Utrecht University

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Making sense of sensors: The prediction of hypocalcemia

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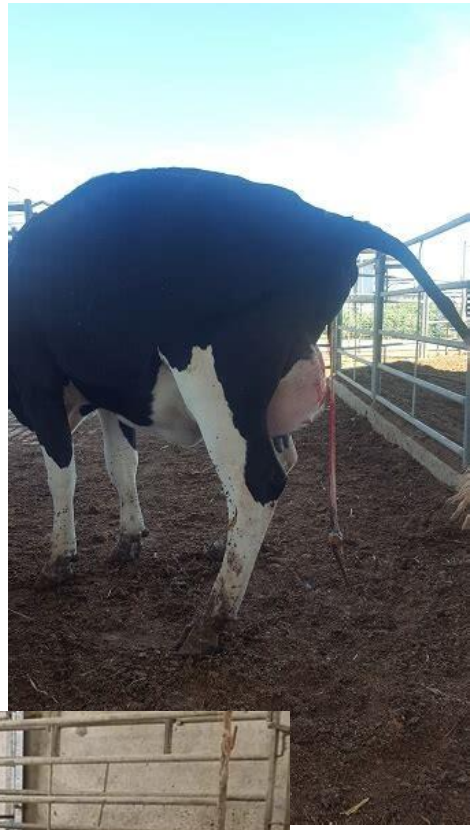
The Transition Period

The most challenging time...

