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 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:

DFS HOL/JER RDC The whole editing process of the fertility data has been renovated. For Finland, pregnancy control results are now available in the data set, improving the correct phenotyping of the animals. Parameters to prolong records in progress and open cases for cc2 have been updated.
Swedish heifer data have been changed after correcting an error in the data process. In the new data, more heifers with poor phenotypic fertility values are included having also an impact on e.g. cc2 ebvs through genetic correlations.
Swedish and Finnish Jersey cows have been included in the Jersey evaluation.
In hco and cc1, the trait definition changed from non-return rate to conception rate

CHE HOL Slightly changed the deduction of type of proofs
(This affects the type of proofs of domestic AI bulls not tested through the official progeny testing scheme and of domestic natural-service bulls. For such bulls the type of proof changed from 21 to 12.)

CHE BSW Slightly changed the deduction of type of proofs
Change in pedigree. Animals with unverified pedigree get a missing dam, sire or both. This is the reason why there are many bulls dropping information.

CZE HOL Base change

CAN HOL/RDC Started using pregnancy check data to determine conception dates when calculating the interval between first service and conception.
JER/BSW
GUE Parameters were re-estimated which also included a much longer data history than the previous
For many of the traits there was a considerable drop in the heritability which resulted in changes in proofs and reliability

ITA HOL Pedigree corrections and data editing causing some decrease in information

DEU HOL/RDC New definition of genetic groups

INTERBULL CHANGES COMPARED TO THE DECEMBER ROUTINE RUN

Subsetting:

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

Window:

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

The upper bounds have been set to 0.99 as these were judged to have very little effect on evaluations. The lower values have been set to about the 25% percentile value. The largest changes are for the lower values for conformation traits, with the lowest window being 40% for OFL otherwise it is about 50% for all other confirmation traits. It is anticipated that these low values may not have large impact on evaluations since there were very few countries combinations whose estimated correlations fell between the old limit of 0.30 and these new limits.

DATA AND METHOD OF ANALYSIS

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

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

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

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

SCIENTIFIC LITERATURE

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

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

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

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

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

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

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

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

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

NEXT ROUTINE INTERNATIONAL EVALUATION

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

NEXT TEST INTERNATIONAL EVALUATION

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

PUBLICATION OF INTERBULL TEST RUN

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

^LTable 1. National evaluation data considered in the Interbull
evaluation for fertility (December Routine Evaluation 2016).
Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		118	7310	1489	620	
BEL			1092			
CAN	126	37	7855	422	469	
CHE	2543		2918			
CZE			3499			
DEA	5168					
DEU			23936		322	
DFS			14891	2234	9232	
ESP			2991			
EST						
FRA	340		15163			
FRM						
GBR	78	209	5920	495	324	
HUN						
IRL			2422	137	52	
ISR			1250			
ITA	1631		8943			
JPN						
KOR						
LTU						
LVA						
NLD	158		14001	119	62	
NOR					3710	
NZL	47	57	6943	4302	1223	
POL			6084			
PRT						
SVK						
SVN						
URY			1271			
USA	1006	726	34829	4030	639	
ZAF		30	1179	641	141	
HRV						
FRR			174			
No.Records	11097	1177	162671	13869	16794	
Pub. Proofs	10274	979	138509	11794	15719	0

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

BSW hco

	CAN	DEA	FRA	USA	CHE	NLD
CAN	9.14					
DEA	0.88	9.77				
FRA	0.82	0.82	0.91			
USA	0.83	0.85	0.90	2.63		
CHE	0.94	0.94	0.88	0.88	13.11	
NLD	0.80	0.73	0.84	0.88	0.88	3.64

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.96								
CHE	0.85	11.21							
DEA	0.85	0.94	14.17						
NLD	0.87	0.88	0.85	3.40					
NZL	0.61	0.65	0.71	0.61	10.29				
USA	0.85	0.86	0.85	0.85	0.62	3.35			
GBR	0.76	0.76	0.75	0.80	0.64	0.83	3.82		
FRA	0.86	0.96	0.93	0.91	0.62	0.86	0.80	1.77	
ITA	0.85	0.85	0.85	0.87	0.69	0.85	0.80	0.87	19.67

