GEroNIMO and RUMIGEN Joint Final Event

The RUMIGEN EpiChip, a sensor of environment and breeding practices

Dr. Gabriel Costa Monteiro Moreira
Researcher in Epigenetics of Adaptation in Ruminants
INRAE – France | Paris

Presented on behalf of collaborators (alphabetical order): A. Asset, F. Besnard, D. Boichard, M. Brochard, L. Brun-Lafleur, Z. Cai, V. Costes, V. David, C. Fouéré, G. Foucras, S. Fritz, V. Gélin, H. Jammes, M. Joigner, E. Karaman, H. Kiefer, C. Le Danvic, L. Le Berre, M. S. Lund, D. Makowski, G. Costa Monteiro Moreira, M. Prézelin, C. Patry, G. Potier, A. De Paula Reis, C. Richard, G. Sahana, M.-P. Sanchez, R. B. Stephensen, B. Vaillant, E. Vanbergue.

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Rumigen

GERONIMO

GEroNIMO and RUMIGEN Joint Final Event

Climate change vs dairy production

WORLD METEOROLOGICAL ORGANIZATION

PRESS RELEASE
19 March 2025

WMO report documents spiralling weather and climate impacts

PRESS RELEASE
19 March 2024

Climate change indicators reached record levels in 2023: WMO

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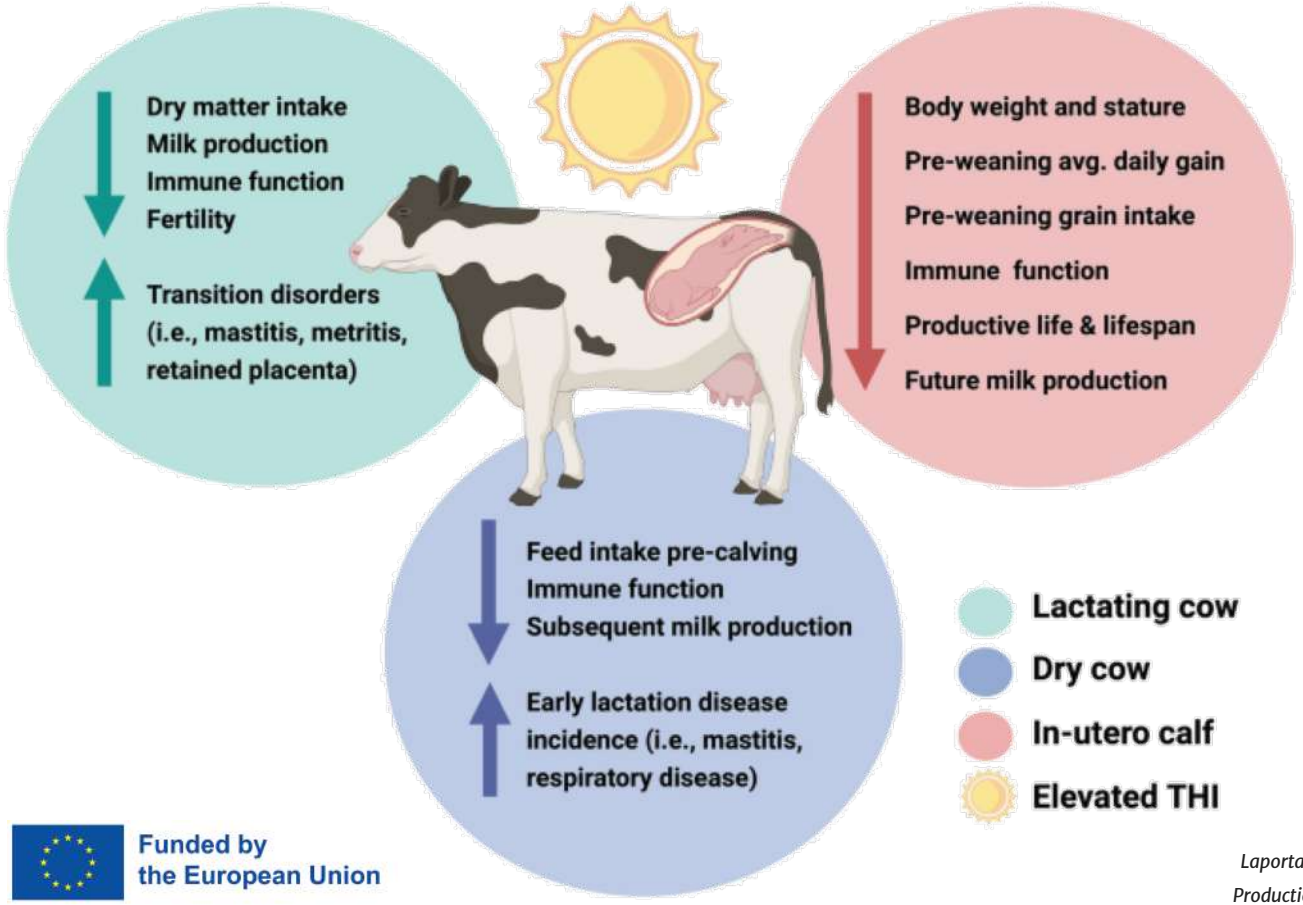
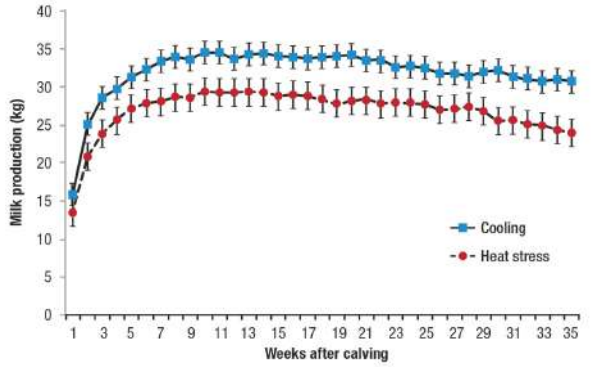
Climate change vs dairy production





