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RÉSEAU CANADIEN POUR L'EXCELLENCE LAITIÈRE
CANADIAN NETWORK FOR DAIRY EXCELLENCE

Predicting cumulative yields using test data and Neural Networks

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Background

Interest to increase Longevity

- Society, consumer, performance, economics, sustainability, resilience…

Numerous decisions are required

- Genotype, inseminate, type of semen, keep heifers to raise, cull, dry off etc.
- At all stages of life for each cow, from birth to end of life
- Continuously at the herd level (milk shipping, health, tests, treatments, etc.)

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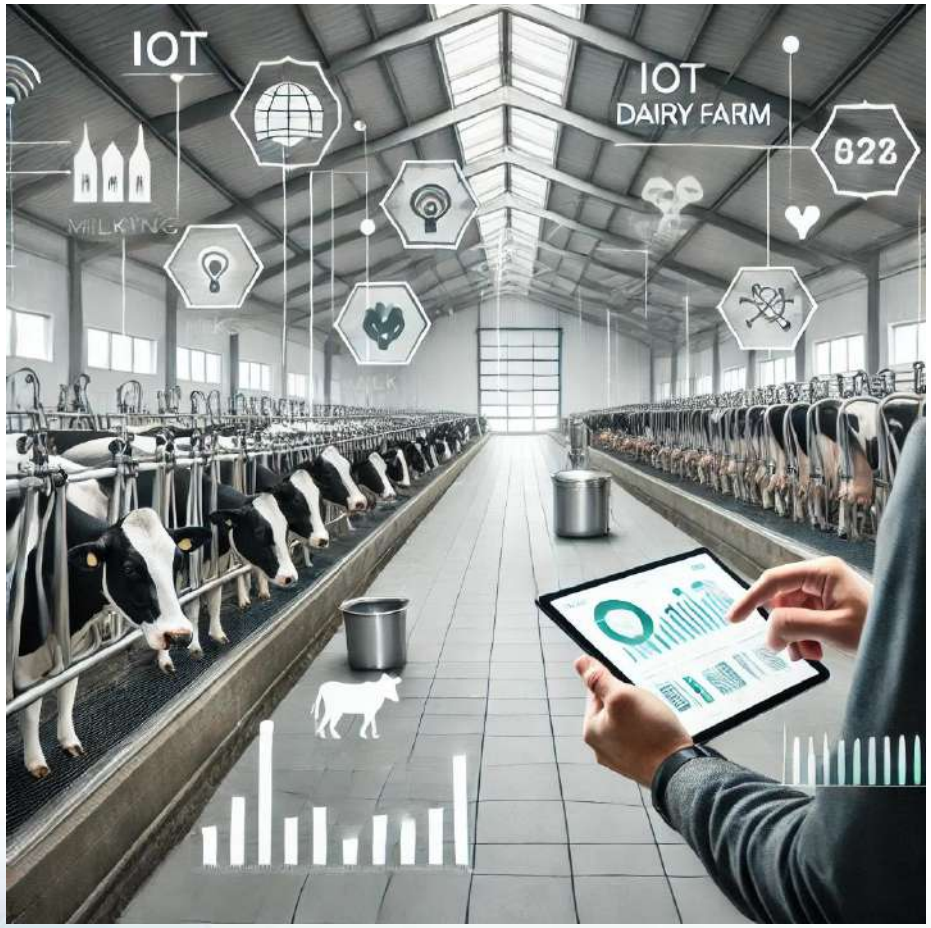
Background



A lot of data exists to help with decisions, perhaps too much to be ingested all at once…

Decision support tools are required

Good news: Digital technologies can help!

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Objective

Develop a model to predict the future cow value based on lifetime production using DHI (Dairy Herd Improvement) data

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Materials & Methods

TD records obtained from the Lactanet database (14 inputs)

- Age, parity, DIM
- Milk, fat and protein yields at the test
- Linear score of SC
- Yields of current lactation (Milk, fat, protein)
- Cumulative yields (milk, fat, protein)
- Age at the prediction

Materials & Methods

Artificial Neural Network

Multi-Layer perceptron model (MLP)

MLPRegressor sckit-learn package Python

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Materials & Methods

Some details of the model

- Prediction capability for any age in the future
  - Prediction at the next birthday and at age 6 (**Pro$**)
- DHI data from 1 to 8 tests
- Beed-agnostic model
- 14 inputs
- 3 outputs

Pro$ is the Canadian economic selection index that maximizes genetic response for cow lifetime profitability

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Materials & Methods

Some details of the model

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  - Prediction at the next birthday and at age 6 (**Pro$**)
- DHI data from 1 to 8 tests
- Beed agnostic model
- 14 inputs
- 3 outputs

