Estimation of Genetic Parameters for Lactation Persistency and Productive Maturity in the Italian Brown Swiss Breed

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The Imperative: Beyond Peak Yield

Animal Welfare

Post-peak stability drastically reduces metabolic stress, especially during early lactation when energy demands outpace intake.

Biological Efficiency

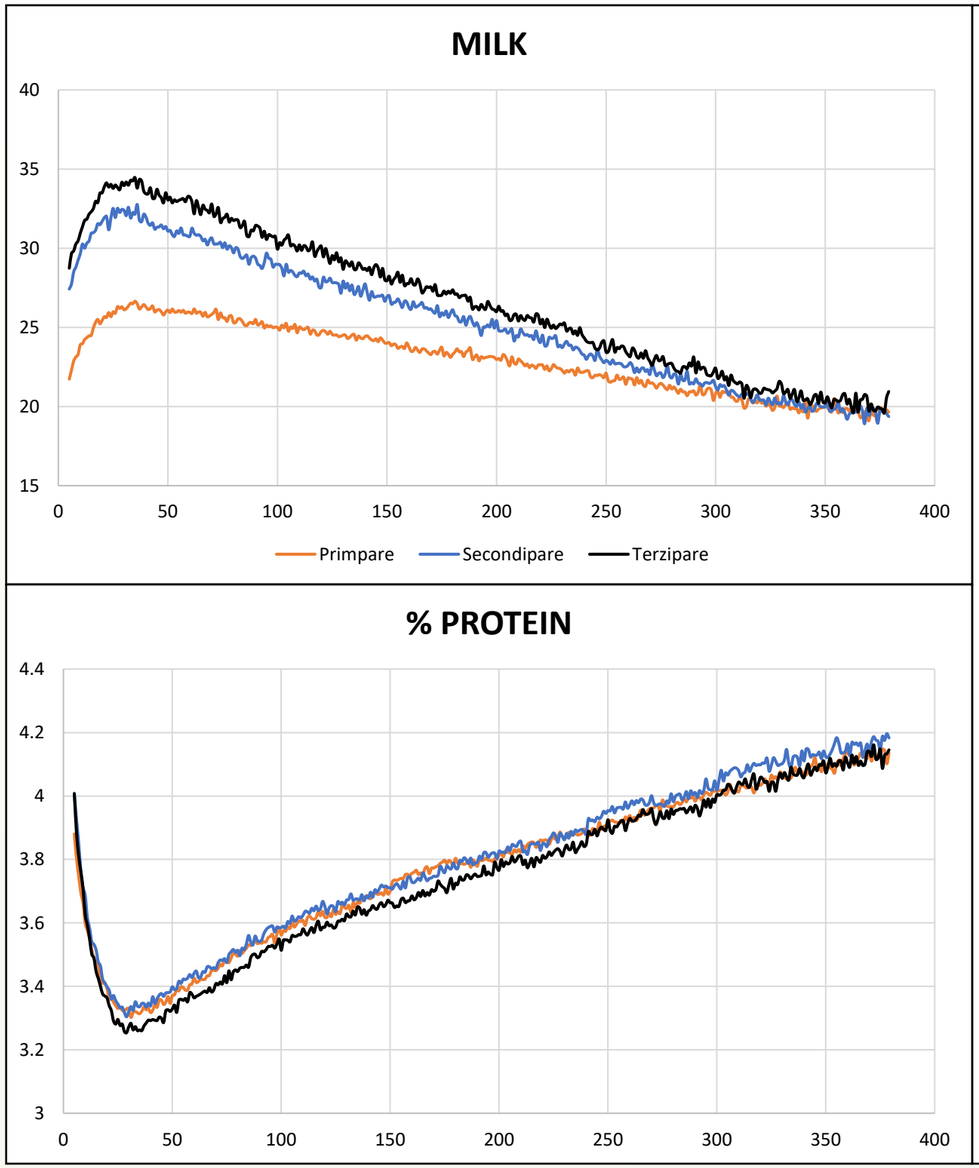
Aligns with the Brown Swiss breed's natural genetic tendency toward flat lactation curves, perfectly optimizing roughage utilization.

