

## 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 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 days open (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	T2=CY T4=C2 T5=IT	Calving interval converted to 42 days pregnancy rate 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 T4=C2	CR=Heifers' Conception rate CF=Interval from Calving to First Service (ICF), days NR=Non Return Rate after 56 Days (NRR), % FL=Interval from first to last insemination cows
CZE	T1=HC T3=C1 T4=C2	CR=Heifers' Conception rate (pregnant or not after 3 months) CR=Cows' Conception rate (pregnant or not after 3 months) 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	DO=Days open
	T4=C2	DO=Days open
	T5=IT	DO=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) for cows
	T4=C2	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	T2=CY	CF=Days to first service
	T3=C1	NR=Non-return rate at 56 days (%)
	T4=C2	CI=Calving Interval (days)
	T5=IT	CI=Calving interval (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	NR=NR=Non-return rate 56 days (heifers)
	T2=CY	CF=Interval calving to first insemination (days)
	T3=C1	NR=NR=Non-return rate 56 days (cows)
	T4=C2	CI=Calving Interval (days)
	T5=IT	CI=Calving Interval (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	Non return rate at 56 days for heifer
	T2=CR	Interval from calving to first insemination
	T3=C1	Non return rate at 56 days for cows
	T4=IT	Days open
	T5=IT	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

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CHANGES IN NATIONAL PROCEDURES  
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Changes in the national genetic evaluation of female fertility traits are as follows:

DEU HOL Corrected an Error detected in genetic group and birth year for some bulls

DEU HOL/RDC Base change

CHE HOL/BSW Use of new software (MiX99) for estimation of breeding values and corresponding reliabilities. Change in data edit for BSW, changes in pedigree for HOL, Base change

CHE BSW/SIM Base change

NOR RDC The rolling definition of hys is causing the daughters to distribute somewhat differently over hys-classes at each evaluation. Therefore some bulls occasionally may lose EDC although the number of daughters stay the same. Reliability changes is a function of the EDC changes

FRA BSW/SIM Base change

FRA HOL Base change, inclusion of FRR in HOLFRA population

ITA HOL Base change + one year cut-off data

NZL BSW/GUE Continuous DNA parentage testing therefore daughter counts, herd counts, edc and reliability are subjected to changes

JER/HOL  
RDC

DEA BSW Base change

INTERBULL CHANGES COMPARED TO THE DECEMBER ROUTINE RUN  
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Sub-setting:  
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As decided by the ITC in Orlando, new sub-setting was introduced in the September test run. Sub-setting is necessary for operational purposes and restrictions of time scales. To minimize the effect of sub-setting, larger subsets with 10-12 countries and with 4 link providing countries have been applied.

Window:  
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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

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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

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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

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

## NEXT TEST INTERNATIONAL EVALUATION

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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 (April Routine Evaluation 2017).

Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		122	7480	1531	631	
BEL			1112			
CAN	119	38	8055	434	479	
CHE	2563		2960			
CZE			3549			
DEA	5205					
DEU			24175		328	
DFS			14985	2250	9274	
ESP			2991			
EST						
FRA	344		15301			
FRM						
GBR	79	212	6017	503	351	
HUN						
IRL			2539	149	54	
ISR			1268			
ITA	1651		8731			
JPN						
KOR						
LTU						
LVA						
NLD	161		14221	120	63	
NOR					3739	
NZL	49	58	7001	4336	1251	
POL			6249			
PRT						
SVK						
SVN						
URY			1277			
USA	1018	731	35217	4109	645	
ZAF			1190	649	143	
HRV						
MEX						
No. Records	11189	1161	164318	14081	16958	
Pub. Proofs	10383	963	139455	11925	15847	0

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

BSW	hco					
	CAN	DEA	FRA	USA	CHE	NLD
CAN	9.28					
DEA	0.85	9.76				
FRA	0.80	0.83	0.91			
USA	0.81	0.85	0.90	2.61		
CHE	0.92	0.94	0.88	0.88	13.00	
NLD	0.81	0.73	0.85	0.88	0.88	3.66

