Introduction

The latest routine international evaluation for females fertility traits took place as scheduled at the Interbull Centre. Data from twentytwo (22) countries were included in this evaluation.

International genetic evaluations for female fertility traits of bulls from Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Netherlands, New Zealand, Norway, Poland, Spain, Sweden, Switzerland, South Africa, the United Kingdom 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	T2=CR	CF=Interval from Calving to First Service (ICF), days
	T3=C1	NR=Non Return Rate after 56 Days (NRR), %
	T4=C2	NR=Non Return Rate after 56 Days (NRR), %
CHR	T2=CR	CF=Interval from Calving to First Service (ICF), days
	T3=C1	NR=Non Return Rate after 56 Days (NRR), %

	T4=C2	NR=Cows' Non Return Rate after 56 Days (NRR), binary
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	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)
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	CR=Cows' Conception rate (binary trait) for cows
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	T2=CY	CF=Interval calving to first insemination (days)
	T3=C1	NR=Non-return rate 56 days (binary trait)
	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
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:

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

FRA(HOL): First time participatation for "int"

USA: Evaluated daughter pregnancy rate (traits cc2 and int) using a multi-trait fertility model
with a revised DPR trait definition. Revised the formula to estimate calving to first insemination (trait crc) from traits int and cc1.
Changed the base for all fertility traits.

ZAF(JER): Inclusion of more data and change in heritability (cc2,int)

INTERBULL CHANGES COMPARED TO THE PREVIOUS RUN

No changes made.

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 in the 01x-proof file.

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 2014).
Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
ARG						
AUS		112	6823	1398	568	
BEL			966			
CAN	113	35	6894	333	408	
CHE	2457		1144			
CHR			1685			
CZE			3173			
DEA	4860					
DEU			22898		305	
DFS			11712	2174	8051	
ESP			2583			
EST						
FRA	305		14475			
FRM						
FRR			160			
GBR	66	197	5413	452	288	
HUN						
IRL			2136	103	45	
ISR			1149			
ITA	1400		8664			
JPN						
KOR						
LTU						
LVA						
NLD	141		13190	110	51	
NOR					3452	
NZL	39	55	6395	3953	1130	
POL			5130			
PRT						
SVK						
SVN						
URY						
USA	940	698	32348	3651	576	
ZAF		31	1128	613	134	
HRV						
No.Records	10321	1128	148066	12787	15008	
Pub. Proofs	9835	940	127518	10804	13947	0

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

BSW hco

	CAN	DEA	FRA	USA	CHE
CAN	8.41				
DEA	0.83	11.82			
FRA	0.64	0.65	0.93		
USA	0.69	0.78	0.83	2.77	
CHE	0.75	0.91	0.86	0.78	12.87

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	7.00								
CHE	0.87	11.07							
DEA	0.86	0.94	14.67						
NLD	0.87	0.89	0.86	3.21					
NZL	0.56	0.59	0.54	0.56	9.60				
USA	0.85	0.87	0.85	0.86	0.54	3.37			
GBR	0.79	0.82	0.85	0.81	0.61	0.87	4.22		
FRA	0.86	0.96	0.91	0.91	0.58	0.88	0.82	1.69	
ITA	0.86	0.86	0.85	0.87	0.63	0.86	0.84	0.88	14.55

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.36						
CHE	0.73	11.84					
DEA	0.80	0.96	11.55				
NLD	0.68	0.70	0.60	3.85			
USA	0.69	0.61	0.59	0.69	2.96		
GBR	0.61	0.78	0.76	0.69	0.58	0.05	
FRA	0.63	0.61	0.56	0.65	0.91	0.64	0.94

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.63								
CHE	0.65	10.96							
DEA	0.84	0.77	13.54						
NLD	0.84	0.64	0.86	3.52					
NZL	0.49	0.35	0.49	0.49	6.78				
USA	0.77	0.76	0.83	0.83	0.59	2.42			
GBR	0.70	0.46	0.77	0.75	0.65	0.85	4.22		
FRA	0.74	0.74	0.82	0.72	0.39	0.76	0.68	0.94	
ITA	0.73	0.46	0.82	0.77	0.60	0.88	0.86	0.61	16.40

