Genetic evaluation of twinning rate in Italian Holstein

Galluzzo F[1,2], Visentin G[2], van Kaam JBCHM[1], Finocchiaro R[1],
Marusi M[1], Cassandro M[1,3]

[1]ANAFIBJ, [2]University of Bologna, [3]University of Padova

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Aims

- Develop and implement a routine genetic evaluation of twinning rate (TWI) in the Italian Holstein breed in order to identify the animals with the highest genetic potential for lowering the risk of twinning

Why TWI?

- Risk of abortion during the first 90 days of pregnancy 4 to 7 times higher (especially if same horn of uterus)
- Higher calving difficulty
- Higher risk of stillbirths
- Reduced birth weight
- Higher cow mortality
- Higher risk of reproductive disorders
- Higher risk of metabolic disorders
- Decrease in production
- Increase in days open and number of inseminations per conception

Loss due to twinning
59-161$
(Cabrera & Fricke, 2021)

(Nielen et al, 1989; Gregory et al, 1996; Echternkamp et al, 1999; Silva de Rio et al, 2009; López-Gatius et al, 2023; …)

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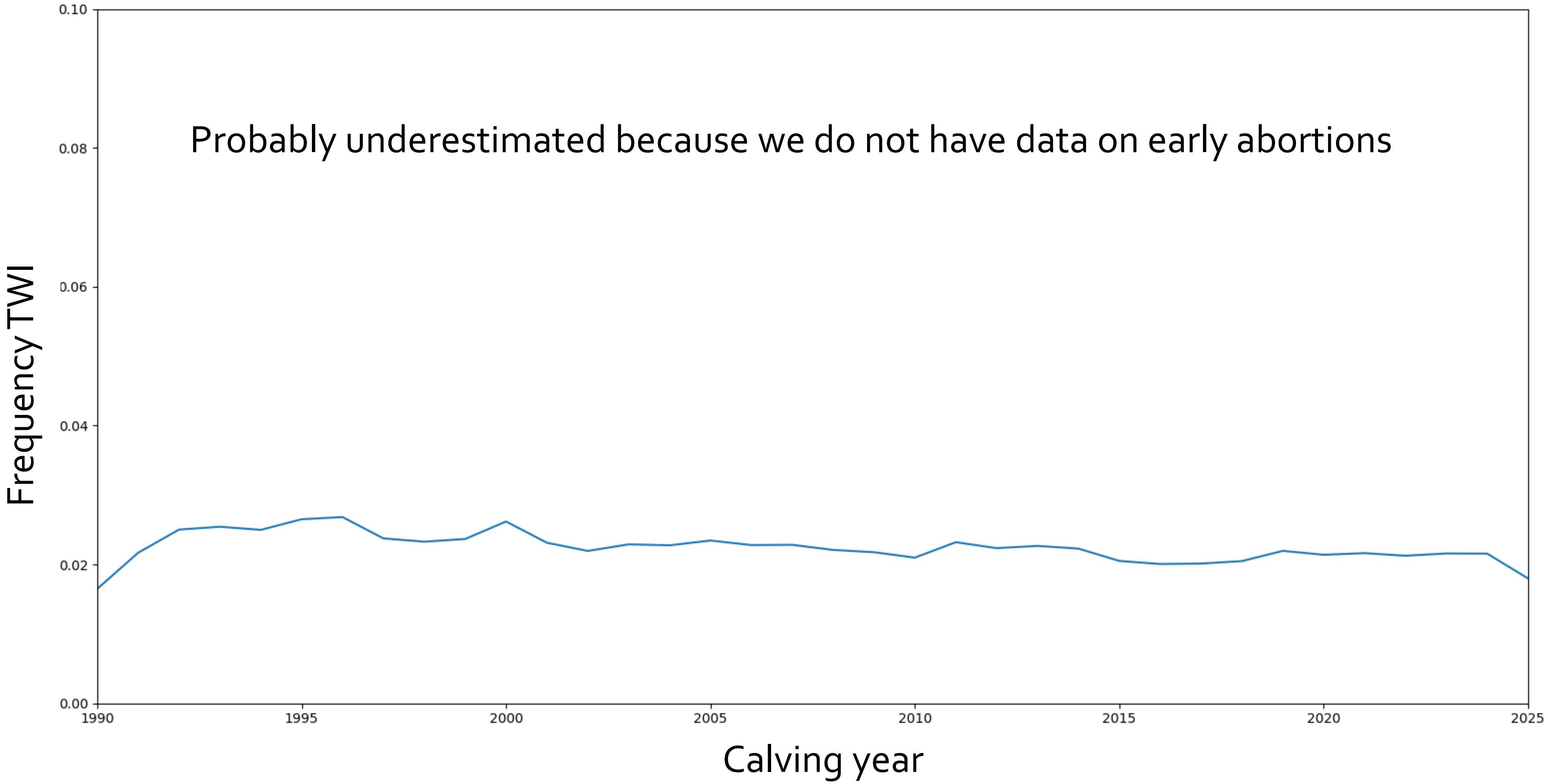
Physiological mechanisms

