

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 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	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 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	CR=Heifers' Conception rate (pregnant or not after 3 months)

	T3=C1	CR=Cows' Conception rate (pregnant or not after 3 months)
	T4=C2	CR=Cows' Conception rate (pregnant or not after 3 months)
AUT/DEU	T1=HC	NR=Heifers' Non Return Rate after 56 days
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	NR=Cows' Non Return Rate after 56 days
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
DFS	T1=HC	CR=Heifers' Conception rate for maiden heifers
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	CR=Cows' conception rate for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
ESP	T2=CY	Interval from Calving to First Service (ICF)
	T3=C1	Conception rate
	T4=C2	Interval from first to last insemination (IFL)
	T5=IT	Sum of Interval to first to last insemination and interval from calving to first service (IFL+ICF)
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
NOR	T1=HC	NI=Number of inseminations (heifers)
	T2=CY	CF=Days from calving to first insemination (days)
	T3=C1	NI=Number of inseminations (cows)
	T4=C2	NI=Number of inseminations (cows)
	T5=IT	CF=Days from calving to first insemination (days)
NZL	T2=CY	PM=Lactating cow's ability to start cycling
	T4=C2	CR= Cow's conception rate at 42 days
	T5=IT	CR= Cow's conception rate at 42 days
POL	T1=HC	CR=Conception Rate (heifer)
	T2=CR	CF=Interval from calving to first insemination
	T3=C1	CR=Conception Rate (cow)
	T4=IT	DO=Days open
	T5=IT	DO=Days open

URY	T4=C2	Days open expressed as Daughter Pregnancy Rate
	T5=IT	Days open expressed as Daughter Pregnancy Rate
USA	T1=HC	CR=Conception rate (heifer)
	T2=CY	CF=Interval from calving to first insemination
	T3=C1	CR=Conception rate (cow)
	T4=C2	DP=Daughter Pregnancy Rate
	T5=IT	DP=Daughter Pregnancy Rate
ZAF	T4=IT	CI=Calving Interval
	T5=IT	CI=Calving Interval
JPN	T1=HC	CR=Heifers' Conception rate
	T3=C1	CR=Cows' Conception rate
	T4=C2	DO=Days open
	T5=IT	DO=Days open

 CHANGES IN NATIONAL PROCEDURES

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

AUS (ALL)	New EDC calculation. Base change, updated the status of bulls to better reflect their status as AI bull. As a result a good number no longer qualify and were not submitted.
NOR (RDC)	The criterion for type=12 was increased from 10 to 70 2nd batch daughters to make it more realistic. 99 bulls were then reversed to type=11.
DFS (ALL)	Updated our pedigree program used for genetic evaluation. The effect is minor. Data from Norway has been included in the HOL evaluation.
ISR (HOL)	Base change
ITA (HOL)	Some changes in number of information due to pedigree update
POL (HOL)	Decrease of info due to data edits.
JPN (HOL)	Base change, now the cows born in 2015 are the base. Changes in data editings and some changes in information due to pedigree verification
BEL (HOL)	Base change set to cows born in 2015
CHE (HOL,BSW)	Embryo transfers (receiving an embryo) are no longer included. This caused slight decreases in herds/daughters/EDC for a considerable number of bulls especially for hco as heifers are used more often as recipient females given their higher implantation success rate.
GBR (ALL)	Changes in information due to chnages from data recording agents
NZL (ALL)	Changes in information due to continuous pedigree verification
ZAF (HOL,JER,RDC)	Refining genetic groups. Changing from PEST software to MIX99 for estimation of breeding values and reliabilities. Base Year Change.

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.

The window so far applied for MAS evaluation have been found too high compared to the within-country genetic correlation between mastitis and SCS available from the literature. It has been an ITC recommendation to adjust the windows for MAS in the 2001t test run to make them more in line with the values available from the literature. The recommendation has been approved by the Steering committee. Also, according to the decision taken by ITC in Orlando (2015) to review all windows every five (5) years, an overall review of the windows for all traits will take place during the first half of 2020. Implementation of the reviewed windows is aimed for January 2021 test run.