BSW      crc

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	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.89								
CHE	0.85	11.13							
DEA	0.85	0.94	14.14						
NLD	0.87	0.88	0.85	3.48					
NZL	0.62	0.65	0.72	0.62	11.08				
USA	0.85	0.86	0.85	0.85	0.62	3.33			
GBR	0.75	0.76	0.75	0.80	0.65	0.83	4.04		
FRA	0.86	0.96	0.93	0.91	0.63	0.86	0.79	1.76	
ITA	0.85	0.85	0.85	0.86	0.69	0.85	0.80	0.87	19.43

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BSW      cc1

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	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.52						
CHE	0.78	11.84					
DEA	0.78	0.96	10.93				
NLD	0.73	0.69	0.67	3.63			
USA	0.74	0.67	0.67	0.91	2.81		
GBR	0.73	0.82	0.78	0.67	0.67	0.04	
FRA	0.71	0.69	0.67	0.86	0.92	0.67	0.95

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BSW      cc2

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	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.36								
CHE	0.72	11.04							
DEA	0.83	0.92	11.62						
NLD	0.87	0.84	0.85	3.41					
NZL	0.63	0.54	0.64	0.63	7.40				
USA	0.85	0.83	0.85	0.88	0.65	2.38			
GBR	0.81	0.77	0.85	0.81	0.69	0.85	4.04		
FRA	0.83	0.88	0.86	0.81	0.62	0.85	0.81	0.95	
ITA	0.85	0.72	0.85	0.85	0.66	0.88	0.86	0.85	24.17

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BSW      int

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	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.90						
DEA	0.88	13.49					
NLD	0.88	0.87	3.22				
NZL	0.58	0.63	0.63	7.23			
USA	0.90	0.87	0.87	0.57	2.38		
GBR	0.87	0.88	0.89	0.66	0.87	4.04	
ITA	0.88	0.93	0.88	0.65	0.89	0.88	18.03

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GUE      crc

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	CAN	GBR	NZL	USA	AUS
CAN	7.21				
GBR	0.75	4.41			
NZL	0.60	0.65	11.57		
USA	0.84	0.86	0.62	3.39	
AUS	0.73	0.87	0.70	0.74	7.02

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GUE      cc1

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	CAN	GBR	USA
CAN	7.07		
GBR	0.71	0.03	
USA	0.80	0.74	3.41

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GUE cc2

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	CAN	GBR	NZL	USA	AUS
CAN	6.75				
GBR	0.81	4.41			
NZL	0.61	0.69	7.52		
USA	0.85	0.85	0.65	2.69	
AUS	0.70	0.74	0.76	0.79	7.12

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GUE int

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	CAN	GBR	NZL	USA	AUS
CAN	7.07				
GBR	0.87	4.41			
NZL	0.57	0.65	7.52		
USA	0.90	0.87	0.60	2.69	
AUS	0.87	0.87	0.73	0.87	7.12

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HOL hco

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	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD
CAN	7.74								
CZE	0.80	17.72							
DEU	0.93	0.80	14.96						
DFS	0.83	0.85	0.90	13.66					
FRA	0.81	0.87	0.82	0.85	0.84				
USA	0.85	0.88	0.87	0.88	0.92	2.40			
POL	0.79	0.66	0.78	0.76	0.65	0.68	18.38		
CHE	0.96	0.86	0.93	0.88	0.86	0.88	0.69	13.84	
NLD	0.81	0.86	0.78	0.81	0.86	0.88	0.68	0.85	4.12

