Introduction

The latest routine international evaluation for females fertility traits took place as scheduled at the Interbull Centre. Data from twentyone (21) countries were included in this evaluation.

International genetic evaluations for female fertility traits of bulls from Australia, Austria, Belgium, Canada, Czech Republic, Denmark-Finland-Sweden, France, Germany, Ireland, Israel, Italy, Netherlands, New Zealand, Norway, Poland, Spain, Switzerland, South Africa, the United Kingdom, Uruguay, Japan and the United States of America were computed. Brown Swiss, Guernsey, Holstein, Jersey, Red Dairy Cattle and Simmental breed data were included in this evaluation.

Based on a decision made by Interbull Steering committee in August 2007, female fertility traits are classified as follows:

T1 (HC): Maiden (H)eifer's ability to (C)onceive. A measure of confirmed conception, such as conception rate (CR), will be considered for this trait group. In the absence of confirmed conception an alternative measure, such as interval first-last insemination (FL), interval first insemination-conception (FC), number of inseminations (NI), or non-return rate (NR,preferably NR56) can be submitted;

T2 (CR): Lactating (C)ow's ability to (R)ecycle after calving. The interval calving-first insemination (CF) is an example for this ability. In the abscence of such a trait, a measure of the interval calving-conception, such as says oprn (DO) or calving interval (CI) can be submitted;

T3 (C1): Lactating (C)ow's ability to conceive (1), expressed as a rate trait. Traits like conception rate (CR) and non-return rate (NR, preferably NR56) will be considered for this trait group;

T4 (C2): Lactating (C)ow's ability to conceive (2), expressed as an interval trait. The interval first insemination-conception (FC) or interval first-last insemination (FL) will be considered for this trait group. As an alternative, number of inseminations (NI) can be submitted. In the abscence of any of these traits, a measure of interval calving-conception such as days open (DO), or calving interval (CI) can be submitted. All countries are expected to submit data for this trait group, and as a last resort the trait submitted under T3 can be submitted for T4 as well.

T5 (IT): Lactating cow's measurements of (I)nterval (T)raits calving-conception, such as days open (DO) and calving interval (CI).

Based on the above trait definitions the following traits have been submitted for international genetic evaluation of female fertility traits.

Country	Traits	Submitted traits and their definitions
AUS	T4=C2	Calving interval converted to 42 days pregnancy rate
	T5=IT	Calving interval converted to 42 days pregnancy rate
BEL	T2=CY	PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
	T4=C2	PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
	T5=IT	PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
CAN	T1=HC	NR=Non Return Rate after 56 Days in heifers (NRR), %
	T2=CY	CF=Interval from Calving to First Service in cows(CF)
	T3=C1	NR=Non Return Rate after 56 Days in cows(NRR), %
	T4=C2	FC=Interval first insemination-conception in cows
	T5=IT	DO=Days open
CHE	T1=HC	CR=Heifers' Conception rate
	T2=CR	CF=Interval from Calving to First Service (ICF), days
	T3=C1	NR=Non Return Rate after 56 Days (NRR), %
	T4=C2	FL=Interval from first to last insemination cows
CZE	T1=HC	CR=Heifers' Conception rate (pregnant or not after 3 months)

	T3=C1	CR=Cows’ Conception rate (pregnant or not after 3 months)
	T4=C2	CR=Cows’ Conception rate (pregnant or not after 3 months)
AUT/DEU	T1=HC	NR=Heifers’ Non Return Rate after 56 days
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	NR=Cows’ Non Return Rate after 56 days
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
DFS	T1=HC	CR=Heifers’ Conception rate for maiden heifers
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	CR=Cows’ conception rate for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
ESP	T2=CY	Interval from Calving to First Service (ICF)
	T3=C1	Conception rate
	T4=C2	Interval first insemination to conception
	T5=IT	Days Open
FRA	T1=HC	CR=Heifers’ Conception rate (binary trait) for maiden heifers
	T2=CY	Interval between calving and first AI
	T3=C1	CR=Cows’ Conception rate (binary trait)
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	FL=Interval from first to last insemination cows (days)
GBR	T2=CY	CI=days between 1st and 2nd calvings
	T3=C1	NR=1st lactation non return at 56 days
	T4=C2	CI=days between 1st and 2nd calvings
	T5=IT	CI=days between 1st and 2nd calvings
IRL	T2=CY	CI=Calving interval
	T4=C2	CI=Calving interval
	T5=IT	CI=Calving interval
ISR	T3=C1	CR=Inverse of the number of insemination to conception (%)
	T4=C2	CR=Inverse of the number of insemination to conception (%)
ITA	T1=HC	NR= non-return rate 56 days (heifers)
	T2=CY	CF=Days to first service
	T3=C1	NR=Non-return rate at 56 days (%)
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=days open (days)
ITA(BSW)	T2=CY	CF=Interval calving to first insemination
	T4=C2	Days Open
	T5=IT	CI=Calving interval
NLD	T1=HC	CR=Heifers’ Conception rate
	T2=CY	CF=Interval calving to first insemination (days)
	T3=C1	CR=Cows’ Conception rate (binary trait) for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	CI=Days Open
NOR	T1=HC	NI=Number of inseminations (heifers)
	T2=CY	CF=Days from calving to first insemination (days)
	T3=C1	NI=Number of inseminations (cows)
	T4=C2	NI=Number of inseminations (cows)
	T5=IT	CF=Days from calving to first insemination (days)
NZL	T2=CY	PM=Lactating cow’s ability to start cycling
	T4=C2	CR= Cow’s conception rate at 42 days
	T5=IT	CR= Cow’s conception rate at 42 days
POL	T1=HC	CR=Conception Rate (heifer)
	T2=CR	CF=Interval from calving to first insemination
	T3=C1	CR=Conception Rate (cow)
	T4=IT	DO=Days open
	T5=IT	DO=Days open

