

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 absence 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 absence 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 T5=IT	Calving interval converted to 42 days pregnancy rate Calving interval converted to 42 days pregnancy rate
BEL	T2=CY T4=C2 T5=IT	PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)} \times 100$, with DO=days open) PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)} \times 100$, with DO=days open) PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)} \times 100$, with DO=days open)
CAN	T1=HC T2=CY T3=C1 T4=C2 T5=IT	NR=Non Return Rate after 56 Days in heifers (NRR), % CF=Interval from Calving to First Service in cows(CF) NR=Non Return Rate after 56 Days in cows(NRR), % FC=Interval first insemination-conception in cows DO=Days open
CHE	T1=HC T2=CR T3=C1	CR=Heifers' Conception rate CF=Interval from Calving to First Service (ICF), days 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	Days Open
	T4=C2	Days Open
	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=Calving Interval (days)
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	PC=Lactating cow's ability to conceive (CR42)
	T5=IT	PC=Lactating cow's ability to conceive (CR42)

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:

NOR (RDC) If the oldest herdx4yr class (of a herd) is small, the data gets dropped. This cause a random loss of 1 to 2 daughters for old bulls, somewhat more if the daughter group was large. Base changed to a rolling cow base, based on cows born

JPN (HOL) Small changes in information due to additional records and pedigree changes

IRL(HOL, JER, RDC) Survival records are all censored where the date of last calving is within 390 days of the date of extraction for the evaluation. Rewritten the code for assigning Proof Type/Status of Bull/Publishable as it was based on a ve

CHE (BSW) Based on manual data edits and the removal of data errors, the number of herds and the number of daughters for very few bulls decreased. The change of herd-year-season assignment of certain data records might explain the very small ch

CHE (HOL) Manual data editings causing drops in infrmation especially for fertility because the changes in the data might affect the composition of the contemporary groups for this trait. The data used for HOL evaluations come from two differer

DEU (HOL, RDC) Herd-years with uninformative NonReturn56, i.e., 100% NR56 are excluded. Some traits are verified with the subsequent calving, e.g. interval first to last insemination, insemination dates must match with calving dates and resul

BEL (HOL) Definition of genetic groups were updated/improved. Genetic groups are always based on selection path, type of breed, degree of Holsteinisation, origin (North-America vs Europe) and time. Periods of time were updated and improved.

POL (HOL) Small decrease in information due to data edits.

GBR (ALL) Small drop in information due to changes in data and the fact NR56 is updated as more information becomes available.

DFS (HOL, RDC, JER) Some drop in information, because AI data is checked with calving information on when the calvings occur. If the calving does not fit with AI information, the AI information is deleted.

USA (ALL) Drops in information due to the normal editing of herds/daughters

NZL (ALL) Seasonal drop in information due to changes in matings, calvings and continuous DNA verification.

ITA (HOL) Drops in information caused by data flow and data editings.

INTERBULL CHANGES COMPARED TO THE PREVIOUS ROUTINE RUN

Subsetting:

As decided by the ITC in Orlando, new subsetting was introduced in the september test run. Sub-setting is necessary for operational purposes and restrictions of time scales. To minimize the effect of subsetting, larger subsets with 10-12 countries and with 4 link providing countries have been applied.

Window:

According to the decision taken by ITC in Orlando, the following changes have been introduced in regards to the windows used for post processing:

The upper bounds have been set to 0.99 as these were judged to have very little effect on evaluations. The lower values have been set to about the 25% percentile value. The largest changes are for the lower values for conformation traits, with the lowest window being

40% for OFL otherwise it is about 50% for all other confirmation traits.
It is anticipated that these low values may not have large impact on
evaluations since there were very few countries combinations whose
estimated correlations fell between the old limit of 0.30 and these new limits.
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 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 (December Routine Evaluation 2019).
 Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		136	8011	1727	714	
BEL			1837			
CAN	151	44	9102	528	532	
CHE	2772		3315			
CZE			3793			
DEA	5462					
DEU			26797		375	
DFS			16054	2387	9945	
ESP			5410			
EST						
FRA	385		16352			
FRM						
GBR	94	235	6716	551	391	
HUN						
IRL			2824	178	62	
ISR			1420			
ITA	1778		9700			
JPN			5858			
KOR						
LTU						
LVA						
NLD	189		15351	158	80	
NOR					2961	
NZL	57	58	7968	4797	1367	
POL			7497			
PRT						
SVK						
SVN						
URY			1637			
USA	1093	759	38795	4716	704	
ZAF			1250	706	146	
HRV						
MEX						
CAM						
=====						
No. Records	11981	1232	189687	15748	17277	
Pub. Proofs	11033	1017	153932	13286	17209	0