Heifers born to cows in heat stress during the dry period produced less milk up to 35 weeks postpartum compared with those born to cows exposed to cooling.

Source: https://www.agproud.com/articles/59804-more-than-milk-production-long-term-effects-of-heat-stress

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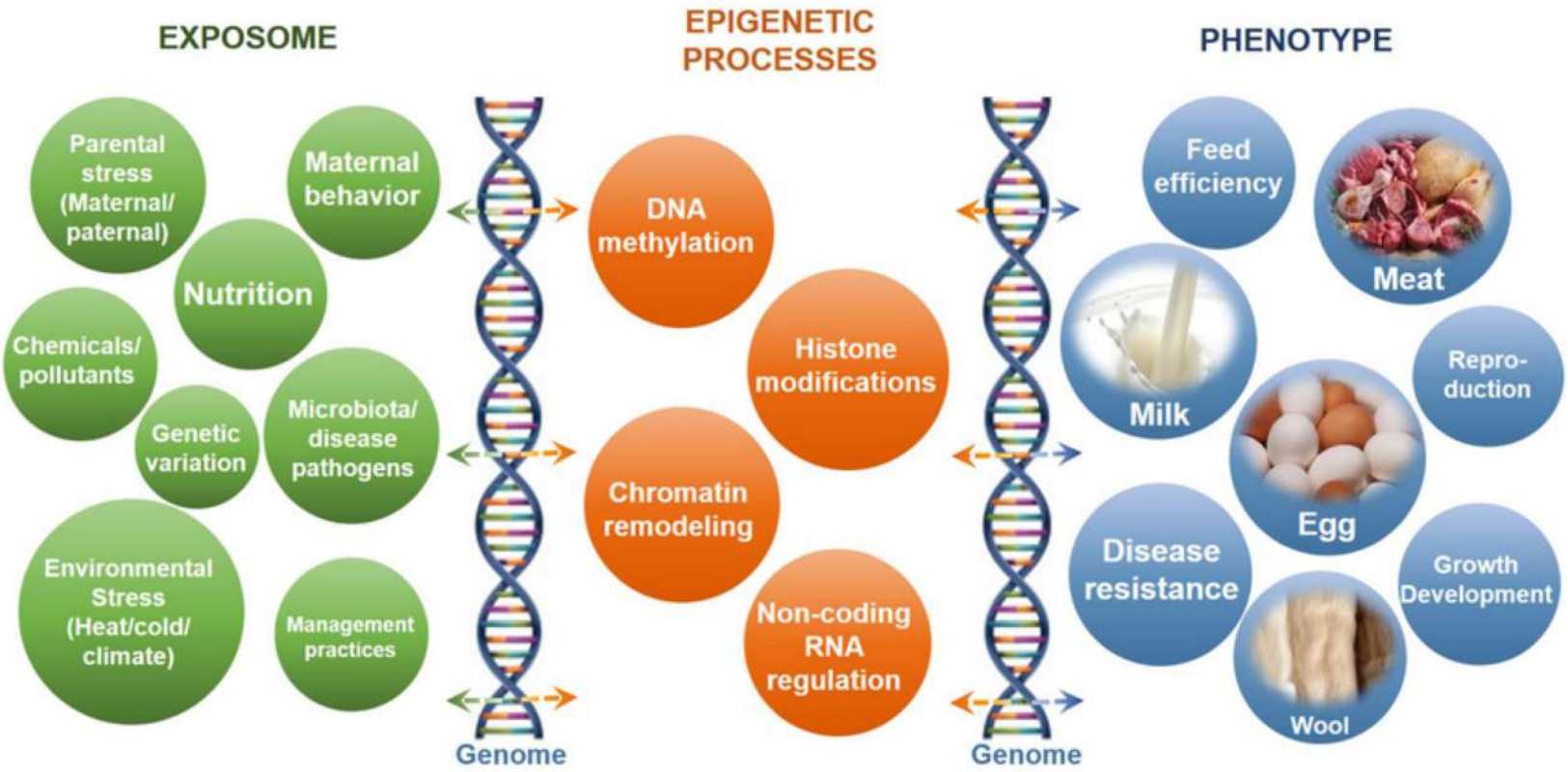
Laporta, J., Skibiel, A.L. (2024). Heat Stress in Lactating and Non-lactating Dairy Cows. In: Gross, J.J. (eds) Production Diseases in Farm Animals. Springer, Cham. https://doi.org/10.1007/978-3-031-51788-4_20