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.58						
CHE	0.78	11.95					
DEA	0.79	0.97	10.94				
NLD	0.73	0.69	0.67	3.68			
USA	0.74	0.68	0.67	0.91	2.86		
GBR	0.72	0.81	0.78	0.67	0.67	0.04	
FRA	0.71	0.69	0.67	0.84	0.91	0.66	0.95

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.41								
CHE	0.71	11.19							
DEA	0.82	0.93	11.65						
NLD	0.87	0.83	0.85	3.41					
NZL	0.61	0.55	0.64	0.61	6.90				
USA	0.85	0.82	0.85	0.89	0.65	2.41			
GBR	0.80	0.77	0.85	0.80	0.69	0.85	3.82		
FRA	0.82	0.87	0.86	0.79	0.59	0.85	0.80	0.95	
ITA	0.85	0.73	0.85	0.85	0.66	0.88	0.86	0.85	24.45

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.92						
DEA	0.88	13.51					
NLD	0.88	0.87	3.20				
NZL	0.57	0.62	0.62	6.90			
USA	0.89	0.87	0.87	0.57	2.41		
GBR	0.87	0.88	0.89	0.65	0.87	3.82	
ITA	0.88	0.93	0.88	0.65	0.89	0.88	18.01

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.07				
GBR	0.74	4.52			
NZL	0.60	0.64	11.55		
USA	0.84	0.86	0.62	3.41	
AUS	0.73	0.86	0.70	0.74	7.02

GUE cc1

	CAN	GBR	USA
CAN	7.10		
GBR	0.70	0.03	
USA	0.80	0.74	3.48

GUE cc2

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.88					
GBR	0.79	4.52				
NZL	0.58	0.69	7.38			
USA	0.85	0.85	0.65	2.75		
ZAF	0.75	0.82	0.70	0.84	13.78	
AUS	0.70	0.77	0.76	0.80	0.85	7.16

GUE int

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	7.08					
GBR	0.87	4.52				
NZL	0.57	0.64	7.38			
USA	0.90	0.87	0.60	2.75		
ZAF	0.87	0.87	0.65	0.87	13.78	
AUS	0.87	0.87	0.73	0.87	0.87	7.16

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD	FRR
CAN	7.70									
CZE	0.80	17.92								
DEU	0.93	0.80	14.83							
DFS	0.83	0.85	0.91	13.65						
FRA	0.79	0.86	0.82	0.84	0.84					
USA	0.85	0.88	0.87	0.87	0.91	2.42				
POL	0.79	0.64	0.77	0.74	0.61	0.68	18.34			
CHE	0.96	0.86	0.93	0.90	0.86	0.88	0.70	13.81		
NLD	0.81	0.85	0.78	0.79	0.85	0.88	0.67	0.84	4.12	
FRR	0.85	0.85	0.85	0.85	0.81	0.85	0.85	0.85	0.85	0.78

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	AUS	FRR
BEL	4.65															
CAN	0.73	6.76														
CHE	0.79	0.85	12.42													
DEU	0.71	0.86	0.89	10.88												
DFS	0.80	0.88	0.94	0.91	12.03											
ESP	0.86	0.73	0.76	0.75	0.75	11.25										
GBR	0.88	0.73	0.77	0.74	0.81	0.91	4.71									
IRL	0.86	0.71	0.71	0.71	0.71	0.86	0.86	3.47								
ITA	0.78	0.85	0.89	0.90	0.92	0.86	0.83	0.72	8.02							
NLD	0.81	0.87	0.92	0.92	0.96	0.76	0.80	0.71	0.88	4.61						
NZL	0.65	0.59	0.62	0.59	0.61	0.63	0.64	0.61	0.69	0.59	8.71					
USA	0.82	0.84	0.84	0.84	0.84	0.88	0.87	0.77	0.84	0.84	0.60	3.32				
POL	0.74	0.88	0.89	0.88	0.89	0.77	0.72	0.71	0.90	0.86	0.61	0.84	13.97			
FRA	0.75	0.86	0.94	0.93	0.94	0.78	0.80	0.71	0.92	0.95	0.60	0.84	0.88	1.19		
AUS	0.86	0.71	0.71	0.71	0.71	0.86	0.86	0.88	0.72	0.71	0.61	0.73	0.70	0.71	4.93	
FRR	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.83	0.85	1.54

