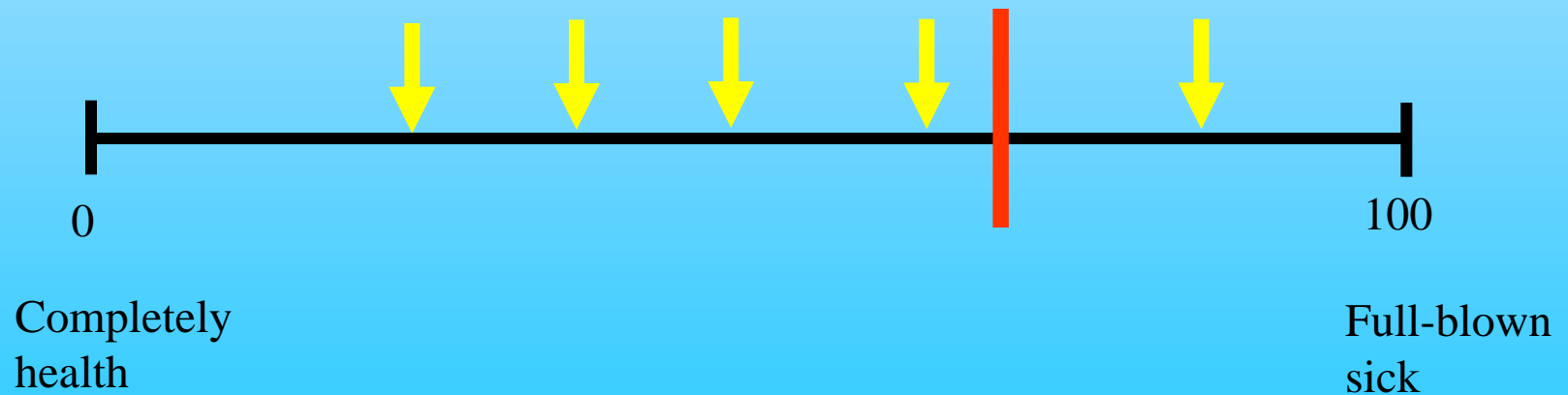


Model Architecture



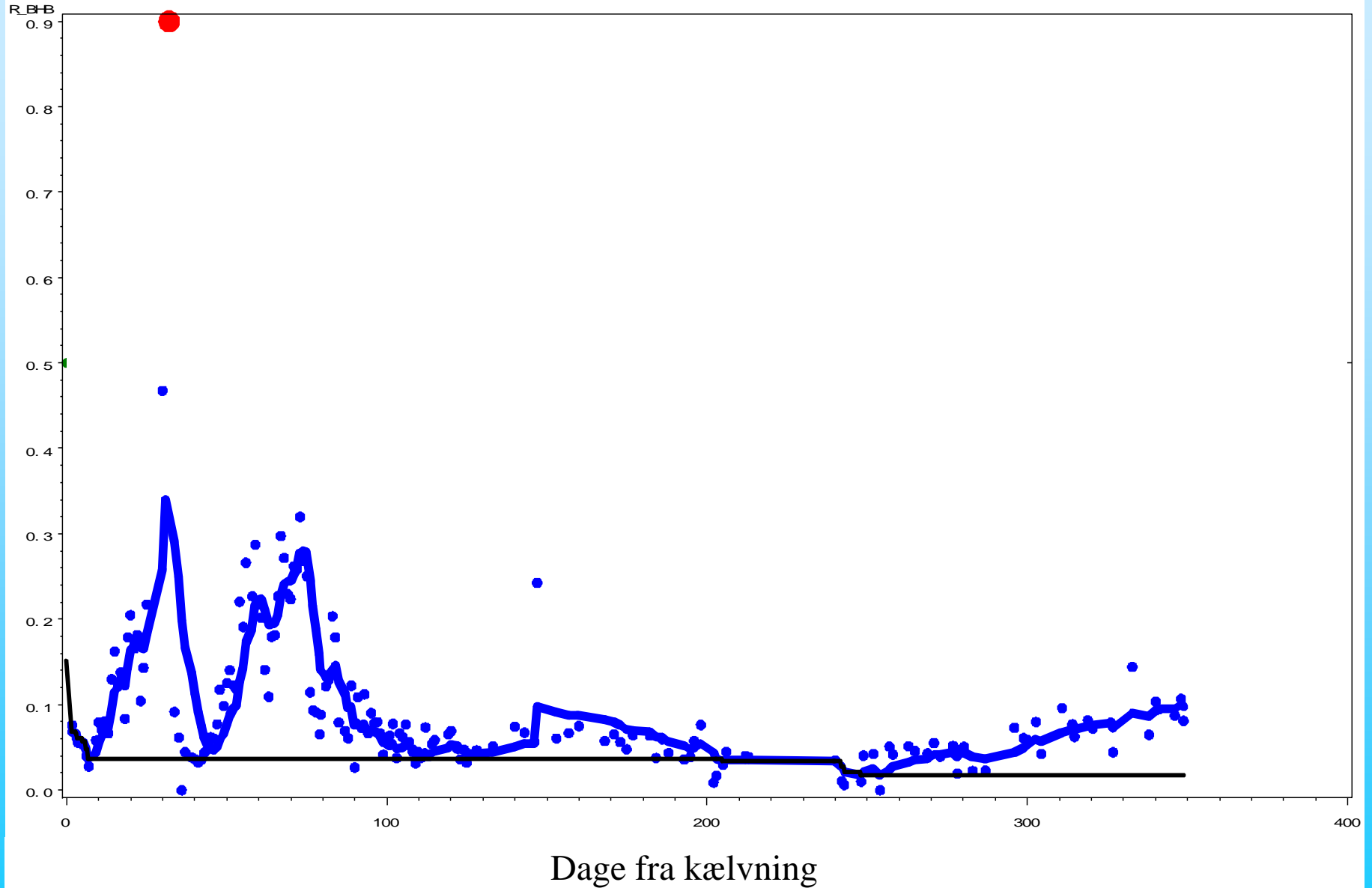
Model Output

- **Degree of ketose/mastitis etc.**
- Continuous scale: 0 to 100%
- **Risk of clinical ketose/mastitis etc.**