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.52						
DEA	0.86	11.44					
NLD	0.86	0.86	3.45				
NZL	0.63	0.61	0.61	6.78			
USA	0.89	0.85	0.87	0.60	2.42		
GBR	0.86	0.87	0.89	0.64	0.85	4.22	
ITA	0.86	0.92	0.88	0.63	0.88	0.88	15.64

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	6.66				
GBR	0.74	4.69			
NZL	0.57	0.62	11.32		
USA	0.85	0.86	0.54	3.31	
AUS	0.71	0.86	0.69	0.71	6.99

GUE cc1

	CAN	GBR	USA
CAN	6.74		
GBR	0.65	0.03	
USA	0.77	0.70	3.45

GUE cc2

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.83					
GBR	0.71	4.69				
NZL	0.41	0.65	7.58			
USA	0.81	0.85	0.60	2.69		
ZAF	0.76	0.87	0.65	0.89	13.78	
AUS	0.71	0.85	0.72	0.86	0.86	6.82

GUE int

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.63					
GBR	0.85	4.69				
NZL	0.60	0.64	7.58			
USA	0.89	0.85	0.60	2.69		
ZAF	0.86	0.87	0.65	0.91	13.78	
AUS	0.86	0.86	0.71	0.86	0.88	6.82

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	FRR
CAN	7.37							
CZE	0.75	17.59						
DEU	0.87	0.80	4.59					
DFS	0.89	0.83	0.93	17.86				
FRA	0.74	0.83	0.81	0.82	0.85			
USA	0.78	0.90	0.85	0.83	0.92	2.42		
POL	0.69	0.57	0.75	0.69	0.54	0.52	18.25	
FRR	0.72	0.70	0.54	0.65	0.74	0.73	0.57	0.80

HOL crc

	BEL	CAN	CHE	CHR	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	FRR	AUS
BEL	4.66																
CAN	0.73	6.60															
CHE	0.79	0.89	13.01														
CHR	0.79	0.85	0.97	14.75													
DEU	0.74	0.86	0.91	0.89	5.78												
DFS	0.81	0.88	0.94	0.91	0.91	12.51											
ESP	0.87	0.75	0.78	0.76	0.78	0.77	11.32										
GBR	0.87	0.74	0.76	0.75	0.74	0.80	0.92	4.75									
IRL	0.85	0.70	0.70	0.70	0.70	0.70	0.85	0.85	3.70								
ITA	0.80	0.86	0.91	0.87	0.90	0.91	0.87	0.83	0.70	8.18							
NLD	0.82	0.86	0.93	0.91	0.92	0.94	0.77	0.80	0.70	0.88	4.18						
NZL	0.64	0.56	0.63	0.58	0.55	0.58	0.64	0.63	0.60	0.68	0.56	8.33					
USA	0.81	0.85	0.85	0.85	0.85	0.85	0.89	0.87	0.77	0.85	0.86	0.53	3.29				
POL	0.73	0.88	0.90	0.89	0.86	0.88	0.74	0.71	0.70	0.88	0.85	0.58	0.85	13.70			
FRA	0.76	0.87	0.95	0.92	0.93	0.92	0.80	0.80	0.70	0.92	0.95	0.59	0.85	0.87	1.17		
FRR	0.77	0.87	0.88	0.87	0.93	0.88	0.75	0.76	0.73	0.86	0.93	0.60	0.83	0.85	0.89	1.47	
AUS	0.85	0.70	0.70	0.70	0.70	0.70	0.85	0.85	0.88	0.70	0.70	0.60	0.70	0.69	0.70	0.73	4.93

