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Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

NODES Nord Ovest Digitale E Sostenibile

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INDIVIDUAL RESPONSE OF DAIRY CATTLE TO HEAT WAVES: PHENOTYPIC AND GENOTYPIC CHARACTERIZATION

R. CRESCI[1,2], A. CESARANI[2], N.P.P. MACCIOTTA[2], A.S. ATZORI[2]

[1] University School for Advanced Studies IUSS Pavia, Pavia, Italy

[2] Department of Agricultural Sciences, University of Sassari, Sassari, Italy

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PhD IN SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE

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INTRODUCTION

Heat wave effects

Climate change is expected to raise average temperatures and increase the occurrence and severity of heat waves (**HW;** IPCC, 2021).

HWs have **negative effects** on the health and **performance** of dairy cows (Vitali et al., 2015; Cresci and Atzori, 2022; Cresci et al., 2023).

Animal response

Milk yield lost (**MYl**): → Primiparous cows are less susceptible to heat stress compared to multiparous cows, with a production drop of 1.16 kg/d and 1.27 kg/d, respectively (Bernabucci et al., 2014);

Milk yield recovered (**MYr**): → Further reduction of 1.2 kg/d during thermoneutral recovery phase (Ominski et al., 2002);

Stress length (**SL**): → Average duration of heat stress periods was estimated to be 5.5 days (Andrè et al., 2011).

