



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

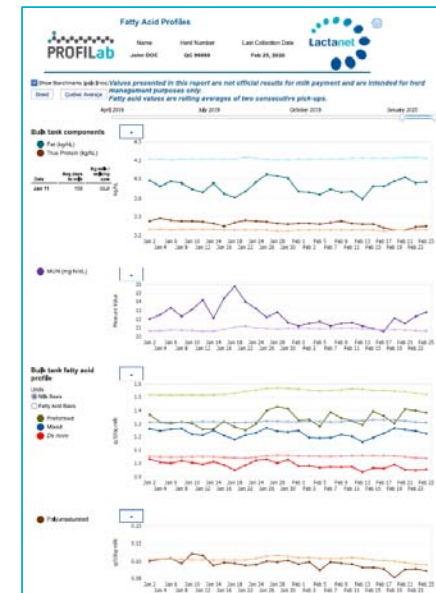
# Automated Anomaly Detection for Milk Components and Diagnostics in Dairy Herds

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ICAR 2022, Montréal

# Component Profile of Bulk Tank Milk

- Includes **basic components** (fat, protein, MUN, etc), but also specific **fatty acids**
- Reflects positive or negative **changes** in management and environmental factors (feed quality, feeding behaviour, ambient conditions, etc)
- Is not that easy to **interpret** and **diagnose**:
  - Many components moving simultaneously
  - Indicators moving at each bulk tank collect
- Is possibly not always **consulted**...





## Fatty Acid Profiles

Name: John DOE  
Herd Number: QC 99999  
Last Collection Date: Feb 25, 2020



☒ Show Benchmarks (pale lines)

Breed:

Quebec Average

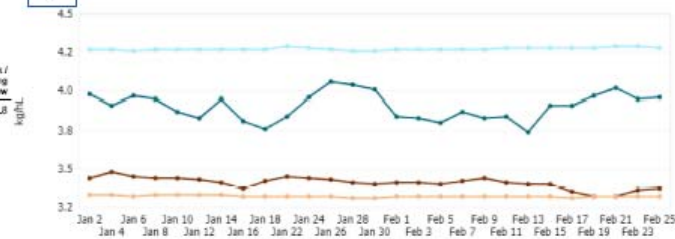
Values presented in this report are not official results for milk payment and are intended for herd management purposes only.  
Fatty acid values are rolling averages of two consecutive pick-ups.

April 2019 July 2019 October 2019 January 2020

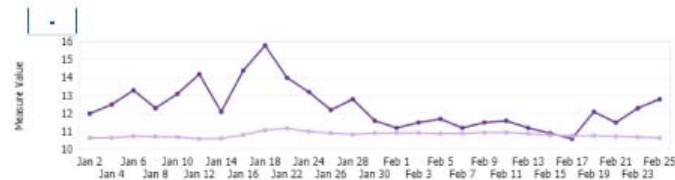
### Bulk tank components

- Fat (kg/hL)
- True Protein (kg/hL)

Date: Jan 11  
Avg days in milk: 158  
Kg milk / milking cow: 32.8  
kg/hL

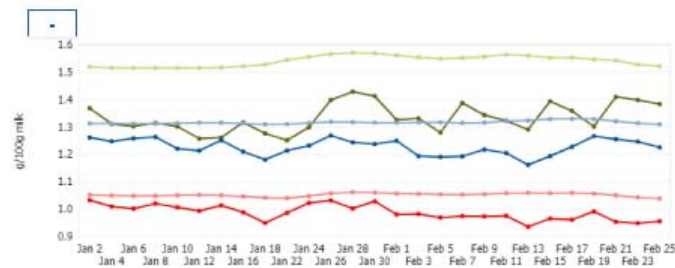


- MUN (mg N/dL)

