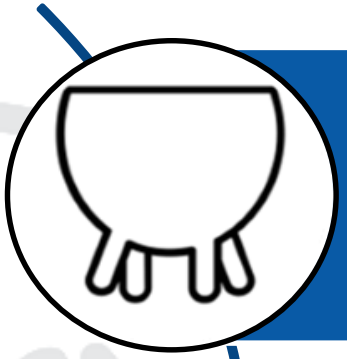
Improved genetic evaluation of health traits using metabolic biomarkers in Nordic dairy cattle

E. Rius-Vilarrasa[1], W.F. Fikse[1], E. Carlén[1], J-Å. Eriksson[1], J. Pöso[2], U.S. Nielsen[3], G. P. Aamand[4]

[1] **Växa Sverige**, Uppsala, Sweden
[2] **Faba co-op,** Vantaa, Finland
[3] **SEGES**, Aarhus N, Denmark
[4] **Nordic Cattle Genetic Evaluation**, Aarhus N, Denmark

Health traits evaluations



UDDER HEALTH

Clinical mastitis , Cell count (indicator trait)

Udder conformation (indicator traits)

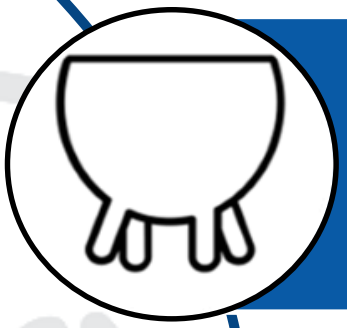
CLAW HEALTH

Claw diseases (trimmers)

GENERAL HEALTH

Reproductive-, Metabolic disorders,
Feet and Leg problems -- Clinical mastitis,
metabolic biomarkers (BHB & Acetone indicator traits)

Health traits evaluations



UDDER HEALTH

Clinical mastitis , Cell count (indicator trait)

Udder conformation (indicator traits)

CLAW HEALTH

Claw diseases (trimmers)

GENERAL HEALTH

Reproductive-, Metabolic disorders,
Feet and Leg problems -- Clinical mastitis,
metabolic biomarkers ***(BHB & Acetone indicator traits)***

General Health index

GH index = Early Reproductive Disorders (**ERP**)

+ Late Reproductive Disorders (**LRP**)

+ Feet & Leg Problems (**FLP**)

+ *Ketosis (**KET**)*

+ *Other Metabolic Disorders (**OMB**)*

General Health index

GH index = Early Reproductive Disorders (**ERP**)

+ Late Reproductive Disorders (**LRP**)

+ Feet & Leg Problems (**FLP**)

Metabolic Disorders	+ *Ketosis (**KET**)* + *Other Metabolic Disorders (**OMB**)*

General Health index

GH index = Early Reproductive Disorders (**ERP**)

+ Late Reproductive Disorders (**LRP**)

+ Feet & Leg Problems (**FLP**)

+ *Ketosis (**KET**)*

+ *Other Metabolic Disorders (**OMB**)*

Metabolic Biomarkers - New indicator traits

Metabolic Biomarkers

Ketone bodies detectable in milk samples:

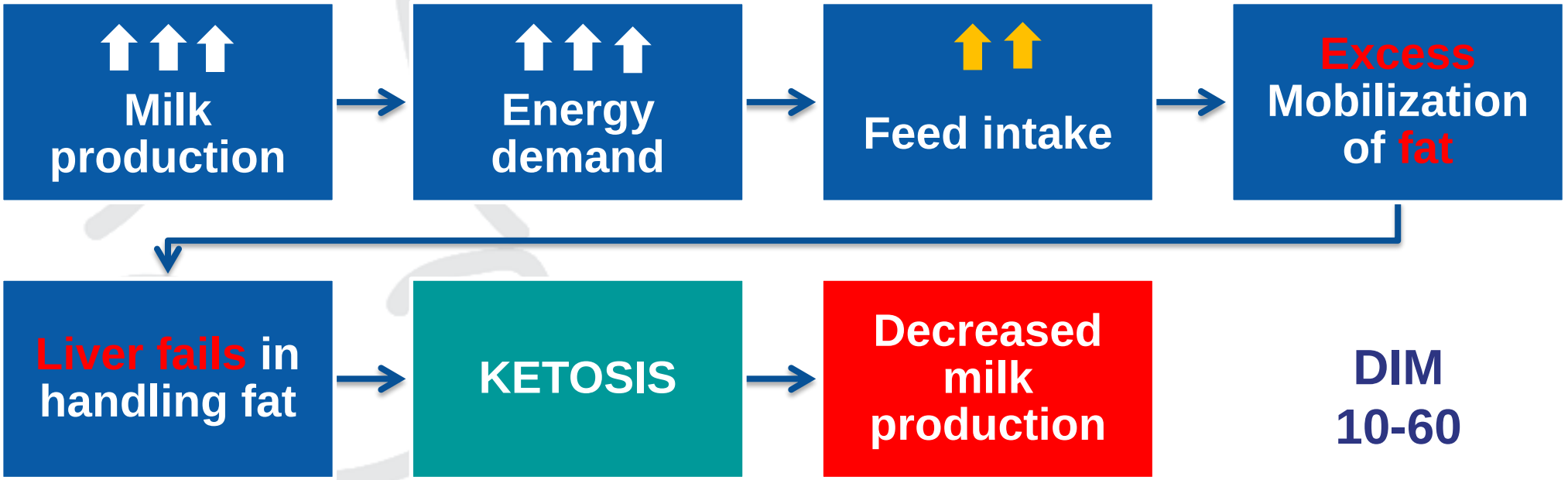
β-hydroxybutyrate (BHB) & Acetone

Metabolic Biomarkers

Ketone bodies detectable in milk samples:

β-hydroxybutyrate (BHB) & Acetone

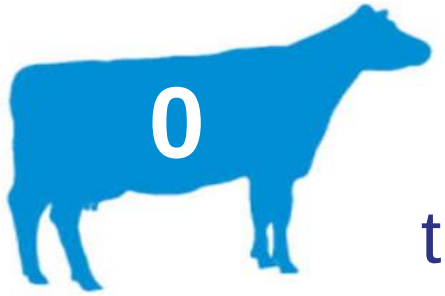
Leading to ketosis:



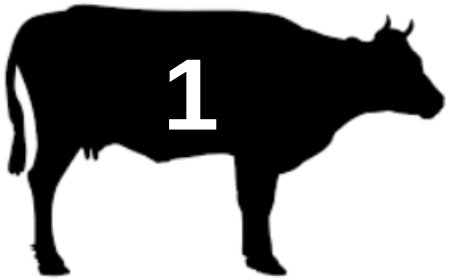
Data – Disease traits

- **Treatment records since the 80's**
- **Veterinarians, AI technicians and Farmers**
- **Breeds:** Holstein, Jersey and Red Dairy Cattle (RDC)
- **Lactations 1-3**
- **Defined as binary 0/1 trait**

Healthy
non-treated

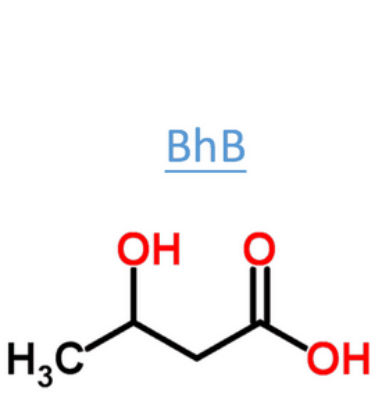


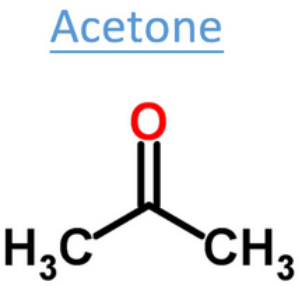
Sick
treated



Data - BHB and Acetone

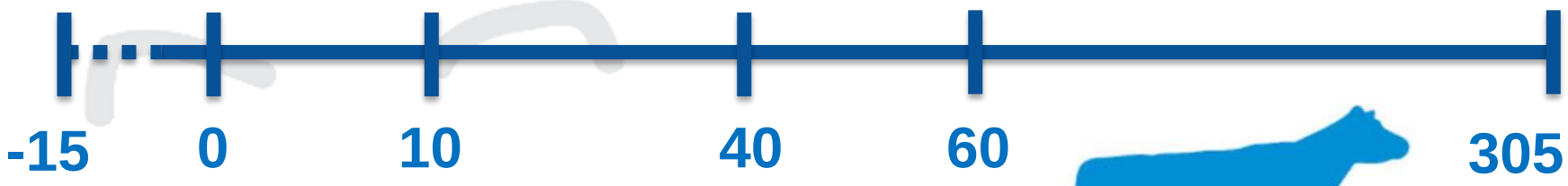
- **Since 2013 –** Denmark
- **From 2018 –** Finland and Sweden
- **Routine predictions from milk samples collected within the milk recording scheme –** mmol/L
- **Lactations** 1-3