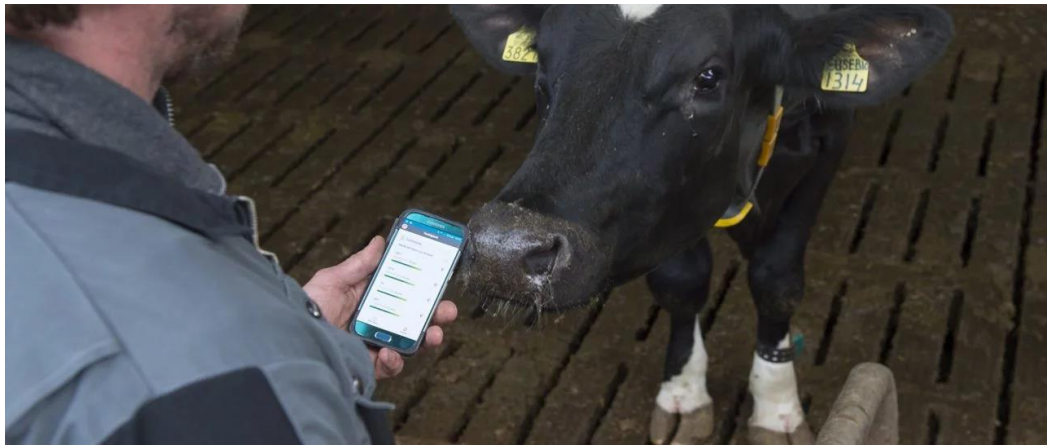


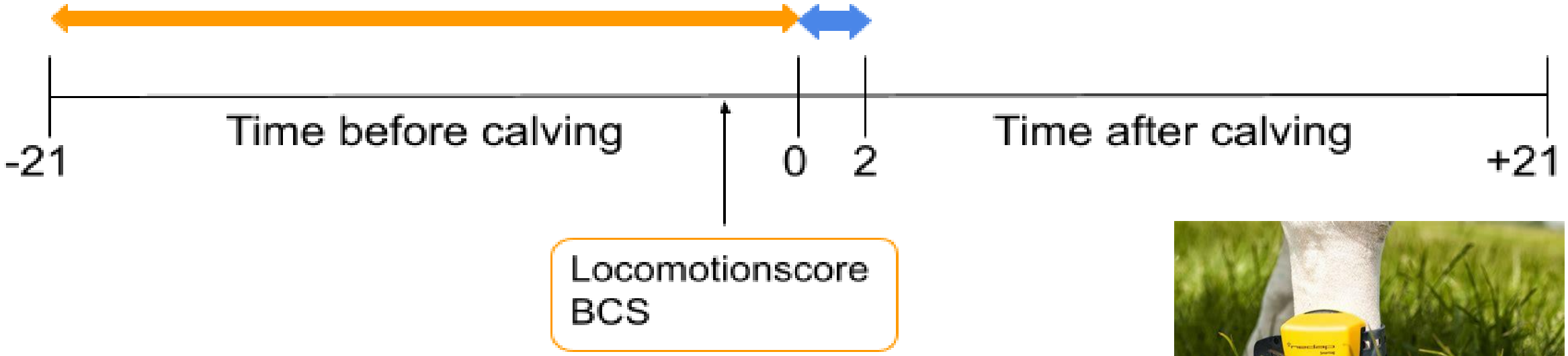
Hypocalcemia

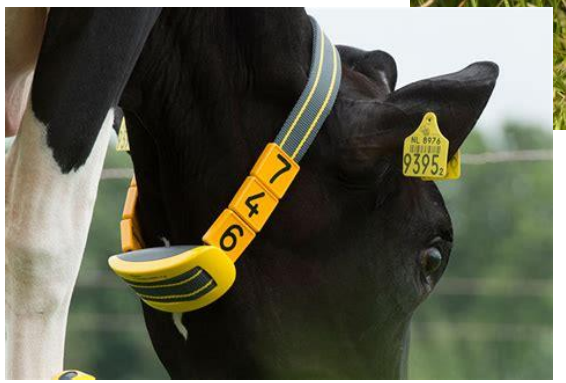
- Sudden increase in calcium demand
- Clinical vs Subclinical
- Associated with many other diseases

Why predict hypocalcemia