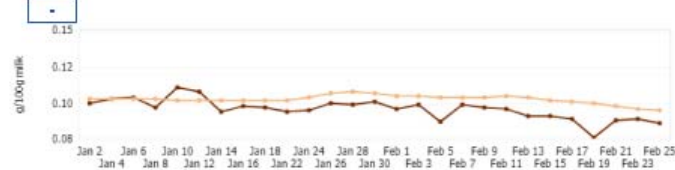


### Bulk tank fatty acid profile

- Units:
- Milk Basis
  - Fatty Acid Basis
  - Preformed
  - Mixed
  - De novo

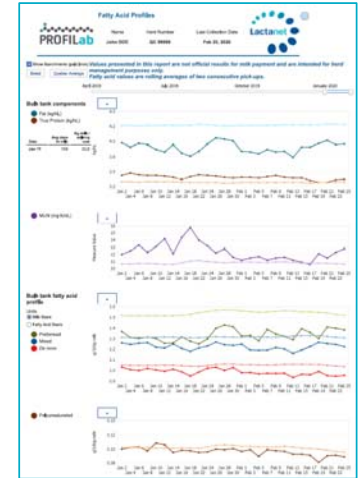


- Polyunsaturated



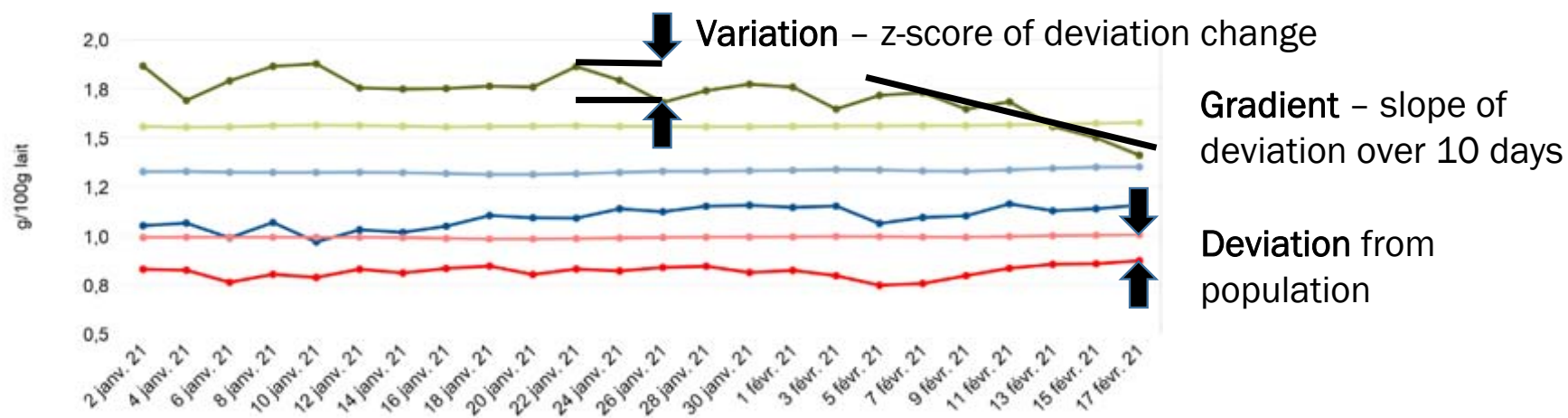
# Assistance Through Anomaly Detection

- Abnormal situation in time-series
  - Large deviation from population
  - Increasing or decreasing deviation
- Bulk tank milk components: multidimensional context
- Anomalies can be good or bad
- Our short-term goal (Phase 1): attention messages and alerts
- Long term (Phase 2): propose possible diagnostics and corrective actions





# Phase 1. Simple Numerical Approach

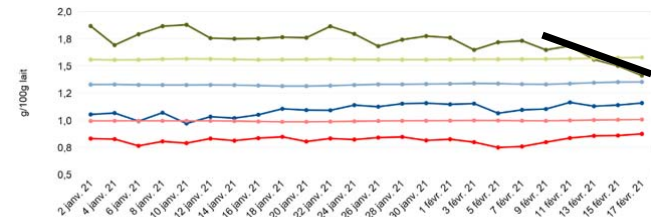


- Approach based on **deviations** removes seasonality and population reaction effects
- Raw values for each herd are transformed to **percentile ranks**
  - **Unitless** and **generic**
  - Set **thresholds** (eg top 10%) and **sensitivity** to alerts
  - Proxy for **likelihood** or degree of confidence

# Phase 1. Alert and Message Triggering

- Basic anomaly assessment: **extreme variations**
- To put in production, start with selected combinations of the three **fatty acid groups**: **de novo**, **preformed** and **mixed**
- Targeted management horizon: **10 days**