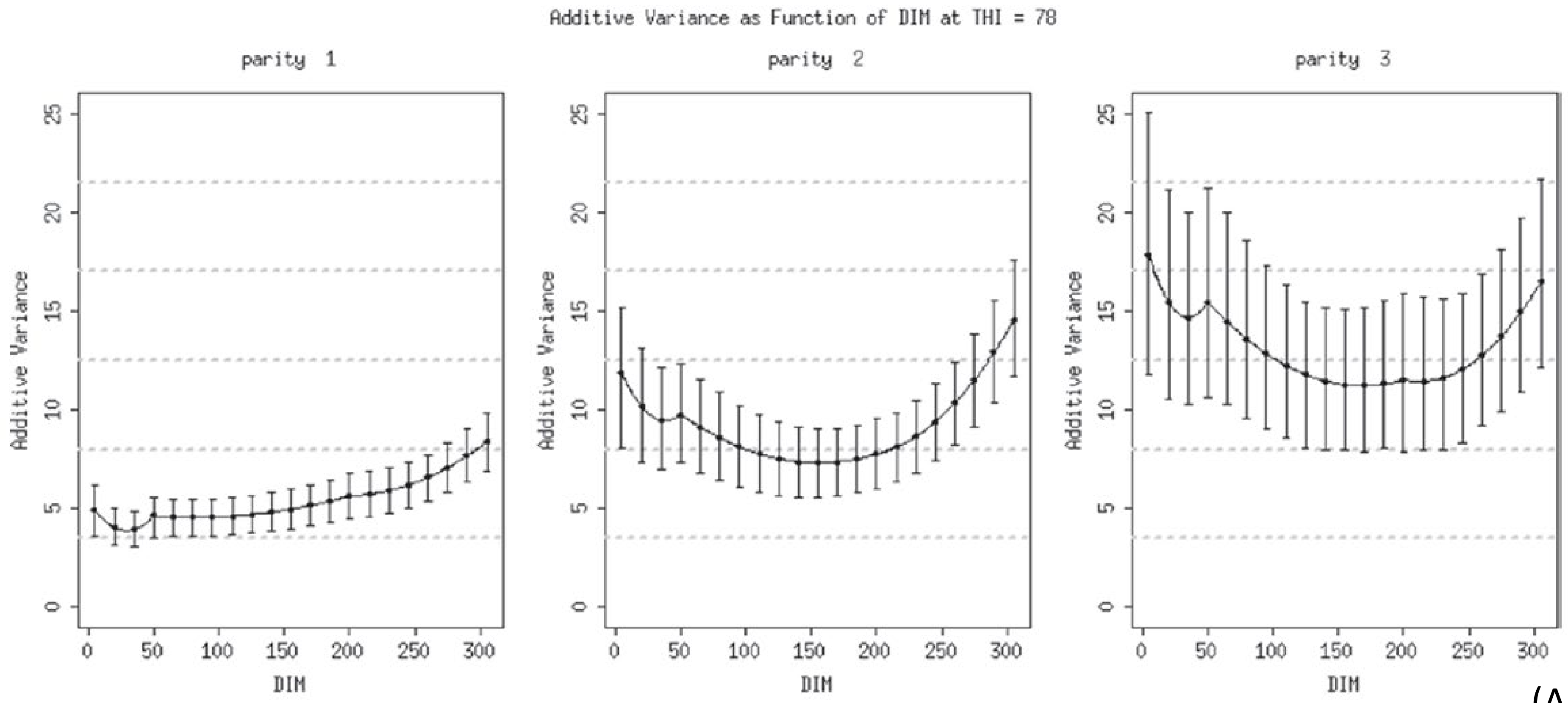
INTRODUCTION

Genotypic animal response

Genetic selection aimed at increasing milk production has, over time, led to a **reduction in heat tolerance** in dairy cows (Ravagnolo and Misztal, 2000; Aguilar et al., 2009).

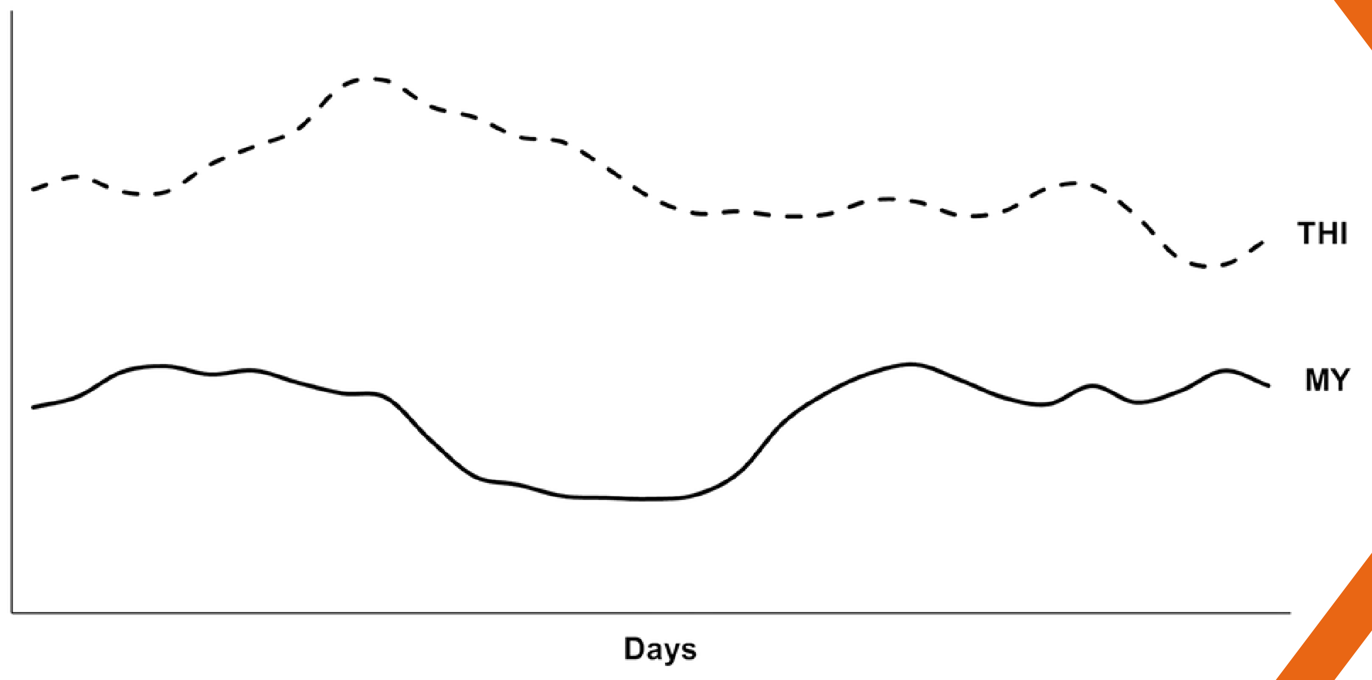
Heat resistance traits like rectal temperature and respiratory rate shown **low heritability**, with h^2 values of 0.06-0.17 (Dikmen et al., 2012; Luo et al., 2020).