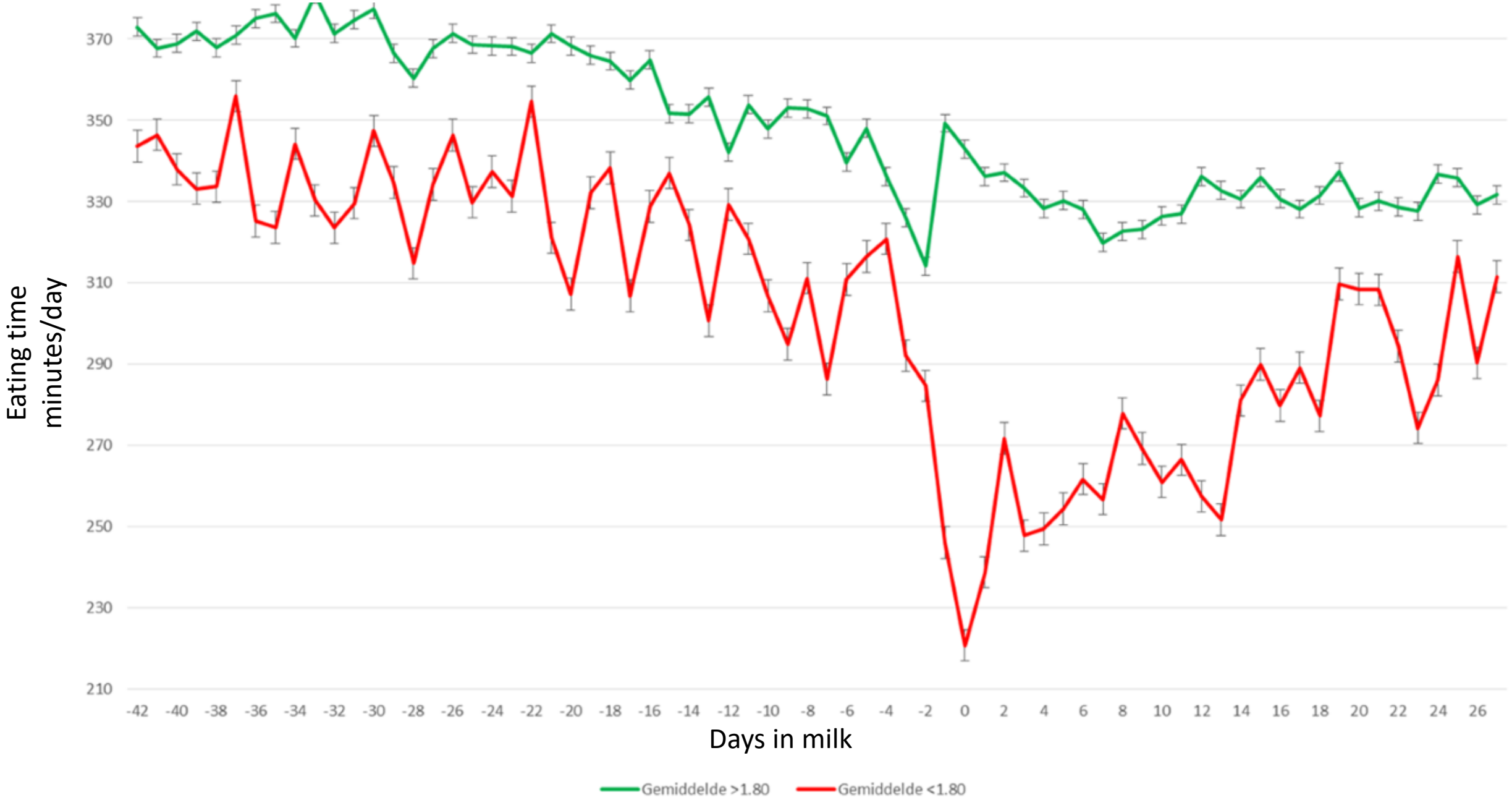
- Difficult to evaluate
- High prevalence (up to 69%)
- Tool to identify animals at risk of transition disease
- Monitoring of the calcium status of the herd
    - Evaluate preventive measures or diet changes
    - Direct focus of herd analysis

