

Multi-breed multi-trait single-step genomic predictions for Holstein and Jersey including crossbred animals

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Crossbreeding and genomic predictions

Advantages

- Heterosis
 - Breed Complementarity
 - ↓ Inbreeding
 - ↑ Fertility
 - ↑ Longevity
- Reference population difficult to establish
 - SNP and QTL effects may differ across breeds due to differences in:
 - genetic backgrounds
 - LD between QTL-SNPs
 - environment

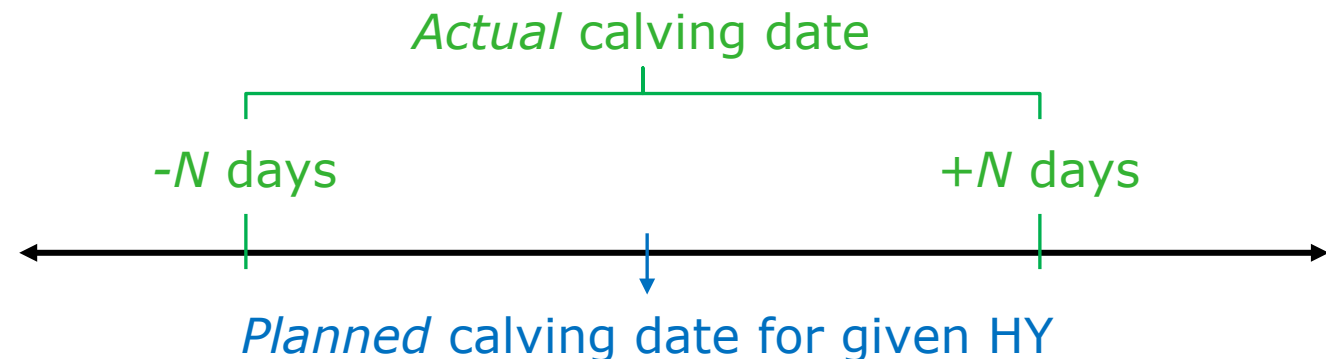
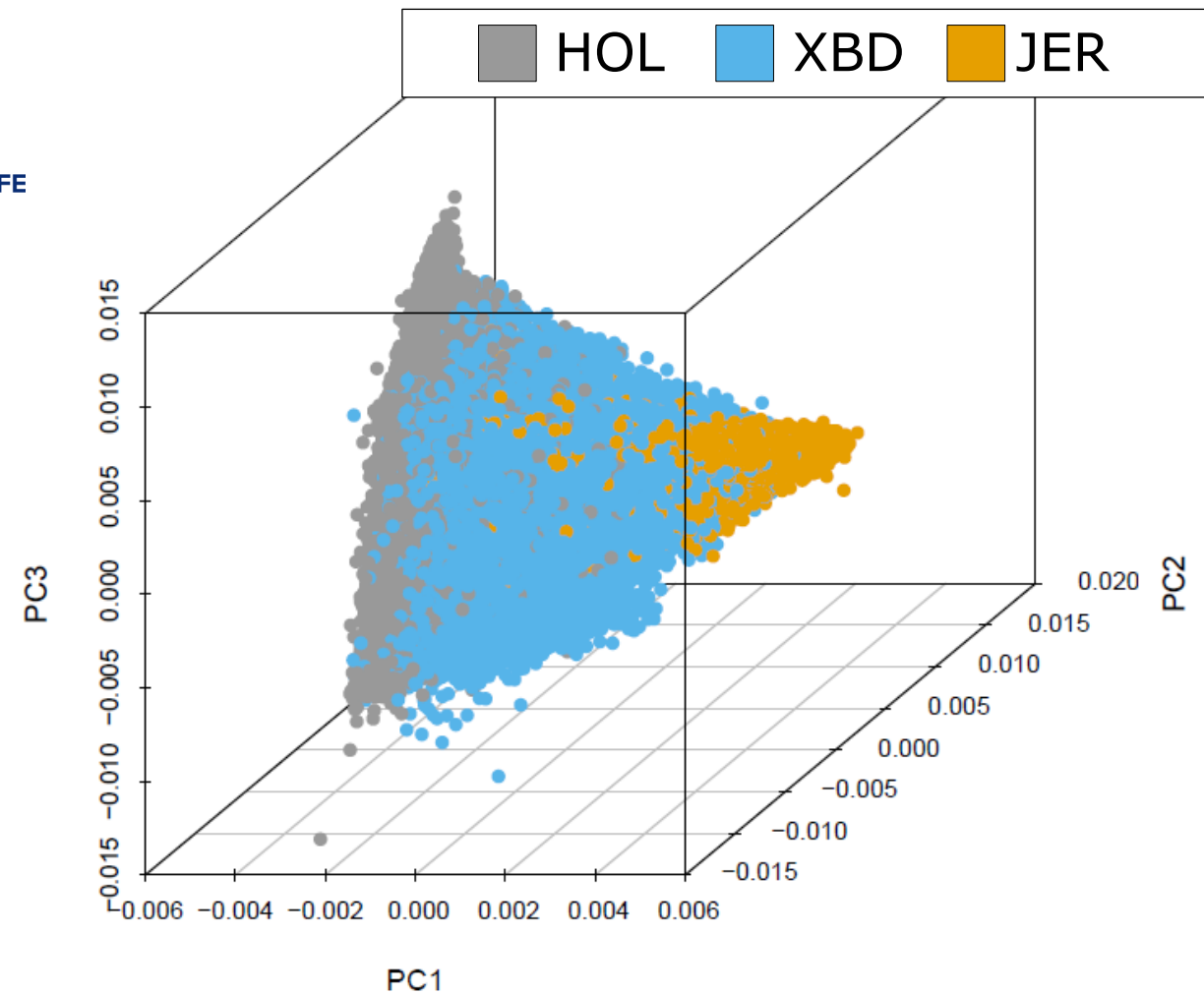
Aim of the study

- Identify the **best** scenario for **multi-breed** single-step evaluations
 - Two purebred populations (PBD)
 - Derived crossbred population (XBD)
- Impact of modelling **missing pedigree information** using genetic groups or meta-founders

Data available



- **Pedigree** (~1,1 M)
 - Purebred HOL & JER, and XBD
- **Genotypes** ~127K, 80K SNPs
- **Phenotypes**
 - Milk yield (~538K) $h^2 = 0.31$
 - CSD (~370K) $h^2 = 0.05$
 - $r_{g \text{ milk, CSD}} = 0.22$



