Introduction

The latest routine international evaluation for **female fertility** traits took place as scheduled at the Interbull Centre. Data from twenty-one (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 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	T2=CY	Calving interval converted to 42 days pregnancy rate
	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	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

CHANGES IN NATIONAL PROCEDURES

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

BEL	HOL	Minor pedigree corrections leading to a decrease of EDC and reliability for some bulls
NOR	RDC	Fixed an error in their procedure which caused more daughters to be added than usual. Some correlations within birth-year are therefore weaker than usual. In 2009 the daughter groups were small and incomplete at last evaluation
CHE	BSW/HOL SIM	Many bulls with decreases in herds/daughters/EDC due to continuous work on the raw data by herd-book organizations
NZL	BSW/JER HOL/RDC GUE	Some decrease in information due to continuous parentage verification
IRL	HOL	Some changes in type of proof due to a program update
ESP	HOL	Base change
GBR	ALL	Updated unknown parent groups
USA	HOL	Many bulls with a decrease in number of herds/daughters due to usual data edits in August run

INTERBULL CHANGES COMPARED TO THE DECEMBER ROUTINE RUN

Sub-setting:

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:

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 calving 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 analyzed 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.

Table 1. National evaluation data considered in the Interbull evaluation for fertility (August Routine Evaluation 2017). Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		124	7537	1542	637	
BEL			1132			
CAN	121	40	8198	445	485	
CHE	2600		3021			
CZE			3598			
DEA	5221					
DEU			24407		334	
DFS			15210	2271	9420	
ESP			4649			
EST						
FRA	348		15563			
FRM						
GBR	82	213	6082	506	356	
HUN						
IRL			2553	153	55	
ISR			1277			
ITA	1670		8832			
JPN						
KOR						
LTU						
LVA						
NLD	163		14389	124	63	
NOR					3807	
NZL	49	58	7016	4338	1252	
POL			6408			
PRT						
SVK						
SVN						
URY			1320			
USA	1027	733	35621	4195	657	
ZAF			1194	655	143	
HRV						
MEX						
No.Records	11281	1168	168007	14229	17209	
Pub. Proofs	10463	965	140818	12068	16081	0

APPENDIX I. Sire standard deviations in diagonal and genetic correlations below diagonal

BSW hco

	CAN	DEA	FRA	USA	CHE	NLD
CAN	9.13					
DEA	0.85	9.76				
FRA	0.80	0.83	0.91			
USA	0.81	0.85	0.90	2.63		
CHE	0.92	0.94	0.88	0.88	13.06	
NLD	0.81	0.73	0.85	0.88	0.88	3.63

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	7.01								
CHE	0.85	11.18							
DEA	0.85	0.94	14.20						
NLD	0.87	0.88	0.85	3.52					
NZL	0.62	0.65	0.72	0.62	11.00				
USA	0.85	0.86	0.85	0.85	0.62	3.34			
GBR	0.75	0.76	0.75	0.80	0.65	0.83	4.20		
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	19.16

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.30						
CHE	0.78	11.83					
DEA	0.78	0.96	10.95				
NLD	0.73	0.69	0.67	3.61			
USA	0.74	0.67	0.67	0.91	2.82		
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

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.25								
CHE	0.72	11.04							
DEA	0.83	0.92	11.64						
NLD	0.87	0.84	0.85	3.34					
NZL	0.63	0.54	0.64	0.63	7.21				
USA	0.85	0.83	0.85	0.88	0.65	2.39			
GBR	0.81	0.77	0.85	0.81	0.69	0.85	4.20		
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	24.06

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.85						
DEA	0.88	13.52					
NLD	0.88	0.87	3.22				
NZL	0.58	0.63	0.63	7.00			
USA	0.90	0.87	0.87	0.57	2.39		
GBR	0.87	0.88	0.89	0.66	0.87	4.20	
ITA	0.88	0.93	0.88	0.65	0.89	0.88	17.96

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.44				
GBR	0.75	4.54			
NZL	0.60	0.65	11.82		
USA	0.84	0.86	0.62	3.36	
AUS	0.73	0.87	0.70	0.74	6.96