DATA AND METHOD OF ANALYSIS

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

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

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

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

SCIENTIFIC LITERATURE

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

International genetic evaluation computation:

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

Verification and Genetic trend validation:

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

Weighting factors:

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

De-regression:

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

Genetic parameter estimation:

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

Post-processing of estimated genetic correlations:

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

Time edits

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

International reliability estimation

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

NEXT ROUTINE INTERNATIONAL EVALUATION

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

NEXT TEST INTERNATIONAL EVALUATION

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

PUBLICATION OF INTERBULL ROUTINE RUN

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

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

PUBLICATION OF INTERBULL TEST RUN

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

^LTable 1. National evaluation data considered in the Interbull
 evaluation for fertility (December Routine Evaluation 2020).
 Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		139	8203	1764	727	
BEL			1913			
CAN	161	47	9457	556	553	
CHE	2839		3423			
CZE			3878			
DEA	5566					
DEU			24052		289	
DFS			16403	2407	10134	
ESP			5733			
EST						
FRA	401		16646			
FRM						
GBR	97	242	7009	571	408	
HUN						
IRL			2948	196	64	
ISR			1494			
ITA	1824		9754			
JPN			6072			
KOR						
LTU						
LVA						
NLD	196		15717	178	86	
NOR					2996	
NZL	62	58	8260	4841	1389	
POL			7843			
PRT						
SVK						
SVN						

URY			1703		
USA	1120	769	39833	4888	729
ZAF			1258	716	151
HRV					
MEX					
CAM					
=====					
No. Records	12266	1255	191599	16117	17526
Pub. Proofs	11267	1029	153552	13517	17422
					0

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

BSW	hco					
	CAN	DEA	FRA	USA	CHE	NLD
CAN	8.65					
DEA	0.85	9.82				
FRA	0.78	0.84	0.90			
USA	0.79	0.77	0.88	2.74		
CHE	0.92	0.95	0.88	0.88	13.19	
NLD	0.75	0.70	0.88	0.88	0.87	3.98

BSW	crc									
	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA	
CAN	7.05									
CHE	0.85	11.40								
DEA	0.85	0.94	14.32							
NLD	0.87	0.88	0.87	3.92						
NZL	0.63	0.64	0.71	0.64	0.09					
USA	0.85	0.85	0.84	0.84	0.62	3.38				
GBR	0.74	0.76	0.75	0.79	0.64	0.84	3.83			
FRA	0.86	0.96	0.94	0.91	0.64	0.86	0.78	1.80		
ITA	0.85	0.85	0.84	0.85	0.69	0.84	0.79	0.86	17.51	

BSW	cc1						
	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	8.01						
CHE	0.79	11.72					
DEA	0.79	0.94	11.05				
NLD	0.76	0.71	0.67	4.12			
USA	0.75	0.68	0.67	0.89	2.88		
GBR	0.73	0.79	0.74	0.72	0.67	0.03	
FRA	0.73	0.69	0.67	0.92	0.91	0.70	0.96

BSW	cc2									
	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA	
CAN	6.82									
CHE	0.75	11.15								
DEA	0.84	0.91	11.78							
NLD	0.88	0.82	0.85	3.55						
NZL	0.73	0.60	0.71	0.65	7.53					
USA	0.86	0.83	0.85	0.85	0.73	2.44				
GBR	0.84	0.78	0.86	0.84	0.77	0.85	3.83			
FRA	0.86	0.86	0.88	0.88	0.71	0.86	0.85	0.96		
ITA	0.85	0.69	0.85	0.85	0.64	0.87	0.81	0.85	22.83	

BSW	int						
	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN							
DEA							
NLD							
NZL							
USA							
GBR							
ITA							

DEU	0.72	0.85	0.88	11.03																
DFS	0.79	0.88	0.94	0.91	11.75															
ESP	0.87	0.82	0.86	0.84	0.85	11.12														
GBR	0.90	0.74	0.77	0.73	0.80	0.88	4.61													
IRL	0.87	0.72	0.72	0.72	0.72	0.87	0.87	3.49												
ITA	0.79	0.85	0.87	0.87	0.88	0.91	0.81	0.72	8.10											
NLD	0.81	0.87	0.93	0.90	0.96	0.86	0.79	0.72	0.86	4.99										
NZL	0.63	0.60	0.61	0.60	0.61	0.62	0.63	0.61	0.70	0.60	0.08									
USA	0.84	0.84	0.84	0.84	0.84	0.85	0.88	0.76	0.84	0.84	0.60	3.23								
POL	0.74	0.89	0.90	0.86	0.85	0.88	0.74	0.72	0.94	0.85	0.63	0.84	13.98							
FRA	0.76	0.86	0.94	0.92	0.94	0.87	0.79	0.72	0.90	0.94	0.62	0.84	0.88	1.18						