Scenarios

r_g between breeds

- **Single-breed** reference population (**SINGLE**)
 - 3 separate evaluations (with 255 GG)
- **Multi-breed** reference population using :
 - 255 genetic groups : **ALL**
 - 4 genetic groups : **ALL_4GG**
 - 255 metafounders : **ALL_255MF**
 - 4 metafounders : **ALL_4MF**
- **Multi-breed multi-trait** approach (**MBMT**): breeds as traits



Validation

- LR method (Legarra & Reverter, 2018)
- Forward-in-time: whole vs partial dataset
- Cut-off: last 6 years phenotypes removed

Breed	Cows	Bulls
HOL	~ 9K	~ 350
JER	~ 4K	~ 170
XBD	~ 13K	~ 130
<i>Total</i>	<i>~ 27K</i>	<i>~ 650</i>

- Validation groups, by breed:
 - Cows: with genotyped & phenotype for milk and/or CSD, born after cut-off
 - Bulls: genotyped & ≥ 20 daughters with phenotypes for milk and/or CSD born after cut-off and no daughters with records born before cut-off

Software

- GEBVs estimation using ssSNPBLUP
- (pedigree-based) VCE for MTMB scenario: BLUPF90 (gibbs & postgibbs)
- Validation: R functions

MiBLUP



Genetic correlations between traits and breeds

		CSD			Milk		
		HOL	JER	XBD	HOL	JER	XBD
CSD	HOL	0.03 (0.00)					
	JER	0.59 (0.09)	0.04 (0.01)				
	XBD	0.93 (0.03)	0.66 (0.06)	0.03 (0.00)			
Milk	HOL	0.41 (0.05)	-0.02 (0.10)	0.47 (0.05)	0.24 (0.01)		
	JER	0.55 (0.06)	0.24 (0.07)	0.70 (0.06)	0.82 (0.05)	0.27 (0.02)	
	XBD	0.34 (0.04)	-0.03 (0.10)	0.46 (0.04)	0.96 (0.01)	0.87 (0.03)	0.26 (0.01)

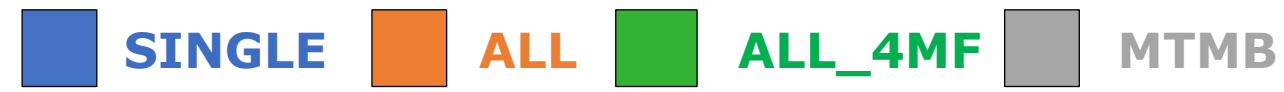
Metafounders

- ALL_4MF

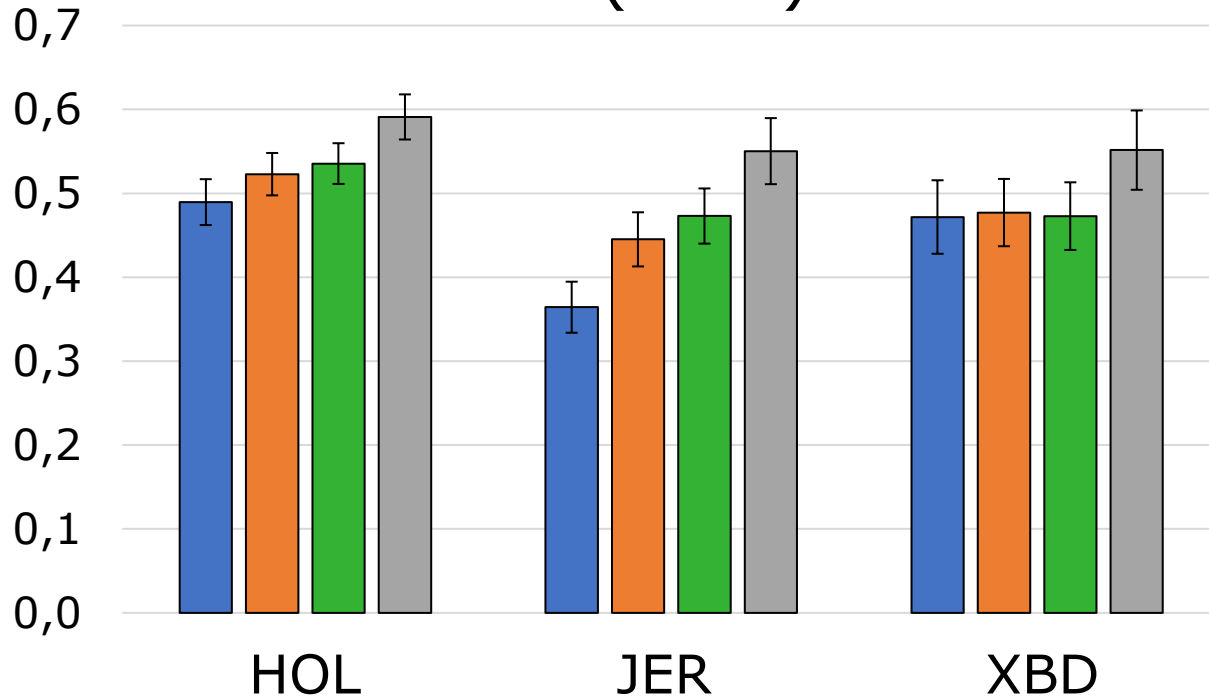
Γ matrix

	HOL	JER	XBD	OTHER
HOL	<i>0.93</i>	0.78	0.83	0.57
JER		<i>0.72</i>	0.75	0.54
XBD			<i>0.78</i>	0.56
OTHER				<i>0.77</i>

