

Developing a genetic submodule in the Ruminant Farm Systems (RuFaS) model for enhanced whole-farm representation

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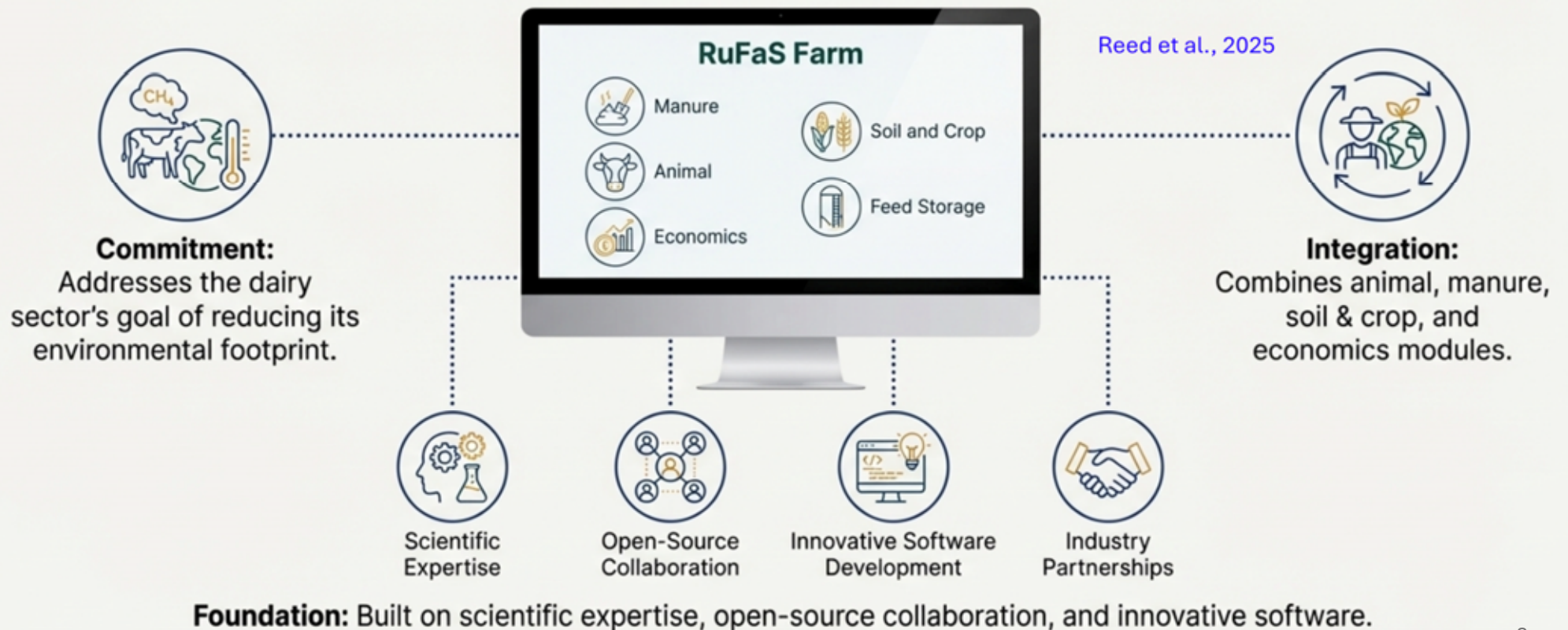