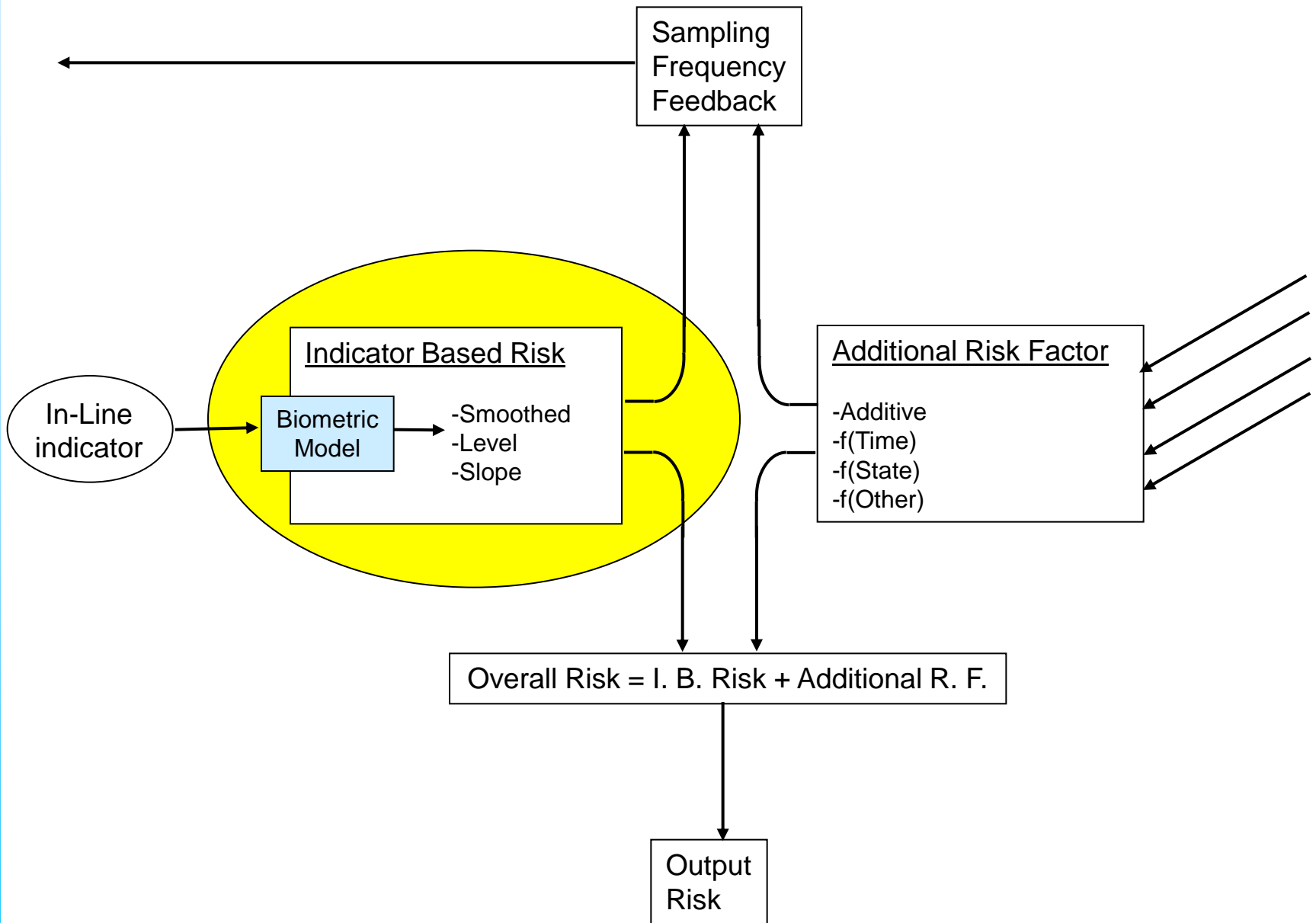


BHB

dyr nr =2314802992 I_Par i ty=2



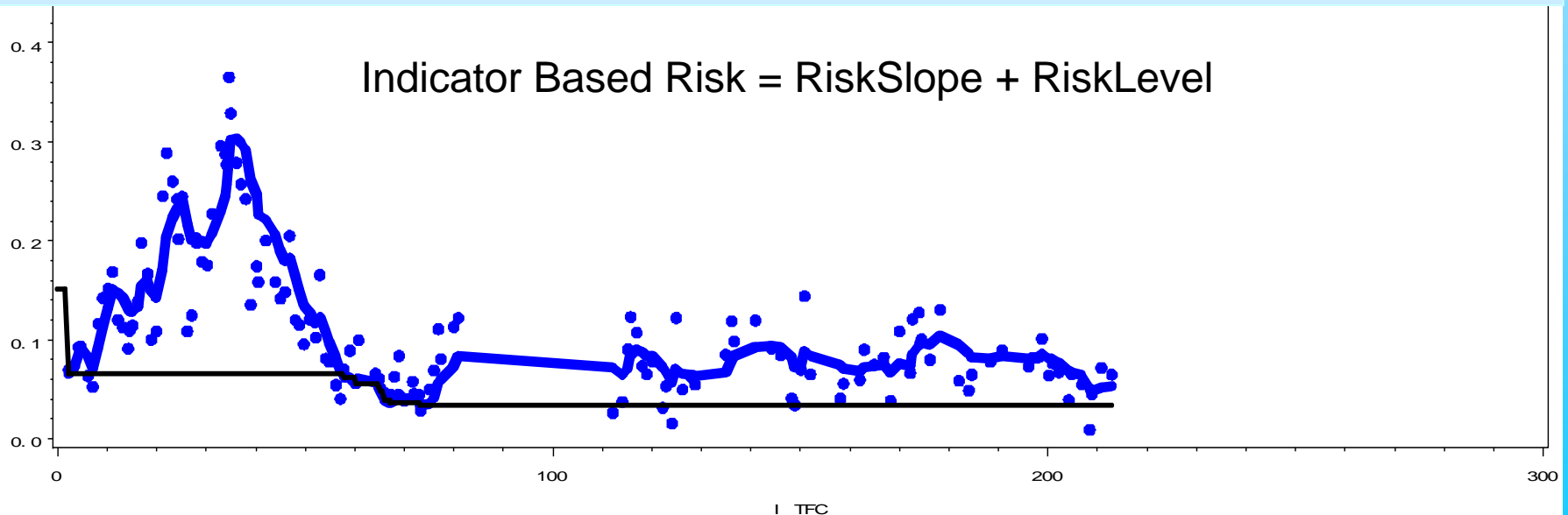
Model Architecture



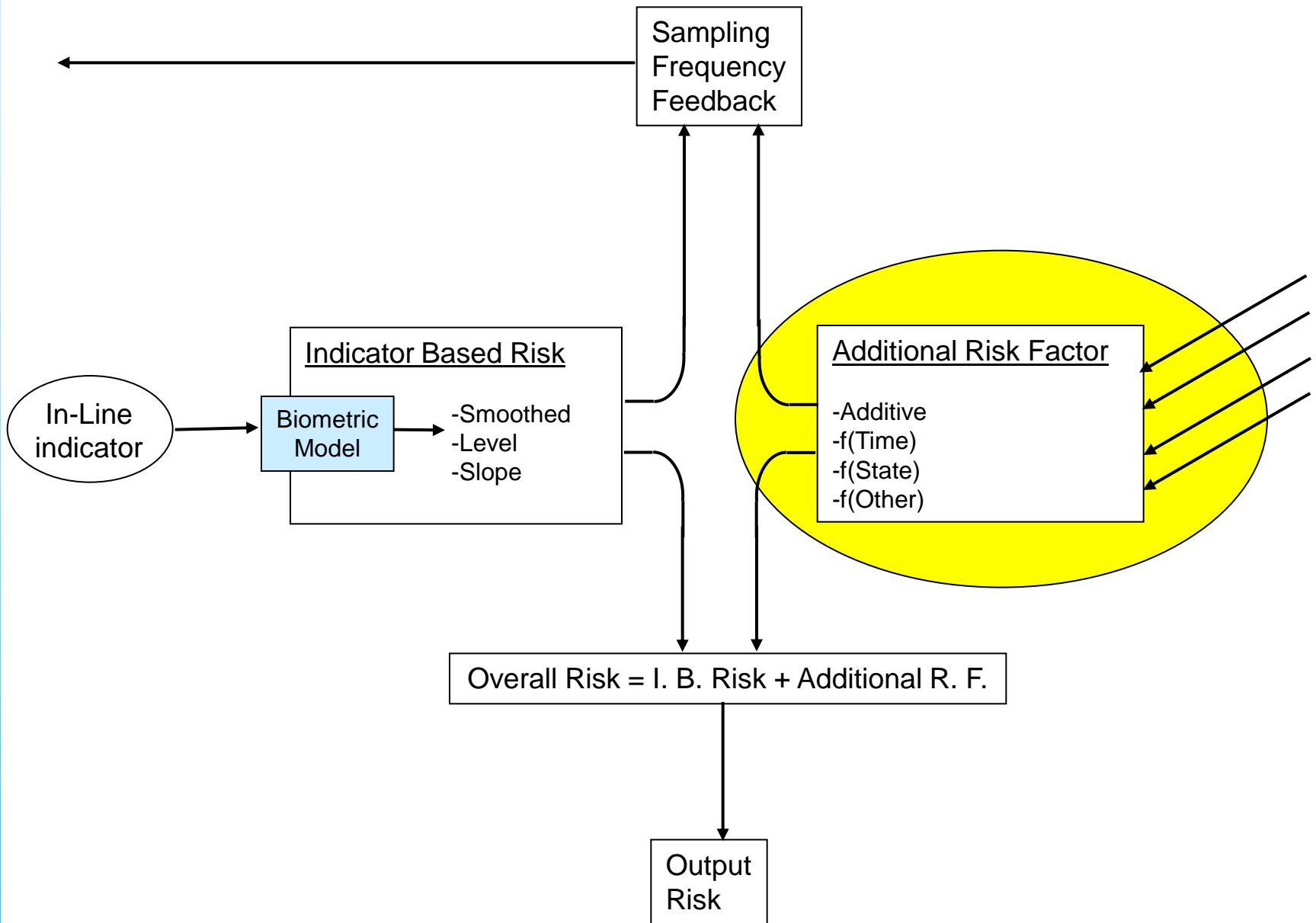
Indicator Based Risk

$$\text{RiskLevel} = \frac{(\text{Level} - \text{Baseline})}{K_L}$$

$$\text{RiskSlope} = \frac{(\text{Top} - \text{Bottom}) * \exp(-\exp(R * (\text{Slope} - T))) + \text{Bottom}}{K_S}$$



Model Architecture

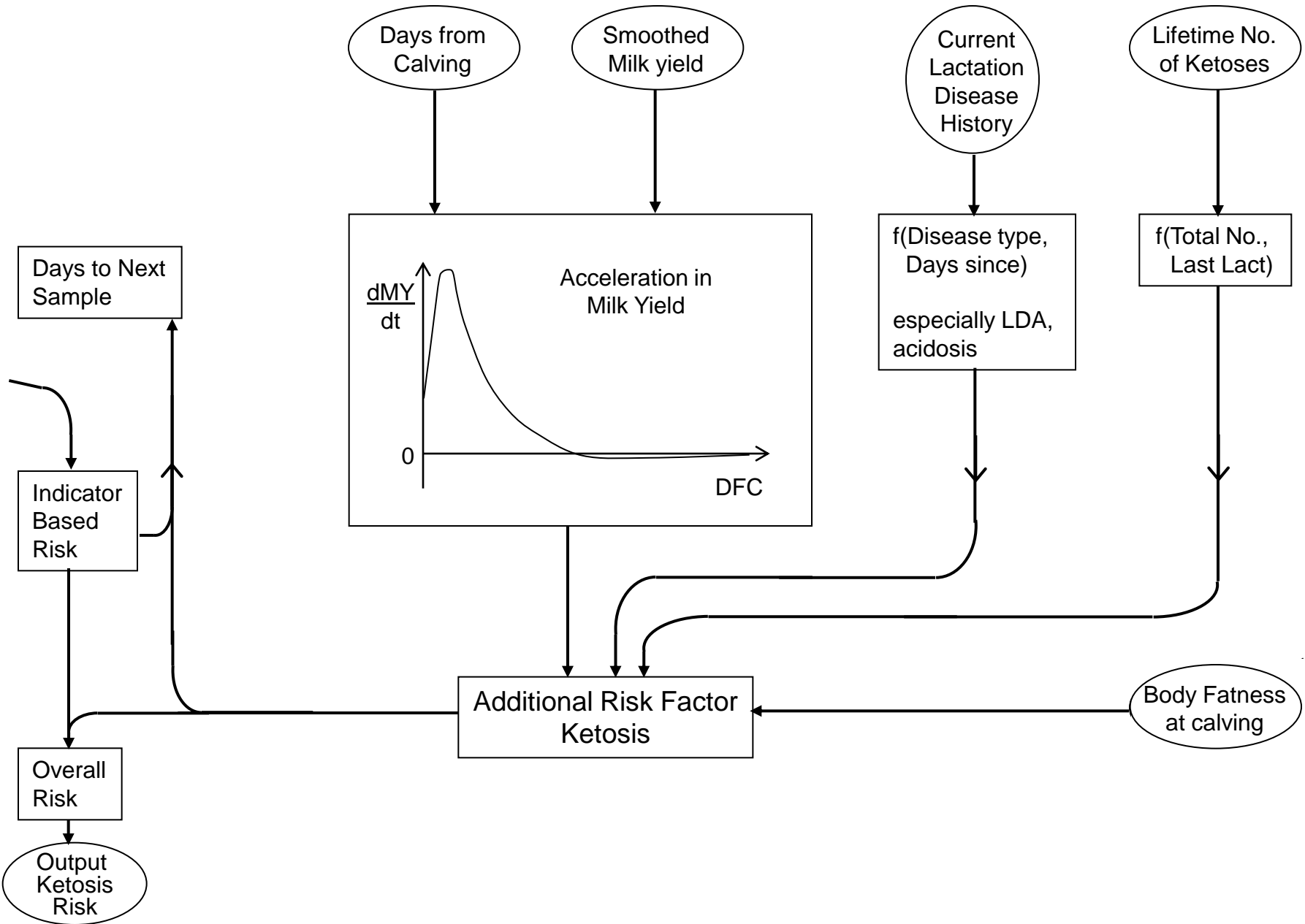


Additional Risk Factors

$$\text{Overall Risk} = \text{IBR} + 0.25 * \text{ARF}$$

The model functions without ARF

Diagram 2 Part 2: Ketosis – Additional Risk Factors

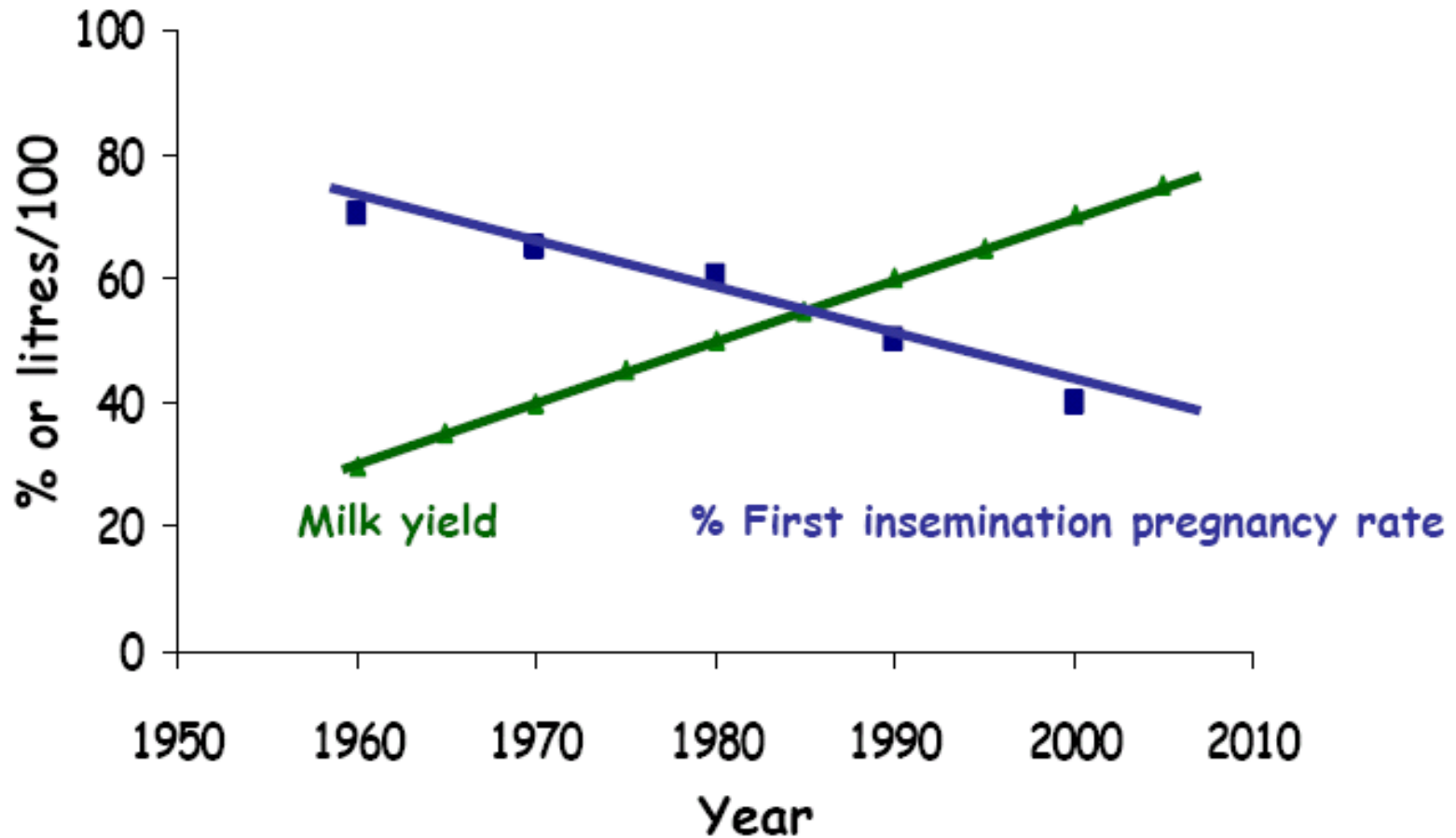


Reproductive Status in Dairy Cows:

- Why?
- Accuracy
- Adding value, biology
- Adding value, technology

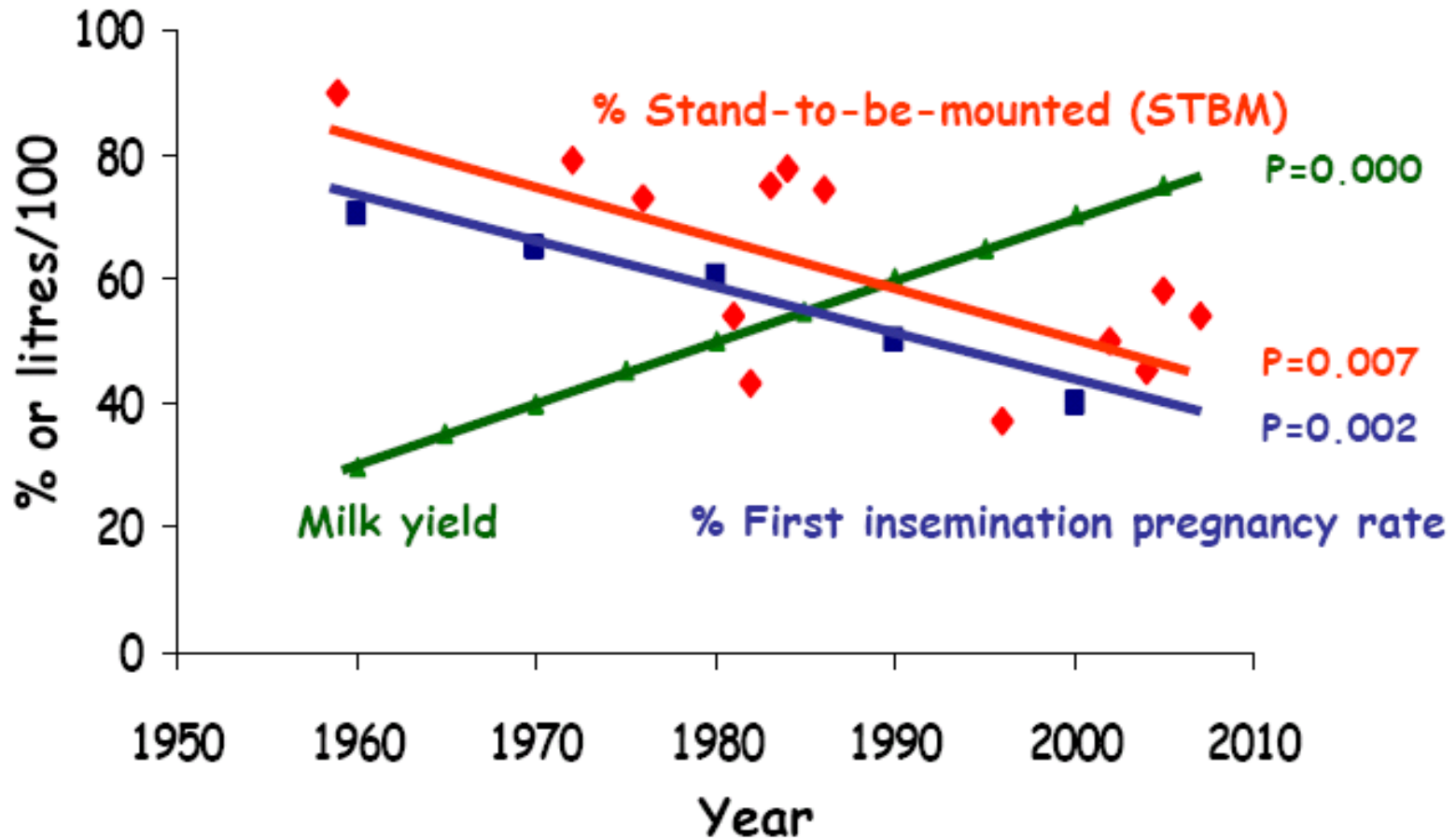
Chagunda, M. G. G., Bjerring, M., Ridder, C.,
Løvendahl, P., Højsgaard, S. and Larsen, T.