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HOL crc

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	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA
POL	FRA	AUS										
BEL	4.67											
CAN	0.73	6.84										
CHE	0.79	0.85	12.34									
DEU	0.71	0.86	0.89	11.08								
DFS	0.80	0.88	0.94	0.91	12.03							
ESP	0.86	0.75	0.78	0.75	0.78	11.25						
GBR	0.88	0.74	0.77	0.74	0.81	0.90	4.70					
IRL	0.86	0.71	0.72	0.71	0.72	0.86	0.86	3.47				
ITA	0.79	0.85	0.89	0.89	0.92	0.86	0.83	0.72	7.92			
NLD	0.81	0.87	0.92	0.92	0.96	0.78	0.80	0.72	0.88	4.60		
NZL	0.65	0.59	0.62	0.59	0.62	0.63	0.64	0.61	0.69	0.59	8.70	
USA	0.83	0.84	0.84	0.84	0.84	0.86	0.87	0.77	0.84	0.84	0.60	3.25
POL	0.75	0.89	0.89	0.88	0.89	0.79	0.73	0.71	0.91	0.87	0.62	0.84
14.10												
FRA	0.75	0.86	0.94	0.92	0.94	0.80	0.80	0.71	0.92	0.95	0.60	0.84
0.88	1.19											
AUS	0.86	0.71	0.72	0.71	0.71	0.86	0.86	0.88	0.72	0.72	0.61	0.72
0.71	0.71	4.93										

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HOL cc1

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	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL
CAN	6.87											
CHE	0.91	11.02										
CZE	0.83	0.75	16.02									
DEU	0.89	0.94	0.74	13.83								
DFS	0.73	0.72	0.88	0.71	13.19							
FRA	0.72	0.75	0.88	0.66	0.83	1.01						
GBR	0.72	0.76	0.68	0.76	0.70	0.67	0.03					
ISR	0.79	0.69	0.89	0.69	0.84	0.84	0.73	3.10				
ITA	0.84	0.88	0.71	0.93	0.70	0.64	0.75	0.72	0.05			
NLD	0.74	0.71	0.88	0.68	0.92	0.89	0.67	0.86	0.66	4.53		
USA	0.78	0.70	0.95	0.68	0.86	0.89	0.66	0.89	0.70	0.92	2.80	
POL	0.70	0.74	0.63	0.83	0.70	0.61	0.67	0.63	0.84	0.63	0.66	17.41

HOL	cc2											
	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA
NLD	NZL	USA	POL	ZAF	AUS	URY						
BEL	4.67											
CAN	0.84	6.21										
CHE	0.78	0.85	11.13									
CZE	0.65	0.84	0.86	16.02								
DEU	0.81	0.92	0.89	0.88	12.40							
DFS	0.83	0.85	0.86	0.81	0.93	13.16						
ESP	0.86	0.84	0.75	0.70	0.81	0.82	11.25					
FRA	0.82	0.86	0.91	0.78	0.87	0.83	0.78	0.98				
GBR	0.89	0.84	0.72	0.64	0.81	0.83	0.90	0.79	4.70			
IRL	0.84	0.83	0.79	0.66	0.81	0.81	0.85	0.81	0.85	3.47		
ISR	0.50	0.63	0.65	0.79	0.72	0.65	0.54	0.63	0.54	0.60	3.10	
ITA	0.84	0.84	0.78	0.75	0.84	0.84	0.92	0.79	0.87	0.84	0.61	17.84
NLD	0.81	0.91	0.88	0.84	0.92	0.90	0.81	0.84	0.81	0.82	0.69	0.83
4.55												
NZL	0.73	0.64	0.52	0.48	0.60	0.60	0.69	0.59	0.70	0.73	0.45	0.66
0.61	5.59											
USA	0.84	0.85	0.83	0.86	0.89	0.89	0.87	0.85	0.84	0.84	0.72	0.93
0.89	0.65	2.32										
POL	0.82	0.82	0.67	0.62	0.78	0.78	0.85	0.74	0.84	0.81	0.48	0.87
0.79	0.61	0.83	13.09									
ZAF	0.74	0.76	0.79	0.71	0.82	0.78	0.85	0.79	0.80	0.86	0.61	0.90
0.80	0.69	0.87	0.75	15.98								
AUS	0.78	0.71	0.78	0.66	0.72	0.69	0.77	0.79	0.76	0.87	0.57	0.79
0.71	0.70	0.79	0.67	0.84	5.06							
URY	0.84	0.81	0.68	0.58	0.79	0.81	0.84	0.81	0.85	0.84	0.49	0.82
0.81	0.76	0.83	0.86	0.79	0.73	1.44						

