International Bull Evaluation Service
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OVERVIEW OF FEMALE FERTILITY TRAITS IN INTERNATIONAL EVALUATIONS

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The aim of this report is to present the current situation regarding Female Fertility traits in dairy cattle, both from the point of view of national information and international evaluations. This is the starting point to the further work leading to an increase in harmonization between countries and improve the international evaluations.

Female Fertility traits are evaluated internationally by Interbull since 2007. Currently, in international evaluations, there are five traits included in this trait group: Maiden heifers' ability to conceive (HCO), Lactating cows' ability to recycle after calving (CRC), Lactating cows' ability to conceive measured as a rate trait (CC1), Lactating cows' ability to conceive measured as an interval trait (CC2) and Lactating cows' measurement of interval calving conception (INT). All the organizations sending their data for international evaluations are also providing information regarding their national procedures and methodologies for trait recording and evaluations.

In total, there are 22 countries/populations providing information about national recording and evaluation procedures for the traits listed above.

Table 1 presents the countries, traits and breeds included in the international evaluation for Female Fertility.

Table 1 Breeds and countries in International Evaluation for Female Fertility Traits..

Country/Region	Female Fertility traits	Breeds	count
Denmark-Finland-Sweden	HCO	HOL, JER, RDC	3
	CRC	HOL, JER, RDC	3
	CC1	HOL, JER, RDC	3
	CC2	HOL, JER, RDC	3
	INT	HOL, JER, RDC	3
France	HCO	HOL, BSW	2
	CRC	HOL, BSW	2
	CC1	HOL, BSW	2
	CC2	HOL, BSW	2
	INT	HOL, BSW	2

Germany-Austria-Luxemburg	HCO	HOL, BSW[1], RDC	3
	CRC	HOL, BSW[1], RDC	3
	CC1	HOL, BSW[1], RDC	3
	CC2	HOL, BSW[1], RDC	3
	INT	HOL, BSW[1], RDC	3
The Netherlands	HCO	HOL, BSW, JER, RDC	4
	CRC	HOL, BSW, JER, RDC	4
	CC1	HOL, BSW, JER, RDC	4
	CC2	HOL, BSW, JER, RDC	4
	INT	HOL, BSW, JER, RDC	4
Czech Republic	HCO	HOL	1
	CC1	HOL	1
	CC2	HOL	1
Italy	HCO	HOL	1
	CRC	HOL, BSW	2
	CC1	HOL	1
	CC2	HOL, BSW	2
	INT	HOL, BSW	2
Poland	HCO	HOL	1
	CRC	HOL	1
	CC1	HOL	1
	CC2	HOL	1
	INT	HOL	1
Belgium	CRC	HOL	1
	CC2	HOL	1
	INT	HOL	1
Ireland	CRC	HOL, JER, RDC	3
	CC2	HOL, JER, RDC	3
	INT	HOL, JER, RDC	3
Spain	CRC	HOL	1
	CC2	HOL	1
	INT	HOL	1
Slovenia	INT	HOL, BSW	2
Norway*	HCO	RDC	1
	CRC	RDC	1
	CC1	RDC	1
	CC2	RDC	1

