The Genetic Transformation of the Italian Mediterranean Buffalo

Five Years of Progress and New Frontiers

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Presentation Overview

1. Background & Population Overview
2. Genomic Evaluation
3. New Selection Indices
4. Key Results & Accuracy Gains
5. Conclusions & Future Directions

A Globally Significant Breed

*The Italian Mediterranean Buffalo represents over **90%** of Europe's buffalo population and about **95%** of its buffalo milk. Mainly used to produce **Mozzarella di Bufala Campana PDO**.*

1,392,199

Registered buffaloes

326,089

Live buffalo heads

210,794

Morphological evaluations

74,914

DNA-certified animals

7,200

SNP-genotyped animals

182

AI-authorized bulls

From Genetics to Genomics

01

Until 2022

Pedigree BLUP

- *Pedigree and phenotypic*
- *Only family relationships*
- *No molecular information*
- *Limited accuracy for young animals*
- *Longer generation intervals*
- *Single-trait and multi-trait BLUP models*

02

From 2023

ssGBLUP Integration

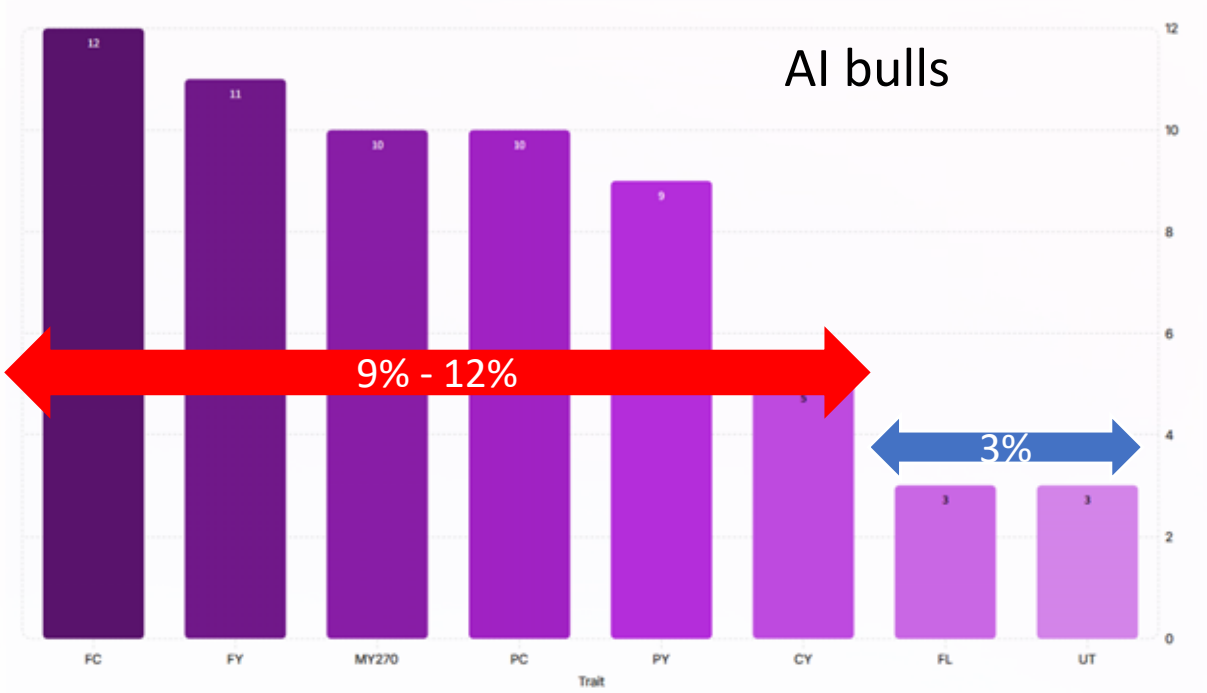
- *Pedigree + phenotypic + genomic*
- *One unified model*
- ***7,200** SNP-genotyped animals*
- ***+40%** improved EBV reliability*
- *It is more accurate and less biased.*

03

IBMI genomic

This improved us to publish the genomic IBMI Index for the first time.