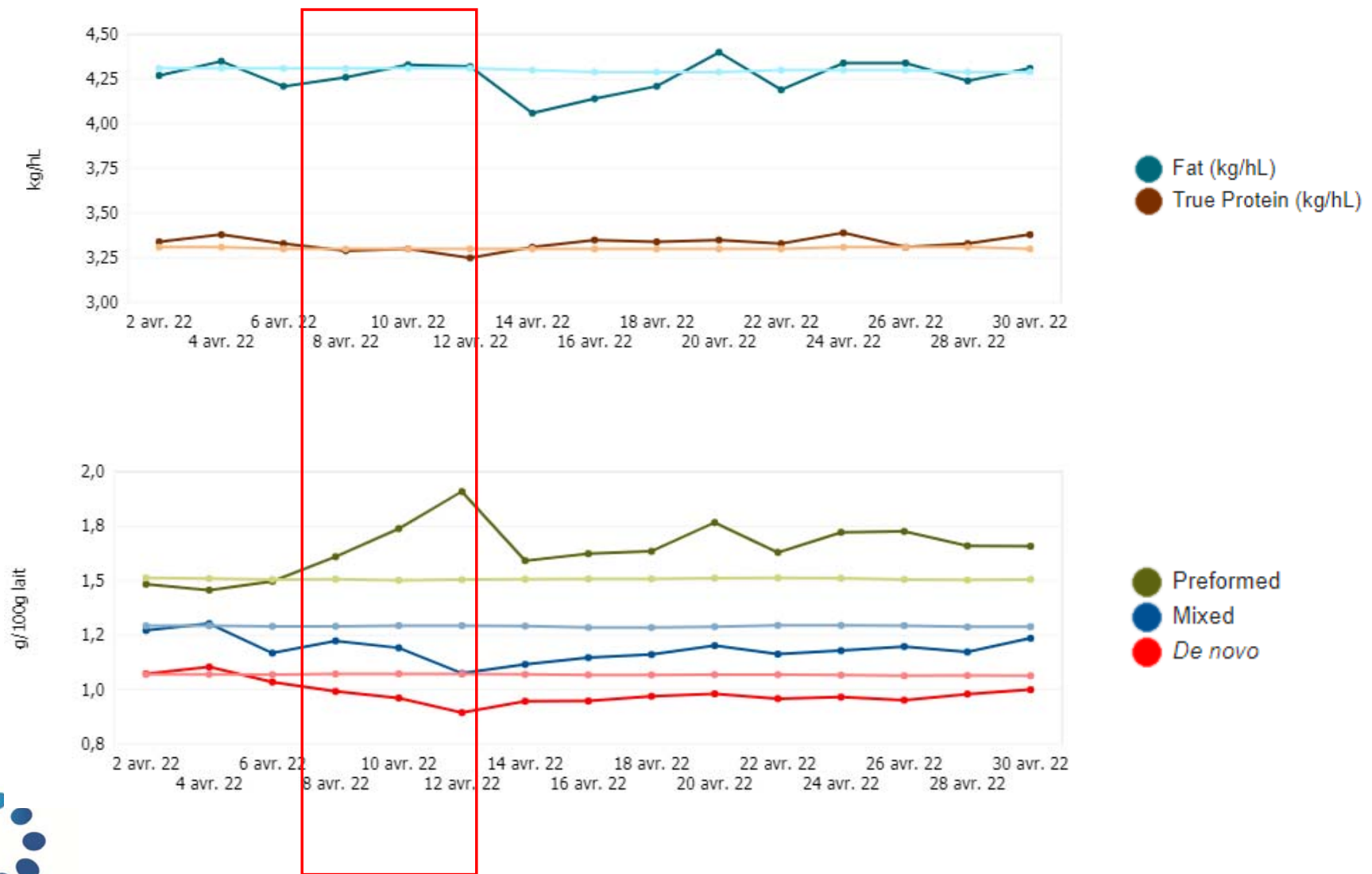
Leave interpretation to  
advisor/producer



## RULE #1

*De novo* ↓  
(< 10%)

Preformed ↑  
(> 90%)