GUE cc1

	CAN	GBR	USA
CAN	7.11		
GBR	0.71	0.03	
USA	0.80	0.74	3.43

GUE cc2

	CAN	GBR	NZL	USA	AUS
CAN	6.80				
GBR	0.81	4.54			
NZL	0.61	0.69	7.62		
USA	0.85	0.85	0.65	2.72	
AUS	0.70	0.74	0.76	0.79	7.15

GUE int

	CAN	GBR	NZL	USA	AUS
CAN	7.42				
GBR	0.87	4.54			
NZL	0.57	0.65	7.62		
USA	0.90	0.87	0.60	2.72	
AUS	0.87	0.87	0.73	0.87	7.15

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD
CAN	7.76								
CZE	0.80	17.67							
DEU	0.93	0.80	14.96						
DFS	0.83	0.85	0.90	13.62					
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	18.31		
CHE	0.96	0.86	0.93	0.88	0.86	0.88	0.69	13.90	
NLD	0.81	0.86	0.78	0.81	0.86	0.88	0.68	0.85	4.13

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	AUS
BEL	4.66														
CAN	0.73	6.81													
CHE	0.79	0.85	12.37												
DEU	0.71	0.86	0.89	11.04											
DFS	0.80	0.88	0.94	0.91	12.01										
ESP	0.86	0.75	0.78	0.75	0.78	11.27									
GBR	0.88	0.74	0.77	0.74	0.81	0.90	4.72								
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	7.87						
NLD	0.81	0.87	0.92	0.92	0.96	0.78	0.80	0.72	0.88	4.59					
NZL	0.65	0.59	0.62	0.59	0.62	0.63	0.64	0.61	0.69	0.59	8.72				
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	14.01		
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	4.94

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL
CAN	6.84											
CHE	0.91	11.02										
CZE	0.83	0.75	15.88									
DEU	0.89	0.94	0.74	13.85								
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	4.51		
USA	0.78	0.70	0.95	0.68	0.86	0.89	0.66	0.89	0.70	0.92	2.81	
POL	0.70	0.74	0.63	0.83	0.70	0.61	0.67	0.63	0.84	0.63	0.66	17.33

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY
BEL	4.66																		
CAN	0.84	6.17																	
CHE	0.78	0.85	11.15																
CZE	0.65	0.84	0.86	15.88															
DEU	0.81	0.92	0.89	0.88	12.43														
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	11.26												
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	4.72										
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	17.79							
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	4.52						
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	12.97			
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	15.99		
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	5.08	
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	1.45

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY
BEL	4.66														
CAN	0.88	6.58													
DEU	0.86	0.87	10.57												
DFS	0.90	0.90	0.93	13.08											
ESP	0.86	0.87	0.88	0.86	11.28										
GBR	0.87	0.87	0.87	0.90	0.91	4.72									
IRL	0.87	0.87	0.86	0.86	0.86	0.87	3.47								
ITA	0.86	0.89	0.90	0.89	0.95	0.88	0.87	17.79							
NLD	0.91	0.91	0.92	0.94	0.87	0.90	0.86	0.89	4.43						
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	12.95			
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	16.01		
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	5.07	
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	1.45

JER hco

	CAN	DFS	USA	NLD
CAN	7.82			
DFS	0.82	17.39		
USA	0.85	0.87	2.70	
NLD	0.79	0.80	0.88	4.40

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.79							
DFS	0.87	13.92						
GBR	0.73	0.87	4.11					
NLD	0.87	0.91	0.78	3.86				
NZL	0.59	0.65	0.67	0.60	6.95			
USA	0.84	0.85	0.84	0.85	0.64	3.81		
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	1.88

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.68				
DFS	0.73	15.54			
GBR	0.73	0.71	0.03		
NLD	0.73	0.88	0.67	3.54	
USA	0.75	0.87	0.68	0.91	2.89

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.62								
DFS	0.85	16.08							
GBR	0.85	0.83	4.11						
NLD	0.90	0.89	0.82	3.68					
NZL	0.65	0.63	0.70	0.62	4.44				
USA	0.85	0.87	0.85	0.88	0.68	2.62			
ZAF	0.71	0.73	0.77	0.79	0.71	0.86	10.98		
AUS	0.67	0.71	0.73	0.71	0.69	0.70	0.77	3.67	
IRL	0.84	0.84	0.85	0.83	0.67	0.85	0.74	0.78	1.88