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

BSW	hco					
	CAN	DEA	FRA	USA	CHE	NLD
CAN	8.59					
DEA	0.84	9.78				

FRA	0.78	0.84	0.90			
USA	0.79	0.79	0.89	2.72		
CHE	0.92	0.95	0.88	0.88	13.09	
NLD	0.77	0.70	0.87	0.88	0.87	3.20

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	7.17								
CHE	0.85	11.35							
DEA	0.85	0.94	14.28						
NLD	0.87	0.88	0.86	3.53					
NZL	0.62	0.65	0.77	0.65	11.09				
USA	0.84	0.86	0.84	0.85	0.62	3.32			
GBR	0.75	0.76	0.75	0.79	0.65	0.83	3.85		
FRA	0.86	0.96	0.94	0.91	0.65	0.86	0.78	1.81	
ITA	0.85	0.85	0.84	0.86	0.69	0.84	0.80	0.86	17.89

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.87						
CHE	0.79	11.77					
DEA	0.79	0.95	11.05				
NLD	0.75	0.71	0.67	3.83			
USA	0.74	0.68	0.67	0.90	2.82		
GBR	0.72	0.79	0.75	0.71	0.67	0.04	
FRA	0.72	0.69	0.67	0.91	0.92	0.70	0.95

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.58								
CHE	0.73	11.10							
DEA	0.84	0.91	11.72						
NLD	0.88	0.84	0.85	3.21					
NZL	0.65	0.54	0.65	0.65	7.16				
USA	0.85	0.84	0.85	0.87	0.65	2.37			
GBR	0.83	0.78	0.86	0.84	0.71	0.85	3.85		
FRA	0.85	0.86	0.87	0.87	0.64	0.85	0.84	0.95	
ITA	0.85	0.69	0.85	0.85	0.61	0.88	0.83	0.85	23.21

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	7.11						
DEA	0.88	13.61					
NLD	0.89	0.88	3.38				
NZL	0.61	0.64	0.66	7.03			
USA	0.91	0.87	0.87	0.58	2.37		
GBR	0.87	0.88	0.89	0.67	0.87	3.85	
ITA	0.88	0.93	0.88	0.65	0.89	0.88	17.83

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.59				
GBR	0.75	5.16			
NZL	0.61	0.65	12.13		
USA	0.84	0.87	0.62	3.21	
AUS	0.74	0.87	0.76	0.75	6.96

GUE cc1			
	CAN	GBR	USA
CAN	7.34		
GBR	0.72	0.03	
USA	0.80	0.72	3.39

GUE cc2					
	CAN	GBR	NZL	USA	AUS
CAN	6.89				
GBR	0.84	5.16			
NZL	0.64	0.71	7.68		
USA	0.86	0.85	0.66	2.62	
AUS	0.75	0.73	0.80	0.82	12.63

GUE int					
	CAN	GBR	NZL	USA	AUS
CAN	7.84				
GBR	0.87	5.16			
NZL	0.62	0.67	7.68		
USA	0.92	0.87	0.63	2.62	
AUS	0.87	0.86	0.78	0.87	12.63

HOL hco											
	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD	ITA	JPN
CAN	7.78										
CZE	0.76	18.76									
DEU	0.93	0.78	15.06								
DFS	0.81	0.87	0.85	13.68							
FRA	0.82	0.88	0.81	0.88	0.84						
USA	0.84	0.88	0.86	0.89	0.90	2.38					
POL	0.70	0.88	0.71	0.86	0.84	0.84	19.54				
CHE	0.95	0.86	0.93	0.86	0.87	0.88	0.81	14.04			
NLD	0.79	0.87	0.79	0.86	0.87	0.88	0.82	0.87	3.80		
ITA	0.84	0.87	0.92	0.88	0.88	0.88	0.87	0.90	0.88	0.04	
JPN	0.84	0.74	0.79	0.75	0.76	0.83	0.68	0.84	0.74	0.73	6.27