Accuracy partial EBV

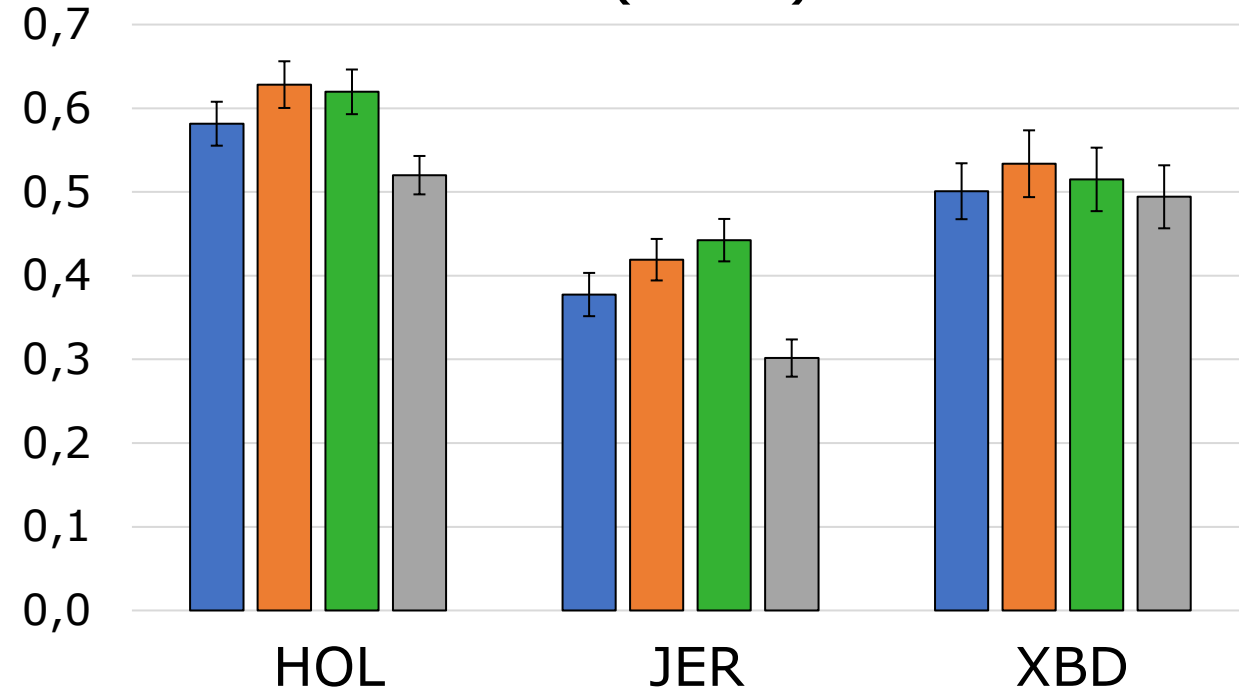


Milk (Bulls)



- MTMB: highest accuracy
- ALL, ALL_4MF
- SINGLE: lowest accuracy

CSD (Bulls)



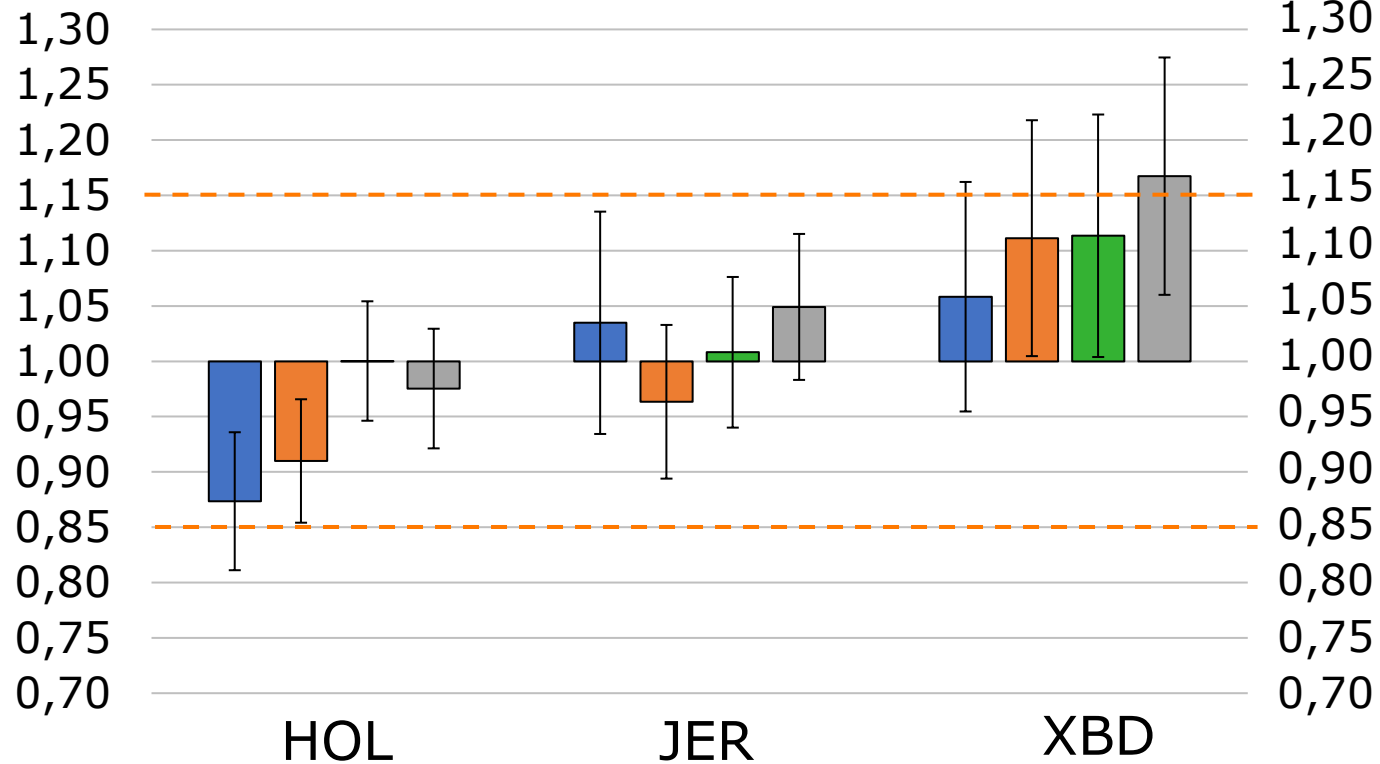
- ALL, ALL_4MF: increased accuracy compared to the SINGLE (2nd lowest)
- MTMB: lowest accuracy

- Similar results for cows (smaller SE)
- Similar results between: ALL, ALL_255MF, ALL_4GG, ALL_4MF