Victor E. Cabrera | ICAR 2026 | Verona, Italy



Introducing RuFaS: A Whole-Farm Simulation Platform

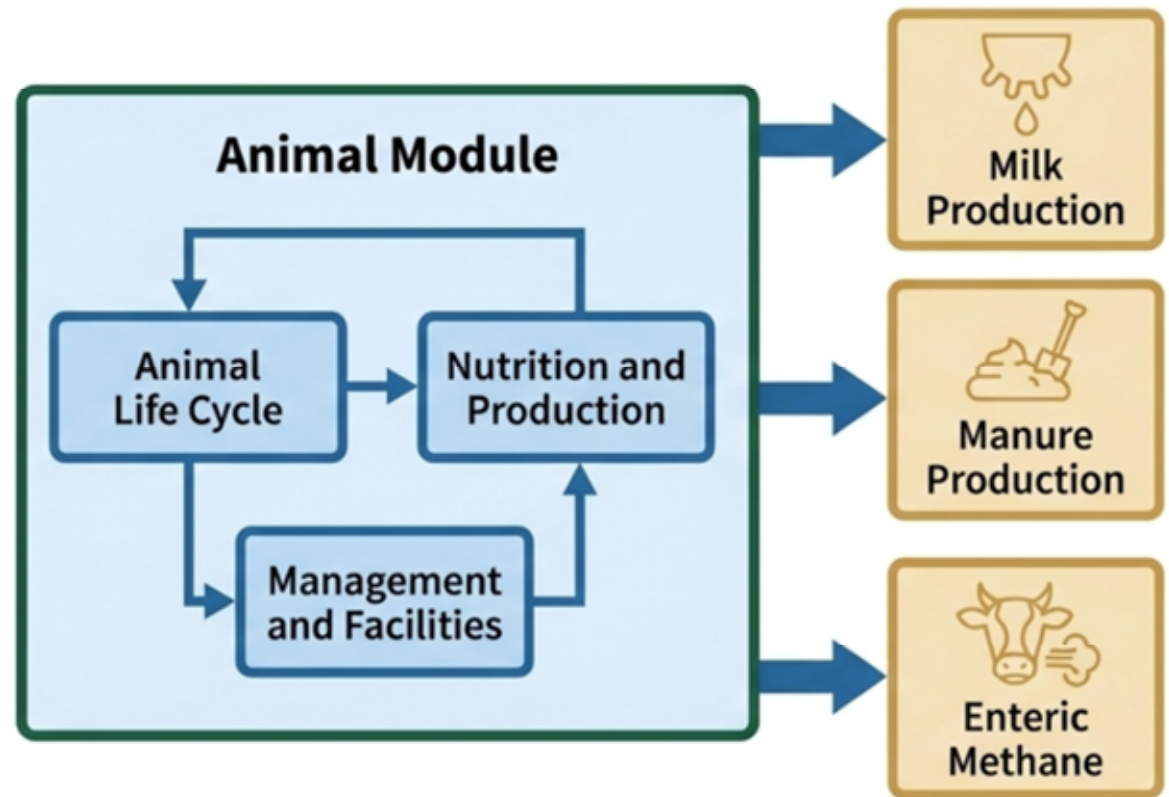
RuFaS is an open-source model that integrates the key functions of a dairy farm to simulate the real-world impact of management decisions.



A Closer Look: The Animal Module


The Animal Module simulates the life cycle, health, and productivity of dairy cattle at both the individual and herd level. It operates on a daily time step, capturing key events:

- ✓ Growth and Reproduction
- ✓ Lactation and Production
- ✓ Health and Disease
- ✓ Culling and Replacement



What's missing from the RuFaS Animal Module?

Today in RuFaS
no genetic identity



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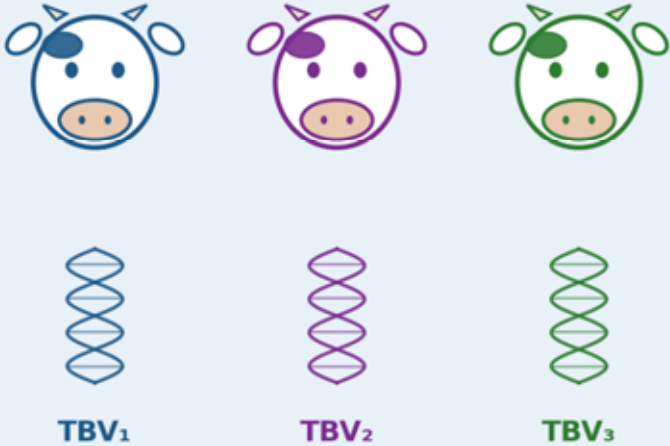
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Therefore, selection, voluntary culling, and beef-on-dairy strategies can't yet be evaluated in RuFaS