Lifetime cumulative yields:
Milk, fat and protein
At a specific age

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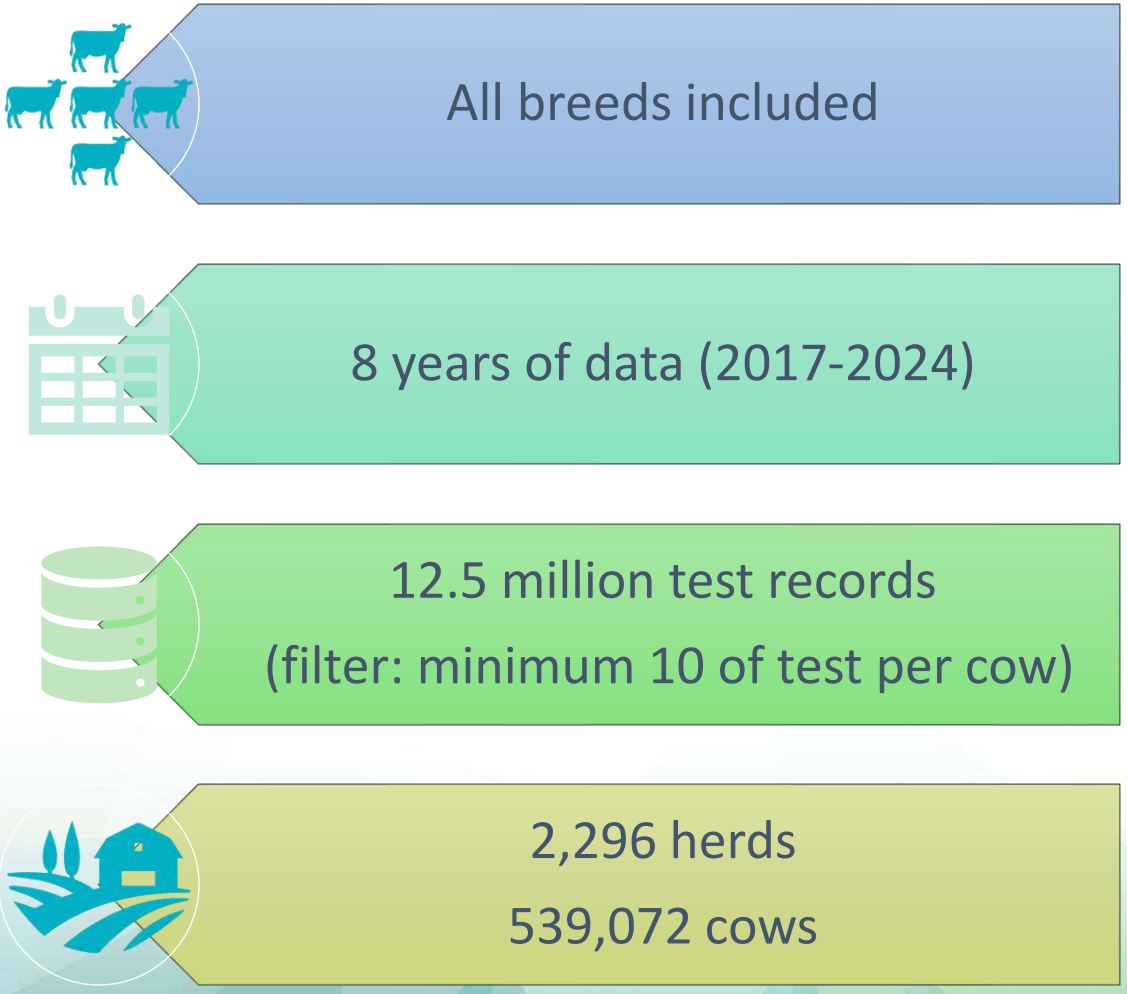
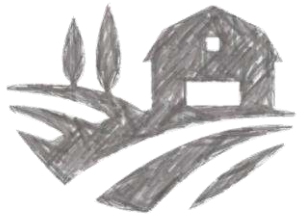
Materials & Methods

Data for building the model



Materials & Methods

Data for test & training

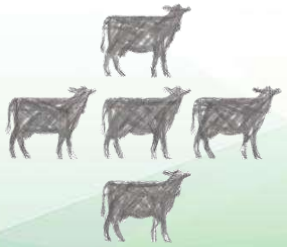


80% Train

n=1,836 herds;
431,940 cows

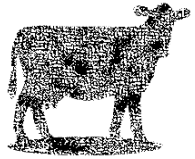
20% Test

n=460 herds
107,132 cows



Materials & Methods

Test-day data used for training and testing:



- Include only cows with at least 10 test-day records
- For each cow, randomly select between 1 to 8 consecutive test-day records

anm_id	age_d	lact_no	age_at_calving	dim	:c_linear_scor	hr_24_mk	lact_date_mk	hr_24_ft	lact_date_ft	hr_24_pt	lact_date_pt	lt_mk	lt_ft	lt_pt
999999	936	1	26.2	138	3.5	34.9	4951	1.40	185	1.22	162	4951	185	162
999999	977	1	26.2	179	2.6	27.9	6218	1.31	241	0.96	206	6218	241	206
999999	1012	1	26.2	214	2.5	30.2	7324	1.17	284	1.02	243	7324	284	243
999999	1047	1	26.2	249	2.9	33.8	8503	1.26	329	1.19	284	8503	329	284
999999	1080	1	26.2	282	2.9	34.5	9603	1.28	369	1.16	321	9603	369	321
999999	1116	1	26.2	318	2.9	28.9	10651	1.10	410	0.97	357	10651	410	357
999999	1151	1	26.2	353	3.3	25.6	11605	1.00	446	0.87	389	11605	446	389
999999	1186	1	26.2	388	3.5	22.1	12439	0.91	480	0.80	418	12439	480	418
999999	1342	2	41.3	86	0.1	50.9	4423	1.69	150	1.62	143	17117	641	570
999999	1376	2	41.3	120	0.1	47.3	6097	1.57	205	1.52	196	18791	696	624
999999	1411	2	41.3	155	0.2	46.9	7790	1.45	257	1.55	251	20484	747	679
999999	1454	2	41.3	198	5.2	42	9710	1.32	318	1.35	314	22404	809	742
999999	1481	2	41.3	225	2.3	38.4	10811	1.26	354	1.24	350	23504	844	778
999999	1514	2	41.3	258	2.5	33.5	11978	1.24	393	1.13	389	24672	884	817
999999	1558	2	41.3	302	2.4	30.5	13373	1.20	445	1.08	437	26067	935	865
999999	1592	2	41.3	336	3.8	22.4	14277	1.05	480	0.84	469	26971	971	897