HOL cc1

	CAN	CHE	CHR	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	FRR
CAN	6.54													
CHE	0.89	13.34												
CHR	0.86	0.96	13.32											
CZE	0.77	0.73	0.74	18.07										
DEU	0.79	0.94	0.96	0.73	5.86									
DFS	0.73	0.84	0.84	0.56	0.88	12.32								
FRA	0.71	0.72	0.68	0.87	0.66	0.54	1.00							
GBR	0.64	0.71	0.73	0.65	0.74	0.71	0.67	0.03						
ISR	0.65	0.68	0.67	0.81	0.64	0.62	0.81	0.69	3.11					
ITA	0.75	0.90	0.89	0.68	0.93	0.84	0.60	0.72	0.69	0.05				
NLD	0.72	0.81	0.80	0.71	0.77	0.75	0.69	0.72	0.73	0.73	3.88			
USA	0.76	0.70	0.69	0.96	0.65	0.53	0.88	0.60	0.88	0.68	0.70	2.82		
POL	0.69	0.80	0.76	0.51	0.80	0.77	0.51	0.58	0.58	0.80	0.64	0.51	17.65	
FRR	0.73	0.67	0.64	0.68	0.54	0.63	0.70	0.66	0.76	0.64	0.69	0.75	0.58	1.09

HOL cc2

	BEL	CAN	CHE	CHR	CZE	DEU	DFS	ESP	FRA	GBR	IRL
ISR	ITA	NLD	NZL	USA	POL	ZAF	FRR	AUS			
BEL	4.66										
CAN	0.70	6.12									
CHE	0.26	0.69	13.34								
CHR	0.25	0.61	0.94	13.32							
CZE	0.60	0.80	0.70	0.67	18.07						
DEU	0.78	0.87	0.64	0.61	0.88	5.38					
DFS	0.80	0.85	0.58	0.58	0.78	0.91	13.57				
ESP	0.88	0.69	0.26	0.24	0.64	0.77	0.79	11.32			
FRA	0.62	0.83	0.75	0.65	0.85	0.84	0.73	0.60	1.00		
GBR	0.89	0.70	0.25	0.25	0.60	0.74	0.81	0.92	0.59	4.75	
IRL	0.85	0.71	0.35	0.26	0.64	0.75	0.74	0.85	0.70	0.85	3.70
ISR	0.43	0.65	0.58	0.48	0.80	0.70	0.59	0.50	0.70	0.47	0.58
3.10											
ITA	0.86	0.73	0.32	0.27	0.73	0.82	0.85	0.95	0.63	0.89	0.85
0.59	18.11										
NLD	0.75	0.85	0.60	0.59	0.81	0.90	0.89	0.76	0.79	0.76	0.78
0.67	0.81	4.26									
NZL	0.70	0.40	0.24	0.24	0.47	0.46	0.45	0.68	0.39	0.66	0.71
0.32	0.64	0.47	5.64								
USA	0.84	0.82	0.41	0.34	0.85	0.86	0.87	0.86	0.74	0.85	0.85
0.71	0.93	0.86	0.60	2.32							
POL	0.82	0.69	0.23	0.21	0.58	0.70	0.74	0.85	0.48	0.84	0.80
0.50	0.87	0.70	0.62	0.82	12.86						
ZAF	0.85	0.76	0.40	0.32	0.75	0.85	0.83	0.92	0.72	0.86	0.89
0.65	0.95	0.83	0.65	0.92	0.82	18.47					
FRR	0.59	0.60	0.50	0.53	0.57	0.80	0.61	0.46	0.57	0.49	0.51
0.52	0.49	0.69	0.31	0.49	0.52	0.55	1.09				
AUS	0.84	0.70	0.37	0.26	0.66	0.70	0.70	0.84	0.72	0.85	0.87
0.56	0.85	0.71	0.70	0.85	0.82	0.88	0.45	4.97			