Mostly dizygotic (from two different oocytes)

Normally:
follicular waves → corpus luteum regression → progesterone (P4) decreases, FSH increases → dominant follicle (DF) → production of estrogen + inhibin → FSH collapse → atresia of other follicles → LH surge → ovulation

- Low inhibin production by the DF
- Fast P4 metabolism → FSH alteration → increased likelihood of codominance

Phenotypic trend



Probably underestimated because we do not have data on early abortions

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Data editing

~20M calvings until April 2025

- Cutoff: 1987
- Max parity: 3
- Age at calving range: 18-77 months
- Gestation length range: 240-315 days
- DIM at conception range: 21-305 days
- AI bulls only
- Minimum number of obs per level of fixed effects: 100
- Minimum number of contemporaries: 10
- Removed extreme categories

Maternal trait
Thanks to a study published in collaboration with University of Padova (*Katende et al, 2025*), we were able to directly apply the linear model and avoid evaluating the direct effect.

Iterative approach to meet all constraints without invalidating any.

Observations after edits: 12M

Modello statistico: MT repeatability linear animal model

$$P_{ijklmnopq} = M_j * Y_k + H_l + \mathrm{SYNC}_m + AGEC\_PAR_n * Y_k + DIM_o + herd\_year_i + a_p + pe_p + e_{ijklmnopq}$$

- $P_{ijklmnopq}$: twin calving phenotypic observation [0/1]
- $herd\_year_i$: herd_year (conception) [R]
- $M_j * Y_k$: year_month (conception) [F]
- H_l: herd (conception) [F]
- SYNC_m: synchronization protocol [F]
- $AGEC\_PAR_n * Y_k$: 9 classes of $AGEC\_PAR_n$ (age-at-calving_parity) by year of conception [F]
- DIM_o: DIM class [F]
- a_p: additive genetic (dam) [R]
- pe_p: permanent environment (dam) [R]

Results

Software: THRGIBBS1F90 *(Misztal et al, 2014)*
Obs: 635,026 (500 herds)
Convergence: R package BOA *(Smith, 2007)*

Heritability
0.01 (0.001)

Genomic validation

Multi-step genomic evaluation (EDPs as pseudo-phenotypes)

MiX99 (*MiX99 Development Team, 2022*) + GS3 (*Legarra et al, 2011*)