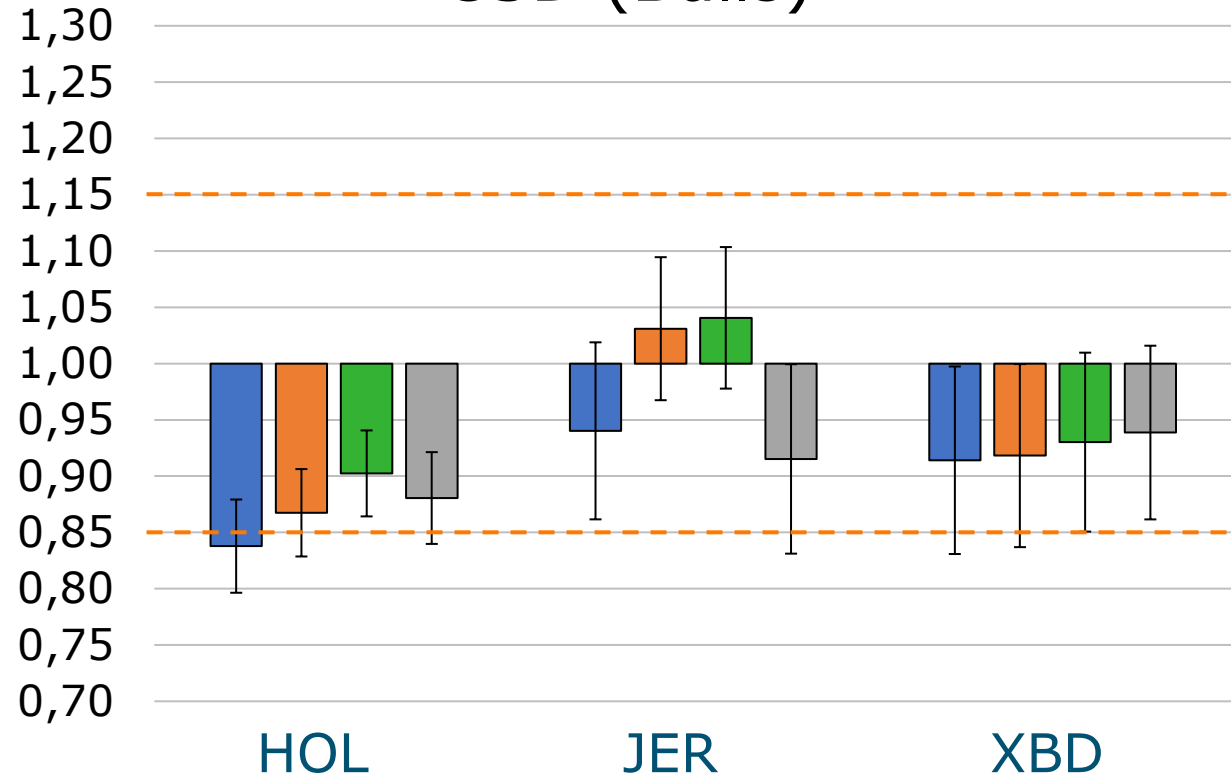
Dispersion



Milk (Bulls)



CSD (Bulls)



- **Dispersion within $\pm 15\%$** (except milk-XBD bulls, CSD-HOL bulls)
- Milk: both **over/under-dispersion**. CSD: mainly **over-dispersion** (except JER bulls).
- Cows have less dispersion and smaller SE
- Similar results for **level bias**: overall smaller for Milk (within $\pm 0.05 \sigma_A$) than CSD (within $\pm 0.1 \sigma_A$)

Conclusions

- Benefit of combining data in multi-breed evaluations for PBD and XBD
- Reduce n. GG (similar results with 255 and 4)
- Limited added benefit of using metafounders instead of GG
- MTMB accuracy highest for milk - lowest for CSD
- Further investigations using conformation traits

Acknowledgments



Conclusions

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Thanks for your attention

Additional slides

Bulls and cows

Accuracy partial EBV



SINGLE



ALL



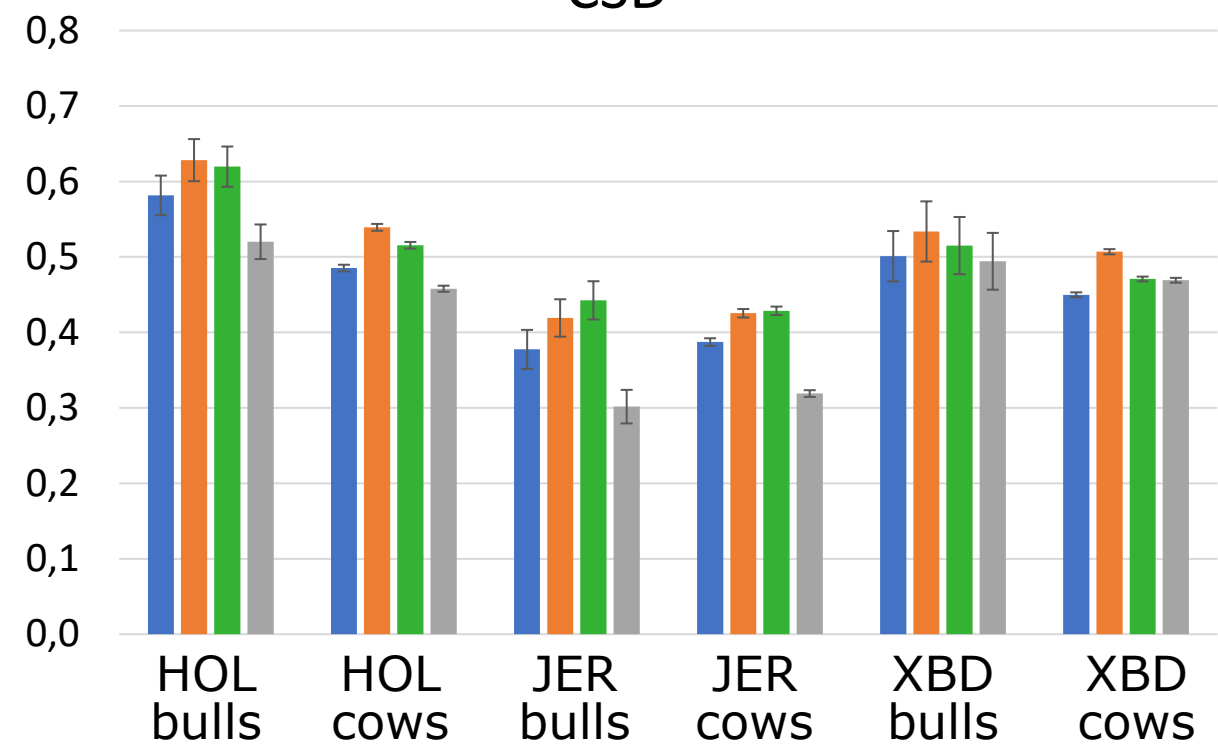
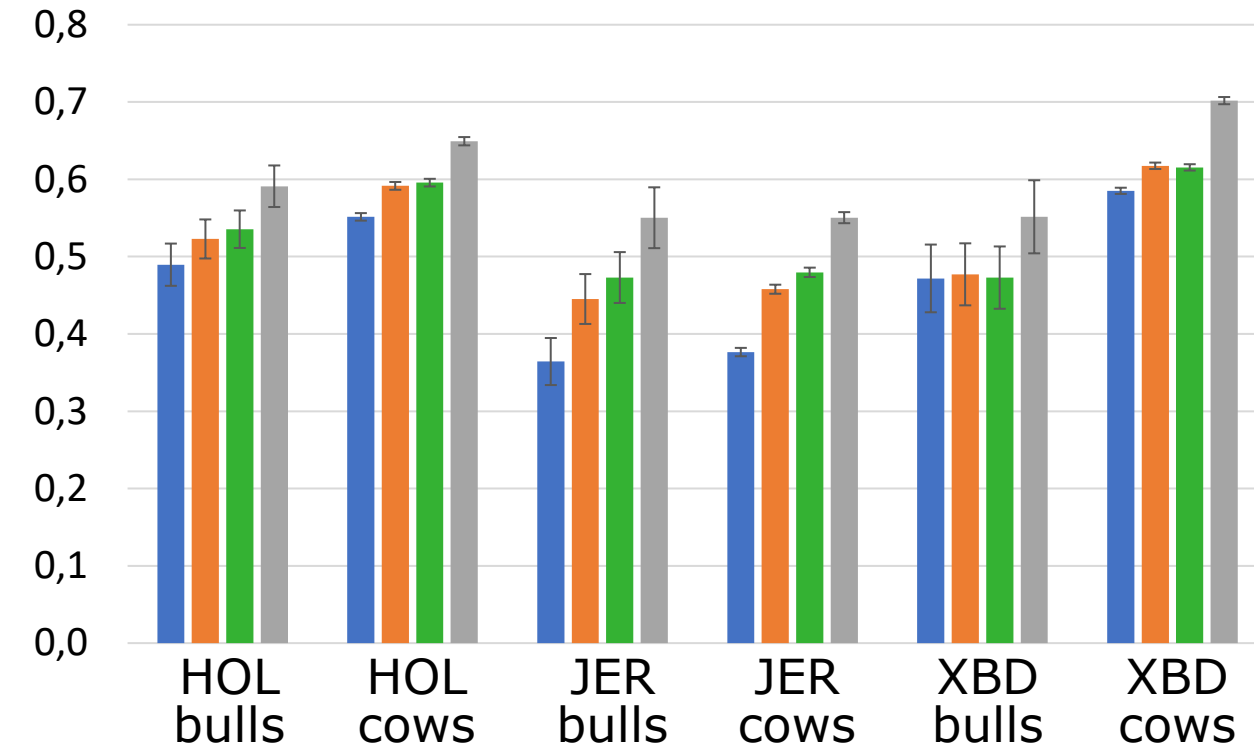
ALL_4MF