Why study epigenetics?



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Wang M, Ibeagha-Awemu EM. Impacts of Epigenetic Processes on the Health and Productivity of Livestock. Front Genet. 2021 Feb 23;11:613636. doi: 10.3389/fgene.2020.613636. PMID: 33708235; PMCID: PMC7942785.

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Can we use epigenetics to monitor environment and improve livestock resilience?

We need a tool for large-cohort **epi**genotyping…

bioRxiv THE PREPRINT SERVER FOR BIOLOGY

Dr. Valentin Costes

ELIANCE

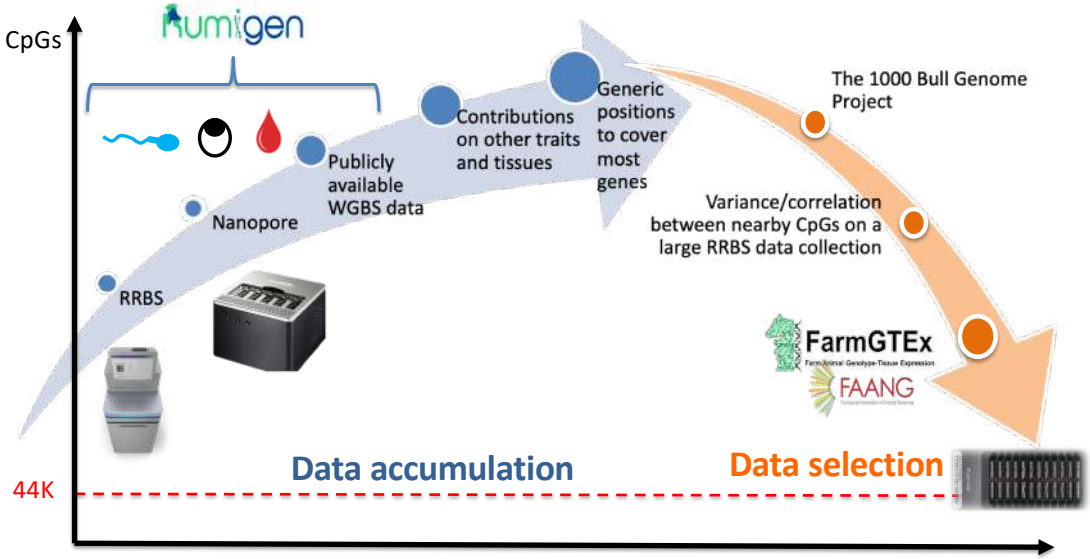
Dr. Helene Kiefer

INRAE

The RUMIGEN EpiChip: a versatile, medium density DNA methylation Beadchip for large scale population studies in cattle