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Materials & Methods

Data preparation

anm_id	age_d	lact_no	age_at_calving	dim	cc_linear_scor	hr_24_mk	lact_date_mk	hr_24_ft	lact_date_ft	hr_24_pt	lact_date_pt	lt_mk	lt_ft	lt_pt
999999	936	1	26.2	138	3.5	34.9	4951	1.40	185	1.22	162	4951	185	162
999999	977	1	26.2	179	2.6	27.9	6218	1.31	241	0.96	206	6218	241	206
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999999	1080	1	26.2	282	2.9	34.5	9603	1.28	369	1.16	321	9603	369	321
999999	1116	1	26.2	318	2.9	28.9	10651	1.10	410	0.97	357	10651	410	357
999999	1151	1	26.2	353	3.3	25.6	11605	1.00	446	0.87	389	11605	446	389
999999	1186	1	26.2	388	3.5	22.1	12439	0.91	480	0.80	418	12439	480	418
999999	1342	2	41.3	86	0.1	50.9	4423	1.69	150	1.62	143	17117	641	570
999999	1376	2	41.3	120	0.1	47.3	6097	1.57	205	1.52	196	18791	696	624
999999	1411	2	41.3	155	0.2	46.9	7790	1.45	257	1.55	251	20484	747	679
999999	1454	2	41.3	198	5.2	42	9710	1.32	318	1.35	314	22404	809	742
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999999	1514	2	41.3	258	2.5	33.5	11978	1.24	393	1.13	389	24672	884	817
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999999	1592	2	41.3	336	3.8	22.4	14277	1.05	480	0.84	469	26971	971	897

Age at prediction: age at the last available test

X_i

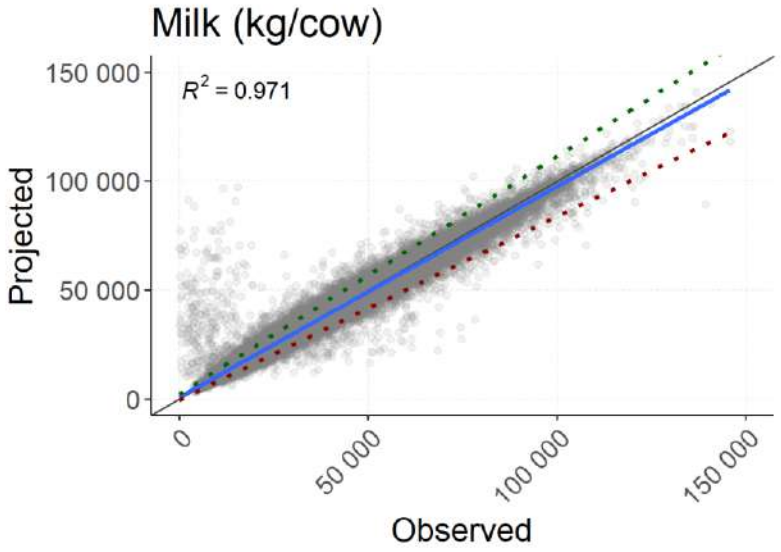
age_d	lact_no	age_at_calving	dim	cc_linear_scor	hr_24_mk	lact_date_mk	hr_24_ft	lact_date_ft	hr_24_pt	lact_date_pt	lt_mk	lt_ft	lt_pt	age_d_pred
1116	1	26.2	318	2.9	28.9	10651	1.10	410	0.97	357	10651	410	357	1592
1151	1	26.2	353	3.3	25.6	11605	1.00	446	0.87	389	11605	446	389	1592
1186	1	26.2	388	3.5	22.1	12439	0.91	480	0.80	418	12439	480	418	1592
1342	2	41.3	86	0.1	50.9	4423	1.69	150	1.62	143	17117	641	570	1592
1376	2	41.3	120	0.1	47.3	6097	1.57	205	1.52	196	18791	696	624	1592

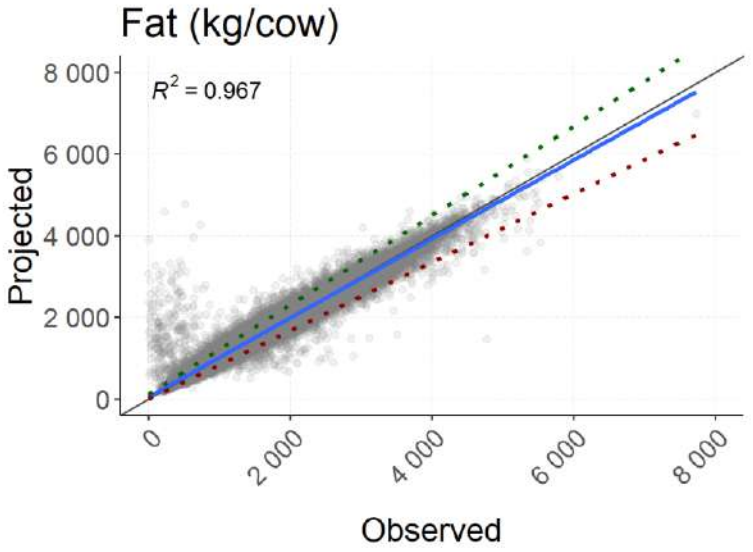
Y_i

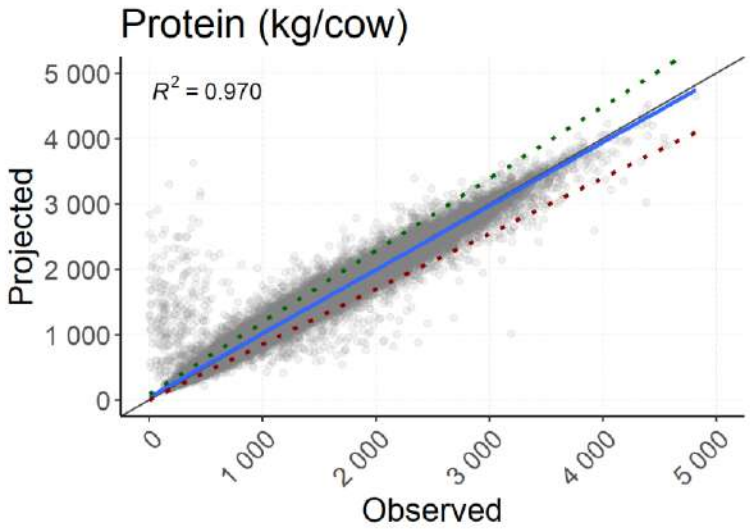
lt_mk_out	lt_ft_out	lt_pt_out
26971	971	897