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	JPN
CAN	6.61												
CHE	0.92	11.12											
CZE	0.82	0.75	17.82										
DEU	0.91	0.93	0.78	14.79									
DFS	0.74	0.71	0.89	0.75	13.30								
FRA	0.76	0.75	0.90	0.73	0.88	1.01							
GBR	0.73	0.77	0.70	0.78	0.67	0.70	0.03						
ISR	0.76	0.67	0.90	0.73	0.86	0.86	0.73	3.19					
ITA	0.87	0.88	0.77	0.95	0.69	0.71	0.77	0.74	0.05				
NLD	0.78	0.75	0.90	0.76	0.92	0.93	0.71	0.89	0.72	4.98			
USA	0.80	0.72	0.96	0.73	0.89	0.89	0.66	0.92	0.75	0.89	2.79		
POL	0.73	0.75	0.88	0.78	0.87	0.87	0.66	0.84	0.79	0.86	0.87	20.37	
JPN	0.77	0.69	0.89	0.70	0.83	0.80	0.70	0.82	0.69	0.81	0.91	0.68	7.63

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	JPN
BEL	4.71																			
CAN	0.83	6.01																		
CHE	0.80	0.87	11.23																	
CZE	0.65	0.84	0.87	17.82																
DEU	0.83	0.93	0.91	0.90	13.47															
DFS	0.84	0.85	0.86	0.80	0.94	12.90														
ESP	0.85	0.86	0.81	0.77	0.89	0.85	11.11													
FRA	0.84	0.88	0.90	0.81	0.91	0.85	0.87	0.98												
GBR	0.89	0.84	0.74	0.65	0.84	0.84	0.87	0.83	4.61											
IRL	0.84	0.83	0.81	0.66	0.83	0.83	0.85	0.84	0.84	3.49										
ISR	0.53	0.62	0.63	0.81	0.75	0.69	0.67	0.66	0.58	0.61	3.19									
ITA	0.75	0.85	0.87	0.90	0.91	0.84	0.87	0.84	0.77	0.77	0.82	15.64								
NLD	0.84	0.89	0.89	0.84	0.95	0.91	0.88	0.91	0.84	0.84	0.73	0.85	4.68							
NZL	0.78	0.71	0.58	0.53	0.71	0.72	0.73	0.71	0.78	0.78	0.48	0.58	0.64	4.98						
USA	0.84	0.86	0.84	0.86	0.91	0.88	0.88	0.85	0.84	0.84	0.75	0.91	0.86	0.72	2.33					
POL	0.83	0.83	0.73	0.62	0.83	0.82	0.84	0.82	0.84	0.82	0.54	0.78	0.83	0.73	0.83	13.49				
ZAF	0.74	0.76	0.80	0.70	0.80	0.76	0.84	0.78	0.79	0.85	0.55	0.83	0.77	0.67	0.86	0.76	15.55			
AUS	0.70	0.70	0.74	0.63	0.71	0.66	0.72	0.72	0.71	0.87	0.55	0.71	0.67	0.67	0.75	0.63	0.81	7.97		
URY	0.83	0.81	0.68	0.60	0.80	0.81	0.82	0.80	0.85	0.83	0.48	0.65	0.81	0.82	0.83	0.84	0.76	0.68	1.42	
JPN	0.83	0.84	0.82	0.74	0.84	0.84	0.89	0.84	0.86	0.84	0.59	0.85	0.84	0.72	0.92	0.88	0.86	0.73	0.81	18.47