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA
POL	ZAF	AUS	FRA								
BEL	4.66										
CAN	0.85	6.07									
DEU	0.85	0.85	8.19								
DFS	0.88	0.85	0.93	12.76							
ESP	0.87	0.85	0.89	0.86	11.31						
GBR	0.87	0.85	0.86	0.89	0.92	4.75					
IRL	0.85	0.85	0.85	0.85	0.85	0.85	3.70				
ITA	0.85	0.85	0.91	0.89	0.95	0.88	0.85	18.11			
NLD	0.90	0.86	0.93	0.93	0.88	0.89	0.85	0.90	4.51		
NZL	0.66	0.60	0.60	0.60	0.65	0.63	0.67	0.63	0.60	5.64	
USA	0.85	0.90	0.88	0.87	0.86	0.85	0.85	0.92	0.87	0.60	2.32
POL	0.86	0.85	0.85	0.86	0.86	0.85	0.86	0.88	0.85	0.64	0.85
12.86											
ZAF	0.85	0.85	0.86	0.85	0.93	0.85	0.87	0.95	0.86	0.64	0.92
0.88	18.48										
AUS	0.85	0.85	0.85	0.85	0.85	0.85	0.87	0.85	0.85	0.67	0.85
0.86	0.88	4.97									
FRA	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.60	0.85
0.85	0.85	0.85	0.97								

JER hco

	CAN	DFS	USA
CAN	7.57		
DFS	0.87	17.13	
USA	0.80	0.75	2.58

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.33							
DFS	0.87	13.38						
GBR	0.72	0.84	4.11					
NLD	0.87	0.90	0.76	3.37				
NZL	0.52	0.60	0.64	0.55	6.61			
USA	0.85	0.86	0.82	0.86	0.63	3.74		
AUS	0.71	0.71	0.85	0.71	0.60	0.70	3.67	
IRL	0.72	0.71	0.85	0.71	0.60	0.75	0.87	2.05

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.55				
DFS	0.68	14.01			
GBR	0.65	0.59	0.03		
NLD	0.69	0.70	0.65	3.13	
USA	0.68	0.64	0.67	0.63	2.86

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.53								
DFS	0.86	17.35							
GBR	0.71	0.75	4.10						
NLD	0.85	0.88	0.75	3.45					
NZL	0.51	0.50	0.69	0.51	4.42				
USA	0.76	0.81	0.85	0.82	0.67	2.57			
ZAF	0.72	0.76	0.86	0.77	0.71	0.88	12.76		
AUS	0.71	0.71	0.85	0.71	0.66	0.85	0.86	3.64	
IRL	0.72	0.73	0.85	0.76	0.64	0.86	0.88	0.87	2.05

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.28								
DFS	0.86	15.12							
GBR	0.85	0.87	4.10						
NLD	0.86	0.90	0.88	3.60					
NZL	0.60	0.63	0.65	0.61	4.42				
USA	0.87	0.86	0.85	0.87	0.66	2.57			
ZAF	0.86	0.86	0.85	0.84	0.75	0.89	12.76		
AUS	0.85	0.86	0.85	0.86	0.67	0.85	0.86	3.64	
IRL	0.86	0.86	0.86	0.86	0.63	0.86	0.87	0.87	2.05

RDC hco

	CAN	DEU	DFS	NOR	USA
CAN	7.08				
DEU	0.85	4.31			
DFS	0.86	0.83	15.03		
NOR	0.83	0.71	0.77	13.03	
USA	0.83	0.82	0.89	0.82	2.79

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	6.31									
DEU	0.87	5.01								
DFS	0.87	0.91	12.91							
GBR	0.73	0.75	0.76	4.22						
NOR	0.90	0.88	0.88	0.75	12.64					
NZL	0.55	0.56	0.52	0.62	0.54	9.98				
USA	0.85	0.85	0.85	0.82	0.87	0.64	3.43			
NLD	0.86	0.92	0.92	0.79	0.87	0.57	0.86	2.60		
AUS	0.71	0.71	0.71	0.85	0.73	0.61	0.71	0.71	4.70	
IRL	0.71	0.70	0.71	0.85	0.72	0.61	0.77	0.71	0.88	2.70