MTMB

Milk

CSD



- **MTMB**: highest accuracy
- **ALL, ALL_4MF**
- **SINGLE**: lowest accuracy

- **ALL, ALL_4MF**: increased accuracy compared to the **SINGLE** (2nd lowest accuracy)
- **MTMB**: lowest accuracy

Dispersion



SINGLE



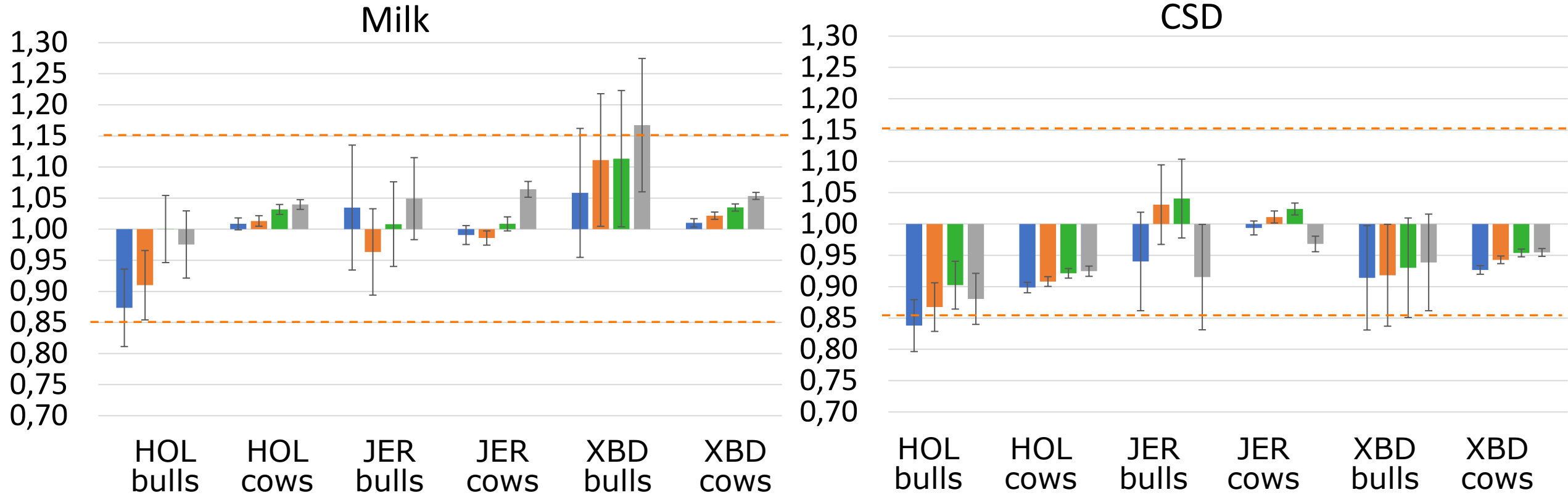
ALL



ALL_4MF



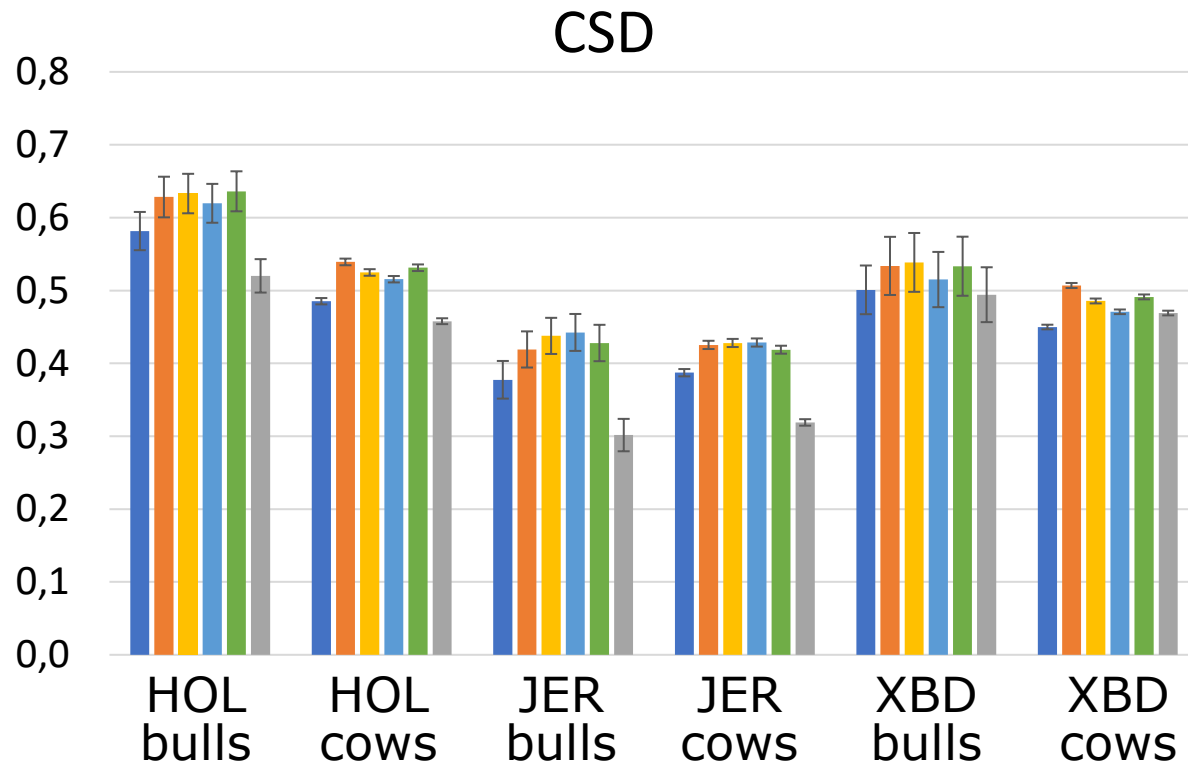
MTMB



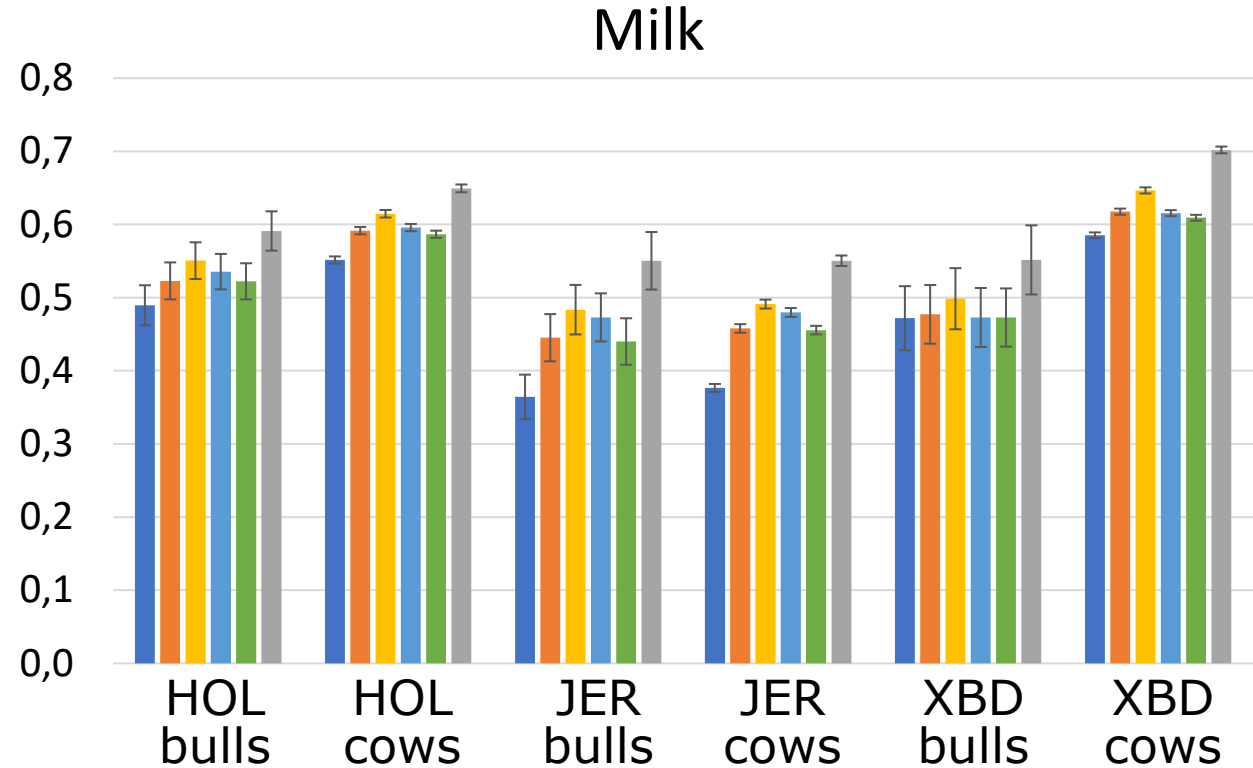
- CSD: mostly **over-dispersion** (except JER bulls). Milk: both **over/under-dispersion**
- Overall, **dispersion bias within $\pm 15\%$** (except milk-XBD bulls, CSD-HOL bulls)
- Larger SE for bulls
- Similar results for **level bias**: overall higher for CSD than Milk

All scenarios (bulls and cows)

Accuracy of partial EBV



- **ALL, ALL_255MF, ALL_4MF, ALL_4GG:** increased accuracy compared to the **SINGLE** (2nd lowest accuracy)
- **MTMB:** lowest accuracy