URY	T4=C2	Days open expressed as Daughter Pregnancy Rate
	T5=IT	Days open expressed as Daughter Pregnancy Rate

USA	T1=HC	CR=Conception rate (heifer)
	T2=CY	CF=Interval from calving to first insemination
	T3=C1	CR=Conception rate (cow)
	T4=C2	DP=Daughter Pregnancy Rate
	T5=IT	DP=Daughter Pregnancy Rate

ZAF	T4=IT	CI=Calving Interval
	T5=IT	CI=Calving Interval

JPN	T1=HC	CR=Heifers'Conception rate
	T3=C1	CR=Cows'Conception rate
	T4=C2	DO=Days open
	T5=IT	DO=Days open

CHANGES IN NATIONAL PROCEDURES

Changes in the national genetic evaluation of female fertility traits are as
follows:

BEL (HOL)	Few bulls missing due to no longer having enough daughters. Some bulls changed in ToP due to the new program assigning such values.
NOR (RDC)	High quality reliability meant for IB test 4 are now used.
AUS (ALL)	Change in information due to data clean up: pedigree changes or changes in status of a bull causing a good number of bulls to be no longer qualified.
JPN (HOL)	Small decrease in information due to pedigree's update
ZAF (HOL,JER)	Decrease in reliability due to wrongly submitting GEBVs' reliability in previous evaluation (Sept test run). The correct value of reliability has now been provided
FRA (BSW,HOL)	Base change
POL (HOL)	Small decrease in information due to data edits
DFS (ALL)	Decrease in information and EDC as data is checked when the calving occur and the information is deleted if it does not fit with calving data.
ITA (BSW)	Base change, updated the data and pedigree editing procedures and fixed effects.
GBR (ALL)	Base change
DEA (BSW)	Base change, same model as usual but new data edit: data used since 2000 instead of 1990 causing decrease in information and chanes in ToP, additionally ToP are now derived separately for each trait and no longer using the same ToP from the milk evaluation.
CHE (ALL)	Slight changes in number of daughters, number of herds and EDC are due to manual edits in the database.
ITA (HOL)	Cut-off of one year of data causing decrease in information. Base change
NLD (ALL)	INT: Now send Days open instead of Calving Interval. Conception rate heifers and cows: added the used sire to the model and done some minor data edits.
IRL (ALL)	Changes in number of daughters, edc and herd numbers due to pedigree changes
DEU (ALL)	Base change, drop in information due to data editing.
NZl (ALL)	Drops in information due to continuous DNA parentage testing
CAN (ALL)	Base change
CZE (HOL)	Trimming of odl data causing drops in information

INTERBULL CHANGES COMPARED TO THE PREVIOUS ROUTINE RUN

Post-processing Windows:

According to the decision taken by ITC in Orlando (2015) to review the
post-processing windows every 5 years, during the 2020 the relative working group
has been re-activated and new windows have been identified.

As before, the upper bounds have been set to 0.99 as these were judged to have
very little effect on evaluations while the lower values have been reduced
to the 10th percentile. This reduction would provide post-processed correlations to be closer to the
real estimated ones. Over the past five years, in fact, the previous adopted lower value (25th percentile) had been found too high
causing estimated and post-processed correlations to differ significantly from each other.
The new lower values have been applied to all breeds and traits.

The weight assigned to the magnitude of the changes tested by each country has also been revised. The new weight will allow post-processed correlations
to take more in consideration the value of the new estimated ones even when no changes are applied by the countries.
The new weights are as follows:
No changes   :: 2
Small changes:: 1
Big changes :: 0

More information can be read on https://interbull.org/ib/rg_procedure

DATA AND METHOD OF ANALYSIS

Data were national genetic evaluations of AI sampled bulls with at least
10 daughters or 10 EDC (for clinical mastitis and maternal calving traits at least
50 daughters or 50 EDC, and for direct calving traits at least 50 calvings or 50 EDC) in at
least 10 herds. Table 1 presents the amount of data included
in this Interbull evaluation for all breeds.

National proofs were first de-regressed within country and then analysed
jointly with a linear model including the effects of evaluation country,
genetic group of bull and bull merit. Heritability estimates used in both
the de-regression and international evaluation were as in each country's
national evaluation.

Table 2 presents the date of evaluation as supplied by each country

Estimated genetic parameters and sire standard deviations are shown in APPENDIX I
and the corresponding number of common bulls are listed in APPENDIX II.

