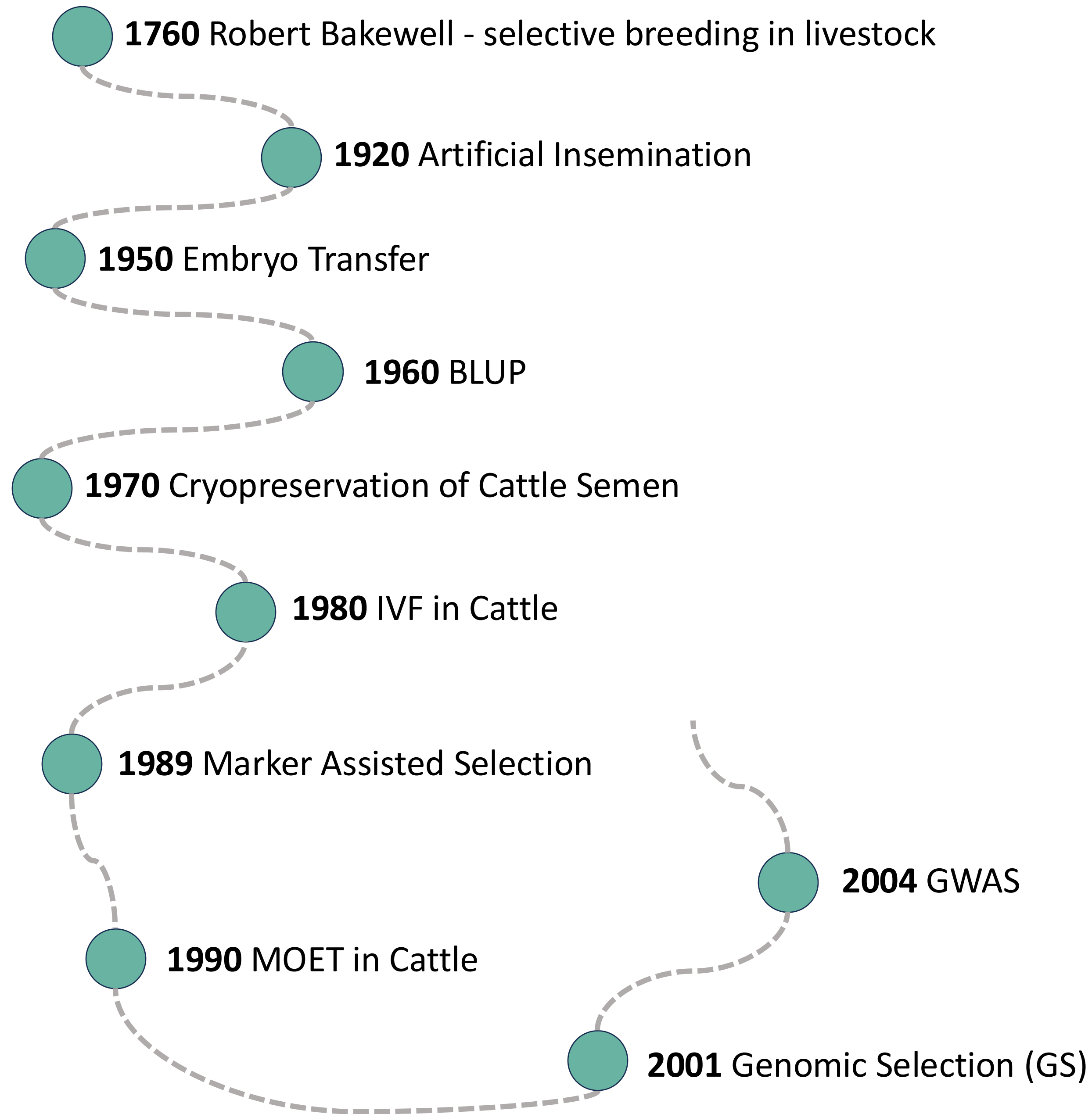


Introducing Single-step — evaluation in Polish Holstein- Friesian cattle —

M. Pszczola, S. Savoia, M. Graczyk-Bogdanowicz, W. Jagusiak,
T. Suchocki, K. Stachowicz, L. Zhang, K. Żukowski,
K. Rzewuska, M. Skarwecka, S. Mucha

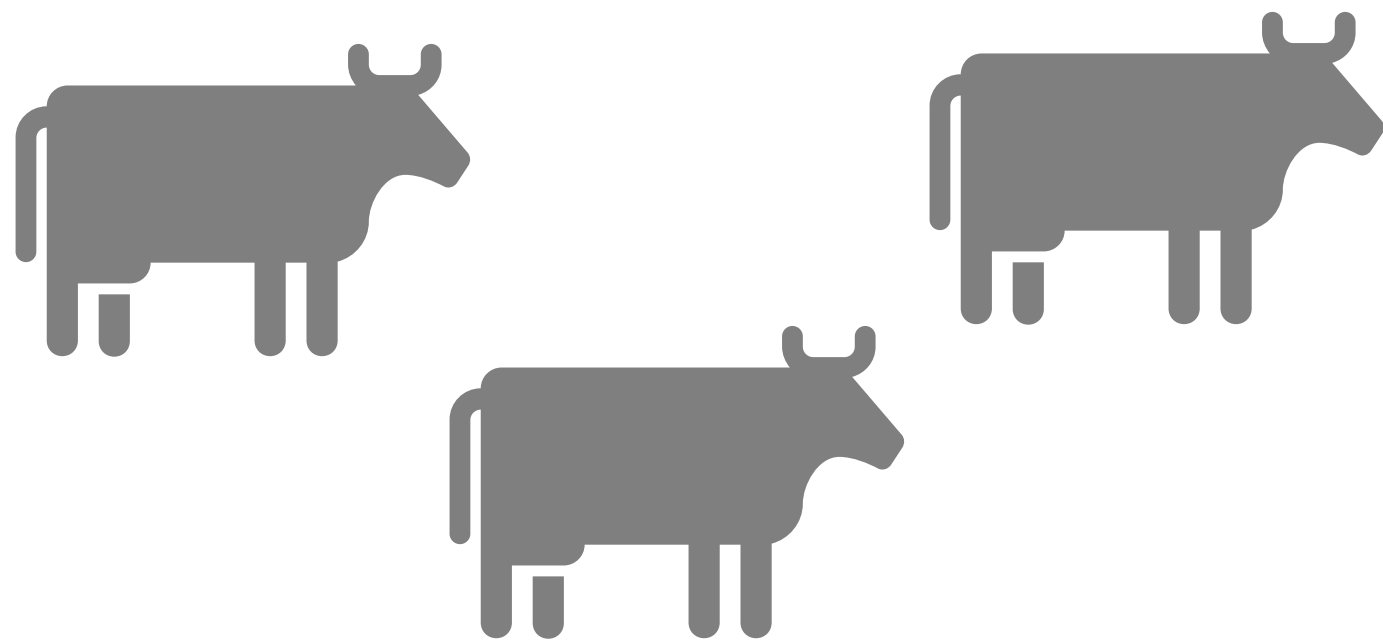
GS ROADMAP



Reference population

Phenotype + 

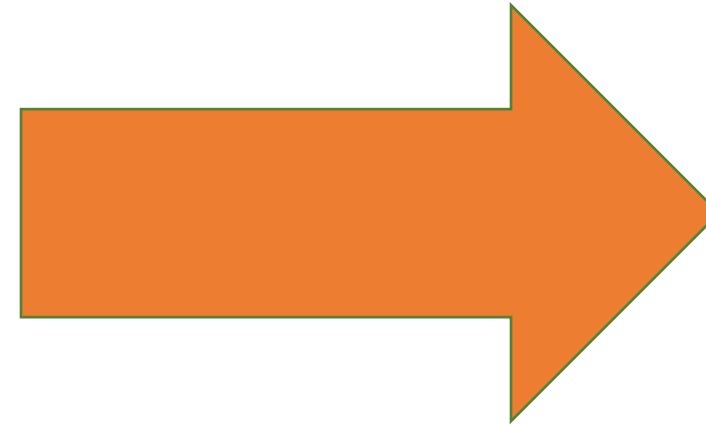
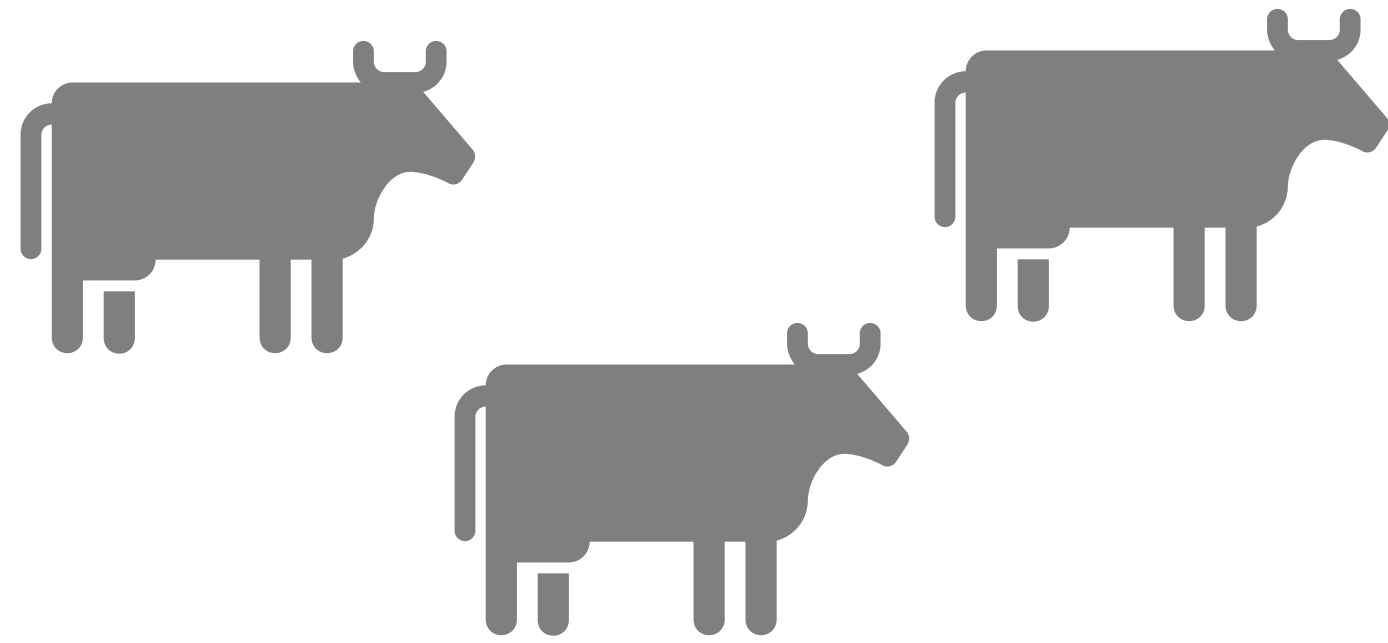
Reference population



Reference population

Phenotype + 

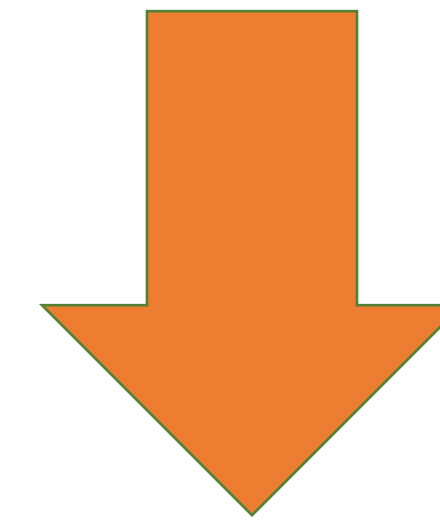
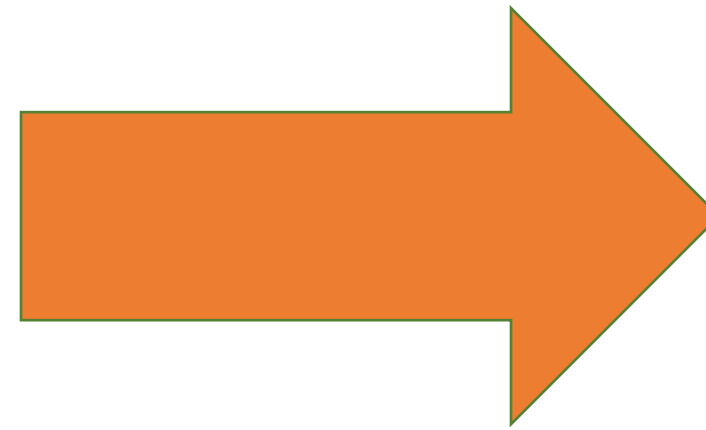
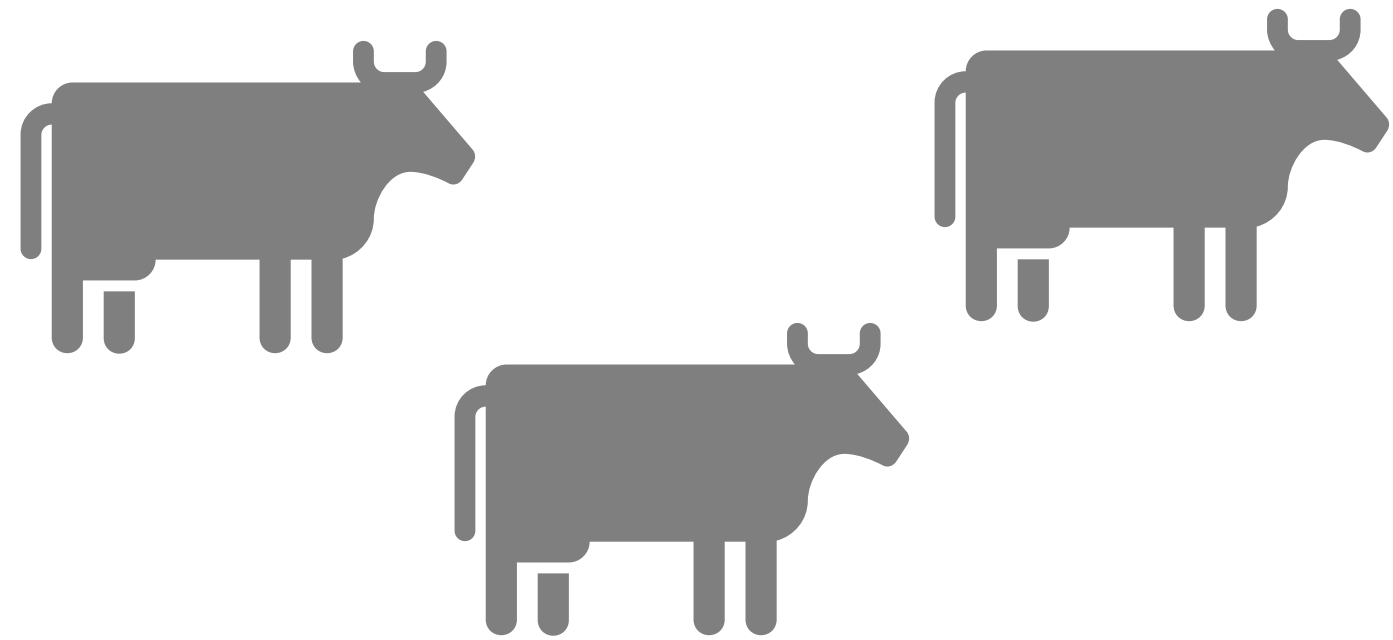
Reference population