Valentin Costes, Adrian Lopez-Catalina, Amrita Raja Ravi Shankar, Gabriel Costa Monteiro Moreira, Sophie Martel, Ludivine Liétar, Carmen Garcia Alba, Javier L. Viana, Aurélie Chaulot-Talmon, Francesca Ali, Christine Couldrey, Mekki Boussaha, Sébastien Fritz, Eveline M. Ibeagha-Awemu, Nathalie Bissonnette, Jess Powell, Pau Navarro, Alex Caulton, Kumiko Takeda, Eiji Kobayashi, Gilles Foucras, Daniel Rico, Chrystelle Le Danvic, Laurent Schibler, Zexi Cai, Goutam Sahana, Shannon Clarke, Hélène Jammes, Oscar Gonzalez-Recio, Clotilde Patry, Hélène Kiefer

doi: https://doi.org/10.64898/2025.12.19.695474



Publicly available Illumina!!

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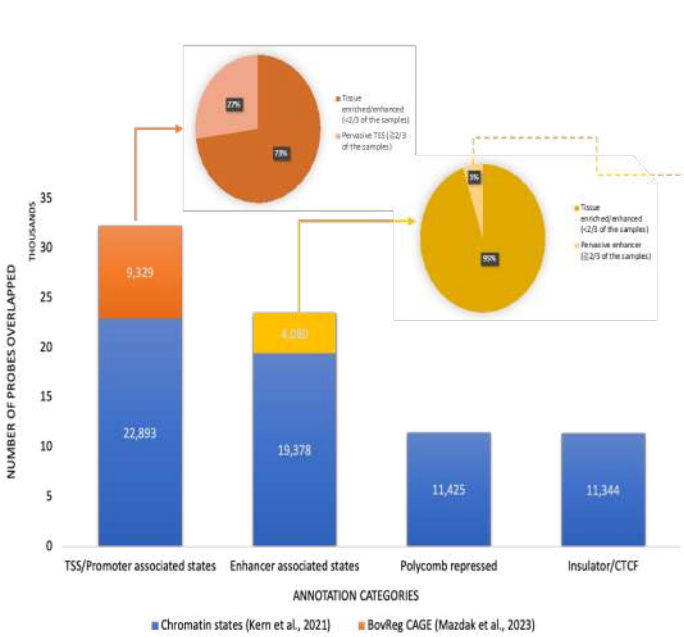

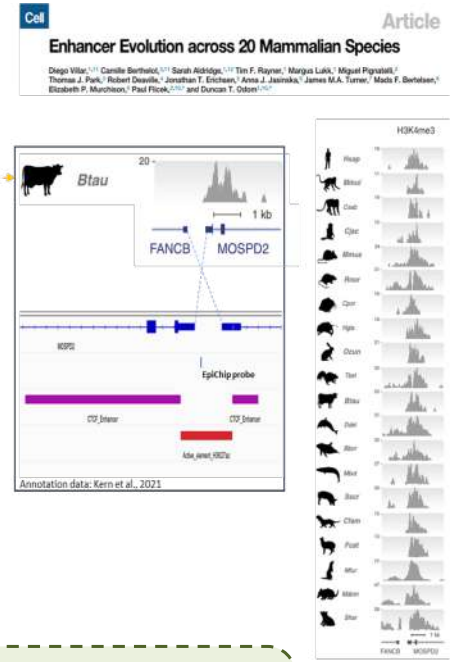

- Kern et al., 2021: 10.1038/s41467-021-22100-8 (**8** tissue types; ChIP-Seq data)
- Mazdak et al., 2023: 10.1093/g3journal/jkad108 (**24** tissue types; CAGE experiment)

Publicly available Illumina!!

CpGs on the EpiChip represent regulatory regions, including both tissue-specific and ubiquitous elements.