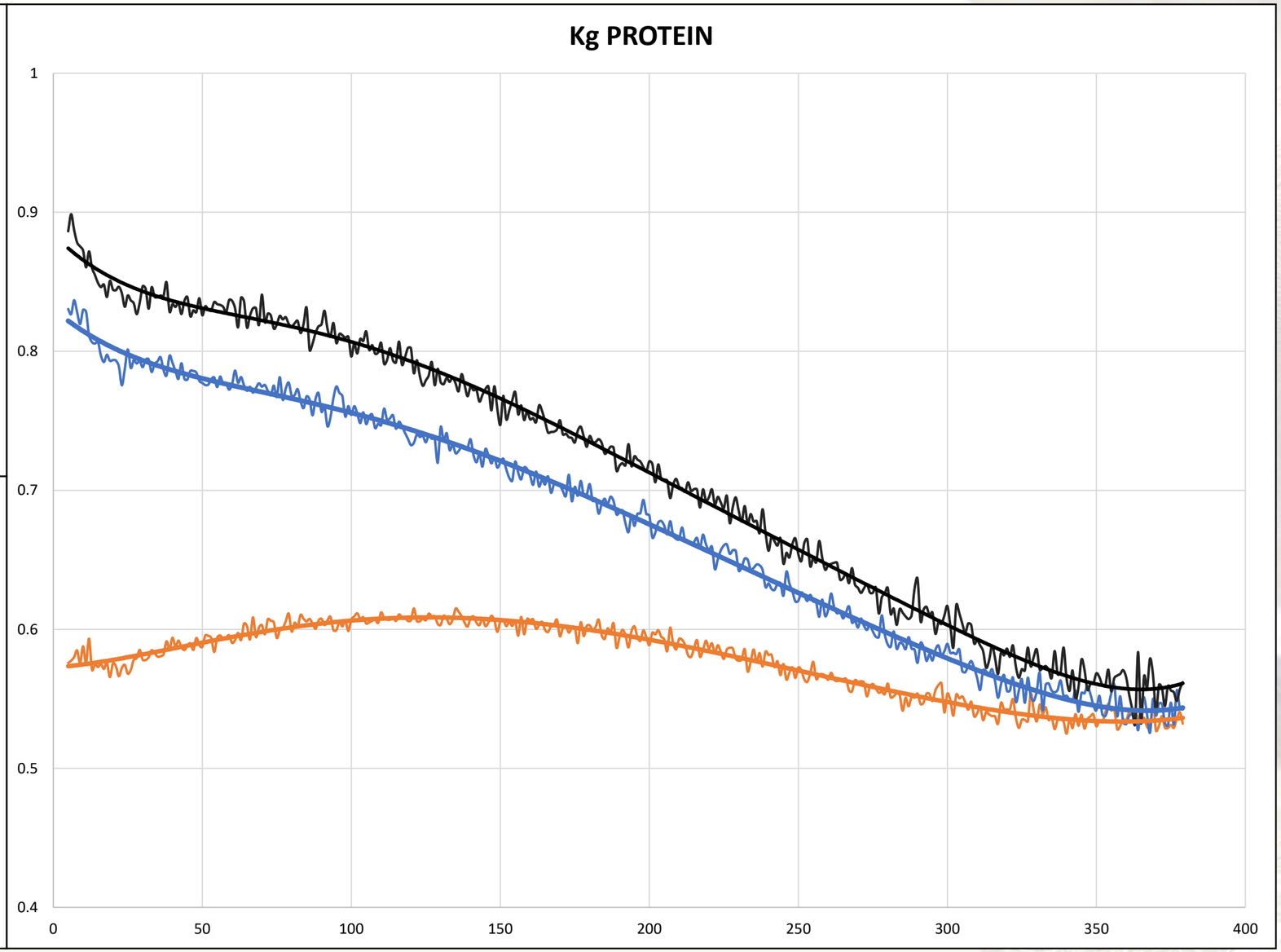
Economic Sustainability

Growth across parities (maturity) maximizes lifetime profitability, lowers replacement costs, and significantly increases herd longevity.

A balanced production cycle is the absolute foundation of a functional, long-lived herd.