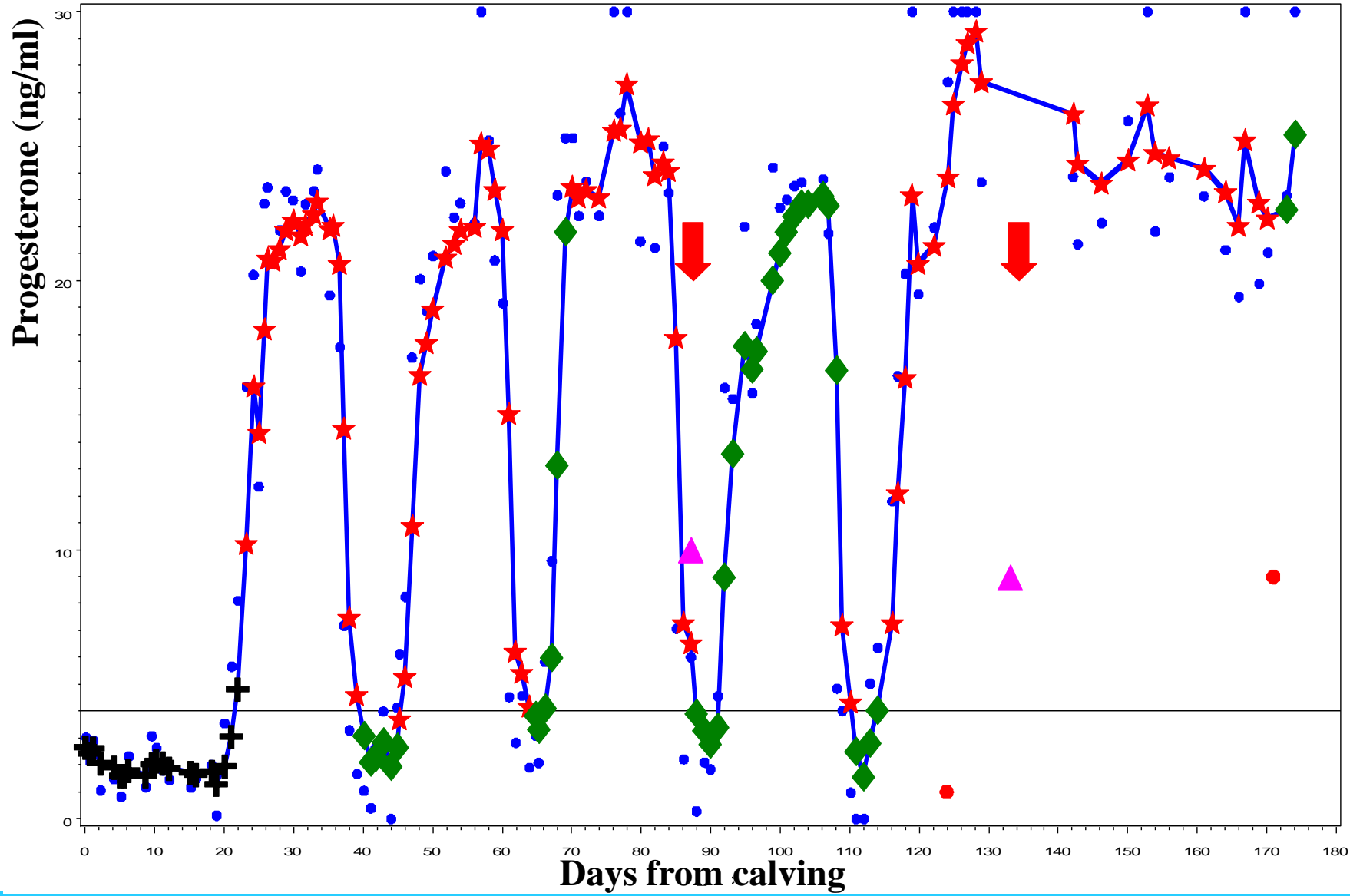
Increasing Herd Size






Oestrus detection is becoming increasingly difficult

- % cows 'standing' also declining





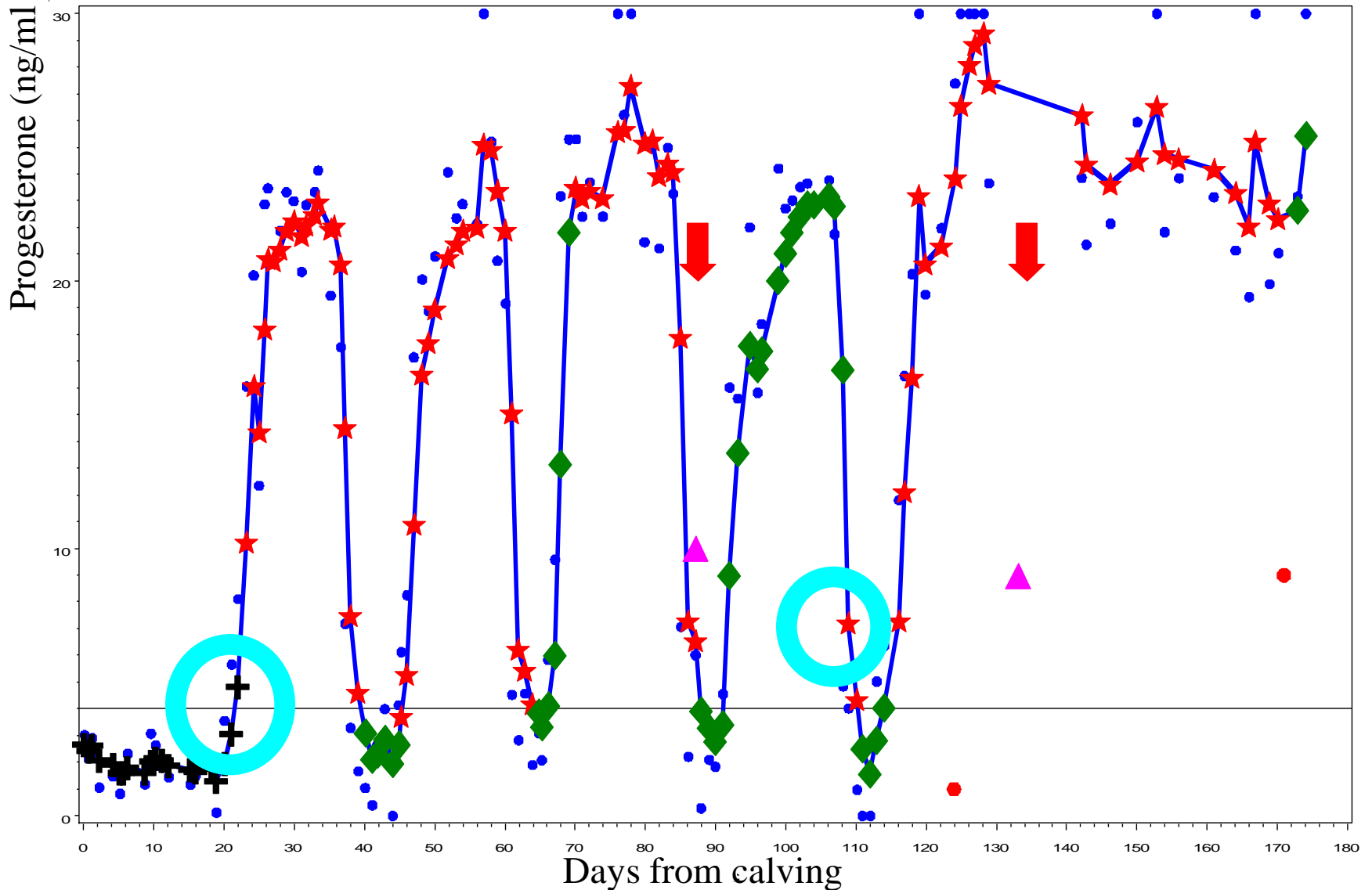
Reproductive Status

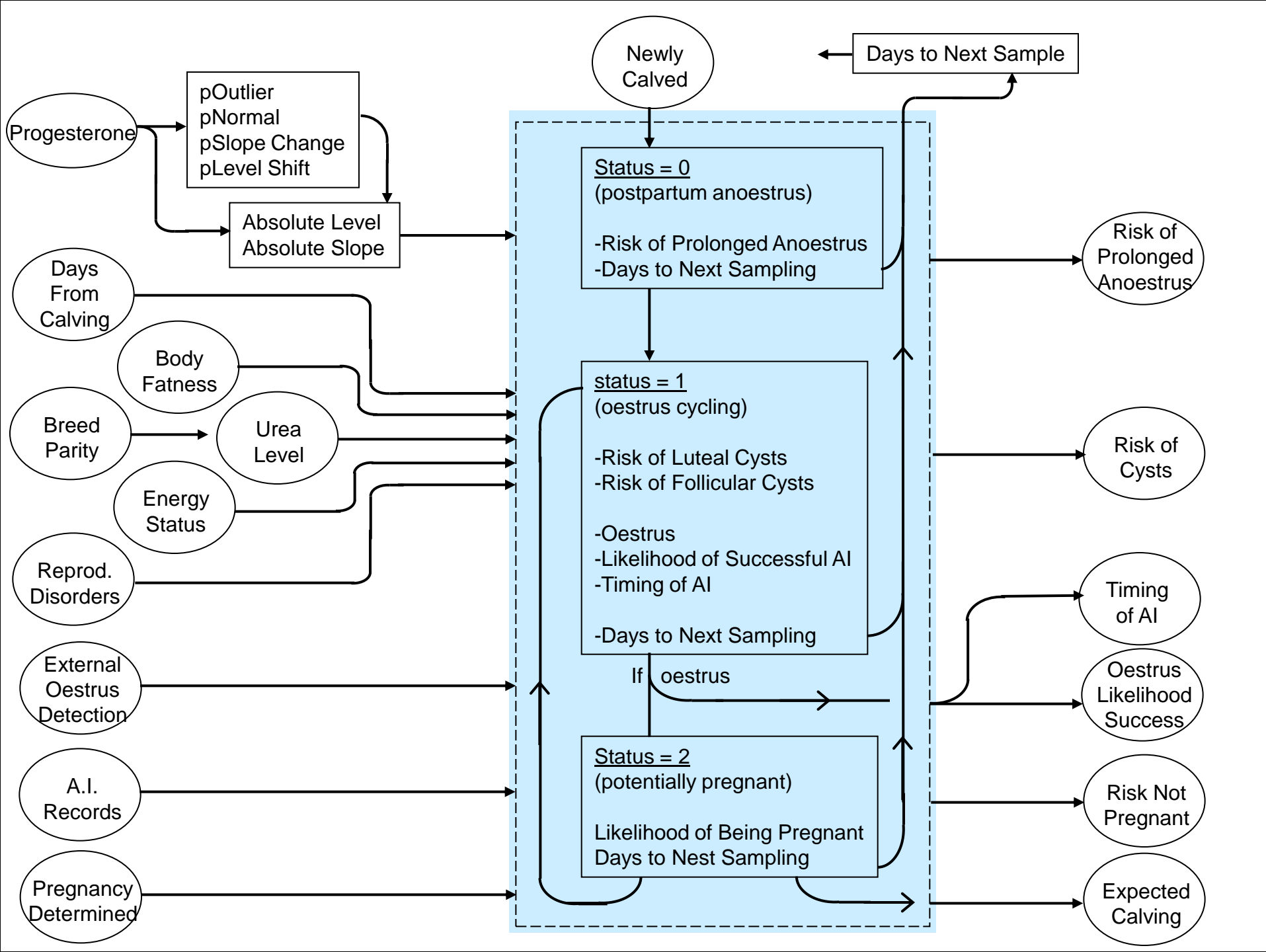
- Postpartum anoestrus 
- Oestrus cycling 
- Potentially pregnant 

