UNIVERSITÀ DEGLI STUDI DI PADOVA

DAFNAE
Department of Agronomy Food Natural resources Animals Environment

Ph.D. COURSE ANIMAL & FOOD SCIENCE
UNIVERSITY OF PADOVA

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Genetic aspects of milk β-hydroxybutyrate in Italian Holstein cows

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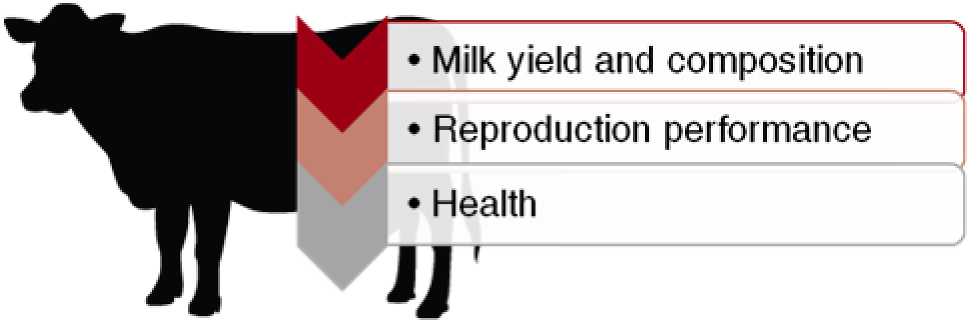
What is ketosis?

- A frequent metabolic disorder in dairy cattle.
- It occurs when the cow is unable to cope with the high energy demand for milk production in early lactation.
- Abnormal concentration of circulating ketone bodies (hyperketonemia).

(Herdt, 2000; Duffield et al., 2009; Berge & Vertenten, 2014)



Introduction

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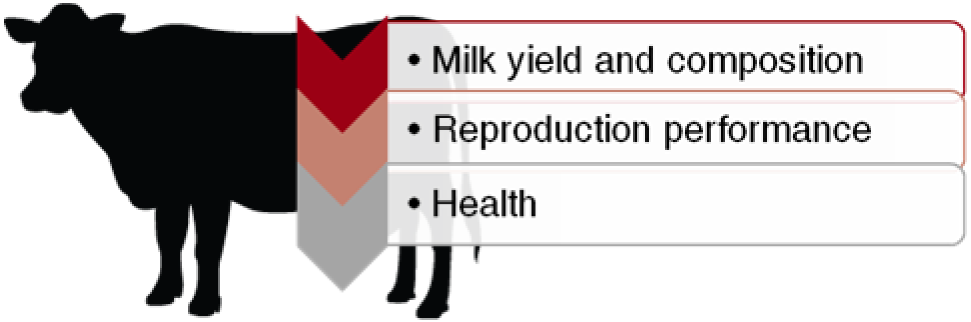

Relevant economic losses for farmers

US$289 per case

(McArt et al., 2015)

Ketosis can be …

Clinical

- Decrease in milk yield
- Sweet-smelling breath
- Reduced feed intake and appetite
- Reduced activity and changes in behavior
- Excessive loss of body condition
- Constipation or hard/dry feces
- Nervous signs

(Berge & Vertenten, 2014)

Subclinical

- Hyperketonemia
- Absence of clinical signs
- More frequent than clinical ketosis

(Andersson, 1988; Duffiled et al., 2009; Suthar et al., 2013)

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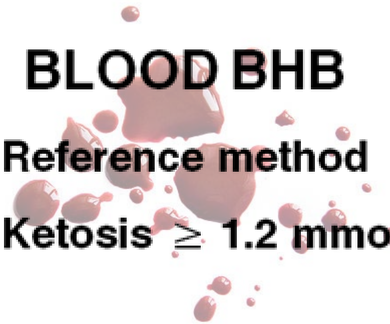
Prevalence in Italy 30-40%

Ketosis diagnosis

- Through the measurement of β-hydroxybutyrate (BHB) concentration in body fluids of dairy cows



BLOOD BHB

- **Reference method**
- **Ketosis ≥ 1.2 mmol/L**

MILK BHB

- **More practical tool**

BHB in milk can be routinely predicted by MIR spectroscopy for screening hyperketonemia

(Oetzel, 2004; van Knegsel et al., 2010; Denis-Robichaud et al., 2014; Koeck et al., 2014)

Ketosis and genetics

Worldwide

Milk BHB has been demonstrated to be a heritable trait → selection to reduce susceptibility to ketosis is possible