Full run and reduced run (YYYY-4)

$$EDP_{full} = a + bDGV_{red} + e$$

Trait	N_training	b
TWI	4,070	0,94

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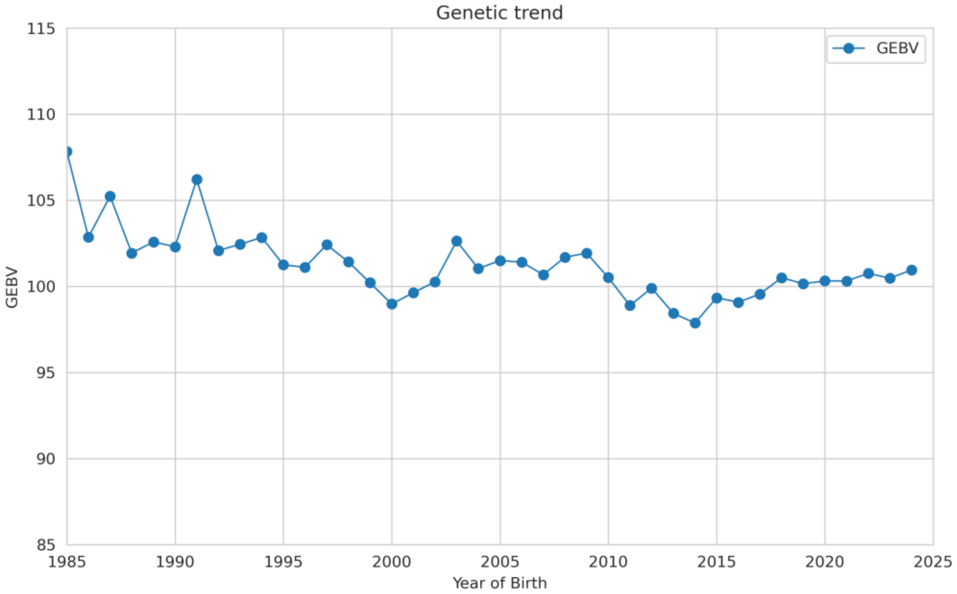
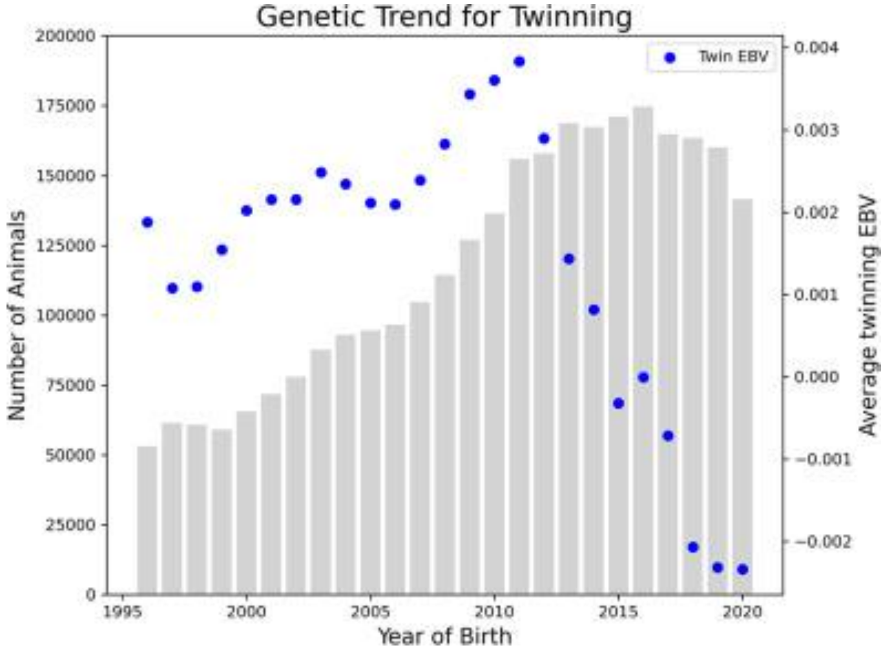
Trend GEBV (> 100 = lower TWI)





(Kirkpatrick & Berry, 2024)

Genetic trend consistent with literature results.
Hp: selection for functional traits (fertility, longevity) may have had an indirect impact on TWI.