SCIENTIFIC LITERATURE

The international genetic evaluation procedure is based on international work
described in the following scientific publications:

International genetic evaluation computation:
Schaeffer. 1994. J. Dairy Sci. 77:2671-2678
Klei, 1998. Interbull Bulletin 17:3-7

Verification and Genetic trend validation:
Klei et al., 2002. Interbull Bulletin 29:178-182.
Boichard et al., 1995. J. Dairy Sci. 78:431-437

Weighting factors:
Fikse and Banos, 2001. J. Dairy Sci. 84:1759-1767

De-regression:
Sigurdsson and G. Banos. 1995. Acta Agric. Scand. 45:207-219
Jairath et al. 1998. J. Dairy Sci. Vol. 81:550-562

Genetic parameter estimation:
Klei and Weigel, 1998, Interbull Bulletin 17:8-14
Sullivan, 1999. Interbull Bulletin 22:146-148

Post-processing of estimated genetic correlations:
Mark et al., 2003, Interbull Bulletin 30:126-135
Jorjani et al., 2003. J. Dairy Sci. 86:677-679
https://wiki.interbull.org/public/rG%20procedure?action=print

Time edits
Weigel and Banos. 1997. J. Dairy Sci. 80:3425-3430

International reliability estimation
Harris and Johnson. 1998. Interbull Bulletin 17:31-36

NEXT ROUTINE INTERNATIONAL EVALUATION

Dates for the next routine evaluation can be found on
http://www.interbull.org/ib/servicecalendar.

NEXT TEST INTERNATIONAL EVALUATION

Dates for the next test run can be found on
http://www.interbull.org/ib/servicecalendar.

PUBLICATION OF INTERBULL ROUTINE RUN

Results were distributed by the Interbull Centre to designated representatives in each country. The international evaluation file comprised international proofs expressed on the base and unit of each country included in the analysis. Such records readily provide more information on bull performance in various countries, thereby minimizing the need to resort to conversions.

At the same time, all recipients of Interbull results are expected to honor the agreed code of practice, decided by the Interbull Steering Committee, and only publish international evaluations on their own country scale. Evaluations expressed on another country scale are confidential and may only be used internally for research and review purposes.

PUBLICATION OF INTERBULL TEST RUN

Test evaluation results are meant for review purposes only and should not be published.

^LTable 1. National evaluation data considered in the Interbull evaluation for fertility (April Routine Evaluation 2021).
Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		138	8261	1774	736	
BEL			1948			
CAN	172	47	9586	575	560	
CHE	2863		3460			
CZE			3849			
DEA	4703					
DEU			24249		291	
DFS			16468	2461	10169	
ESP			5724			
EST						
FRA	407		16721			
FRM						
GBR	103	243	7119	578	415	
HUN						
IRL			2985	196	64	
ISR			1520			
ITA	1843		9444			
JPN			6082			
KOR						
LTU						
LVA						
NLD	199		15846	182	87	
NOR					3005	
NZL	64	59	8287	4857	1400	
POL			7999			
PRT						
SVK						
SVN						
URY			1715			
USA	1129	769	40139	4948	738	
ZAF			1264	724	152	
HRV						
CAM						

No.Records	11483	1256	192666	16295	17617
Pub. Proofs	10052	1028	153843	13641	17490 0

^LAPPENDIX I. Sire standard deviations in diagonal and genetic correlations below diagonal

BSW hco

	CAN	DEA	FRA	USA	CHE	NLD
CAN	10.02					
DEA	0.85	9.96				
FRA	0.77	0.85	0.90			
USA	0.79	0.76	0.88	2.70		
CHE	0.92	0.95	0.88	0.82	13.17	
NLD	0.74	0.66	0.77	0.78	0.73	3.96

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.80								
CHE	0.84	11.37							
DEA	0.81	0.94	14.85						
NLD	0.85	0.89	0.88	3.89					
NZL	0.58	0.63	0.78	0.59	0.09				
USA	0.78	0.84	0.82	0.81	0.56	7.93			
GBR	0.73	0.73	0.69	0.78	0.65	0.74	3.77		
FRA	0.84	0.96	0.95	0.90	0.65	0.84	0.76	1.81	
ITA	0.83	0.81	0.81	0.83	0.67	0.79	0.77	0.84	17.20

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.99						
CHE	0.80	11.73					
DEA	0.79	0.95	11.45				
NLD	0.76	0.71	0.67	4.12			
USA	0.75	0.68	0.67	0.88	2.84		
GBR	0.74	0.80	0.76	0.72	0.67	0.03	
FRA	0.73	0.69	0.67	0.90	0.90	0.71	0.96

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.76								
CHE	0.76	11.10							
DEA	0.81	0.92	12.19						
NLD	0.86	0.83	0.85	3.52					
NZL	0.69	0.62	0.67	0.64	7.57				
USA	0.84	0.84	0.85	0.83	0.65	2.41			
GBR	0.79	0.79	0.84	0.79	0.71	0.83	3.77		
FRA	0.85	0.86	0.88	0.87	0.65	0.84	0.82	0.96	
ITA	0.83	0.70	0.83	0.83	0.60	0.85	0.79	0.81	22.45

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	7.14						
DEA	0.84	14.14					
NLD	0.88	0.90	3.46				
NZL	0.70	0.80	0.68	7.28			
USA	0.92	0.86	0.85	0.64	2.41		
GBR	0.85	0.85	0.87	0.73	0.86	3.77	

ITA	0.87	0.92	0.88	0.70	0.86	0.86	17.85

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.69				
GBR	0.74	5.14			
NZL	0.58	0.63	0.11		
USA	0.79	0.78	0.56	6.84	
AUS	0.72	0.83	0.88	0.66	6.96

