Prediction of test-day body weight from dairy cow characteristics and milk spectra

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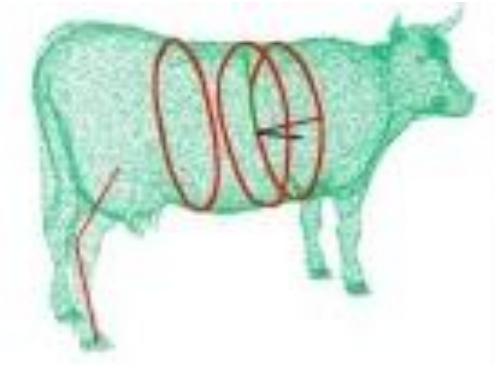
Body Weigth (BW)

- Key for herd management
- Calibrated electronic or mechanic weighing scale

- Not in all farms
- Not always well calibrated

Alternatives



- Digital image for body measurements
  - R=0.97 for live weight [Tasdemir et al., 2011]
  - Such camera not installed in many farms
- Correlated traits
  - Body measurements
    - Digital image
    - Linear classification
      - Not all cows are classified
      - One classification in first lactation

Innovative aspect

Use of data easily recorded on farms to estimate regularly BW throughout the lactation in order to develop management tools

Easily recorded data

Stage of lactation

Number of lactation

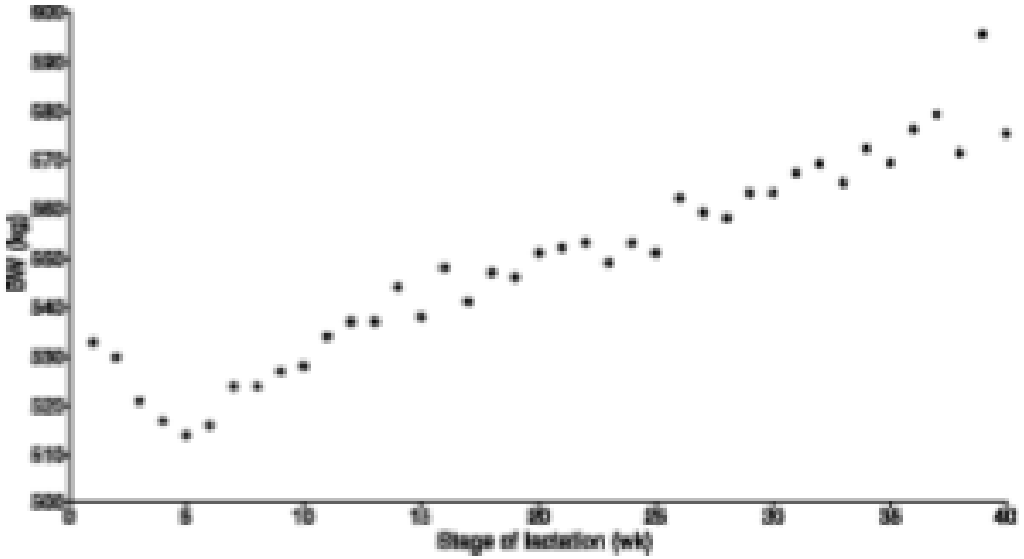


Figure 1. Mean unadjusted BW (♦) of heifers during lactation.

[Koenen et al., 1999]