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN
BEL	4.71																
CAN	0.88	6.48															
DEU	0.87	0.90	12.31														
DFS	0.90	0.91	0.94	12.83													
ESP	0.88	0.89	0.88	0.88	11.11												
GBR	0.89	0.87	0.87	0.89	0.89	4.61											
IRL	0.87	0.87	0.87	0.87	0.87	0.87	3.49										
ITA	0.87	0.89	0.90	0.90	0.93	0.87	0.87	20.52									
NLD	0.93	0.90	0.91	0.95	0.88	0.89	0.87	0.88	4.71								
NZL	0.79	0.72	0.72	0.73	0.74	0.79	0.79	0.76	0.64	4.98							

USA	0.87	0.93	0.91	0.89	0.90	0.87	0.87	0.93	0.87	0.73	2.33						
POL	0.86	0.87	0.87	0.87	0.87	0.87	0.86	0.90	0.87	0.77	0.87	13.49					
ZAF	0.86	0.87	0.86	0.86	0.88	0.86	0.87	0.87	0.87	0.78	0.88	0.85	15.55				
AUS	0.87	0.87	0.87	0.87	0.87	0.87	0.88	0.87	0.87	0.77	0.87	0.86	7.97				
URY	0.86	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.86	0.83	0.87	0.87	0.86	0.87	1.42		
FRA	0.79	0.85	0.79	0.80	0.82	0.72	0.78	0.80	0.80	0.54	0.82	0.69	0.77	0.73	0.63	0.98	
JPN	0.86	0.93	0.90	0.90	0.91	0.87	0.86	0.94	0.87	0.75	0.92	0.91	0.89	0.87	0.86	0.78	18.47

JER hco

	CAN	DFS	USA	NLD
CAN	8.00			
DFS	0.75	17.47		
USA	0.82	0.88	2.75	
NLD	0.75	0.88	0.88	4.40

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	6.74						
DFS	0.87	13.55					
GBR	0.73	0.85	4.06				
NLD	0.87	0.90	0.77	3.98			
NZL	0.61	0.69	0.70	0.61	0.07		
USA	0.84	0.84	0.84	0.84	0.65	3.74	
IRL	0.74	0.73	0.87	0.73	0.62	0.75	2.07

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.89				
DFS	0.72	15.48			
GBR	0.76	0.68	0.03		
NLD	0.76	0.91	0.70	3.89	
USA	0.74	0.89	0.67	0.89	2.92

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.70								
DFS	0.86	15.70							
GBR	0.85	0.85	4.06						
NLD	0.89	0.89	0.85	3.45					
NZL	0.75	0.75	0.80	0.65	4.02				
USA	0.86	0.86	0.85	0.86	0.76	2.61			
ZAF	0.69	0.68	0.74	0.71	0.75	0.85	11.09		
AUS	0.67	0.67	0.67	0.67	0.68	0.69	0.76	6.05	
IRL	0.84	0.85	0.85	0.85	0.76	0.85	0.73	0.75	2.07

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.47								
DFS	0.89	15.44							
GBR	0.87	0.88	4.06						
NLD	0.89	0.91	0.88	3.54					
NZL	0.75	0.74	0.81	0.60	4.02				
USA	0.89	0.88	0.87	0.87	0.76	2.61			
ZAF	0.87	0.87	0.87	0.87	0.80	0.87	11.09		
AUS	0.87	0.87	0.87	0.87	0.74	0.87	0.87	6.05	
IRL	0.86	0.87	0.86	0.87	0.66	0.86	0.86	0.87	2.07

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.61					
DEU	0.91	14.23				
DFS	0.78	0.80	12.32			
NOR	0.86	0.87	0.86	16.57		
USA	0.84	0.83	0.89	0.74	2.76	
NLD	0.75	0.77	0.88	0.72	0.88	5.08

RDC	crc								
	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	6.37								
DEU	0.85	9.98							
DFS	0.87	0.90	12.70						
GBR	0.77	0.74	0.76	4.12					
NOR	0.89	0.87	0.86	0.74	13.75				
NZL	0.62	0.62	0.61	0.64	0.65	0.11			
USA	0.84	0.84	0.84	0.82	0.85	0.74	3.47		
NLD	0.87	0.90	0.92	0.78	0.86	0.62	0.84	3.38	
IRL	0.73	0.73	0.74	0.87	0.74	0.63	0.76	0.73	2.72