Genomic Evaluation: Key Results



Accuracy Improvement: ssGBLUP vs BLUP (%)

J. Dairy Sci. 109:2771–2786
https://doi.org/10.3168/jds.2025-27102

Single-step genomic evaluation for production and type traits in the Italian Mediterranean buffalo

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Why ssGBLUP Wins

- ***Reduced bias***
  Breeding values move closer to unity.
- ***Better validation***
  Higher correlations for production traits.
- ***Works with sparse data***
  Performs well with incomplete pedigree depth.
- ***Earlier selection***
  Enables more confident decisions sooner.

ssGBLUP gives more reliable EBV across all traits

Genomic Selection Advantage

*Accuracy **the most important result of genomic selection for our program** - Genomic information provides detailed genetic insights beyond pedigree alone, enabling more accurate breeding value estimates.*

0.29

Accuracy Without Genotyping

Bulls without daughters/ phenotypic showed accuracy.

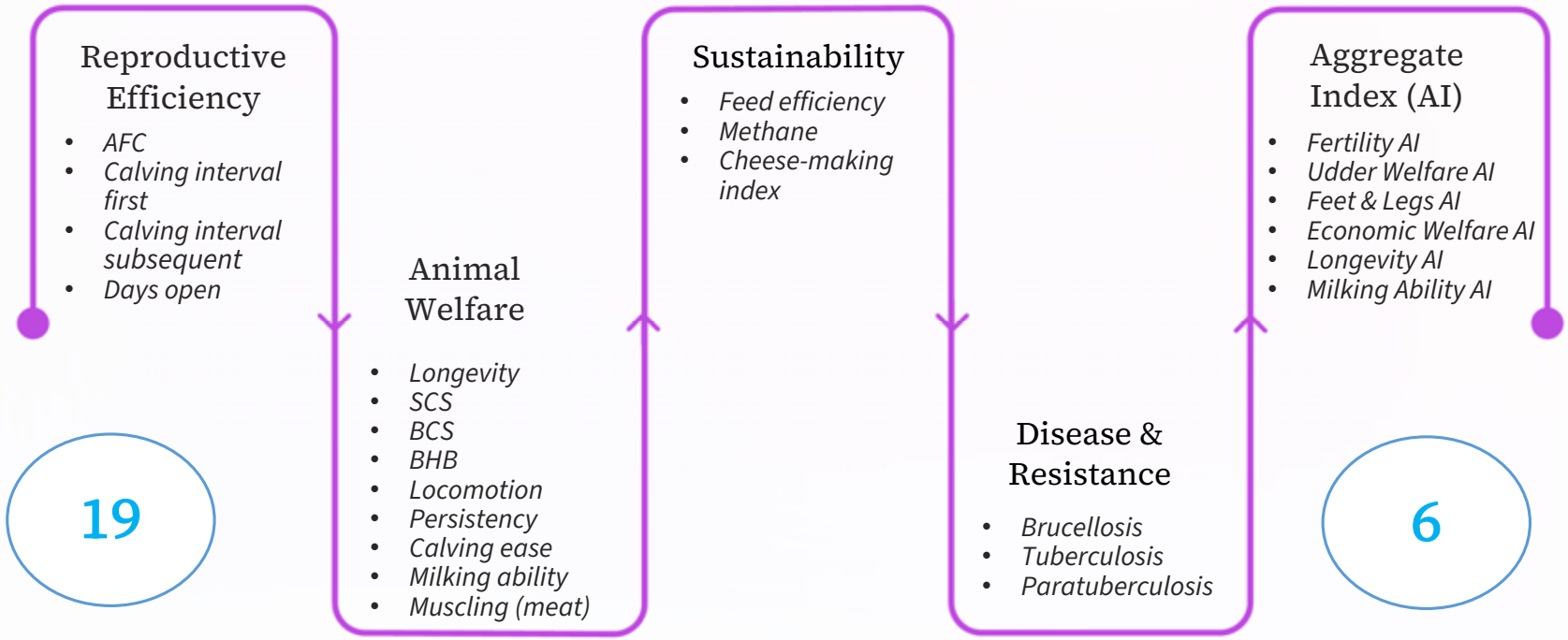
0.60

Accuracy With Genotyping

Accuracy after genotyping – more than double the precision for breeding decisions.
Before, we had to wait 6 years, after progeny testing. Now, with genomic information at 1 year of age or less.