	INT	RDC	1
United Kingdom*	CRC	HOL, BSW, JER, RDC, GUE	5
	CC1	HOL, BSW, JER, RDC, GUE	5
	CC2	HOL, BSW, JER, RDC, GUE	5
	INT	HOL, BSW, JER, RDC, GUE	5
Switzerland*	HCO	HOL, BSW	2
	CRC	HOL, BSW	2
	CC1	HOL, BSW	2
	CC2	HOL, BSW	2
Japan**	HCO	HOL	1
	CRC	HOL	1
	CC1	HOL	1
	INT	HOL	1
Israel**	CC1	HOL	1
	CC2	HOL	1
United States**	HCO	HOL, BSW, JER, RDC	4
	CRC	HOL, BSW, JER, RDC, GUE	5
	CC1	HOL, BSW, JER, RDC, GUE	5
	CC2	HOL, BSW, JER, RDC, GUE	5
	INT	HOL, BSW, JER, RDC, GUE	5
Canada**	HCO	HOL, BSW, JER, RDC	4
	CRC	HOL, BSW, JER, RDC, GUE	5
	CC1	HOL, BSW, JER, RDC, GUE	5
	CC2	HOL, BSW, JER, RDC, GUE	5
	INT	HOL, BSW, JER, RDC, GUE	5
Australia**	CC2	HOL, JER, RDC, GUE	4
	INT	HOL, JER, RDC, GUE	4
New Zealand**	CRC	HOL, BSW, JER, RDC, GUE	5
	CC2	HOL, BSW, JER, RDC, GUE	5
	INT	HOL, BSW, JER, RDC, GUE	5
Uruguay**	CC2	HOL	1
	INT	HOL	1
South Africa**	CC2	HOL, JER, RDC	3
	INT	HOL, JER, RDC	3

** Not EU member; ** Not European country; [1] Only Germany and Austria*
BREED CODES: HOL – Holstein, BSW – Brown Swiss, JER – Jersey, RDC – Red Dairy Cattle, GUE - Guernsey

TRAITS MEASURED AND EVALUATED

There is a level of discrepancy between the fertility traits that are evaluated internationally and the traits actually recorded by the countries. The five traits defined by Interbull for international evaluations were defined in such a way to cover all aspects of fertility and do correspond to one or more ICAR-defined traits.

Nationally recorded traits

There is a large variety between countries in fertility traits recorded nationally. Below, we present the list of traits as reported to be recorded by all the countries and abbreviations used for these traits on national level. Numbers in brackets indicate the number of populations.

- *CTFS/CFS/ICF/CF/DF/DTFS/ICI/PM21 -Days between calving and first insemination, cow (16)**
- *CR/CCR/CR42 –Cow Conception rate after X months from insemination or between inseminations (10)**
- *DO -Days open - days between calving and conception (9)*
- *FSTCc/IFLc -Days between first insemination and conception, cow (8)*
- *CI/CIV -Calving interval – time between calvings or lactations (7)*
- *NRRh –Heifer Non-Return Rate at 56 days after first insemination (6)*
- *NRRc/NRC/NR56 –Cow Non-Return Rate at 56 days after first insemination (6)*
- *CRh/HCO –Heifer Conception Rate (6)*
- *PR/DPR -Pregnancy rate (4)**
- *NS -Number of inseminations (4)**
- *FSh/IFLh -Days between first and last insemination, heifer (3)*
- *AFI -Heifer age at first insemination in months (2)*
- *LL -Lactation length (1)*
- *FNRR -Twenty-five-day first service non-return rate (1)*
- *EFD -Early fertility disorders (1)*
- *CYS -Ovarian cysts (1)*

** different parities or other country-specific conditions*

Interbull vs ICAR-defined traits

In order to consider the variety across countries and the recommendations from ICAR, Interbull has defined which of the recorded traits should be included in the international evaluation (Table 2).

Table 2 Recommendation for inclusion of ICAR-defined traits for international evaluations for Female Fertility traits.

	Conception Rate (CR)	Interval first-last insemination (FL)	Interval first insemination – conception (FC)	Number of inseminations (NI)	Non-return rate (NR)	Interval calving-first insemination (CF)	Days open (DO)	Calving interval (CI)
HCO	**	*	*	*	*			
CRC						**	*	*
CC1	**				**			
CC2		**	**	*			*	*
INT							**	**

** - highly recommended; * - accepted

Table 3 shows which national traits are currently being sent by countries participating to this international evaluation for particular fertility traits in international evaluations.

Table 3 ICAR-defined traits sent by countries for specific Female Fertility traits for international evaluations.