Average lactation curves in Italian Brown Swiss





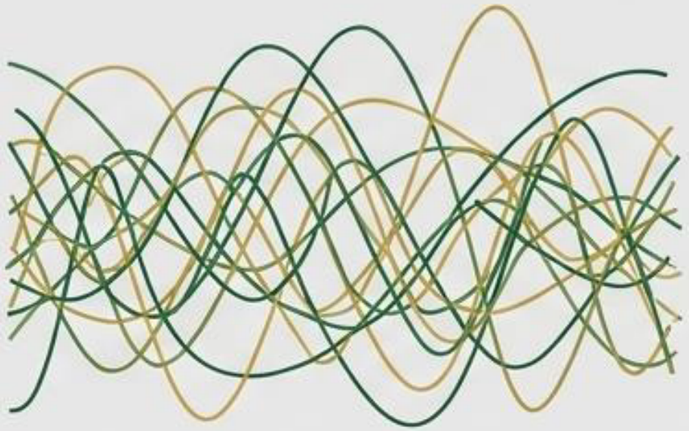
1° Lactation

2° Lactation

3° Lactation

Translating Phenotypic Geometry into Practical Genetic Tools

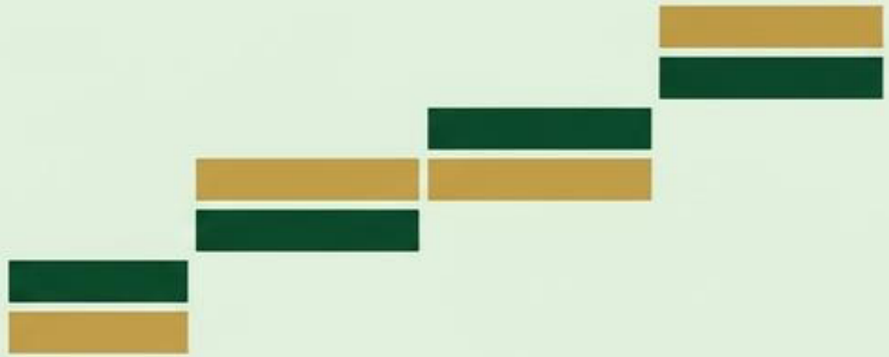
The Methodological Pivot



Random Regression

Mechanism: Generates continuous genetic lactation curves.

The Problem: Highly complex and statistically unstable for highly stratified datasets with small cohort sizes (e.g., Italian mountain herds). Fails to stabilize early genomic evaluations.

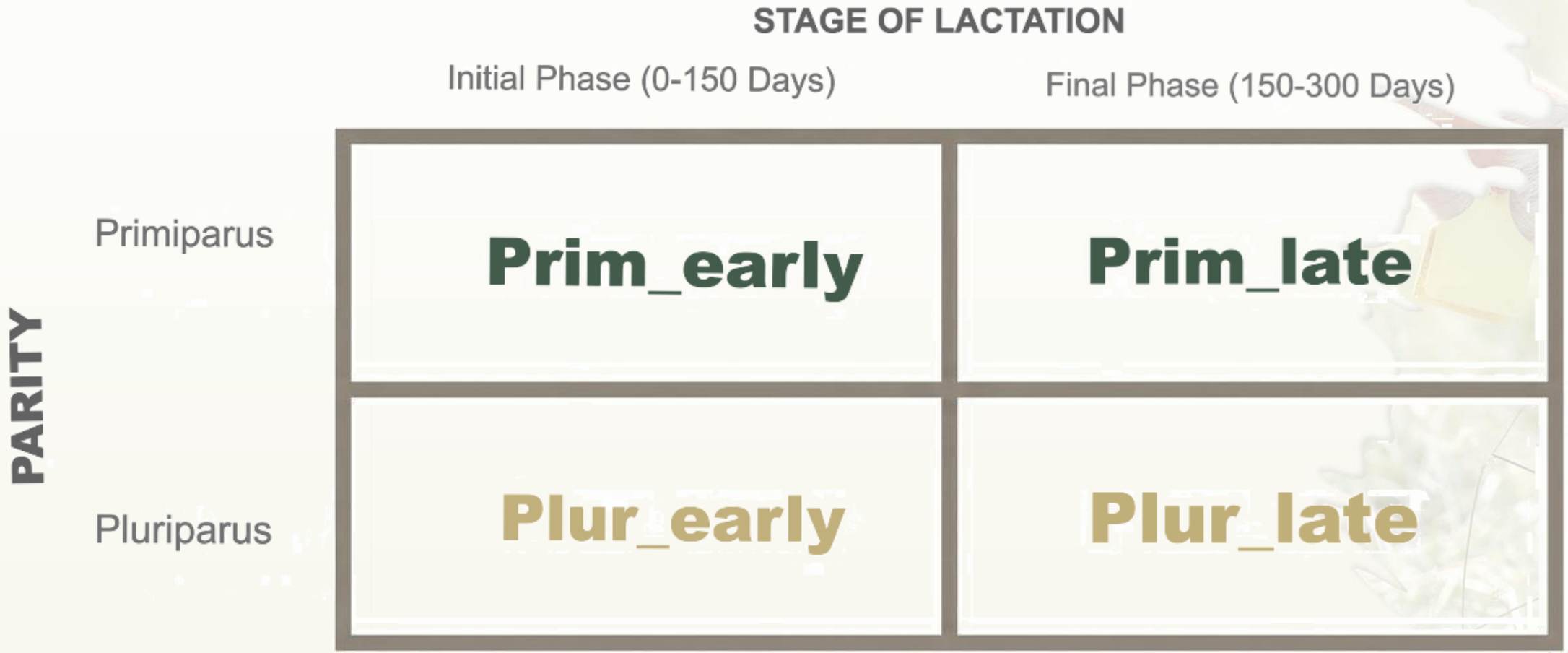


Multi-Trait Repeatability Model

Mechanism: Assigns a single, highly stable genetic value for distinct, isolated phases of the productive career.