HOL	int											
	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL
ZAF	AUS	URY										
BEL	4.66											
CAN	0.88	6.62										
DEU	0.86	0.87	10.58									
DFS	0.90	0.90	0.93	13.08								
ESP	0.86	0.87	0.88	0.86	11.23							
GBR	0.87	0.87	0.87	0.90	0.91	4.70						
IRL	0.87	0.87	0.86	0.86	0.86	0.87	3.46					
ITA	0.86	0.89	0.90	0.89	0.95	0.88	0.87	17.85				
NLD	0.91	0.91	0.92	0.94	0.87	0.90	0.86	0.89	4.45			
NZL	0.70	0.57	0.60	0.59	0.68	0.68	0.68	0.67	0.61	5.59		
USA	0.87	0.92	0.87	0.88	0.87	0.87	0.87	0.92	0.87	0.60	2.32	
POL	0.87	0.87	0.86	0.86	0.87	0.86	0.87	0.89	0.86	0.66	0.87	13.08
ZAF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.92	0.87	0.66	0.87	0.87
16.00												
AUS	0.86	0.87	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.68	0.87	0.87
0.87	5.06											
URY	0.88	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.74	0.87	0.87
0.87	0.87	1.44										

JER	hco			
	CAN	DFS	USA	NLD
CAN	7.84			
DFS	0.82	17.41		
USA	0.85	0.87	2.70	
NLD	0.79	0.80	0.88	4.42



JER crc

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.83							
DFS	0.87	13.90						
GBR	0.73	0.87	4.06					
NLD	0.87	0.91	0.78	3.93				
NZL	0.59	0.65	0.67	0.60	6.93			
USA	0.84	0.85	0.84	0.85	0.64	3.78		
AUS	0.72	0.73	0.86	0.72	0.61	0.73	3.67	
IRL	0.73	0.73	0.87	0.73	0.62	0.76	0.88	1.93

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.78				
DFS	0.73	15.55			
GBR	0.73	0.71	0.03		
NLD	0.73	0.88	0.67	3.56	
USA	0.75	0.87	0.68	0.91	2.87

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.64								
DFS	0.85	16.05							
GBR	0.85	0.83	4.06						
NLD	0.90	0.89	0.82	3.66					
NZL	0.65	0.63	0.70	0.62	4.43				
USA	0.85	0.87	0.85	0.88	0.68	2.61			
ZAF	0.71	0.73	0.77	0.79	0.71	0.86	10.97		
AUS	0.67	0.71	0.73	0.71	0.69	0.70	0.77	3.69	
IRL	0.84	0.84	0.85	0.83	0.67	0.85	0.74	0.78	1.93

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.46								
DFS	0.88	15.77							
GBR	0.87	0.88	4.06						
NLD	0.89	0.91	0.89	3.65					
NZL	0.59	0.64	0.69	0.60	4.43				
USA	0.88	0.88	0.87	0.87	0.66	2.61			
ZAF	0.87	0.87	0.87	0.87	0.68	0.87	10.97		
AUS	0.87	0.87	0.87	0.87	0.66	0.87	0.87	3.69	
IRL	0.87	0.86	0.86	0.87	0.49	0.87	0.86	0.87	1.93

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.07					
DEU	0.92	13.86				
DFS	0.83	0.83	12.31			
NOR	0.85	0.83	0.80	15.20		
USA	0.87	0.85	0.90	0.76	2.67	
NLD	0.81	0.78	0.81	0.72	0.88	4.68

RDC crc										
	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	6.27									
DEU	0.86	9.99								
DFS	0.86	0.90	12.90							
GBR	0.74	0.74	0.77	4.27						
NOR	0.90	0.87	0.90	0.77	14.97					
NZL	0.61	0.61	0.60	0.66	0.65	10.61				
USA	0.84	0.84	0.84	0.83	0.85	0.70	3.47			
NLD	0.87	0.91	0.93	0.80	0.86	0.61	0.85	3.05		
AUS	0.72	0.72	0.72	0.87	0.75	0.68	0.74	0.73	4.70	
IRL	0.73	0.72	0.73	0.87	0.74	0.63	0.77	0.73	0.88	2.41