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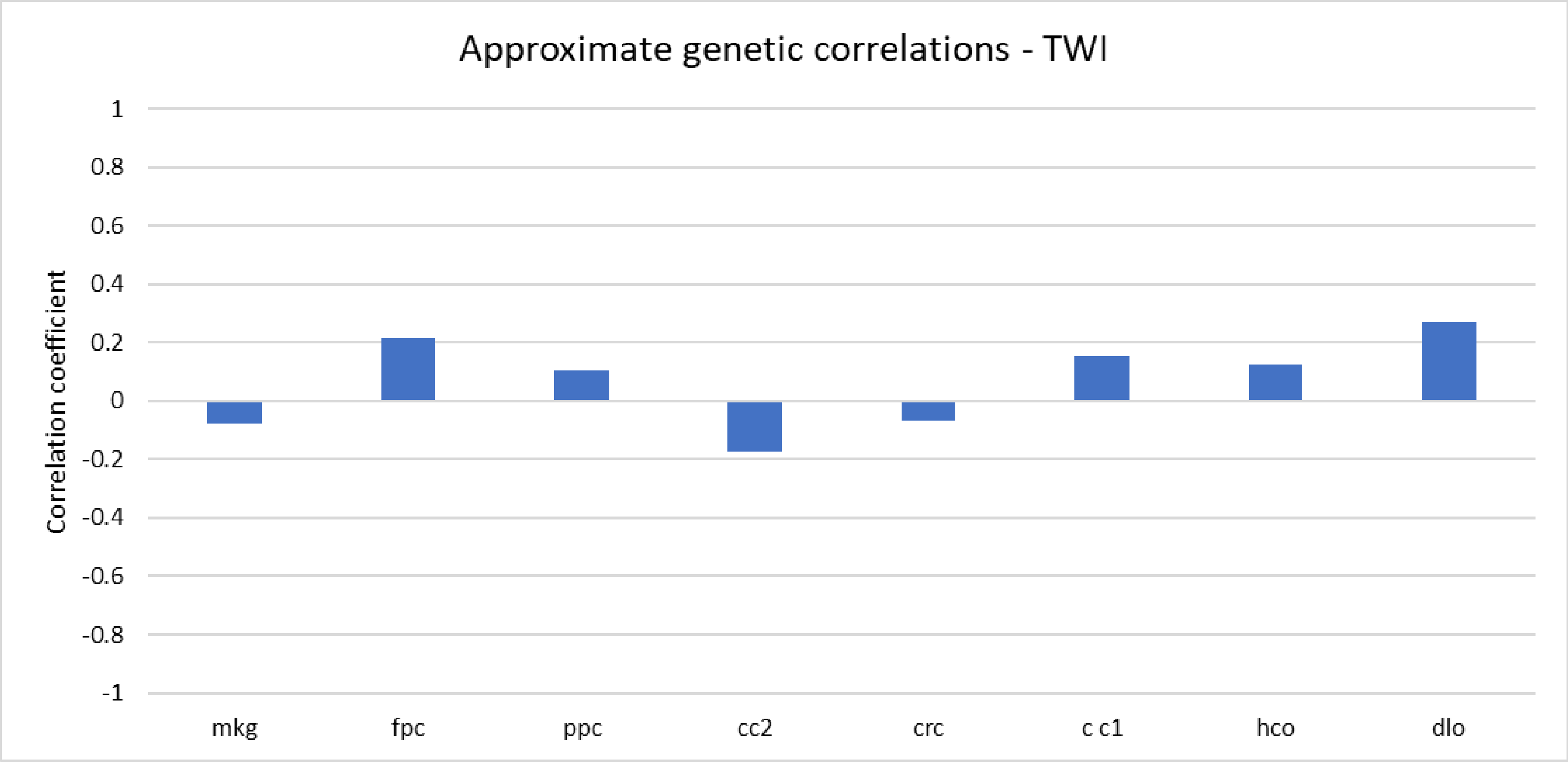
Approximate genetic correlations