6 yrs prediction:
age_d_pred = 6*365d = 2190d

Results







MAPE

Milk=5.68%

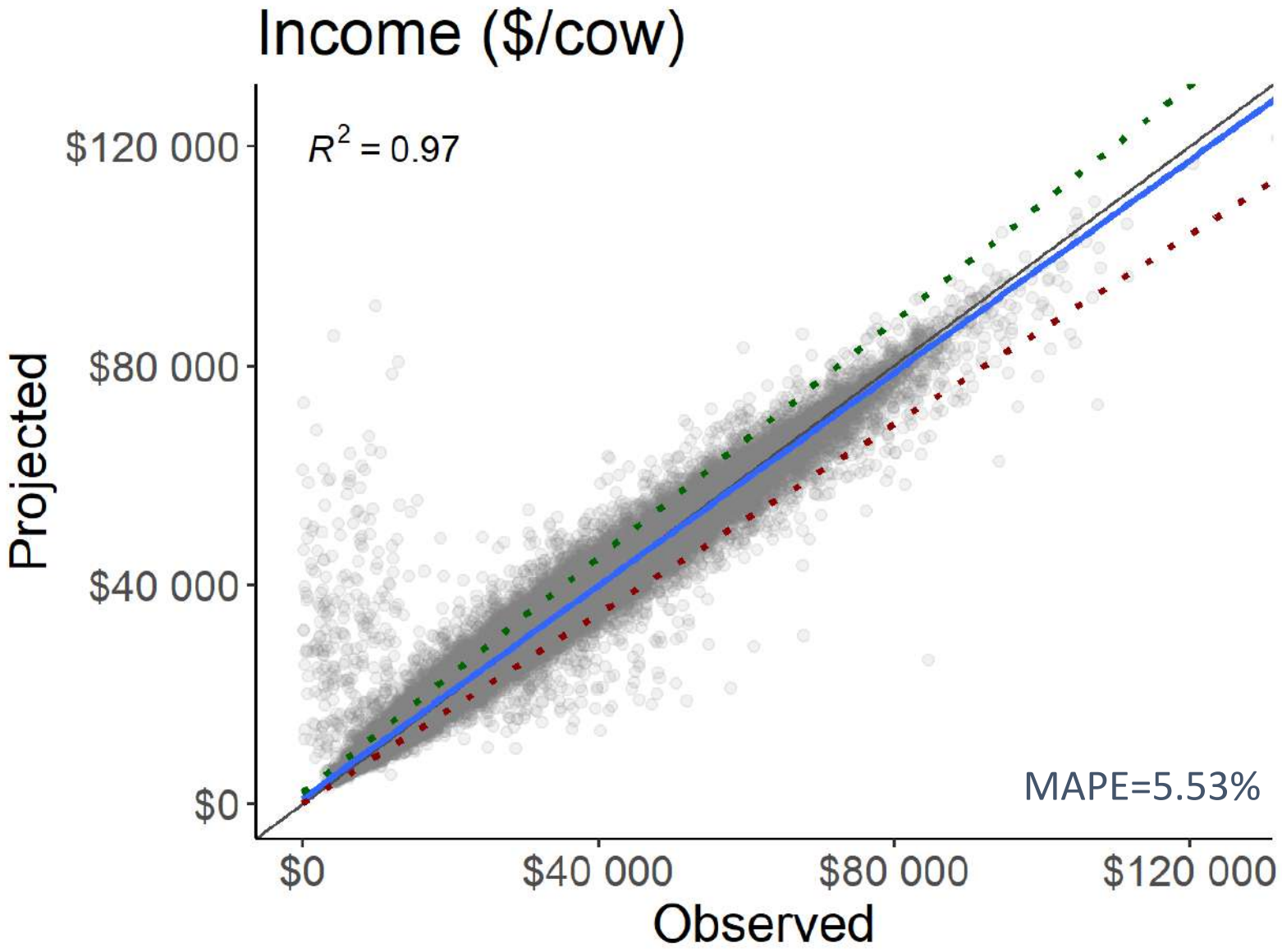
Fat =5.92%

Protein = 5.51%

R^2 (train): 0.972

R^2 (test): 0.972

Results



Revenue: Calculated as a linear combination of lifetime cumulative yields of milk, fat and protein and milk components prices