Reference population

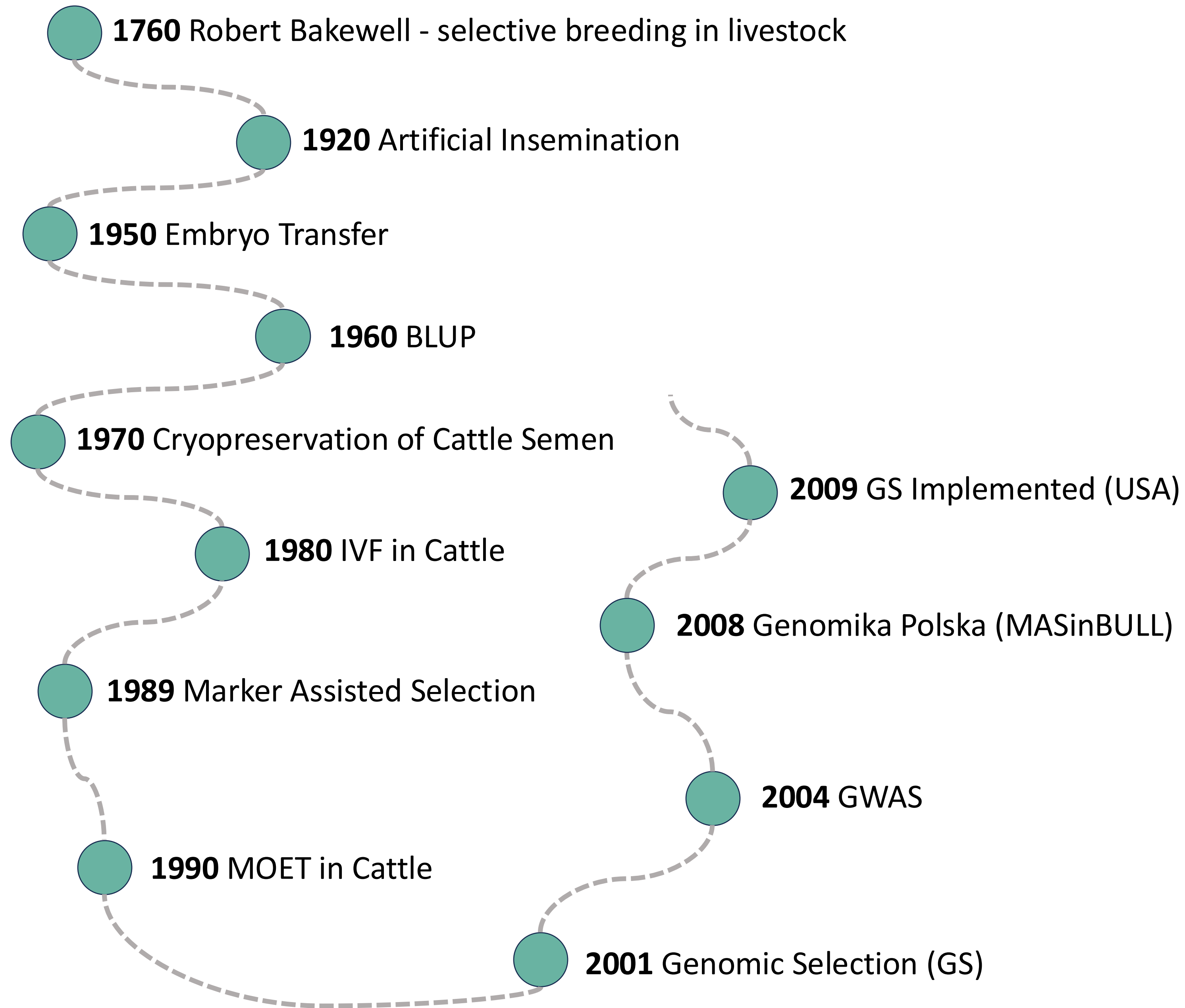
Phenotype + 

Reference population



Breeding
value

GS ROADMAP



Problem:

Two separate estimations

BLUP $\rightarrow$ EBV

Two separate estimations

BLUP → **EBV**

GBLUP → **DGV**

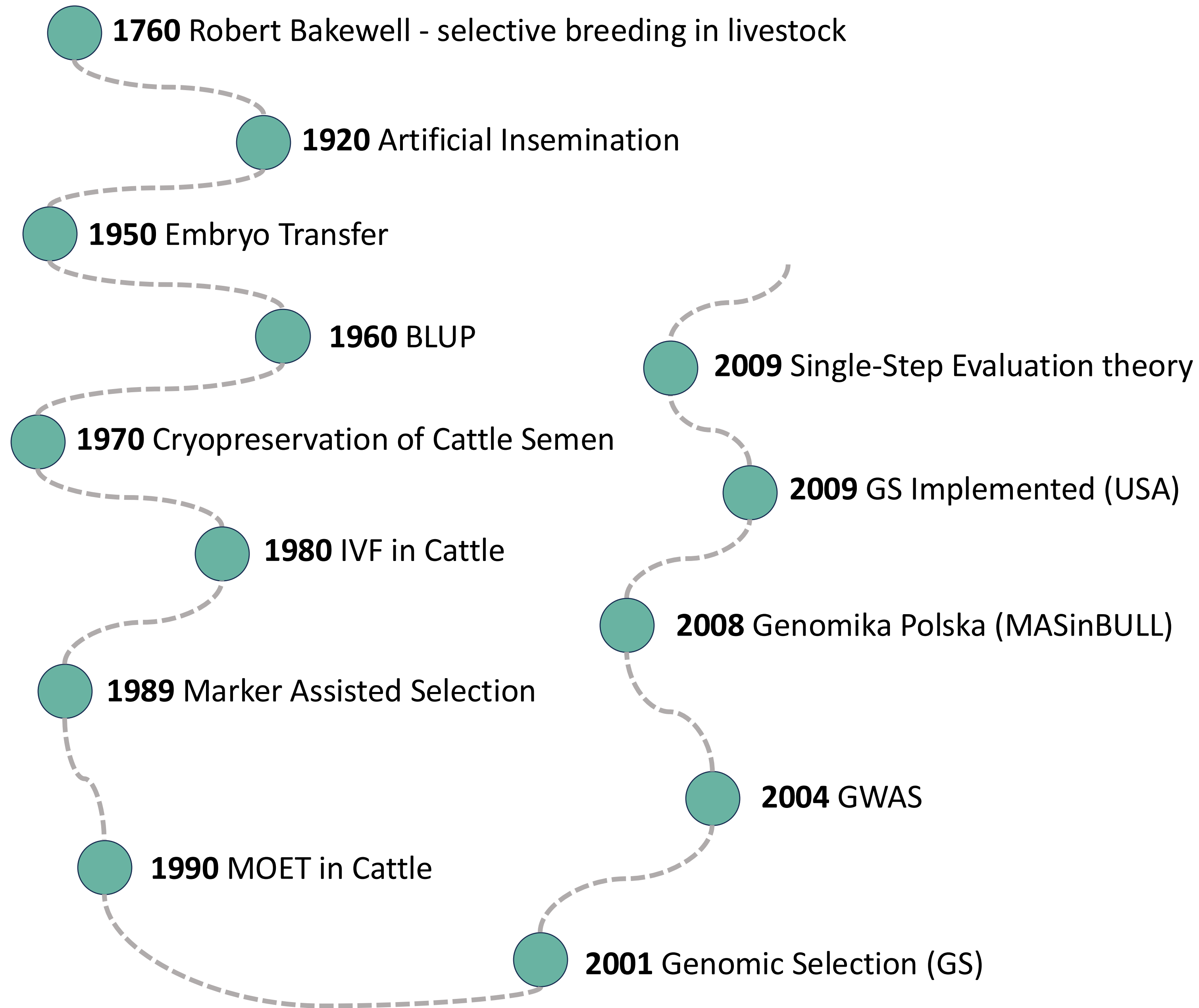
Two separate estimations



Problems of two separate estimations

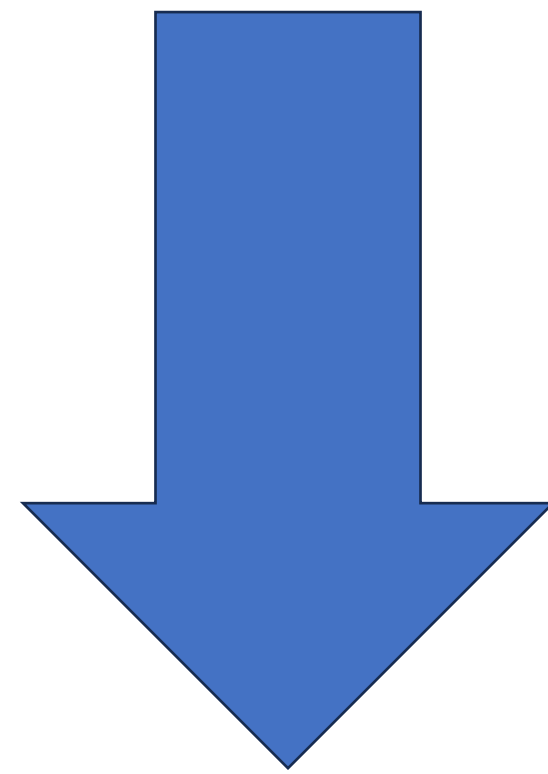
- **Complexity**
- **Accumulation of estimation errors**
- **Influence of genomics only on genotyped animals**