GUE cc1

	CAN	GBR	USA
CAN	7.58		
GBR	0.74	0.03	
USA	0.80	0.72	3.44

GUE cc2

	CAN	GBR	NZL	USA	AUS
CAN	7.00				
GBR	0.77	5.14			
NZL	0.63	0.71	7.71		
USA	0.86	0.83	0.66	2.69	
AUS	0.69	0.69	0.72	0.74	9.89

GUE int

	CAN	GBR	NZL	USA	AUS
CAN	7.86				
GBR	0.84	5.14			
NZL	0.64	0.71	7.71		
USA	0.92	0.84	0.63	2.69	
AUS	0.81	0.78	0.73	0.82	9.89

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD	ITA	JPN
CAN	7.84										
CZE	0.77	18.29									
DEU	0.92	0.79	15.24								
DFS	0.80	0.87	0.84	13.71							
FRA	0.82	0.85	0.81	0.88	0.84						
USA	0.84	0.87	0.84	0.88	0.89	2.37					
POL	0.67	0.74	0.67	0.74	0.73	0.75	19.56				
CHE	0.96	0.84	0.93	0.84	0.86	0.88	0.72	14.08			
NLD	0.76	0.81	0.78	0.85	0.84	0.84	0.73	0.83	4.65		
ITA	0.82	0.82	0.92	0.82	0.82	0.84	0.78	0.89	0.80	0.04	
JPN	0.84	0.73	0.81	0.73	0.77	0.84	0.66	0.84	0.72	0.74	6.23

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA
BEL	4.70													
CAN	0.74	7.16												
CHE	0.81	0.83	12.42											
DEU	0.72	0.84	0.88	11.03										
DFS	0.79	0.88	0.94	0.91	11.74									
ESP	0.86	0.85	0.88	0.87	0.88	11.11								
GBR	0.90	0.74	0.77	0.72	0.79	0.86	4.60							
IRL	0.86	0.65	0.69	0.65	0.66	0.79	0.84	3.50						
ITA	0.80	0.86	0.87	0.87	0.87	0.93	0.81	0.69	7.99					

NLD	0.81	0.87	0.93	0.90	0.96	0.88	0.79	0.66	0.85	4.95										
NZL	0.60	0.57	0.58	0.52	0.57	0.63	0.63	0.55	0.72	0.55	0.08									
USA	0.74	0.79	0.83	0.81	0.86	0.85	0.79	0.59	0.80	0.82	0.54	6.78								
POL	0.76	0.88	0.90	0.86	0.85	0.90	0.75	0.70	0.94	0.84	0.63	0.76	13.90							
FRA	0.77	0.85	0.94	0.92	0.94	0.90	0.79	0.68	0.90	0.94	0.61	0.83	0.89	1.18						

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	JPN
CAN	6.68												
CHE	0.92	11.08											
CZE	0.82	0.73	17.78										
DEU	0.91	0.93	0.79	14.79									
DFS	0.75	0.71	0.88	0.76	13.26								
FRA	0.77	0.74	0.90	0.74	0.88	1.01							
GBR	0.74	0.77	0.70	0.78	0.66	0.71	0.03						
ISR	0.74	0.61	0.88	0.72	0.84	0.84	0.71	3.21					
ITA	0.86	0.87	0.78	0.95	0.69	0.72	0.77	0.73	0.05				
NLD	0.78	0.75	0.90	0.77	0.92	0.94	0.72	0.87	0.73	4.94			
USA	0.80	0.71	0.95	0.74	0.87	0.88	0.66	0.90	0.76	0.88	2.78		
POL	0.73	0.75	0.79	0.77	0.76	0.76	0.66	0.72	0.79	0.77	0.77	20.04	
JPN	0.77	0.71	0.89	0.72	0.83	0.80	0.72	0.79	0.72	0.82	0.91	0.67	7.62

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	JPN
BEL	4.70																			
CAN	0.80	6.11																		
CHE	0.80	0.88	11.18																	
CZE	0.65	0.86	0.86	17.78																
DEU	0.82	0.93	0.91	0.91	13.47															
DFS	0.83	0.85	0.87	0.81	0.94	12.89														
ESP	0.84	0.87	0.83	0.81	0.91	0.86	11.10													
FRA	0.83	0.88	0.91	0.83	0.92	0.85	0.89	0.98												
GBR	0.89	0.79	0.74	0.65	0.81	0.82	0.85	0.80	4.60											
IRL	0.84	0.81	0.81	0.67	0.82	0.81	0.84	0.82	0.84	3.50										
ISR	0.60	0.69	0.68	0.85	0.79	0.74	0.73	0.72	0.61	0.66	3.21									
ITA	0.76	0.85	0.87	0.90	0.91	0.84	0.88	0.85	0.78	0.78	0.85	15.53								
NLD	0.83	0.89	0.90	0.85	0.95	0.92	0.89	0.92	0.81	0.82	0.77	0.85	4.63							
NZL	0.74	0.62	0.54	0.53	0.62	0.62	0.64	0.62	0.71	0.73	0.54	0.55	0.62	4.99						
USA	0.81	0.86	0.85	0.88	0.91	0.87	0.89	0.83	0.83	0.83	0.81	0.91	0.85	0.62	2.32					
POL	0.83	0.78	0.73	0.62	0.78	0.78	0.81	0.78	0.83	0.81	0.60	0.78	0.78	0.70	0.80	13.36				
ZAF	0.75	0.77	0.81	0.71	0.81	0.76	0.83	0.78	0.79	0.86	0.62	0.84	0.76	0.69	0.86	0.78	15.40			
AUS	0.69	0.69	0.73	0.64	0.71	0.65	0.72	0.71	0.70	0.86	0.59	0.70	0.67	0.66	0.74	0.63	0.81	7.96		
URY	0.79	0.77	0.67	0.61	0.76	0.77	0.77	0.76	0.79	0.79	0.53	0.65	0.77	0.79	0.76	0.80	0.76	0.67	1.42	
JPN	0.84	0.83	0.84	0.76	0.84	0.84	0.88	0.83	0.86	0.85	0.66	0.86	0.83	0.63	0.92	0.89	0.87	0.73	0.78	18.47