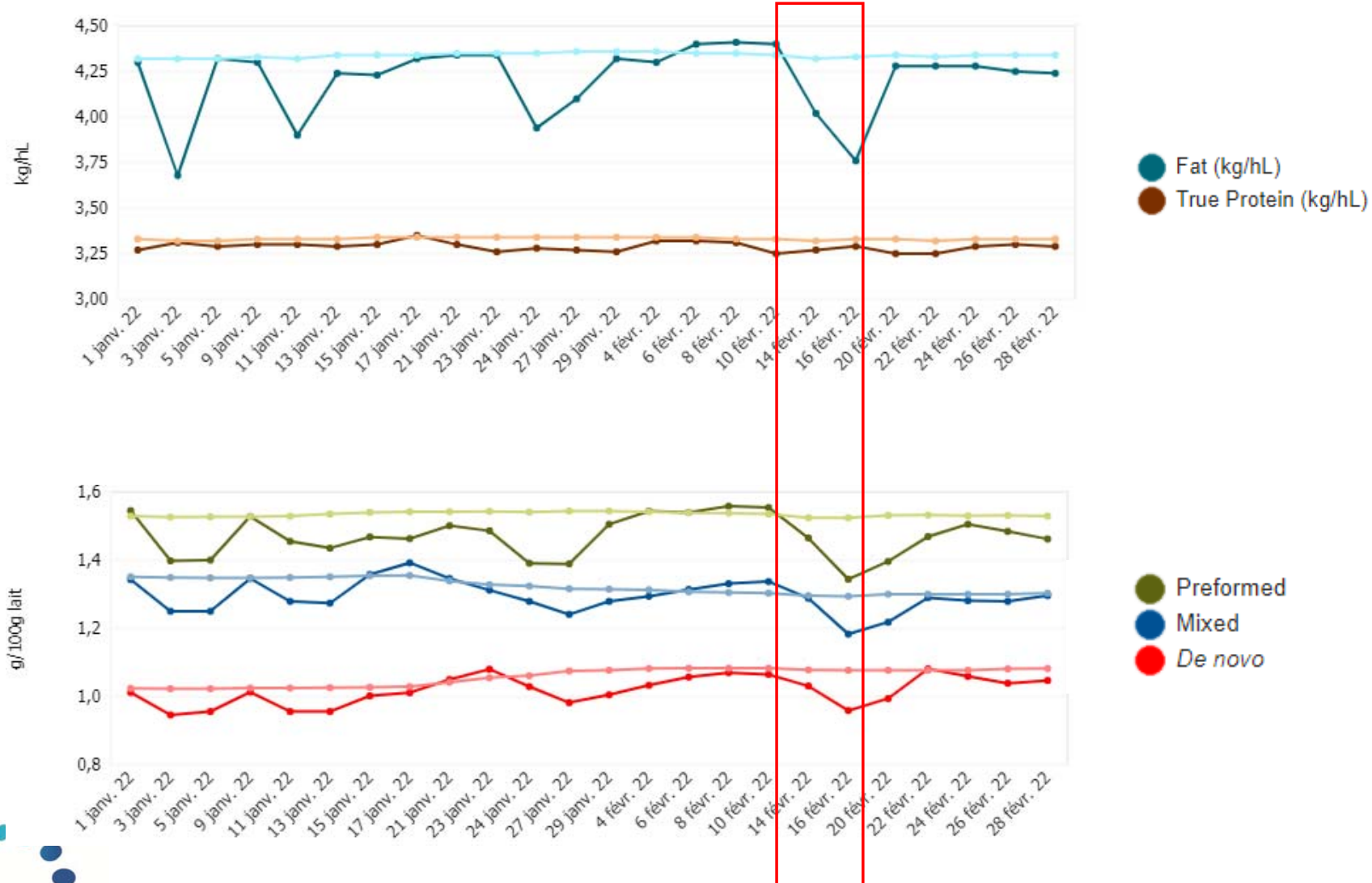


## RULE #2

**De novo** ↓  
( < 10%)

**Mixed** ↓  
( < 10%)

**Preformed** ↓  
( < 10%)

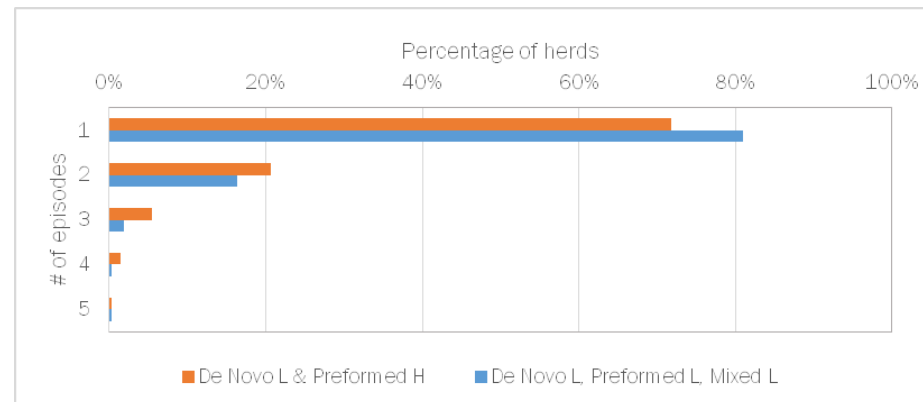




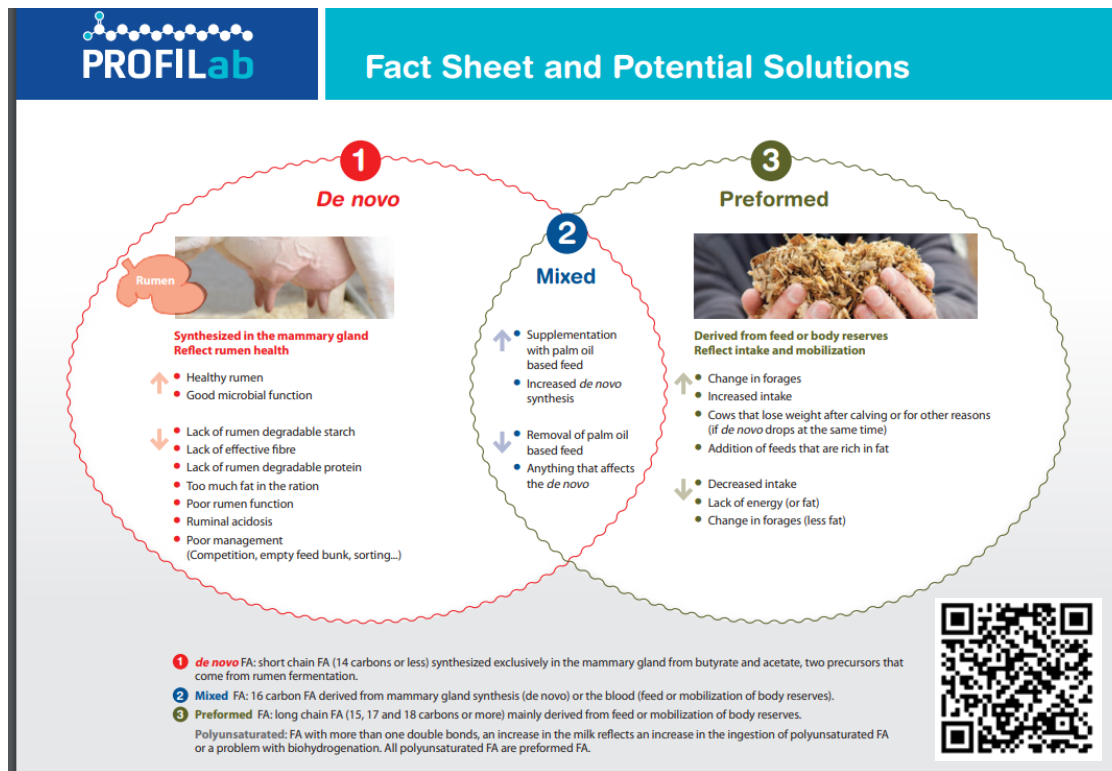
# Some Results...