RDC	cc1						
	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	7.15						
DEU	0.90	13.55					
DFS	0.75	0.78	13.08				
GBR	0.72	0.78	0.72	0.03			
NOR	0.78	0.87	0.92	0.72	13.94		
NLD	0.78	0.78	0.91	0.72	0.77	4.36	
USA	0.83	0.75	0.88	0.67	0.77	0.89	2.71

RDC	cc2										
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.80										
DEU	0.92	11.11									
DFS	0.85	0.94	12.85								
GBR	0.85	0.84	0.85	4.13							
NOR	0.88	0.87	0.90	0.86	13.94						
NZL	0.74	0.73	0.75	0.77	0.76	6.73					
USA	0.88	0.90	0.86	0.85	0.86	0.78	2.45				
ZAF	0.73	0.78	0.77	0.71	0.70	0.69	0.85	17.77			
NLD	0.89	0.95	0.90	0.85	0.86	0.65	0.86	0.75	3.71		
AUS	0.68	0.70	0.65	0.69	0.66	0.68	0.71	0.75	0.67	7.34	
IRL	0.84	0.84	0.85	0.85	0.86	0.78	0.85	0.81	0.85	0.82	2.72

RDC	int										
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.65										
DEU	0.90	10.96									
DFS	0.89	0.94	13.16								
GBR	0.87	0.87	0.88	4.13							
NOR	0.89	0.89	0.87	0.88	13.75						
NZL	0.77	0.72	0.73	0.77	0.75	6.73					
USA	0.92	0.91	0.88	0.87	0.88	0.79	2.44				
ZAF	0.87	0.87	0.87	0.87	0.92	0.79	0.88	17.77			
NLD	0.90	0.91	0.93	0.89	0.88	0.62	0.87	0.87	3.47		
AUS	0.87	0.87	0.87	0.87	0.88	0.78	0.87	0.87	0.87	7.34	
IRL	0.87	0.87	0.87	0.87	0.88	0.77	0.87	0.87	0.87	0.88	2.72

^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	91	52	100	94	29
DEA	76	0	199	180	586	133
FRA	44	144	0	70	158	72
USA	90	136	53	0	196	47
CHE	77	489	116	161	0	86
NLD	26	125	59	43	81	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	111	106	36	21	129	44	69	100
CHE	91	0	571	94	28	262	57	159	421
DEA	89	469	0	148	38	217	55	202	570
NLD	32	86	137	0	26	56	35	78	117
NZL	19	22	32	21	0	22	17	22	30
USA	121	228	169	51	19	0	58	92	164
GBR	38	40	37	26	13	50	0	43	61
FRA	58	115	148	63	17	63	33	0	175
ITA	85	357	440	94	23	116	40	131	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	111	106	36	129	44	72
CHE	91	0	566	93	262	58	166
DEA	89	465	0	145	217	58	214
NLD	32	86	136	0	56	35	83
USA	121	228	169	51	0	61	97
GBR	39	42	39	26	52	0	47
FRA	62	123	160	69	69	38	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	97	91	35	20	121	41	66	91
CHE	76	0	557	94	28	318	57	166	421
DEA	75	458	0	146	39	309	54	213	557
NLD	31	86	136	0	27	79	35	83	117
NZL	18	22	32	21	0	31	17	23	30
USA	109	294	272	68	27	0	68	117	212
GBR	34	40	37	26	13	60	0	45	61
FRA	57	123	160	69	18	83	36	0	188
ITA	75	357	433	94	23	148	40	143	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	95	37	21	125	43	95
DEA	78	0	148	39	308	54	671
NLD	34	139	0	27	80	35	124