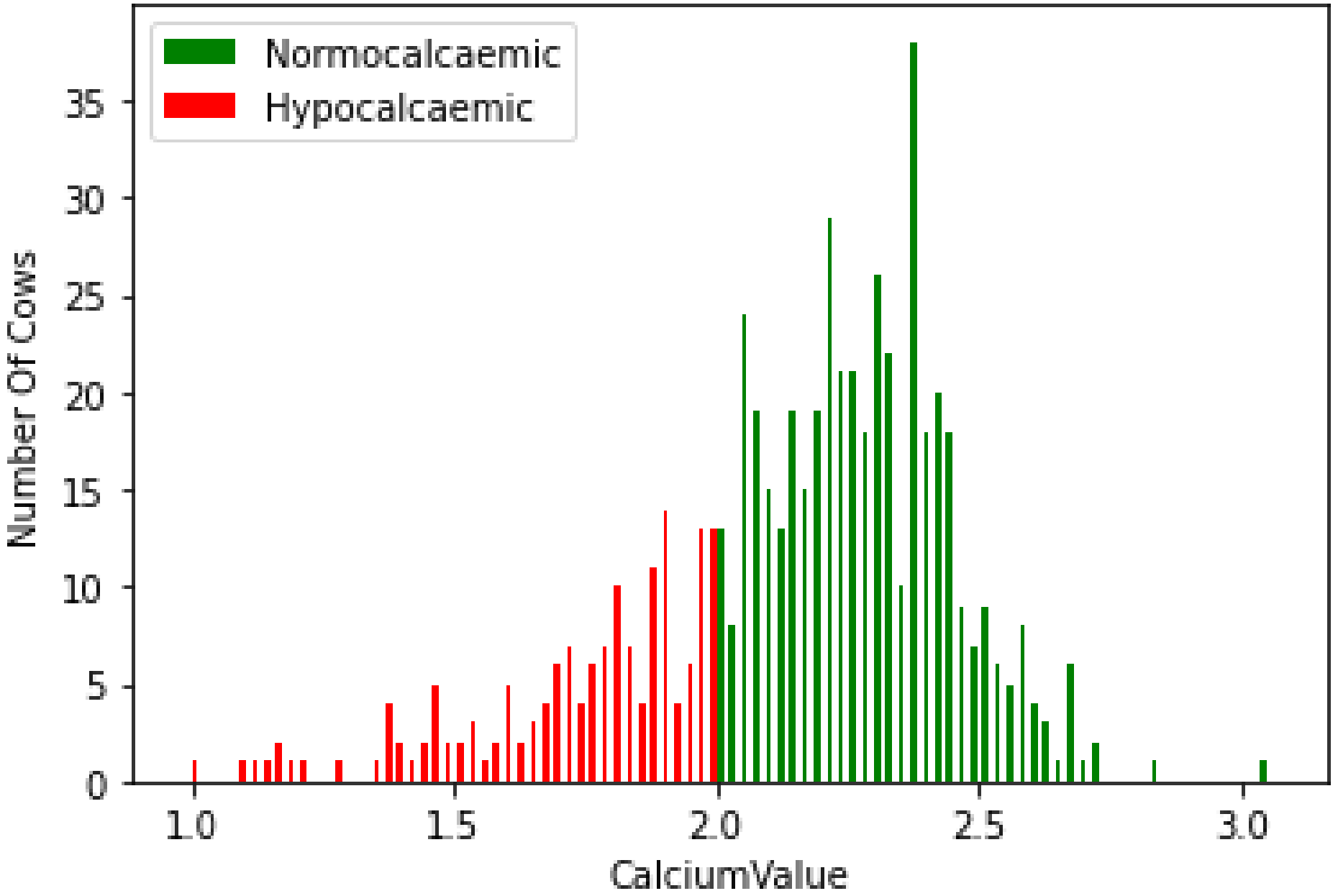






The Transition Period

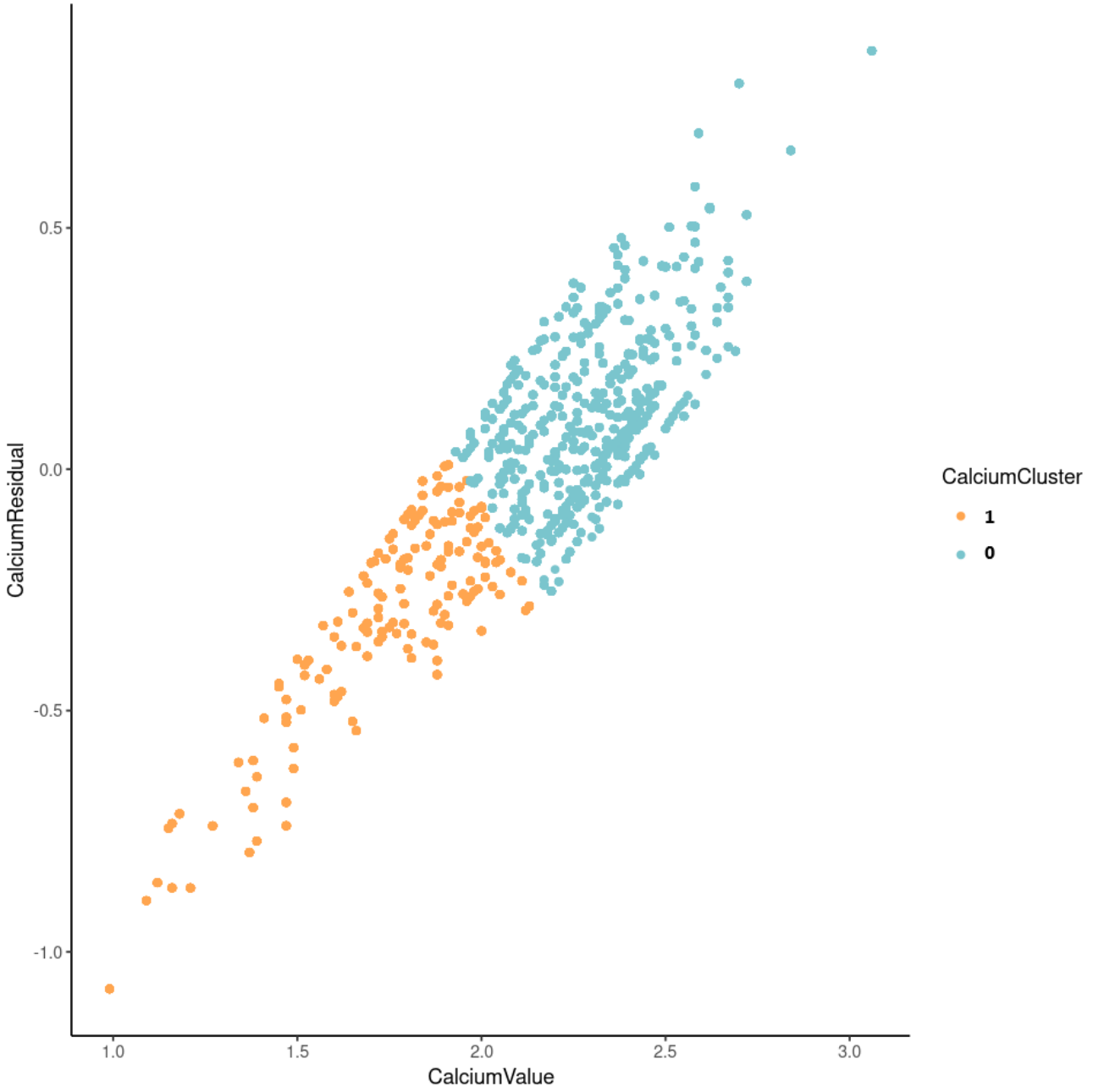

Eating time minutes/day
370
350
330
310
290
270
250
230
210
-42 -40 -38 -36 -34 -32 -30 -28 -26 -24 -22 -20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20 22 24 26
Days in milk
Gemiddelde >1.80
Gemiddelde <1.80