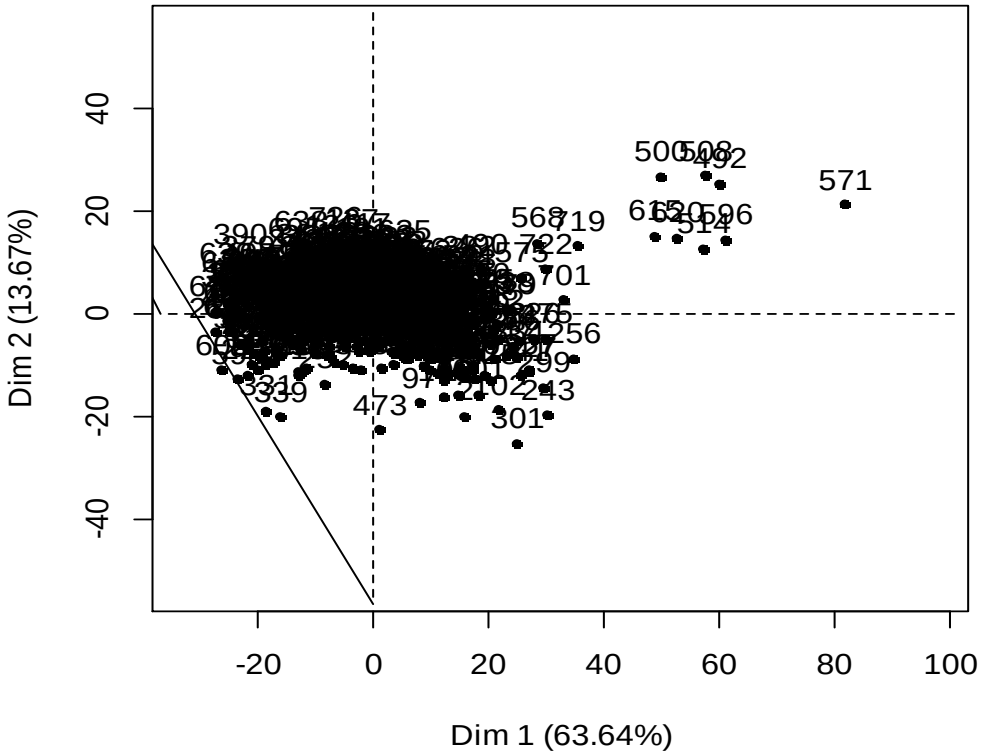
Easily recorded data

- Milk yield
  - Positive association [Roche et al., 2007]
  - But weak [Berry et al., 2003]
- Milk composition [Roche et al., 2007]
  - Positive association with milk fat
    - Fat mobilization
  - Positive association with lactose
  - Positive association with protein

Objective

Build a predictive equation from animal characteristics and milk mid-infrared spectrum

Principal Component Analysis



N=737
6 herds
- 2 commercial herds
- 4 research herds

Records with GH distance higher than 3 were discarded

➔ N = 721

Equations

- Equation 1

  First derivative milk MIR spectra

- Equation2

  Equation 1 + class of 15 DIM + number of lactation + month of test

- Equation3

  Equation 2 + milk yield

3 other equations using spectra regressed using Legendre Polynomials of order 2

Calibration models

N=721		only spectra	spectra + DIM, lactation and month of test	spectrum + DIM, lactation, month of test and milk yield
Without PL	N factors	13	12	8
	R^2c	0.29	0.50	0.51
	R^2cv	0.19	0.44	0.47
	RMSEPc	61	51	51
	RMSEPcv	65	54	53

Number of factors decreased.
Equation 3 was the best

Calibration models

N=721		only spectra	spectra + DIM, lactation and month of test	spectrum + DIM, lactation, month of test and milk yield
Without PL	N factors	13	12	8
	R^2c	0.29	0.50	0.51
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	RMSEPc	61	51	51
	RMSEPcv	65	54	53
With PL	Nf	14	11	10
	R^2c	0.36	0.50	0.52
	R^2cv	0.23	0.43	0.46
	RMSEPc	58	51	50
	RMSEPcv	64	55	53

Same conclusions for PL equations

- Number of factors decreased
- The best was equation 3

Calibration models

N=721		only spectra	spectra + DIM, lactation and month of test	spectrum + DIM, lactation, month of test and milk yield
Without PL	N factors	13	12	8
	R^2c	0.29	0.50	0.51
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Less factors for equation 3 without PL
Similar metrics with and without PL