RDC cc1							
	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	6.94						
DEU	0.88	12.50					
DFS	0.77	0.72	12.93				
GBR	0.72	0.77	0.78	0.03			
NOR	0.85	0.76	0.75	0.74	14.34		
NLD	0.74	0.69	0.85	0.68	0.70	4.19	
USA	0.83	0.70	0.83	0.67	0.72	0.91	2.66

RDC cc2											
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.76										
DEU	0.91	10.19									
DFS	0.85	0.93	12.99								
GBR	0.85	0.81	0.85	4.27							
NOR	0.89	0.86	0.85	0.87	16.31						
NZL	0.65	0.62	0.65	0.68	0.66	6.92					
USA	0.87	0.88	0.86	0.85	0.86	0.69	2.38				
ZAF	0.70	0.81	0.75	0.73	0.70	0.72	0.85	17.93			
NLD	0.91	0.92	0.89	0.83	0.86	0.63	0.88	0.79	3.80		
AUS	0.69	0.70	0.66	0.73	0.66	0.70	0.72	0.77	0.71	4.58	
IRL	0.84	0.83	0.84	0.85	0.86	0.72	0.85	0.84	0.84	0.83	2.41

RDC int											
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.68										
DEU	0.87	9.48									
DFS	0.87	0.93	13.29								
GBR	0.87	0.87	0.88	4.27							
NOR	0.89	0.89	0.87	0.88	16.31						
NZL	0.62	0.59	0.58	0.67	0.51	6.92					
USA	0.89	0.88	0.88	0.88	0.88	0.68	2.39				
ZAF	0.88	0.87	0.88	0.88	0.90	0.67	0.89	17.93			
NLD	0.89	0.92	0.92	0.90	0.89	0.60	0.87	0.87	3.20		
AUS	0.87	0.87	0.87	0.87	0.88	0.68	0.87	0.88	0.87	4.58	
IRL	0.87	0.87	0.87	0.87	0.88	0.66	0.87	0.87	0.87	0.87	2.41

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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

	CAN	DEA	FRA	USA	CHE	NLD
CAN	0	64	39	72	66	23
DEA	43	0	174	148	514	111
FRA	29	128	0	66	141	66
USA	54	109	50	0	171	38
CHE	43	420	107	142	0	73
NLD	18	102	54	34	68	0

BSW  
 -----

common bulls below diagonal  
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	82	79	29	15	95	37	56	74
CHE	52	0	497	81	22	238	51	142	367
DEA	53	396	0	124	29	191	51	176	493
NLD	23	73	111	0	20	46	33	72	103
NZL	12	17	22	14	0	17	15	18	24
USA	74	207	142	40	15	0	51	88	147
GBR	27	38	36	25	11	48	0	42	55
FRA	41	106	130	57	14	60	32	0	155
ITA	52	308	373	82	18	102	39	118	0

BSW  
 -----

common bulls below diagonal  
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	84	80	30	98	40	60
CHE	54	0	496	81	238	56	149
DEA	54	393	0	123	191	57	187
NLD	24	73	111	0	46	34	77
USA	76	207	142	40	0	55	92
GBR	28	40	38	25	50	0	47
FRA	43	112	143	63	65	37	0

BSW  
 -----

common bulls below diagonal  
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	73	73	28	14	89	35	55	68
CHE	47	0	491	81	22	294	51	149	367
DEA	49	391	0	123	29	288	50	186	484
NLD	22	73	111	0	20	69	33	77	103
NZL	11	17	22	14	0	26	15	19	24
USA	65	276	251	56	23	0	62	113	196
GBR	24	38	36	25	11	58	0	44	55
FRA	40	112	143	63	15	79	35	0	165
ITA	48	308	368	82	18	135	39	129	0

BSW

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

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	74	30	15	91	36	69
DEA	50	0	125	29	287	50	591
NLD	25	113	0	20	70	33	110
NZL	12	22	14	0	26	15	24
USA	67	251	59	23	0	62	212
GBR	25	36	25	11	58	0	56
ITA	48	494	90	18	148	39	0