NZL	19	32	21	0	31	17	31
USA	113	272	71	27	0	68	229
GBR	36	37	26	13	60	0	62
ITA	79	569	103	24	163	40	0

GUE

GUE

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

CAN	0	15	3	38	18
GBR	12	0	13	52	28
NZL	2	11	0	9	26
USA	37	49	7	0	19
AUS	13	22	24	16	0

GUE

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

CAN	0	16	39
GBR	13	0	53
USA	38	50	0

GUE

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

CAN	0	11	2	38	22
GBR	8	0	13	83	32
NZL	2	11	0	29	26
USA	36	84	28	0	62
AUS	18	26	26	58	0

GUE

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

CAN	0	11	2	38	22
GBR	8	0	13	83	32
NZL	2	11	0	29	26
USA	36	84	28	0	62
AUS	18	26	26	58	0

HOL

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

CAN	0	1000	2052	1193	1219	2630	1117	801	1235	1677	1070
CZE	722	0	1708	1146	1172	1343	1032	489	1390	1247	769
DEU	1596	1275	0	2349	2211	2708	1915	1104	2796	2510	1251
DFS	1096	750	1714	0	1583	1499	1185	703	2009	1595	911
FRA	892	704	1199	883	0	1601	1316	687	1856	1726	1091
USA	3012	1055	2040	1308	934	0	1571	838	1674	2229	1377
POL	979	790	1604	929	838	1570	0	489	1351	1316	751
CHE	685	329	974	619	610	754	370	0	871	749	453
NLD	1199	1203	2406	1717	1189	1450	1165	844	0	1697	988
ITA	1414	868	1687	1229	976	1765	979	675	1393	0	1152