Calibration models

N=721		only spectra	spectra + DIM, lactation and month of test	spectrum + DIM, lactation, month of test and milk yield
Without PL	N factors	13	12	8
	R^2c	0.29	0.50	0.51
	R^2cv	0.19	0.44	0.47
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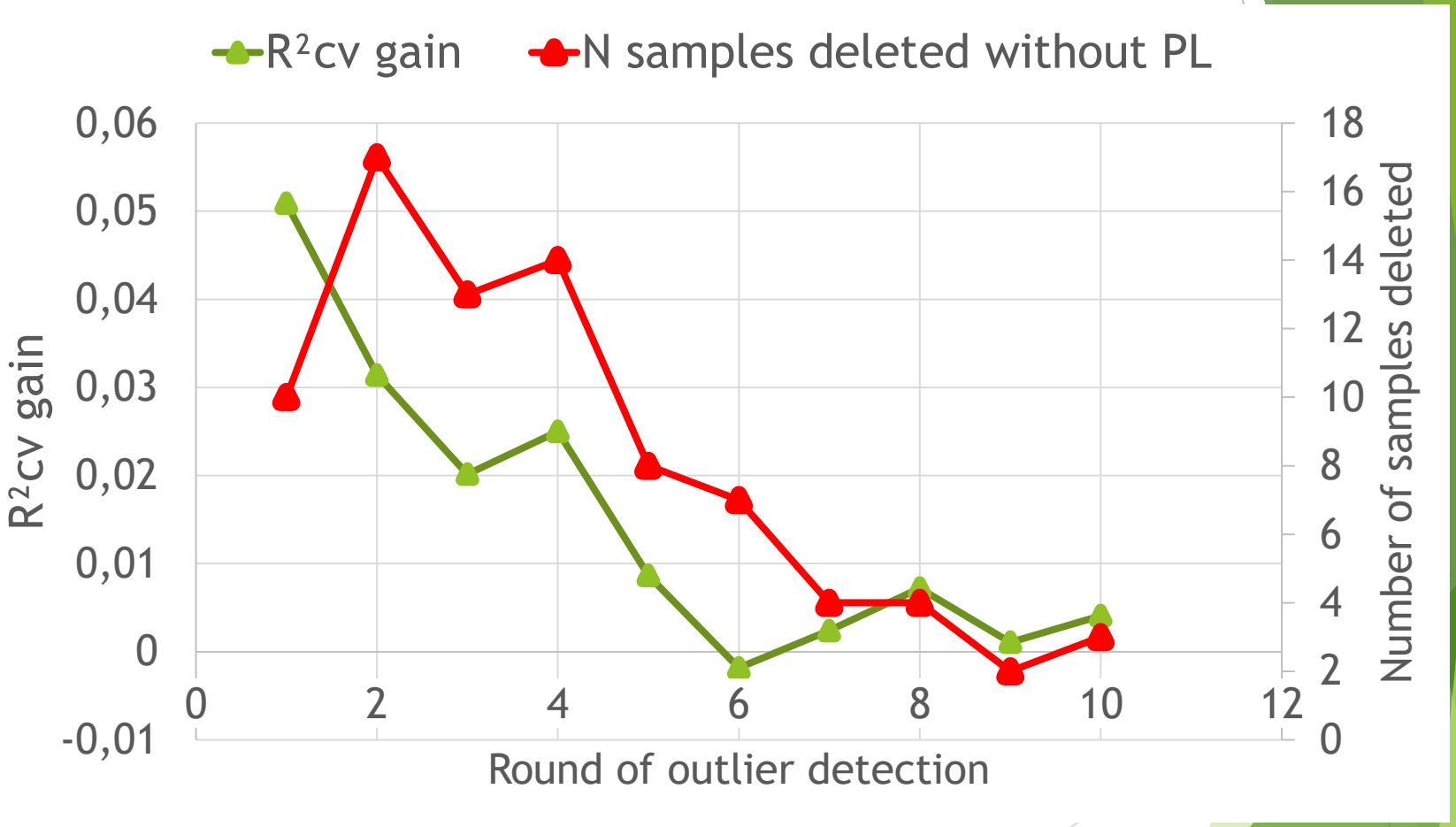
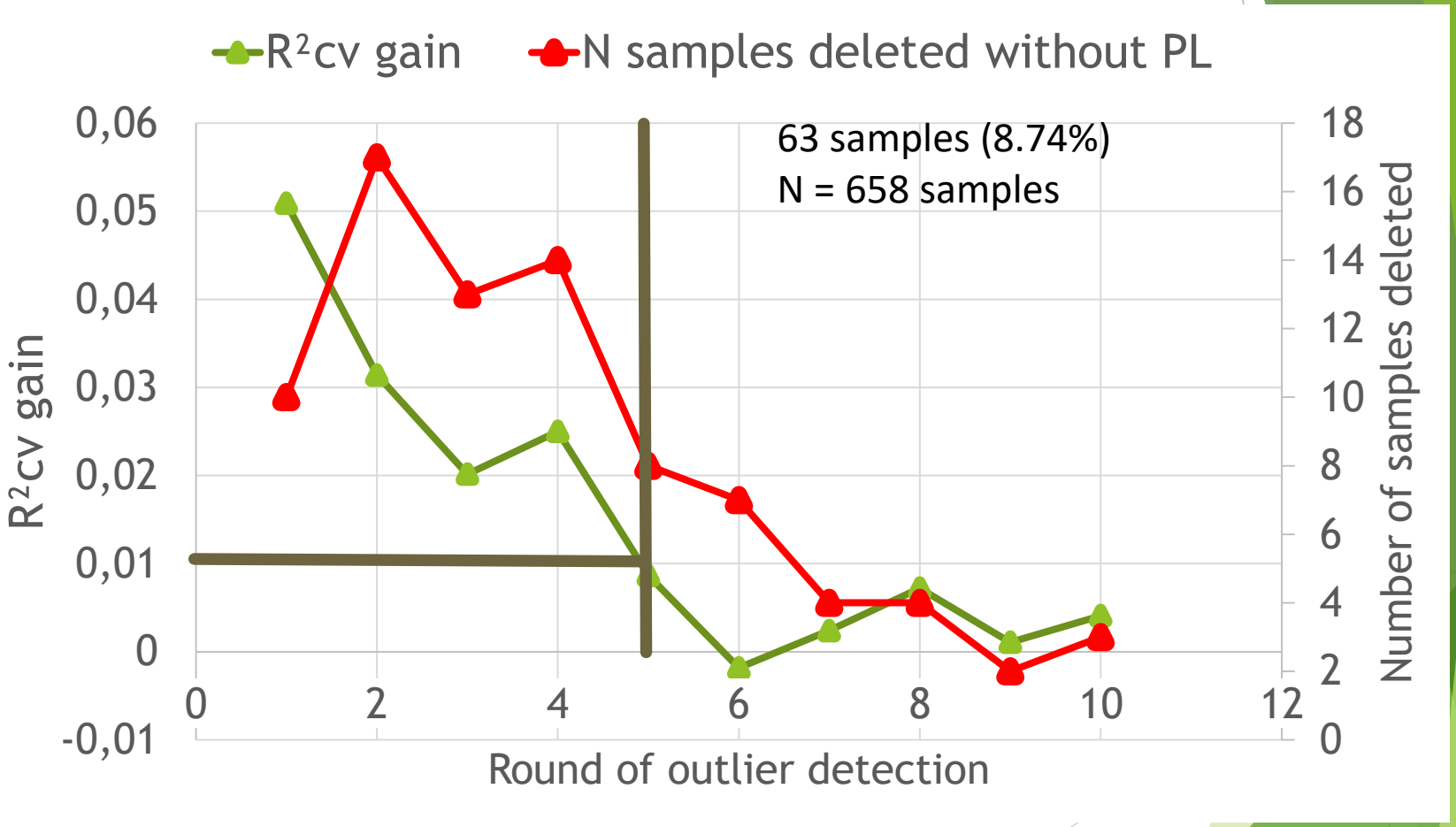
A noise can be present in the BW calibration dataset due to BW measurements.