With genetic submodule
each animal carries a unique genetic identity



TBV₁

TBV₂

TBV₃

Our objectives:

Build a genetics-aware framework in RuFaS

1

Represent genetic merit

True and estimated
with realistic (co)variance

2

Express phenotypes

Trait performance shaped by
genetic merit, environmental
effects, and production
baselines

3

Model inheritance

Parental average
+ Mendelian sampling

4

Support ranking

Trait-based index for future
selection, mating, and culling
decisions

Prototype traits: fat yield & protein yield (305-d, kg)

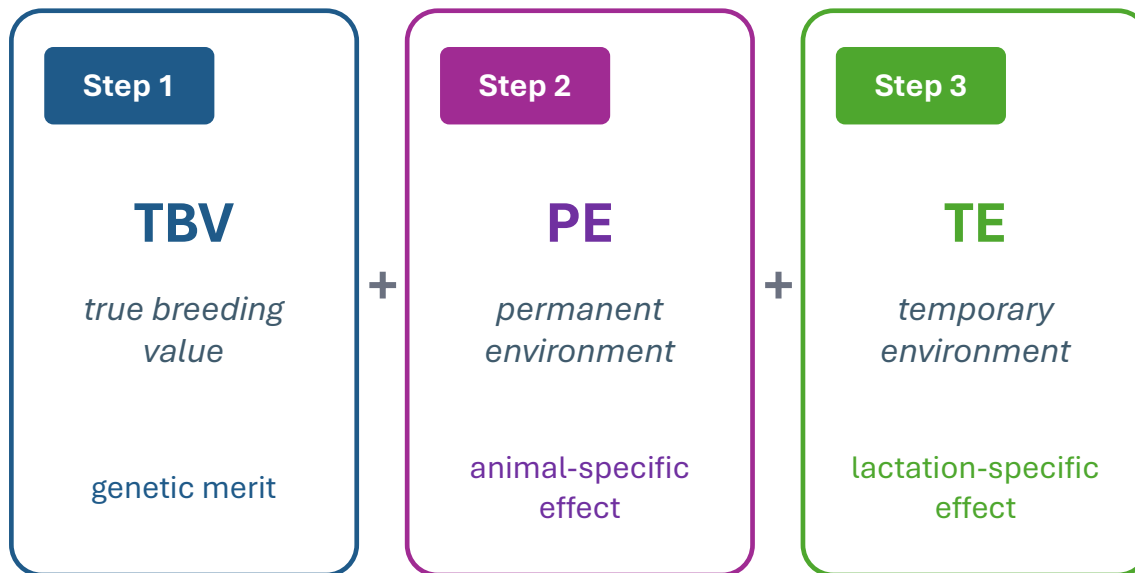
A genetic identity for every animal



TBV	true breeding value <i>underlying genetic merit</i>
EBV	estimated breeding value <i>decision-facing estimate</i>
PE	permanent env. effect <i>animal-specific lifetime effect</i>
TE	temporary env. effect <i>lactation-specific effect</i>
Index	ranking index <i>aggregates EBVs for future decisions</i>