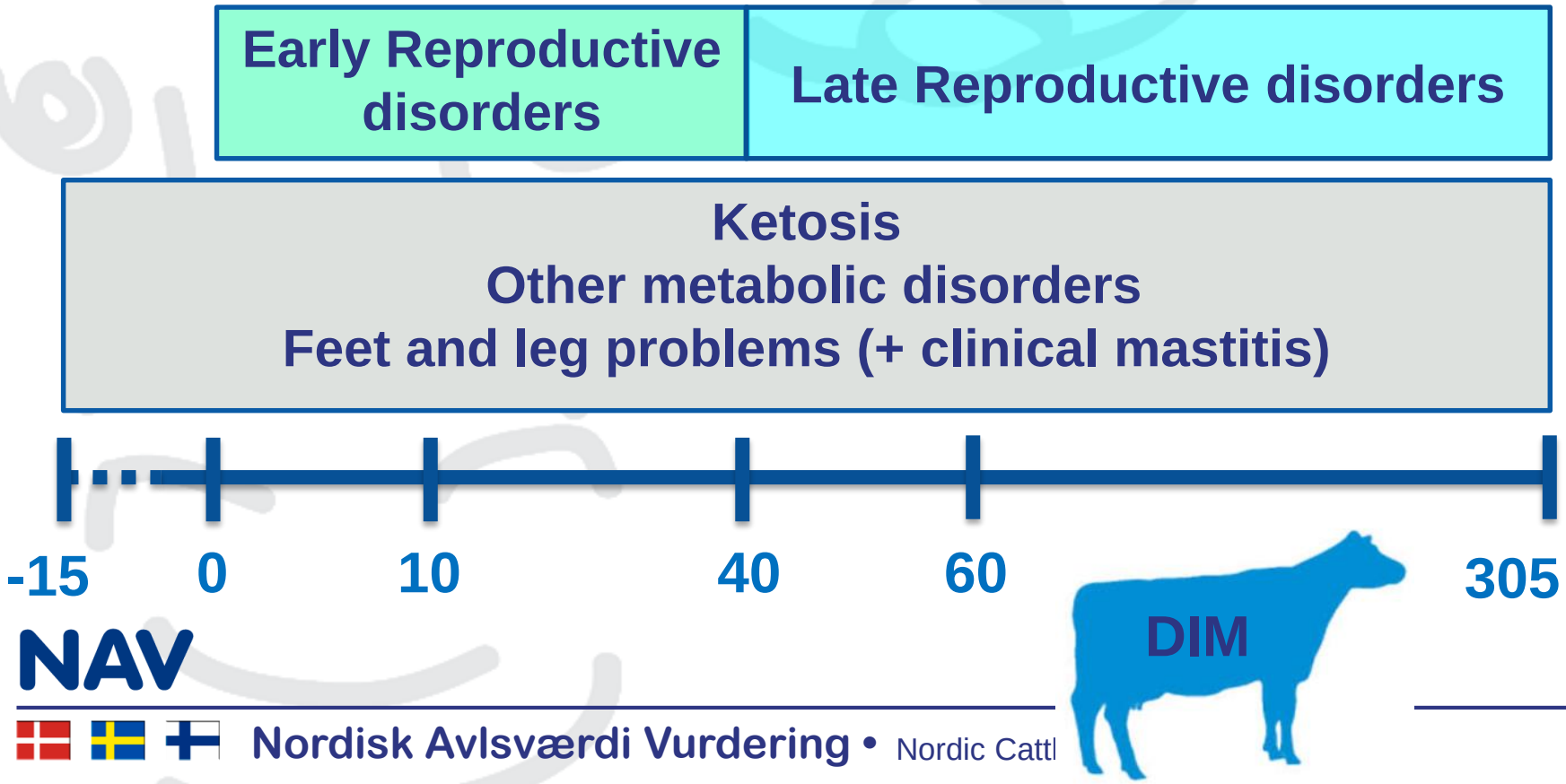


Trait definitions

Ketosis
Other metabolic disorders
Feet and leg problems (+ clinical mastitis)



Trait definitions



Trait definitions

BHB
Acetone

Early Reproductive disorders

Late Reproductive disorders

Ketosis
Other metabolic disorders
Feet and leg problems (+ clinical mastitis)

-15 0 10 40 60 305

DIM

Model - Multi-trait multi-lactation animal model

Fixed effects

Herd-year * country

Calving age * country

Year-month calving * country

Random effects

Animal

Cow Permanent environmental effect *(only BHB/Acetone)*

(fixed) Regression

Lactation stage *(only BHB/Acetone)*

Breeds and heterosis *(only HOL)*

***Pre-adjustment for heterogeneous variance*

Heritabilities and genetic correlations
Holstein, lactation 1

	Early reproductive disorders	Late reproductive disorders	Other metabolic disorders	Ketosis	Feet and leg problems
Early reproductive disorders	**0.020**	0.40	0.40	0.29	0.35
Late reproductive disorders		**0.010**	0.29	0.21	0.36
Other metabolic disorders			**0.006**	0.74	0.38
Ketosis				**0.012**	0.19
Feet and leg problems					**0.010**