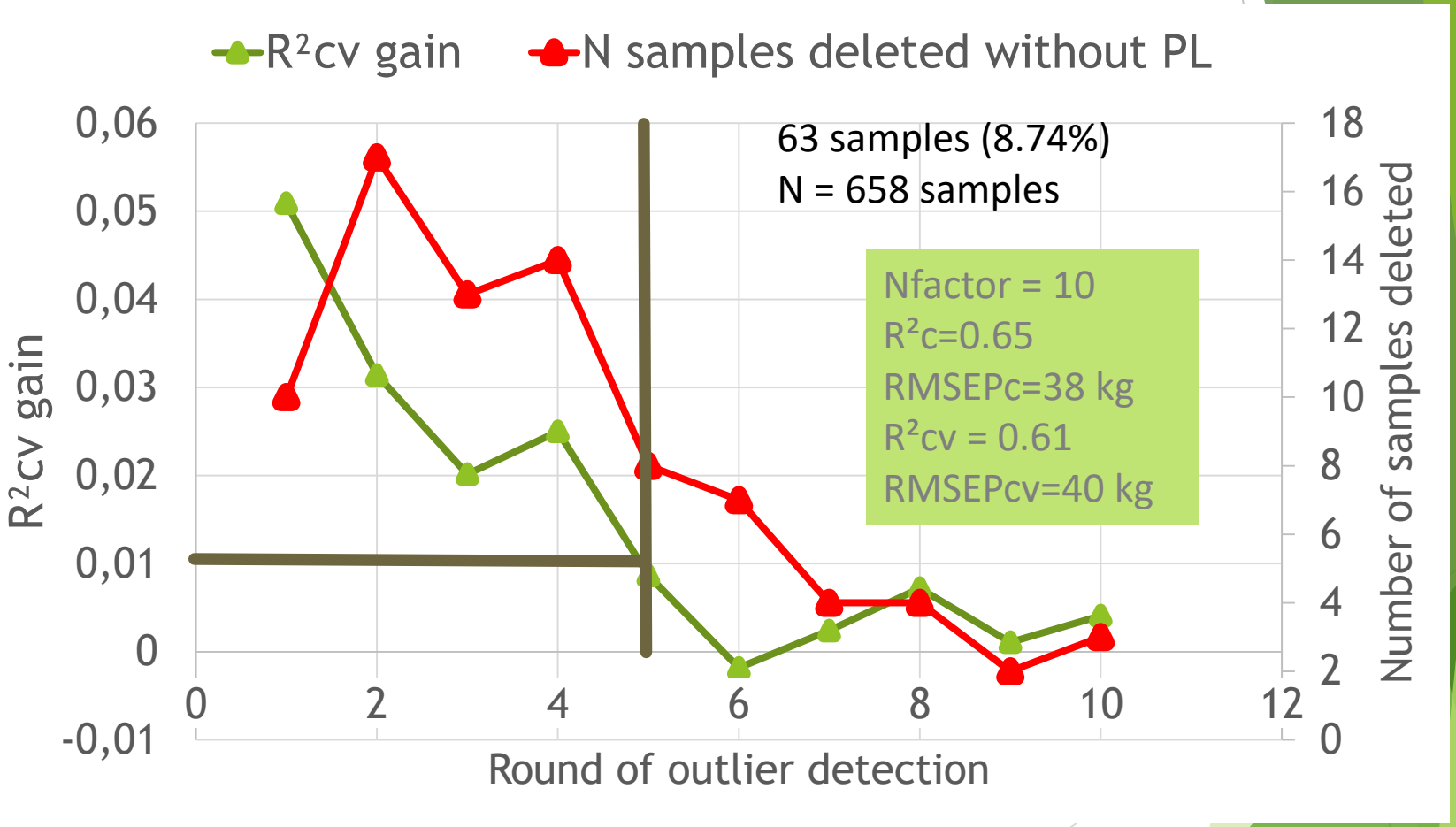
Outliers


R²cv gain
N samples deleted without PL
0,06
0,05
0,04
0,03
0,02
0,01
0
-0,01
R²cv gain
0
2
4
6
8
10
12
Round of outlier detection
18
16
14
12
10
8
6
4
2
0
Number of samples deleted

Outliers


R²cv gain
N samples deleted without PL
63 samples (8.74%)
N = 658 samples
R²cv gain
Number of samples deleted
Round of outlier detection
0,06
0,05
0,04
0,03
0,02
0,01
0
-0,01
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12

Outliers


R²cv gain
N samples deleted without PL
63 samples (8.74%)
N = 658 samples
Nfactor = 10
R²c=0.65
RMSEPc=38 kg
R²cv = 0.61
RMSEPcv=40 kg
R²cv gain
Number of samples deleted
Round of outlier detection
0,06
0,05
0,04
0,03
0,02
0,01
0
-0,01
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12

Herd validation

	Removed herd	Calibration and cross-validation			
		N	R^2c	RMSEPc	R^2cv
without PL	1	629	0.65	37	0.60
	2	624	0.64	37	0.60
	3	604	0.65	38	0.61
	4	599	0.66	37	0.62
	5	306	0.69	36	0.61
	6	528	0.65	37	0.60