The Advantage: Maximizes accuracy, eliminates early-evaluation bias for genomic bulls, and fully stabilizes proofs for the specific environmental distribution of the Italian population.

Information Architecture: The 4-Phase Matrix



Strategic Insight: This strict phase separation empowers the model to completely isolate the distinct genetic drivers of persistency and maturity.

Repeatability Model

Linear model used for genetic evaluation:

$$y = htd + Ye \times L \times nlat \times age \times dim \times prg + pe + a + e$$

htd: Herd-Test-Day

Ye: Year (quinquennium)

L: Herd level (primiparous vs multiparous gap)

nlat: Lactation number,

age: Calving age

dim: Days in milk

prg: Pregnancy days

Variance Components & Heritability

Prim_early

10.7%

Repeatability: 26.4%

Prim_late

25.3%

Repeatability: 61.1%

Plur_early

14.9%

Repeatability: 36.0%

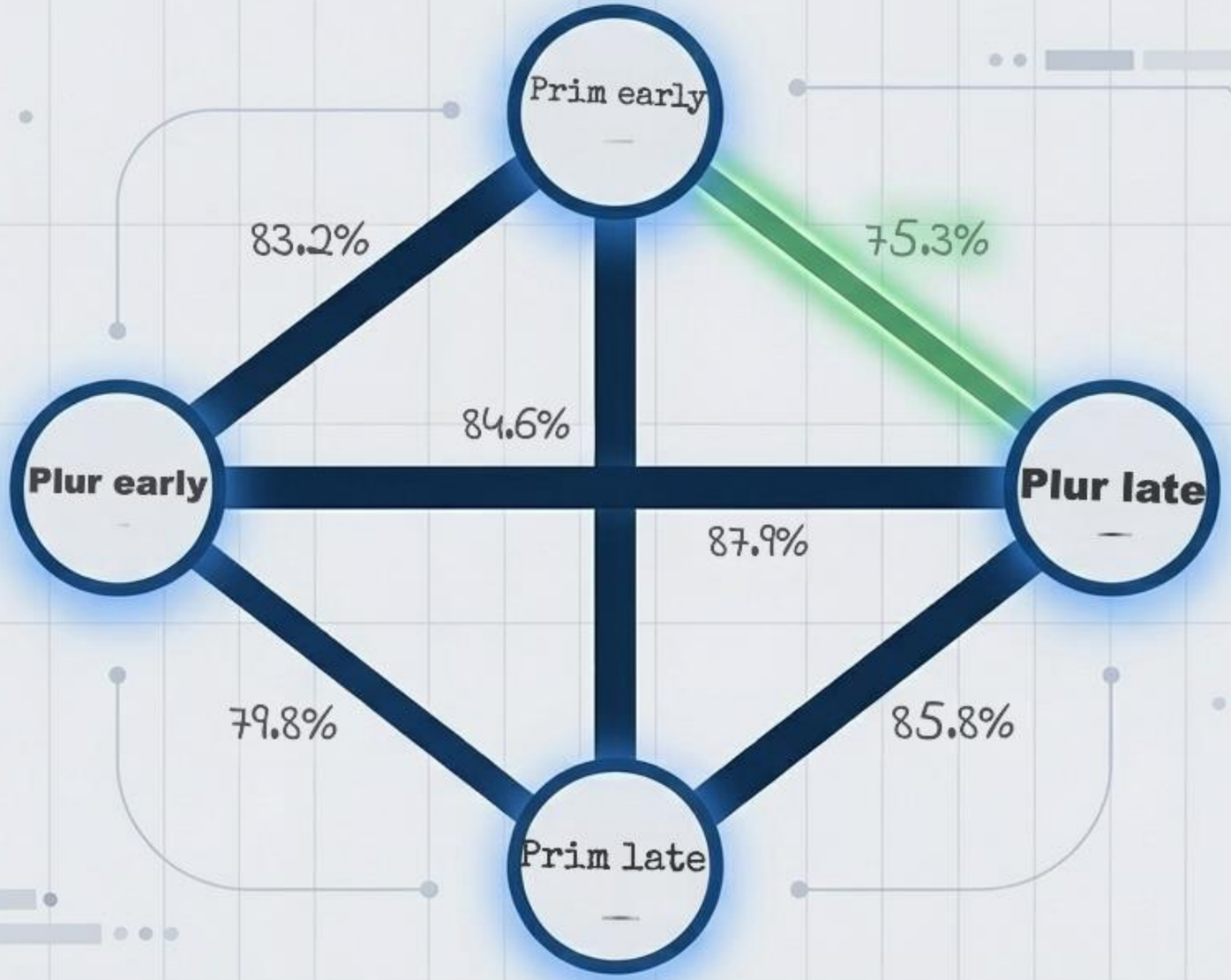
Plur_late

19.8%

Repeatability: 46.5%

Insight: Peak heritability occurs in the late phase of the first lactation. While multiparous cows follow a similar pattern, the differential is significantly more pronounced in primiparous cows.

Genetic Correlations: Model Stability & Trait Independence



Core Finding: High overall correlations (75.3% to 87.9%) confirm the multi-trait model's internal stability.

Insight: The lowest correlation (75.3%) proves that the first phase of the first lactation behaves with relative genetic independence from late-career maturity, validating the necessity of a 4-phase architecture.

How to calculate the Persistency Index