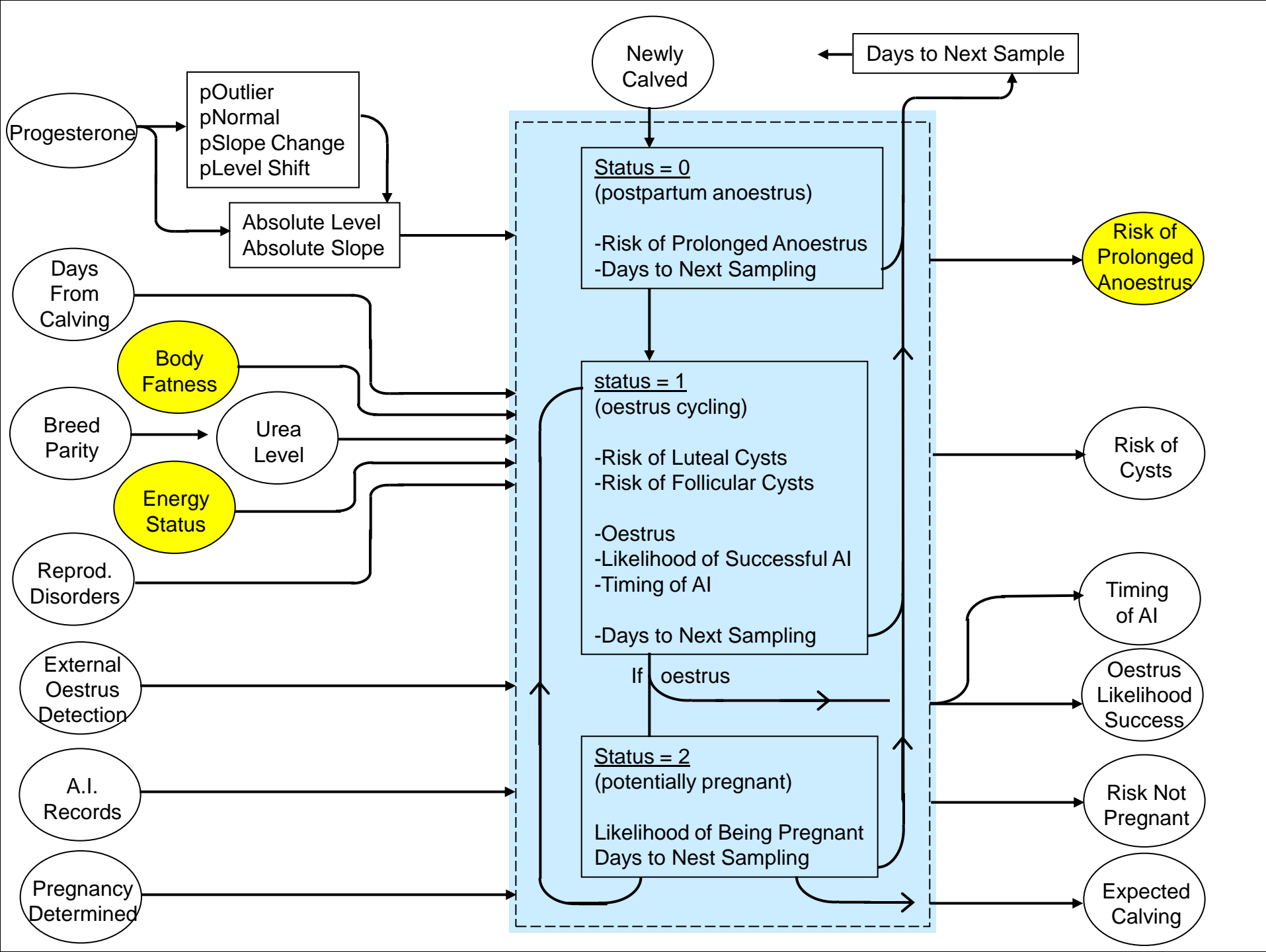
4 ng/ml progesterone threshold

(Friggens and Chagunda 2005)