GUE

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

	CAN	GBR	NZL	USA	AUS
CAN	0	12	3	31	17
GBR	9	0	13	42	27
NZL	1	11	0	9	26
USA	30	39	6	0	18
AUS	12	21	24	15	0

GUE

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

	CAN	GBR	USA
CAN	0	12	31
GBR	9	0	44
USA	30	41	0

GUE

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

	CAN	GBR	NZL	USA	AUS
CAN	0	9	2	29	18
GBR	6	0	13	73	29
NZL	1	11	0	29	27
USA	27	74	27	0	56
AUS	14	23	25	52	0

GUE

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

	CAN	GBR	NZL	USA	AUS
CAN	0	9	2	29	18
GBR	6	0	13	73	29
NZL	1	11	0	29	27
USA	27	74	27	0	56
AUS	14	23	25	52	0

HOL

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common bulls below diagonal  
common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD
CAN	0	827	1616	889	994	1975	762	629	925
CZE	559	0	1489	951	1016	1115	785	405	1142
DEU	904	990	0	2209	2059	2075	1294	920	2515
DFS	726	544	1222	0	1383	1145	832	567	1649
FRA	686	573	987	689	0	1347	925	550	1587
USA	2093	806	1147	875	711	0	1099	649	1304
POL	565	524	862	553	470	967	0	343	932
CHE	518	266	750	492	500	571	251	0	723
NLD	814	940	1829	1243	949	996	695	694	0

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HOL

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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	AUS
BEL	0	418	374	694	510	396	521	344	491	737	324	434	253	571	404
CAN	382	0	664	1765	978	931	1178	438	1345	1048	554	2091	701	1081	766
CHE	344	550	0	957	575	456	588	351	605	743	336	692	317	554	412
DEU	627	1103	796	0	2279	1228	1789	788	2230	2781	837	2348	1191	2192	1199
DFS	426	796	495	1282	0	805	1275	648	1315	1646	704	1275	759	1392	895
ESP	358	570	359	726	555	0	880	438	1001	865	443	1022	500	905	598
GBR	463	1175	543	1194	867	680	0	829	1343	1475	794	1438	629	1345	991
IRL	319	427	351	676	525	406	849	0	593	792	640	519	271	661	569
ITA	399	968	528	1252	861	692	922	505	0	1473	675	1856	825	1594	871
NLD	782	955	715	2232	1273	722	1204	736	1069	0	890	1526	863	1678	1057
NZL	241	506	282	609	470	323	666	545	483	799	0	643	302	712	953
USA	373	2201	617	1398	938	601	1249	497	1130	1205	558	0	1004	1525	872
POL	173	488	222	753	478	244	364	180	488	595	192	791	0	859	360
FRA	528	750	493	1026	673	627	798	524	763	973	402	784	397	0	940
AUS	304	627	335	709	496	398	753	454	522	810	902	701	164	542	0

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HOL

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common bulls below diagonal  
common three quarter sib group above diagonal

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL
CAN	0	664	875	1714	982	1080	1222	76	1353	1059	2135	737
CHE	550	0	408	935	575	562	589	43	605	743	692	341
CZE	600	269	0	1486	943	1013	838	81	1038	1171	1190	772
DEU	986	751	993	0	2248	2160	1808	115	2182	2688	2267	1238
DFS	799	495	551	1208	0	1400	1297	107	1316	1645	1278	808
FRA	767	502	564	996	689	0	1375	100	1599	1694	1516	891
GBR	1225	542	481	1131	874	822	0	99	1370	1511	1498	667
ISR	56	29	60	94	87	56	68	0	102	112	95	62
ITA	974	528	632	1175	860	781	941	77	0	1473	1853	859
NLD	966	715	962	2035	1273	991	1232	95	1067	0	1527	922
USA	2254	617	853	1256	938	795	1311	83	1130	1205	0	1045
POL	520	248	512	812	543	435	397	43	523	669	837	0