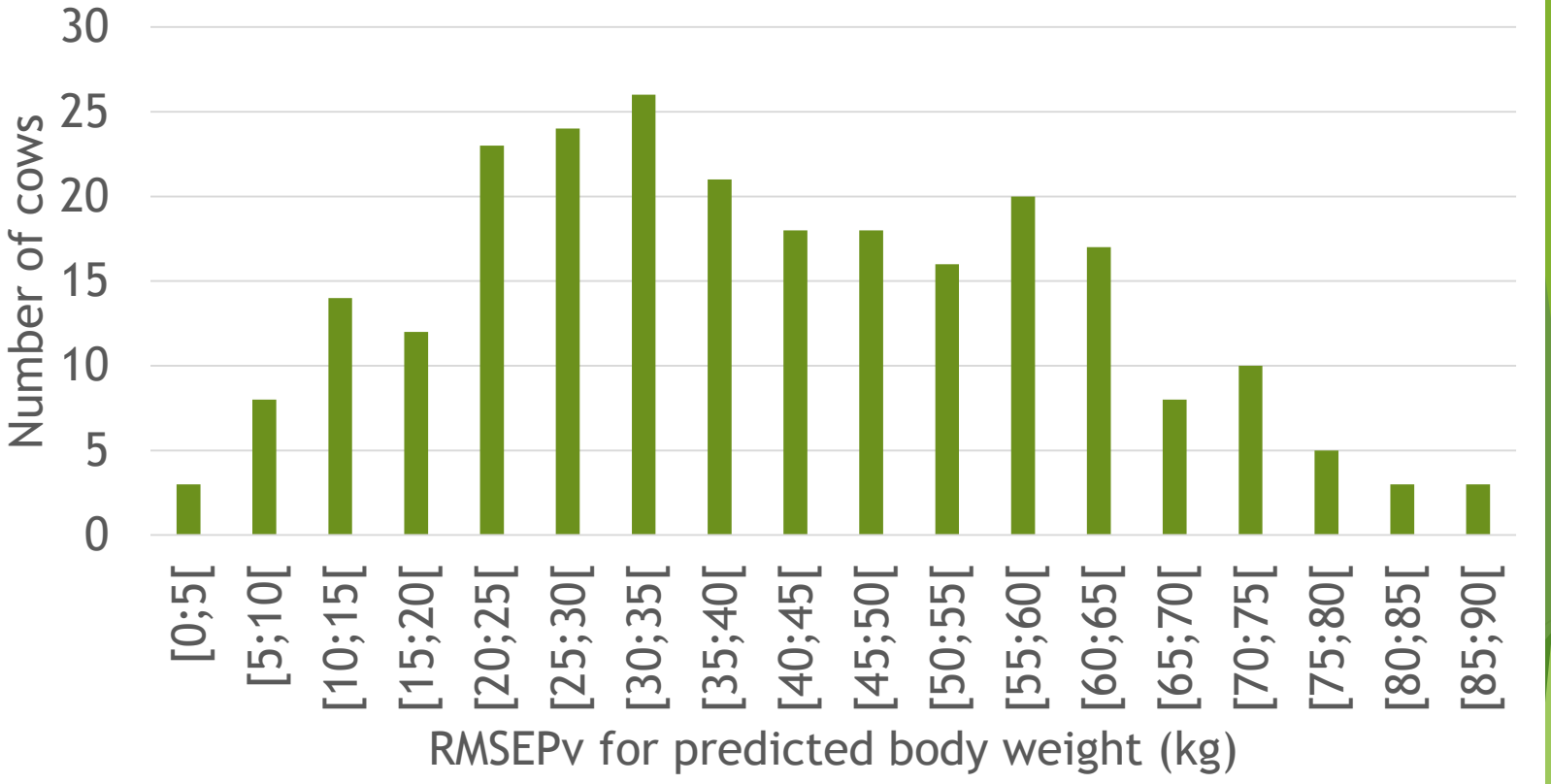
Calibration results similar even if the dataset changed
Herd no specific equation

Herd validation

	Removed herd	Calibration and cross-validation				herd validation		
		N	R^2c	RMSEPc	R^2cv	N	R^2v	RMSEPv
without PL	1	629	0.65	37	0.60	29	0.47	64
	2	624	0.64	37	0.60	34	0.67	52
	3	604	0.65	38	0.61	54	0.49	39
	4	599	0.66	37	0.62	59	0.32	44
	5	306	0.69	36	0.61	352	0.53	57
	6	528	0.65	37	0.60	130	0.51	47