	Conception Rate (CR)	Pregnancy rate*	Interval first insemination – conception (FC)	Number of inseminations (NI)	Non-return rate (NR)	Interval calving-first insemination (CF)	Days open (DO)	Calving interval (CI)
HCO	CHE, CZE, DFS, FRA, JPN, NLD, POL, USA			NOR	CAN, DEU, ITA			
CRC		BEL				CAN, CHE, DEU, DFS, ESP, FRA, ITA, NLD, NOR, NZL, POL, USA		GBR, IRL
CC1	CZE, DFS, ESP, FRA, JPN, NLD, POL, USA			ISR,NOR	CAN, CHE, DEU, GBR, ITA			
CC2	CZE, NZL	AUS, BEL, URY, USA	CAN, CHE, DEU, DFS, ESP, FRA, ITA_{HOL}, NLD	ISR,NOR			ITA_{BSW}, JPN, POL	GBR, IRL, ZAF
INT	NZL	AUS, BEL, URY, USA	FRA			NOR	CAN, DEU, DFS, ESP, ITA_{HOL}, NLD, POL	GBR, IRL, ITA_{BSW}, SVN, ZAF

* - trait reported, not included as such in Interbull list;
Highly recommended traits are highlighted in green, accepted- in yellow.

The table highlighted some differences on the type of traits submitted by different countries which not always appear to be in line with Interbull recommendations: looking both across and within traits, we observe both the same national trait in several evaluations and many different traits within one evaluation. Many countries do have the tendency to submit the same trait, as a substitute to several traits evaluated internationally, adding variation in the type of data included in the analysis.

CONSEQUENCES OF HIGH ACROSS COUNTRIES DIFFERENCES

The observed high level of diversity both in the trait recording procedures as well as in the data submitted for the international evaluation is expected to affect the correlations across the countries. In order to investigate the impact, we compared international correlations from two groups: countries submitting the same trait and these submitting different ones . The test was conducted on the CC2 trait(interval trait for lactating cows' ability to conceive). This trait was chosen as it is the one evaluated by all the countries and showing the biggest variety for the type of trait (information) submitted by the participating countries. (6 out of 8).

To assess the impact on the countries sending different national traits for CC2, we analysed the differences in between countries' correlations with an ANCOVA analysis from python package pinguin. Since the correlations were estimated based on the, sometimes very, different number of common bulls, we included the number of common bulls as covariate.
The results indicated that countries using the same trait definition do have higher correlations than the countries using different ones (Table 4 and Figure 1).

Table 4. Results of ANCOVA (pinguin) analysis. TRTd is a grouping factor and takes the value SAME for the combinations of countries using the same definition and DIFFERENT for the combinations using different definitions. Data from Holstein breed from January test run 2022.

Source	SS	DF	F	p	np2
TRTd	0.141	1	25.966	0.000	0.134
Number of Bulls	0.103	1	19.057	0.000	0.102
Residual	0.912	168	nan	nan	nan

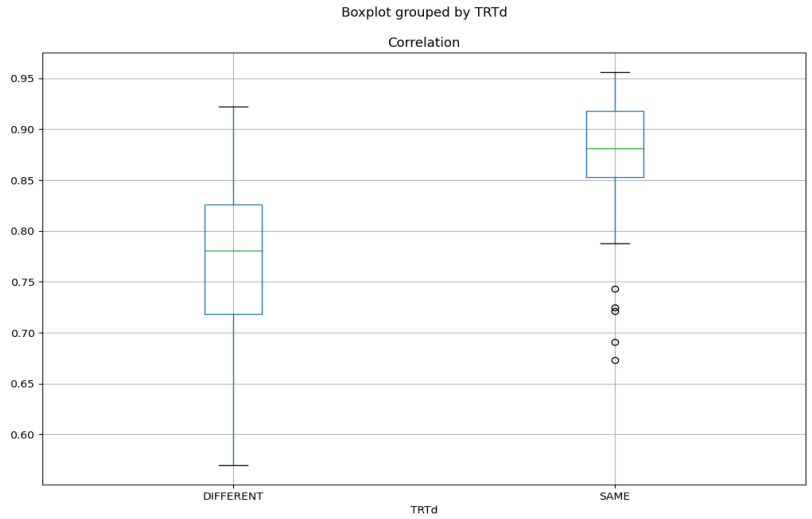

Figure 1. Differences in correlations between countries' combinations using the same trait definition (national trait) – SAME and DIFFERENT definition (national trait) for CC2 internationally evaluated trait. Data for Holstein breed from January run 2022.