Real benefit is the time - this reduction in generation interval accelerates genetic progress

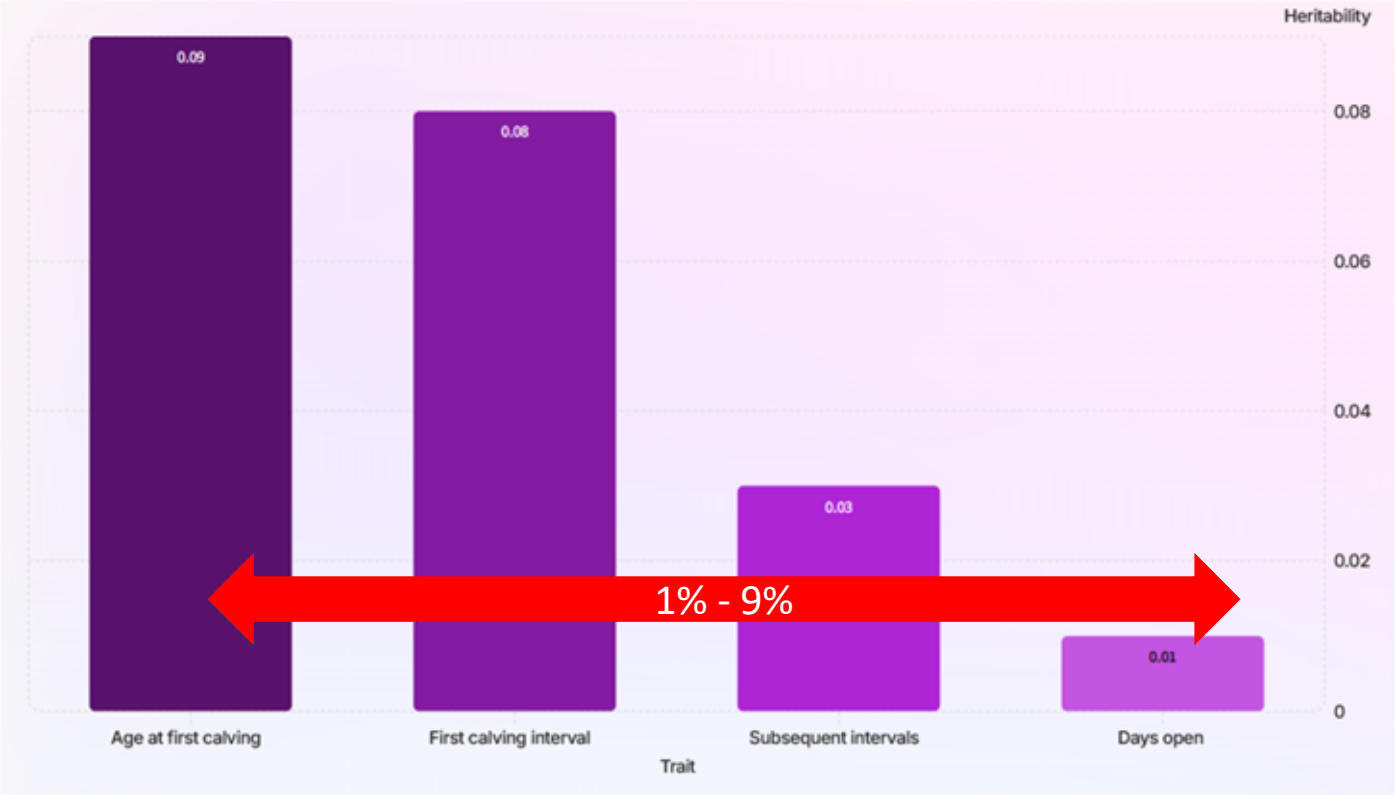
New Selection Indices (2021–2025)



*The breeding objective was structurally redefined across **five functional categories**, reflecting a paradigm shift from production-centered selection to a **multidimensional** genomic **framework**.*

Statistical models included single-trait linear, multi-trait, repeatability, and threshold models. Variance components estimated via REML or Bayesian Gibbs sampling.