n = 3,200 females born in 2025

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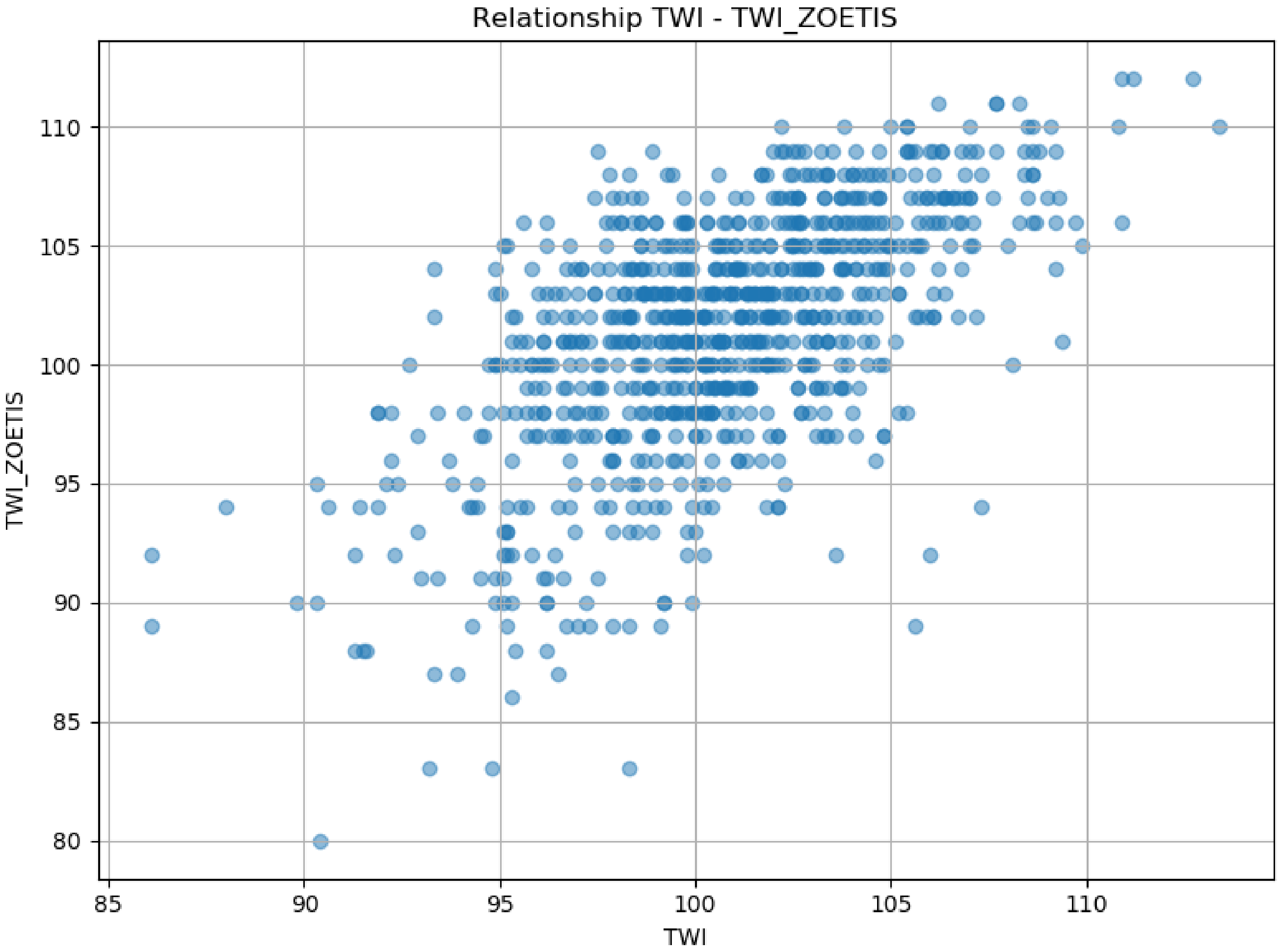
Relationship with ZOETIS TWI (threshold model)



n_common = 862
pearson_r = 0.61 (0.0)