HOL crc														
	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA
BEL	4.74													
CAN	0.72	6.98												
CHE	0.80	0.84	12.45											
DEU	0.72	0.85	0.88	11.18										
DFS	0.79	0.89	0.94	0.90	11.78									
ESP	0.87	0.78	0.81	0.78	0.80	11.17								
GBR	0.89	0.74	0.77	0.73	0.80	0.89	4.64							
IRL	0.87	0.72	0.72	0.72	0.72	0.87	0.87	3.46						
ITA	0.78	0.85	0.88	0.87	0.89	0.85	0.82	0.72	8.25					
NLD	0.81	0.87	0.93	0.90	0.96	0.79	0.80	0.72	0.86	4.53				
NZL	0.65	0.60	0.61	0.60	0.61	0.64	0.64	0.61	0.70	0.60	8.42			
USA	0.84	0.84	0.84	0.84	0.84	0.85	0.88	0.77	0.84	0.84	0.60	3.22		
POL	0.74	0.89	0.89	0.87	0.87	0.81	0.74	0.72	0.93	0.86	0.62	0.84	14.11	
FRA	0.76	0.86	0.94	0.92	0.94	0.82	0.80	0.72	0.91	0.94	0.62	0.84	0.88	1.19

HOL cc1	
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	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	JPN
CAN	6.70												
CHE	0.92	11.15											
CZE	0.81	0.75	18.02										
DEU	0.90	0.93	0.77	14.39									
DFS	0.74	0.72	0.89	0.74	13.30								
FRA	0.75	0.75	0.89	0.71	0.87	1.01							
GBR	0.73	0.77	0.71	0.78	0.68	0.70	0.03						
ISR	0.76	0.68	0.90	0.73	0.86	0.86	0.74	3.16					
ITA	0.86	0.88	0.75	0.95	0.69	0.69	0.76	0.74	0.05				
NLD	0.76	0.74	0.90	0.73	0.92	0.93	0.70	0.88	0.70	4.71			
USA	0.79	0.71	0.95	0.72	0.88	0.89	0.66	0.92	0.74	0.90	2.78		
POL	0.74	0.75	0.88	0.81	0.85	0.84	0.67	0.83	0.79	0.82	0.84	19.63	
JPN	0.77	0.69	0.89	0.70	0.83	0.79	0.70	0.82	0.70	0.82	0.90	0.67	7.68

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	JPN
BEL	4.74																			
CAN	0.84	5.98																		
CHE	0.80	0.87	11.22																	
CZE	0.65	0.84	0.87	18.03																
DEU	0.83	0.92	0.86	0.80	13.06															
DFS	0.84	0.85	0.86	0.80	0.94	12.88														
ESP	0.85	0.86	0.79	0.74	0.87	0.84	11.16													
FRA	0.84	0.87	0.91	0.81	0.90	0.85	0.86	0.98												
GBR	0.89	0.84	0.73	0.65	0.83	0.84	0.88	0.83	4.64											
IRL	0.84	0.83	0.81	0.66	0.83	0.83	0.86	0.83	0.85	3.46										
ISR	0.53	0.63	0.64	0.82	0.75	0.70	0.63	0.66	0.57	0.62	3.16									
ITA	0.75	0.85	0.86	0.90	0.91	0.84	0.86	0.84	0.77	0.78	0.82	15.79								
NLD	0.84	0.90	0.89	0.84	0.94	0.91	0.86	0.89	0.84	0.84	0.72	0.85	4.43							
NZL	0.73	0.64	0.53	0.49	0.63	0.63	0.68	0.63	0.71	0.74	0.46	0.58	0.63	5.34						
USA	0.84	0.86	0.85	0.86	0.90	0.88	0.87	0.85	0.84	0.84	0.75	0.92	0.87	0.65	2.31					
POL	0.83	0.83	0.71	0.62	0.81	0.82	0.85	0.80	0.84	0.83	0.53	0.77	0.82	0.64	0.83	13.02				
ZAF	0.76	0.77	0.80	0.70	0.82	0.77	0.84	0.79	0.80	0.87	0.58	0.84	0.79	0.71	0.87	0.77	15.90			
AUS	0.77	0.77	0.81	0.70	0.77	0.71	0.80	0.78	0.76	0.92	0.61	0.78	0.74	0.74	0.82	0.70	0.90	9.60		
URY	0.84	0.81	0.68	0.60	0.80	0.81	0.83	0.81	0.85	0.84	0.48	0.65	0.81	0.75	0.83	0.86	0.78	0.72	1.43	
JPN	0.83	0.85	0.83	0.74	0.84	0.85	0.90	0.85	0.86	0.84	0.60	0.86	0.84	0.65	0.92	0.90	0.87	0.80	0.82	18.59