Low heritabilities & low, moderate to high genetic correlations

Heritabilities and genetic correlations
Holstein, lactation 1

	Early reproductive disorders	Late reproductive disorders	Other metabolic disorders	Ketosis	Feet and leg problems
Early reproductive disorders	**0.020**	0.40	0.40	0.29	0.35
Late reproductive disorders		**0.010**	0.29	0.21	0.36
Other metabolic disorders			**0.006**	0.74	0.38
Ketosis				**0.012**	0.19
Feet and leg problems					**0.010**

Low heritabilities & low, moderate to high genetic correlations

Heritabilities and genetic correlations
Holstein, lactation 1

	Other metabolic disorders	Ketosis	BHB	Acetone
Other metabolic disorders	**0.006**	0.74	0.48	0.65
Ketosis		**0.012**	0.65	0.76
BHB			**0.15**	0.88
Acetone				**0.06**

Low to moderate heritabilities & high genetic correlations

Heritabilities and genetic correlations
Holstein, lactation 1

	Other metabolic disorders	Ketosis	BHB	Acetone
Other metabolic disorders	**0.006**	0.74	0.48	0.65
Ketosis		**0.012**	0.65	0.76
BHB			**0.15**	0.88
Acetone				**0.06**

Low to moderate heritabilities & high genetic correlations

Heritabilities and genetic correlations
Holstein, lactation 1

	Other metabolic disorders	Ketosis	BHB	Acetone
Other metabolic disorders	**0.006**	0.74	0.48	0.65
Ketosis		**0.012**	0.65	0.76
BHB			**0.15**	0.88
Acetone				**0.06**

Low to moderate heritabilities & high genetic correlations

Value of including BHB & acetone

Reliabilities for cows with or without BHB and Acetone observations, that have veterinary treatment observations but not own progeny

Breed	BHB & Acetone obs	Other Metabolic disorders		Ketosis		GH index	
HOL	Yes	0.34	**15%**	0.36	**19%**	0.32	**6%**
	No	0.29		0.29		0.30	

Summary

- New objective indicator traits for Ketosis in the General Health evaluation
  - Diagnosis for subclinical and clinical ketosis

Summary

- New objective indicator traits for Ketosis in the General Health evaluation
  - Diagnosis for subclinical and clinical ketosis
- Metabolic biomarkers showed favorable and high genetic correlations with Ketosis

Summary

- New objective indicator traits for Ketosis in the General Health evaluation
  - Diagnosis for subclinical and clinical ketosis
- Metabolic biomarkers showed favorable and high genetic correlations with Ketosis
- Higher heritability of BHB and acetone than for Ketosis

Summary

- New objective indicator traits for Ketosis in the General Health evaluation
  - Diagnosis for subclinical and clinical ketosis
- Metabolic biomarkers showed favorable and high genetic correlations with Ketosis
- Higher heritability of BHB and acetone than for Ketosis
- The inclusion of the metabolic biomarkers increases cow EBV reliability, especially for ketosis and metabolic disorders

Summary

- The new General Health evaluation was introduced November 2017 for all breeds (Holstein, RDC and Jersey)

NAV

Nordisk Avlsværdi Vurdering • Nordic Cattle Genetic Evaluation

November 2017

Disease traits and sub-traits used in the GH evaluation

Early reproductive disorders	Late reproductive disorders	Ketosis	Other metabolic diseases	Feet and leg problems
• Retained placenta • Hormonal reproductive disorders • Infective reproductive disorders • Other reproductive disorders	• Hormonal reproductive disorders • Infective reproductive disorders • Other reproductive disorders	• Ketosis • *BHB (β-hydroxybutyrate)* • *Acetone*	• Milk fever • Other metabolic diseases • Other feed related disorders • Other diseases	• Feet and legs disorders

Disease frequencies in % - HOLSTEIN

Traits	DNK	SWE	FIN
ERP	12	2	3
LRP	4	8	13
KET	5	<1	2
OMB	2-9*	1-7	2-8
F&L	8	3	2

***Lactation 1 to lactation 3**

Disease frequencies in % - RDC

Traits	DNK	SWE	FIN
ERP	8	2	3
LRP	2	6	12
KET	1-4*	<1	1
OMB	1-7	1-5	1-6
F&L	7	2	2

***Lactation 1 to lactation 3**

Disease frequencies in % - Jersey

Traits	DNK
ERP	3
LRP	2-3*
KET	2-3
OMB	2-15
F&L	5-7

***Lactation 1 to lactation 3**