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN
BEL	4.70																
CAN	0.88	6.56															
DEU	0.86	0.90	12.32														
DFS	0.90	0.91	0.94	12.82													
ESP	0.88	0.89	0.89	0.89	11.10												
GBR	0.89	0.85	0.86	0.89	0.88	4.60											
IRL	0.86	0.85	0.85	0.84	0.87	0.85	3.50										
ITA	0.86	0.89	0.90	0.89	0.93	0.87	0.85	20.33									
NLD	0.93	0.90	0.92	0.96	0.89	0.89	0.85	0.88	4.69								
NZL	0.77	0.63	0.60	0.60	0.68	0.72	0.74	0.67	0.63	4.99							
USA	0.84	0.93	0.91	0.89	0.91	0.85	0.84	0.92	0.86	0.59	2.32						
POL	0.85	0.86	0.84	0.85	0.85	0.85	0.83	0.90	0.85	0.72	0.83	13.36					
ZAF	0.83	0.85	0.86	0.84	0.87	0.84	0.87	0.87	0.84	0.72	0.88	0.84	15.40				
AUS	0.81	0.81	0.81	0.80	0.84	0.81	0.87	0.81	0.77	0.66	0.80	0.80	0.84	7.96			
URY	0.81	0.79	0.80	0.80	0.82	0.81	0.81	0.81	0.77	0.81	0.76	0.81	0.83	0.80	1.42		
FRA	0.80	0.86	0.80	0.80	0.84	0.72	0.79	0.80	0.81	0.59	0.82	0.70	0.78	0.72	0.64	0.98	

JPN	0.87	0.93	0.90	0.90	0.91	0.87	0.86	0.94	0.88	0.65	0.92	0.91	0.89	0.82	0.82	0.79	18.47

JER hco

	CAN	DFS	USA	NLD
CAN	7.89			
DFS	0.75	17.48		
USA	0.82	0.87	2.74	
NLD	0.75	0.86	0.82	4.28

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	6.85						
DFS	0.84	13.54					
GBR	0.69	0.84	4.07				
NLD	0.86	0.88	0.75	3.89			
NZL	0.54	0.65	0.73	0.55	0.07		
USA	0.77	0.83	0.78	0.80	0.58	8.15	
IRL	0.67	0.67	0.83	0.67	0.56	0.60	2.09

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.92				
DFS	0.72	15.50			
GBR	0.77	0.67	0.03		
NLD	0.77	0.88	0.71	3.78	
USA	0.74	0.87	0.67	0.84	2.90

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.72								
DFS	0.84	15.70							
GBR	0.80	0.81	4.07						
NLD	0.87	0.89	0.81	3.32					
NZL	0.63	0.63	0.77	0.63	4.05				
USA	0.84	0.84	0.82	0.84	0.67	2.59			
ZAF	0.68	0.67	0.73	0.70	0.77	0.85	11.13		
AUS	0.66	0.66	0.66	0.66	0.58	0.68	0.74	6.12	
IRL	0.80	0.79	0.81	0.81	0.66	0.81	0.77	0.74	2.09

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.53								
DFS	0.87	15.44							
GBR	0.82	0.86	4.07						
NLD	0.87	0.90	0.84	3.43					
NZL	0.61	0.60	0.77	0.63	4.05				
USA	0.87	0.86	0.84	0.83	0.66	2.59			
ZAF	0.81	0.82	0.82	0.80	0.78	0.87	11.13		
AUS	0.81	0.80	0.80	0.77	0.60	0.80	0.82	6.12	
IRL	0.83	0.80	0.80	0.82	0.64	0.82	0.83	0.81	2.09

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.63					
DEU	0.91	14.29				
DFS	0.76	0.81	12.32			
NOR	0.87	0.89	0.86	16.52		

USA	0.83	0.83	0.87	0.73	2.74	
NLD	0.75	0.77	0.83	0.70	0.83	5.07

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	6.48								
DEU	0.84	10.03							
DFS	0.86	0.90	12.70						
GBR	0.77	0.72	0.73	4.13					
NOR	0.86	0.84	0.86	0.68	13.86				
NZL	0.62	0.55	0.54	0.67	0.62	0.11			
USA	0.78	0.81	0.80	0.77	0.77	0.72	8.33		
NLD	0.87	0.90	0.93	0.78	0.83	0.58	0.81	3.36	
IRL	0.67	0.66	0.68	0.84	0.68	0.57	0.61	0.67	2.71

RDC cc1

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	7.06						
DEU	0.90	13.50					
DFS	0.73	0.79	13.07				
GBR	0.74	0.79	0.70	0.03			
NOR	0.79	0.87	0.92	0.74	13.92		
NLD	0.79	0.79	0.90	0.72	0.75	4.24	
USA	0.83	0.75	0.84	0.67	0.77	0.87	2.71