GS ROADMAP



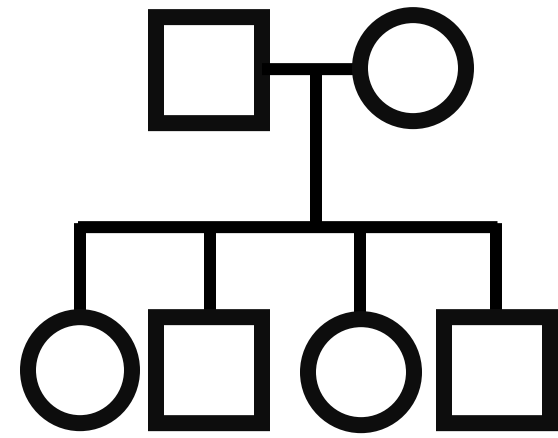
Single-step evaluation

Single-step evaluation

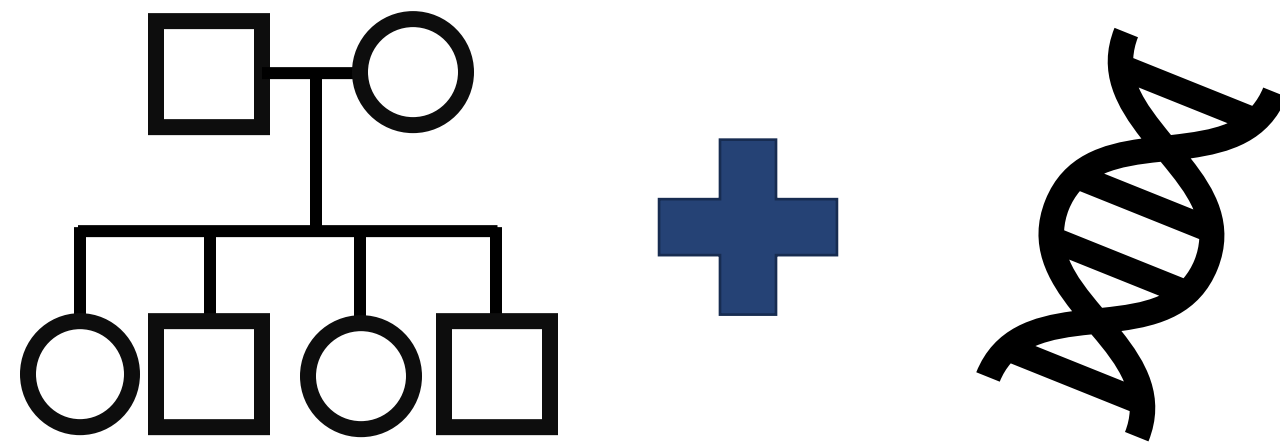


SSBLUP

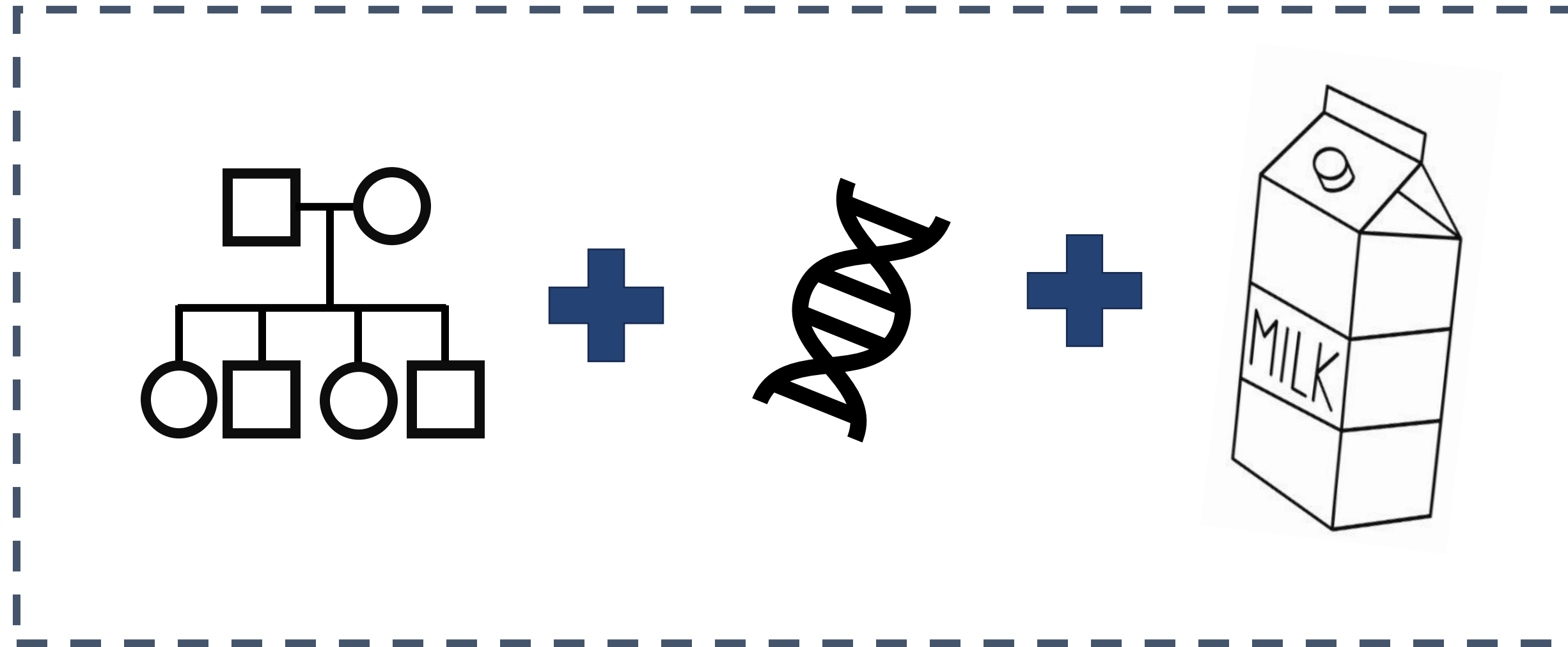
Single-step evaluation



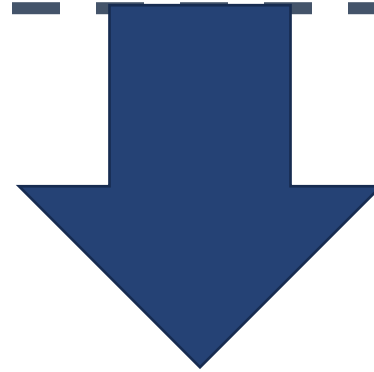
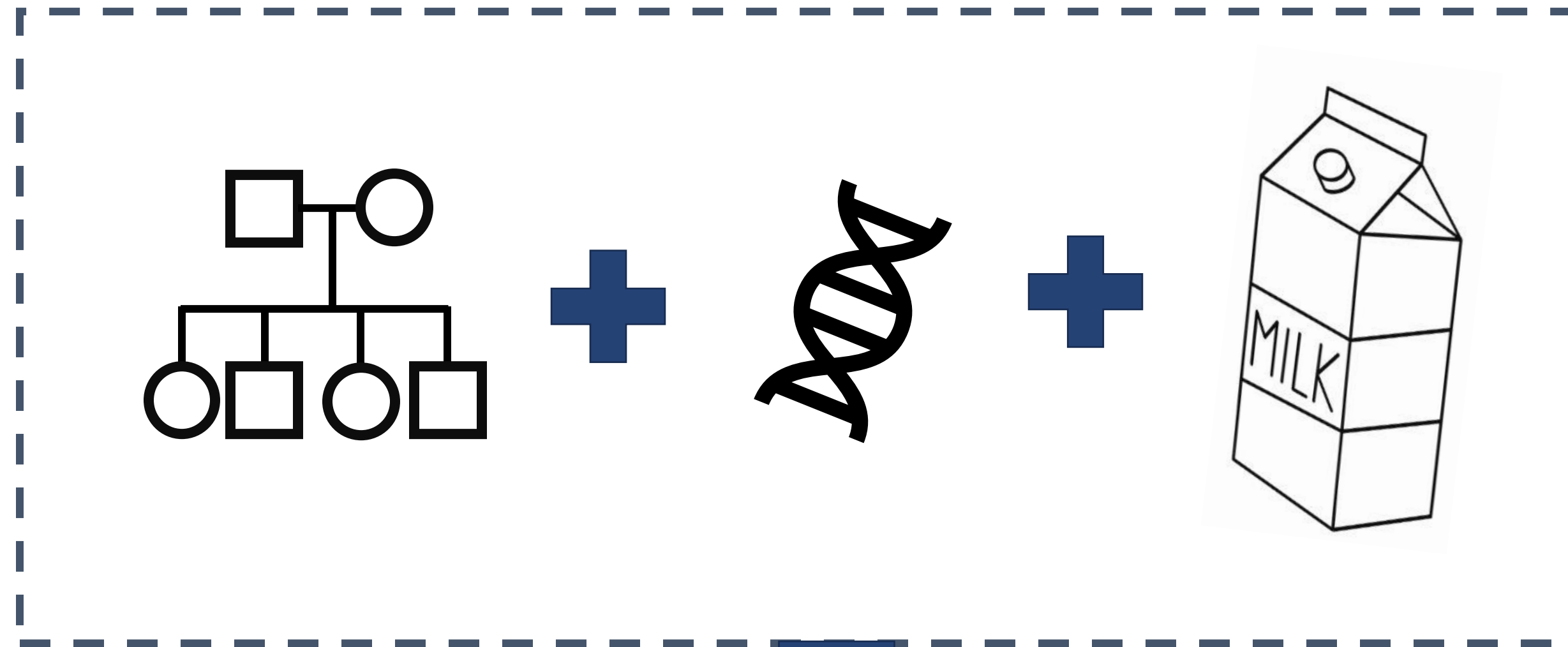
Single-step evaluation



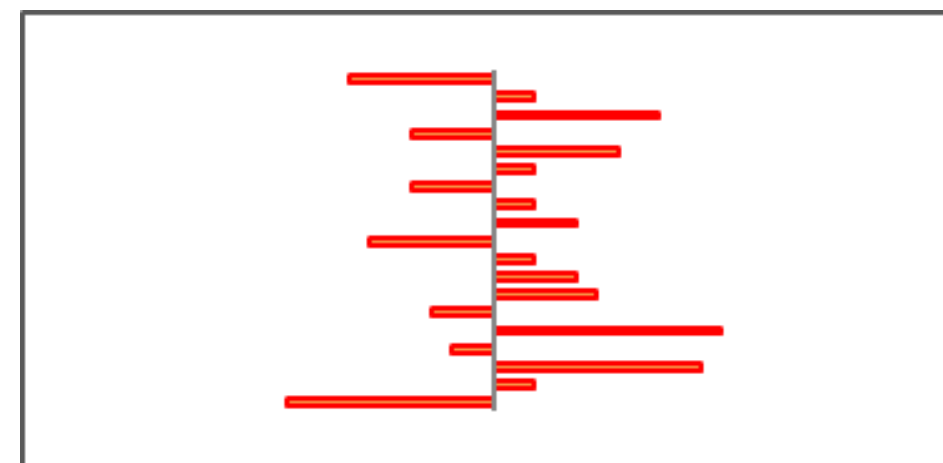
Single-step evaluation



Single-step evaluation

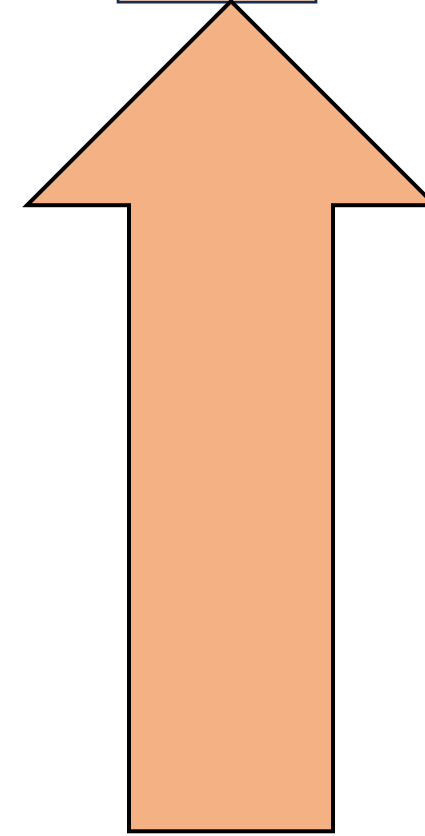


Breeding values



BLUP

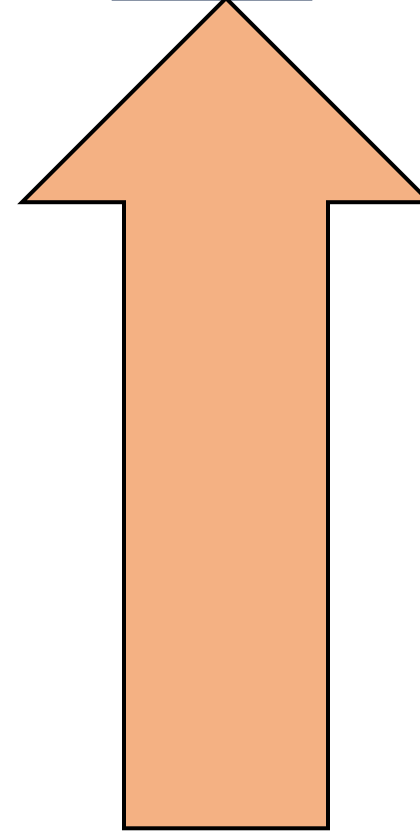
$$\begin{pmatrix} \hat{b} \\ \hat{u} \end{pmatrix} = \begin{pmatrix} X'X & X'Z \\ Z'X & Z'Z + \lambda A^{-1} \end{pmatrix}^{-1} \begin{pmatrix} X'y \\ Z'y \end{pmatrix}$$



Relationship matrix

GBLUP

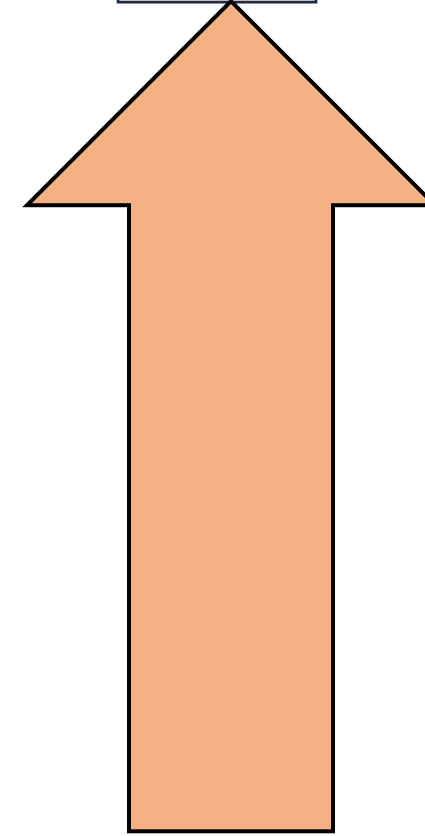
$$\begin{pmatrix} \hat{b} \\ \hat{u} \end{pmatrix} = \begin{pmatrix} X'X & X'Z \\ Z'X & Z'Z + \lambda G^{-1} \end{pmatrix}^{-1} \begin{pmatrix} X'y \\ Z'y \end{pmatrix}$$



Genomic relationship matrix

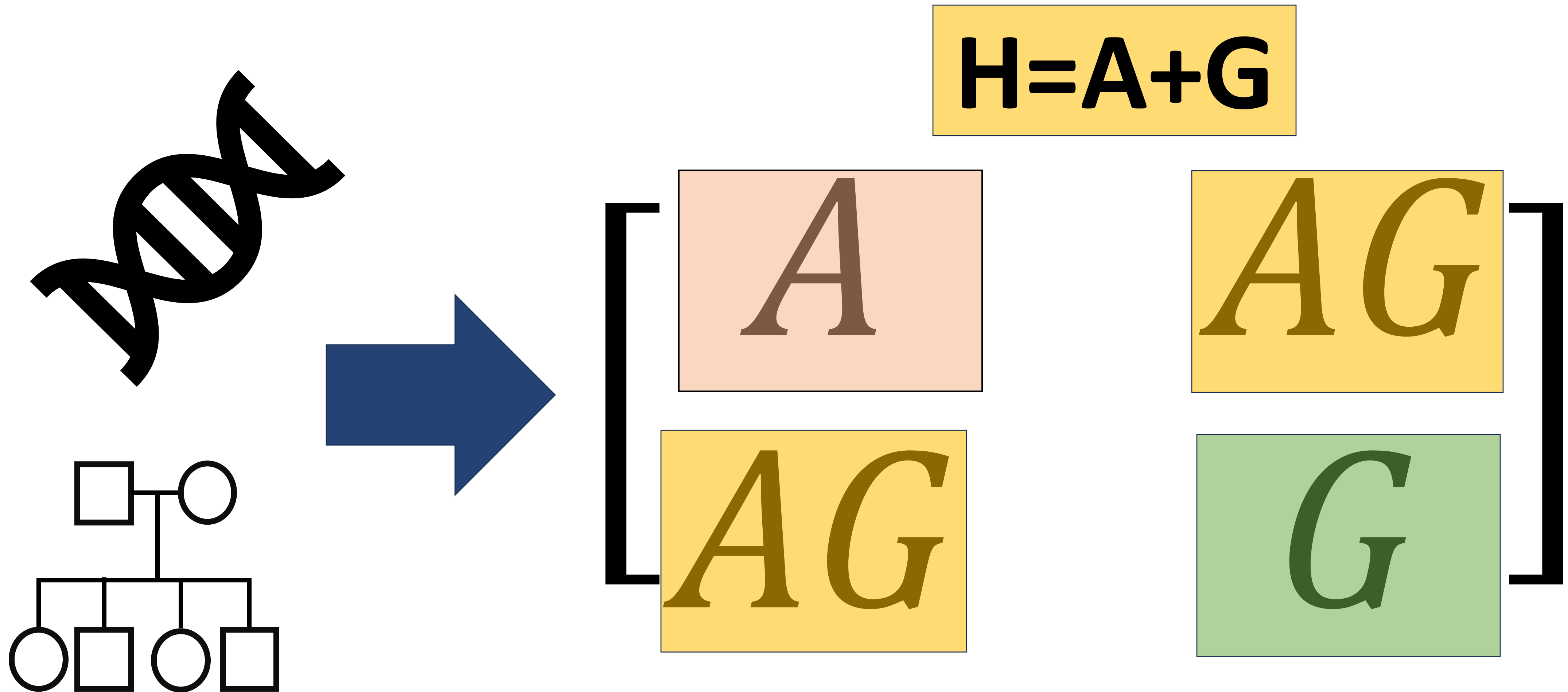
ssBLUP

$$\begin{pmatrix} \hat{b} \\ \hat{u} \end{pmatrix} = \begin{pmatrix} X'X & X'Z \\ Z'X & Z'Z + \lambda H^{-1} \end{pmatrix}^{-1} \begin{pmatrix} X'y \\ Z'y \end{pmatrix}$$



Hybrid relationships

Hybrid relationships



Hybrid relationships

$$\mathbf{H}^{-1} = \mathbf{A}^{-1} + \begin{bmatrix} 0 & 0 \\ 0 & \mathbf{G}^{-1} - \mathbf{A}_{22}^{-1} \end{bmatrix}$$

Benefits of single step

- **Higher reliability for young animals**
 - **Faster genetic progress**

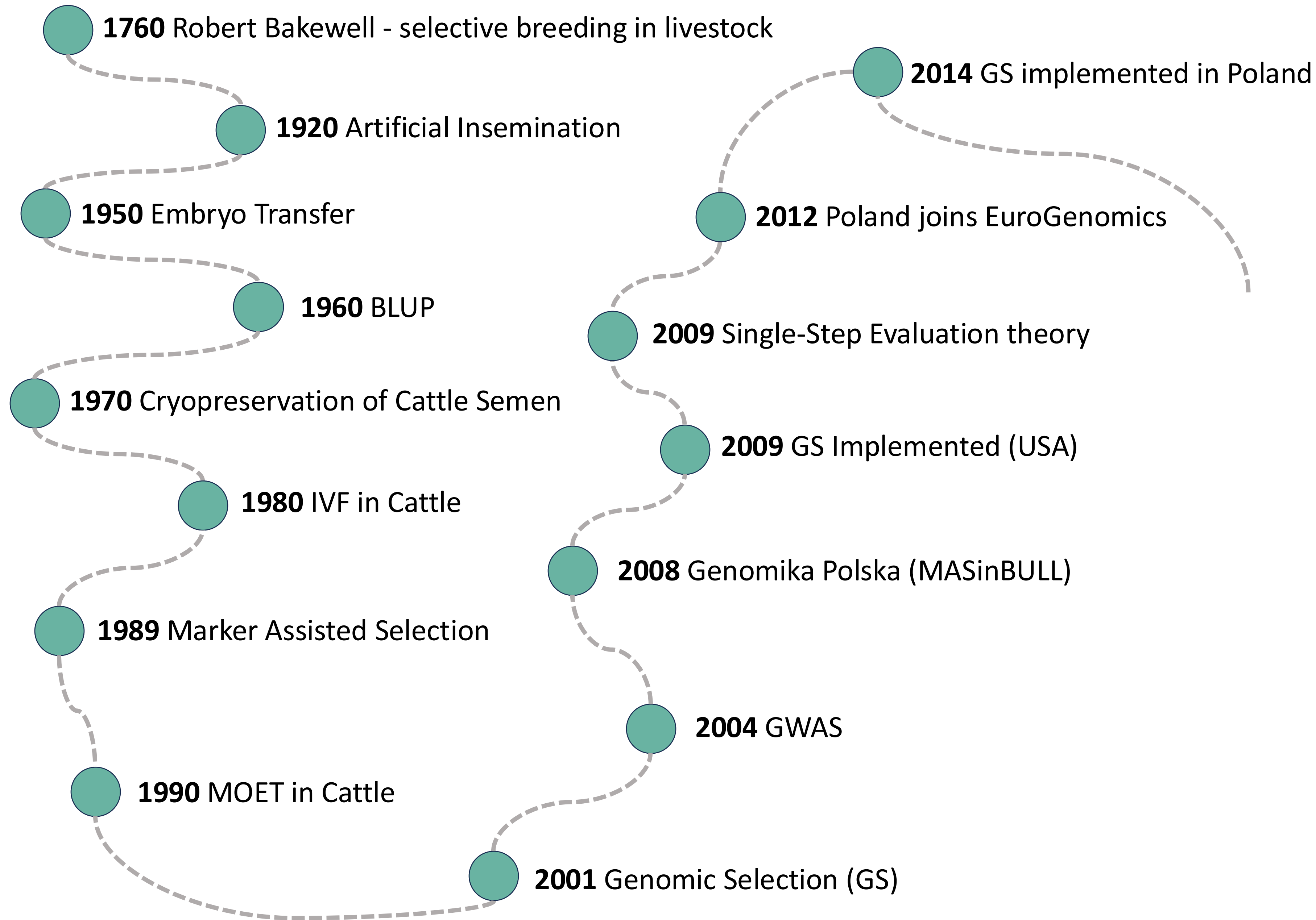
Benefits of single step

- **Higher reliability for young animals**
 - **Faster genetic progress**
- **More stable breeding values**