Misztal (2017) noted that the **genetic variance** for heat stress increases with parity, likely due to rising sensitivity and milk production.



(Aguilar et al., 2009)

OBJECTIVE



This study aimed at evaluating the impact of heat stress exposure on milk production patterns in terms of milk decline and recovery, and length of stress.

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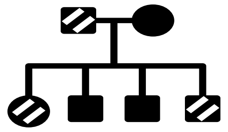
MATERIAL AND METHODS

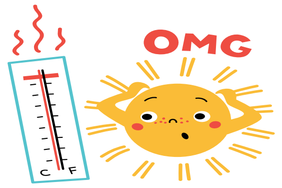
Data

763 phenotypes
from 523 cows

697 genotypes
from 700 cows



5218 pedigree



2 HWs
August 2022 – July 2023

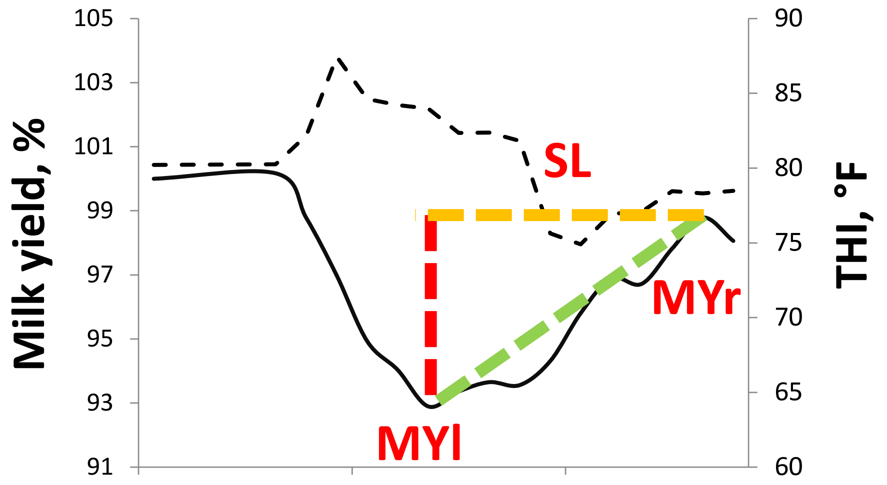
Parameters estimation

3 parameters of heat stress resistance were identified and calculated using a **linear regression model**, with farm and parity as predictor variables:

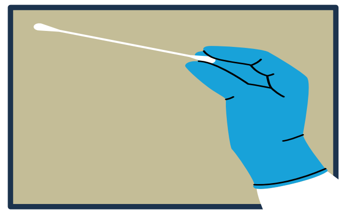
Milk yield lost (MYl)
the minimum MY value recorded in the 10 days following the HW, expressed as a percentage relative to the pre-HW production

Milk yield recovered (MYr)
the MY equal to or greater than the pre-HW recorded after the minimum

Stress length (SL)
the number of days between the MYl and MYr



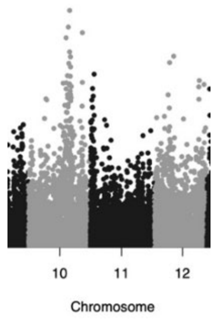
Genetic Analysis



Genotyping
Medium density SNP bead chip

h^2

Heritability
Estimated for the 3 traits



GWAS
identify potential genetic markers

Sample collection and genotyping in collaboration with the Sardinia Region Breeders' Association (AARS) and the National Friesian, Brown and Jersey Breeders' Association (ANAFIBJ)