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.81										
DEU	0.92	11.13									
DFS	0.84	0.94	12.84								
GBR	0.80	0.82	0.81	4.15							
NOR	0.85	0.86	0.89	0.81	13.92						
NZL	0.64	0.64	0.63	0.68	0.66	6.75					
USA	0.87	0.90	0.84	0.83	0.82	0.69	2.44				
ZAF	0.73	0.80	0.78	0.71	0.73	0.72	0.85	17.60			
NLD	0.89	0.95	0.90	0.82	0.83	0.64	0.85	0.75	3.57		
AUS	0.67	0.69	0.65	0.69	0.66	0.67	0.70	0.73	0.67	7.31	
IRL	0.81	0.83	0.82	0.83	0.81	0.72	0.83	0.83	0.83	0.81	2.71

RDC int

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.71										
DEU	0.90	10.99									
DFS	0.88	0.94	13.15								
GBR	0.85	0.86	0.85	4.15							
NOR	0.85	0.84	0.81	0.81	13.86						
NZL	0.68	0.62	0.60	0.68	0.66	6.75					
USA	0.92	0.90	0.85	0.85	0.81	0.69	2.44				
ZAF	0.86	0.86	0.85	0.83	0.88	0.74	0.88	17.60			
NLD	0.90	0.92	0.94	0.87	0.75	0.64	0.83	0.81	3.31		
AUS	0.81	0.81	0.80	0.81	0.81	0.68	0.81	0.82	0.67	7.31	
IRL	0.85	0.85	0.84	0.85	0.81	0.72	0.84	0.87	0.81	0.86	2.71

^LAPPENDIX II. Number of common bulls

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	FRA	USA	CHE	NLD

CAN	0	90	52	102	94	29
DEA	79	0	188	180	558	126
FRA	45	139	0	70	158	73
USA	93	139	53	0	197	47
CHE	78	467	116	162	0	88
NLD	26	120	60	43	83	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	113	106	37	22	130	45	70	104
CHE	95	0	573	96	29	263	57	160	426
DEA	93	474	0	144	37	221	52	198	558
NLD	32	88	134	0	27	56	36	78	121
NZL	21	23	33	22	0	22	17	22	32
USA	126	228	171	51	19	0	59	92	165
GBR	39	40	38	27	13	50	0	44	62
FRA	61	116	146	63	17	63	34	0	179
ITA	91	361	444	99	25	116	41	134	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	114	107	37	131	44	74
CHE	96	0	571	95	263	58	167
DEA	94	471	0	144	220	55	210
NLD	32	88	134	0	56	36	83
USA	127	228	170	51	0	61	97
GBR	40	42	40	27	52	0	48
FRA	65	123	157	69	69	39	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	102	93	35	20	125	42	68	93
CHE	83	0	564	96	29	319	57	167	426
DEA	81	468	0	145	38	295	52	209	554
NLD	31	88	134	0	28	79	36	83	121
NZL	19	23	33	22	0	31	17	23	32
USA	117	294	252	68	27	0	69	117	213
GBR	35	40	38	27	13	60	0	46	62
FRA	60	123	156	69	18	83	37	0	191
ITA	81	361	441	99	25	148	41	145	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	97	36	21	130	44	100
DEA	84	0	144	38	294	52	651
NLD	32	134	0	28	79	36	127
NZL	20	33	22	0	31	17	32
USA	122	252	68	27	0	69	235
GBR	37	38	27	13	60	0	63
ITA	87	570	105	25	167	41	0

GUE

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR NZL USA AUS

  CAN   0   16   3   39   18
  GBR   13   0   14   51   28
  NZL   2   12   0   10   26
  USA   38   48   7   0   19
  AUS   13   22   24   16   0

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR USA

  CAN   0   16   39
  GBR   13   0   52
  USA   38   49   0

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR NZL USA AUS

  CAN   0   11   2   38   21
  GBR   8   0   14   83   32
  NZL   2   12   0   30   26
  USA   36   84   28   0   61
  AUS   17   26   26   58   0

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR NZL USA AUS

  CAN   0   11   2   38   21
  GBR   8   0   14   83   32
  NZL   2   12   0   30   26
  USA   36   84   28   0   61
  AUS   17   26   26   58   0

HOL
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN CZE DEU DFS FRA USA POL CHE NLD ITA JPN

  CAN   0 1011 2085 1210 1231 2696 1162 815 1261 1707 1076
  CZE 736   0 1730 1157 1178 1365 1065 493 1410 1253 773
  DEU 1637 1300   0 2372 2224 2760 1986 1128 2845 2524 1258
  DFS 1115 757 1739   0 1591 1518 1216 712 2028 1573 920
  FRA 907 710 1215 894   0 1618 1342 700 1867 1687 1096
  USA 3104 1080 2095 1331 952   0 1640 857 1713 2274 1388
  POL 1031 821 1691 963 869 1657   0 507 1404 1363 767
  CHE 696 333 996 628 623 769 384   0 884 754 457
  NLD 1231 1221 2463 1743 1205 1494 1229 855   0 1696 998
  ITA 1456 887 1730 1244 973 1829 1044 682 1405   0 1131
  JPN 584 325 536 461 388 701 396 278 486 507   0

HOL
----
 common bulls below diagonal
 common three quarter sib group above diagonal