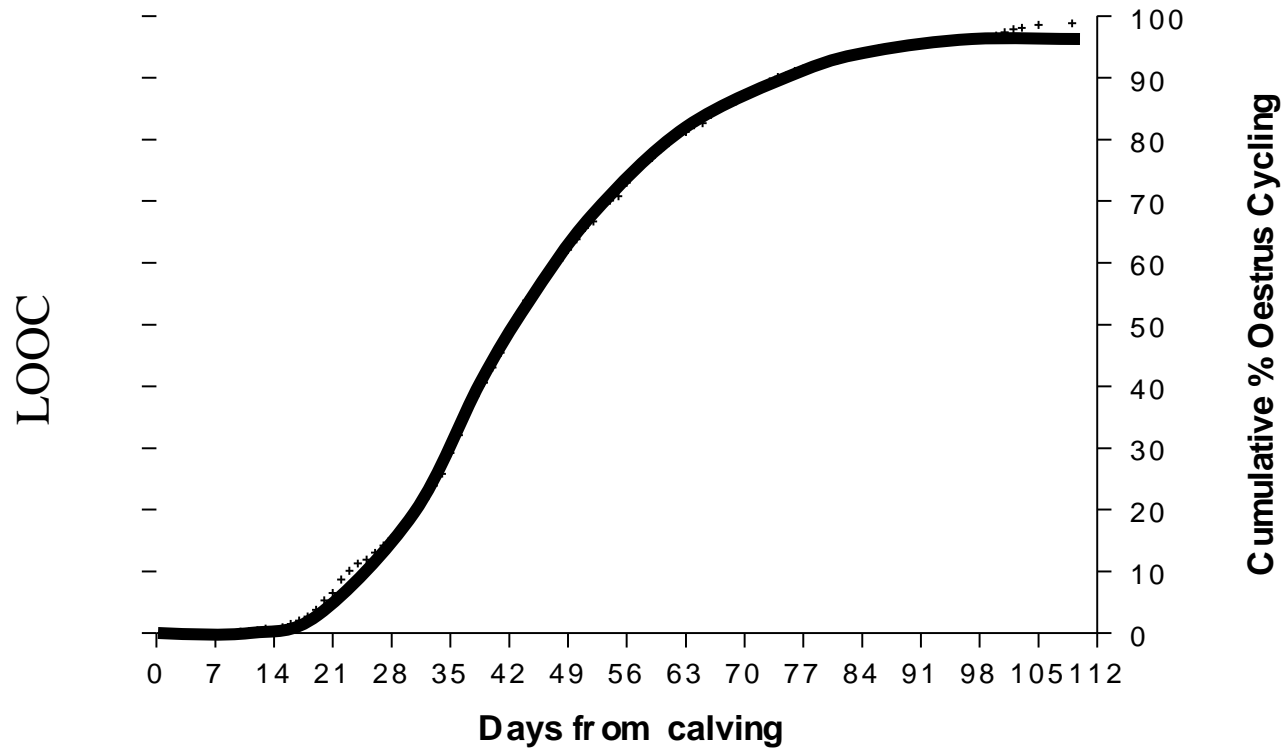
Not just Oestrus Detection





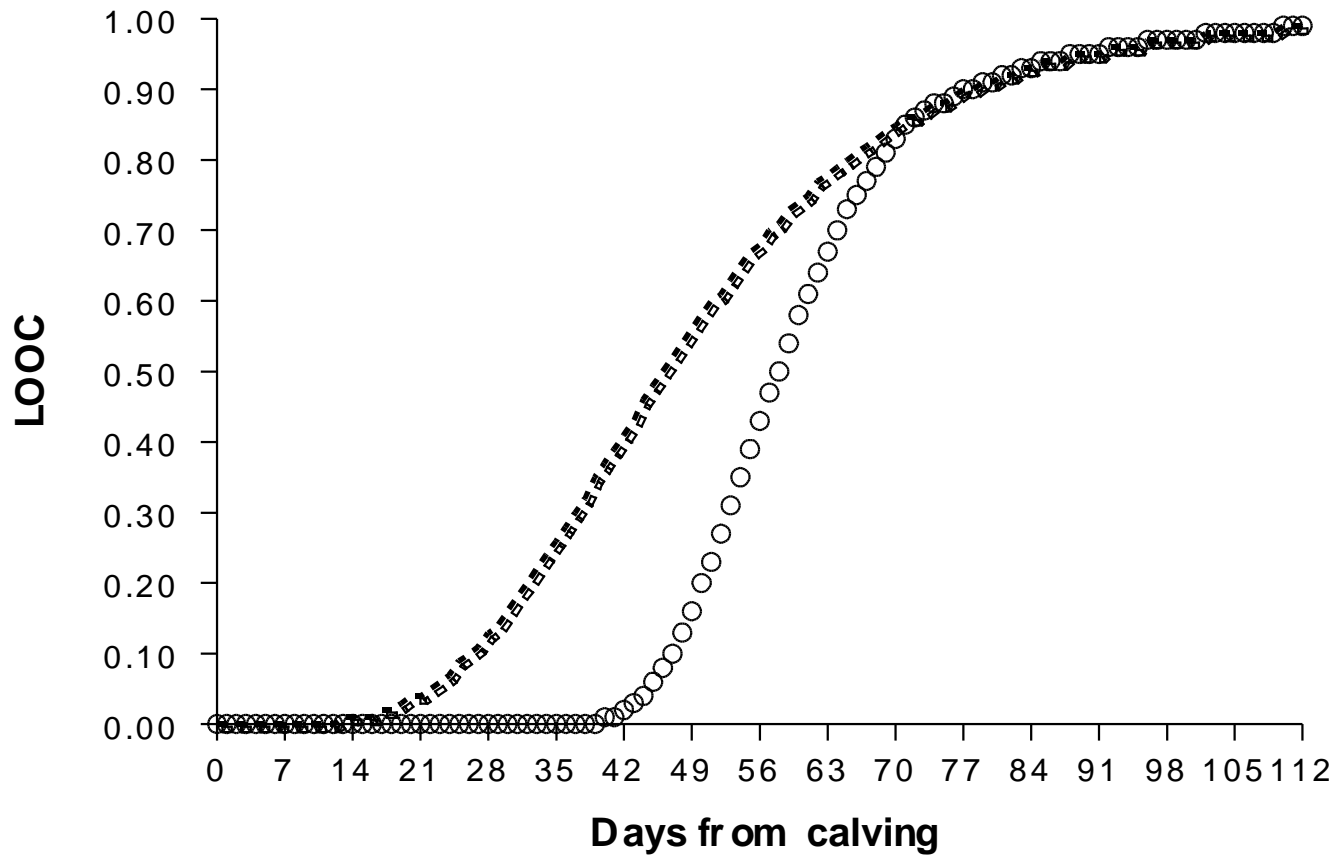


Likelihood of Onset of Oestrus Cycling

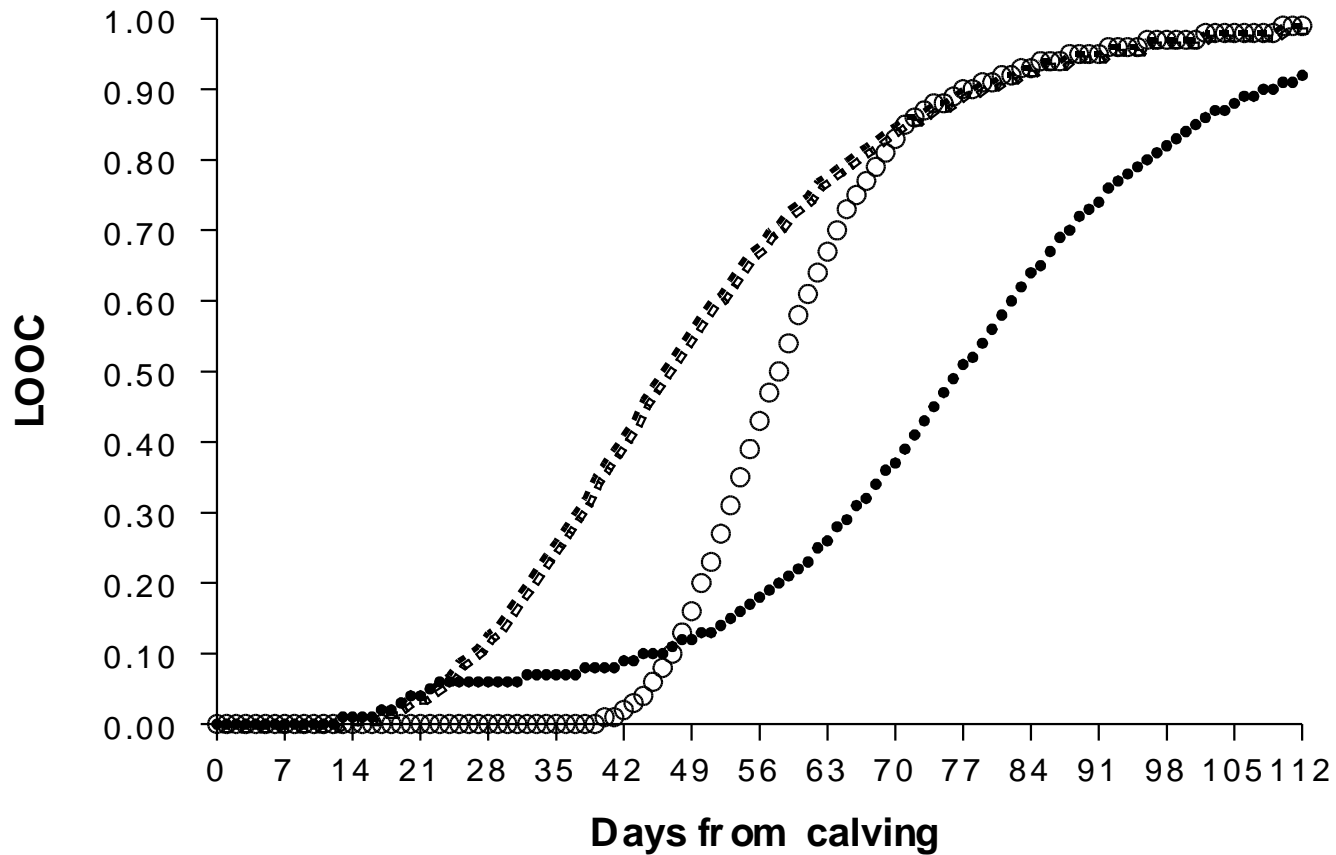


$$LOOC = bc * \exp(-\exp(\text{Rat} * (\text{DFC} - T)))$$

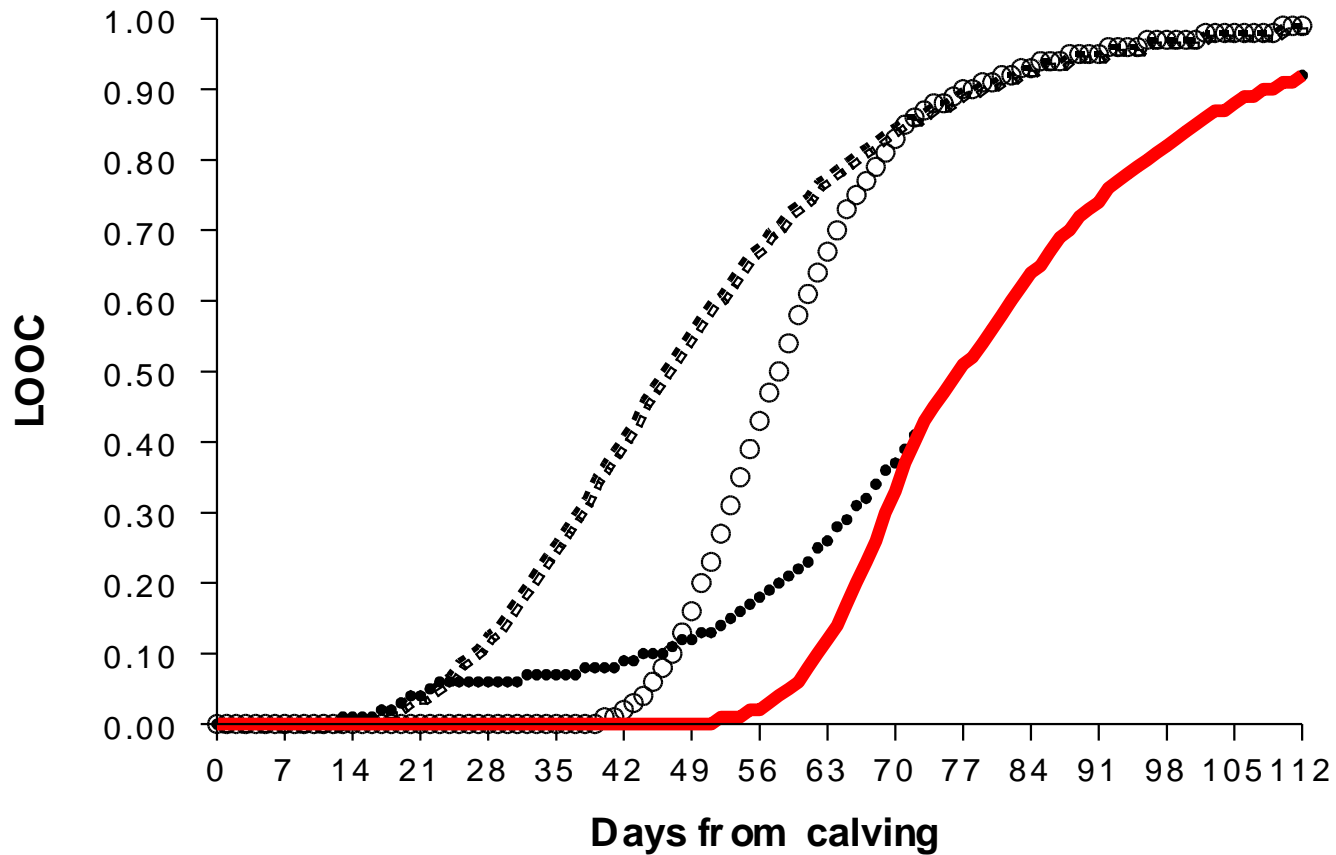
Effect of Body Fatness and Energy Mobilisation on LOOC



Effect of Body Fatness and Energy Mobilisation on LOOC

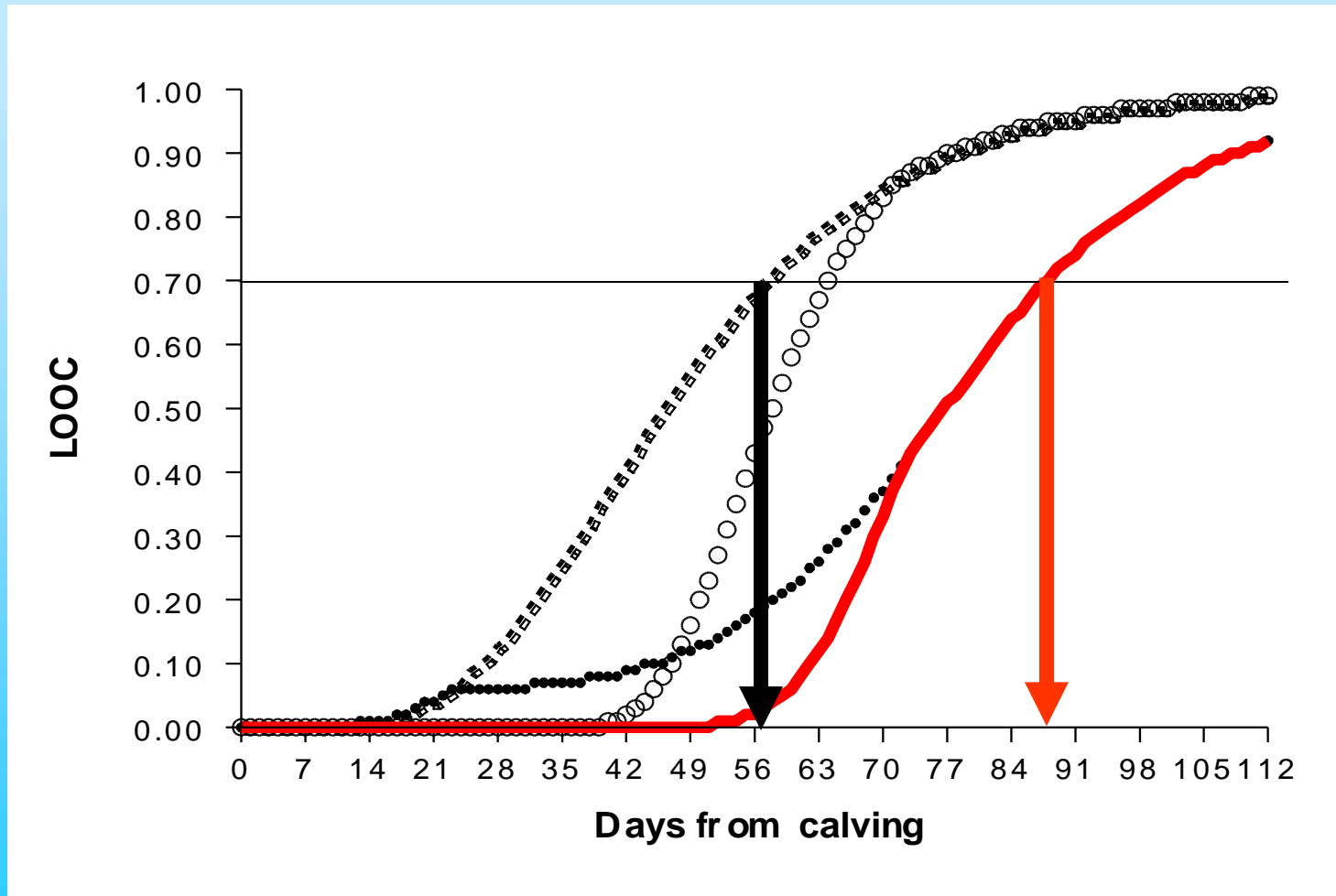


Effect of Body Fatness and Energy Mobilisation on LOOC



Example

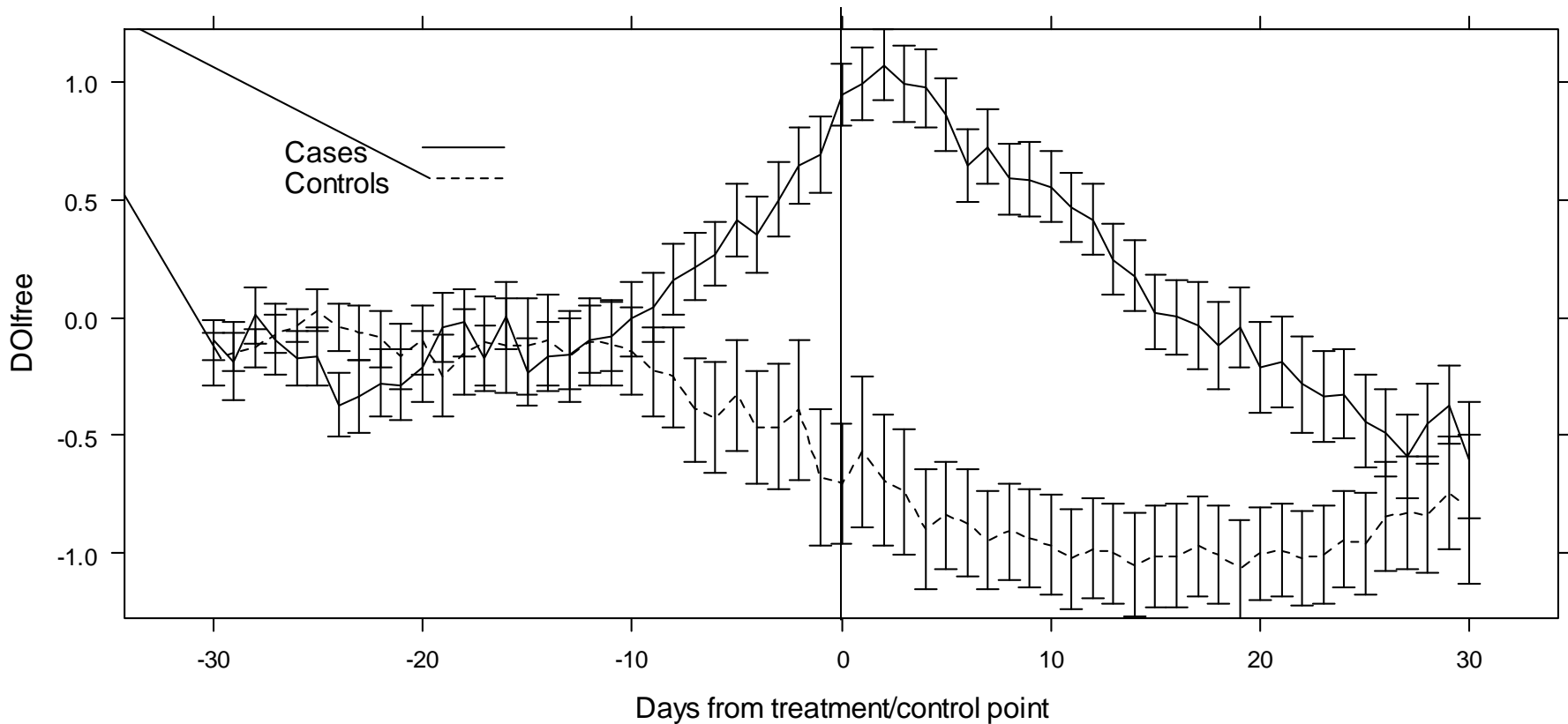
Assume we wish to treat anoestrus cows when LOOC reaches 0.7