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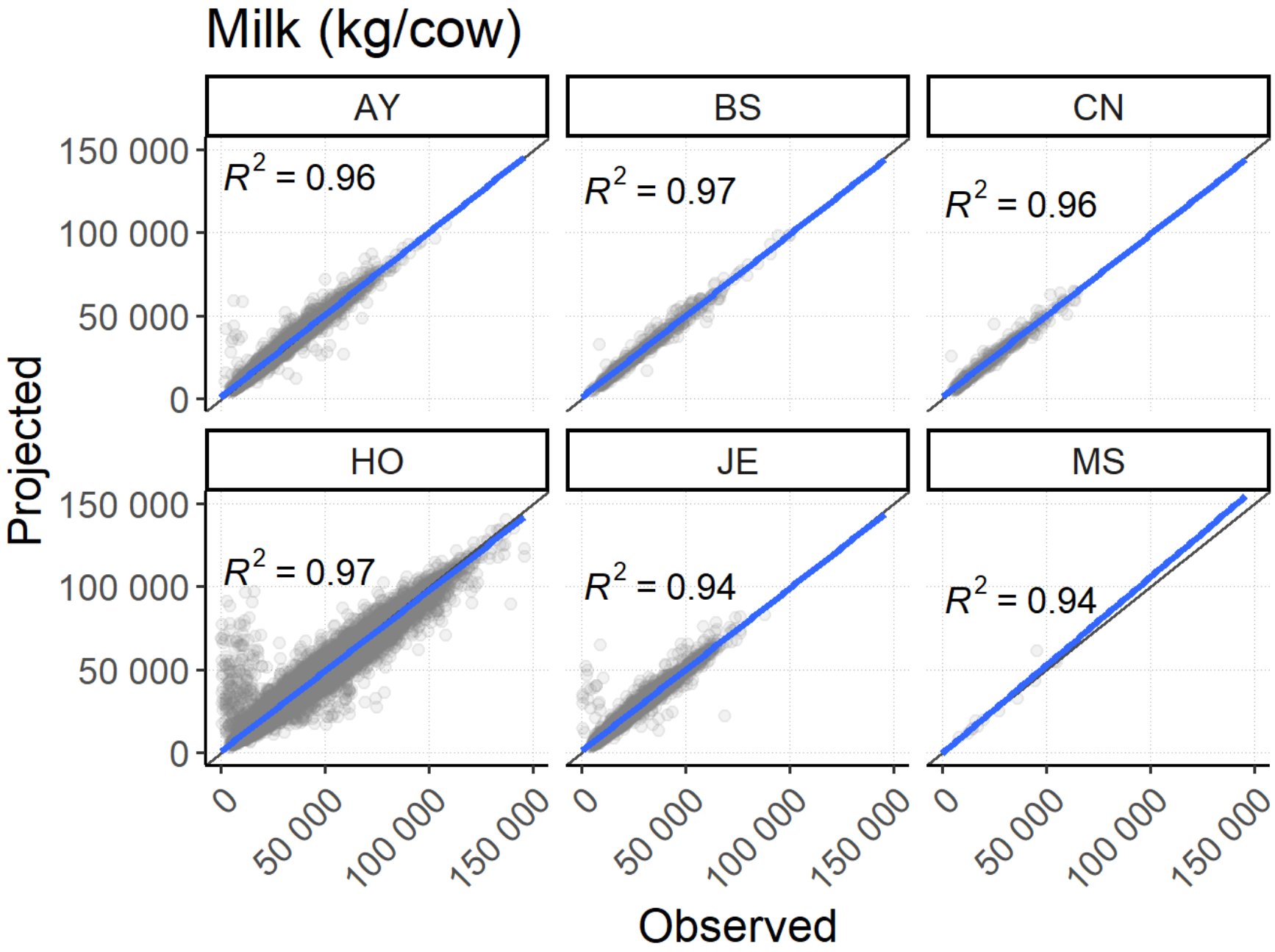
Results



Breeds: Milk prediction

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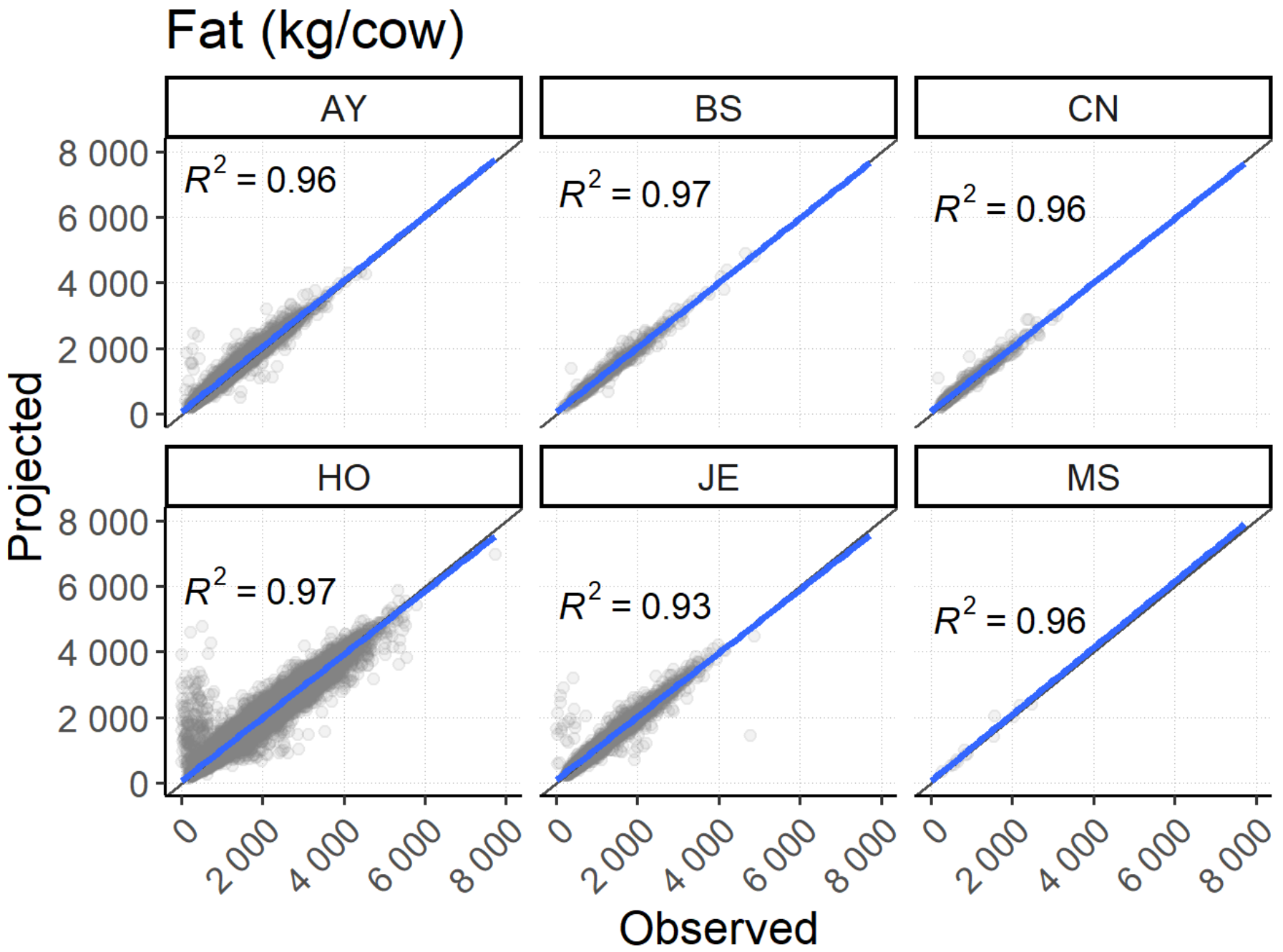
Results