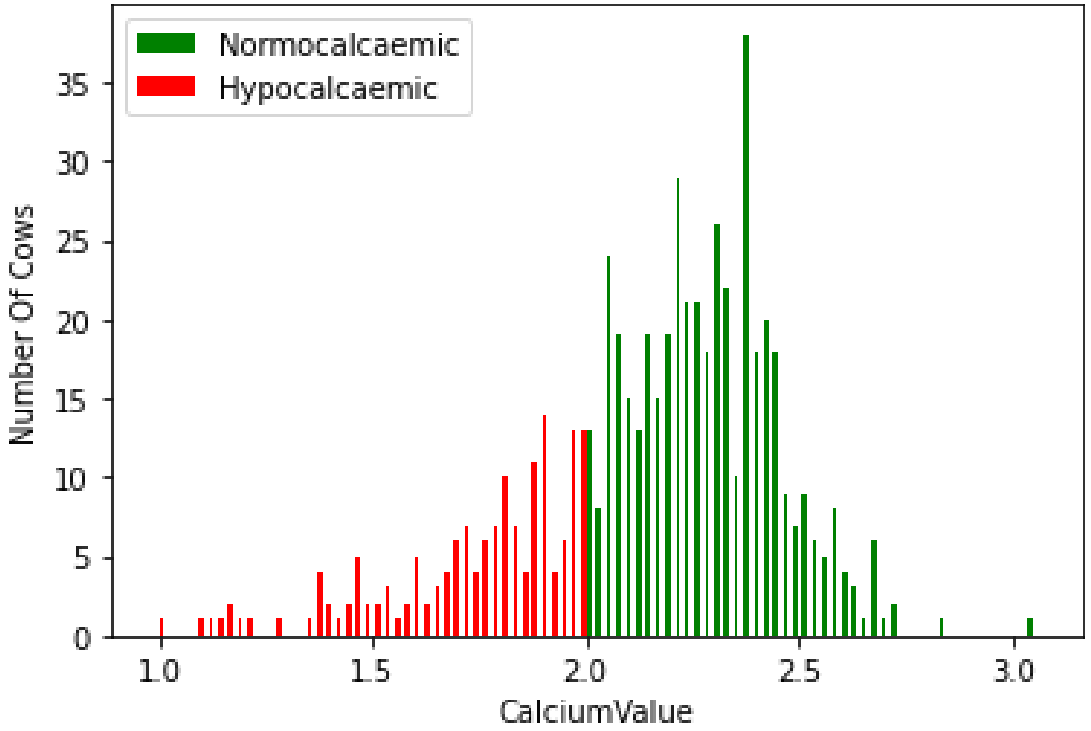

Normocalcaemic
Hypocalcaemic
Number Of Cows
0
5
10
15
20
25
30
35
1.0
1.5
2.0
2.5
3.0
CalciumValue