- Ratio between the second phase on the first phase of lactation:

$$\boldsymbol{Persistency} \div = \frac{(\text{Prim\_late}/\text{Prim\_early}) + (\text{Plur\_late}/\text{Plur\_early})}{2}$$

- Percentage of milk produced in the first phase of lactation compared to the total:

$$\boldsymbol{Persistency}\ \% = \frac{(Prim\_early + Plur\_early)}{(Prim\_late + Prim\_early + Plur\_late + Plur\_early)}$$

- Average difference between the productions of the second and first phase of lactation:

$$\boldsymbol{Persistency} -= \frac{[(Prim\_late - Prim\_early) + (Plur\_late - Plur\_early)]}{2}$$

How to calculate the Maturity Index

- *Ratio of the production of the 1° lactation to the following lactations:*

$$\boldsymbol{Maturity} \div = \frac{(Prim\_early/Plur\_early) + (Prim\_late/Plur\_late)}{2}$$

- *Percentage of milk produced in the first lactation compared to the total:*

$$\boldsymbol{Maturity}\ \% = \frac{(Prim\_early + Prim\_late)}{(Prim\_late + Prim\_early + Plur\_late + Plur\_early)}$$

- *Average difference between the productions of the 1° lactation and the following:*

$$\boldsymbol{Maturity} -= \frac{[(Prim\_early - Plur\_early) + (Prim\_late - Plur\_late)]}{2}$$

EBV – correlation (sires)

	prok_Tor	prim_early	prim_late	plur_early	plur_late
***Persistency*÷**	**18%**	2%	20%	7%	25%
***Persistency*%**	**24%**	8%	26%	13%	30%
***Persistency*-**	**63%**	49%	67%	54%	72%
***Maturity*÷**	**-30%**	-22%	-26%	-32%	-34%
***Maturity*%**	**-38%**	-25%	-30%	-41%	-44%
***Maturity*-**	**-83%**	-75%	-81%	-88%	-90%