Breeds: Fat prediction

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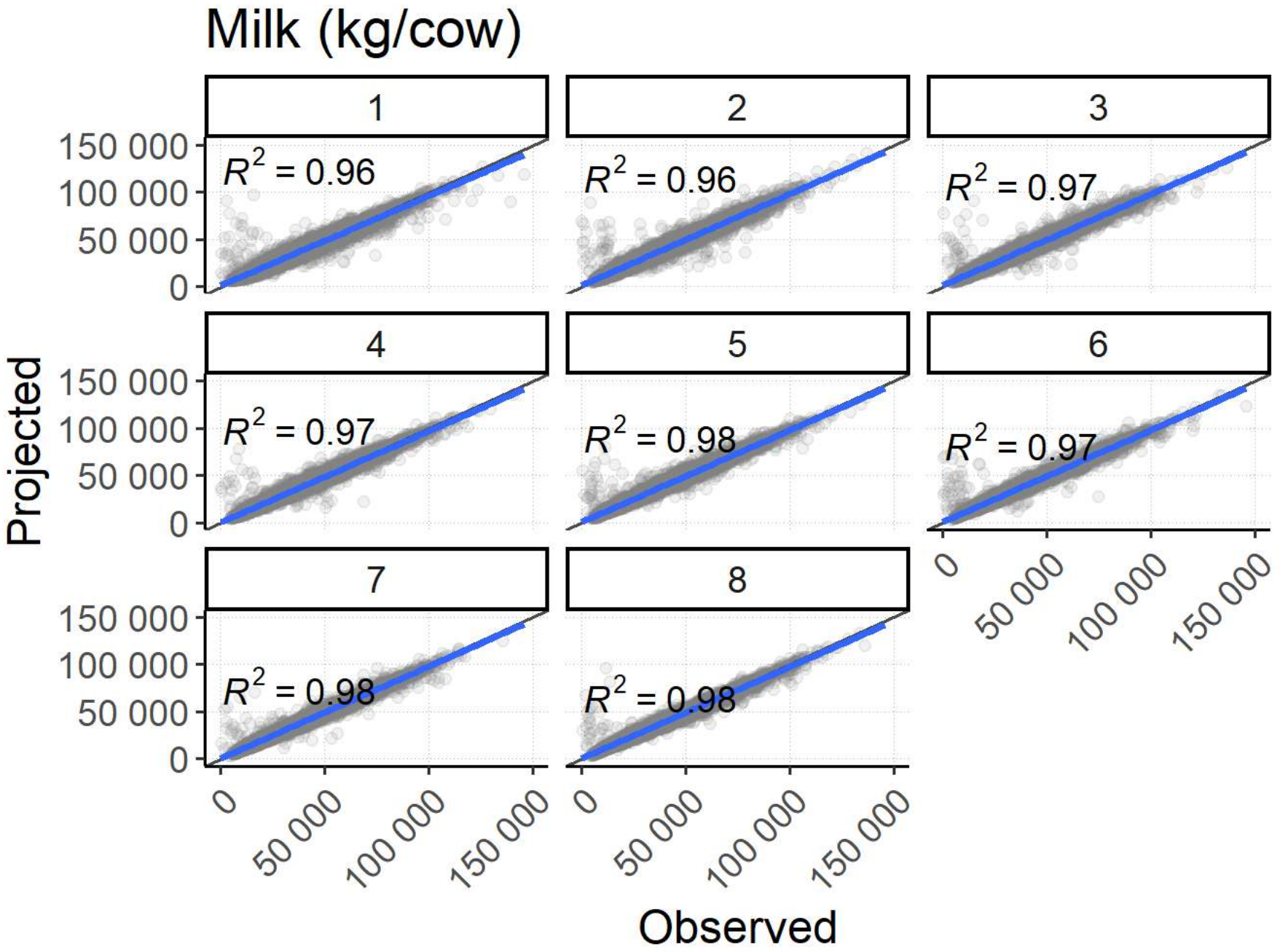
Results