- Over a period of 4 months (February-May 2022)
- 60,076 observations on 1279 herds

	% obs	% episodes	% herds
All records	100%	100%	100%
De novo L	10%	5%	93%
De Novo L, Preformed H	2%	1%	41%
De Novo L, Preformed L, Mixed L	1%	1%	21%



# Phase 2. Anomaly Assessment and Diagnostic



## RULE X – Risk of acidosis

IF

Fat is low & **De Novo** ↓ & **Mixed** is low  
& **Preformed** ↑ & **Polyunsaturates** ↑ & ....

THEN

Profile = risk\_acidosis

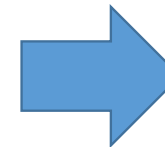
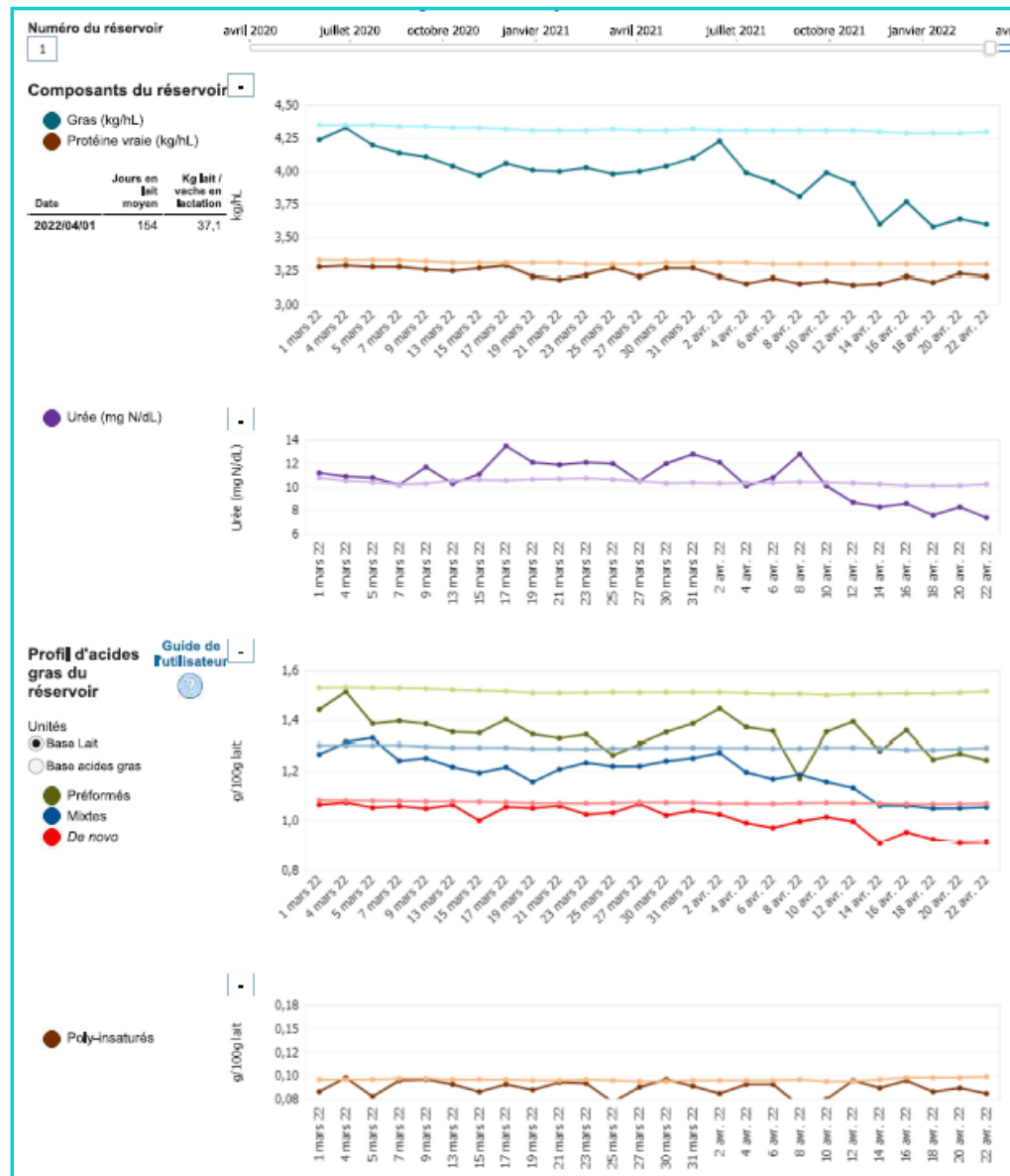