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.43								
DFS	0.88	15.80							
GBR	0.87	0.88	4.11						
NLD	0.89	0.91	0.89	3.63					
NZL	0.59	0.64	0.69	0.60	4.44				
USA	0.88	0.88	0.87	0.87	0.66	2.62			
ZAF	0.87	0.87	0.87	0.87	0.68	0.87	10.98		
AUS	0.87	0.87	0.87	0.87	0.66	0.87	0.87	3.67	
IRL	0.87	0.86	0.86	0.87	0.49	0.87	0.86	0.87	1.88

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.12					
DEU	0.92	14.16				
DFS	0.83	0.83	12.28			
NOR	0.85	0.83	0.80	15.37		
USA	0.87	0.85	0.90	0.76	2.60	
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	6.31									
DEU	0.86	10.02								
DFS	0.86	0.90	12.88							
GBR	0.74	0.74	0.77	4.23						
NOR	0.90	0.87	0.90	0.77	14.96					
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	3.48			
NLD	0.87	0.91	0.93	0.80	0.86	0.61	0.85	3.10		
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	6.96						
DEU	0.88	12.64					
DFS	0.77	0.72	12.95				
GBR	0.72	0.77	0.78	0.03			
NOR	0.85	0.76	0.75	0.74	14.56		
NLD	0.74	0.69	0.85	0.68	0.70	4.22	
USA	0.83	0.70	0.83	0.67	0.72	0.91	2.67

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.72										
DEU	0.91	10.17									
DFS	0.85	0.93	13.01								
GBR	0.85	0.81	0.85	4.22							
NOR	0.89	0.86	0.85	0.87	16.68						
NZL	0.65	0.62	0.65	0.68	0.66	6.90					
USA	0.87	0.88	0.86	0.85	0.86	0.69	2.40				
ZAF	0.70	0.81	0.75	0.73	0.70	0.72	0.85	18.07			
NLD	0.91	0.92	0.89	0.83	0.86	0.63	0.88	0.79	3.89		
AUS	0.69	0.70	0.66	0.73	0.66	0.70	0.72	0.77	0.71	4.61	
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	6.67										
DEU	0.87	9.50									
DFS	0.87	0.93	13.30								
GBR	0.87	0.87	0.88	4.22							
NOR	0.89	0.89	0.87	0.88	16.68						
NZL	0.62	0.59	0.58	0.67	0.51	6.90					
USA	0.89	0.88	0.88	0.88	0.88	0.68	2.40				
ZAF	0.88	0.87	0.88	0.88	0.90	0.67	0.89	18.07			
NLD	0.89	0.92	0.92	0.90	0.89	0.60	0.87	0.87	3.30		
AUS	0.87	0.87	0.87	0.87	0.88	0.68	0.87	0.88	0.87	4.61	
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

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	FRA	USA	CHE	NLD
CAN	0	67	40	73	68	24
DEA	45	0	176	151	517	112
FRA	30	128	0	66	141	66
USA	55	110	50	0	175	38
CHE	45	423	107	146	0	73
NLD	19	103	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	85	80	30	15	99	39	57	76
CHE	55	0	501	82	22	239	52	142	373
DEA	54	398	0	125	29	191	52	177	498
NLD	24	74	112	0	20	46	33	72	103
NZL	12	17	22	14	0	17	15	18	24
USA	77	209	142	40	15	0	52	88	148
GBR	27	38	36	25	11	48	0	43	56
FRA	42	106	131	57	14	60	32	0	155
ITA	53	313	379	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	86	81	31	101	40	61
CHE	56	0	500	82	239	56	150
DEA	54	396	0	124	191	57	188
NLD	25	74	112	0	46	34	77
USA	78	209	142	40	0	55	92
GBR	28	40	38	25	50	0	47
FRA	43	113	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	75	73	28	14	90	35	55	68
CHE	49	0	495	82	22	295	52	150	373
DEA	49	394	0	124	29	289	51	187	489
NLD	22	74	112	0	20	69	33	77	103
NZL	11	17	22	14	0	26	15	19	24
USA	66	278	251	56	23	0	63	113	197
GBR	24	38	36	25	11	58	0	45	56
FRA	40	113	143	63	15	79	35	0	165
ITA	48	313	374	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	93	36	70
DEA	50	0	126	29	288	51	596
NLD	25	114	0	20	70	33	110
NZL	12	22	14	0	26	15	24
USA	69	251	59	23	0	63	214
GBR	25	36	25	11	58	0	57
ITA	49	499	90	18	149	39	0