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN
BEL	4.74																
CAN	0.87	6.43															
DEU	0.87	0.89	12.25														
DFS	0.90	0.91	0.94	12.82													
ESP	0.88	0.88	0.87	0.88	11.16												
GBR	0.89	0.87	0.87	0.89	0.90	4.64											
IRL	0.87	0.87	0.87	0.87	0.87	0.87	3.46										
ITA	0.87	0.89	0.90	0.90	0.93	0.87	0.87	20.75									
NLD	0.93	0.90	0.91	0.95	0.88	0.90	0.87	0.87	4.52								
NZL	0.73	0.61	0.60	0.60	0.67	0.71	0.73	0.66	0.63	5.34							
USA	0.87	0.92	0.90	0.89	0.89	0.87	0.87	0.93	0.87	0.62	2.31						
POL	0.86	0.87	0.87	0.87	0.86	0.87	0.87	0.90	0.87	0.68	0.87	13.02					
ZAF	0.87	0.87	0.87	0.87	0.88	0.87	0.88	0.89	0.87	0.71	0.88	0.87	15.90				
AUS	0.87	0.87	0.87	0.87	0.87	0.87	0.93	0.87	0.87	0.75	0.87	0.87	0.91	9.60			
URY	0.87	0.87	0.86	0.86	0.86	0.87	0.87	0.87	0.87	0.76	0.87	0.87	0.87	1.43			
FRA	0.77	0.84	0.77	0.79	0.81	0.71	0.78	0.79	0.77	0.49	0.82	0.67	0.78	0.80	0.61	0.98	
JPN	0.87	0.93	0.90	0.90	0.91	0.87	0.87	0.94	0.87	0.64	0.92	0.92	0.89	0.87	0.87	0.76	18.59

JER hco

	CAN	DFS	USA	NLD
CAN	8.00			
DFS	0.78	17.58		
USA	0.81	0.88	2.73	
NLD	0.77	0.87	0.88	3.60

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	6.67						
DFS	0.87	13.62					
GBR	0.73	0.85	4.14				
NLD	0.87	0.91	0.77	3.72			
NZL	0.63	0.67	0.69	0.61	6.75		
USA	0.84	0.84	0.84	0.84	0.66	3.75	
IRL	0.74	0.73	0.87	0.73	0.62	0.75	1.98

JER ccl

	CAN	DFS	GBR	NLD	USA
CAN	6.64				
DFS	0.72	15.60			
GBR	0.76	0.68	0.03		
NLD	0.76	0.90	0.69	3.71	
USA	0.74	0.88	0.67	0.90	2.90

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.55								
DFS	0.85	15.69							
GBR	0.85	0.84	4.14						
NLD	0.89	0.89	0.84	3.25					
NZL	0.65	0.65	0.74	0.64	4.30				
USA	0.85	0.87	0.85	0.87	0.68	2.59			
ZAF	0.70	0.70	0.76	0.74	0.75	0.86	11.11		
AUS	0.70	0.71	0.69	0.71	0.73	0.77	0.83	7.16	
IRL	0.84	0.85	0.85	0.85	0.67	0.85	0.73	0.77	1.98

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.37								
DFS	0.88	15.43							
GBR	0.87	0.88	4.14						
NLD	0.88	0.91	0.88	3.43					
NZL	0.64	0.63	0.73	0.62	4.30				
USA	0.89	0.87	0.87	0.87	0.67	2.59			
ZAF	0.87	0.87	0.87	0.86	0.72	0.87	11.11		
AUS	0.87	0.87	0.87	0.87	0.73	0.87	0.88	7.16	
IRL	0.85	0.86	0.85	0.87	0.46	0.85	0.84	0.87	1.98

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.42					
DEU	0.92	14.11				
DFS	0.81	0.80	12.35			
NOR	0.86	0.84	0.82	14.68		
USA	0.85	0.84	0.90	0.72	2.62	
NLD	0.78	0.79	0.87	0.72	0.88	4.04