## Possible actions

- Analyse fiber
- Verify 18:2 in feed
- Adjust feed sequence
- Verify competition
- etc

# Phase 2. Anomaly Assessment and Diagnostic

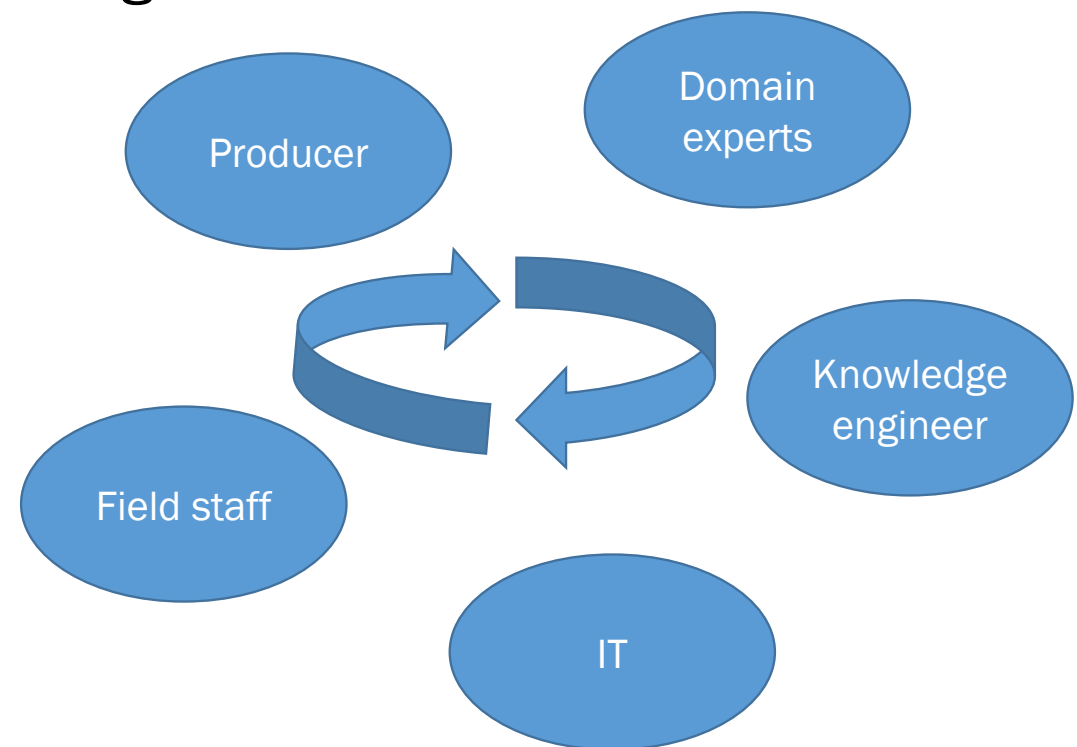
herd_id	anb_cd	col_rec_dt	acidosis	intake	starch	protein	energy	propionate	rumen
1	HO	2022-05-06	81	0	0	0	0	0	0
2	HO	2022-05-04	0	0	0	84	0	0	0
3	HO	2022-05-05	0	0	0	81	0	0	0
4	HO	2022-05-06	0	0	0	75	0	0	0
5	HO	2022-05-07	0	80	0	0	0	0	0
6	HO	2022-05-04	0	95	0	0	0	0	92
7	HO	2022-05-07	0	0	0	0	0	75	0
8	AY	2022-05-06	0	0	0	0	87	0	0
9	HO	2022-05-05	0	87	0	91	0	0	84
10	HO	2022-05-05	0	0	0	0	0	84	0
11	HO	2022-05-05	0	0	0	97	0	0	0
12	HO	2022-05-06	0	0	0	0	0	76	0
13	HO	2022-05-07	0	0	73	0	0	0	0
14	HO	2022-05-07	0	0	67	0	0	0	0
15	HO	2022-05-05	0	0	0	0	90	0	0



Low or inadequate DMI

# Rule-Based Approach: Challenges

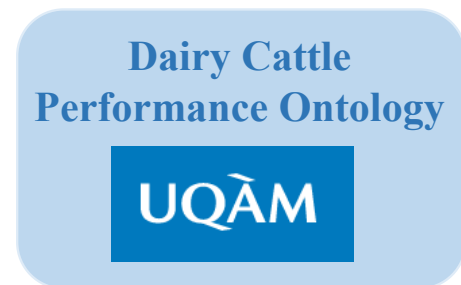
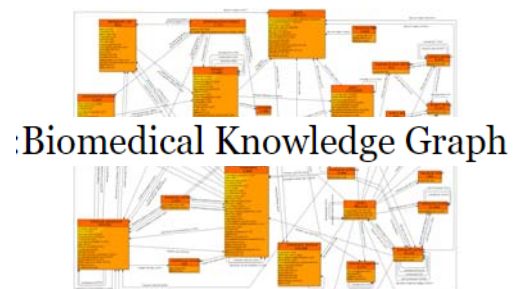
- Knowledge elicitation and structuring
- Development of rules
- Validation
- Maintenance
- Not flexible when hard-coded