RDC cc1

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	6.59						
DEU	0.79	5.25					
DFS	0.81	0.86	15.43				
GBR	0.62	0.74	0.76	0.03			
NOR	0.79	0.65	0.70	0.68	12.19		
NLD	0.72	0.77	0.70	0.71	0.61	3.31	
USA	0.80	0.65	0.66	0.60	0.60	0.68	2.79

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.22										
DEU	0.87	4.43									
DFS	0.85	0.91	13.64								
GBR	0.71	0.75	0.78	4.22							
NOR	0.76	0.75	0.71	0.88	13.54						
NZL	0.50	0.48	0.48	0.64	0.61	6.84					
USA	0.83	0.86	0.85	0.85	0.86	0.63	2.38				
ZAF	0.73	0.85	0.84	0.86	0.88	0.66	0.89	19.94			
NLD	0.84	0.89	0.86	0.77	0.87	0.49	0.86	0.83	3.68		
AUS	0.71	0.71	0.70	0.85	0.87	0.65	0.85	0.86	0.74	4.64	
IRL	0.71	0.75	0.74	0.85	0.86	0.70	0.85	0.89	0.79	0.87	2.70

RDC int

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.12										
DEU	0.86	7.17									
DFS	0.86	0.92	12.90								
GBR	0.86	0.87	0.88	4.22							
NOR	0.90	0.89	0.86	0.88	13.54						
NZL	0.62	0.61	0.60	0.62	0.61	6.84					
USA	0.88	0.88	0.86	0.86	0.87	0.64	2.38				
ZAF	0.86	0.87	0.87	0.86	0.91	0.68	0.89	19.94			
NLD	0.86	0.93	0.92	0.89	0.87	0.61	0.87	0.87	3.35		
AUS	0.86	0.86	0.85	0.86	0.87	0.63	0.85	0.87	0.86	4.64	
IRL	0.86	0.85	0.86	0.85	0.86	0.63	0.86	0.88	0.86	0.88	2.70

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^LAPPENDIX II. Number of common bulls

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

	CAN	DEA	FRA	USA	CHE
CAN	0	55	36	60	62
DEA	45	0	156	134	474
FRA	32	114	0	62	128
USA	53	94	45	0	157
CHE	50	376	92	129	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	14	87	38	51	67
CHE	64	0	477	68	15	218	46	122	310
DEA	63	378	0	110	22	181	44	151	402
NLD	25	63	101	0	15	40	27	59	84
NZL	13	13	17	9	0	13	11	14	16
USA	83	187	138	37	11	0	46	77	125
GBR	36	36	33	23	8	46	0	34	44
FRA	43	86	110	45	10	49	28	0	126
ITA	56	253	263	65	12	83	33	91	0

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

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	81	75	29	88	38	59
CHE	64	0	475	65	219	47	134
DEA	63	376	0	106	182	46	168
NLD	24	60	99	0	38	25	65
USA	83	187	138	36	0	47	85
GBR	36	36	33	21	46	0	37
FRA	51	98	128	53	59	32	0