Lactation curves of daughters of the top e bottom sires for persistency

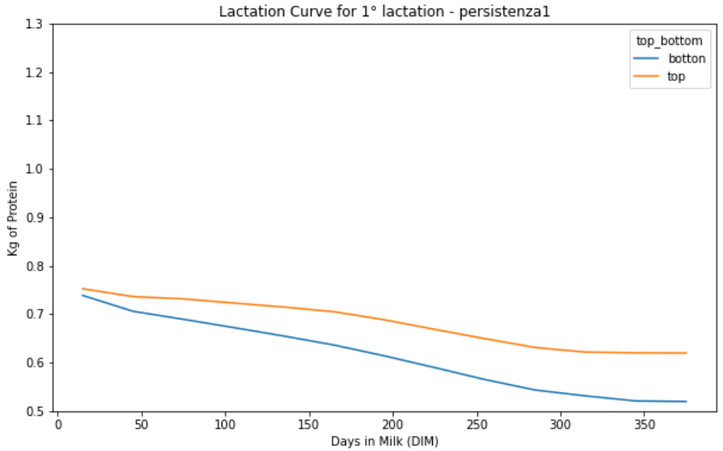
top 10% sires Bottom 10% sires

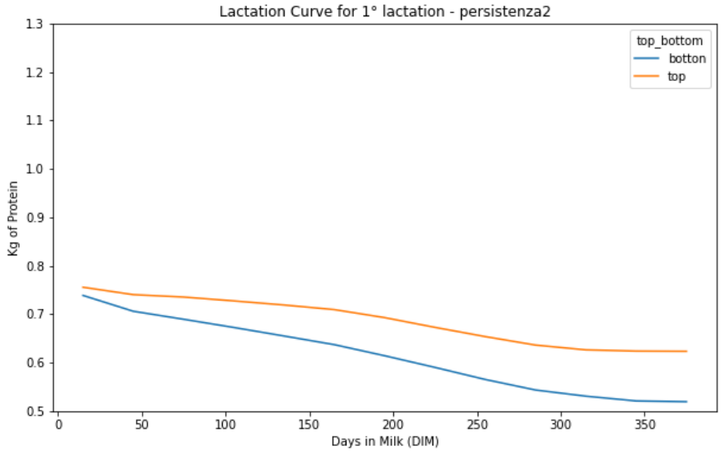
Persistency ÷ Persistency % Persistency -

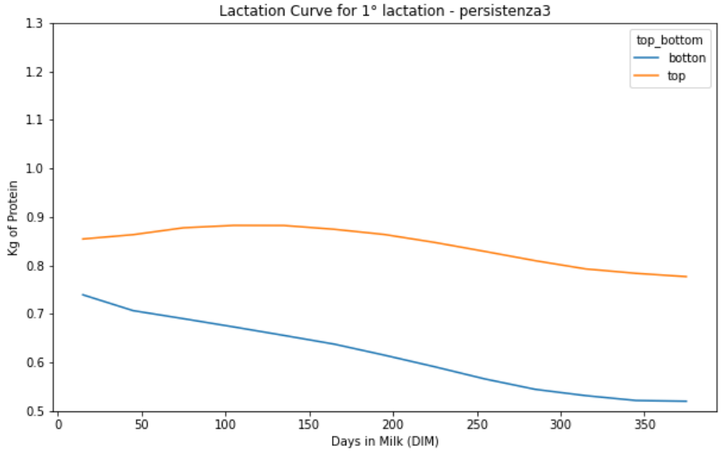
1° Lact.

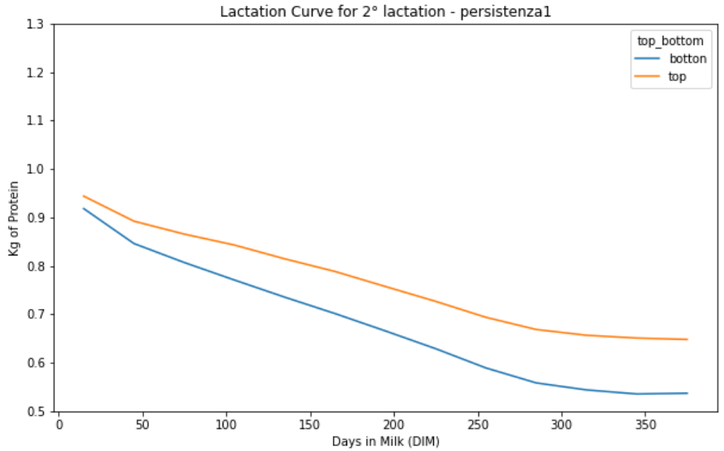
2° Lact.