RMSEPv ranged from 39 to 64 kg

Cow validation



RMSEPv of 38 kg with a SD of 20 kg

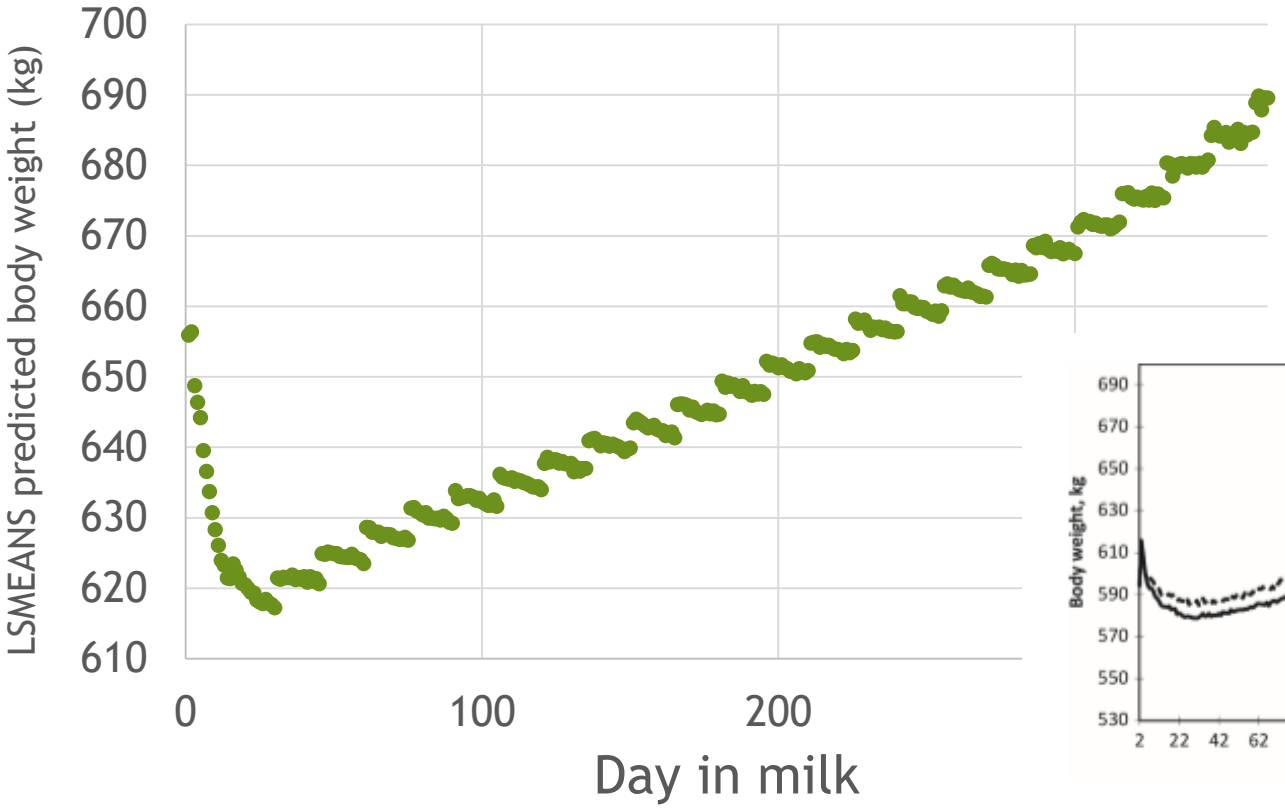
Machine Learning

	PLS	Random Forest	SVM
N factor	10		
R^2 calibration	0.51	0.89	0.64
RMSEP calibration	48.53	23.48	41.54
R^2 test	0.49	0.46	0.48
RMSEP test	56.43	57.59	56.58