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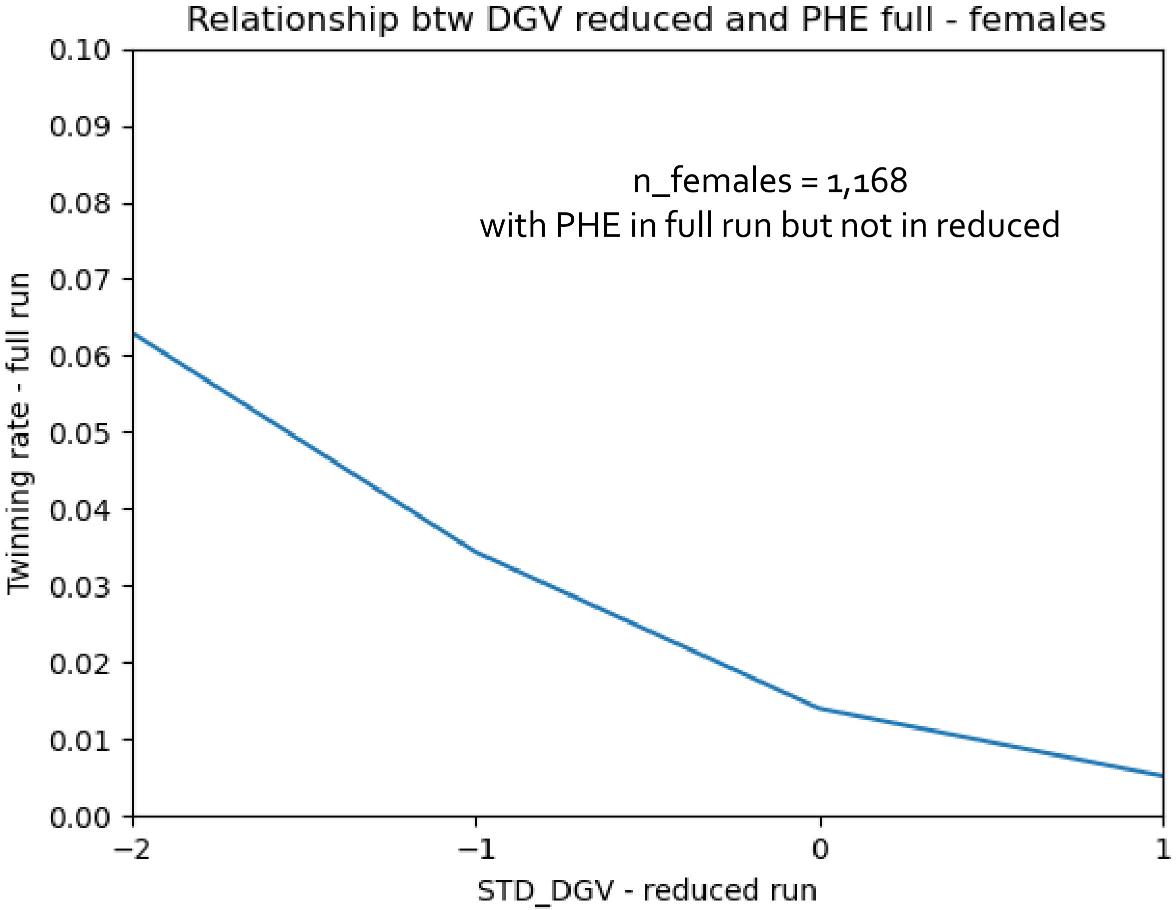
GENO-PHENO relationship



n_females = 1,168
with PHE in full run but not in reduced

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Take home messages

- Selection against twinning is feasible and can have an impact at farm level
- Genetic correlations didn’t reveal risks in including TWI in the maternal calving composite index for Italian Holstein
- The developed model is stable enough and suitable for routine genetic evaluation

This trait is planned to be part of the Italian Holstein routine genetic evaluation (after CTC approval)

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Thanks for your attention

Ferdinando Galluzzo

ferdinandogalluzzo@anafibj.it

www.anafibj.it

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