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HOL

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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
BEL	0	407	374	349	681	510	396	569	521	345	45	489	737	324	545	250	232	469	189
CAN	373	0	654	855	1648	958	928	1030	1152	426	73	1289	1019	534	2269	679	392	950	499
CHE	344	539	0	409	930	576	456	545	588	351	43	598	744	336	816	308	239	499	222
CZE	238	571	269	0	1479	944	628	1005	821	393	81	1023	1173	469	1334	718	291	667	340
DEU	602	931	745	987	0	2233	1214	2130	1758	773	116	2135	2650	824	2944	1131	515	1382	536
DFS	426	773	496	551	1198	0	810	1385	1278	648	108	1302	1651	706	1671	739	459	1044	448
ESP	358	556	359	369	699	556	0	908	884	439	76	1002	870	445	1221	496	395	695	377
FRA	525	699	480	553	948	657	621	0	1336	663	100	1566	1663	711	2199	840	431	1092	439
GBR	463	1139	543	476	1111	868	680	784	0	829	99	1327	1477	795	1821	619	455	1162	478
IRL	319	408	351	266	645	525	406	521	849	0	75	594	793	640	687	264	306	645	281
ISR	25	53	29	60	94	87	46	54	67	60	0	101	113	83	120	58	49	78	49
ITA	395	895	522	612	1141	843	691	735	907	504	75	0	1439	668	2207	798	452	1017	510
NLD	782	916	715	962	1987	1275	723	947	1205	736	95	1026	0	893	2090	836	456	1238	467
NZL	241	486	282	292	581	471	323	392	666	545	71	473	801	0	941	295	329	1050	375
USA	426	2316	719	926	1566	1071	742	1057	1495	602	102	1241	1624	867	0	1016	582	1554	796
POL	166	457	212	447	683	461	235	375	353	172	38	461	567	185	766	0	177	470	267
ZAF	177	352	190	178	371	325	337	287	386	263	34	335	370	260	540	103	0	427	258
AUS	378	878	433	379	860	666	474	690	950	550	53	660	1016	1030	1421	265	357	0	459
URY	124	455	149	215	334	289	283	243	367	209	24	331	340	285	968	183	214	334	0

HOL

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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
BEL	0	411	684	506	394	518	343	485	733	322	541	248	230	467	188
CAN	378	0	1701	964	928	1161	433	1300	1034	540	2284	682	394	957	502
DEU	615	1036	0	2255	1225	1779	783	2170	2721	833	3008	1150	518	1404	543
DFS	426	784	1255	0	804	1276	645	1300	1650	704	1669	735	457	1039	444
ESP	358	565	722	556	0	880	435	998	867	443	1214	492	393	692	374
GBR	463	1154	1174	868	680	0	826	1325	1479	795	1820	615	453	1161	477
IRL	319	417	667	525	406	848	0	592	790	639	685	260	306	644	278
ITA	395	911	1200	843	691	906	503	0	1439	668	2204	790	451	1015	507
NLD	784	939	2137	1280	728	1209	736	1030	0	892	2092	825	453	1237	464
NZL	241	491	603	471	323	666	545	473	802	0	941	295	328	1049	375
USA	426	2349	1691	1071	741	1495	601	1241	1630	867	0	1009	579	1551	793
POL	166	464	716	461	235	353	171	461	561	185	766	0	175	464	263
ZAF	177	358	379	325	337	386	263	335	371	260	540	102	0	424	258
AUS	378	884	906	666	474	950	549	660	1020	1030	1421	264	356	0	458
URY	124	461	354	289	281	366	209	331	343	285	967	183	214	334	0

JER

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common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	50	220	20
DFS	38	0	88	51
USA	203	68	0	40
NLD	15	48	40	0