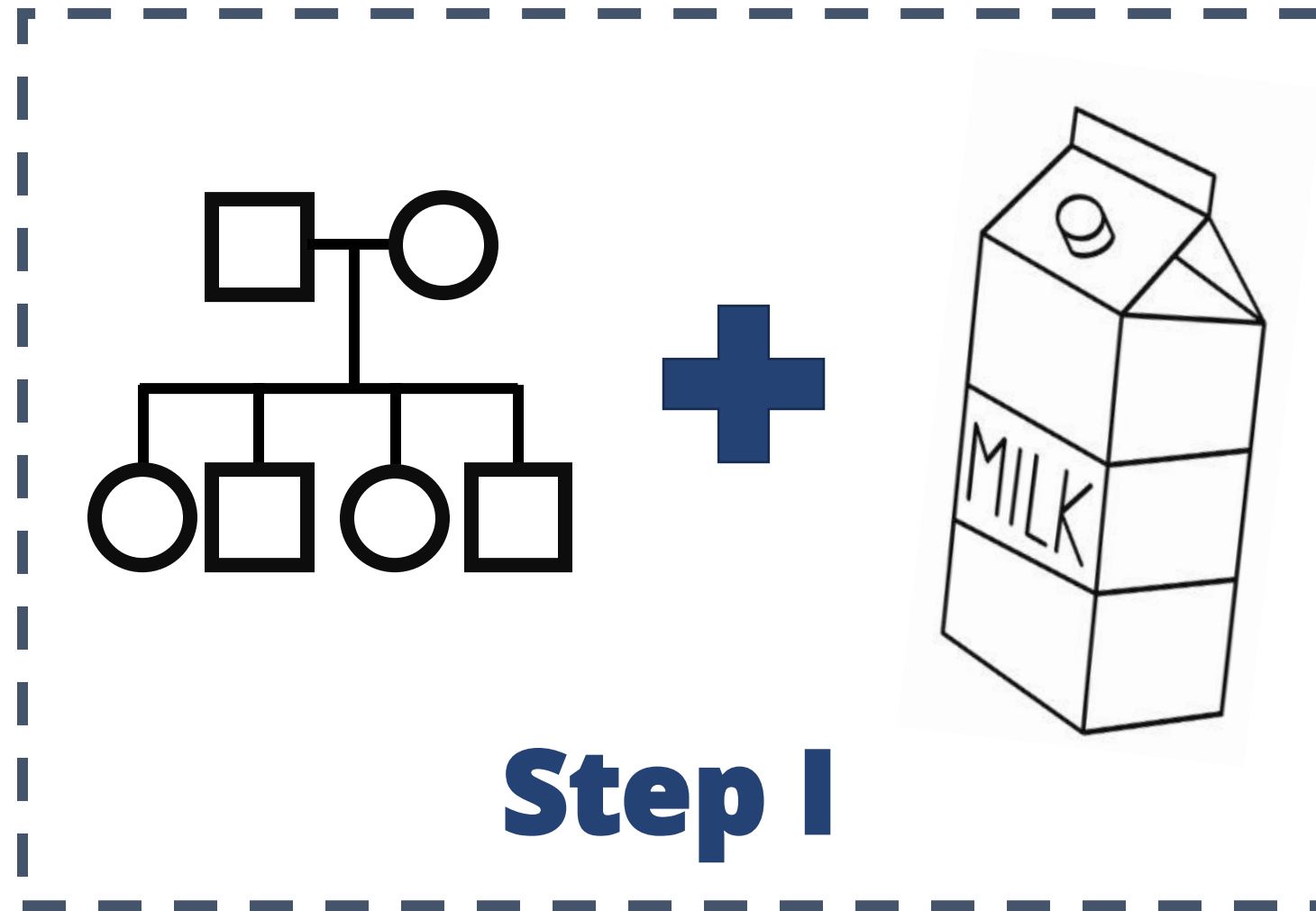
Benefits of single step

- **Higher reliability for young animals**
 - **Faster genetic progress**
- **More stable breeding values**
- **Novel traits**