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

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	74	69	28	13	91	38	55	63
CHE	58	0	467	68	15	279	46	134	310
DEA	57	372	0	109	22	277	43	167	395
NLD	23	63	101	0	15	62	27	68	84
NZL	12	13	17	9	0	21	11	15	16
USA	81	259	247	52	19	0	56	106	171
GBR	34	36	33	23	8	56	0	37	44
FRA	46	98	128	55	11	73	32	0	139
ITA	51	253	261	65	12	114	33	104	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	69	29	13	91	38	62
DEA	57	0	110	22	277	43	430
NLD	24	103	0	15	62	27	85
NZL	12	17	9	0	21	11	16
USA	81	247	55	19	0	56	178
GBR	34	33	23	8	56	0	44
ITA	51	277	66	12	118	33	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	13	1	29	17
GBR	10	0	13	35	28
NZL	0	11	0	8	23
USA	28	32	6	0	18
AUS	12	22	22	15	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	USA
CAN	0	13	30
GBR	10	0	37
USA	29	35	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	9	0	26	1	15
GBR	6	0	13	66	5	28
NZL	0	11	0	27	3	23
USA	24	67	29	0	10	49
ZAF	1	4	1	6	0	5
AUS	11	22	22	46	4	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	9	0	26	1	15
GBR	6	0	13	66	5	28
NZL	0	11	0	27	3	23
USA	24	67	29	0	10	49
ZAF	1	4	1	6	0	5
AUS	11	22	22	46	4	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	FRR
CAN	0	728	1502	767	842	1603	587	0
CZE	468	0	1380	813	887	957	621	9
DEU	882	920	0	2002	1860	1861	1022	66
DFS	586	421	989	0	1218	977	618	12
FRA	540	461	854	530	0	1163	721	2
USA	1545	650	1047	665	543	0	829	3
POL	394	383	615	367	293	646	0	39
FRR	0	3	44	2	0	0	35	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	CHE	CHR	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	FRR	AUS
BEL	0	354	221	180	616	422	335	448	289	433	657	280	373	172	490	11	390
CAN	301	0	375	251	1592	831	821	1034	364	1192	899	483	1795	495	882	2	761
CHE	198	261	0	270	489	321	288	355	219	333	362	215	365	103	314	3	279
CHR	164	211	284	0	446	191	166	209	128	230	350	129	274	81	182	12	181
DEU	511	910	370	360	0	2149	1098	1629	695	2146	2591	762	2110	891	1964	76	1209
DFS	316	605	249	153	1011	0	706	1126	574	1247	1449	623	1108	545	1253	13	883
ESP	298	475	231	125	651	458	0	783	374	896	766	396	895	374	778	2	588
GBR	376	990	308	178	1023	692	595	0	721	1230	1310	709	1258	465	1203	4	980
IRL	254	344	213	114	572	415	347	710	0	527	685	541	435	169	580	1	538
ITA	317	778	253	186	1123	699	613	780	415	0	1396	619	1655	605	1515	1	896
NLD	667	764	325	315	2018	974	636	1013	607	935	0	807	1331	639	1492	40	1049
NZL	200	444	180	103	539	383	285	585	440	420	707	0	563	207	630	0	932
USA	295	1754	272	245	1149	701	507	1021	394	902	975	474	0	729	1313	3	868
POL	103	328	49	58	485	293	170	233	96	324	398	128	513	0	633	37	324
FRA	422	549	271	163	824	489	518	642	423	640	743	332	582	239	0	3	921
FRR	7	1	2	4	50	3	0	1	1	1	10	0	0	35	0	0	4
AUS	289	624	225	149	715	468	391	747	428	517	802	888	696	149	522	1	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	CHR	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	FRR
CAN	0	376	251	751	1590	832	882	1069	67	1196	892	1818	520	2
CHE	262	0	270	213	490	321	316	358	24	333	362	366	113	3
CHR	211	284	0	148	441	191	186	211	10	230	349	274	92	12