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	FRR
CAN	6.85												
CHE	0.91	11.06											
CZE	0.83	0.75	16.15										
DEU	0.89	0.93	0.73	13.74									
DFS	0.73	0.72	0.87	0.70	13.19								
FRA	0.72	0.75	0.88	0.66	0.76	1.00							
GBR	0.72	0.76	0.68	0.76	0.70	0.67	0.03						
ISR	0.79	0.68	0.88	0.68	0.84	0.81	0.72	3.08					
ITA	0.84	0.88	0.71	0.93	0.70	0.63	0.75	0.71	0.05				
NLD	0.74	0.71	0.87	0.67	0.92	0.87	0.67	0.84	0.66	4.56			
USA	0.78	0.71	0.95	0.68	0.86	0.89	0.66	0.87	0.70	0.91	2.84		
POL	0.70	0.75	0.62	0.83	0.70	0.58	0.66	0.60	0.84	0.62	0.65	17.42	
FRR	0.81	0.78	0.78	0.80	0.81	0.69	0.79	0.79	0.80	0.78	0.80	0.79	1.10

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA
NLD	NZL	USA	POL	ZAF	AUS	URY	FRR					
BEL	4.65											
CAN	0.84	6.22										
CHE	0.78	0.85	11.21									
CZE	0.65	0.84	0.86	16.15								
DEU	0.81	0.92	0.89	0.88	12.25							
DFS	0.82	0.85	0.86	0.81	0.93	13.15						
ESP	0.86	0.84	0.73	0.67	0.81	0.81	11.25					
FRA	0.80	0.85	0.91	0.78	0.86	0.82	0.75	0.98				
GBR	0.89	0.84	0.71	0.63	0.80	0.83	0.92	0.76	4.71			
IRL	0.84	0.83	0.79	0.66	0.80	0.80	0.85	0.80	0.85	3.47		
ISR	0.49	0.63	0.64	0.78	0.71	0.64	0.51	0.62	0.53	0.59	3.08	
ITA	0.84	0.84	0.77	0.75	0.84	0.84	0.94	0.77	0.87	0.84	0.60	17.96
NLD	0.80	0.91	0.87	0.84	0.92	0.90	0.80	0.83	0.80	0.82	0.68	0.83
4.58												
NZL	0.73	0.64	0.52	0.48	0.59	0.59	0.70	0.57	0.69	0.73	0.44	0.66
0.59	5.60											
USA	0.84	0.85	0.83	0.86	0.89	0.89	0.87	0.85	0.84	0.84	0.71	0.93
0.89	0.65	2.36										
POL	0.82	0.82	0.65	0.61	0.77	0.77	0.85	0.69	0.83	0.80	0.46	0.86
0.77	0.61	0.83	12.96									
ZAF	0.74	0.76	0.79	0.71	0.82	0.78	0.87	0.79	0.79	0.86	0.60	0.90
0.80	0.69	0.87	0.74	15.89								
AUS	0.79	0.71	0.78	0.66	0.71	0.69	0.78	0.78	0.77	0.87	0.56	0.80
0.71	0.71	0.79	0.69	0.84	5.03							
URY	0.84	0.81	0.68	0.58	0.79	0.81	0.84	0.80	0.85	0.84	0.48	0.82
0.81	0.76	0.83	0.86	0.78	0.72	1.44						
FRR	0.82	0.84	0.77	0.80	0.85	0.83	0.83	0.70	0.82	0.84	0.77	0.85
0.84	0.80	0.87	0.80	0.82	0.81	0.79	1.10					