JPN 579 322 530 455 382 693 381 275 478 502 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	704	578	1130	795	849	811	495	783	1164	488	758	490	898
CAN	707	0	833	2197	1279	1444	1490	518	1744	1375	664	2775	1010	1311
CHE	581	719	0	1139	706	697	722	405	743	896	408	899	439	697
DEU	1157	1649	1009	0	2548	2116	2081	882	2604	3252	970	2965	1670	2443
DFS	740	1178	624	1806	0	1410	1510	731	1579	2026	815	1644	1065	1598
ESP	910	1212	633	1827	1205	0	1393	683	1642	1590	710	1685	1007	1604
GBR	797	1548	655	1546	1151	1273	0	961	1596	1745	922	1874	890	1546
IRL	492	517	411	770	610	701	1000	0	654	883	721	625	352	739
ITA	759	1468	672	1762	1224	1450	1236	579	0	1758	748	2379	1155	1732
NLD	1326	1350	872	2924	1787	1656	1514	833	1473	0	1039	1915	1205	1961
NZL	403	621	340	749	587	599	802	628	569	946	0	791	401	799
USA	721	3194	803	2131	1385	1423	1780	610	1821	1685	729	0	1427	1796
POL	395	843	325	1302	802	770	635	262	806	995	295	1359	0	1190
FRA	883	973	609	1321	872	1507	978	599	966	1236	489	1025	709	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	836	1026	2196	1285	1325	1543	103	1744	1381	2813	1048	1208
CHE	721	0	472	1136	706	702	726	54	742	896	899	462	483
CZE	780	324	0	1685	1092	1142	955	98	1217	1364	1420	1011	770
DEU	1646	1005	1294	0	2548	2458	2129	148	2592	3239	2944	1799	1436
DFS	1184	624	753	1800	0	1608	1543	133	1580	2025	1649	1139	962
FRA	993	618	703	1342	887	0	1581	113	1741	1978	1799	1248	1215
GBR	1619	667	640	1588	1183	1007	0	123	1644	1786	1945	944	1058
ISR	74	33	75	121	103	63	88	0	132	136	136	90	95
ITA	1469	671	871	1747	1221	987	1288	102	0	1756	2372	1210	1204
NLD	1357	872	1219	2905	1786	1262	1559	110	1468	0	1915	1307	1056
USA	3242	803	1117	2099	1385	1044	1882	128	1813	1685	0	1481	1567
POL	896	354	781	1506	902	769	700	66	869	1141	1433	0	740
JPN	690	311	360	617	519	445	549	43	571	570	840	401	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	695	578	552	1125	796	849	895	813	497	69	782	1166	488	908	484	327	708	328	501
CAN	696	0	821	1008	2123	1257	1432	1280	1462	506	100	1691	1339	649	2913	975	436	1189	673	1123
CHE	581	703	0	472	1130	707	698	691	722	405	55	739	896	409	1014	429	271	613	295	453
CZE	428	752	324	0	1679	1092	1037	1132	943	443	98	1213	1364	520	1517	936	310	737	458	733
DEU	1149	1569	995	1285	0	2536	2120	2423	2069	878	147	2572	3213	971	3493	1614	548	1613	733	1360
DFS	740	1151	625	753	1782	0	1418	1597	1513	731	135	1577	2029	821	2034	1039	501	1230	606	910
ESP	910	1186	633	821	1821	1212	0	1605	1396	684	121	1644	1596	714	2006	987	510	1133	613	1051
FRA	878	938	605	695	1289	862	1495	0	1539	743	116	1712	1948	804	2483	1161	475	1252	569	1156
GBR	797	1511	655	631	1526	1151	1274	968	0	962	123	1590	1747	924	2250	870	495	1363	628	1000
IRL	492	497	411	323	762	610	701	597	1000	0	91	653	886	723	789	346	334	725	358	435
ISR	42	71	33	75	120	103	95	62	87	70	0	132	138	99	161	86	57	97	78	93
ITA	753	1397	666	866	1701	1211	1443	942	1228	577	100	0	1747	749	2657	1121	478	1175	646	1143
NLD	1328	1304	872	1219	2846	1788	1659	1220	1514	834	110	1449	0	1045	2477	1170	497	1424	625	998
NZL	403	599	341	376	741	589	602	485	802	629	83	569	952	0	1079	393	353	1180	489	549
USA	800	3256	901	1158	2357	1519	1687	1311	2021	709	145	1913	2119	1025	0	1429	625	1839	1046	1879
POL	385	800	314	679	1234	777	750	683	619	254	57	780	952	286	1330	0	218	660	400	675
ZAF	270	398	219	203	418	365	465	325	431	290	38	376	411	284	598	145	0	468	306	399
AUS	606	1177	528	489	1168	868	906	835	1172	626	63	869	1214	1180	1799	460	407	0	612	850
URY	236	621	212	304	491	399	533	328	494	276	39	460	470	403	1271	298	251	466	0	527
JPN	301	566	266	308	513	442	479	381	467	263	34	476	475	258	713	325	249	425	250	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  FRA  JPN
-----
BEL    0  697 1123  796  849  813  497  781 1169  488  908  483  327  708  328  895  501
CAN   700    0 2128 1265 1439 1471  512 1698 1358  654 2927  979  440 1197  678 1288 1128
DEU  1148 1578    0 2533 2118 2069  878 2571 3230  971 3488 1606  548 1613  732 2422 1360
DFS   740 1161 1779    0 1418 1513  731 1577 2036  821 2032 1038  501 1230  605 1597  910
ESP   910 1202 1821 1212    0 1396  684 1643 1604  714 2003  987  510 1132  613 1604 1050
GBR   797 1524 1526 1151 1274    0  962 1590 1757  924 2250  870  495 1363  627 1539 1000
IRL   492  505  762  610  701 1000    0  653  890  723  789  346  334  725  358  743  435
ITA   753 1411 1702 1211 1442 1228  577    0 1755  749 2657 1118  478 1175  646 1712 1143
NLD  1338 1333 2876 1799 1677 1526  838 1464    0 1046 2489 1174  498 1429  629 1953 1006
NZL   403  603  742  589  602  802  629  570  954    0 1079  393  353 1180  489  804  549
USA   800 3287 2357 1519 1687 2021  709 1913 2140 1025    0 1427  625 1839 1046 2483 1879
POL   385  807 1231  776  750  619  254  779  958  286 1330    0  218  660  400 1161  675
ZAF   270  405  418  365  465  431  290  376  412  284  598  145    0  468  306  475  399
AUS   606 1182 1168  868  906 1172  626  869 1223 1180 1799  460  407    0  612 1252  850
URY   236  627  491  399  533  494  276  460  474  403 1271  298  251  466    0  569  527
FRA   878  946 1289  862 1495  968  597  942 1228  485 1311  683  325  835  328    0 1156
JPN   301  569  513  442  479  467  263  476  480  258  713  325  249  425  250  381    0
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JER