Clusters as an alternative way of dividing the data

Linear mixed-effects model combined with k-means clustering

Compensates for: Parity, farm and day of calcium measurements

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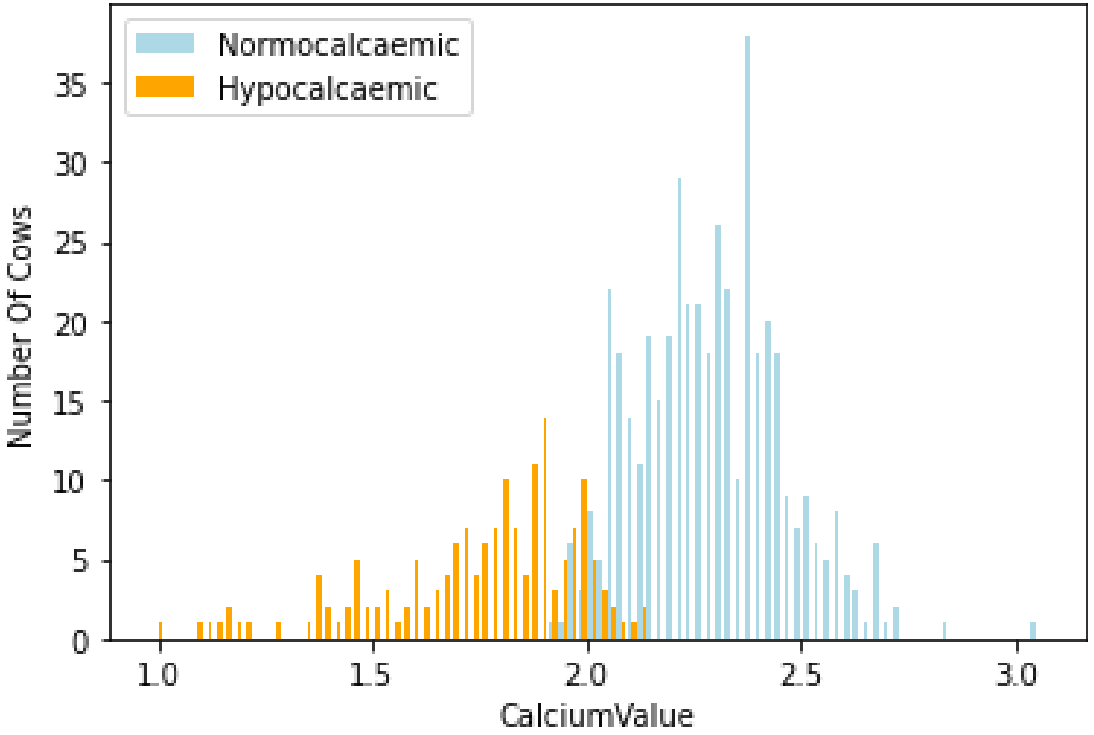
3.0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25
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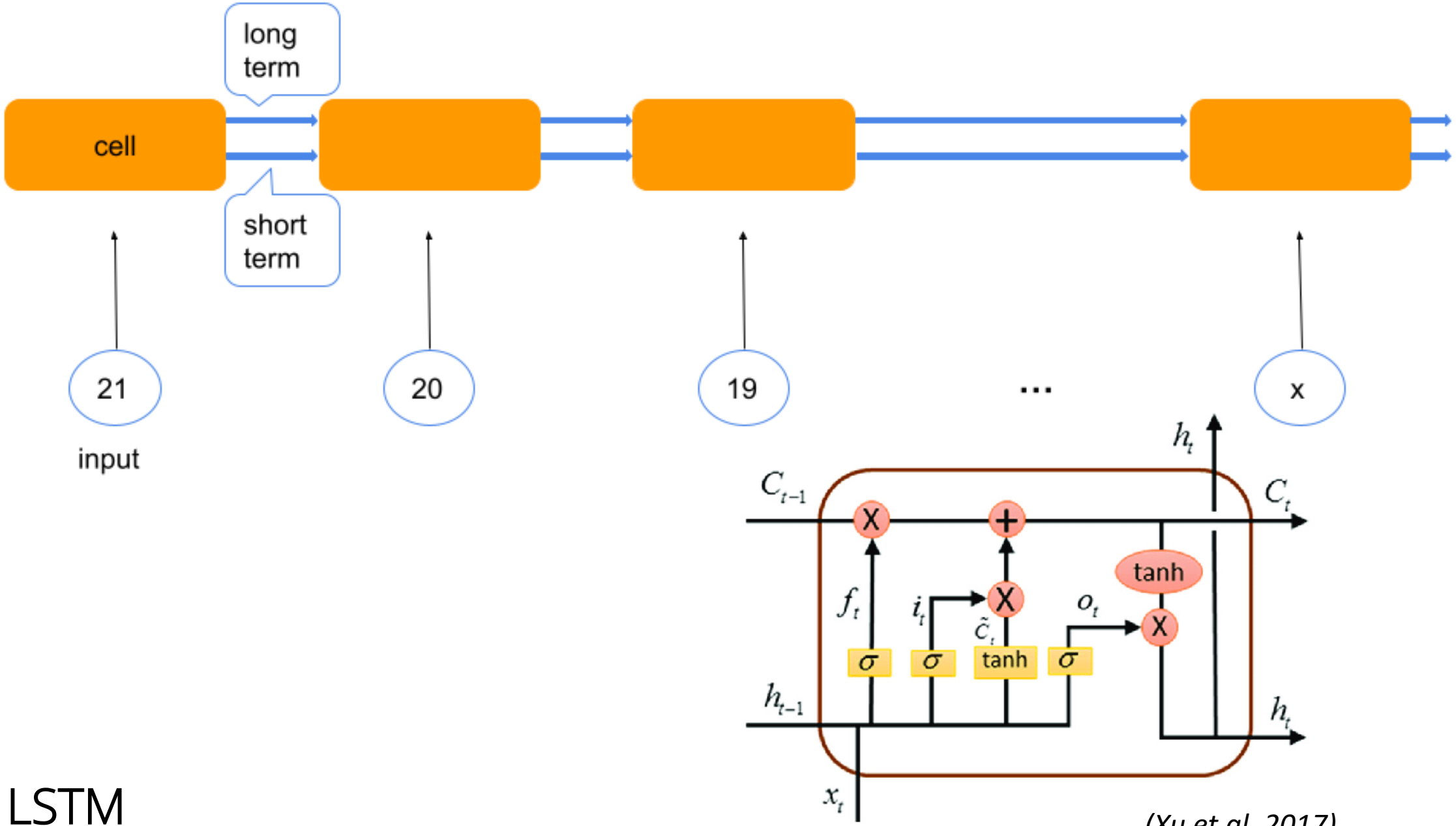
35
1.0
1.5
2.0
2.5
3.0