Reproductive Efficiency

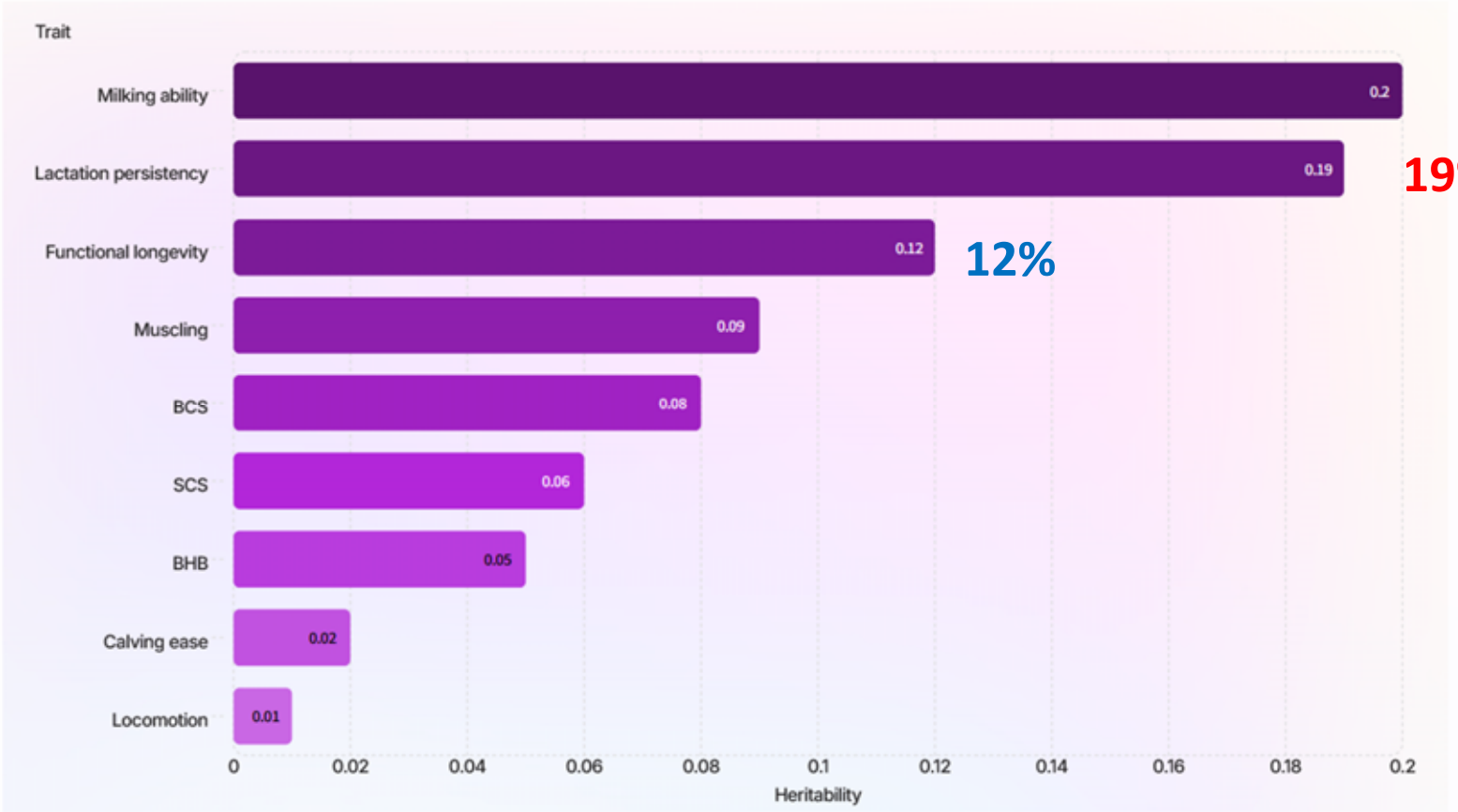


Influenced by farm management decisions and thus have large environmental component

Heritability estimates are low to moderate, ***0.09*** *(AFC),* ***0.08*** *(first calving interval),* ***0.03*** *(subsequent intervals),* ***0.01*** *(DO). However, even at these low levels, is possible to improve fertility. We can use multi-trait models and aggregated reproductive indices, reducing calving intervals and increasing farm profitability.*