CZE	490	123	103	0	1367	816	861	728	70	915	1018	1031	580	10
DEU	903	371	356	923	0	2132	1962	1674	105	2134	2539	2091	963	74
DFS	605	249	153	414	995	0	1257	1148	90	1242	1440	1107	577	13
FRA	568	275	165	442	843	508	0	1226	88	1511	1494	1310	659	2
GBR	1023	307	175	396	1042	701	661	0	90	1266	1339	1301	496	4
ISR	48	16	6	53	85	67	48	63	0	95	102	86	47	0
ITA	780	253	186	523	1117	697	657	794	68	0	1383	1652	640	1
NLD	747	325	314	782	1955	966	761	1031	83	923	0	1318	693	39
USA	1775	273	245	694	1126	699	598	1058	71	902	955	0	765	3
POL	352	54	67	369	568	332	262	255	29	360	461	549	0	37
FRR	1	2	4	3	50	3	0	1	0	1	10	0	35	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	CHE	CHR	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	FRR	AUS
BEL	0	348	222	180	287	605	422	335	495	448	290	40	432	657	280	483	169	206	11	404
CAN	295	0	372	244	721	1500	806	818	849	1010	355	63	1133	858	468	1942	474	357	2	795
CHE	199	259	0	270	214	484	322	288	316	355	219	24	332	362	215	425	100	175	3	296
CHR	164	204	284	0	149	433	191	166	186	209	128	10	229	351	129	350	79	102	12	191
CZE	181	467	123	103	0	1348	819	541	864	713	323	70	906	1024	407	1176	536	261	10	575
DEU	493	787	368	347	893	0	2107	1096	1939	1607	689	105	2064	2484	759	2775	866	487	74	1256
DFS	316	581	250	153	415	961	0	709	1263	1126	574	92	1237	1450	624	1501	535	419	13	925
ESP	298	469	231	125	323	639	458	0	789	786	374	70	897	770	397	1098	372	358	2	611
FRA	431	551	275	165	442	821	509	535	0	1210	585	90	1501	1499	637	2026	627	400	2	970
GBR	376	962	308	178	395	984	692	595	661	0	721	90	1225	1312	709	1641	458	420	4	1025
IRL	254	333	213	114	207	559	415	347	433	710	0	65	526	686	541	604	165	273	1	549
ISR	22	47	16	6	53	83	67	45	48	62	53	0	92	104	73	109	44	47	0	71
ITA	316	729	253	184	512	1051	686	613	651	770	414	65	0	1376	617	2130	592	431	1	935
NLD	667	717	325	315	790	1828	976	637	764	1014	607	83	911	0	810	1899	623	420	39	1096
NZL	200	424	180	103	250	524	384	285	339	585	440	63	414	709	0	857	203	303	0	955
USA	348	1808	312	315	762	1392	814	645	910	1267	497	88	1045	1389	774	0	750	540	7	1374
POL	98	307	49	56	323	455	284	167	233	226	92	26	311	380	126	495	0	139	37	341
ZAF	159	327	146	82	162	351	291	310	264	358	235	33	309	343	240	499	79	0	2	395
FRR	7	1	2	4	3	50	3	0	0	1	1	0	1	10	0	1	35	1	0	4
AUS	298	667	237	155	303	745	516	407	575	797	445	49	551	853	925	1173	171	329	1	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
BEL	0	348	605	422	335	448	290	432	657	280	483	169	206	404	488
CAN	295	0	1498	807	817	1010	355	1133	860	468	1942	474	356	795	832
DEU	493	787	0	2113	1094	1607	690	2065	2498	759	2778	864	486	1257	1914
DFS	316	582	966	0	708	1128	574	1238	1456	624	1504	536	418	926	1248
ESP	298	469	639	458	0	785	374	896	770	396	1096	371	357	609	774
GBR	376	962	985	693	595	0	721	1225	1314	709	1641	458	419	1025	1195
IRL	254	333	560	415	347	710	0	526	688	541	604	165	273	549	581
ITA	316	729	1053	687	613	770	414	0	1378	617	2130	592	431	935	1480
NLD	670	723	1848	985	642	1018	610	916	0	810	1903	622	419	1098	1481
NZL	200	424	524	384	285	585	440	414	710	0	857	203	302	955	631