GUE

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	13	3	32	18
GBR	10	0	13	44	28
NZL	1	11	0	9	26
USA	31	41	6	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	13	32
GBR	10	0	48
USA	31	45	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	10	2	31	19
GBR	7	0	13	74	30
NZL	1	11	0	29	27
USA	29	75	27	0	57
AUS	15	24	25	53	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	10	2	31	19
GBR	7	0	13	74	30
NZL	1	11	0	29	27
USA	29	75	27	0	57
AUS	15	24	25	53	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD
CAN	0	838	1651	932	1015	2052	787	657	962
CZE	574	0	1495	972	1035	1113	802	413	1163
DEU	942	1006	0	2251	2141	2117	1323	941	2555
DFS	767	569	1272	0	1419	1189	867	588	1692
FRA	701	588	1049	713	0	1366	996	569	1648
USA	2189	822	1188	926	729	0	1126	676	1344
POL	597	547	902	585	549	1024	0	354	966
CHE	545	273	768	504	512	599	260	0	742
NLD	852	962	1876	1291	978	1037	732	713	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	AUS
BEL	0	430	385	713	519	536	528	348	505	753	329	448	266	595	404
CAN	394	0	688	1800	1008	1169	1197	443	1375	1084	558	2154	724	1106	766
CHE	356	575	0	977	592	585	601	358	623	764	343	716	326	583	416
DEU	644	1144	818	0	2326	1826	1815	793	2258	2838	843	2401	1230	2296	1200
DFS	437	833	511	1343	0	1174	1301	655	1343	1693	712	1310	789	1426	895
ESP	529	907	535	1545	942	0	1184	610	1370	1327	604	1331	740	1302	797
GBR	470	1199	554	1219	898	1063	0	839	1362	1491	804	1463	645	1368	991
IRL	325	433	360	683	533	624	862	0	599	797	642	523	277	671	570
ITA	411	1007	544	1284	887	1136	941	509	0	1500	681	1890	844	1614	873
NLD	800	999	736	2311	1329	1331	1225	743	1097	0	898	1564	888	1747	1060
NZL	245	511	290	619	477	497	681	550	489	806	0	649	306	720	953
USA	384	2295	643	1452	983	1029	1280	501	1184	1251	563	0	1037	1553	873
POL	186	512	235	797	500	518	379	191	506	629	201	829	0	927	361
FRA	548	776	512	1105	699	1195	823	538	786	1008	407	818	475	0	947
AUS	304	627	338	710	496	588	753	454	526	813	902	702	164	545	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
CAN	0	688	894	1750	1014	1100	1252	78	1380	1098	2204	760
CHE	575	0	422	953	592	584	610	45	623	764	716	349
CZE	617	278	0	1509	963	1037	851	81	1061	1192	1209	791
DEU	1018	773	1014	0	2289	2255	1833	117	2205	2737	2308	1275
DFS	838	511	570	1261	0	1430	1327	109	1345	1692	1315	840
FRA	785	512	581	1068	708	0	1393	103	1615	1754	1538	959
GBR	1255	558	493	1158	908	840	0	101	1402	1535	1530	682
ISR	56	30	60	95	88	57	68	0	104	114	96	63
ITA	1009	544	655	1203	887	800	976	77	0	1501	1887	881
NLD	1007	736	986	2094	1328	1024	1255	96	1096	0	1565	947
USA	2349	643	872	1294	984	817	1358	85	1184	1251	0	1078
POL	547	260	531	855	568	509	415	43	543	706	881	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
BEL	0	420	385	359	698	519	536	594	528	349	45	504	753	329	557	263	235	479	191
CAN	386	0	677	871	1685	989	1154	1050	1172	433	75	1312	1051	539	2320	701	395	972	519
CHE	356	562	0	423	949	593	585	566	601	358	45	615	765	343	840	317	242	515	224
CZE	245	585	278	0	1502	964	877	1028	835	397	81	1046	1194	473	1354	736	292	678	348
DEU	618	969	766	1008	0	2276	1798	2222	1783	778	117	2167	2697	832	2994	1166	518	1402	549
DFS	437	809	512	570	1256	0	1182	1415	1304	655	110	1333	1698	714	1705	772	462	1066	456
ESP	529	883	535	656	1482	948	0	1303	1186	611	99	1375	1332	606	1652	724	469	940	482
FRA	542	711	490	566	1015	673	1179	0	1353	673	103	1584	1722	716	2225	908	439	1111	445
GBR	470	1168	554	487	1138	899	1063	794	0	839	100	1353	1493	805	1844	634	458	1177	486
IRL	325	417	360	271	652	533	624	529	862	0	76	599	798	642	691	270	309	648	285
ISR	25	53	30	60	94	88	79	55	67	61	0	103	115	84	121	59	51	79	51