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RDC      crc
-----
      CAN      DEU      DFS      GBR      NOR      NZL      USA      NLD      IRL
CAN      6.32
DEU      0.85      10.16
DFS      0.87      0.90      12.68
GBR      0.76      0.74      0.77      4.52
NOR      0.89      0.87      0.86      0.75      13.62
NZL      0.62      0.62      0.61      0.66      0.68      10.51
USA      0.84      0.84      0.84      0.83      0.85      0.71      3.41
NLD      0.87      0.89      0.92      0.79      0.86      0.62      0.85      3.19
IRL      0.73      0.73      0.74      0.87      0.74      0.63      0.76      0.73      2.66
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RDC      cc1
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      CAN      DEU      DFS      GBR      NOR      NLD      USA
CAN      7.05
DEU      0.89      12.92
DFS      0.77      0.77      13.10
GBR      0.72      0.78      0.74      0.03
NOR      0.84      0.83      0.87      0.72      12.20
NLD      0.77      0.76      0.90      0.71      0.72      3.97
USA      0.83      0.73      0.87      0.67      0.78      0.90      2.65
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RDC      cc2
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      CAN      DEU      DFS      GBR      NOR      NZL      USA      ZAF      NLD      AUS      IRL
CAN      6.81
DEU      0.92      10.39
DFS      0.85      0.94      12.81
GBR      0.85      0.84      0.85      4.52
NOR      0.88      0.87      0.85      0.86      11.67
NZL      0.65      0.65      0.65      0.69      0.66      6.76
USA      0.87      0.90      0.86      0.85      0.86      0.71      2.38
ZAF      0.71      0.81      0.74      0.72      0.70      0.73      0.85      17.66
NLD      0.89      0.95      0.90      0.85      0.86      0.65      0.86      0.77      3.46
AUS      0.72      0.73      0.67      0.76      0.66      0.78      0.80      0.81      0.72      8.69
IRL      0.84      0.84      0.85      0.85      0.86      0.72      0.85      0.84      0.85      0.86      2.66
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RDC      int
-----
      CAN      DEU      DFS      GBR      NOR      NZL      USA      ZAF      NLD      AUS      IRL
CAN      6.71
DEU      0.89      10.58
DFS      0.88      0.94      13.11
GBR      0.87      0.87      0.88      4.52
NOR      0.90      0.89      0.87      0.88      13.38
NZL      0.67      0.58      0.59      0.67      0.66      6.76
USA      0.91      0.89      0.88      0.87      0.88      0.70      2.37
ZAF      0.87      0.87      0.87      0.87      0.91      0.70      0.88      17.66
NLD      0.90      0.91      0.92      0.89      0.88      0.62      0.87      0.87      3.38
AUS      0.87      0.87      0.87      0.87      0.88      0.76      0.87      0.89      0.87      8.69
IRL      0.87      0.87      0.87      0.87      0.88      0.68      0.87      0.89      0.88      0.91      2.66
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^LAPPENDIX II. Number of common bulls
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BSW
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common bulls below diagonal
common three quarter sib group above diagonal

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	CAN	DEA	FRA	USA	CHE	NLD
CAN	0	83	50	94	87	29
DEA	70	0	194	170	569	128
FRA	43	141	0	70	155	71
USA	85	129	52	0	192	43
CHE	71	474	114	158	0	83
NLD	26	121	58	39	78	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	103	98	36	20	123	44	65	94
CHE	82	0	555	92	26	256	57	157	401
DEA	81	452	0	143	34	213	56	196	545
NLD	32	84	133	0	25	52	35	77	113
NZL	18	21	27	19	0	21	17	21	28
USA	115	223	164	47	18	0	57	92	159
GBR	38	40	38	27	13	50	0	44	62
FRA	55	114	143	62	17	62	34	0	171
ITA	77	337	421	90	21	111	41	130	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	105	99	36	124	44	69
CHE	84	0	547	91	256	58	162
DEA	80	445	0	140	213	59	204
NLD	32	84	132	0	52	36	82
USA	116	223	163	47	0	60	95
GBR	39	42	40	27	52	0	48
FRA	59	120	154	68	67	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	93	90	35	19	115	41	64	88
CHE	73	0	541	92	26	311	57	162	401
DEA	73	442	0	141	34	306	55	203	534
NLD	31	84	132	0	25	75	35	82	113
NZL	17	21	27	19	0	30	17	22	28
USA	102	289	266	64	26	0	67	115	206
GBR	34	40	38	27	13	60	0	46	62
FRA	55	120	154	68	18	81	37	0	182
ITA	72	337	415	90	21	143	41	141	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	94	37	20	119	43	93
DEA	76	0	143	34	304	55	643
NLD	34	135	0	25	76	35	119
NZL	18	27	19	0	30	17	28
USA	106	265	67	26	0	67	224