Key Project Features

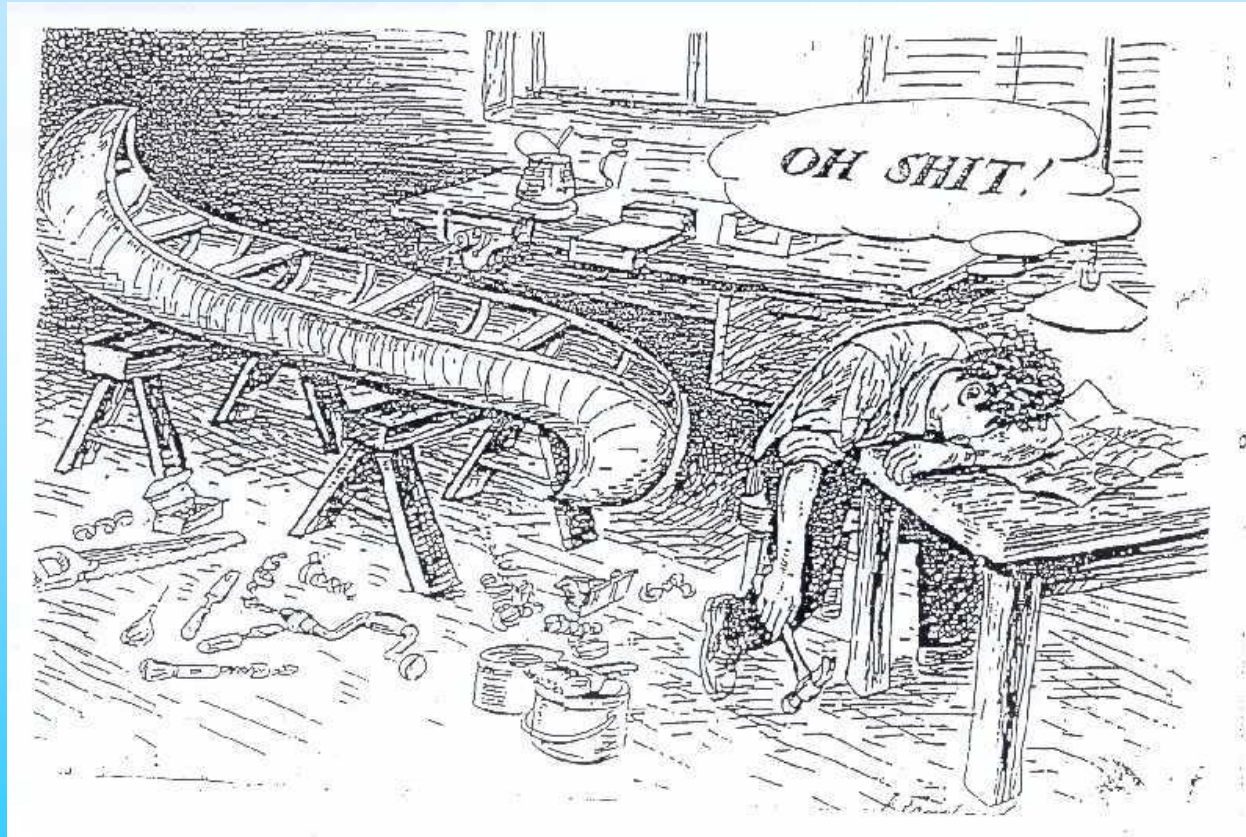
- A strong collaboration with industry
 - Building mutual respect
- Keeping it simple
 - Ensure deliver an application to time
- Sufficient reference data for proper validation
- A clear view of the biological system
 - Can add value to interpretation
 - Make best use of additional information
 - Advance our scientific understanding

DOI distinguishes mastitis cows 5 days prior to treatment



58 cases, 71 controls. Matched for stage of lactation, parity, etc.

Merci de votre attention



Model Testing: Oestrus

Test Criteria

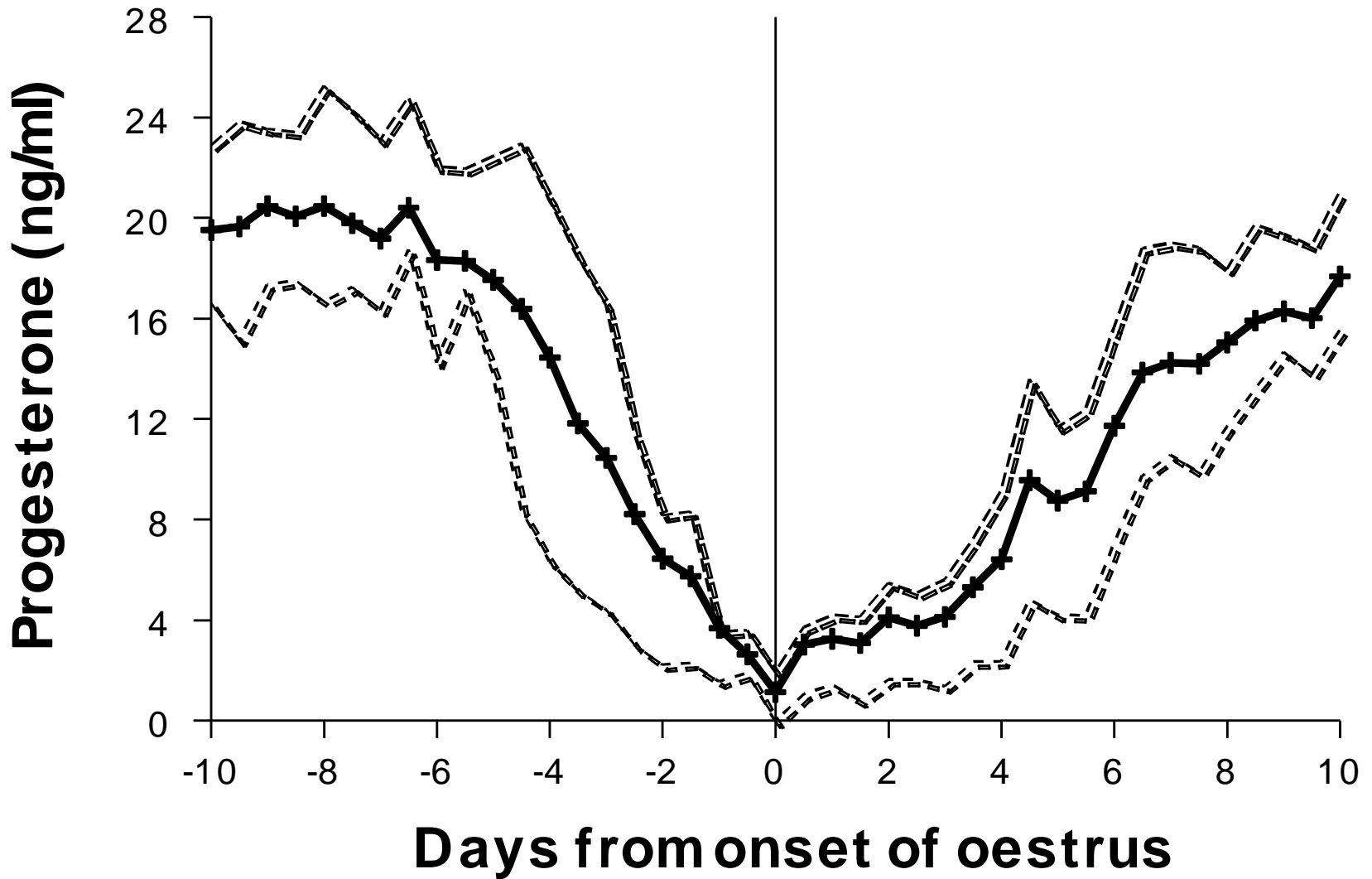
- What reference measure
 - progesterone is the gold standard
- Confirmed oestruses
 - resulted in confirmed pregnancy
- Ratified oestruses

Test data

total progesterone records:	55036
number of cows:	380
number of lactations:	578

Pregnancy Confirmed oestrus:	121
Ratified oestrus:	587

Confirmed Oestrus

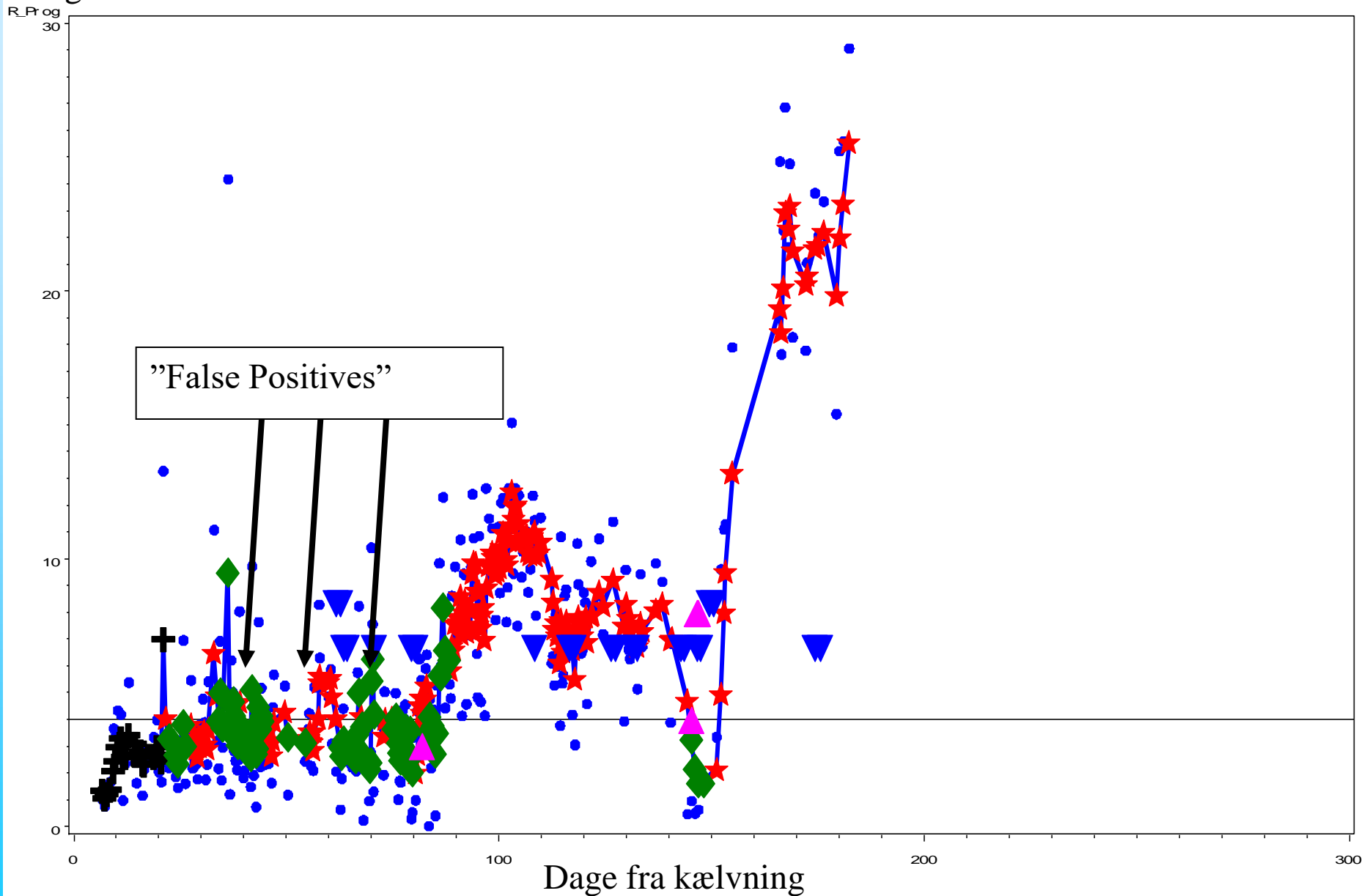


Method	Sensitivity
Milk Progesterone - confirmed oestrus	99%
- ratified oestrus	93%