Animal Welfare

Animal Welfare



20%

19%

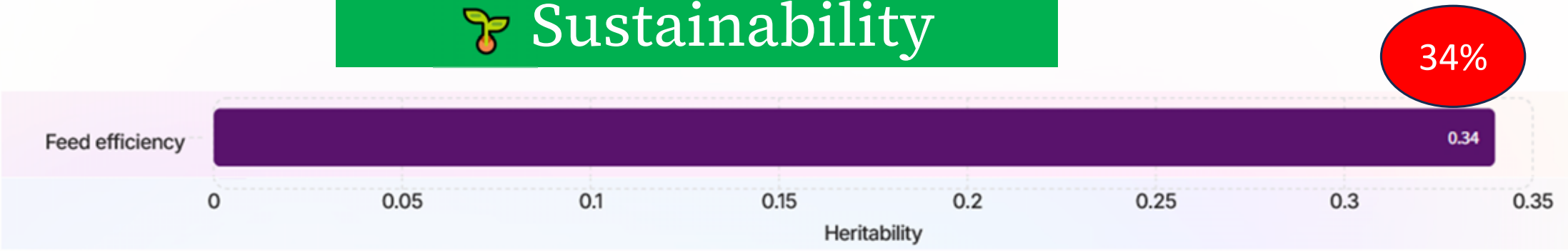
12%

*The welfare traits show moderate variation in heritability, with **milking ability (0.20)** and **lactation persistency (0.19)** leading the group.*

These estimates suggest meaningful selection opportunities for improving functional traits tied to health, productivity, and animal well-being.

Even traits with lower heritability, still offer useful selection opportunities in a multi-trait index

Sustainability



- ***Feed efficiency*** $h^2 = 0.34$ — *highest* — meaning *greater potential for direct selection*
- ***Methane*** *production is inversely related to feed efficiency*
  More efficient animals tend to produce less methane

Selecting for feed efficiency could also help reduce greenhouse gas emissions, linking genetic improvement with environmental goals

matter intake (DMI)

$$DMI = (91\,g * Metabolic\ Weight) + (0.27\,kg * kg\ ECM)$$

Neglia, G., Cotticelli, A., Vassetti, A. *et al.* Buffalo milk and rumen fluid metabolome are significantly affected by green feed. *Sci Rep* **13**, 1381 (2023). https://doi.org/10.1038/s41598-022-25491-w

Height / Width / Body Length, Stature, Width of Ilium / Ischium, BCS → Body weight

Disease Resistance & Resilience

Exploitable Genetic Variability

Including these traits in the breeding program allows us to:

- select animals that are genetically more resilient,
- reducing the need for veterinary treatments and antibiotic use

IMB is currently the **only** breed and species in Italy with developed indices for these diseases

Brucellosis

Heritability: **0.15**

Paratuberculosis

Heritability: **0.15**

Tuberculosis

Heritability: **0.07**

Five Years of Transformation — Key Achievements

Genomic Integration

ssGBLUP operational since 2023

Pedigree + phenotype + genotype

STR-to-SNP Imputation

Novel imputation pipeline

From STR markers to SNP arrays

Accuracy Gains

+3% to +12% across production and morphological traits

40% of the accuracy in young animals

19 New Indices + 6 Aggregate Index

Reproductive, animal welfare, climate change and farm sustainability

Global Leadership

One of the most advanced buffalo genetic programs worldwide

~8,000 Genotyped

Largest buffalo genomic dataset
Making the IMB genetic program the most advanced for this species

Conclusions

IMB program has undergone a true genetic revolution

1. Cost-effective and efficient genotyping - combining genomic tools

STR-from-SNP imputation ensuring parentage verification and reducing genotyping costs.

2. Faster genetic gain

Genomic selection reduced the generation interval from 6 to 1 year in young bulls, accelerating annual genetic progress.

3. More reliable EBV

The result is a more efficient, reliable, and sustainable breeding program.

4. Modern breeding leadership

Disease resistance, feed efficiency, and methane indices place the IMB program at the forefront of modern breeding.

It addresses climate change, sustainability, and animal welfare challenges.

5. Replicable model

Buffalo genomics model that can be replicated for other local dairy breeds around the world.

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