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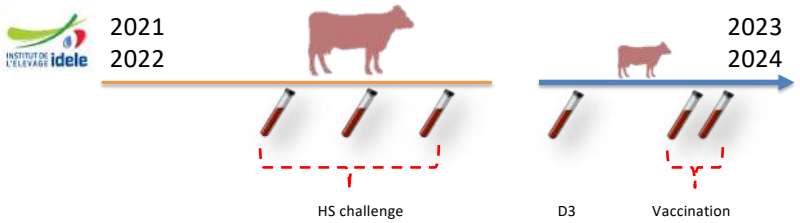
Heat Stress Tolerance in Dairy Cows



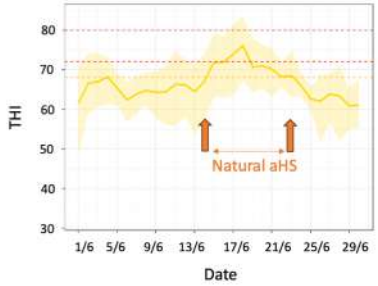
Description of the impacts of acute heat stress on Dairy cows[1]

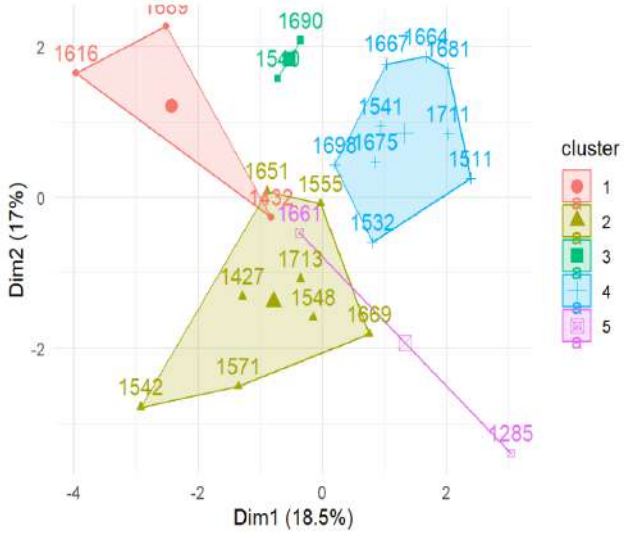
- Multi-criteria thermotolerance phenotyping
- Multi-variate analysis


Elise Vanbergue
IDELE


Mickaël Brochard
IDELE

Ranges of THI (av. 24h)	Nb of days
0-67 – no HS	20
68-72 – slight HS	8
72-80 – moderate HS	2





	CI 1 (n=3)	CI 2 (n=8)	CI 3 (n=3)	CI 4 (n=9)	CI5 (n=2)
Ruminal T °C	+0,35	+0,35	+0,4	+0,25	+0,20
Indicator	**CI 1 (n=3)**	**CI 2 (n=8)**	**CI 3 (n=3)**	**CI4 (n=9)**	**CI5 (n=2)**
Resting (min/d)	=	-36	=	-36	-48
Panting (min/d)	+96	+132	+34	+72	+84
MY (kg/d)	-1,8	- 1,2	- 0,3	- 0,2	- 1,8
Ingestion (min/d)	- 96	-60	-24	-48	-48
Rumination (min/d)	- 24	-48	-48	=	- 12
Veal Weight	=	=	=	=	=
IGG colostrum	=	=	--	=	=
Cortisol	=	=	=	=	++

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Elise Vanbergue, Laure Brun-Lafleur, Michel Prezelin, Benoit Vaillant, Valérie David, Mickael Brochard

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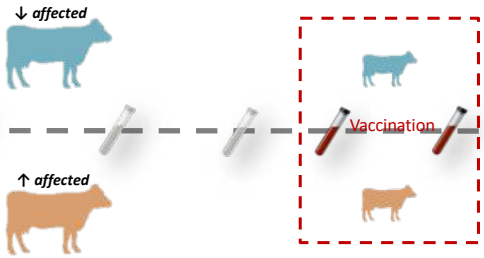
Heat Stress Tolerance in Dairy Cows