Phenotype = genetics + environment

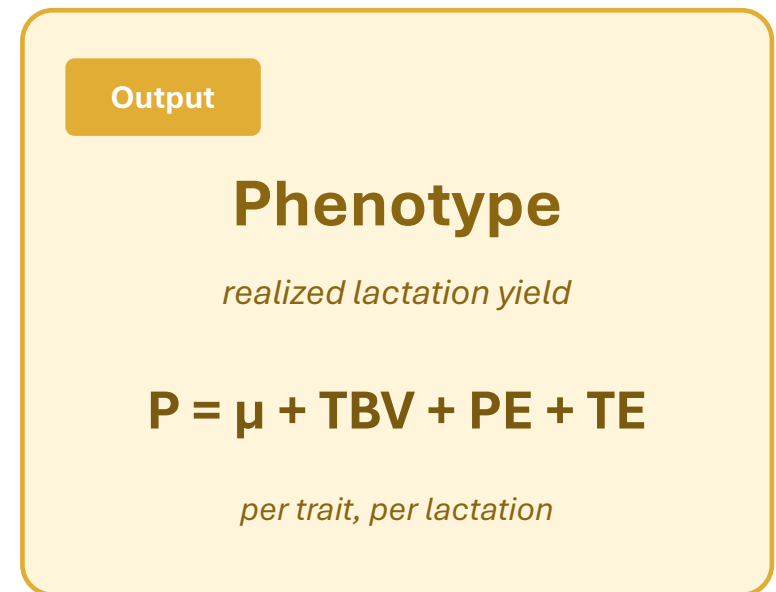
Sample trait components



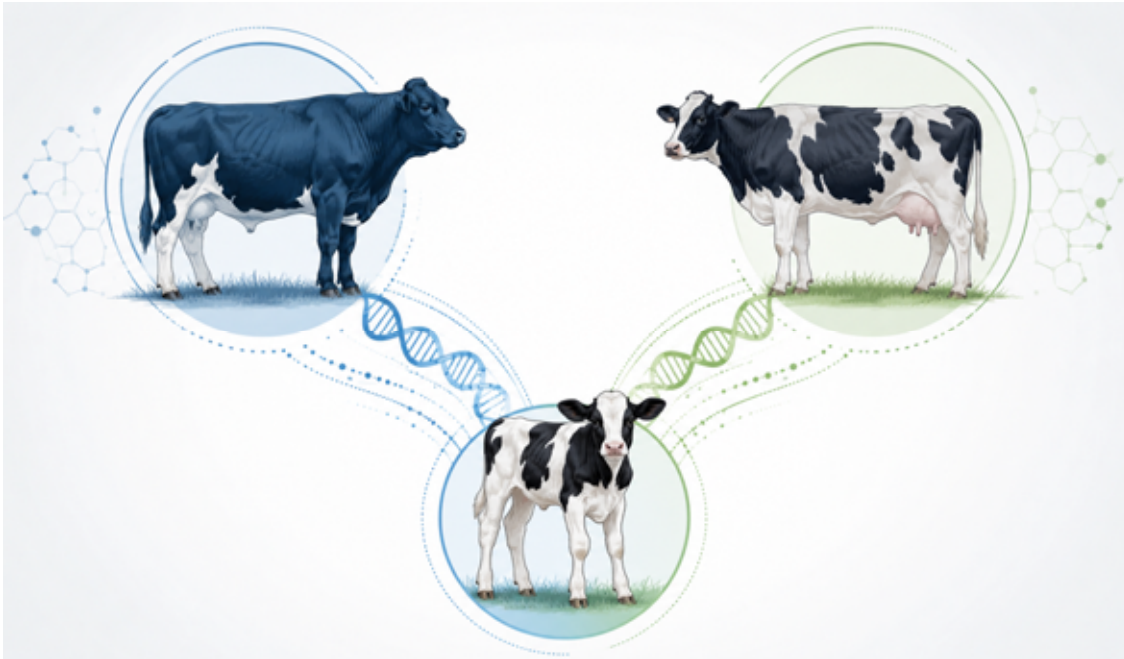
Set once at birth – lifetime “fingerprint”

Resampled each lactation
– year, weather noise

Construct realized phenotype



Genetic merit passes to the next generation



Calf TBV

Newborn calves' true breeding values

=

Parental average

Centers on the average of sire and dam genetic merit.

+

Mendelian sampling

Adds variation among offspring, even from the same parents.