No. tests

Milk prediction

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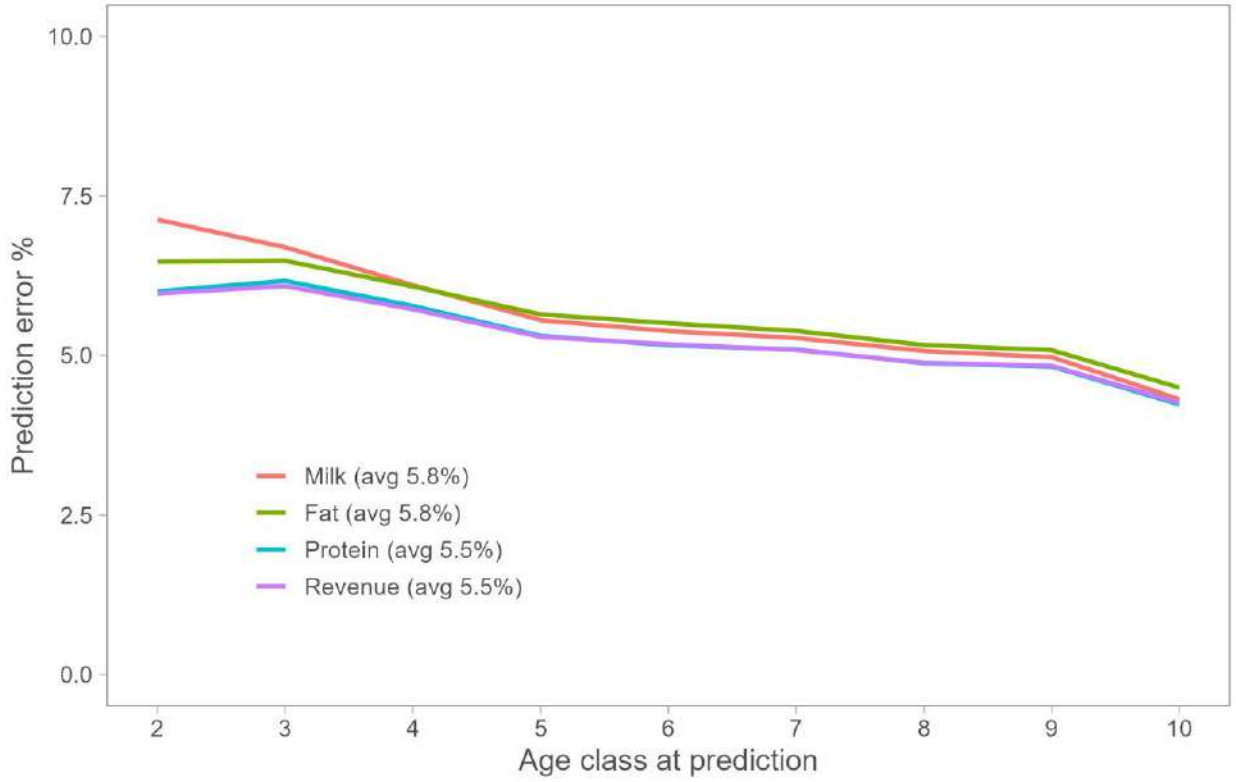
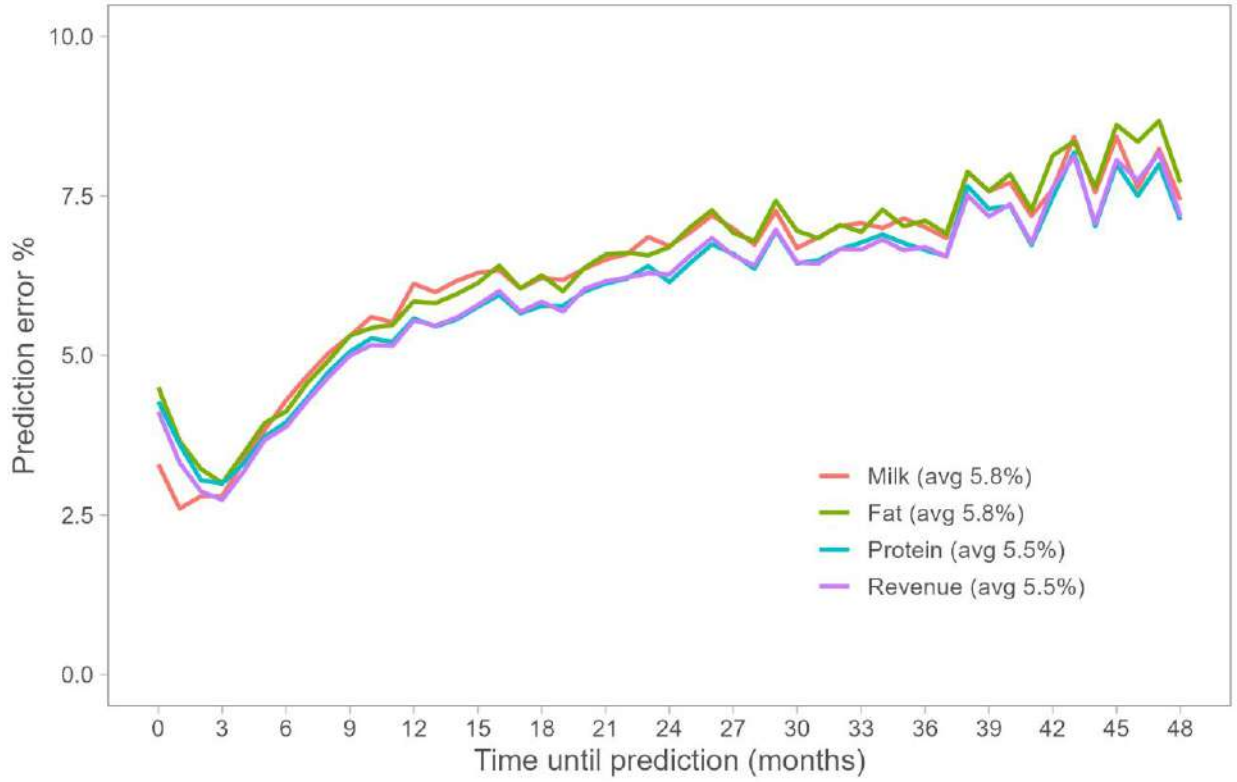
Results

Effect on the precision of the predictions due to time interval until prediction and age at prediction