Rumigen

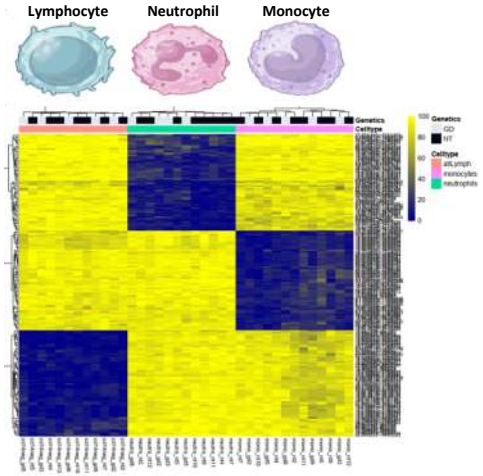
~44k CpGs

EpiChip
Array-based method



EpiChip results

- *Prenatal (or early-life) programming of the immune system*
- *More reactive or altered immune response to vaccination*
- *A different immunological strategy or sensitivity to challenges*

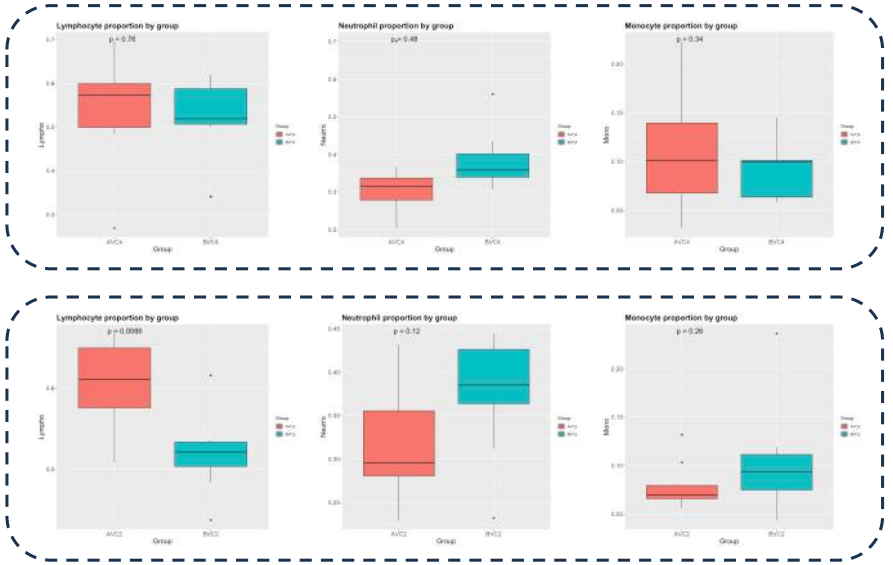


Heifers from ↓ affected cows

(before vs after vaccination)

Heifers from ↑ affected cows

(before vs after vaccination)



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G. Costa Monteiro Moreira, M. Joigner, E. Vanbergue, L. Brun-Lafleur, M. Prezelin, B. Vaillant, V. David, M. Brochard, H. Jammes

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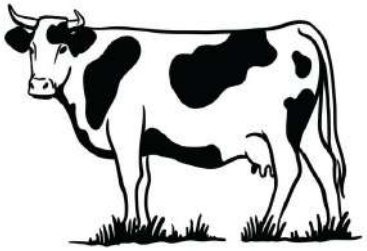
Epigenome–Environments Associations in Holstein Cows

World Congress on Genetics Applied to Livestock Production
Madison, Wisconsin
12-17 July 2026