Subsequently, we compared all combinations of submitted (national) traits. Combinations with only 1 or 2 cases have been excluded from the analysis.
Results show clearly that some combinations of the national traits provided do give higher correlations than others. (Table 5 and Figure 2).

Table 5. Results of ANCOVA (pinguin) analysis. TRT is a grouping factor with values including all the national traits' combinations with the number of observations at least 3. Data for Holstein breed from January run 2022.

Source	SS	DF	F	p	np2
TRT	0.439	14	7.925	0.000	0.417
Number of Bulls	0.070	1	17.781	0.000	0.103
Residual	0.614	155	nan	nan	nan

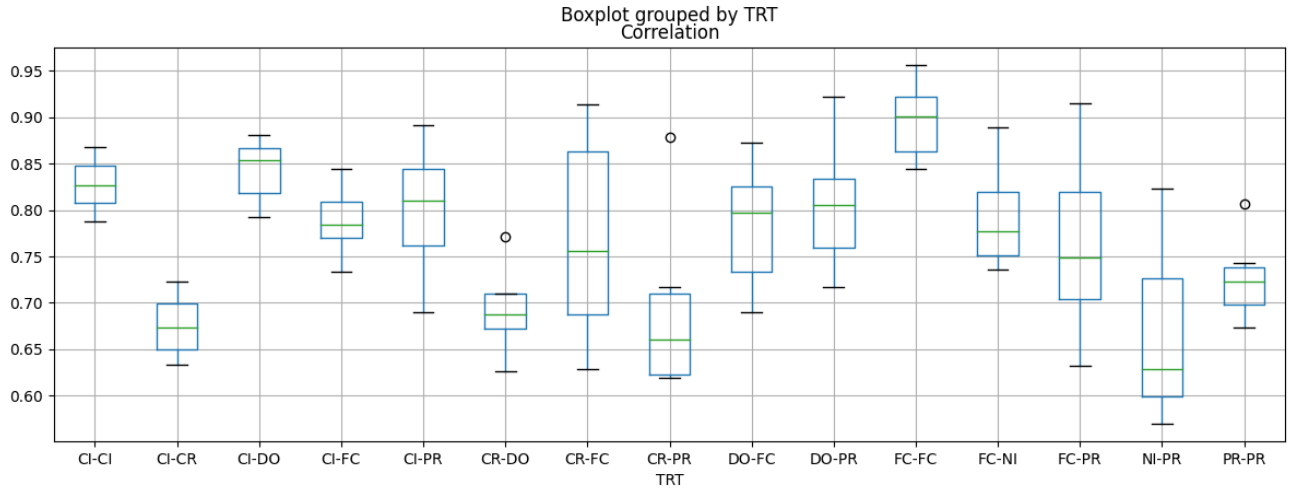

Figure 2. Correlations between countries' combinations for national traits sent to the CC2 Interbull evaluation. Data from Holstein breed from January test run 2022.
Abbreviations: CI – Calving Interval; CR – Conception Rate; DO – Days Open; FC – Interval from First insemination to Conception; PR – Pregnancy Rate; NI – Number of Inseminations.

The same pattern is visible when including only the combinations of the countries using different trait definitions (national traits) (Table 6 and Figure 3), thus it is not only the effect of higher correlations for combinations with the same definitions.

Table 6. Results of ANCOVA (pinguin) analysis including only combinations with DIFFERENT national traits. TRT is a grouping factor with values including all the national traits' combinations with the number of observations at least 3. Data for Holstein breed from January run 2022.