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA
BEL	0	720	588	1151	813	852	823	501	790	1189	498	773	511	915
CAN	728	0	849	2221	1294	1446	1530	528	1761	1406	671	2824	1046	1330
CHE	587	733	0	1158	715	701	735	409	751	912	416	915	455	711
DEU	1176	1684	1033	0	2567	2117	2115	892	2580	3304	982	2997	1734	2463
DFS	754	1195	637	1834	0	1412	1529	739	1558	2049	824	1664	1098	1609
ESP	915	1213	635	1830	1205	0	1396	687	1610	1590	711	1685	1022	1608
GBR	810	1601	671	1594	1178	1280	0	976	1591	1779	933	1921	925	1560
IRL	498	530	415	780	619	706	1015	0	643	894	729	635	364	745
ITA	773	1494	679	1786	1237	1412	1258	574	0	1764	721	2407	1200	1695
NLD	1353	1383	887	2988	1811	1653	1555	843	1490	0	1051	1961	1254	1982
NZL	409	629	344	760	593	598	813	636	560	956	0	804	411	805
USA	739	3258	818	2175	1410	1421	1847	621	1884	1734	745	0	1479	1818
POL	416	883	336	1373	834	787	675	274	852	1047	304	1419	0	1222
FRA	906	993	628	1348	887	1513	1001	606	967	1261	493	1050	739	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	JPN
CAN	0	852	1022	2223	1298	1339	1578	111	1778	1414	2882	1087	1213
CHE	738	0	472	1154	715	714	742	56	750	912	915	477	488
CZE	787	327	0	1674	1084	1125	949	101	1211	1361	1419	1033	762
DEU	1686	1029	1297	0	2571	2479	2153	153	2568	3292	2984	1866	1441
DFS	1197	637	764	1831	0	1618	1555	138	1557	2048	1669	1180	970
FRA	1013	635	699	1365	898	0	1590	114	1704	1998	1824	1275	1222
GBR	1654	681	648	1619	1198	1022	0	132	1633	1820	1979	973	1063
ISR	78	35	77	123	104	64	95	0	136	141	145	95	98
ITA	1518	678	888	1768	1234	985	1299	102	0	1760	2402	1254	1179
NLD	1395	887	1229	2971	1810	1285	1594	111	1486	0	1961	1358	1062
USA	3339	818	1131	2154	1410	1065	1921	136	1879	1734	0	1533	1574
POL	933	368	805	1581	942	796	726	68	910	1196	1491	0	761
JPN	694	314	361	623	522	451	554	44	572	573	844	412	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	JPN
BEL	0	709	588	553	1148	814	852	909	825	503	70	784	1191	498	925	502	329	718	326	507
CAN	715	0	838	1003	2160	1276	1433	1292	1502	514	108	1720	1376	656	2983	1014	439	1207	675	1127
CHE	587	719	0	472	1151	716	702	701	735	409	57	745	912	416	1029	444	270	619	294	457
CZE	437	757	327	0	1669	1084	1025	1118	942	439	101	1207	1361	512	1509	960	306	727	448	723
DEU	1171	1607	1018	1291	0	2565	2122	2441	2105	889	154	2542	3271	984	3535	1682	552	1631	737	1363
DFS	754	1169	638	764	1820	0	1421	1607	1533	739	140	1550	2052	829	2057	1074	505	1240	609	915
ESP	915	1188	635	817	1824	1212	0	1608	1399	688	123	1607	1596	715	2004	1000	514	1137	611	1052
FRA	895	951	613	693	1311	873	1500	0	1556	747	117	1672	1968	810	2500	1197	477	1265	568	1159
GBR	810	1561	671	643	1574	1178	1281	990	0	977	133	1583	1782	935	2298	907	499	1382	630	1006
IRL	498	508	415	329	773	619	706	602	1015	0	94	641	897	731	800	356	334	732	356	440
ISR	42	75	35	77	122	104	96	63	93	74	0	135	143	102	170	92	59	103	77	95
ITA	769	1439	672	883	1728	1220	1407	942	1253	573	100	0	1749	719	2630	1164	470	1153	634	1118
NLD	1355	1344	887	1229	2924	1812	1656	1240	1556	844	111	1472	0	1055	2522	1217	499	1437	628	1000
NZL	409	606	344	375	755	594	603	489	813	637	85	561	960	0	1093	403	354	1195	494	551
USA	819	3348	916	1167	2413	1545	1687	1327	2089	723	154	1960	2170	1043	0	1478	629	1862	1051	1880
POL	403	840	326	708	1303	808	766	714	660	265	59	821	1002	294	1384	0	223	678	402	690
ZAF	273	402	221	206	422	370	469	328	436	292	38	373	414	285	604	151	0	471	307	400
AUS	616	1209	535	493	1192	884	910	846	1197	633	67	874	1235	1192	1841	477	410	0	614	854
URY	239	625	212	301	502	405	537	329	501	278	39	457	480	406	1280	303	252	472	0	525
JPN	306	569	267	309	517	442	480	384	472	264	35	477	475	257	716	335	251	427	252	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN

BEL	0	711	1146	814	852	825	503	783	1191	498	925	501	329	718	326	909	507
CAN	719	0	2165	1284	1440	1511	520	1727	1385	661	2996	1017	443	1215	680	1300	1132
DEU	1170	1616	0	2562	2120	2105	889	2541	3268	984	3530	1674	552	1631	736	2440	1363
DFS	754	1179	1817	0	1420	1533	739	1550	2051	829	2055	1073	505	1240	608	1607	915
ESP	915	1204	1824	1212	0	1399	688	1606	1594	715	2001	1000	514	1136	611	1607	1051
GBR	810	1574	1574	1178	1281	0	977	1583	1782	935	2298	907	499	1382	629	1556	1006
IRL	498	516	773	619	706	1015	0	641	897	731	800	356	334	732	356	747	440
ITA	769	1451	1728	1220	1406	1253	573	0	1749	719	2630	1160	470	1153	634	1672	1118
NLD	1355	1357	2923	1811	1656	1556	844	1472	0	1055	2522	1213	499	1437	628	1968	1000
NZL	409	610	756	594	603	813	637	561	960	0	1093	403	354	1195	493	810	551
USA	819	3377	2413	1545	1687	2089	723	1960	2170	1043	0	1476	629	1862	1051	2500	1880
POL	403	846	1300	807	766	660	265	820	1002	294	1384	0	223	678	402	1197	689
ZAF	273	409	422	370	469	436	292	373	414	285	604	151	0	471	307	477	400
AUS	616	1214	1192	884	910	1197	633	874	1235	1192	1841	477	410	0	614	1265	854
URY	239	631	502	405	537	501	278	457	480	406	1280	303	252	472	0	568	525
FRA	895	959	1311	873	1500	990	602	942	1240	489	1327	714	328	846	329	0	1159
JPN	306	572	517	442	480	472	264	477	475	257	716	335	251	427	252	384	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	84	305	26
DFS	77	0	130	68
USA	291	116	0	57
NLD	20	65	57	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	0	88	137	32	152	348	10
DFS	79	0	159	113	139	144	47
GBR	134	151	0	80	206	198	69
NLD	28	110	73	0	70	76	29
NZL	152	117	208	63	0	269	119
USA	349	130	213	81	294	0	39
IRL	9	43	71	29	133	41	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	88	140	32	354
DFS	79	0	158	112	144
GBR	136	150	0	80	200
NLD	28	109	74	0	76
USA	356	130	215	81	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	86	135	32	148	361	124	206	10
DFS	77	0	160	113	143	191	147	151	47
GBR	130	151	0	80	208	225	165	208	69
NLD	27	110	73	0	71	89	72	70	29
NZL	145	119	208	64	0	368	205	433	119
USA	360	164	246	96	441	0	303	482	45
ZAF	123	128	166	68	214	316	0	235	39

AUS	199	120	213	65	470	524	225	0	54
IRL	9	43	71	29	133	47	40	52	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	87	136	32	150	364	126	207	10
DFS	78	0	160	113	143	191	147	151	47
GBR	132	151	0	80	208	225	165	208	69
NLD	28	110	73	0	71	89	72	70	29
NZL	149	119	208	64	0	368	205	433	119
USA	366	164	246	96	441	0	303	481	45
ZAF	125	128	166	68	214	316	0	235	39
AUS	203	120	213	65	470	523	225	0	54
IRL	9	43	71	29	133	47	40	52	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	10	160	7	95	6
DEU	10	0	50	13	16	11
DFS	167	41	0	119	152	52
NOR	6	12	97	0	66	36
USA	90	15	145	66	0	34
NLD	6	10	49	35	32	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	0	13	161	69	7	71	133	6	4
DEU	12	0	55	14	14	16	17	15	5
DFS	167	43	0	99	137	172	172	54	18
GBR	69	13	93	0	51	74	87	33	21
NOR	6	13	108	54	0	41	72	42	53
NZL	71	16	168	71	40	0	98	18	12
USA	129	17	166	82	72	100	0	38	27
NLD	6	14	51	32	41	18	36	0	11
IRL	4	5	13	20	52	12	27	11	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	0	12	161	71	7	6	134
DEU	11	0	53	14	14	15	17
DFS	167	41	0	103	125	54	172
GBR	71	13	97	0	54	36	91
NOR	6	13	100	57	0	40	73
NLD	6	14	51	35	39	0	38
USA	130	17	166	86	73	36	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	12	155	65	6	70	157	72	6	69	4

DEU	11	0	52	14	14	16	20	3	15	39	5
DFS	161	41	0	99	125	173	195	57	54	197	18
GBR	65	13	93	0	50	77	100	42	33	75	21
NOR	6	13	100	53	0	40	76	0	40	63	53
NZL	70	16	169	73	39	0	122	40	18	139	12
USA	158	19	193	97	76	125	0	72	43	123	28
ZAF	76	3	55	40	0	38	67	0	3	43	3
NLD	6	14	51	32	39	18	41	3	0	28	11
AUS	69	38	173	73	53	138	122	44	26	0	16
IRL	4	5	13	20	52	12	28	3	11	15	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	12	156	66	6	70	158	72	6	69	4
DEU	11	0	52	14	14	16	20	3	15	39	5
DFS	162	41	0	99	137	173	195	57	54	197	18
GBR	66	13	93	0	51	77	100	42	33	75	21
NOR	6	13	108	54	0	41	76	0	42	67	53
NZL	70	16	169	73	40	0	122	40	18	139	12
USA	159	19	192	97	75	124	0	72	43	123	28
ZAF	76	3	55	40	0	38	67	0	3	43	3
NLD	6	14	51	32	41	18	41	3	0	28	11
AUS	69	38	173	73	57	138	122	44	26	0	16
IRL	4	5	13	20	52	12	28	3	11	15	0

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