Alexandre Asset

CpGs
(epi)genotypes

Blood methylation
EpiChip

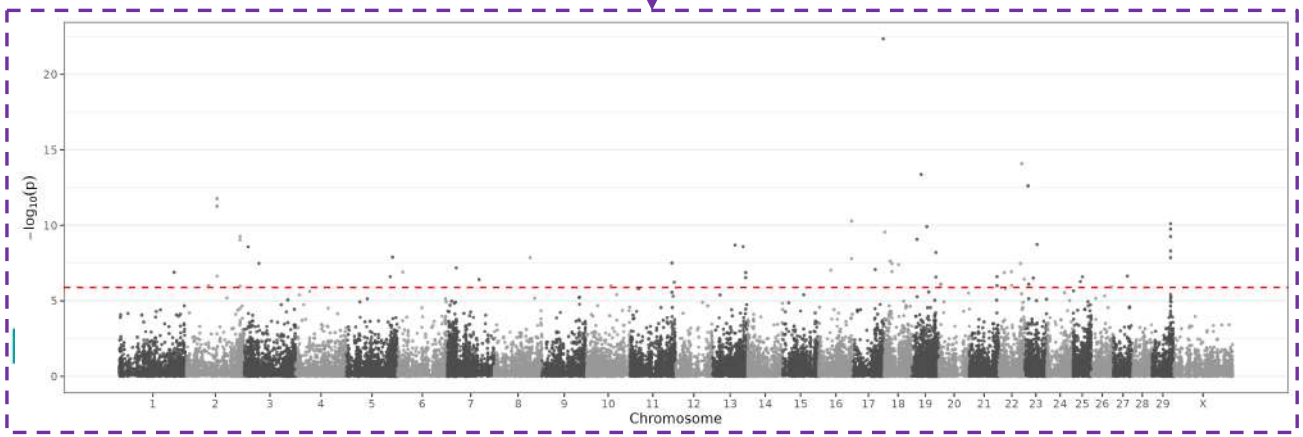


4,608 Holstein cows with EpiChip methylation data

Born between 2013 and 2023 & from 261 French farms

Husbandry practices	Number of cows	Number of Cps associated
Grazing duration	2,945	1,121
Type of ration	2,945	690
Target age at first calving	2,945	465
Dry-off management	2,945	61

DNA methylation associated with agronomic phenotypes in dairy cattle, as well as with several farming practices



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A. Asset, V. Costes, G. Potier, M-P. Sanchez, F. Besnard, C. Fouere, S. Fritz, C. Patry, G. Foucras, H. Jammes, C. Richard, V. Gelin, L. Le Berre, A. De Paula Reis, D. Boichard, C. Le Danvic, G. Costa Monteiro Moreira, D. Makowski and H. Kiefer

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DNA Methylation Variation in Jersey Cows Across Contrasting Environments



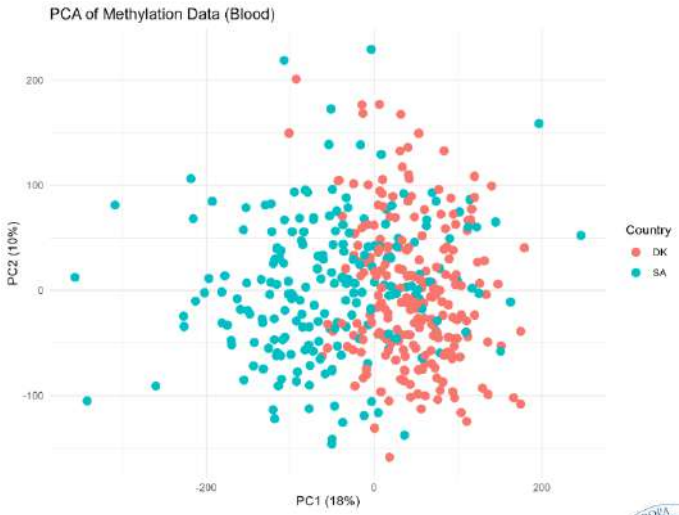
G. Sahana
AARHUS UNIVERSITY


Z. Cai
AARHUS UNIVERSITY

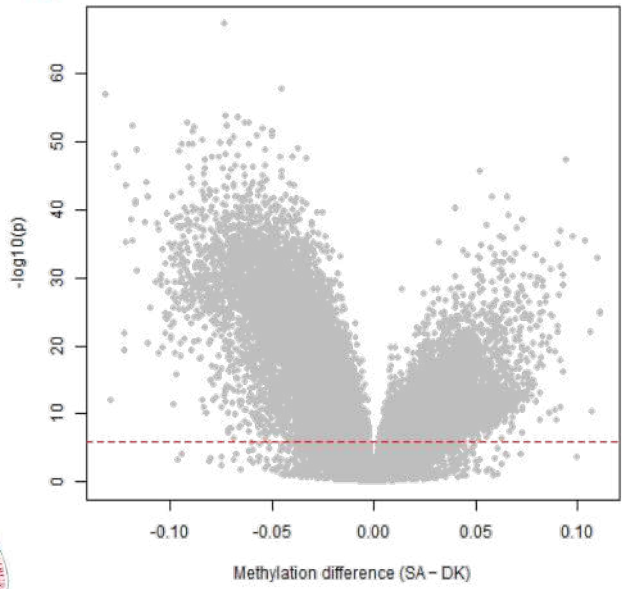
440 Jersey cows with EpiChip methylation data