GS ROADMAP



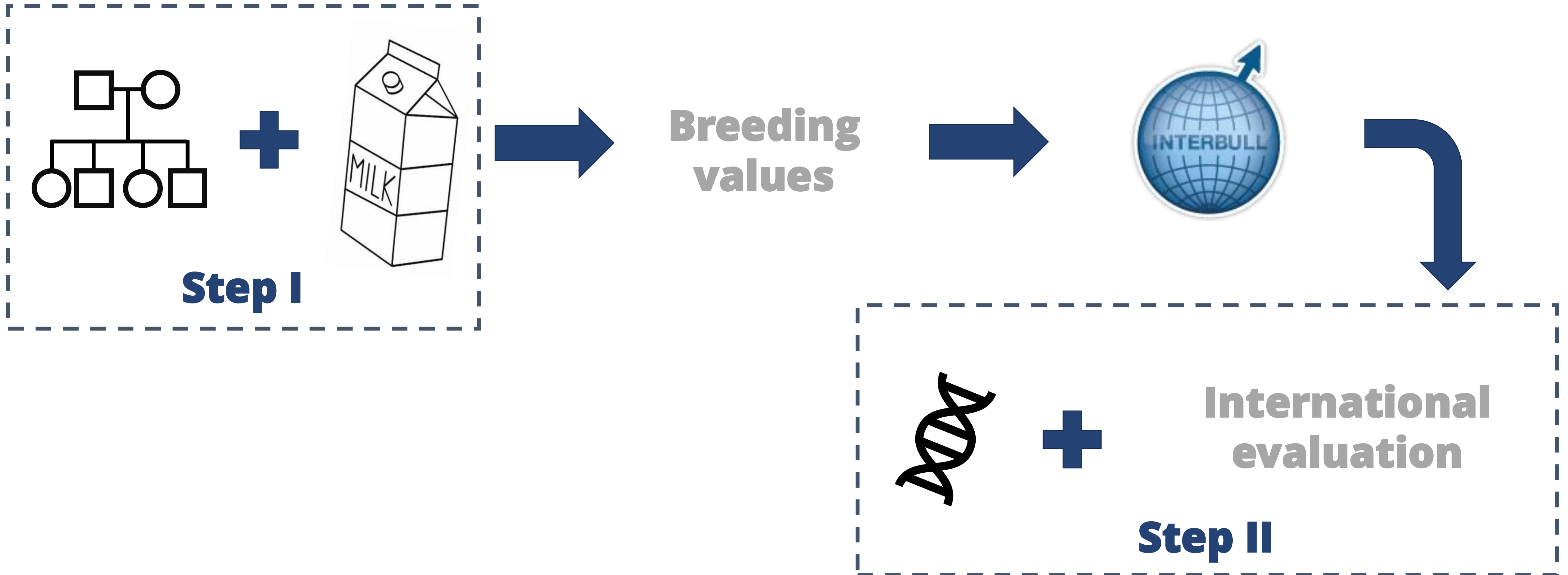
Current BV estimation system in PL



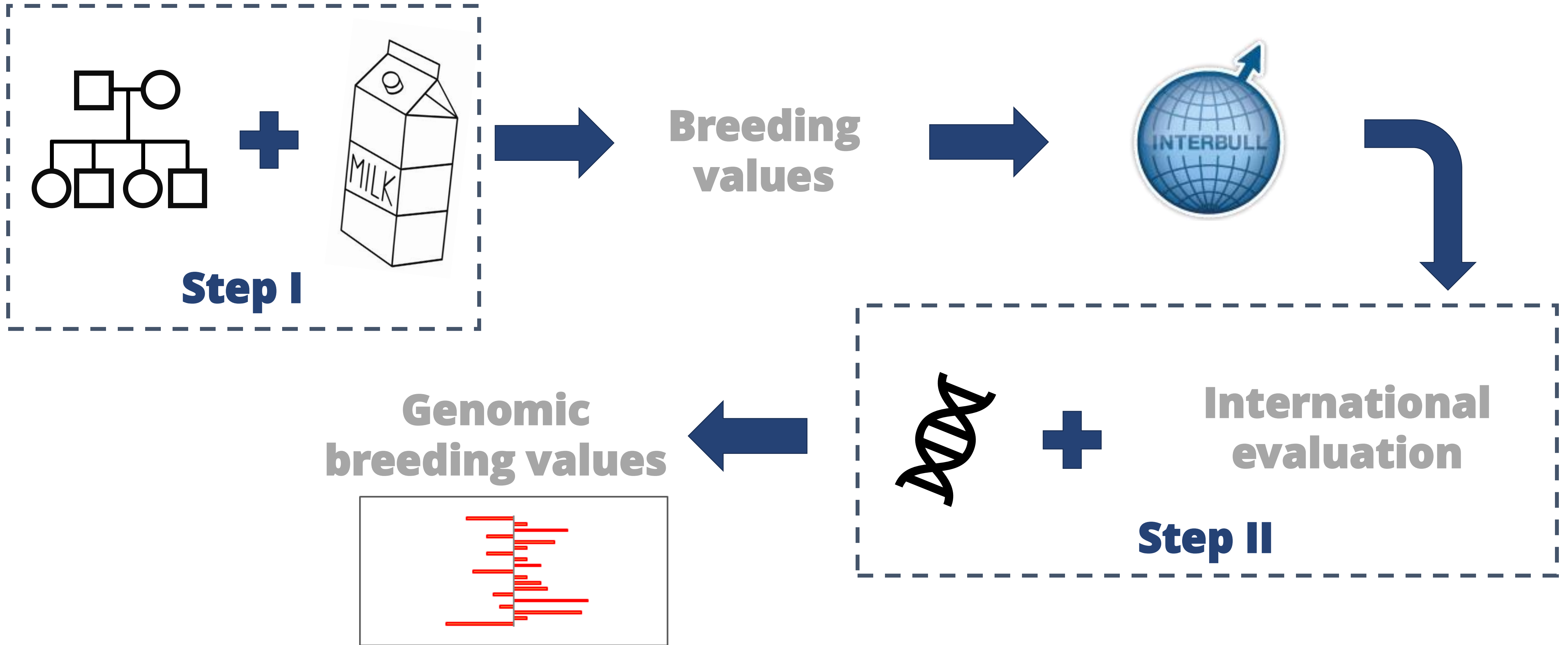
**Breeding
values**



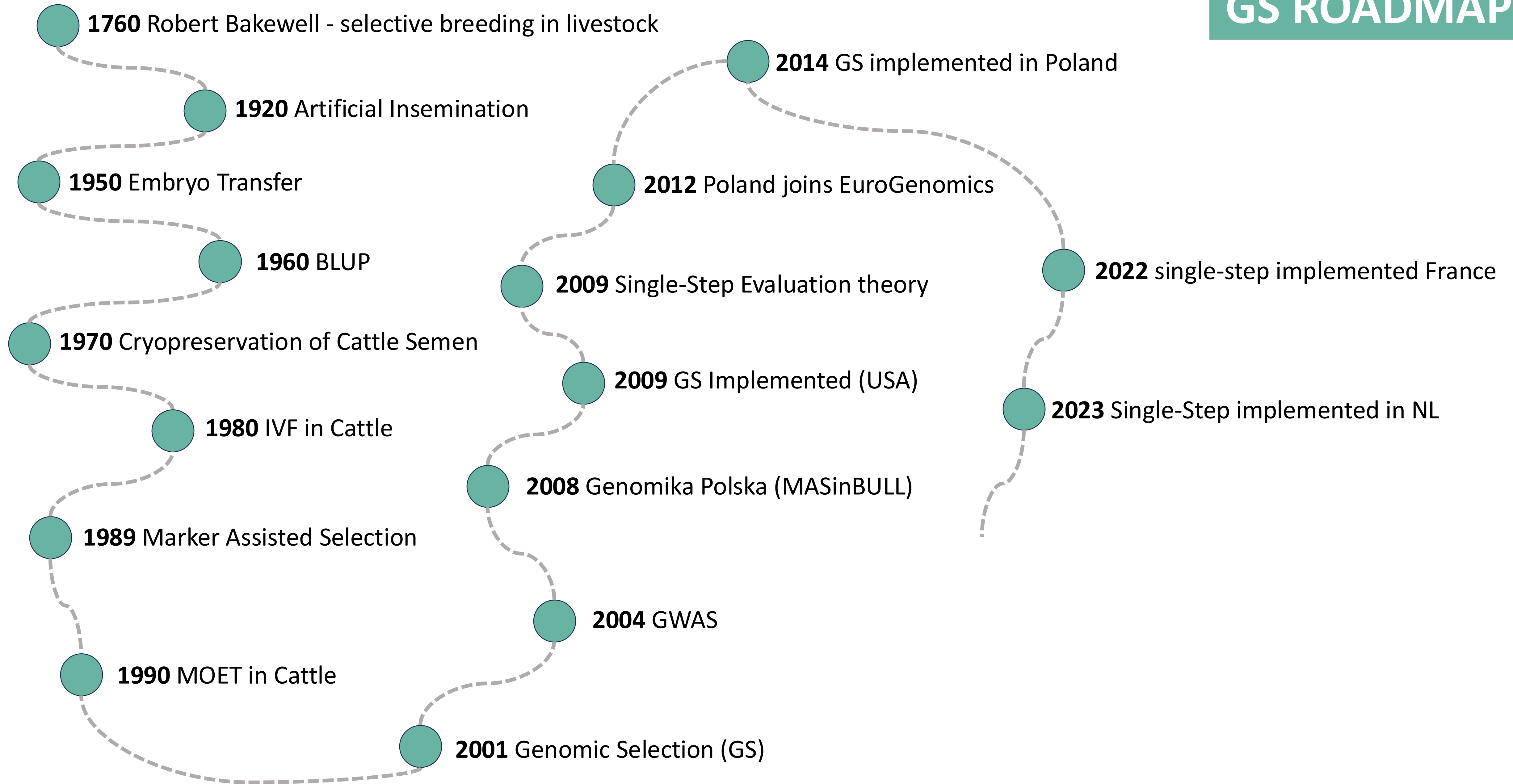
Current BV estimation system in PL



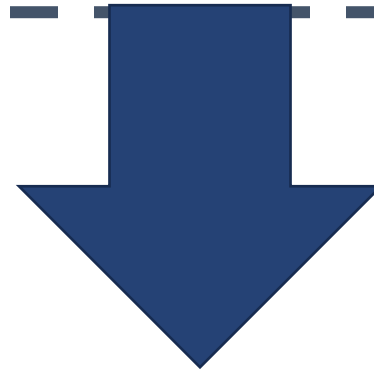
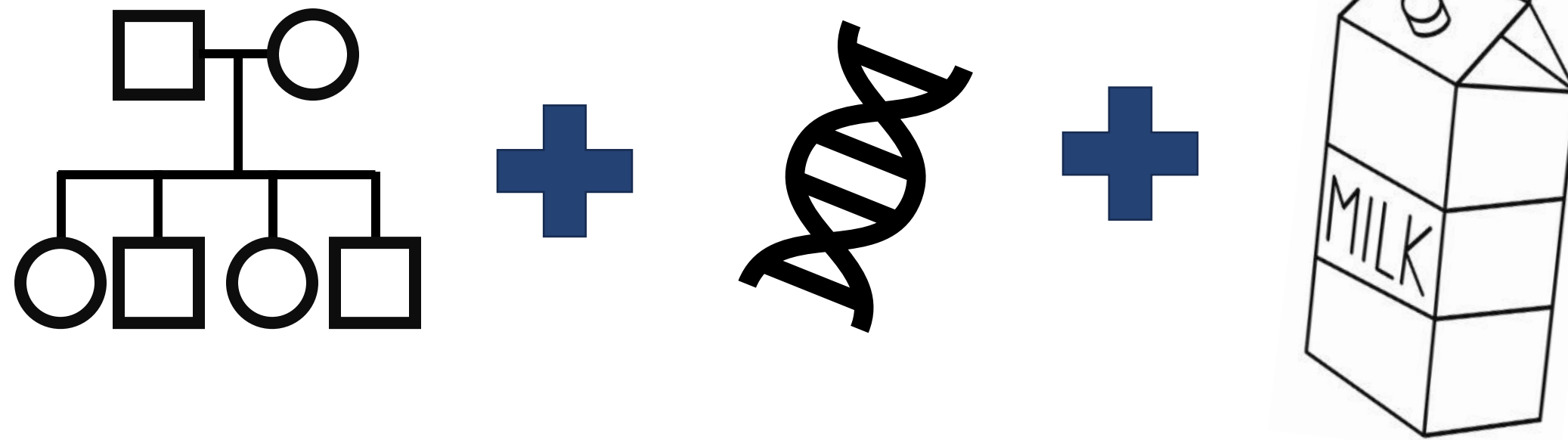
Current BV estimation system in PL



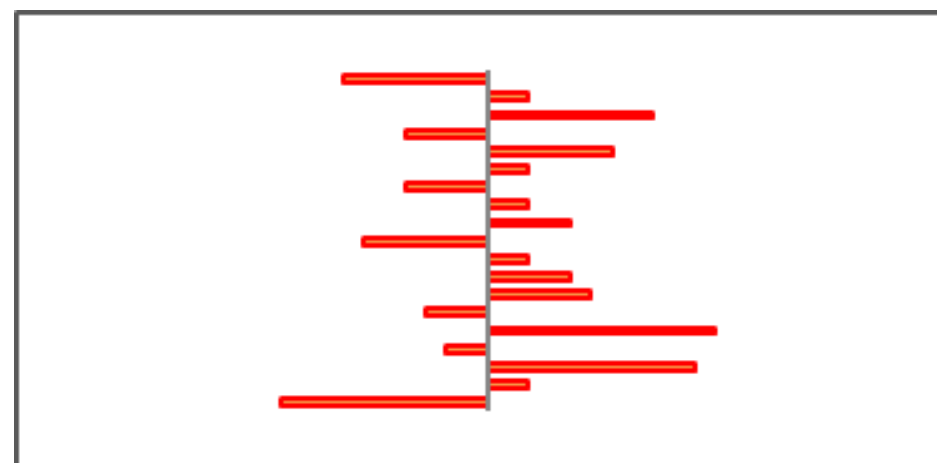
GS ROADMAP



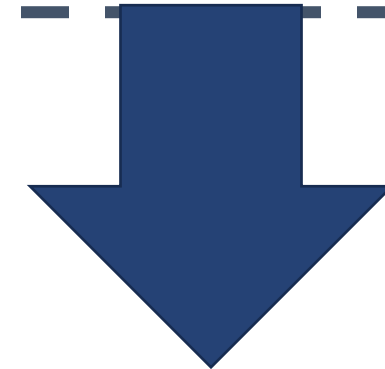
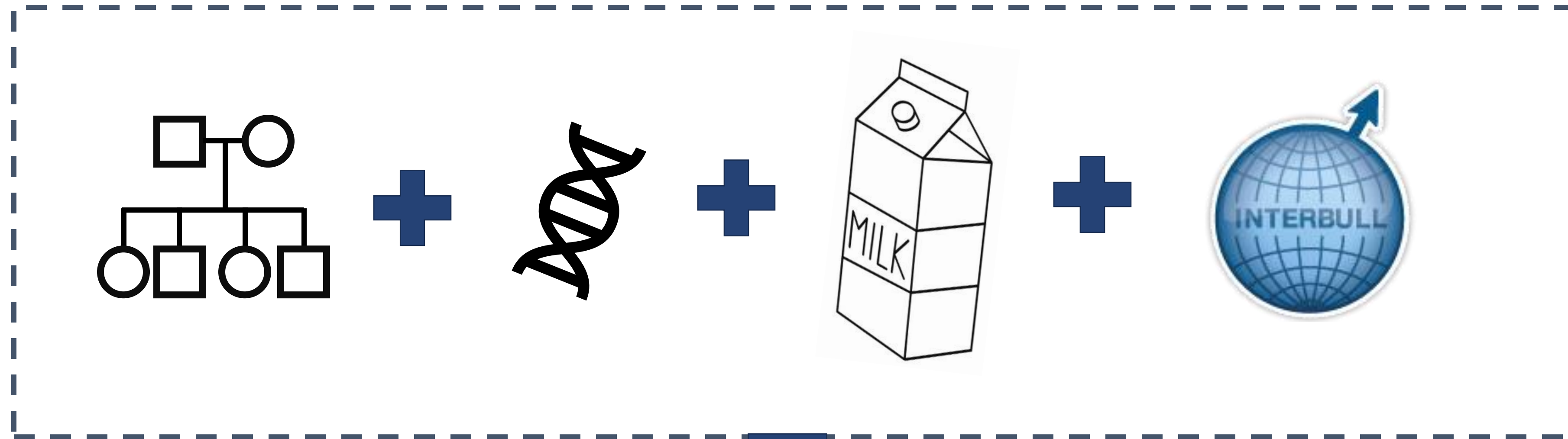
Single-step evaluation