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL
ZAF	AUS	FRA	URY									
BEL	4.65											
CAN	0.88	6.62										
DEU	0.86	0.87	10.40									
DFS	0.89	0.90	0.93	13.08								
ESP	0.86	0.87	0.88	0.86	11.24							
GBR	0.87	0.87	0.87	0.90	0.91	4.71						
IRL	0.86	0.87	0.86	0.86	0.86	0.86	3.47					
ITA	0.86	0.88	0.90	0.89	0.95	0.88	0.86	17.96				
NLD	0.91	0.91	0.91	0.94	0.87	0.90	0.86	0.89	4.45			
NZL	0.69	0.57	0.60	0.59	0.68	0.67	0.68	0.66	0.61	5.60		
USA	0.87	0.92	0.87	0.88	0.87	0.87	0.87	0.92	0.87	0.60	2.36	
POL	0.86	0.87	0.86	0.86	0.86	0.86	0.86	0.89	0.86	0.66	0.87	12.97
ZAF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.92	0.87	0.66	0.87	0.86
15.89												
AUS	0.86	0.87	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.68	0.87	0.86
0.87	5.03											
FRA	0.86	0.87	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.49	0.87	0.86
0.87	0.86	0.97										
URY	0.88	0.87	0.87	0.86	0.87	0.87	0.87	0.87	0.87	0.74	0.87	0.87
0.87	0.87	0.86	1.44									

JER hco

	CAN	DFS	USA	NLD
CAN	7.98			
DFS	0.82	17.40		
USA	0.84	0.87	2.72	
NLD	0.79	0.80	0.88	4.47

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.74							
DFS	0.87	13.86						
GBR	0.73	0.87	4.08					
NLD	0.87	0.91	0.77	3.87				
NZL	0.59	0.65	0.67	0.60	6.90			
USA	0.84	0.85	0.83	0.85	0.65	3.81		
AUS	0.72	0.72	0.86	0.72	0.61	0.73	3.68	
IRL	0.73	0.73	0.87	0.73	0.62	0.76	0.88	1.92

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.91				
DFS	0.73	15.51			
GBR	0.73	0.71	0.03		
NLD	0.73	0.88	0.66	3.57	
USA	0.75	0.87	0.68	0.91	2.90

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.69								
DFS	0.85	16.06							
GBR	0.85	0.82	4.08						
NLD	0.90	0.89	0.81	3.69					
NZL	0.65	0.62	0.70	0.60	4.42				
USA	0.85	0.87	0.85	0.88	0.68	2.63			
ZAF	0.71	0.73	0.77	0.78	0.71	0.86	11.04		
AUS	0.67	0.71	0.75	0.71	0.69	0.70	0.78	3.66	
IRL	0.84	0.82	0.85	0.82	0.67	0.85	0.74	0.80	1.92

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.38								
DFS	0.88	15.76							
GBR	0.87	0.88	4.08						
NLD	0.88	0.91	0.88	3.61					
NZL	0.59	0.64	0.68	0.60	4.42				
USA	0.88	0.88	0.87	0.87	0.67	2.63			
ZAF	0.87	0.87	0.87	0.87	0.69	0.87	11.04		
AUS	0.87	0.87	0.86	0.86	0.66	0.87	0.87	3.66	
IRL	0.86	0.86	0.86	0.87	0.52	0.87	0.86	0.87	1.92

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.05					
DEU	0.92	13.61				
DFS	0.84	0.83	12.31			
NOR	0.85	0.83	0.80	15.12		
USA	0.87	0.85	0.90	0.82	2.69	
NLD	0.81	0.78	0.81	0.72	0.88	4.60

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	6.34									
DEU	0.86	9.27								
DFS	0.86	0.90	12.89							
GBR	0.73	0.74	0.77	4.31						
NOR	0.90	0.87	0.90	0.77	14.80					
NZL	0.61	0.61	0.60	0.66	0.65	10.63				
USA	0.84	0.84	0.84	0.84	0.85	0.70	3.53			
NLD	0.87	0.91	0.93	0.80	0.86	0.61	0.85	3.02		
AUS	0.72	0.72	0.72	0.86	0.75	0.68	0.74	0.72	4.69	
IRL	0.72	0.72	0.73	0.87	0.74	0.62	0.77	0.73	0.88	2.36