↓

Italy

Paucity of studies that assessed genetic parameters of milk BHB in Italian dairy cattle population

Introduction

(Van der Drift et al., 2012; Koeck et al., 2014; Penasa et al., 2015; Jamrozik et al., 2016)

Aim

To estimate heritability and repeatability of milk BHB and its genetic correlations with milk production and composition traits in Italian Holstein dairy cattle

Data

Sample collection

- 67,131 individual milk samples from May 2015 to June 2017.
- 21,223 cows (parity 1 to 9): at least 2 tests between 5 and 100 DIM.
- 3,488 herd-test-date (HTD): at least 5 cows per HTD.
- 261 herds in Veneto region (northeast Italy): subset of 30% of herds.
- 79,539 individuals in pedigree file: cows and ancestors up to 6 generations back.

Milk analysis

Milk samples were analysed using FTIR prediction models provided by FOSS (Application Note 35 – Ketosis)

Statistical analysis

- Single-trait repeatability animal model to estimate heritability and repeatability.
- Bivariate models to assess genetic correlations between milk BHB, yield, fat, protein, fat to protein ratio (F:P), lactose, urea and SCS*.

$$\mathbf{y = Xb + Za + Wp + e}$$

y = vector of observations for BHB and other test-day traits;

$\log_e$[BHB(mmol/L) +1]

b = vector of fixed effects

- Parity = 5 levels
- DIM = 15 classes
- Season of calving = winter, spring, summer and autumn
- HTD = 3,488 levels

a = vector of random animal additive genetic effects

p = vector of random permanent environmental effects

e = vector of random residuals

X, Z, W = incidence matrices

*SCS = 3+$\log_2$(SCC/100,000)

Descriptive statistics

Descriptive statistics of $\log_e$-transformed milk β-hydroxybutyrate (BHB), milk yield, composition traits and somatic cell score (SCS) in the first 100 days in milk (n = 67,131).

Trait	Mean	SD	Minimum	Maximum
BHB	0.059	0.059	0	1.043
Milk yield, kg/d	37.38	9.42	4.10	64.70
Fat, %	3.71	0.79	0.90	6.84
Protein, %	3.10	0.32	2.00	4.89
F:P[1]	1.20	0.25	0.26	2.90
Lactose, %	4.92	0.19	4.04	5.61
Urea, mg/dL	22.65	6.06	10.00	66.30
SCS	2.50	2.04	-3.64	10.79

[1] F:P = fat-to-protein ratio.

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Heritability and repeatability

Estimates[1] of additive genetic variance (σ_a^2), heritability and repeatability for log_e-transformed milk β-hydroxybutyrate (BHB), milk yield, composition traits, and somatic cell score (SCS) in the first 100 days in milk.

Trait	σ_a^2	Heritability	Repeatability
BHB	0.00012	0.08	0.20
Milk yield, kg/d	4.29366	0.09	0.45
Fat, %	0.05511	0.12	0.24
Protein, %	0.01621	0.25	0.48
F:P[2]	0.00355	0.07	0.19
Lactose, %	0.00894	0.34	0.51
Urea, mg/dL	2.24204	0.12	0.28
SCS	0.20814	0.06	0.39

[1] Standard errors ranged from 0.00001 to 0.48461 for additive genetic variance, 0.008 to 0.0015 for heritability, 0.0045 to 0.0050 for repeatability.
[2] F:P = fat-to-protein ratio.

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Genetic correlations

Genetic correlations between BHB, milk yield, composition traits, and somatic cell score (SCS) in the first 100 days in milk.