GBR	36	38	27	13	60	0	63
ITA	76	544	98	21	158	41	0

GUE

GUE

common bulls below diagonal
 common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	15	3	37	18
GBR	12	0	13	51	28
NZL	2	11	0	9	26
USA	36	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	15	38
GBR	12	0	53
USA	37	50	0

GUE

common bulls below diagonal
 common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	11	2	35	19
GBR	8	0	13	82	32
NZL	2	11	0	29	26
USA	33	83	28	0	59
AUS	15	26	26	55	0

GUE

common bulls below diagonal
 common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	11	2	35	19
GBR	8	0	13	82	32
NZL	2	11	0	29	26
USA	33	83	28	0	59
AUS	15	26	26	55	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	950	2012	1123	1162	2439	1003	768	1161	1576	1031
CZE	672	0	1701	1076	1129	1270	957	458	1303	1183	733
DEU	1503	1249	0	2529	2389	2624	1737	1121	3038	2552	1332
DFS	1010	673	1667	0	1544	1401	1080	669	1905	1550	874
FRA	841	666	1302	830	0	1538	1214	651	1805	1716	1068
USA	2748	977	1893	1182	880	0	1422	795	1578	2102	1324
POL	840	709	1413	811	742	1393	0	440	1221	1189	694
CHE	650	303	978	578	584	711	333	0	837	716	435
NLD	1107	1108	2540	1588	1135	1325	1022	803	0	1643	955

ITA	1280	793	1640	1139	938	1576	843	635	1301	0	1136
JPN	538	290	500	420	366	641	350	256	445	462	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	669	553	1127	757	811	779	480	766	1118	473	721	452	870
CAN	666	0	788	2095	1194	1361	1385	496	1624	1282	636	2584	917	1254
CHE	556	673	0	1117	671	657	680	389	707	854	388	852	397	659
DEU	1153	1545	975	0	2588	2079	2046	873	2550	3318	964	2848	1527	2515
DFS	692	1082	590	1700	0	1323	1443	708	1525	1919	783	1544	972	1546
ESP	863	1109	600	1805	1101	0	1337	660	1573	1502	681	1584	923	1518
GBR	756	1434	616	1489	1073	1202	0	915	1536	1656	890	1725	805	1492
IRL	475	492	393	766	585	680	958	0	645	859	697	594	330	722
ITA	727	1338	637	1676	1140	1380	1153	566	0	1697	750	2230	1054	1723
NLD	1270	1247	827	2963	1650	1543	1413	810	1387	0	1001	1810	1091	1907
NZL	386	589	324	740	549	567	763	604	557	907	0	757	376	781
USA	679	2899	757	1978	1264	1298	1611	581	1616	1557	687	0	1298	1730
POL	364	741	292	1148	702	685	556	243	708	867	270	1211	0	1106
FRA	847	920	581	1325	812	1404	930	584	931	1176	463	970	641	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	788	979	2089	1202	1263	1441	96	1630	1291	2637	957	1160
CHE	674	0	448	1117	671	664	686	53	707	854	852	424	454
CZE	720	302	0	1648	1041	1117	926	95	1155	1296	1338	929	739
DEU	1536	974	1225	0	2589	2529	2099	137	2531	3294	2809	1657	1454
DFS	1086	590	684	1695	0	1554	1472	123	1526	1918	1549	1041	922
FRA	942	591	673	1343	831	0	1521	112	1737	1923	1736	1167	1189
GBR	1497	625	594	1525	1097	957	0	114	1574	1700	1813	856	1016
ISR	70	32	75	117	97	63	81	0	123	129	122	81	88
ITA	1345	637	800	1658	1139	955	1197	96	0	1695	2225	1106	1176
NLD	1253	827	1125	2937	1649	1203	1463	108	1383	0	1810	1187	1014
USA	2972	757	1030	1942	1264	995	1709	114	1614	1557	0	1353	1498
POL	789	322	690	1336	787	694	603	55	765	995	1276	0	695
JPN	643	290	330	580	482	425	514	40	533	527	781	365	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	658	553	539	1119	758	811	864	781	482	67	763	1120	473	871	445	320	684	315	479
CAN	651	0	775	959	2021	1169	1346	1213	1359	485	91	1577	1241	620	2709	887	432	1125	639	1077
CHE	556	656	0	449	1112	672	657	651	680	389	54	701	855	388	968	384	265	578	284	425
CZE	407	689	302	0	1645	1043	984	1109	913	434	95	1156	1299	512	1467	863	314	720	441	708
DEU	1141	1457	964	1215	0	2571	2081	2489	2041	872	140	2510	3260	958	3556	1484	566	1594	722	1386
DFS	692	1047	591	684	1679	0	1331	1538	1447	708	125	1512	1921	787	1933	948	497	1175	578	876
ESP	863	1081	600	761	1793	1108	0	1519	1340	661	115	1580	1508	685	1906	908	504	1079	590	1013
FRA	836	873	571	662	1287	800	1392	0	1487	725	115	1710	1893	786	2418	1083	471	1213	553	1130
GBR	756	1398	616	577	1477	1073	1202	918	0	916	115	1534	1658	891	2101	790	490	1291	597	967
IRL	475	473	393	308	763	585	680	582	958	0	85	647	862	699	758	321	329	698	341	417
ISR	42	65	32	75	117	97	90	62	80	67	0	123	131	95	147	76	57	90	76	87
ITA	720	1268	627	795	1616	1119	1372	905	1146	563	93	0	1682	751	2573	1026	480	1151	639	1123
NLD	1272	1193	827	1125	2869	1651	1546	1151	1413	811	108	1359	0	1004	2373	1057	490	1363	597	962
NZL	386	566	324	348	730	550	569	458	763	605	80	556	910	0	1042	368	351	1147	459	530
USA	757	2955	853	1089	2299	1396	1561	1249	1851	680	131	1738	1991	981	0	1304	619	1753	1002	1815
POL	354	698	281	603	1087	681	669	616	535	233	48	679	824	262	1178	0	212	599	377	631