No gain with other methods

Implementation on Walloon database

N= 3,205,153 test-day records



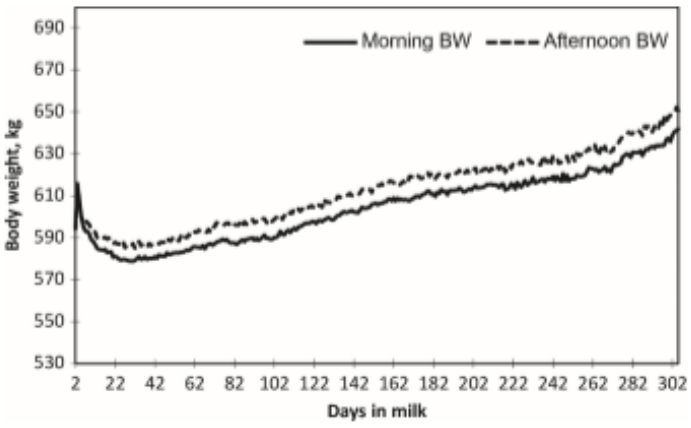
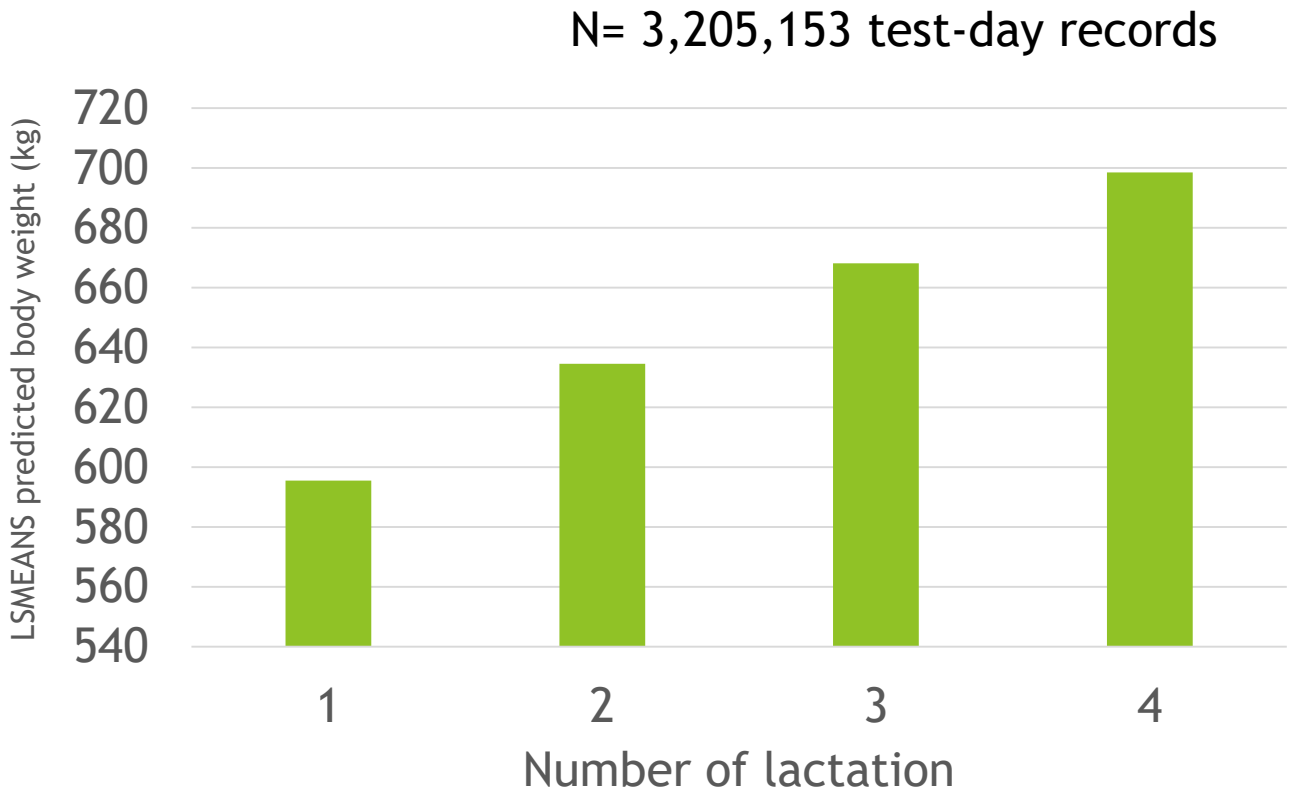


Figure 1. Lactation day averages of morning (around 0700 h) and afternoon (around 1700 h) BW of the Nordic Red Dairy cows (230 cows).

[Mäntyssari et al., 2015]

Implementation on Walloon database



Conclusion

- Repeated BW traits
- Expected accuracy based on herd and cow validation
  - 30 to 65 kg
- Expected behaviour on a large spectral database
- Validate the equation using a large calibration dataset
- Management and breeding objectives:
  - BW changes
  - Feed efficiency
- Can be combined with existing BW predictions
  - Linear classification
  - BW measurements

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