JER

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common bulls below diagonal  
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	0	56	111	24	128	254	119	7
DFS	41	0	122	69	113	103	93	28
GBR	109	110	0	62	170	160	143	45
NLD	19	63	59	0	59	53	47	21
NZL	130	85	174	51	0	219	325	91
USA	249	83	171	56	244	0	233	29
AUS	119	57	148	42	354	237	0	34
IRL	5	23	46	21	100	31	31	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	USA
CAN	0	56	114	24	255
DFS	41	0	122	69	102
GBR	109	110	0	62	163
NLD	19	63	59	0	53
USA	250	83	172	56	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	54	108	23	124	269	101	170	6
DFS	39	0	122	69	113	149	109	107	28
GBR	103	110	0	62	171	190	138	170	45
NLD	17	63	59	0	60	67	59	55	21
NZL	123	85	174	52	0	320	176	379	91
USA	260	116	207	72	393	0	254	428	36
ZAF	99	85	144	55	186	263	0	199	29
AUS	158	69	173	48	408	457	188	0	45
IRL	4	23	46	21	100	38	30	41	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	55	109	23	126	271	103	172	6
DFS	40	0	122	71	113	149	109	107	28
GBR	105	110	0	66	171	190	138	170	45
NLD	19	66	63	0	63	72	62	57	22
NZL	127	85	174	56	0	320	176	379	91
USA	267	116	207	78	393	0	254	428	36
ZAF	102	85	144	59	186	263	0	199	29
AUS	163	69	173	50	408	457	188	0	45
IRL	4	23	46	21	100	38	30	41	0

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RDC

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

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CAN	0	8	113	4	75	3
DEU	7	0	40	12	11	11
DFS	113	30	0	115	114	39
NOR	4	12	86	0	49	27
USA	70	11	107	49	0	25
NLD	3	11	38	26	23	0

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RDC

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

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CAN	0	10	108	57	4	55	105	4	54	3
DEU	9	0	46	11	12	13	13	10	20	4
DFS	107	36	0	78	108	152	127	39	137	15
GBR	58	10	76	0	35	56	66	22	46	15
NOR	4	12	78	36	0	39	53	27	34	45
NZL	56	13	147	54	37	0	73	13	101	8
USA	102	13	125	63	54	74	0	25	52	19
NLD	4	10	38	20	26	13	23	0	12	7
AUS	53	19	117	44	29	103	50	10	0	8
IRL	3	4	11	14	44	8	19	6	7	0

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RDC

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

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CAN	0	9	109	60	4	4	109
DEU	8	0	46	11	13	11	13
DFS	108	36	0	81	109	39	127
GBR	61	10	79	0	35	23	69
NOR	4	13	79	36	0	27	53
NLD	4	11	38	21	26	0	25
USA	106	13	124	65	53	23	0

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RDC

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common bulls below diagonal  
common three quarter sib group above diagonal  
CAN DEU DFS GBR NOR NZL USA ZAF NLD AUS IRL

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CAN	0	8	107	53	4	54	131	67	4	58	3
DEU	7	0	44	11	12	12	14	1	11	31	4
DFS	106	35	0	78	96	152	146	52	39	167	15
GBR	54	10	76	0	34	57	77	37	22	62	15
NOR	4	12	71	35	0	38	57	0	25	50	45
NZL	55	12	147	55	36	0	98	35	13	121	8
USA	133	14	144	77	57	99	0	67	26	99	20
ZAF	72	1	51	35	0	33	62	0	2	37	2
NLD	4	11	38	20	24	13	24	2	0	21	7
AUS	57	30	143	60	41	123	98	37	19	0	11
IRL	3	4	11	14	44	8	20	2	6	10	0

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RDC

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common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	9	107	54	4	54	131	67	5	58	3
DEU	8	0	46	11	12	13	15	2	11	32	4
DFS	106	37	0	78	96	152	146	52	39	167	15
GBR	55	10	76	0	34	57	77	37	22	62	15
NOR	4	12	71	35	0	38	57	0	27	50	45
NZL	55	13	147	55	36	0	98	35	13	121	8
USA	133	15	145	77	58	99	0	67	29	99	20
ZAF	72	2	51	35	0	33	62	0	2	37	2
NLD	5	11	38	20	26	13	26	2	0	21	7
AUS	57	31	143	60	41	123	98	37	19	0	11
IRL	3	4	11	14	44	8	20	2	6	10	0

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