Specificity: 94 %

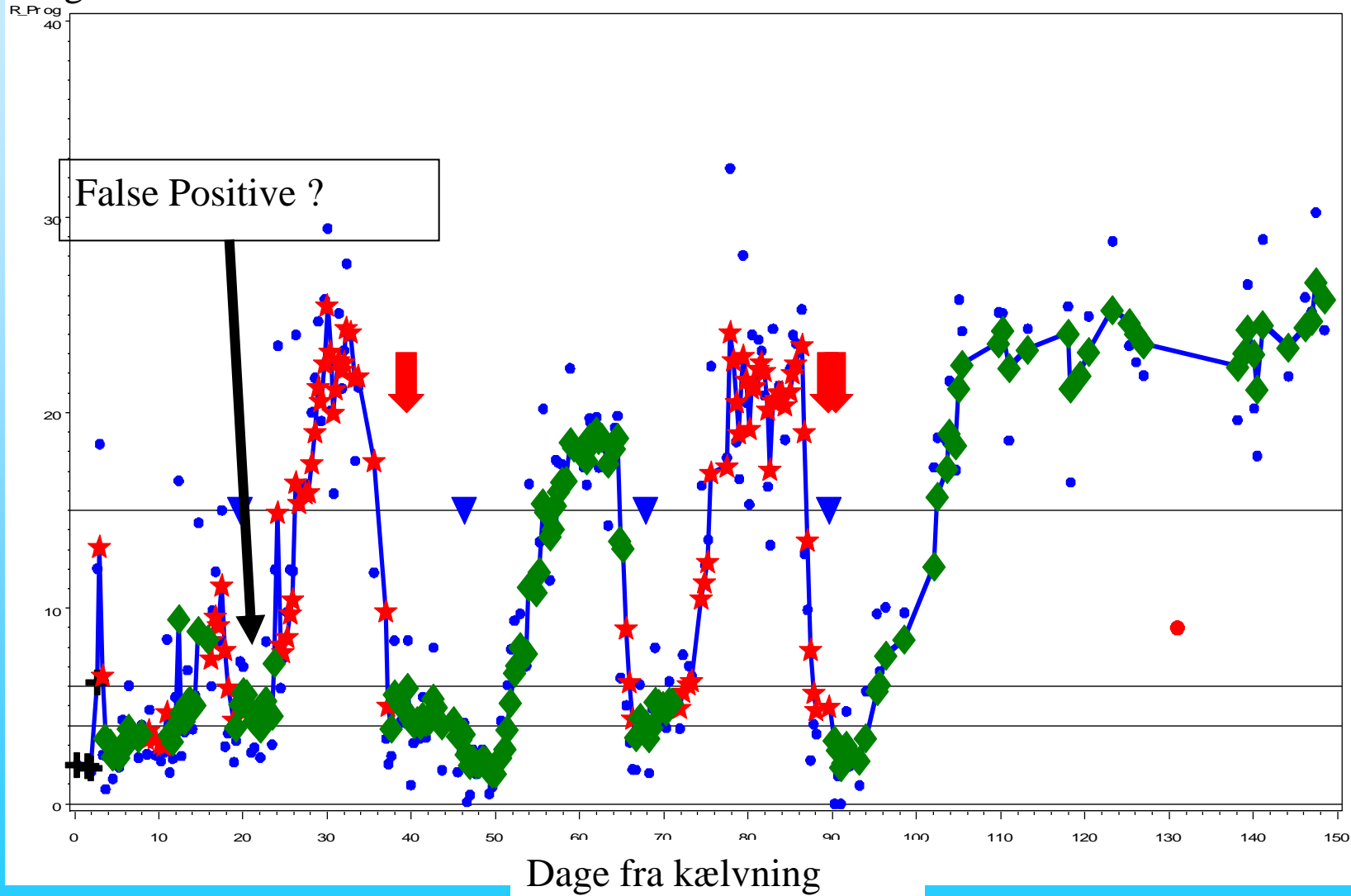
Progesterone

dyr nr =2314802672 l_Par i t y=2



Progesterone

dyr nr =2314802775 I_Parity=2



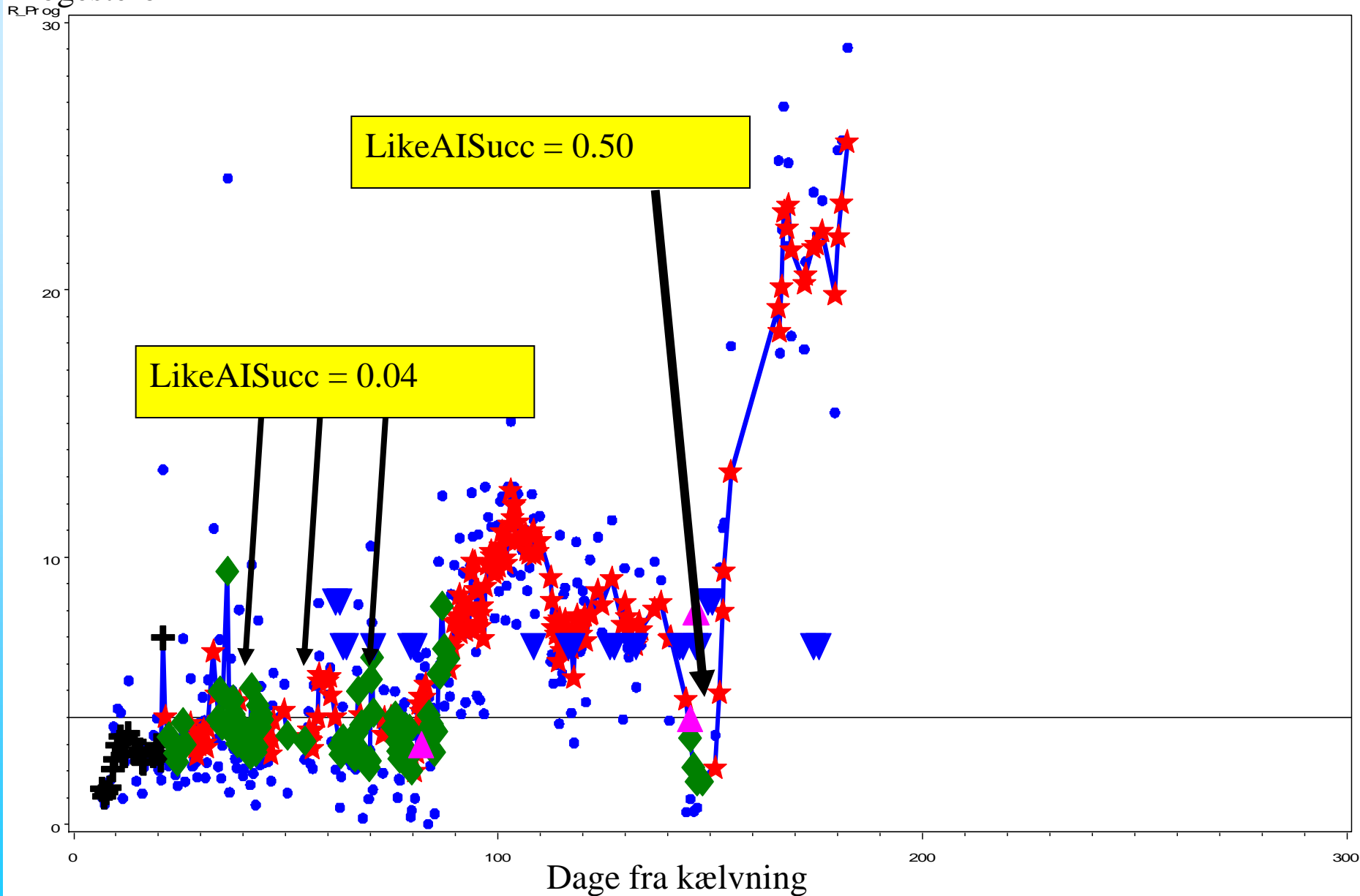
Is the cow ready for insemination?

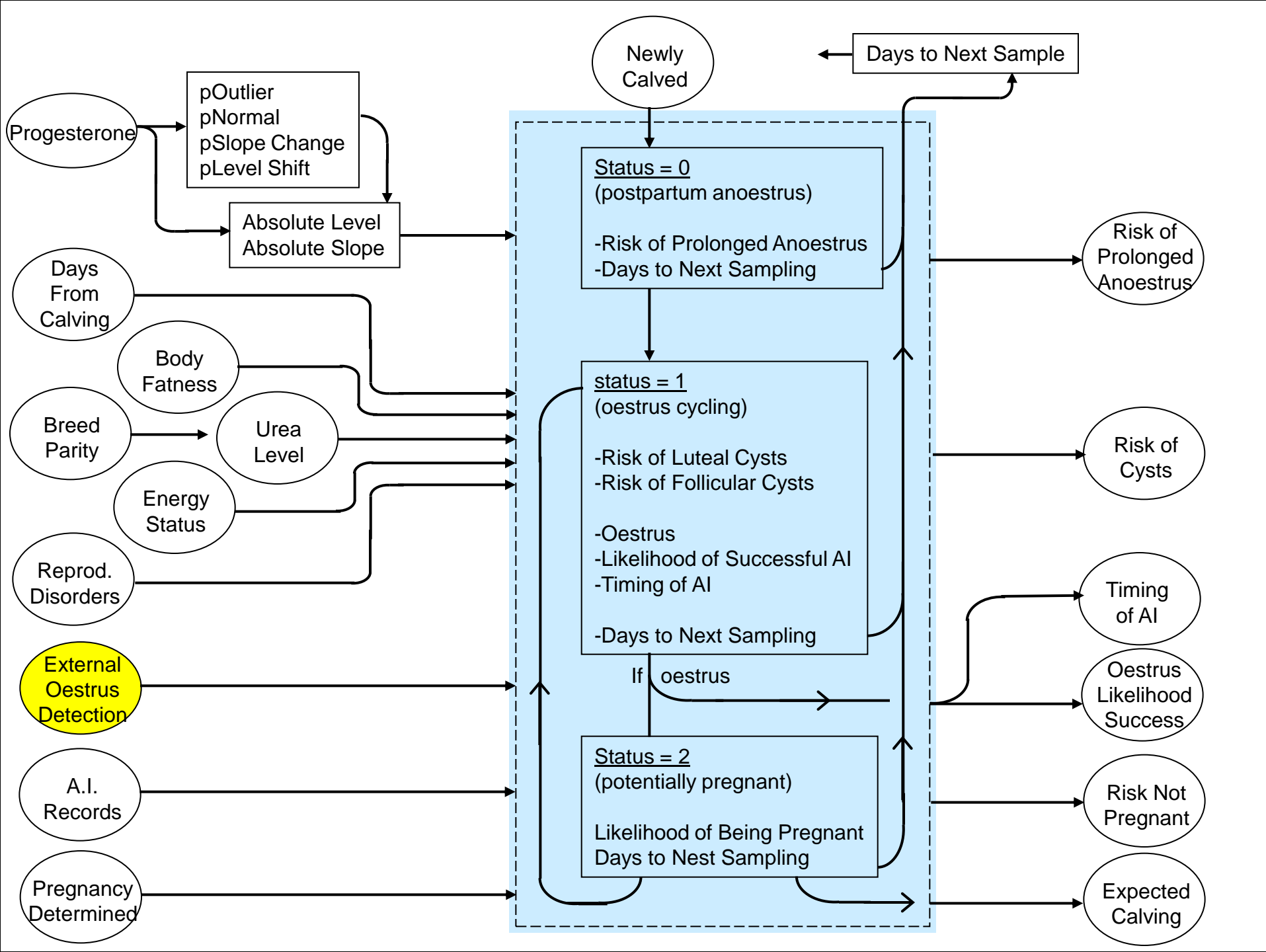
Likelihood of Success of a Prospective Insemination

- Under perfect conditions = 0.9
- Oocyte quality decreased by:
 - Excessive energy mobilisation 50 days prior
 - Disease/disorder 50 days prior
 - Luteal cysts (extended cycle length)
- Uterine quality decreased by:
 - shallow progesterone slope coming in to oestrus
 - short preceding cycle
 - high urea levels