The models

3 Different kinds of models

- Logistic regression
- XgBoost
- LSTM deep learning model



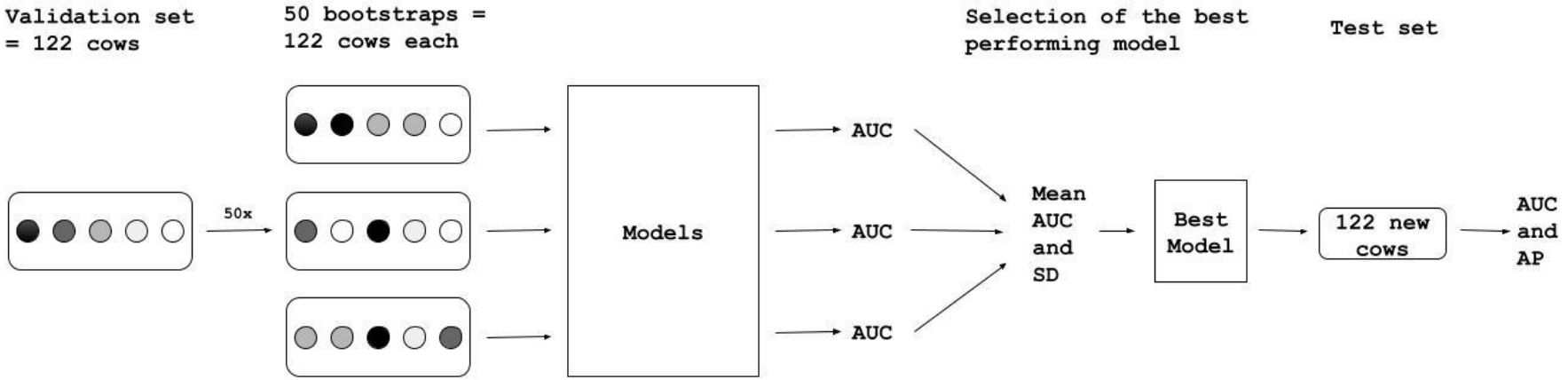
An LSTM

(Xu et al. 2017)

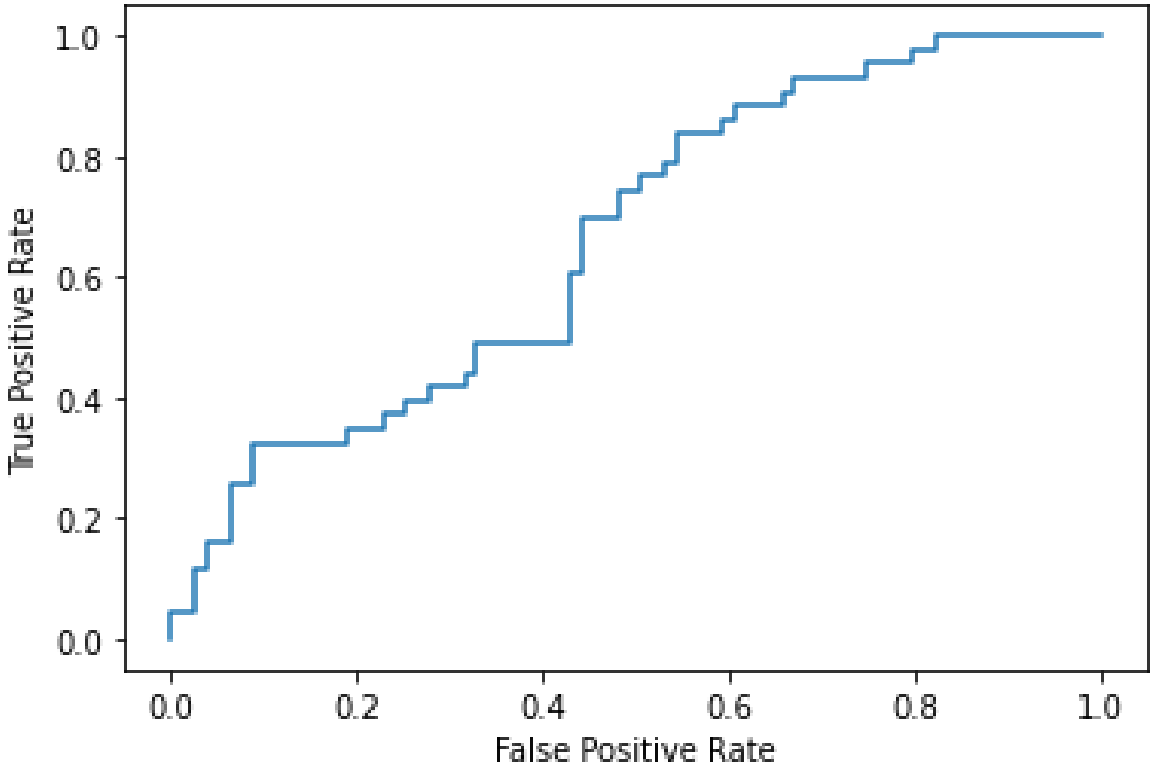
Hyperparameter tuning

- Find the best configuration
- Take random samples
- Add parity, day of measurement and calving season
- Add BCS and locomotion score