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-----
common bulls below diagonal
common three quarter sib group above diagonal
  CAN  DFS  USA  NLD
-----
CAN    0  80  301  26
DFS   74    0  128  68
USA  287 114    0  57
NLD   20  65  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  IRL
-----
CAN    0  84  135  31  152  341  10
DFS   76    0  155  111  136  140  47
GBR  132 147    0  77  204  197  69
NLD   27 108  70    0  69  74  29
NZL  150 116 206  62    0  261 119
USA  340 127 210  79 285    0  39
IRL    9  43  71  29 133  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  USA
-----
CAN    0  84  139  31  346
DFS   76    0  157  110  140
GBR  134 148    0  79  198
NLD   27 107  73    0  74
USA  346 127 211  79    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  80  132  31  145  348  124  203  10
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DFS	72	0	156	111	140	188	144	149	47
GBR	127	147	0	77	206	223	163	206	69
NLD	26	108	70	0	70	87	69	69	29
NZL	141	118	206	63	0	363	203	432	119
USA	345	162	242	94	435	0	299	477	45
ZAF	122	125	164	65	211	310	0	232	39
AUS	197	119	210	64	465	519	222	0	54
IRL	9	43	71	29	133	47	40	52	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	81	133	32	147	351	126	205	10
DFS	73	0	156	115	140	188	144	149	47
GBR	129	147	0	82	206	223	163	206	69
NLD	28	113	75	0	74	93	72	72	30
NZL	145	118	206	67	0	363	203	432	119
USA	351	162	242	100	435	0	299	477	45
ZAF	124	125	164	69	211	310	0	232	39
AUS	201	119	210	66	465	519	222	0	54
IRL	9	43	71	29	133	47	40	52	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	10	159	7	95	6
DEU	10	0	50	13	15	10
DFS	164	41	0	118	149	50
NOR	6	12	96	0	63	35
USA	90	14	142	63	0	32
NLD	6	10	47	35	30	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	0	12	156	67	6	68	130	6	4
DEU	11	0	52	14	14	16	17	14	5
DFS	162	40	0	97	137	169	164	53	18
GBR	67	13	91	0	50	73	85	32	21
NOR	6	13	108	53	0	41	71	41	53
NZL	68	16	165	69	40	0	93	18	12
USA	125	17	159	79	72	96	0	36	26
NLD	6	14	50	31	41	18	34	0	11
IRL	4	5	13	20	52	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	12	158	69	7	6	130
DEU	11	0	52	14	14	14	17
DFS	163	40	0	99	125	53	164
GBR	68	13	92	0	51	33	87
NOR	6	13	100	54	0	39	71
NLD	6	14	50	32	39	0	36
USA	125	17	158	81	71	34	0

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  12  152  63   6   68  154  72   6  69   4
DEU  11   0   51  14  14  16  18   3  14  39   5
DFS 157  40   0  97 125 170 188  57  53 194  18
GBR  63  13  91   0  49  76  98  42  32  75  21
NOR   6  13 100  52   0  40  74   0  39  62  53
NZL  68  16 166  71  39   0 119  40  18 138  12
USA 155  18 186  94  75 122   0  72  40 119  28
ZAF  76   3   55  40   0  38  67   0   3  43   3
NLD   6  14  50  31  39  18  38   3   0  27  11
AUS  69  38 170  73  52 138 120  44  25   0  16
IRL   4   5  13  20  52  12  28   3  11  15   0
-----

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RDC
-----
common bulls below diagonal
common three quarter sib group above diagonal
  CAN  DEU  DFS  GBR  NOR  NZL  USA  ZAF  NLD  AUS  IRL
-----
CAN   0  12  153  64   6   68  155  72   7  69   4
DEU  11   0   51  14  14  16  18   3  14  39   5
DFS 158  40   0  97 137 170 187  57  53 194  18
GBR  64  13  91   0  50  76  98  42  32  75  21
NOR   6  13 108  53   0  41  74   0  41  66  53
NZL  68  16 166  71  40   0 119  40  18 138  12
USA 156  18 184  94  74 121   0  72  41 119  28
ZAF  76   3   55  40   0  38  67   0   3  43   3
NLD   7  14  50  31  41  18  39   3   0  27  11
AUS  69  38 170  73  56 138 120  44  25   0  16
IRL   4   5  13  20  52  12  28   3  11  15   0
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SIM
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SIM
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SIM
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SIM
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SIM
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