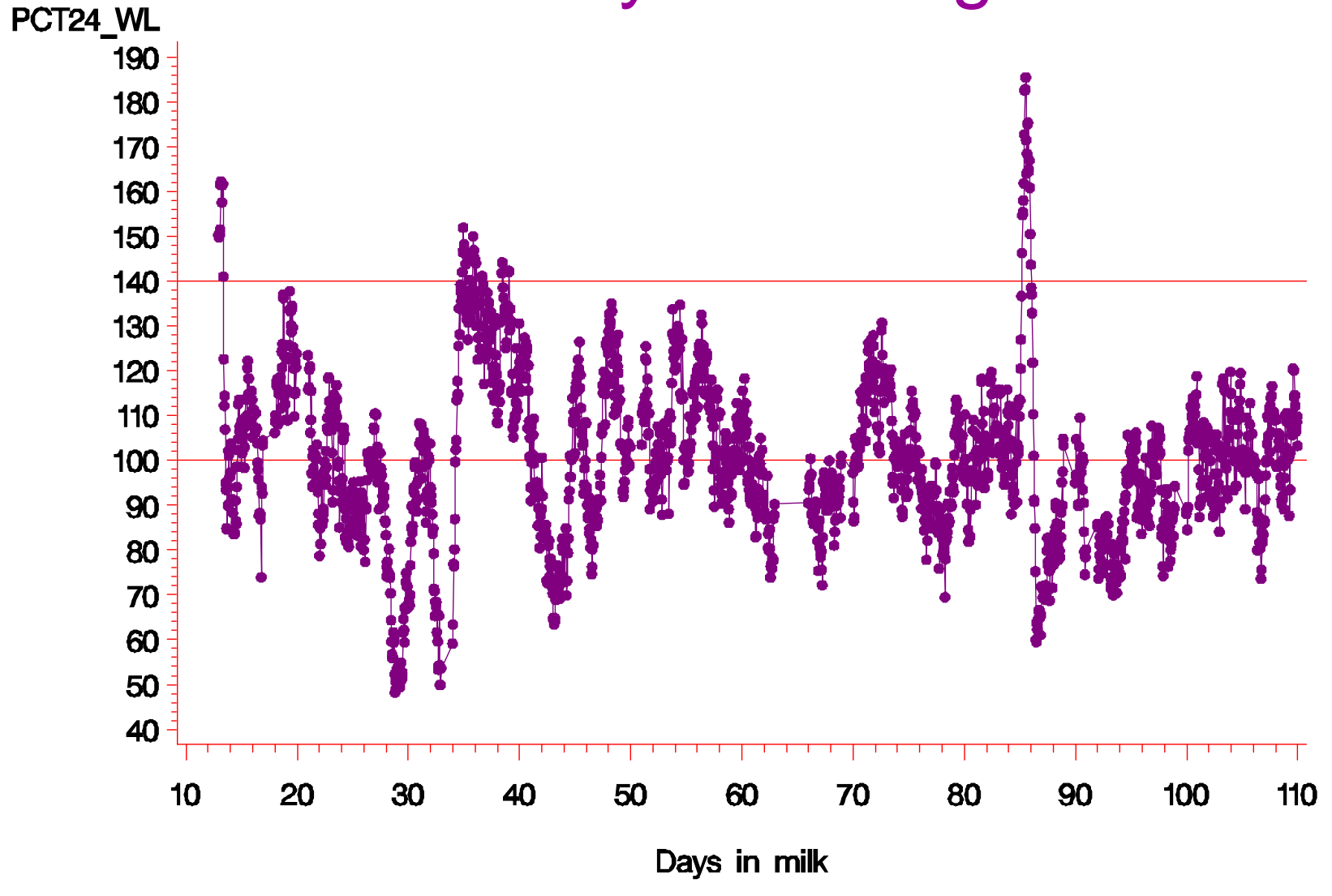
Progesteron

dyr nr =2314802672 l_Par i t y=2



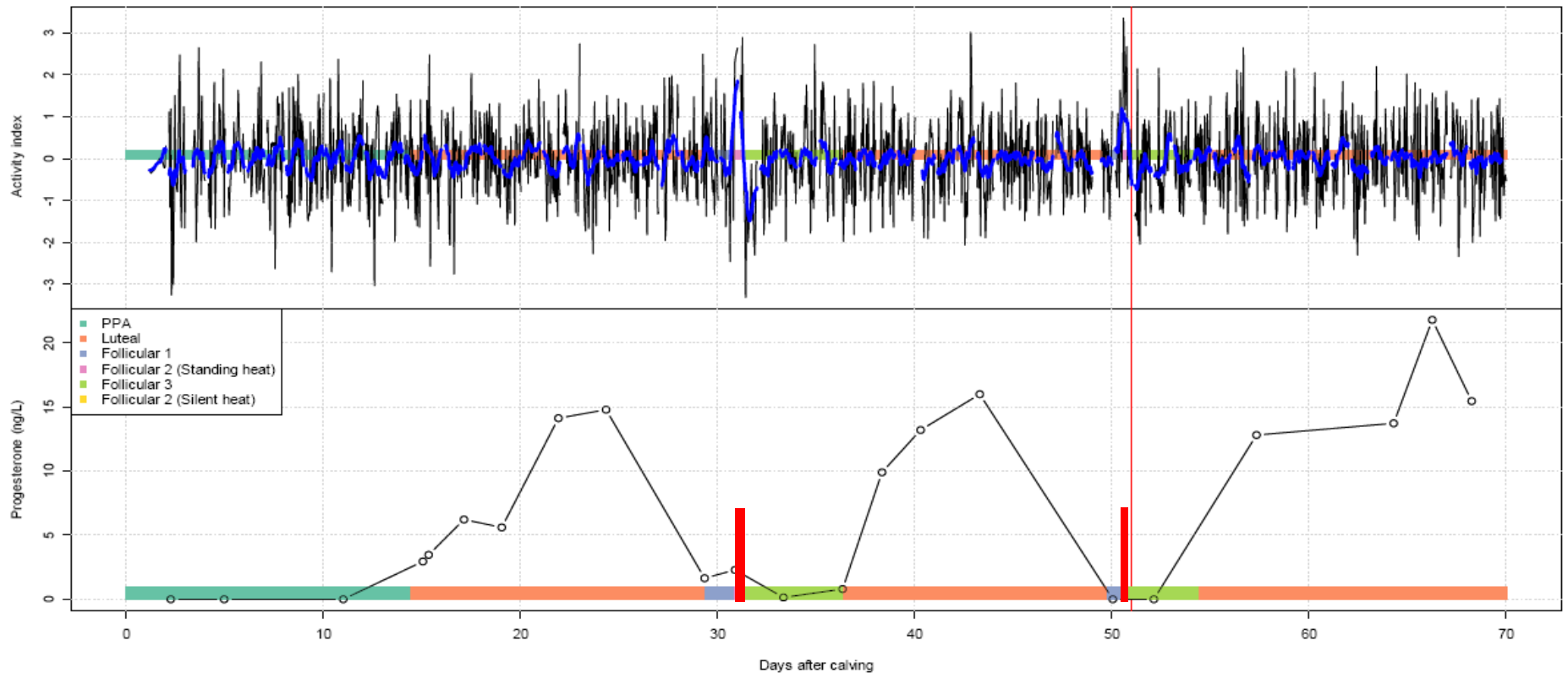


Combined Activity and Progesterone



Combined Activity and Progesterone

cow 10000000257 parity 3



(O'Connell 2009)

Biosens peer-reiewede artikler

Direkte Herd Navigator relaterede:

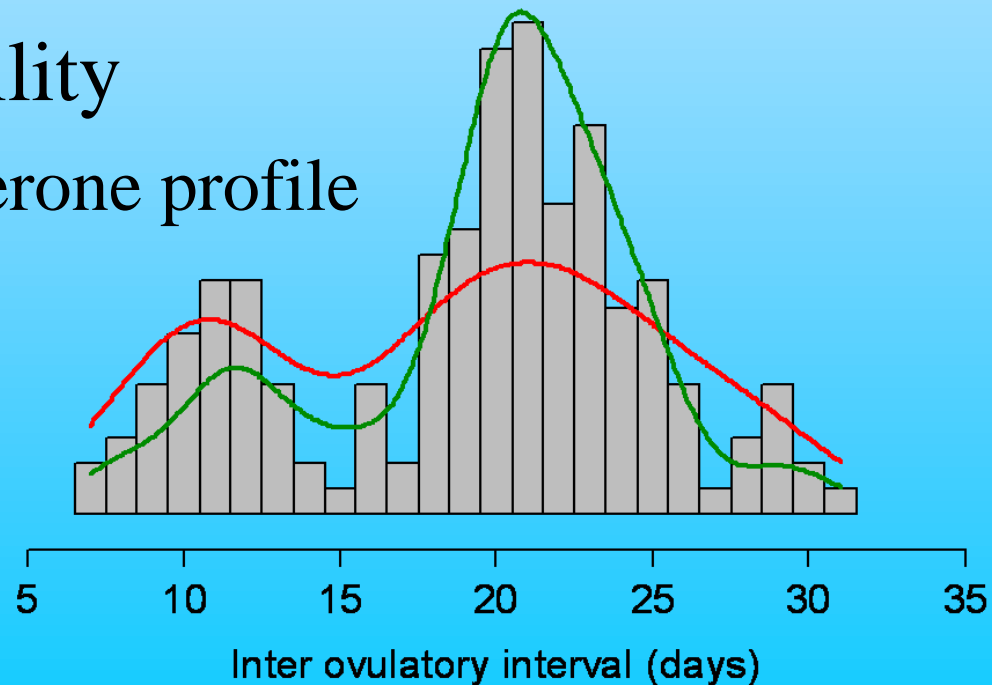
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- Chagunda, M.G.G., Friggens, N.C., Rasmussen, M.D., Larsen, T., 2006. A model for detection of individual cow mastitis based on an indicator measured in milk. *J. Dairy Sci.* 89, 2980-2998.
- Friggens, N.C., Chagunda, M.G.G., Bjerring, M., Ridder, C., Højsgaard, S., Larsen, T., 2007. Prediction of degree of mastitis from repeated measurements in milk: A test of a model based on lactate dehydrogenase measurements. *J. Dairy Sci.* 90, 5415-5427.
- Friggens, N.C., Bjerring, M., Ridder, C., Højsgaard, S., Larsen, T., 2008. Improved Detection of Reproductive Status in Dairy Cows using Milk Progesterone Measurements. *Reprod. Domestic Anim.* 43 (Suppl 2), 113-121.
- Norberg, E., Korsgaard, I.R., Sloth, K.H., Løvendahl, P., 2007. Time-series models on somatic cell score improve detection of mastitis. *Acta Agric. Scand. A*, 58 165-169.

Biosens Grund viden

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- Højsgaard, S., Lauritzen, S., 2007. Inference in graphical Gaussian models with edge and vertex symmetries with the gRcox package for R. *Journal of Statistical Software* – submitted.
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Time-series measurements: Perspectives

- Reliable oestrus detection means:
 - More accurate breeding values
 - Traditionally low $h^2 \sim 0.03$
 - Progesterone based $h^2 \sim 0.17$ (Royal et al. 2002)
- Components of fertility
 - Features of progesterone profile



Matematikken i en tidsserie

Måling(er) nu

= systematisk niveau ved sidste måling

+ (beregnet) systematisk ændring

+ støj på systematisk ændring

+ støj på den enkelte måling

→ to grundlæggende ligninger:

Observations ligning: $Y_t = F_t \Theta_t + v_t$

System ligning: $\Theta_t = G_t \Theta_{t-1} + \omega_t$

4 modeller på fælles skabelon

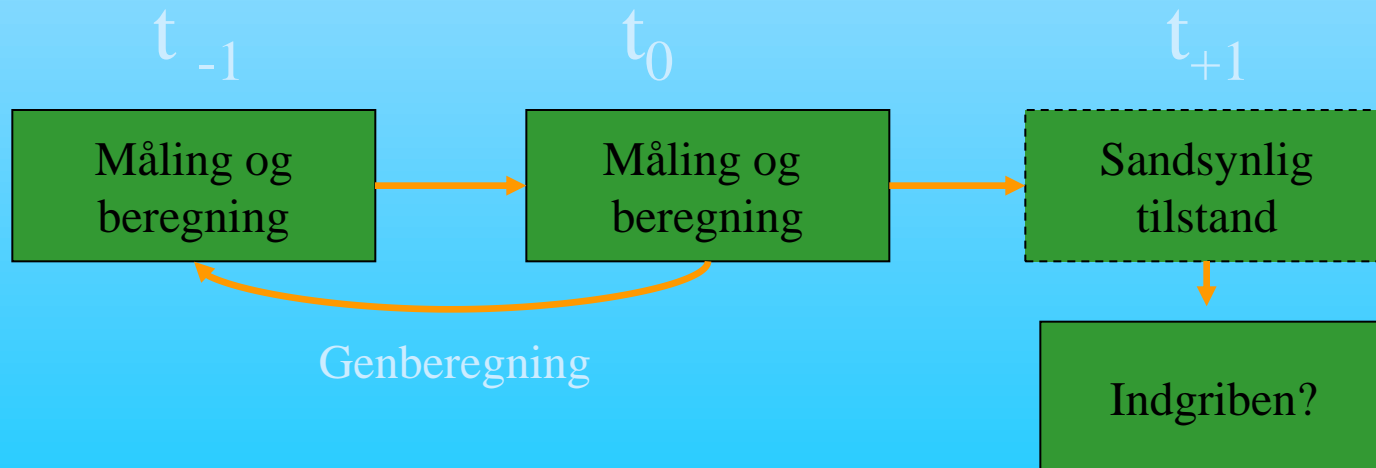
Parameter værdier giver forskelle

Eksempel:

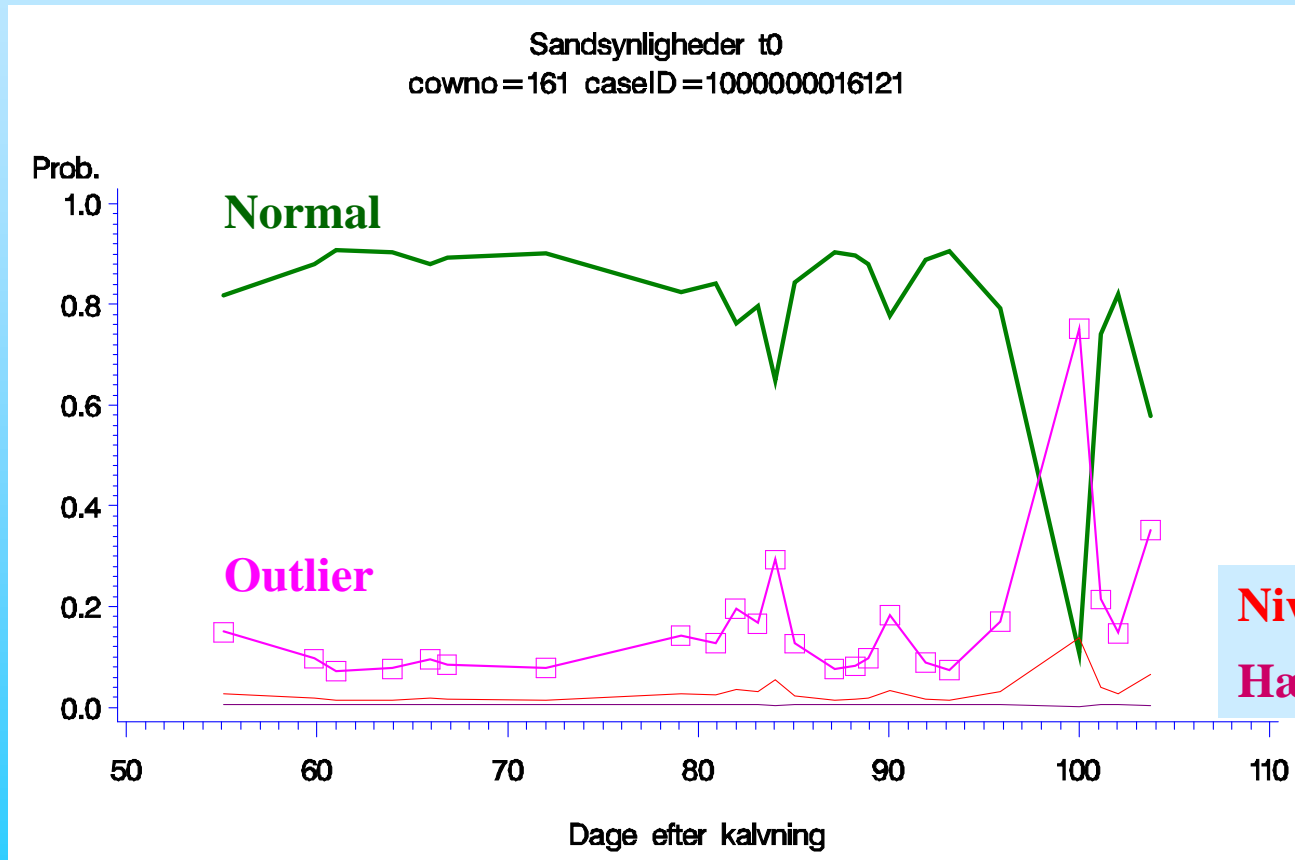
Modeller	P_0 % <i>forekomst</i>	Varians	E_μ <i>niveau</i>	E_β <i>hældning</i>
1 Normal	94	1,0	0,0	0,0
2 Niveau	2	1,0	20,0	0,0
3 Hældning	2	1,0	0,0	10,0
4 Ekstrem	2	50,0	0,0	0,0

Elementer i tidsserien:

lige nu t_0
se fremad $t+1$
se tilbage $t-1$



Sandsynligheder for 4 tilstande t_0 , her og nu



"Backsmoothing" i trin 1 og 2