Model evaluation



- 50 Bootstraps > random samples of the validation set
- AUC > Area under the ROC-curve
- Standard Deviation



Clusters or cut-off y-values	Upsampling	Static features set	AUC	SD
Cluster	+	-	0,49	0.071
Cluster	-	-	0.59	0.061
Cut-off	+	-	0,61	0.062
Cluster	+	Small	0,61	0.058
Cut-off	-	-	0.64	0.074
Cluster	-	Small	0.66	0.054
Cluster	+	All	0.66	0.043
Cut-off	+	All	0.67	0.069
Cluster	-	All	0.68	0.060
Cut-off	+	Small	0.70	0.063
Cut-off	-	All	0.71	0.067
Cut-off	-	Small	0.71	0.057

Results

The best performing model:

- Predicts groups based on the cut-off value
- Does not use upsampling
- Uses sensor data
- Also uses calving season, parity and day of measurements
- Does not use BCS and Locomotion score

Results of the final models

The never used test set, used on the best models

Logistic Regression	AUC 0,57 and AP 0,45
XgBoost	AUC 0,58 and AP 0,43
LSTM model	AUC 0,66 and AP 0,53

But...

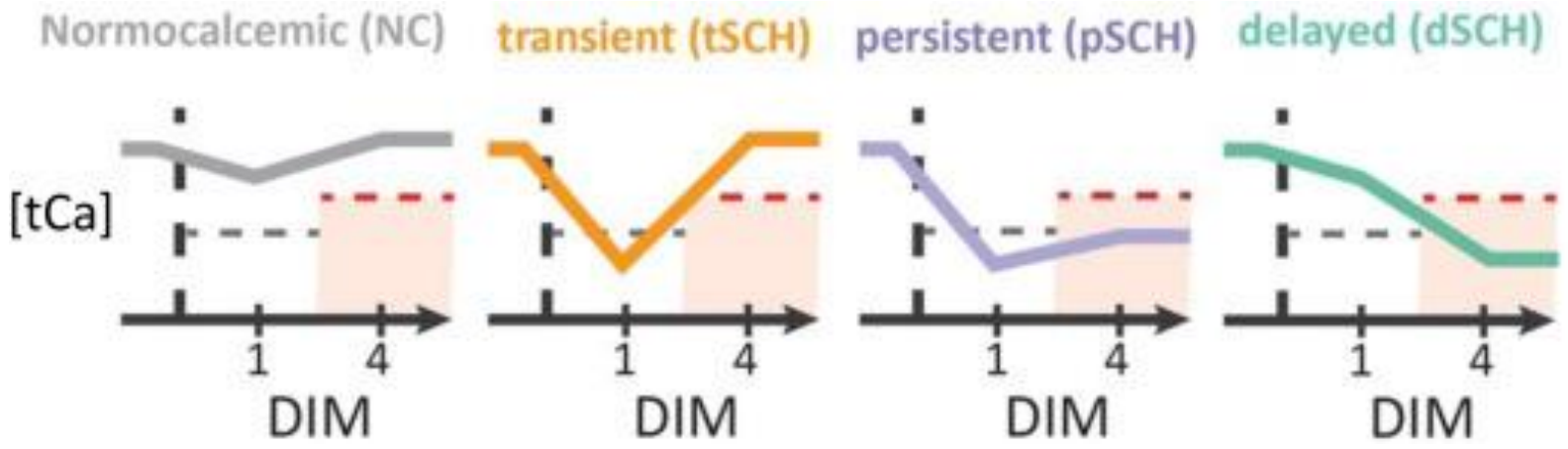
Improving model performance

- Improve input and output quality
- Use non disruptive missing value imputation
- Increase the amount of training data
- Add more features with association to hypocalcemia
- Drop features with less additional predictive value

Zooming in on hypocalcemia

- Clinical hypocalcemia > impairs animal welfare, farm economics, fertility and transition success
- Subclinical hypocalcemia > effect onset dependent
    - Transient
    - Delayed
    - Persistent

- Effect of inflammatory response and reduced feed intake?



(McArt et al. 2023)

Old-fashioned cut-off?

- 2,0 mmol/L seems arbitrarily chosen in the past
- Possible alternative: clusters > context-based cut-off

- Future research:
    - Association with the outcome of interest
    - Multiple blood samples at day 1,2 and 4 after parturition

In Conclusion

- A predictive model can be made
- Neural networks are a promising method
- Still a long road lies ahead before widespread practical implementation

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