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RESULTS Parameters – Primiparous vs Multiparous cows

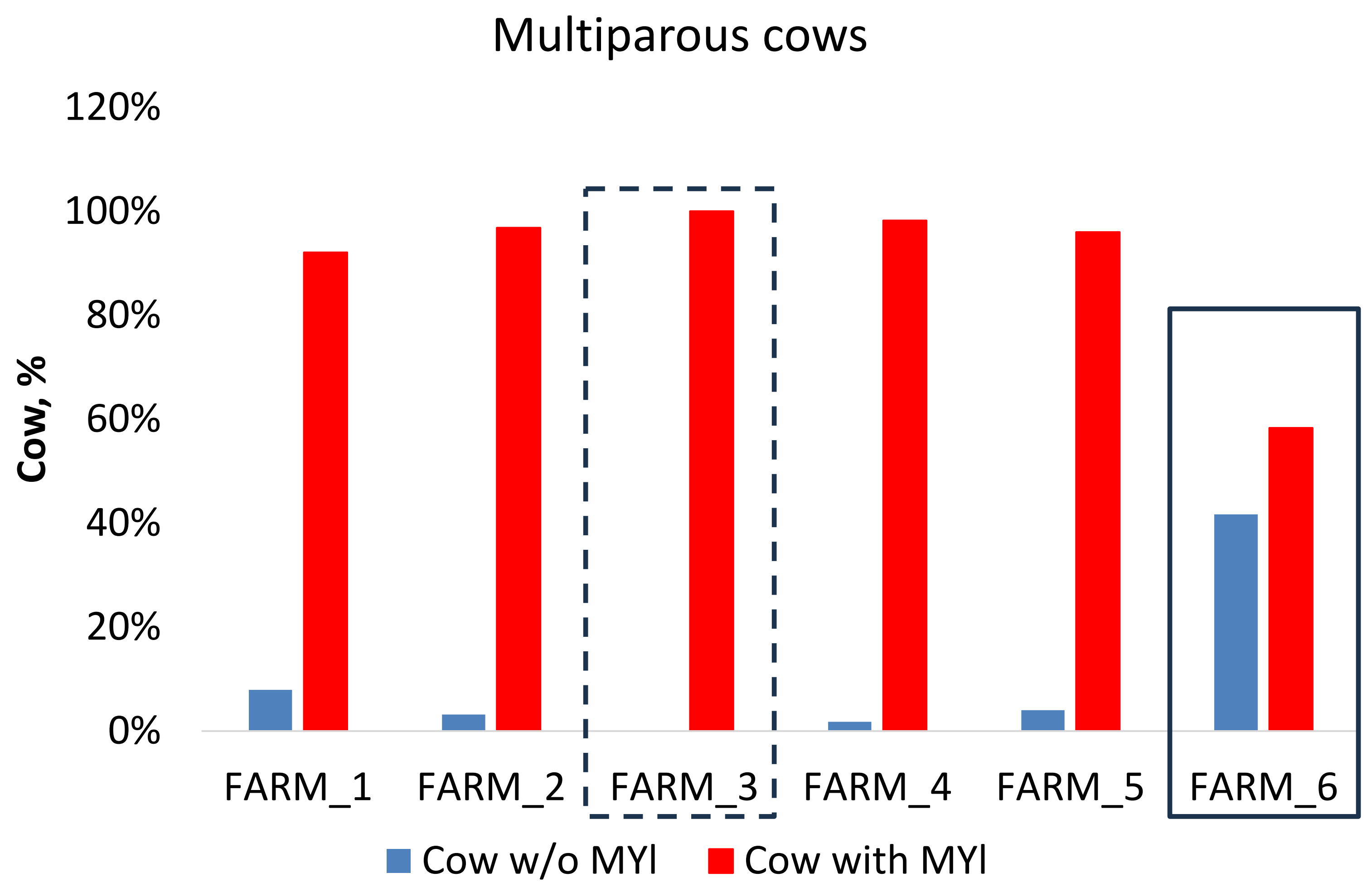
	Primiparous	Multiparous
Milk yield, kg/d	32.97±7.98	37.71±11.67
Milk yield lost (MYl), %	-21.21±13.86	-23.27±16.82
Milk yield recovered (MYr), %	14.19±12.98	15.23±14.72
Stress length (SL), days	2.07±2.7	2.21±3.56