ZAF	262	393	216	202	423	360	455	322	426	286	38	372	404	281	589	139	0	462	304	396
AUS	581	1104	504	452	1124	812	851	799	1091	599	59	828	1160	1133	1689	403	396	0	586	816
URY	228	603	205	292	495	386	515	321	481	269	38	450	463	373	1232	284	251	451	0	505
JPN	286	532	251	283	488	416	449	362	441	252	31	448	447	248	672	293	246	402	242	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	661	1117	758	811	781	482	762	1122	473	871	444	320	684	315	864	479
CAN	657	0	2026	1176	1352	1367	491	1586	1257	626	2722	889	434	1132	645	1221	1080
DEU	1140	1466	0	2570	2080	2041	872	2510	3276	958	3553	1478	565	1594	722	2488	1386
DFS	692	1058	1678	0	1331	1447	708	1512	1926	787	1933	948	496	1175	578	1538	876
ESP	863	1097	1793	1108	0	1340	661	1579	1512	685	1903	908	503	1078	590	1518	1012
GBR	756	1411	1477	1073	1202	0	916	1534	1666	891	2101	790	489	1291	597	1487	967
IRL	475	482	763	585	680	958	0	647	865	699	758	321	329	698	341	725	417
ITA	720	1283	1616	1119	1371	1146	563	0	1689	751	2573	1024	480	1151	639	1710	1123
NLD	1278	1219	2893	1659	1557	1423	814	1371	0	1004	2382	1060	490	1365	600	1896	967
NZL	386	572	730	550	569	763	605	556	912	0	1042	368	350	1147	459	786	530
USA	757	2984	2299	1396	1561	1851	680	1738	2004	981	0	1302	618	1753	1002	2418	1815
POL	354	703	1085	681	669	535	233	679	830	262	1178	0	212	599	377	1083	631
ZAF	262	399	423	360	455	426	286	372	405	281	589	139	0	461	304	471	395
AUS	581	1109	1124	812	851	1091	599	828	1167	1133	1689	403	396	0	586	1213	816
URY	228	611	495	386	515	481	269	450	465	373	1232	284	251	451	0	553	505
FRA	836	882	1287	800	1392	918	582	905	1156	458	1249	616	322	799	321	0	1130
JPN	286	534	488	416	449	441	252	448	451	248	672	293	246	402	242	362	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	57	280	24
DFS	47	0	97	59
USA	264	77	0	51
NLD	18	56	50	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	0	62	124	28	144	318	8
DFS	49	0	131	91	121	114	39
GBR	122	120	0	70	189	183	62
NLD	22	86	63	0	65	69	27
NZL	144	94	193	57	0	254	108
USA	315	93	195	71	278	0	37
IRL	7	33	64	27	120	39	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	62	129	28	326
DFS	49	0	133	91	113
GBR	126	120	0	70	188
NLD	22	86	64	0	69
USA	324	93	201	71	0