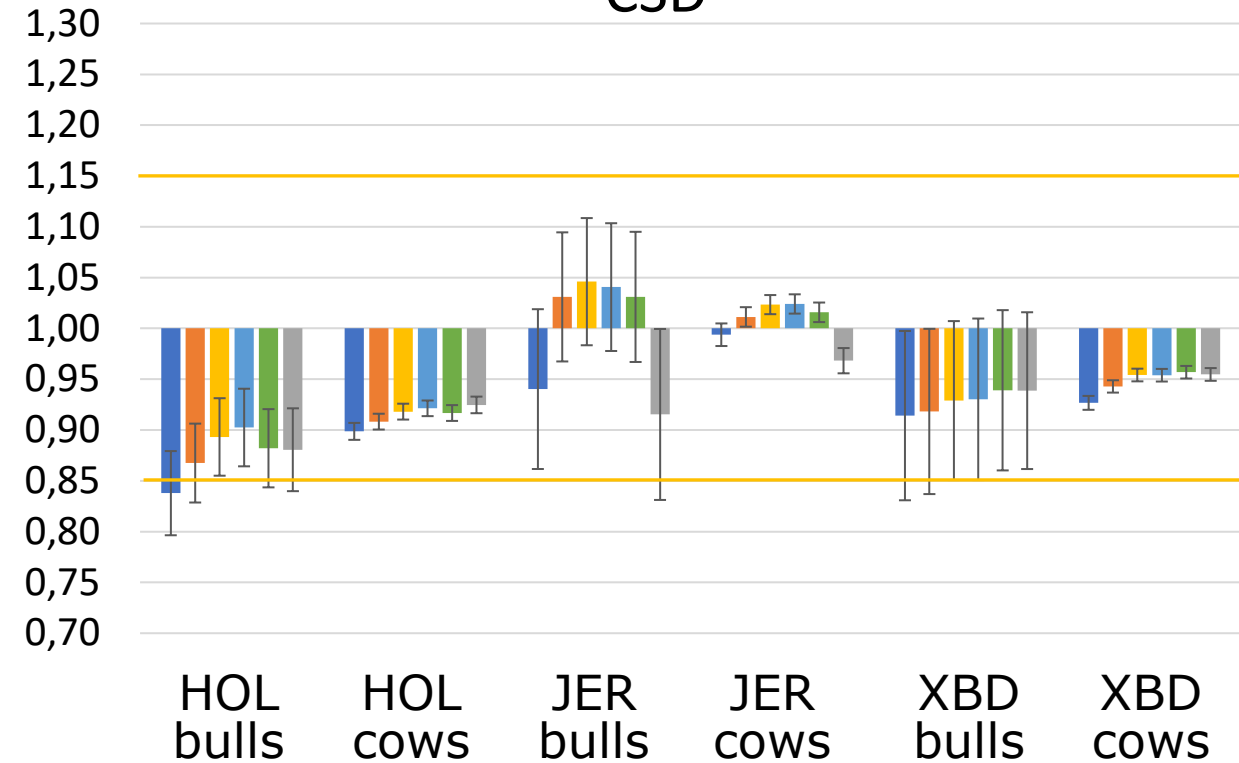


- **MTMB:** highest accuracy
- **ALL_255MF:** 2nd highest accuracy
- **SINGLE:** lowest accuracy