ITA	406	927	539	636	1170	869	1133	748	932	509	76	0	1467	676	2237	821	457	1044	524
NLD	800	957	736	986	2048	1331	1334	972	1226	743	96	1055	0	901	2131	862	460	1258	476
NZL	245	491	290	297	591	478	499	395	681	550	71	482	808	0	945	299	330	1062	380
USA	438	2392	744	943	1612	1116	1295	1076	1526	607	103	1280	1681	871	0	1048	585	1580	820
POL	179	482	224	466	714	485	501	450	369	183	39	481	597	195	810	0	180	488	277
ZAF	179	355	194	179	374	329	422	292	391	267	34	341	374	262	543	106	0	432	261
AUS	389	908	450	391	890	690	735	700	970	554	54	682	1039	1041	1453	283	361	0	469

```
  URY  126  477  155  220  349  296  414  251  373  214   26  340  351  286 1002  200  218
345    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
 ------------------------------------------------------------------------
  BEL    0  423  702  515  528  525  347  500  749  327  553  261  233  477  190
  CAN  390    0 1731  994 1153 1180  439 1323 1066  545 2334  704  397  978  522
  DEU  633 1067    0 2300 1789 1803  788 2202 2771  839 3056 1183  521 1423  556
  DFS  437  819 1315    0 1146 1302  652 1331 1696  712 1702  768  460 1061  452
  ESP  527  899 1531  947    0 1166  598 1341 1290  592 1607  697  466  916  474
  GBR  470 1181 1201  899 1062    0  836 1351 1496  805 1843  630  456 1176  485
  IRL  325  425  677  533  616  862    0  597  796  641  689  266  309  647  282
  ITA  406  942 1231  869 1131  931  508    0 1467  676 2234  813  456 1042  521
  NLD  802  978 2205 1336 1323 1231  745 1059    0  900 2134  850  457 1257  474
  NZL  245  496  610  478  496  681  550  482  809    0  945  299  329 1061  380
  USA  438 2421 1739 1116 1291 1526  606 1280 1687  871    0 1040  582 1577  818
  POL  179  488  751  485  485  369  182  481  591  195  810    0  178  482  273
  ZAF  179  361  383  329  421  391  267  341  375  262  543  105    0  429  261
  AUS  389  913  933  690  728  970  553  682 1043 1041 1453  282  360    0  468
  URY  126  482  370  296  410  372  214  340  353  286 1002  200  218  345    0
 ------------------------------------------------------------------------
JER
--------
 common bulls below diagonal
 common three quarter sib group above diagonal
       CAN  DFS  USA  NLD
 ------------------------------------------------------------------------
  CAN    0   52  231   20
  DFS   40    0   90   52
  USA  210   69    0   42
  NLD   15   49   42    0
 ------------------------------------------------------------------------
JER
--------
 common bulls below diagonal
 common three quarter sib group above diagonal
       CAN  DFS  GBR  NLD  NZL  USA  AUS  IRL
 ------------------------------------------------------------------------
  CAN    0   56  111   25  129  258  119    8
  DFS   41    0  122   73  113  103   93   30
  GBR  109  110    0   65  170  161  142   48
  NLD   20   66   61    0   60   55   47   24
  NZL  131   85  175   52    0  220  324   93
  USA  252   83  172   58  244    0  232   31
  AUS  119   57  148   42  355  235    0   34
  IRL    6   24   49   24  102   33   31    0
 ------------------------------------------------------------------------
JER
--------
 common bulls below diagonal
 common three quarter sib group above diagonal
       CAN  DFS  GBR  NLD  USA
 ------------------------------------------------------------------------
  CAN    0   56  115   25  264
  DFS   41    0  121   73  102
  GBR  111  110    0   64  165
  NLD   20   66   61    0   55
  USA  258   83  175   58    0
 ------------------------------------------------------------------------
```