# Could AI Help Us?

- The ideal situation would be:
  - a **data set** mapping diagnostics to milk component profiles
  - **machine learning** algorithms generate rules or classifiers
- Alternative, **knowledge elicitation** and **encoding** with a symbolic AI approach
  - > **ontologies** and **graphs**



# A Prototype Ontology for Milk Profile Diagnostic

File Edit View Reasoner Tools Refactor Window Help

< > faonto (http://www.lactanet.ca/ontologies/faonto)

SolutionClue > ManagementClue

Active ontology \* Entities \* Classes \* Object properties \* Data properties \* Individuals by class \* DL Query \* SWRLTab \*

Class hierarchy: ManagementClue

Annotations Usage

Asserted

owl:Thing

- AnalysisConfiguration
- Herd
- Profile
  - AcidosisRisk
  - ConsumptionLack
  - EnergyMobilization
  - PropionateLack
  - ProteinLack
  - RumenPerturbation
  - StarchLack
- Recommendation
- SolutionClue
  - ManagementClue
  - NutritionClue

Usage: VerifyFeedRefusal

Show: ☒ this ☒ different

Found 9 uses of VerifyFeedRefusal

- Recom\_AR
  - Recom\_AR suggestsSolution VerifyFeedRefusal
- Recom\_CL
  - Recom\_CL suggestsSolution VerifyFeedRefusal
- VerifyFeedRefusal
  - Individual: VerifyFeedRefusal
  - VerifyFeedRefusal rdfs:comment "Verify the cow is **not** refusing feed"
  - VerifyFeedRefusal Type ManagementClue

Description: VerifyFeedRefusal

Types +

- ManagementClue

Same Individual As +

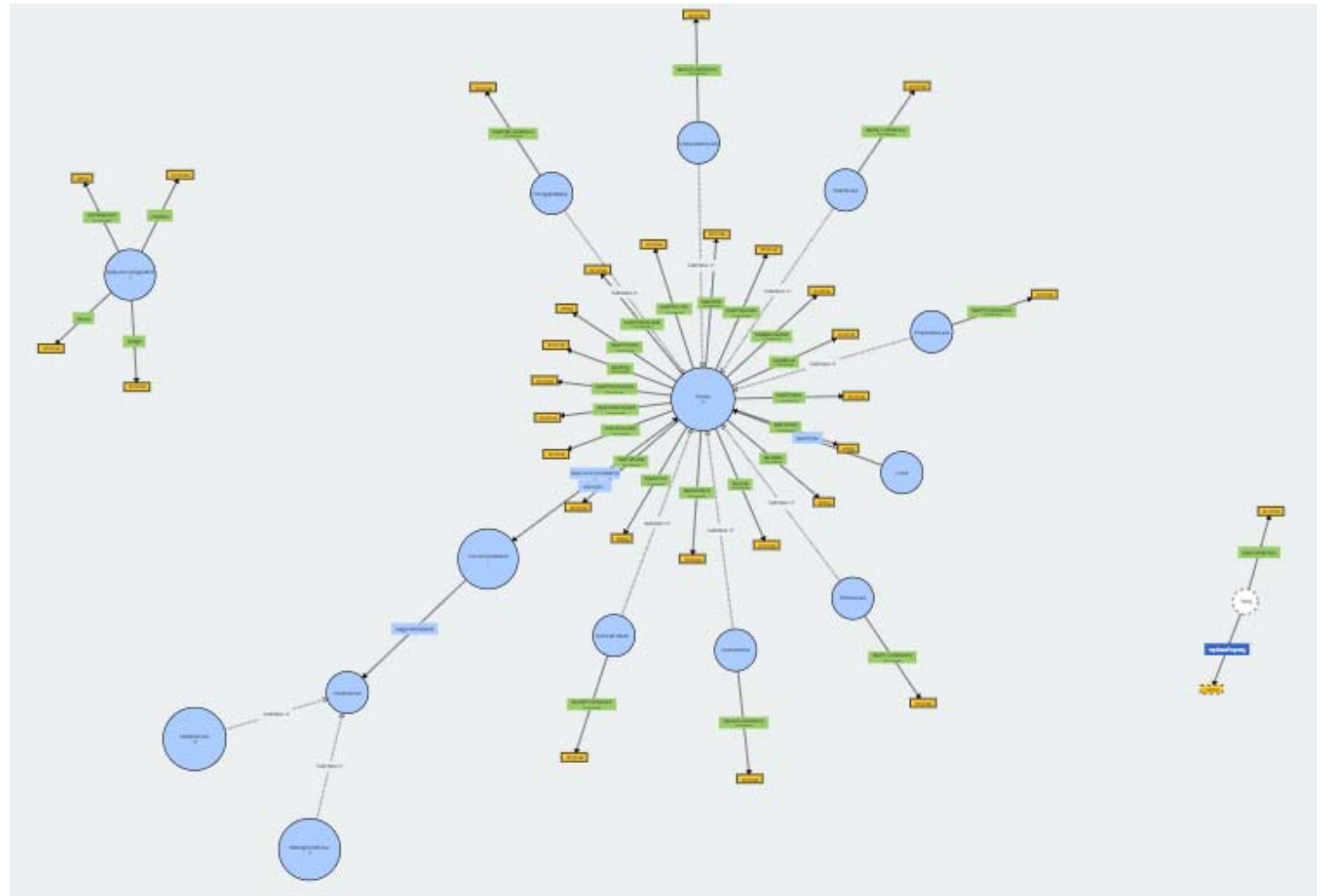
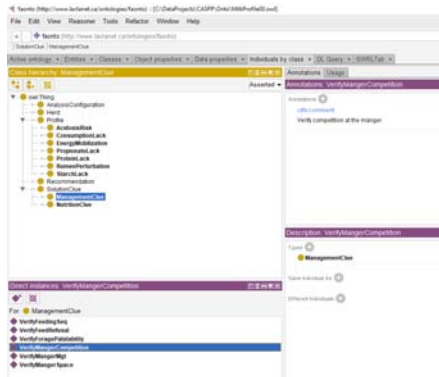
Different Individuals +