JER

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common bulls below diagonal
common three quarter sib group above diagonal
      CAN  DFS  GBR  NLD  NZL  USA  ZAF  AUS  IRL
-----
CAN    0   61  122   28  140  330  122  193   8
DFS   48    0  132   91  123  157  125  120  39
GBR  118  120    0   70  191  209  157  188  62
NLD   21   86   63    0   66   81   67   63  27
NZL  136   95  193   58    0  352  200  421 108
USA  323  123  227   85  423    0  293  458  42
ZAF  119  101  157   62  209  301    0  228  38
AUS  183   85  195   54  453  492  216    0  50
IRL    7   33   64   27  120   44   39   48   0
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JER

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common bulls below diagonal
common three quarter sib group above diagonal
      CAN  DFS  GBR  NLD  NZL  USA  ZAF  AUS  IRL
-----
CAN    0   62  123   28  142  333  124  195   8
DFS   49    0  132   95  123  157  125  120  39
GBR  120  120    0   74  191  209  157  188  62
NLD   23   91   67    0   69   85   70   65  28
NZL  139   95  193   62    0  352  200  421 108
USA  328  123  227   90  423    0  293  458  42
ZAF  121  101  157   66  209  301    0  228  38
AUS  186   85  195   56  453  492  216    0  50
IRL    7   33   64   27  120   44   39   48   0
-----

```

RDC

```

-----
common bulls below diagonal
common three quarter sib group above diagonal
      CAN  DEU  DFS  NOR  USA  NLD
-----
CAN    0   13  145    6   89    4
DEU   12    0   60   16   18   13
DFS  148   49    0  114  139   47
NOR    5   15   91    0   61   31
USA   85   17  130   61    0   29
NLD    4   13   44   31   27    0
-----

```

RDC

```

-----
common bulls below diagonal
common three quarter sib group above diagonal
      CAN  DEU  DFS  GBR  NOR  NZL  USA  NLD  IRL
-----
CAN    0   14  145   65    6   65  124    6   4
DEU   13    0   67   19   19   21   25   14   6
DFS  148   56    0   93  131  162  151   49  18
GBR   66   18   88    0   47   69   82   29  19
NOR    6   18  102   49    0   40   67   38  52
NZL   64   21  157   66   39    0   88   16  12
USA  120   24  145   78   67   89    0   34  26
NLD    6   14   47   28   38   16   32    0  11
IRL    4    6   13   18   51   12   26   11   0
-----

```

RDC

```

-----
common bulls below diagonal
common three quarter sib group above diagonal
      CAN  DEU  DFS  GBR  NOR  NLD  USA
-----

```

CAN	0	14	146	68	5	5	123
DEU	13	0	67	19	18	14	25
DFS	149	56	0	95	118	50	151
GBR	67	18	88	0	48	31	85
NOR	5	17	93	50	0	36	67
NLD	5	14	47	30	36	0	34
USA	119	25	146	80	68	32	0

RDC

common bulls below diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	13	139	61	5	63	147	69	5	66	4
DEU	12	0	64	19	18	21	26	2	14	43	6
DFS	142	53	0	93	118	163	171	54	50	187	18
GBR	62	18	88	0	46	71	95	39	29	71	19
NOR	5	17	93	48	0	39	68	0	36	57	52
NZL	62	21	158	67	38	0	113	36	16	133	12
USA	149	25	167	93	68	114	0	68	35	112	27
ZAF	73	2	52	37	0	34	63	0	3	39	3
NLD	5	14	47	28	36	16	33	3	0	24	11
AUS	66	42	163	69	47	133	113	40	22	0	15
IRL	4	6	13	18	51	12	27	3	11	14	0

RDC

common bulls below diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	13	139	62	5	63	147	69	6	66	4
DEU	12	0	64	19	19	21	26	2	14	43	6
DFS	142	53	0	93	131	163	170	54	50	187	18
GBR	63	18	88	0	47	71	95	39	30	71	19
NOR	5	18	102	49	0	40	68	0	39	61	52
NZL	62	21	158	67	39	0	113	36	16	133	12
USA	149	26	167	93	69	115	0	68	37	112	27
ZAF	73	2	52	37	0	34	63	0	3	39	3
NLD	6	14	47	29	39	16	35	3	0	24	11
AUS	66	42	163	69	51	133	113	40	22	0	15
IRL	4	6	13	18	51	12	27	3	11	14	0

SIM

SIM

SIM

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SIM