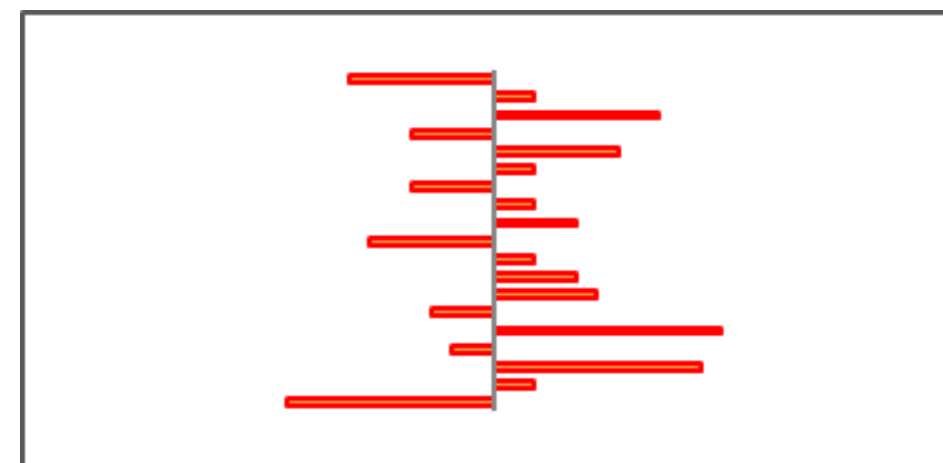
Breeding values



Single-step evaluation + MACE

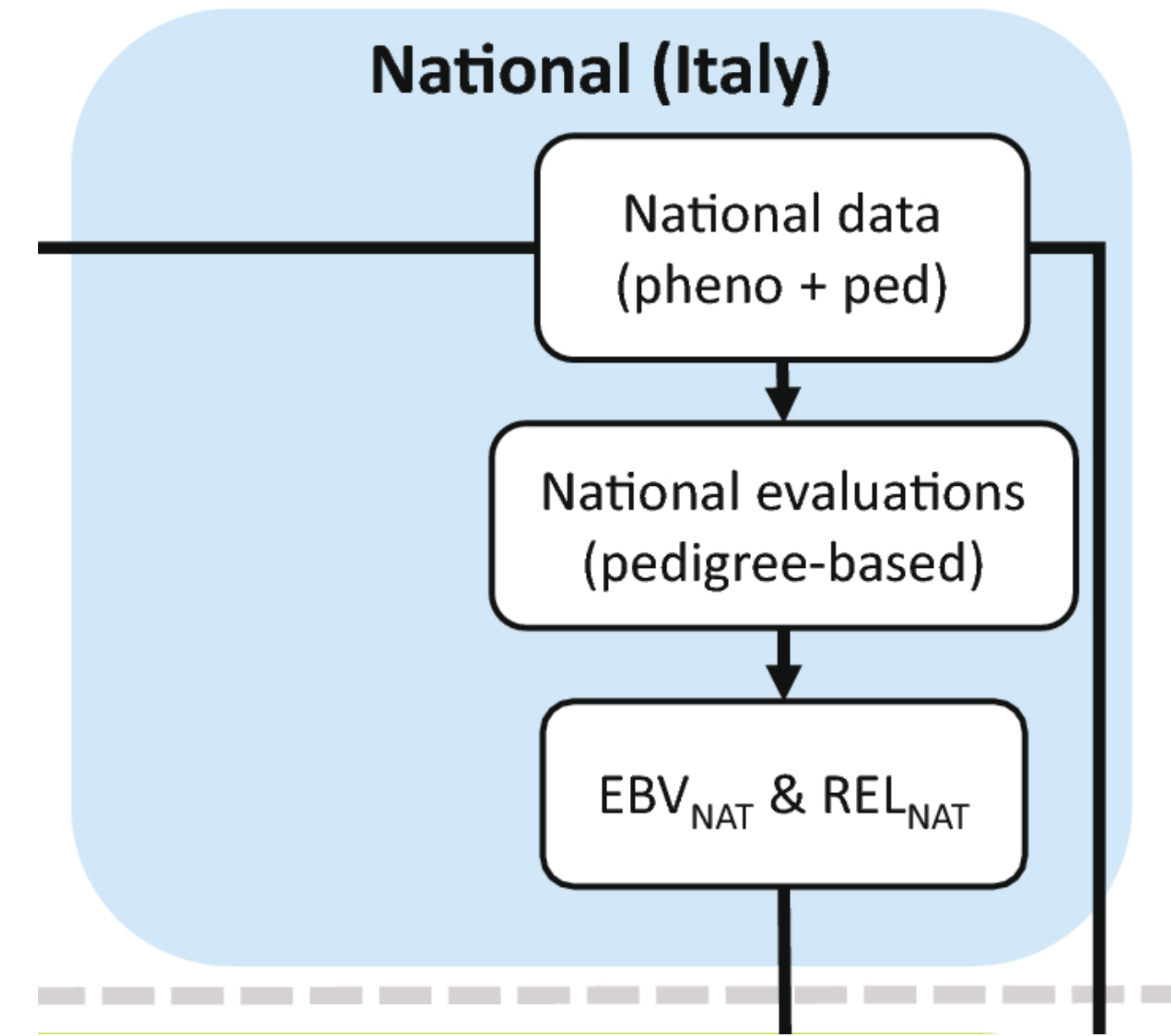


Breeding values

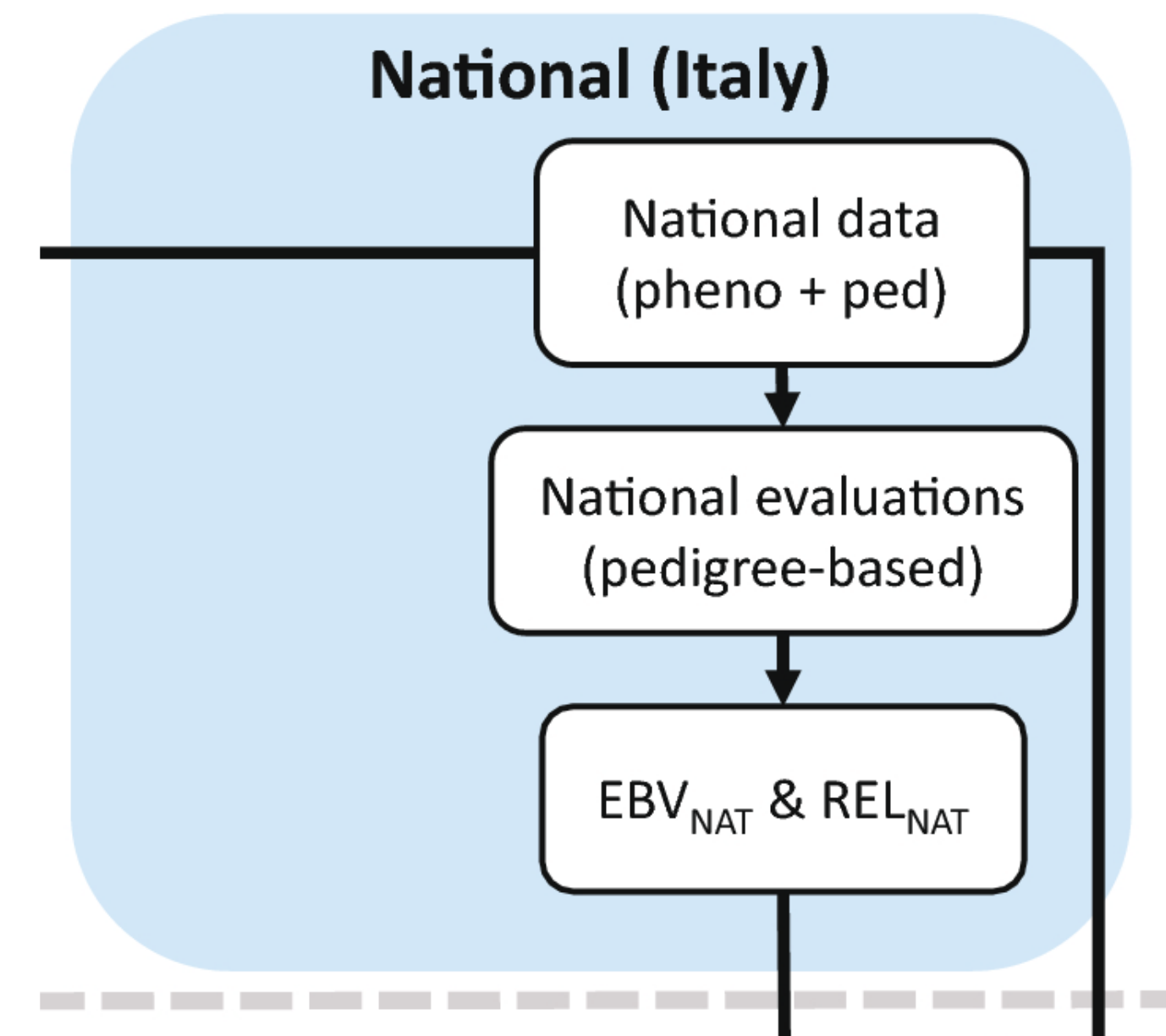
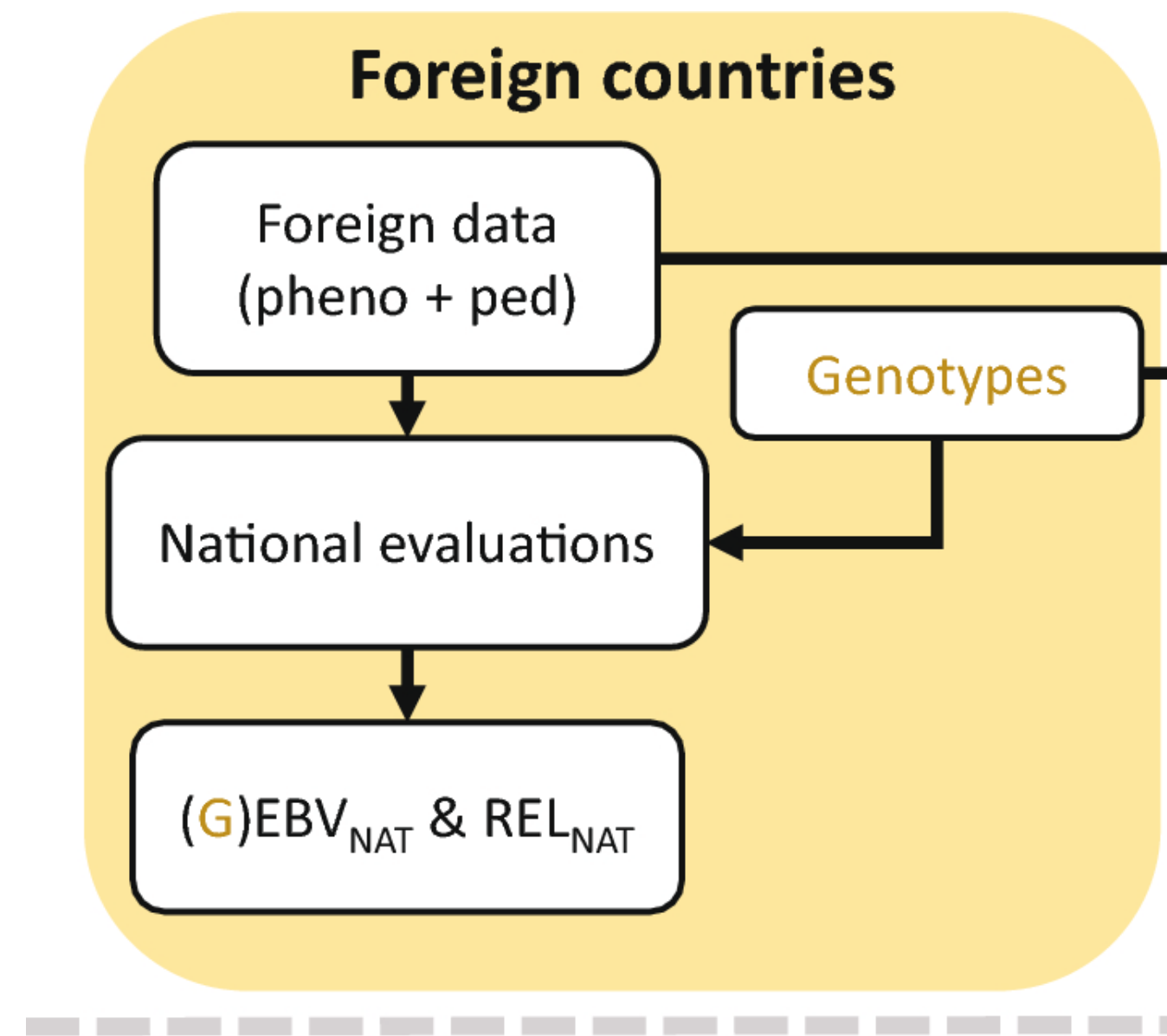