RDC cc1

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	6.83						
DEU	0.88	12.23					
DFS	0.77	0.71	12.93				
GBR	0.72	0.77	0.78	0.03			
NOR	0.86	0.75	0.76	0.74	14.56		
NLD	0.74	0.68	0.85	0.68	0.70	4.17	
USA	0.83	0.70	0.83	0.67	0.75	0.92	2.77

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.64										
DEU	0.91	9.92									
DFS	0.85	0.93	12.98								
GBR	0.85	0.80	0.85	4.31							
NOR	0.89	0.86	0.85	0.87	16.08						
NZL	0.65	0.60	0.65	0.67	0.66	6.89					
USA	0.87	0.88	0.86	0.86	0.86	0.69	2.45				
ZAF	0.69	0.82	0.75	0.73	0.70	0.72	0.85	18.25			
NLD	0.91	0.91	0.89	0.81	0.86	0.60	0.89	0.79	3.82		
AUS	0.69	0.70	0.66	0.74	0.66	0.70	0.72	0.77	0.71	4.61	
IRL	0.83	0.82	0.84	0.85	0.86	0.72	0.85	0.83	0.83	0.84	2.36

RDC int

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.57										
DEU	0.87	8.88									
DFS	0.87	0.93	13.28								
GBR	0.87	0.87	0.88	4.31							
NOR	0.90	0.89	0.87	0.88	16.08						
NZL	0.61	0.59	0.58	0.66	0.51	6.89					
USA	0.89	0.87	0.88	0.88	0.88	0.68	2.45				
ZAF	0.88	0.87	0.87	0.88	0.91	0.67	0.89	18.25			
NLD	0.88	0.91	0.92	0.90	0.89	0.60	0.87	0.87	3.18		
AUS	0.87	0.87	0.86	0.87	0.88	0.67	0.87	0.88	0.87	4.61	
IRL	0.87	0.87	0.87	0.87	0.88	0.65	0.87	0.87	0.87	0.88	2.36