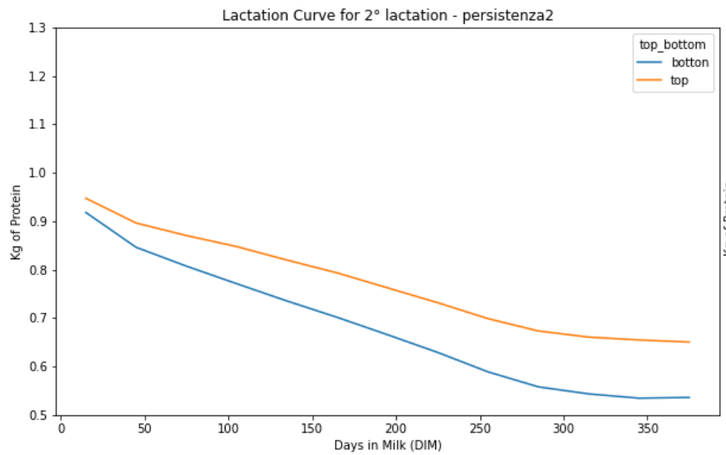
Kg protein per day

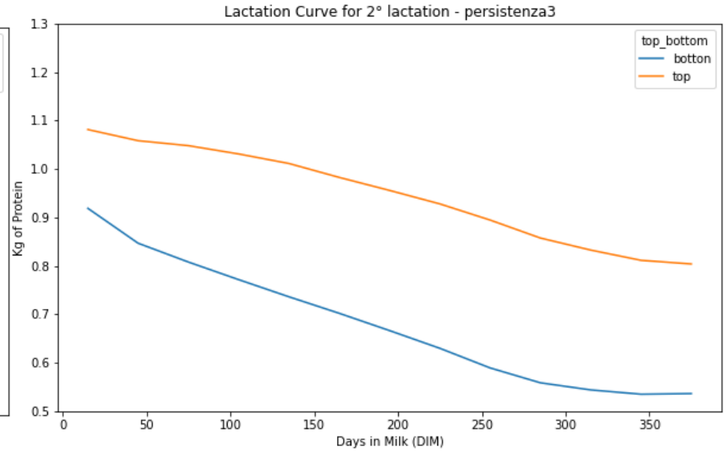










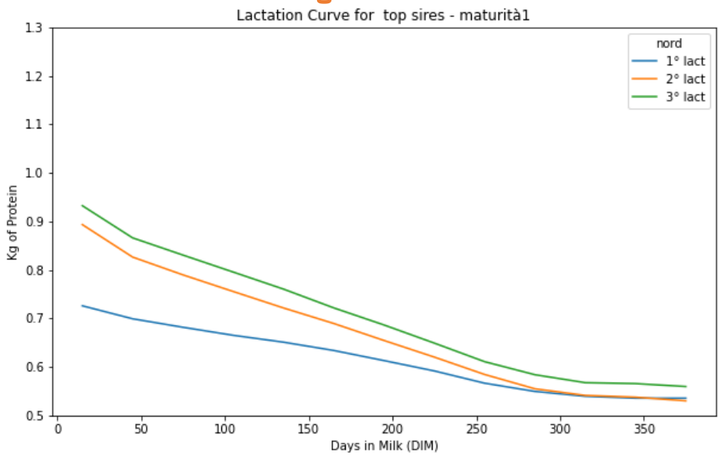


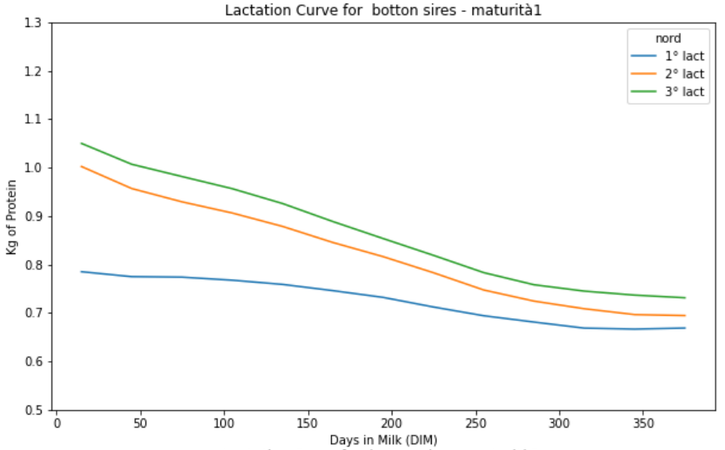
Lactation curves of daughters of the top e bottom sires for maturity