Guarini et al. 2014
Bonifazi et al. 2022, 2023

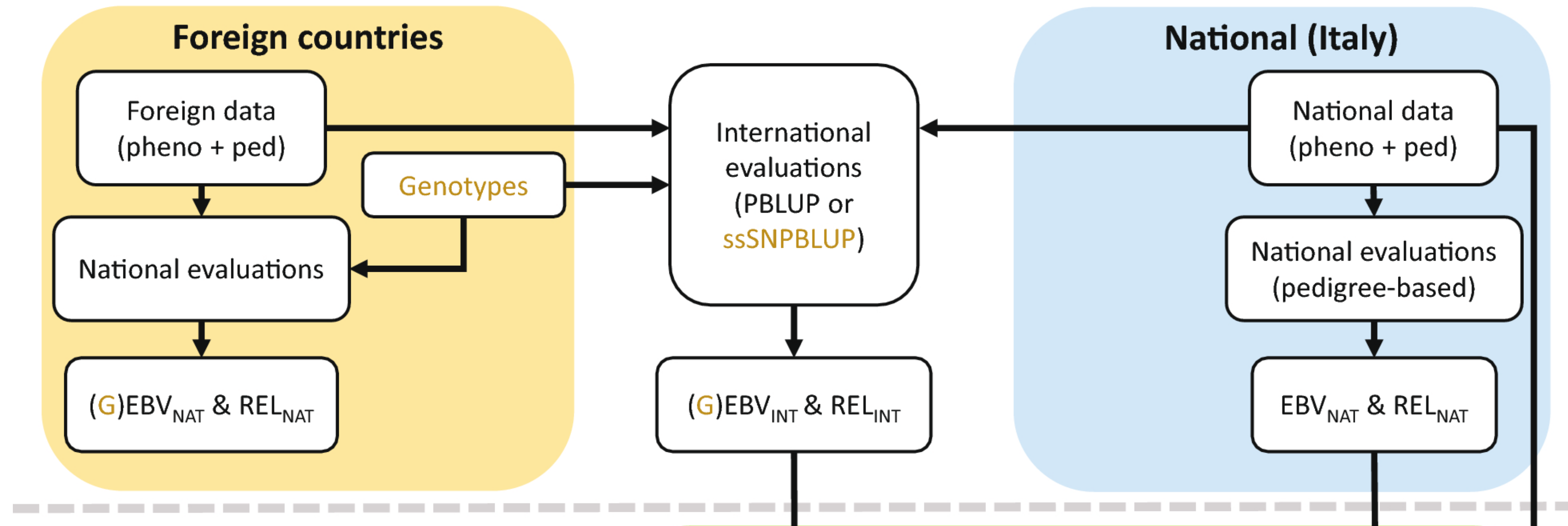
MACE Integration



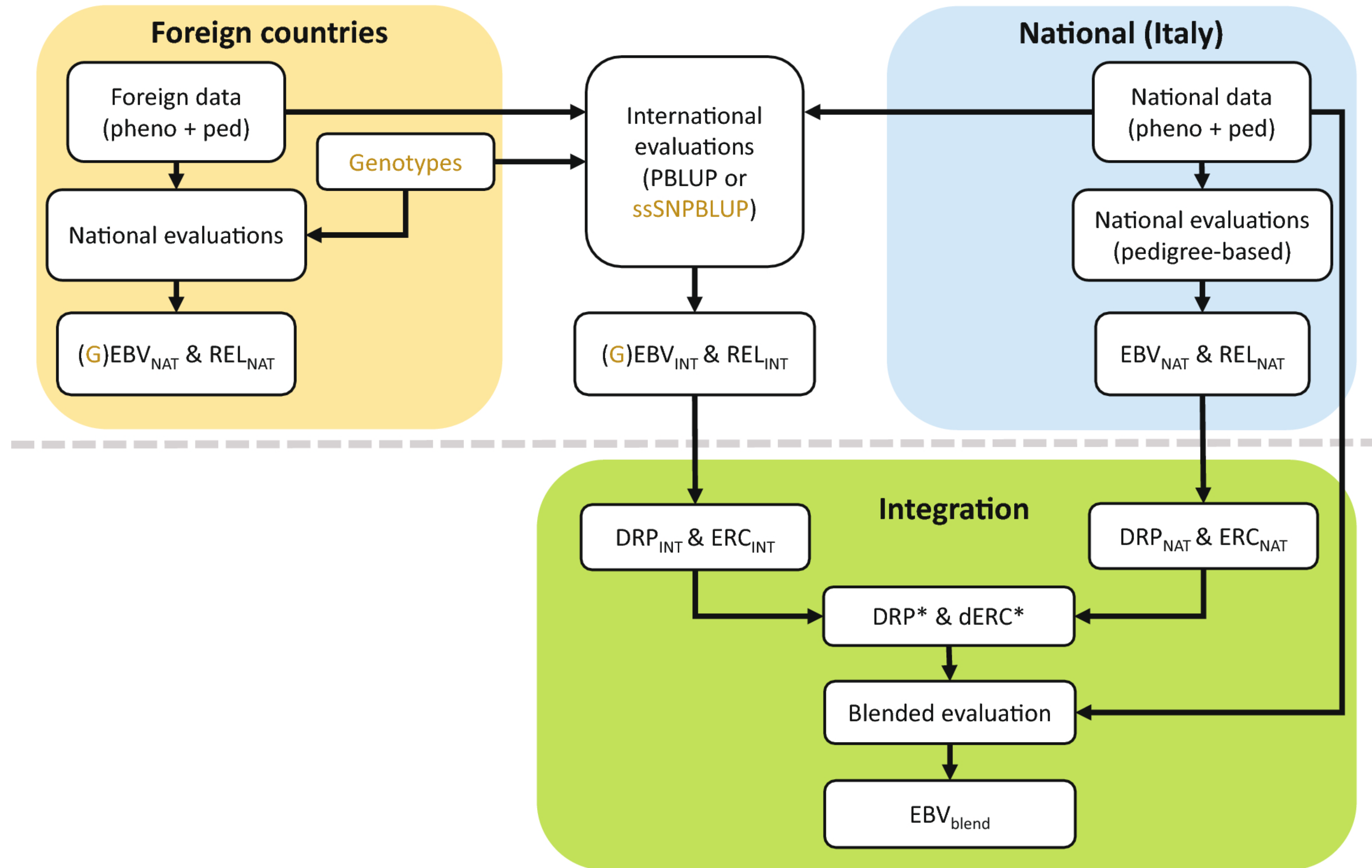
MACE Integration



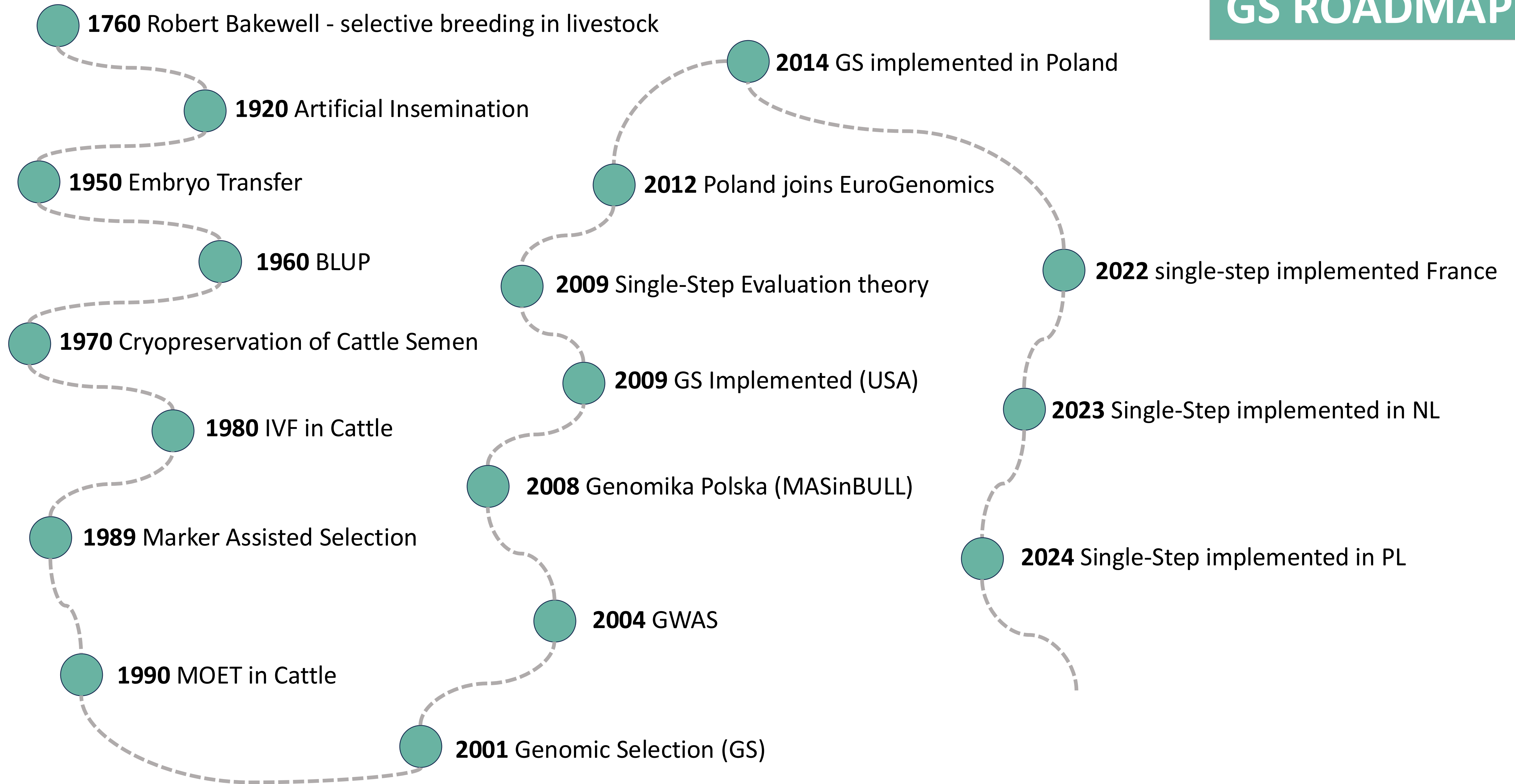
MACE Integration



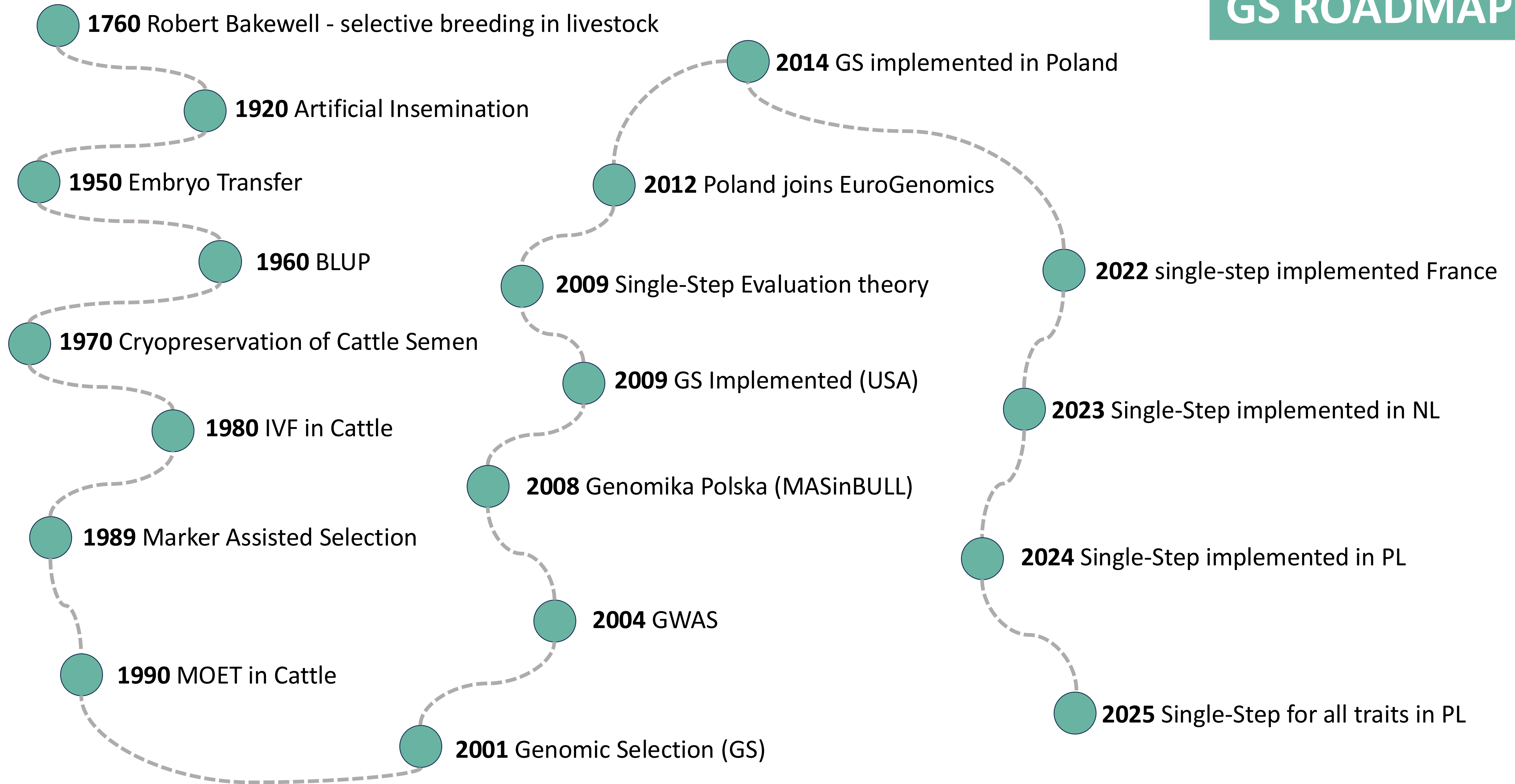
MACE Integration



GS ROADMAP



GS ROADMAP



Changes

- **Multi step -> single-step**
- **Inclusion of novel traits**
- **New trait definitions**
- **Re-modeling existing traits**
- **Inclusion of external MACE information**

Interbull tests

INTERBULL TEST

- **Conformation traits** – Jan 2024
- **Production traits** – Jan 2024

INTERBULL TEST

- **Conformation traits** – Jan 2024 ✓
- **Production traits** – Jan 2024 ✓

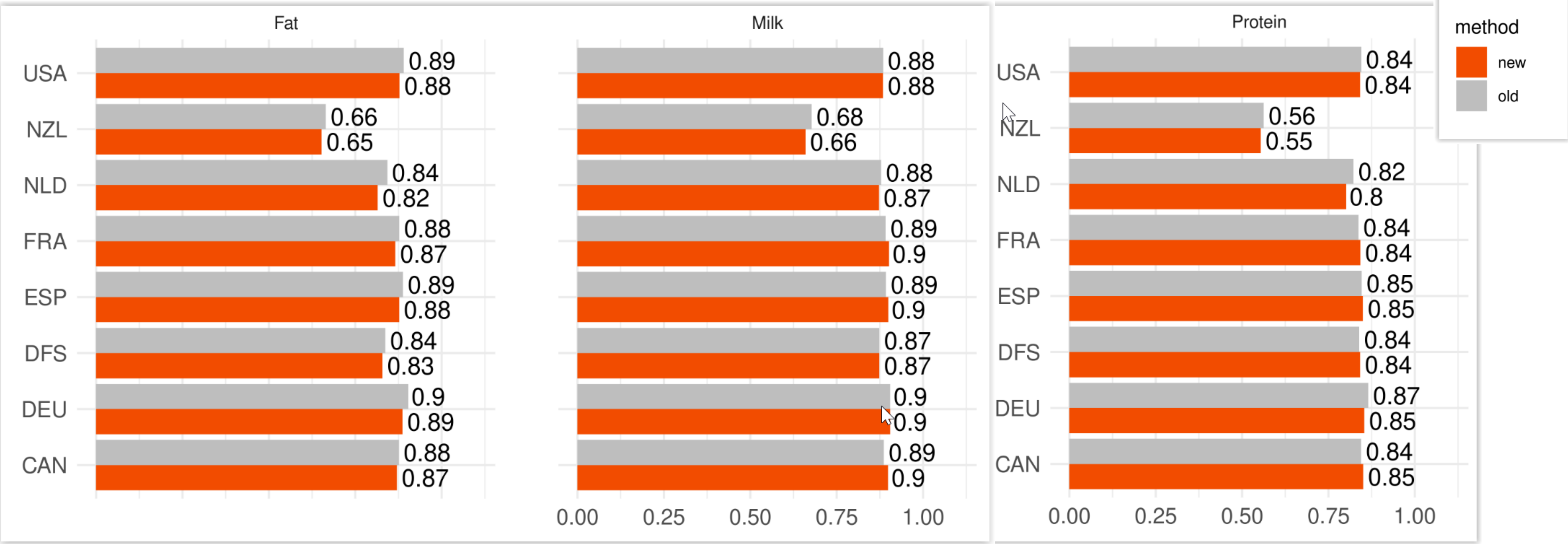
INTERBULL TEST

- **Conformation traits** – Jan 2024 ✓
- **Production traits** – Jan 2024 ✓
- **Remaining traits** – Jan 2025

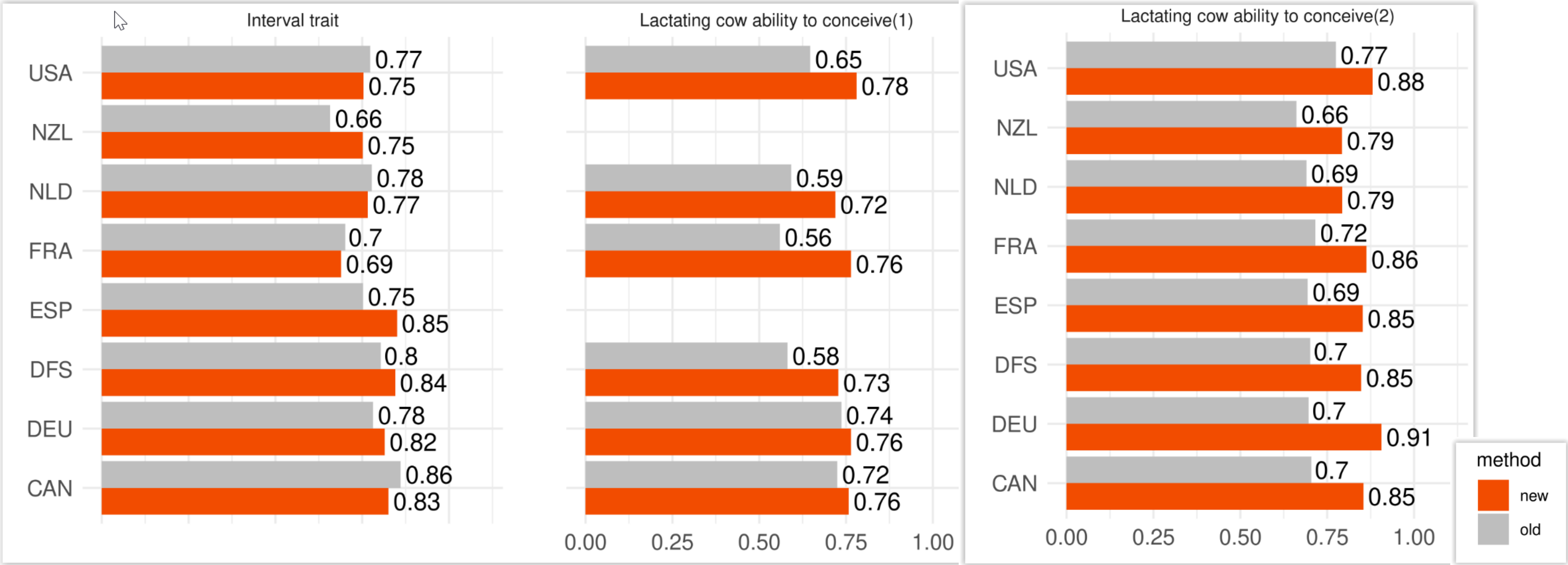
INTERBULL TEST

- **Conformation traits** – Jan 2024 ✓
- **Production traits** – Jan 2024 ✓
- **Remaining traits** – Jan 2025 ✓