Trait	Milk yield	Fat	Protein	F:P	Lactose	Urea	SCS
BHB	0.07	0.21	-0.12	0.33	-0.08	-0.07	0.16
Milk yield		-0.31	-0.48	-0.04	-0.25	-0.11	0.08
Fat			0.64	0.77	0.09	0.15	0.14
Protein				-0.01	0.20	0.01	-0.00
F:P[2]					-0.04	0.18	0.14
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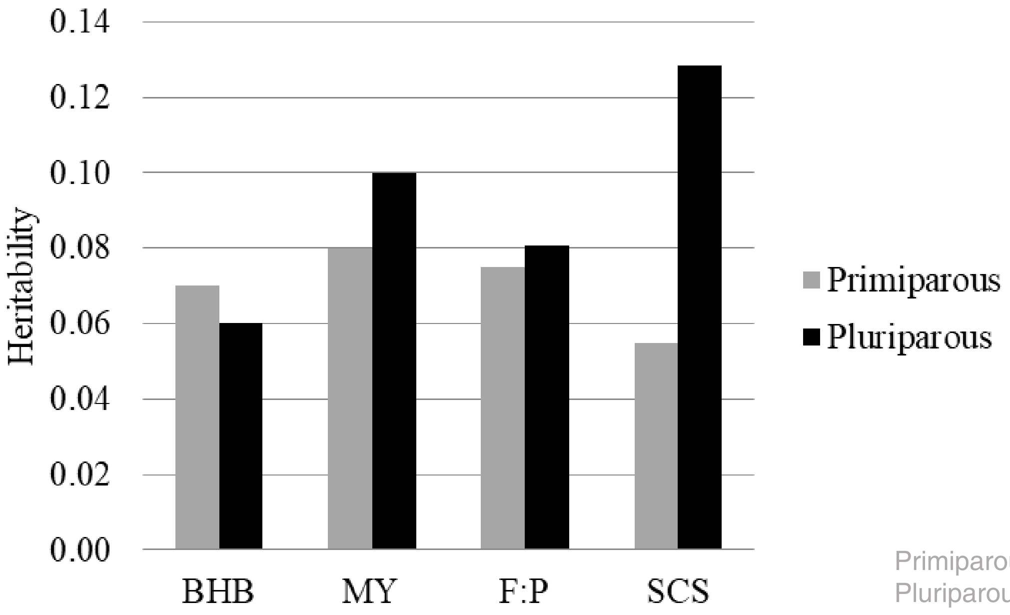
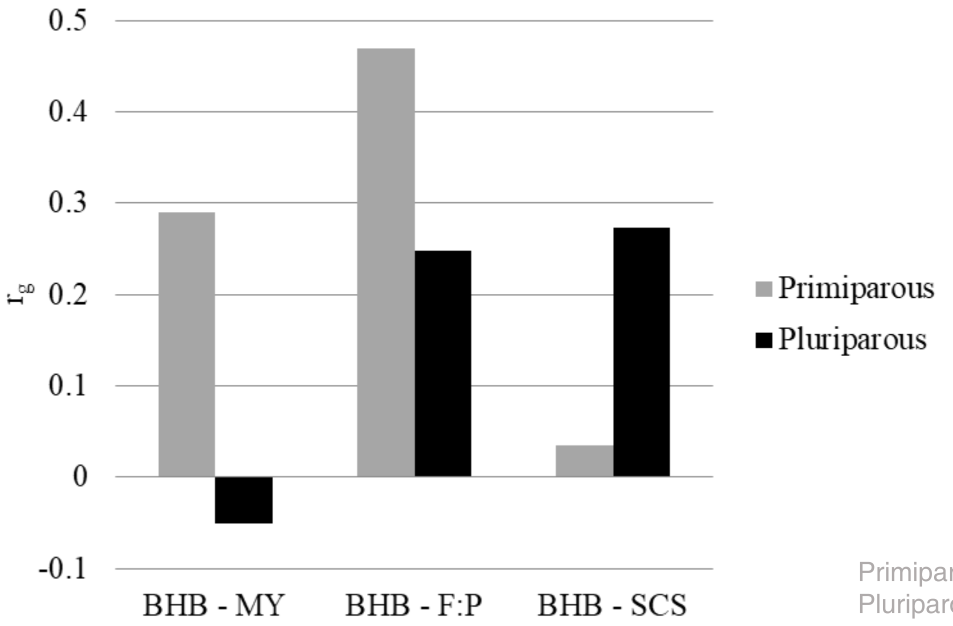
Heritability at different parity order



Primiparous cows (subset of 19,539 obs)
Pluriparous cows (subset of 37,673 obs)