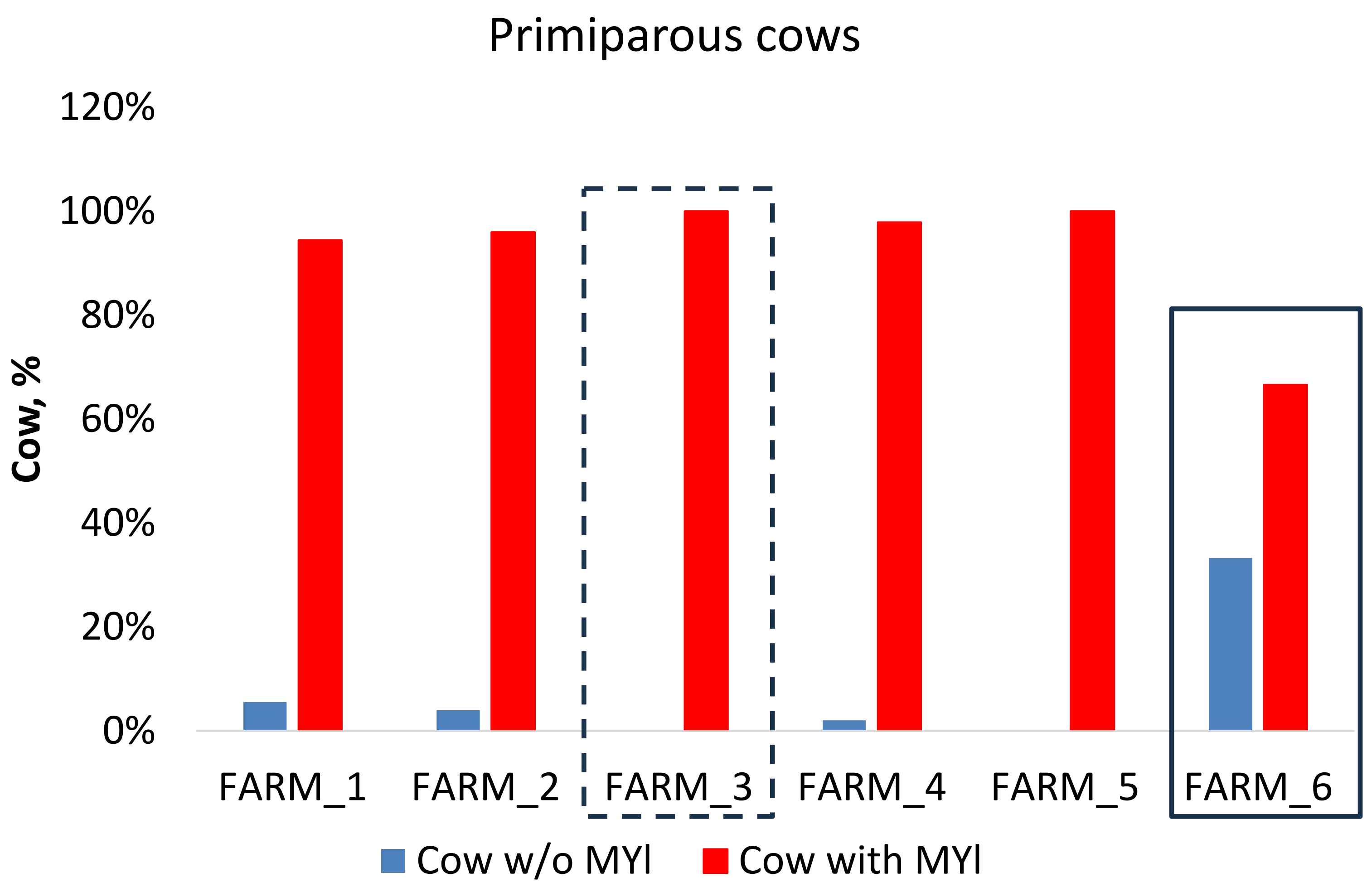
NO STATISTICALLY SIGNIFICANT DIFFERENCE!