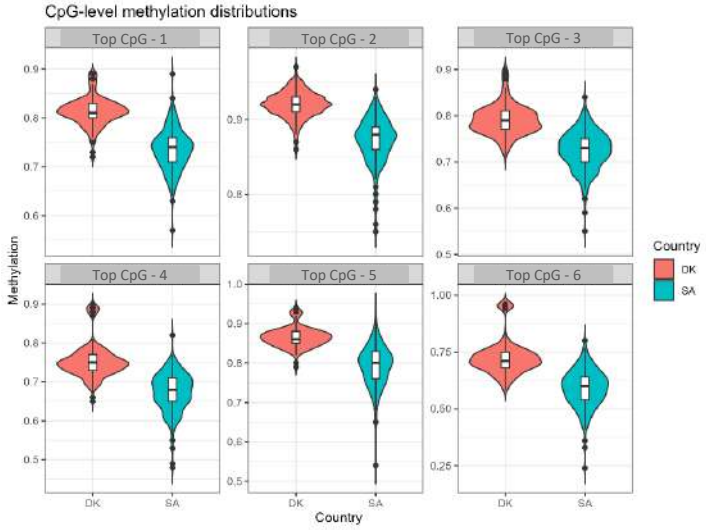
223 cows from Denmark and 217 cows from South Africa; daughters of 23 Danish Jersey bulls

Mild but clear separation between **Danish** and **South African** cows



Methylation levels were higher in **Danish** cows
(representation of both hypo- and hypermethylated CpGs)





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G. Sahana, V. Costes, E. Karaman, R. B. Stephensen, C. Patry, M. S. Lund, H. Kiefer, Z. Cai

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The RUMIGEN EpiChip as a sensor of environment and management in dairy systems

- **DNA methylation links environment, physiology, and performance**
  - → additional layer complementing genetics
- **Farming practices shape the bovine methylome**
  - → signal of environmental and management effects
- **Potential to enrich breeding strategies**
  - → biomarkers for adaptation, resilience, and management response
- **Relevance for the livestock sector**
  - → supports more precise, environment-aware selection tools
  - → aligns with sustainability, welfare, and efficiency goals
- **EU perspective (medium-long term)**
  - → contributes to climate adaptation strategies
  - → enables data-driven innovation in breeding and farming systems

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The RUMIGEN EpiChip: integration of epigenetics into dairy cow selection, Marie-Pierre Sanchez (INRAE)

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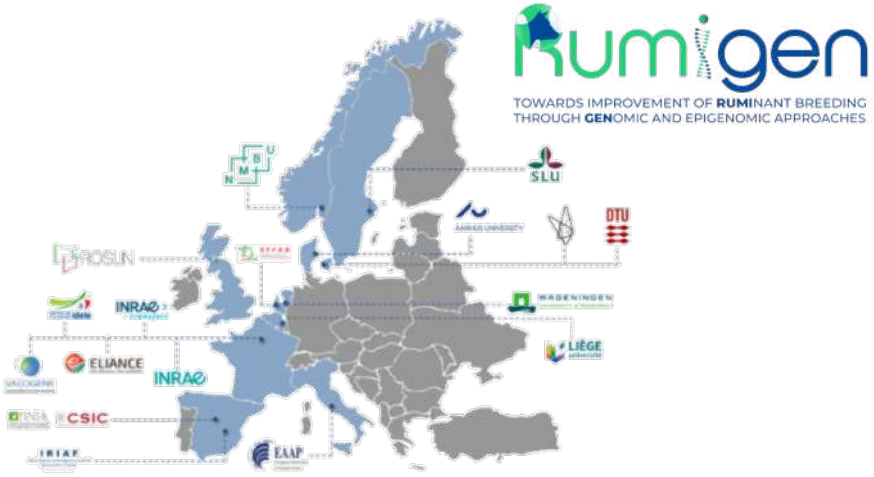
Breeding the Future

Genomics, Epigenomics & Societal Acceptability for Sustainability in Livestock

THANK YOU



TOWARDS IMPROVEMENT OF **RUMI**NANT BREEDING THROUGH **GEN**OMIC AND EPIGENOMIC APPROACHES

GENOME AND EPIGENOME ENABLED BREEDING IN MONOGASTRICS

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