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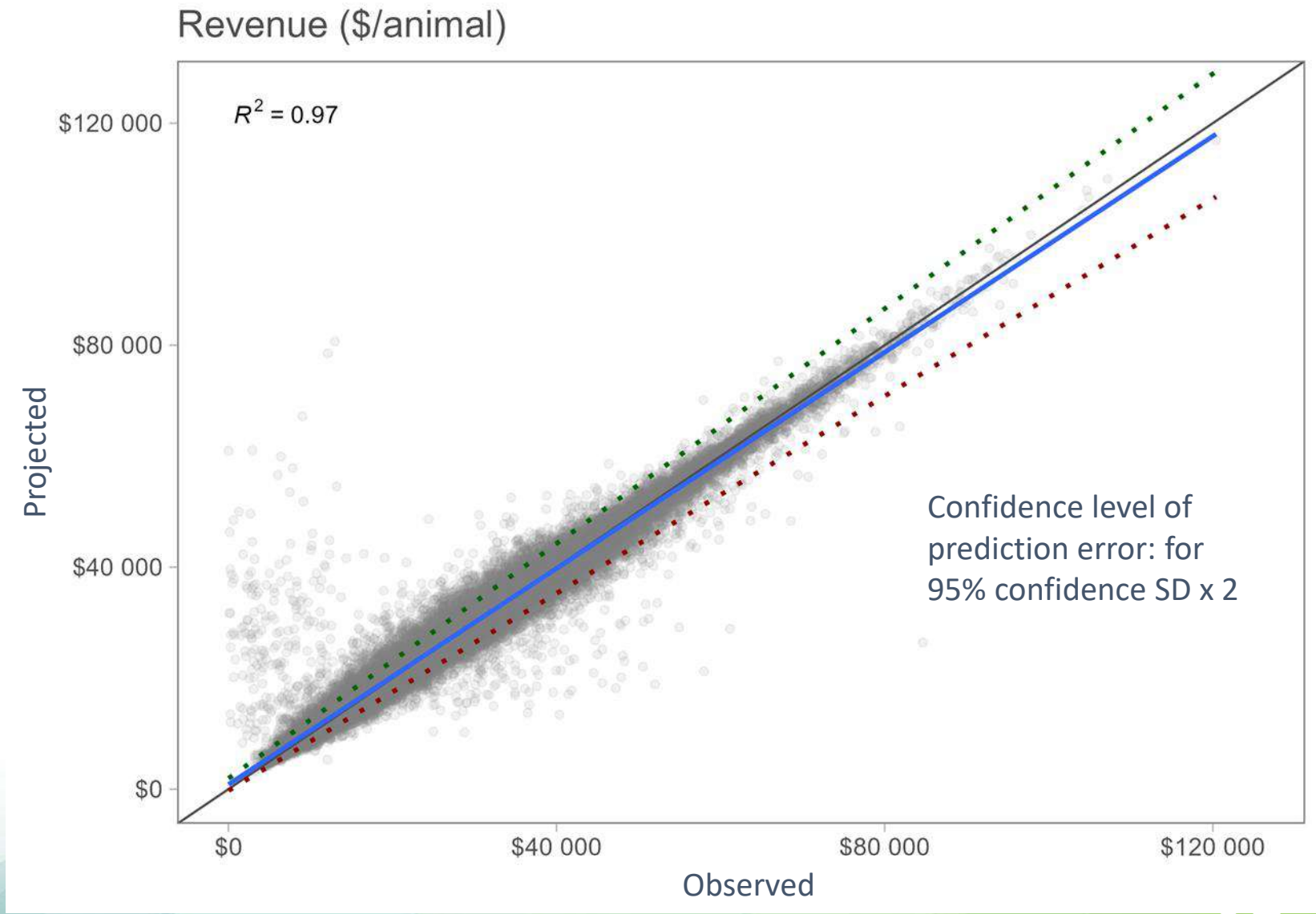
Results

Prediction error estimated for each individual cow

Based on SD of residuals and model parameters (age class at prediction, time to prediction, breed and interactions) estimated via a linear mixed-effect model (NLME)



hrd_id

2

65

Age (an)

- (Blank)
- 2
- 3
- 4
- 5
- 6
- 7
- 8

Groupe pa...

- (Blank)
- 1
- 2
- 3

Indicateurs

- [x] Age (m)
- [ ] Age-prédiction (m)
- [ ] Délai prédiction (j)
- [x] Revenu à vie
- [x] Revenu par jour ($/j)
- [x] Revenu par jour prédit ($/j)
- [x] Revenu prédit
- [x] Couts variables $
- [x] Marge $
- [x] Marge $/d
- [ ] Lait à vie (kg)
- [ ] Gras à vie (kg)
- [ ] Protéine à vie (kg)

Variable costs

3.00 — 5.91

$12.33

Avg Revenue Per Day

$13.37

$11.66

Margin Per Day

$12.35

anm_id	Parité	Jours en lait	Age (m)	Revenu à vie	Revenu prédit	Revenu par jour ($/j)	Revenu par jour prédit ($/j)	Couts variables $	Marge $	Marge $/d
12852596	2	30	36	9,253.02	18883	8.45	13	451.39	8802	$8.04
12852599	2	68	37	9,593.98	18295	8.57	13	491.13	9103	$8.13
12783804	1	399	39	9,822.51	15785	8.25	11	500.56	9322	$7.83
12734597	2	11	41	9,852.22	16291	7.93	11	497.76	9354	$7.53
12783806	2	102	39	10,747.41	17702	8.96	12	568.28	10179	$8.48
12815613	2	111	38	10,874.56	18088	9.44	12	559.06	10316	$8.95
12852598	2	64	36	11,189.25	21747	10.09	15	592.27	10597	$9.56
12783808	2	175	40	11,876.57	17849	9.88	12	610.25	11266	$9.37
12783809	2	68	39	12,391.07	20095	10.44	14	634.35	11757	$9.90
12815617	2	87	38	12,813.44	22261	11.15	15	657.12	12156	$10.58
12734599	2	178	40	13,143.80	19583	10.86	13	662.80	12481	$10.31
12787432	2	57	39	13,275.75	19990	11.08	14	690.96	12585	$10.50
12838009	2	52	38	13,370.48	22566	11.59	15	658.50	12712	$11.02
12783805	2	170	39	13,382.83	19902	11.24	14	688.85	12694	$10.66
12589610	2	278	45	14,340.60	15476	10.37	11	710.40	13630	$9.86
12692693	2	195	41	14,999.64	20475	11.96	14	760.48	14239	$11.35
12625195	2	226	44	15,576.37	18673	11.72	13	770.45	14806	$11.14
12692694	2	170	42	15,868.87	21066	12.50	14	815.90	15053	$11.85
12811654	1	471	38	15,958.53	22306	13.63	15	873.92	15085	$12.88
12787433	2	96	40	16,076.13	23391	13.26	16	834.59	15242	$12.58
Total				**15,181.70**				**784.11**	**14398**	**$11.57**

Key Takeaways

- The model effectively predicted cumulative yields at any future age, with an average prediction range of 5.4 years ahead.

- These findings suggest that the neural network can help farmers make informed decisions by predicting future cow lifetime yields and ranking animals within a herd for any age class.

- Next steps:
  - Develop survival model
  - Co-develop visualisation tool with users

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Thank You

Québec