USA	348	1808	1396	817	645	1267	497	1045	1395	774	0	749	539	1374	2003
POL	98	307	456	284	167	226	92	311	380	126	495	0	139	341	617
ZAF	159	327	351	291	310	358	235	309	344	240	499	79	0	394	395
AUS	298	667	746	517	407	797	445	551	859	925	1173	171	329	0	954
FRA	416	503	772	476	510	622	417	608	724	324	850	217	256	549	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA
CAN	0	46	171
DFS	35	0	79
USA	158	58	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	0	49	92	21	105	200	118	5
DFS	35	0	109	61	110	93	94	23
GBR	94	98	0	53	151	133	142	35
NLD	16	53	49	0	55	49	47	15
NZL	111	76	153	47	0	183	325	65
USA	196	68	145	51	207	0	228	21
AUS	115	54	146	42	351	233	0	33
IRL	4	18	35	15	71	23	30	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	50	95	21	201
DFS	36	0	112	61	93
GBR	95	100	0	54	138
NLD	16	53	50	0	49
USA	197	69	150	51	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	46	91	21	97	201	85	129	5
DFS	33	0	109	61	110	144	104	99	23
GBR	92	98	0	53	152	164	126	153	35
NLD	16	53	49	0	56	62	54	51	15
NZL	103	76	153	48	0	290	164	343	65
USA	199	108	182	66	362	0	230	374	30
ZAF	83	76	127	50	170	242	0	182	26
AUS	124	59	157	45	372	403	171	0	34
IRL	4	18	35	15	71	32	27	31	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	46	91	22	97	201	85	129	5
DFS	33	0	109	63	110	144	104	99	23
GBR	92	98	0	57	152	164	126	153	35
NLD	18	56	53	0	58	66	56	53	16
NZL	103	76	153	51	0	290	164	343	65
USA	199	109	182	71	362	0	230	374	30
ZAF	83	76	127	53	170	242	0	182	26
AUS	124	59	157	47	372	403	171	0	34
IRL	4	18	35	15	71	32	27	31	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA
CAN	0	8	95	4	63
DEU	7	0	41	12	9
DFS	91	32	0	100	90
NOR	4	11	76	0	32
USA	57	9	84	32	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	86	47	4	48	92	3	54	2
DEU	9	0	46	4	12	12	10	11	21	3
DFS	81	37	0	41	89	136	97	32	139	11
GBR	48	4	40	0	11	39	44	10	36	5
NOR	4	11	69	12	0	31	36	22	34	40
NZL	48	12	131	38	30	0	51	7	104	6
USA	89	10	93	42	35	52	0	21	49	9
NLD	3	10	32	10	21	7	19	0	12	6
AUS	53	20	118	35	29	105	47	10	0	7
IRL	2	3	8	5	39	6	9	5	6	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	0	9	88	48	4	3	92
DEU	8	0	44	4	12	10	8
DFS	82	35	0	41	91	31	97
GBR	49	4	40	0	11	10	44
NOR	4	11	70	12	0	22	36
NLD	3	9	31	10	21	0	21
USA	89	8	93	42	35	19	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	84	44	4	46	111	63	3	52	2
DEU	7	0	41	4	8	10	9	1	10	23	3
DFS	78	33	0	44	76	137	116	45	32	149	11
GBR	45	4	42	0	11	40	58	33	10	40	5
NOR	4	8	58	12	0	30	37	0	20	38	40
NZL	45	10	131	39	29	0	75	32	7	110	6
USA	112	9	112	58	37	76	0	61	21	79	12
ZAF	67	1	43	31	0	30	57	0	1	33	1
NLD	3	9	32	10	19	7	19	1	0	14	6
AUS	51	22	125	39	32	111	80	34	12	0	8
IRL	2	3	8	5	39	6	12	1	5	7	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	84	44	4	46	111	63	4	52	2
DEU	8	0	42	4	8	11	10	1	10	23	3
DFS	78	34	0	44	76	137	116	45	32	149	11
GBR	45	4	42	0	11	40	58	33	10	40	5
NOR	4	8	58	12	0	30	37	0	21	38	40
NZL	45	11	131	39	29	0	75	32	7	110	6
USA	112	10	112	58	37	76	0	61	23	79	12
ZAF	67	1	43	31	0	30	57	0	1	33	1
NLD	4	9	32	10	20	7	20	1	0	14	6
AUS	51	22	125	39	32	111	80	34	12	0	8
IRL	2	3	8	5	39	6	12	1	5	7	0