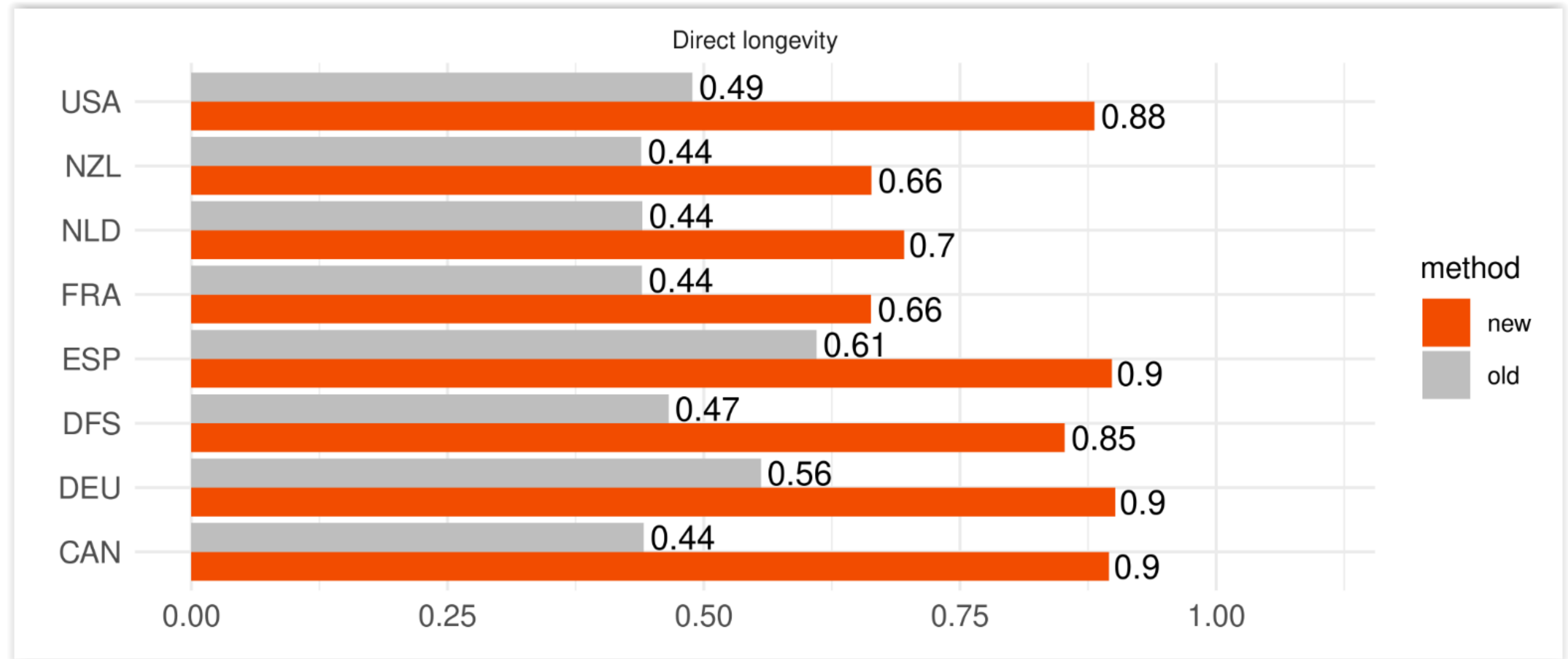
Production – stable correlations



Improved correlations - fertility

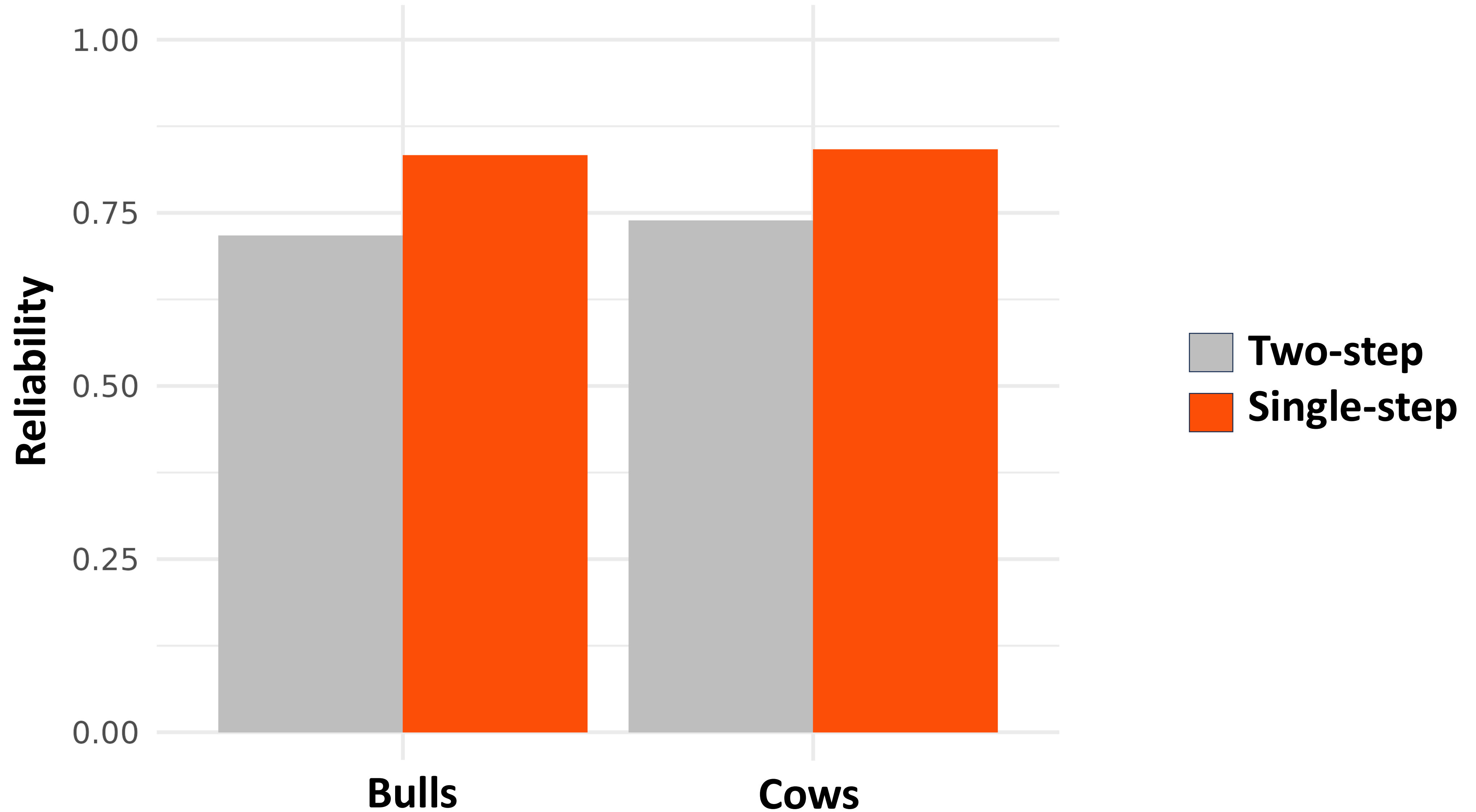


Longevity – high improvement



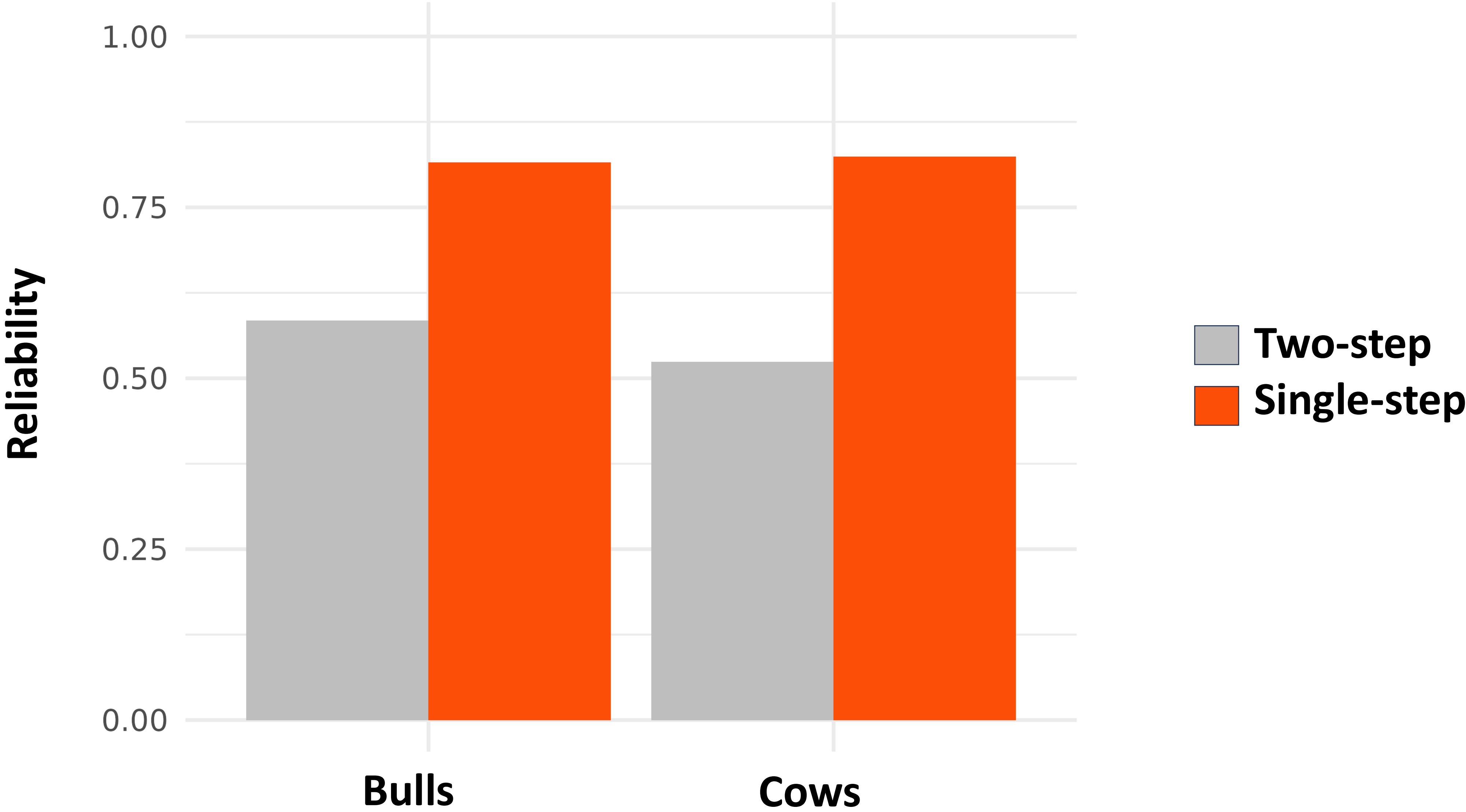
Reliability increase

Milk production



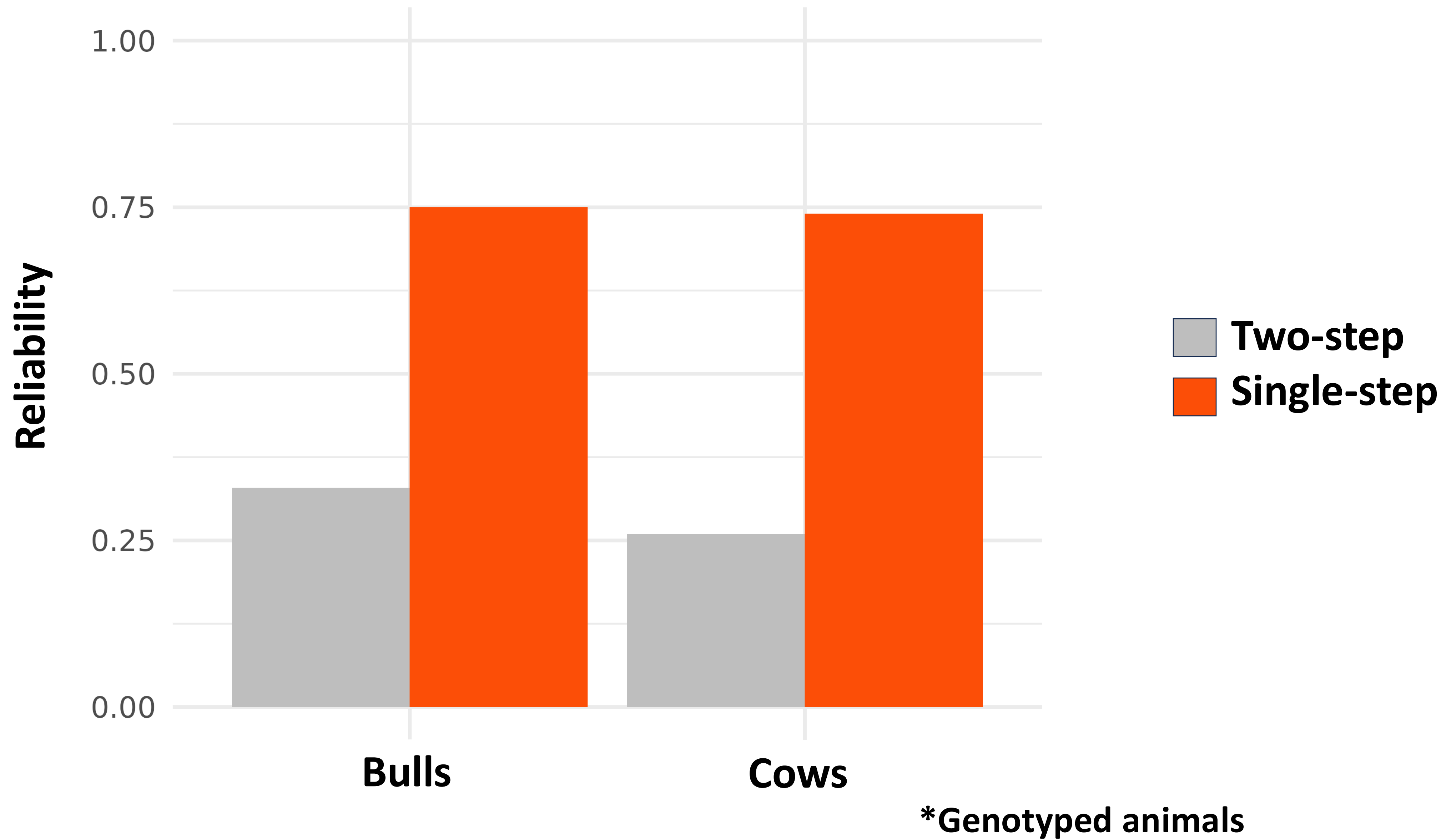
***Genotyped animals**

Body condidtion score

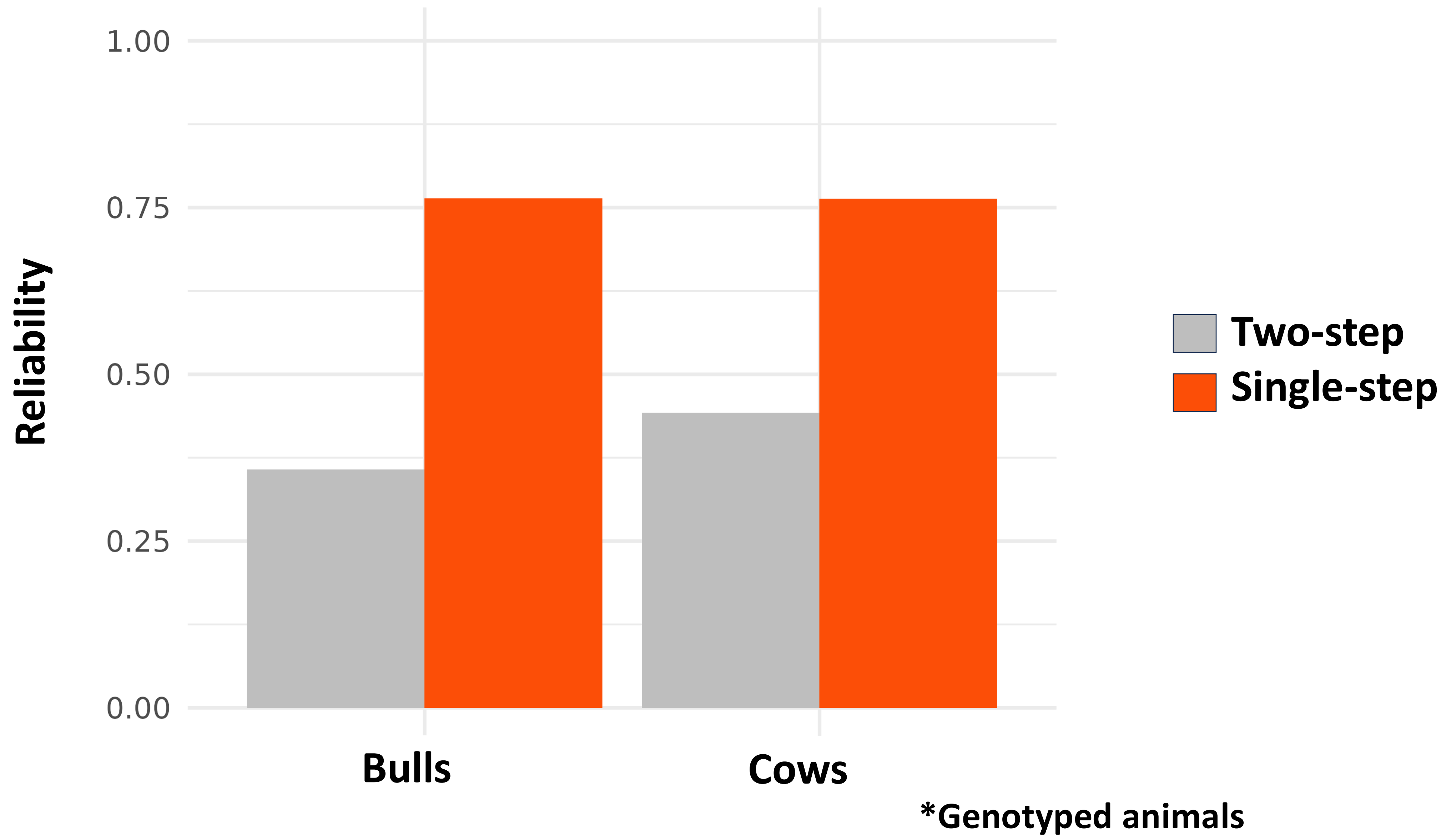


***Genotyped animals**

Udder width



Longevity



Official publication of the results

- **IV 2025**

What next?

- **Implementing novel traits**

New traits in evaluation

- **Phenotypes available**
 - Subclinical ketosis
 - Service period
 - Bone quality
 - Lactation persistency
 - Subclinical mastitis
 - Clinical mastitis

New traits in evaluation

- **Phenotypes available**

- Subclinical ketosis

- Service period

- Bone quality

In progress

- Lactation persistency

- Subclinical mastitis

- Clinical mastitis

New traits in evaluation

- **No phenotypes at the moment**
 - Health traits
 - Feed efficiency
 - Methane emission

Cgen team

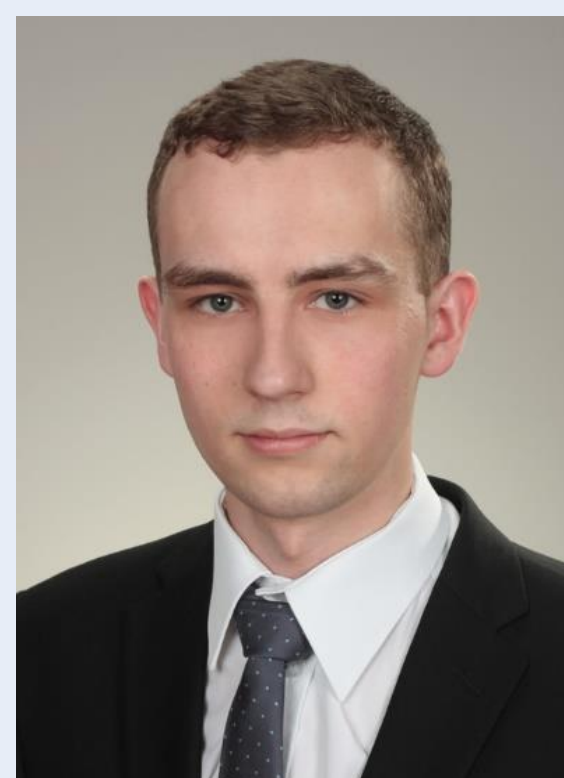
Geneticists



Analytics and knowledge transfer



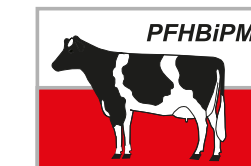
Data scientists



Administration



Acknowledgments



POLISH FEDERATION
OF CATTLE BREEDERS
AND DAIRY FARMERS



WROCŁAW UNIVERSITY
OF ENVIRONMENTAL
AND LIFE SCIENCES



POZNAŃ
UNIVERSITY
OF LIFE SCIENCES



UNIVERSITY
OF AGRICULTURE
IN KRAKOW



UNIVERSITY OF
GEORGIA

Biggest change in the evaluation system since implementing genomic selection!

Biggest change in the evaluation system since implementing genomic selection!

Improved reliability

**Biggest change in the evaluation system
since implementing genomic selection!**

Improved reliability

Better agreement with other countries

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Thank you