^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	65	42	74	71	24
DEA	52	0	173	147	506	111
FRA	37	128	0	66	141	66
USA	63	107	50	0	170	38
CHE	56	411	107	142	0	73
NLD	21	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	91	83	32	17	101	41	62	84
CHE	72	0	494	80	21	238	51	142	361
DEA	68	391	0	123	28	191	51	175	490
NLD	27	71	111	0	20	45	33	71	102
NZL	16	16	21	14	0	17	15	18	24
USA	98	207	142	40	15	0	51	88	146
GBR	37	38	35	25	11	47	0	42	55
FRA	54	106	130	57	14	60	32	0	153
ITA	71	306	370	81	18	101	38	116	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	91	83	32	101	43	65
CHE	72	0	492	80	238	55	149
DEA	68	389	0	122	191	56	187
NLD	27	71	111	0	45	33	76
USA	98	207	142	40	0	54	92
GBR	38	40	37	25	49	0	47
FRA	57	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	81	75	30	15	94	39	58	74
CHE	63	0	485	80	21	294	51	149	361
DEA	62	385	0	122	28	286	50	186	480
NLD	26	71	111	0	20	68	33	76	102
NZL	14	16	21	14	0	26	15	19	24
USA	87	276	251	56	23	0	62	113	195
GBR	33	38	35	25	11	57	0	44	55
FRA	52	112	143	63	15	79	35	0	164
ITA	63	306	366	81	18	134	38	128	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	79	32	16	99	41	79
DEA	65	0	124	28	286	50	589
NLD	29	113	0	20	69	33	109
NZL	15	21	14	0	26	15	24
USA	92	251	59	23	0	62	212
GBR	35	35	25	11	57	0	56
ITA	67	490	89	18	148	38	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	45
USA	30	42	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	9	2	28	0	15
GBR	6	0	13	72	4	28
NZL	1	11	0	29	3	26
USA	26	73	27	0	9	53
ZAF	0	3	1	5	0	4
AUS	11	22	24	49	3	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	9	2	28	0	15
GBR	6	0	13	72	4	28
NZL	1	11	0	29	3	26
USA	26	73	27	0	9	53
ZAF	0	3	1	5	0	4
AUS	11	22	24	49	3	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD	FRR
CAN	0	811	1587	882	968	1925	739	615	903	0
CZE	545	0	1466	942	989	1091	767	395	1124	9
DEU	875	970	0	2186	2012	2034	1264	904	2472	67
DFS	722	535	1195	0	1359	1134	820	558	1630	14
FRA	664	551	944	666	0	1317	897	526	1547	2
USA	2015	786	1105	866	689	0	1063	626	1271	3
POL	530	507	828	541	445	917	0	324	911	52
CHE	503	258	737	486	481	552	241	0	710	6
NLD	788	924	1784	1230	909	964	669	680	0	40
FRR	0	3	44	2	0	0	60	3	9	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	FRR
BEL	0	412	368	686	504	395	513	340	487	729	320	428	244	557	404	11
CAN	368	0	652	1734	968	931	1154	426	1317	1017	541	2035	674	1049	765	2
CHE	334	539	0	943	565	453	582	344	595	734	331	680	303	533	413	12
DEU	607	1065	782	0	2260	1229	1764	772	2229	2730	822	2311	1146	2141	1199	76
DFS	413	782	486	1254	0	805	1267	639	1321	1622	694	1266	732	1369	895	14
ESP	353	569	357	725	554	0	877	430	1009	864	439	1019	492	902	598	2
GBR	444	1142	536	1163	850	679	0	809	1330	1447	786	1407	610	1324	991	6
IRL	308	412	342	651	508	401	824	0	590	776	619	505	256	649	566	3
ITA	385	930	521	1236	846	695	905	495	0	1469	671	1816	794	1596	884	1
NLD	762	916	701	2170	1250	718	1172	712	1041	0	872	1482	834	1633	1051	42
NZL	233	495	278	598	464	321	657	525	474	783	0	631	288	698	950	0
USA	359	2128	602	1350	922	601	1207	479	1083	1158	546	0	960	1485	872	3
POL	160	460	210	712	457	235	345	165	463	569	178	741	0	822	355	43
FRA	510	718	472	976	649	622	777	508	748	927	388	753	367	0	938	3
AUS	304	626	335	709	497	398	753	452	523	806	898	700	161	541	0	4
FRR	7	1	4	50	3	0	1	1	1	10	0	0	49	0	1	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	FRR
CAN	0	650	862	1686	973	1056	1192	73	1317	1027	2074	707	2
CHE	537	0	402	923	566	544	582	42	595	734	680	327	12