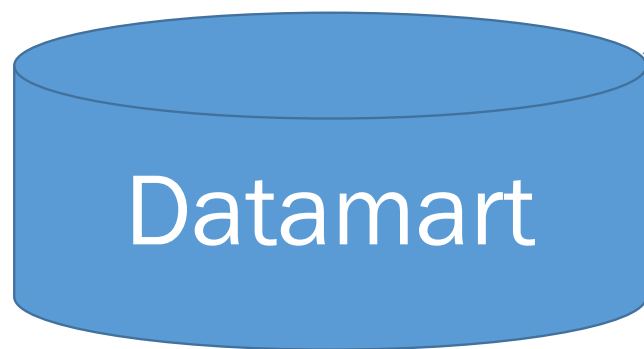
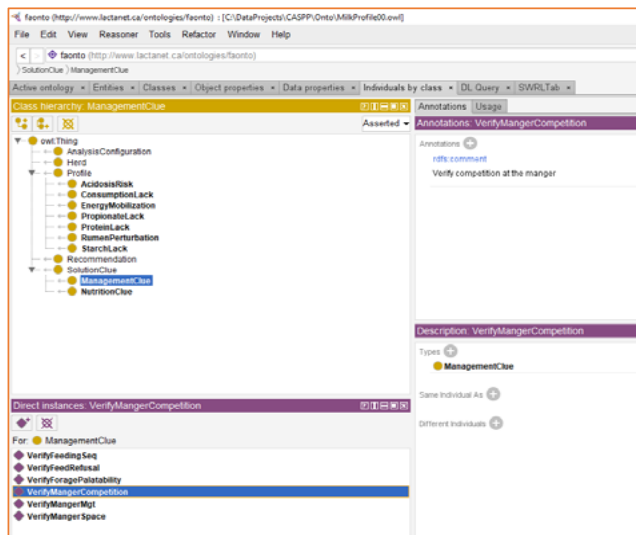
Direct instances: VerifyFeedRefusal

For: ManagementClue

- ReduceContaminatedSilage
- SeveralRecentCalvins
- TestYeastMould
- VerifyFeedingSeq
- VerifyFeedRefusal
- VerifyForagePalatability
- VerifyMangerCompetition
- VerifyMangerMgt
- VerifyMangerSpace

## A Graph View of the Prototype Ontology





Herd:12345 Province:4 Breed:HO Date:2022-03-14

	Fat	Protein	DeNovo	Mixed	Preform	Urea	Poly
Deviations:	42.08	95.13	41.17	46.60	26.31	42.81	73.90
Gradients:	28.76	18.25	9.12	10.86	51.95	1.91	84.45

Diagnostics:  
<\*> AcidosisRisk <\*>

Possible actions:  
 Verify feed rich in 18:2 (Linoleic acid)  
 Verify the cow is not refusing feed  
 Verify food rich in rapidly digestible starch  
 Verify feeding sequence  
 Verify effective fiber

# Conclusion

- We are building an **alert/attention system** based on extreme gradients for selected milk components.
- It seems possible to build a more advanced **diagnostic system** using a rule-based approach
- We could develop a **recommendation system** that goes beyond diagnostic and proposes actions based on **ontology**.



# *Thank you!*

The funding for this project was provided through the Government of Canada's Canadian Agricultural Strategic Priorities Program (CASPP).

Canada 