Source	SS	DF	F	p	np2
TRT	0.178	11	3.419	0.000	0.237
Number of Bulls	0.068	1	14.413	0.000	0.106
Residual	0.574	121	nan	nan	nan

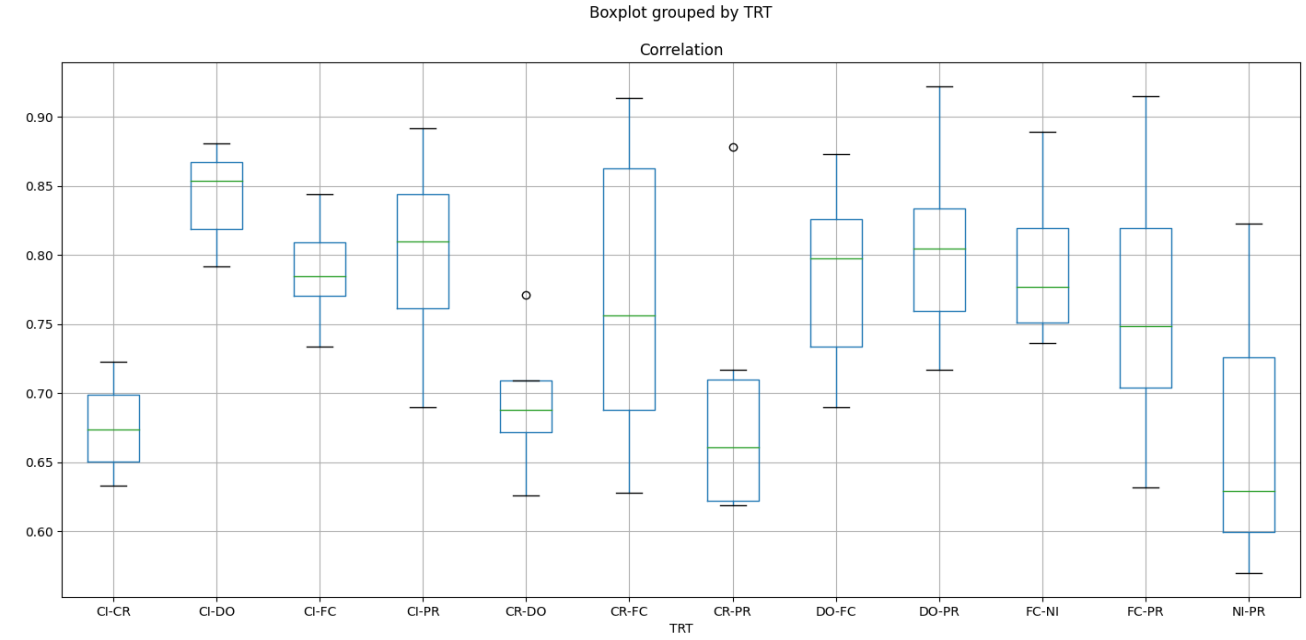

Figure 2. Correlations between DIFFERENT countries' combinations for national traits sent to the CC2 Interbull evaluation. Data from Holstein breed from January test run 2022.
Abbreviations: CI – Calving Interval; CR – Conception Rate; DO – Days Open; FC – Interval from First insemination to Conception; PR – Pregnancy Rate; NI – Number of Inseminations.

Unfortunately, due to a low number of observations, we were unable to run the analyses that would indicate which of the submitted (national) definitions tends to give the highest correlations.

CONCLUSIONS AND NEXT STEPS

This overview shows large diversity in the national traits sent for the same international evaluations. Based on the analyses of the most common international trait - Lactating cows' ability to conceive measured as an interval trait (CC2), we could see how such variety of information significantly affects the correlations between countries. As expected, the highest correlations were achieved for the combinations of the countries submitting the same trait definition (national trait), but we have also shown that there are significant differences in correlations between other national traits' combinations.
This analysis is to be considered just a first step towards the harmonization of the female fertility international evaluation. Due to the complexity of the system, further investigations would be required before any specific recommendations could be formulated.