CZE	583	264	0	1466	936	996	820	79	1024	1149	1170	753	10
DEU	951	740	972	0	2228	2113	1776	111	2174	2633	2222	1198	76
DFS	786	486	538	1181	0	1378	1284	105	1322	1620	1268	783	14
FRA	745	486	546	950	667	0	1352	97	1605	1651	1483	857	3
GBR	1187	536	470	1105	863	803	0	97	1353	1479	1453	648	6
ISR	53	28	57	88	86	53	66	0	102	108	92	61	0
ITA	932	521	614	1157	845	771	923	76	0	1468	1813	828	1
NLD	922	701	936	1972	1250	950	1202	90	1038	0	1483	895	42
USA	2174	602	823	1207	922	773	1259	80	1083	1158	0	1002	3
POL	488	231	488	773	516	401	374	41	496	638	784	0	44
FRR	1	4	3	50	3	0	1	0	1	10	0	50	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	FRR
BEL	0	401	368	343	673	504	395	554	513	341	45	486	729	320	538	242	231	459	191	11
CAN	356	0	639	838	1622	947	928	997	1129	415	71	1268	988	517	2202	653	389	907	497	2
CHE	334	523	0	403	918	566	453	525	582	344	42	591	735	331	802	295	238	487	223	12
CZE	227	548	264	0	1462	937	628	979	808	384	79	1015	1151	462	1315	696	287	645	340	10
DEU	585	890	735	966	0	2211	1213	2077	1729	757	112	2145	2604	811	2912	1091	509	1339	539	76
DFS	413	758	487	538	1173	0	809	1357	1269	639	106	1311	1624	696	1660	713	454	1016	454	14
ESP	353	554	357	367	696	555	0	901	881	431	76	1011	869	441	1221	488	391	686	378	2
FRA	501	666	459	525	897	627	614	0	1312	648	97	1570	1613	694	2165	800	424	1061	436	3
GBR	444	1107	536	465	1080	851	679	755	0	809	97	1326	1449	787	1791	598	451	1134	481	6
IRL	308	394	342	258	623	508	401	501	824	0	71	589	777	619	673	250	305	629	280	3
ISR	24	51	28	57	88	86	45	50	65	57	0	101	109	82	117	57	49	77	49	0
ITA	380	862	513	593	1126	827	691	719	892	491	74	0	1447	665	2229	771	456	1006	514	1
NLD	762	875	701	936	1925	1252	719	894	1173	712	90	1010	0	875	2031	810	449	1193	463	42
NZL	233	472	278	286	567	465	321	381	657	525	68	464	785	0	926	281	326	1023	373	0
USA	412	2217	705	895	1516	1053	741	1026	1454	583	98	1205	1530	853	0	973	576	1505	792	7
POL	156	434	201	426	643	442	229	348	335	161	36	444	544	174	724	0	172	445	257	43
ZAF	173	349	189	176	365	320	333	280	382	259	34	331	362	254	533	101	0	423	258	2
AUS	361	831	417	354	822	638	468	662	923	531	52	637	969	994	1356	247	353	0	455	5
URY	126	451	153	217	333	292	288	241	372	209	24	335	340	286	961	179	216	337	0	1
FRR	7	1	4	3	50	3	0	0	1	1	0	1	10	0	1	49	1	1	0	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	FRA	URY
BEL	0	405	679	504	395	513	341	486	729	320	538	242	231	459	517	191
CAN	361	0	1668	954	929	1138	422	1278	1003	523	2216	657	391	915	863	501
DEU	597	981	0	2238	1231	1752	768	2177	2680	820	2968	1110	517	1364	1926	549
DFS	413	768	1230	0	808	1269	639	1311	1626	696	1660	713	453	1016	1266	454
ESP	353	563	722	555	0	880	431	1010	869	440	1219	487	390	684	827	378
GBR	444	1122	1140	851	679	0	809	1326	1452	787	1791	598	450	1134	1225	481
IRL	308	403	643	508	401	824	0	589	780	619	673	250	305	629	623	280
ITA	380	877	1178	827	691	892	491	0	1449	665	2229	771	456	1006	1447	514
NLD	765	896	2073	1258	724	1177	715	1014	0	875	2036	809	448	1195	1490	464
NZL	233	477	588	465	321	657	525	464	786	0	926	281	325	1023	666	373
USA	412	2248	1630	1053	741	1454	583	1205	1536	853	0	972	575	1505	2009	792
POL	156	440	671	442	229	335	161	444	544	174	724	0	172	445	711	257
ZAF	173	355	373	320	333	382	259	331	363	254	533	101	0	422	416	258
AUS	361	837	863	638	468	923	531	637	975	994	1356	247	353	0	988	455
FRA	441	510	773	506	539	633	455	596	738	334	856	256	266	566	0	411
URY	126	456	352	292	288	372	209	335	343	286	961	179	216	337	215	0