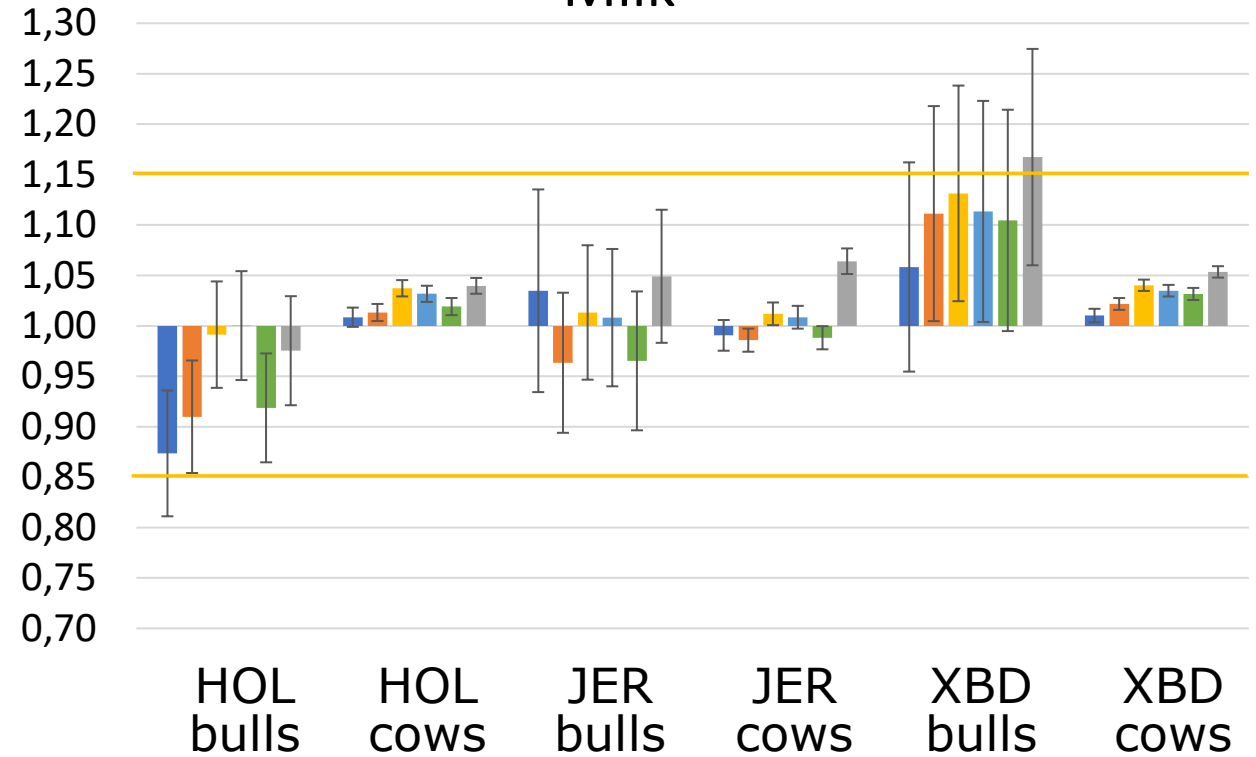
Dispersion



CSD



Milk

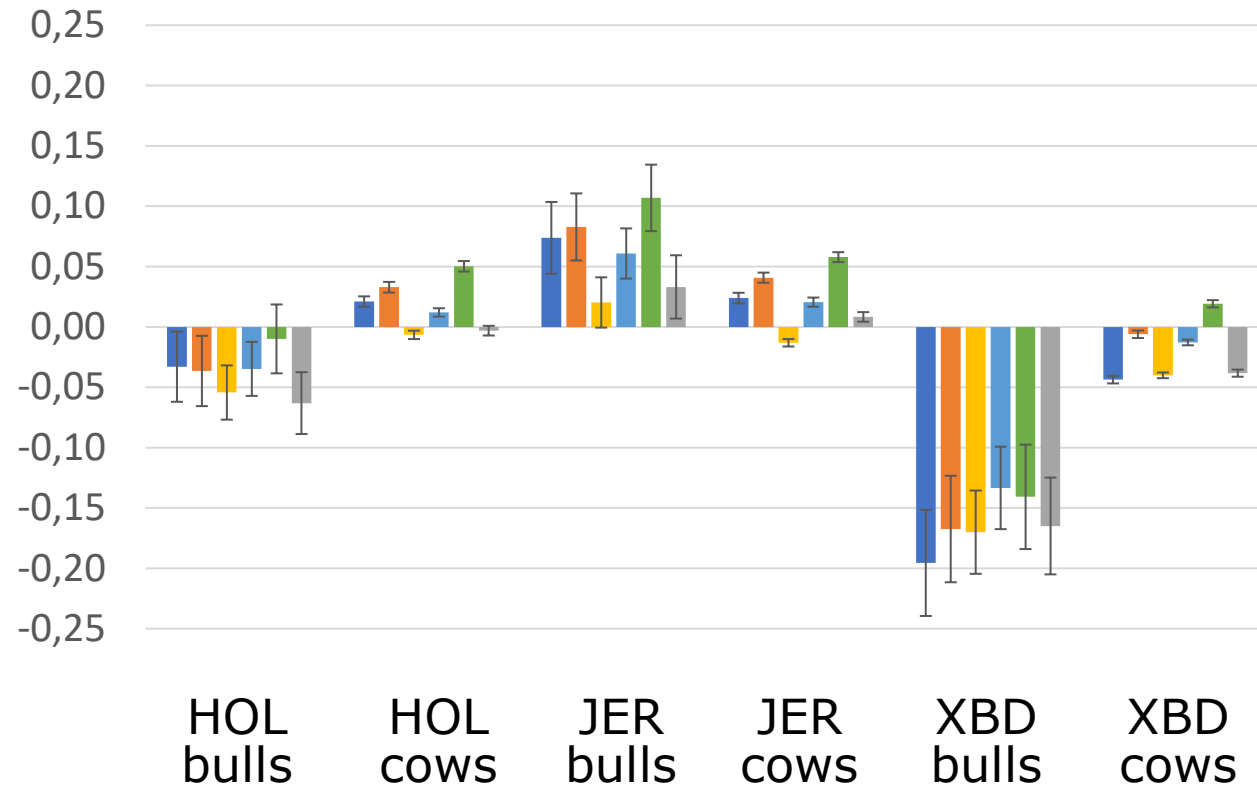


- CSD: mostly **over-dispersion** (except JER bulls). *Milk*: both **over/under-dispersion**
- Overall, dispersion bias within $\pm 15\%$ (except milk-XBD bulls, CSD-HOL bulls)