Multiparous cows experienced a **greater loss** of milk than primiparous cows

The **recovery dynamics** are consistent across different parity groups

RESULTS Parameters – Multiparous vs Primiparous





THE PRODUCTION **DECLINE VARIES MARKEDLY** BETWEEN FARMS AND ANIMAL CATEGORIES

On average **4.8%** of cows showed **no decline** out of the total herd

4.0% of primiparous cows **5.2%** of multiparous cows

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RESULTS Heritability and Reapitability

	h^{2*}	r^{2*}
Milk yield lost (MYl)	0.08±0.05	0.15±0.05
Milk yield recovered (MYr)	0.07±0.04	0.12±0.05
Stress length (SL)	0.04±0.03	0.11±0.05

*h^2 = heritability, r^2 = reapitability

BOTH VALUES FOR THE THREE TRAITS WERE FOUND TO BE LOW

SL showed the **lowest estimated values** of h^2 and r^2

MYl and MYr had values like those found for functional and/or health traits already under selection in dairy cows.

LOW HERITABILITY MEANS THAT THE OBSERVED VARIABILITY IS MOSTLY DUE TO ENVIRONMENTAL FACTORS!

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RESULTS Genome Wide Association Studies

SNP[1]_ID	BTA*	bp	P-value	Lower bp	Upper bp	Gene	Function	Reference
BovineHD14000 10237	14	33418670	5.25E-06	33168670	33668670	SULF1	Regulation of protein sulfation	Gaddis et al., 2018
BovineHD14000 10237	14	33418670	5.25E-06	33168670	33668670	SLCO5A1	Transporter of organic molecules	Gaddis et al., 2018
BovineHD2300 011504	23	40064417	1.47E-05	39814417	40314417	NUP153	Nuclear organization and cystoskeletal architecture	Choudhary and Capuco, 2021
BovineHD23000 11504	23	40064417	1.47E-05	39814417	40314417	FAM8A1	Body structure and mineral content	Illa et al., 2021
BovineHD15000 16769	15	57246859	4.15E-07	56996859	57496859	ANO3	Milk production	Singh et al., 2020
BovineHD1500 016769	15	57246859	4.15E-07	56996859	57496859	SLC5A12	Glucose cotransporter	Ostrowska et al., 2015

MYl (2 SNP)

MYr (1 SNP)

SL (29 SNP)

[1]SNP = Single Nucleotide Polymorphism
*BTA = *Bos taurus* autosome

GENERAL CONCLUSION AND IMPLICATIONS

- Primiparous and multiparous cows exhibited **similar stress lengths**, but multiparous cows, which generally have higher milk production, showed a **greater loss in milk yield** during heat waves.
- Heritability estimates for the traits associated with heat stress response were low, suggesting **limited genetic variability** in heat stress resistance within the population studied.

IMPLICATIONS

Management Strategies:
The study underscores the need for **personalized cooling strategies** tailored to minimize milk losses in cows that are most susceptible to heat stress.

Genetic Selection:
The identification of **genetic markers** associated with better heat tolerance can be integrated into breeding programs.

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THANK YOU

FOR ATTENTION