JER

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common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	49	209	20
DFS	37	0	87	50
USA	190	67	0	40
NLD	15	47	39	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	55	108	23	125	246	119	6
DFS	40	0	121	68	113	101	93	26
GBR	107	109	0	60	167	157	143	42
NLD	18	62	57	0	57	53	47	18
NZL	128	85	172	49	0	215	326	82
USA	243	81	169	56	240	0	233	26
AUS	118	57	147	42	354	237	0	34
IRL	5	21	43	18	91	28	31	0

JER

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common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	54	111	22	249
DFS	39	0	121	68	100
GBR	107	109	0	61	161
NLD	17	62	58	0	53
USA	245	81	171	56	0

JER

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common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	53	105	22	121	262	98	159	5
DFS	38	0	121	68	113	147	109	107	26
GBR	101	109	0	60	168	187	138	166	42
NLD	16	62	57	0	58	66	58	53	18
NZL	120	85	172	50	0	315	176	371	82
USA	256	114	205	71	388	0	250	410	33
ZAF	96	85	143	54	185	258	0	194	28
AUS	146	69	169	47	397	438	182	0	40
IRL	4	21	43	18	91	35	30	38	0

JER

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common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	54	106	22	123	264	100	161	5
DFS	39	0	121	70	113	147	109	107	26
GBR	103	109	0	64	168	187	138	166	42
NLD	18	65	61	0	61	71	61	55	19
NZL	124	85	172	54	0	315	176	371	82
USA	261	114	205	77	388	0	250	410	33
ZAF	99	85	143	58	185	258	0	194	28
AUS	150	69	169	49	397	438	182	0	40
IRL	4	21	43	18	91	35	30	38	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	8	110	4	77	3
DEU	7	0	39	11	10	11
DFS	111	29	0	113	113	38
NOR	4	11	84	0	46	26
USA	72	10	106	46	0	24
NLD	3	11	37	25	22	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	108	51	4	53	101	4	54	2
DEU	9	0	45	4	12	12	12	10	20	4
DFS	108	35	0	53	107	149	122	39	137	13
GBR	52	4	52	0	23	43	54	16	36	9
NOR	4	12	77	24	0	37	53	26	34	45
NZL	54	12	144	41	35	0	68	12	101	7
USA	97	12	118	52	53	69	0	26	52	18
NLD	4	10	38	15	25	12	24	0	12	8
AUS	53	19	117	35	29	103	50	10	0	8
IRL	2	4	9	9	44	7	18	7	7	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	0	9	108	54	4	4	101
DEU	8	0	45	4	12	11	11
DFS	108	35	0	55	108	39	122
GBR	55	4	54	0	23	16	56
NOR	4	12	78	24	0	26	53
NLD	4	11	38	15	25	0	26
USA	98	11	118	53	53	24	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	106	48	4	52	128	66	4	58	2
DEU	7	0	42	4	11	11	13	1	10	29	4
DFS	106	33	0	53	94	149	144	50	39	164	13
GBR	49	4	52	0	22	44	67	34	16	47	9
NOR	4	11	71	23	0	36	56	0	25	49	45
NZL	53	11	144	42	34	0	95	34	12	118	7
USA	130	13	142	67	56	96	0	65	27	99	19
ZAF	71	1	49	32	0	32	60	0	2	36	2
NLD	4	10	38	15	24	12	25	2	0	20	8
AUS	57	28	140	46	40	120	99	36	18	0	10
IRL	2	4	9	9	44	7	19	2	7	9	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	106	49	4	52	128	66	5	58	2
DEU	8	0	44	4	11	12	14	2	10	30	4
DFS	106	35	0	53	94	149	144	50	39	164	13
GBR	50	4	52	0	22	44	67	34	16	47	9
NOR	4	11	71	23	0	36	56	0	27	49	45
NZL	53	12	144	42	34	0	95	34	12	118	7
USA	130	14	143	67	57	96	0	65	30	99	19
ZAF	71	2	49	32	0	32	60	0	2	36	2
NLD	5	10	38	15	26	12	27	2	0	20	8
AUS	57	29	140	46	40	120	99	36	18	0	10
IRL	2	4	9	9	44	7	19	2	7	9	0