- Larger SE for bulls
- Similar results for **level bias**: overall higher for CSD than *milk*

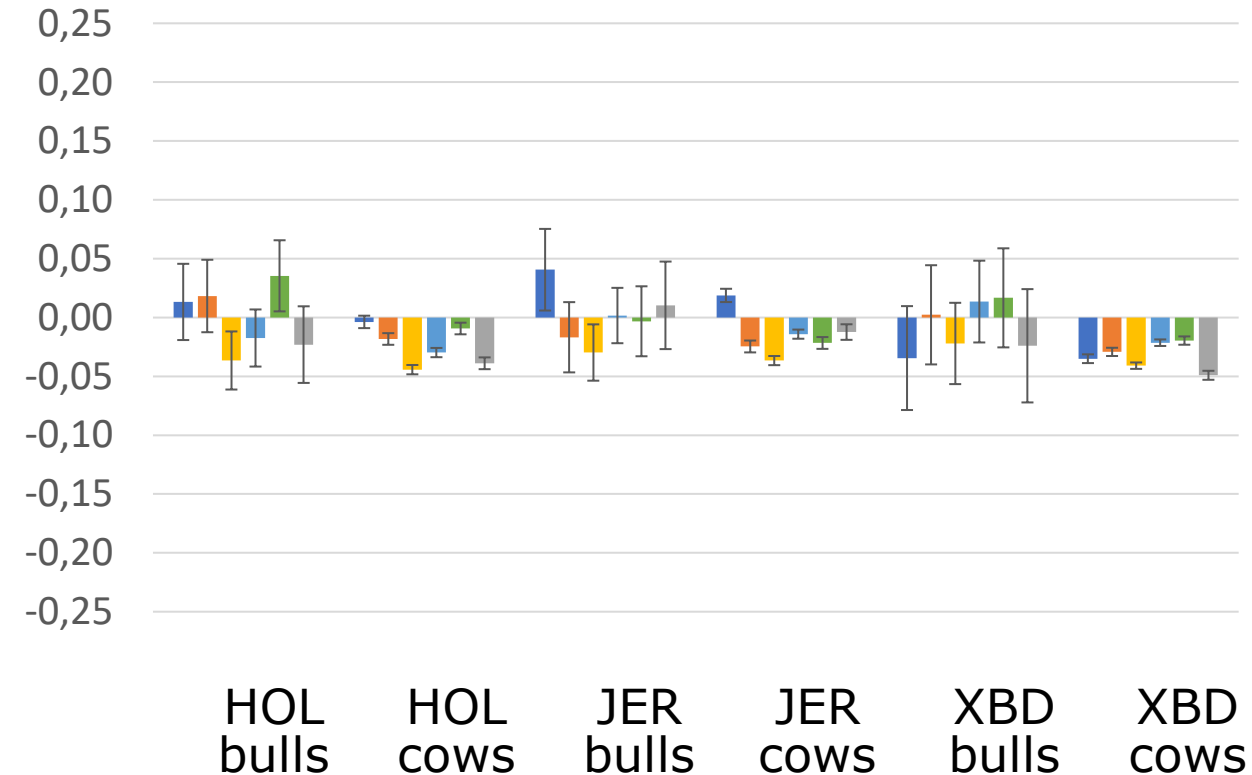
Level Bias (GSD)



CSD



Milk



- Overall higher level bias for CSD than milk
- Large standard errors for bulls