EBVs are imperfect estimates of TBVs

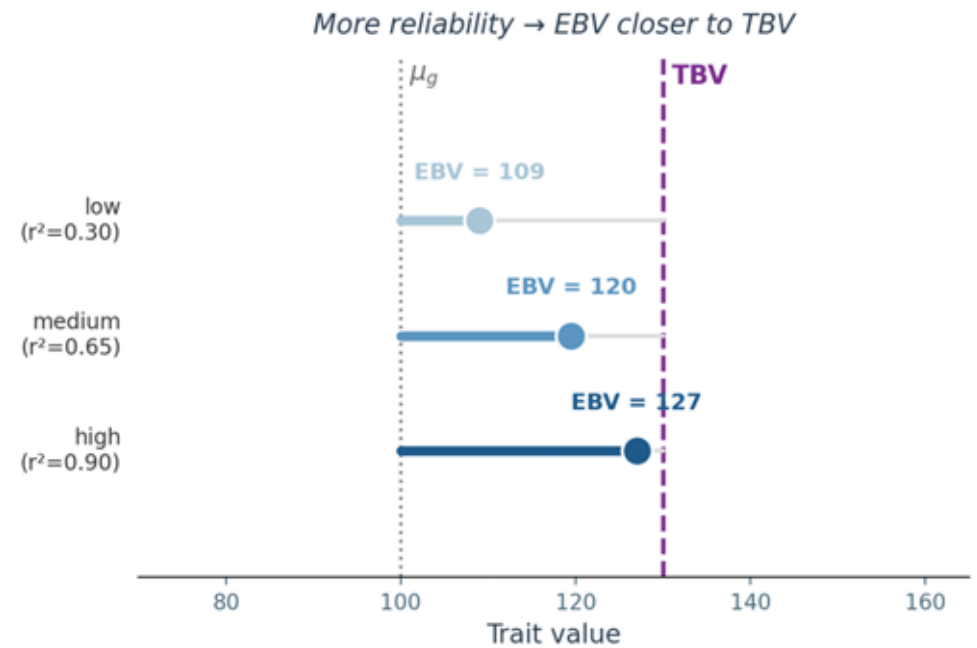
How EBV is generated

$$EBV = \mu_g + r^2(TBV - \mu_g)$$

- TBV true breeding value (unknown)
- μ_g group mean for life stage
- r^2 EBV reliability (0 - 1)

Low r^2 : EBV shrinks toward μ_g (We know the animal little)

High r^2 : EBV approaches TBV (We know the animal well)



Three layers — kept distinct



Key take-aways

RuFaS now has the genetic scaffolding needed to connect inherited merit to phenotypes and future management decisions.

What was built

- Animal-level TBV and EBV
- Permanent and temporary environment
- Trait-specific phenotypes
- Ranking index

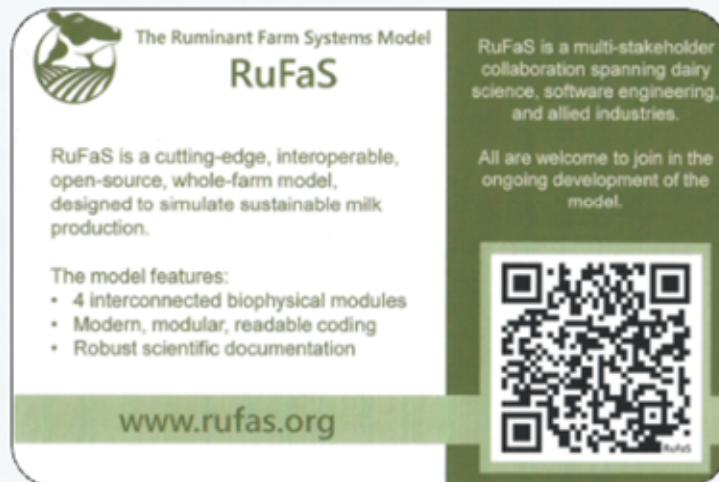
What it enables next

- Selection and mating scenarios
- Voluntary replacement strategies
- Beef-on-dairy allocation studies
- Expanded multi-trait breeding objectives

Contribution: infrastructure first — scenario evaluation comes next.

An Invitation to Collaborate

RuFaS is an open-source platform designed to accelerate collaborative research and shape the future of sustainable dairy.



We invite you to:

- **Explore** RuFaS as a tool for your research.
- **Contribute** to model development.
- **Engage** in a shared effort to advance dairy systems science.

github.com/RuminantFarmSystems/RuFaS



Cornell University