Top sires

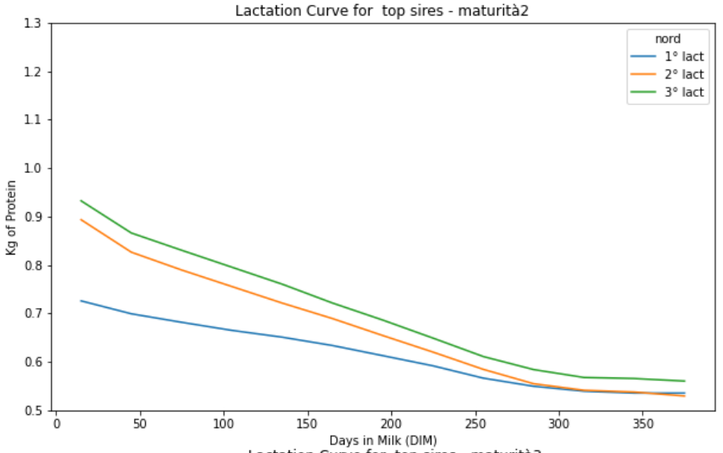
Bottom sires

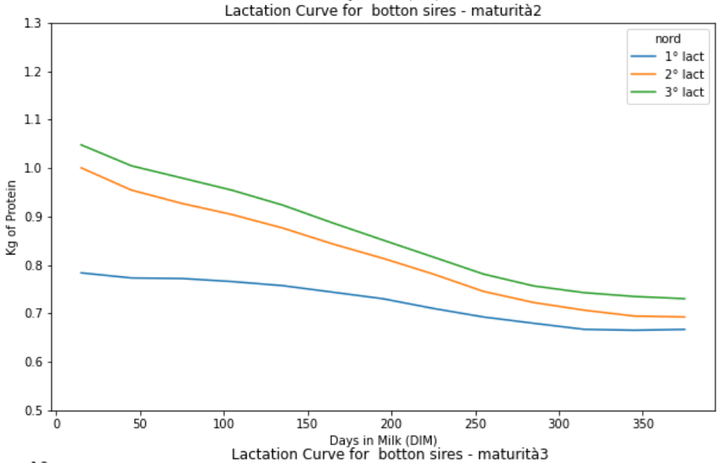
Maturity -



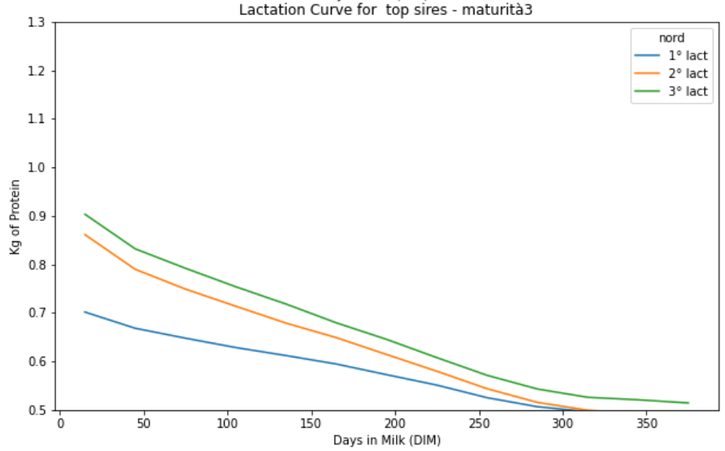


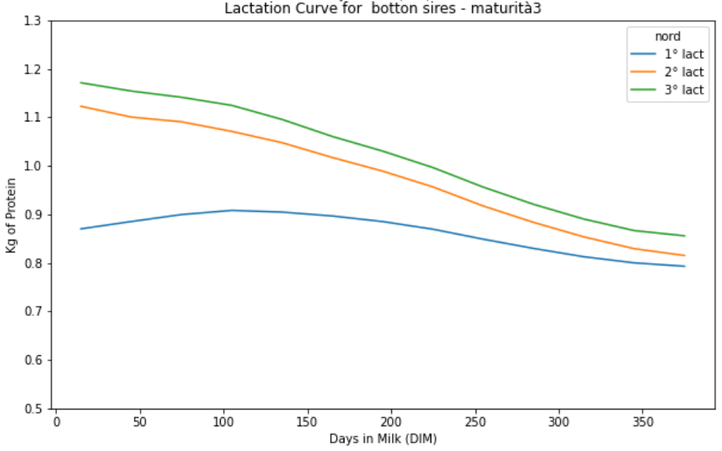
Maturity %





Maturity +





Conclusion

- **Distinct Genetic Control across Phases**
  - Genetic correlations between the four productive phases (ranging from 75.3% to 87.9%) confirm that **genetic control is partially distinct** for each stage of the cow's career.
  - The **early phase of the first lactation** shows the highest degree of independence, confirming its unique biological and genetic status.
- **Persistency Indices for Curve Differentiation**
  - The newly developed persistency indices successfully **discriminate between different lactation curve shapes**.
  - Validation through daughter averages of top and bottom sires demonstrates the model's ability to identify animals that maintain stable production post-peak, reducing metabolic stress.
- **Maturity Index and Yield Antagonism**
  - The productive maturity index exhibits a **strong negative ebv correlation** with the overall protein yield index.
  - This heavy antagonism indicates that selecting for higher maturity would currently lead to a significant decrease in total protein production, **limiting its practical application** in current selection programs.

Future Developments & Alternative Approaches

- **Evaluation of Direct Phenotypic Measures**
  - Exploring the feasibility of working directly with **phenotypic production ratios** between lactation phases (e.g., Phase 2 / Phase 1).
  - Investigating the use of simple **phenotypic differences** (e.g., *Prim_fine–Prim_iniz*) as alternative traits to define individual curve shapes more intuitively for breeders.
- **Residual Analysis from Single-Trait Models**
  - Testing an approach based on the **residuals of the standard single-trait repeatability model** used in the official evaluation.
  - This method analyzes the **individual deviation of each cow** from the expected lactation curve predicted by the model.
- **Optimization for Genomic Selection**
  - Selecting the most stable and heritable alternative phenotypes to be integrated into the national **single-step genomic evaluation** pipeline.

ANARB

Thank you for your attention!