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	54	108	24	125	275	104	172	7
DFS	39	0	122	73	113	148	110	107	30
GBR	103	110	0	65	171	191	138	170	48
NLD	18	66	61	0	61	69	60	57	24
NZL	124	85	175	53	0	322	178	379	93
USA	268	115	207	73	395	0	260	431	39
ZAF	102	86	144	56	188	268	0	202	31
AUS	161	69	174	50	411	460	189	0	46
IRL	5	24	49	24	102	41	32	42	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	56	110	25	128	278	107	175	8
DFS	41	0	122	76	113	148	110	107	30
GBR	106	110	0	69	171	191	138	170	48
NLD	21	70	65	0	64	74	63	59	25
NZL	129	85	175	57	0	322	178	379	93
USA	274	115	207	79	395	0	260	431	39
ZAF	106	86	144	60	188	268	0	202	31
AUS	166	69	174	52	411	460	189	0	46
IRL	6	24	49	24	102	41	32	42	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	9	119	5	81	4
DEU	8	0	40	12	12	11
DFS	119	30	0	120	119	39
NOR	5	12	91	0	51	27
USA	76	12	111	51	0	26
NLD	4	11	38	26	24	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	0	10	114	58	4	55	109	4	54	3
DEU	9	0	48	11	14	13	14	11	20	4
DFS	115	38	0	81	109	152	129	40	137	14
GBR	59	10	78	0	37	57	69	23	48	16
NOR	4	14	80	38	0	39	57	27	34	45
NZL	56	13	147	55	37	0	75	13	101	8
USA	106	14	124	66	57	76	0	27	53	19
NLD	4	11	39	21	26	13	25	0	12	7
AUS	53	19	117	45	29	103	51	10	0	8
IRL	3	4	10	15	44	8	19	6	7	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	0	10	115	61	5	5	110
DEU	9	0	47	11	14	11	13
DFS	116	37	0	84	110	40	129
GBR	62	10	81	0	37	24	72
NOR	5	14	81	38	0	27	57
NLD	5	11	39	22	26	0	27
USA	107	13	124	68	57	25	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	8	112	54	4	54	133	67	4	59	3
DEU	7	0	46	11	13	12	15	1	11	35	4
DFS	113	36	0	81	104	152	150	52	40	170	14
GBR	55	10	78	0	37	58	81	37	23	64	16
NOR	4	13	75	38	0	39	61	0	26	50	45
NZL	55	12	147	56	37	0	99	35	13	122	8
USA	135	15	148	81	61	100	0	67	29	101	20
ZAF	72	1	51	35	0	33	62	0	2	37	2
NLD	4	11	39	21	25	13	27	2	0	21	7
AUS	58	34	145	61	41	124	100	37	19	0	11
IRL	3	4	10	15	44	8	20	2	6	10	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	9	112	55	4	54	133	67	5	59	3
DEU	8	0	48	11	13	13	16	2	11	36	4
DFS	113	38	0	81	104	152	150	52	40	170	14
GBR	56	10	78	0	37	58	81	37	23	64	16
NOR	4	13	75	38	0	39	61	0	28	50	45
NZL	55	13	147	56	37	0	99	35	13	122	8
USA	135	16	148	81	61	100	0	67	32	101	20
ZAF	72	2	51	35	0	33	62	0	2	37	2
NLD	5	11	39	21	27	13	29	2	0	21	7
AUS	58	35	145	61	41	124	100	37	19	0	11
IRL	3	4	10	15	44	8	20	2	6	10	0