Genetic correlations at different parity order



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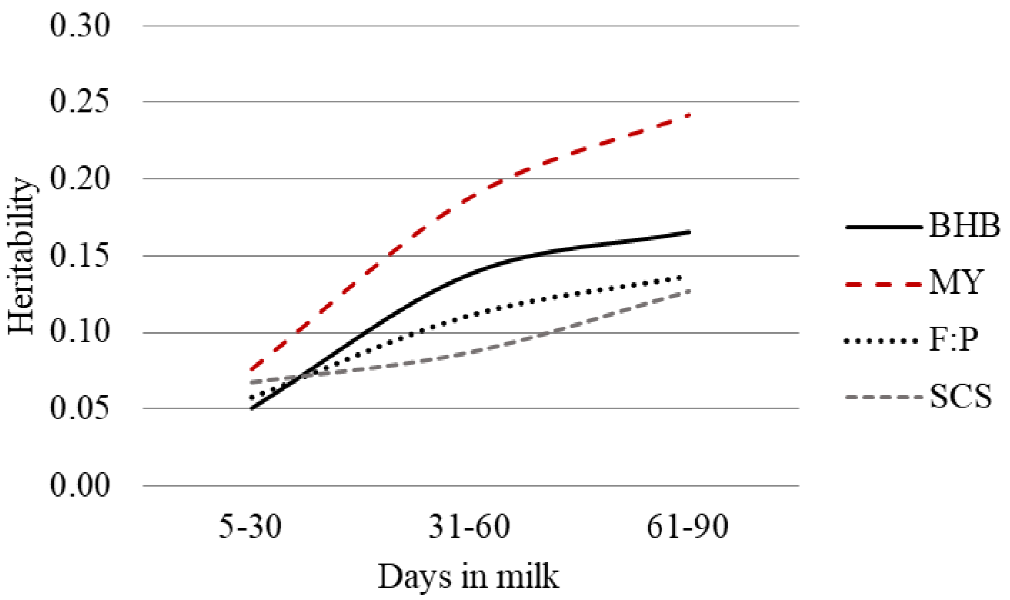
Heritability at different days in milk



Early DIM (subset of 13,328 obs)
Middle DIM (subset of 17,035 obs)
Late DIM (subset of 20,014 obs)

Conclusions

- Milk BHB routinely determined in test-day milk samples exhibits genetic variation, with increasing average heritability estimates moving from 5 to 100 DIM.
- Milk BHB was positively genetically associated with MY and F:P (primiparous cows) and with SCS (pluriparous cows).
- Further research will investigate/simulate possible scenarios of including milk BHB in selection index of Italian Holstein breed.

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THANK YOU!

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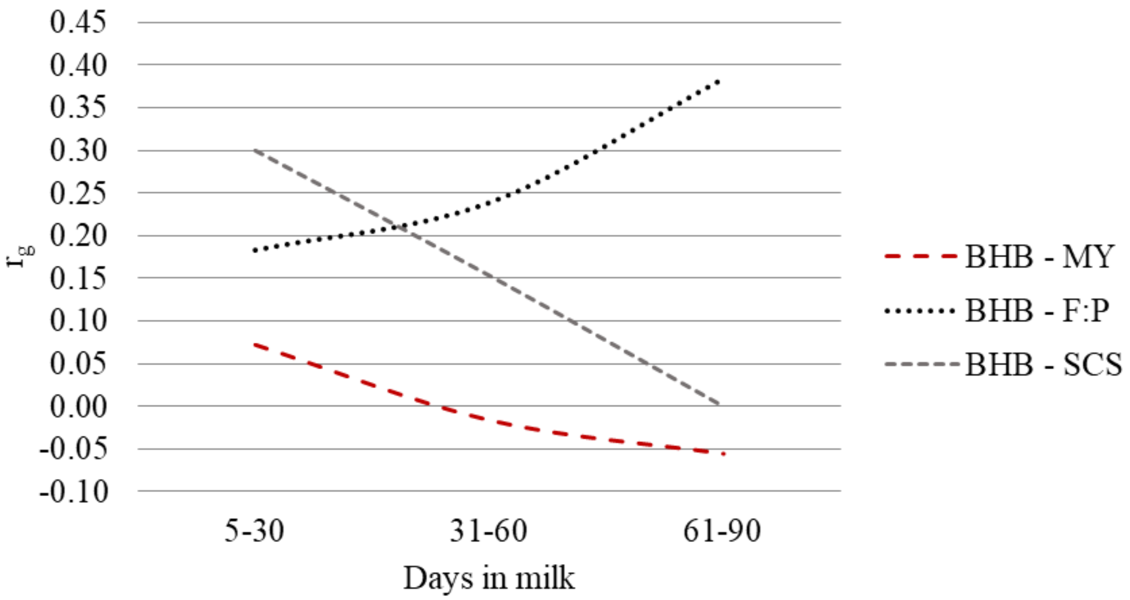
Genetic correlations at different days in milk



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