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 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 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	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	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:

DEA BSW Base group is shifted by 4 months
Minor loss of data for few bulls related to some corrections/updates in the data base

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

DEU HOL/RDC Herd-years with uninformative NonReturn56 have been excluded. Some traits are verified with the subsequent calving, e.g. interval first to last insemination, insemination dates must match with calving dates and result in reasonable gestation length.
Some changes from official to unofficial: bulls belonging to a foreign AI station must have accuracy > 49 %, therefore in each trait quite a number of bulls are not published any more

ZAF RDC Data since Dec 2011 is now included for herds participating in Milk Recording at the ARC

AUS HOL/GUE Changes in number of daughters/herds due to the fact that now only daughters with records are included
JER/RDC

POL HOL Small decrease in number of herds and daughters due to data edits caused decrease of EDC

NZL HOL/JER Base change
RDC/BSW Some decrease in information due to parentage testing
GUE

CHE HOL/BSW Some decrease in information due to continuous work on the raw data by herd-book organizations
SIM

INTERBULL CHANGES COMPARED TO THE APRIL ROUTINE RUN

None

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 (August 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	7309	1489	620	
BEL			1072			
CAN	125	36	7541	394	454	
CHE	2525		2885			
CZE			3348			
DEA	5123					
DEU			23740		319	
DFS			14820	2107	9164	
ESP			2912			
EST						
FRA	336		14996			
FRM						
FRR			169			
GBR	76	209	5847	489	319	
HUN						
IRL			2416	137	52	
ISR			1229			
ITA	1616		8763			
JPN						
KOR						
LTU						
LVA						
NLD	155		13964	118	60	
NOR					3679	
NZL	44	57	6740	4162	1206	
POL			5944			
PRT						
SVK						
SVN						
URY			1245			
USA	994	723	34387	3959	629	
ZAF		30	1168	639	141	
HRV						
No.Records	10994	1173	160495	13494	16643	
Pub. Proofs	10195	975	137252	11524	15630	0

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

BSW hco

	CAN	DEA	FRA	USA	CHE	NLD
CAN	8.00					
DEA	0.80	9.75				
FRA	0.69	0.81	0.92			
USA	0.75	0.86	0.90	2.68		
CHE	0.81	0.94	0.88	0.88	12.95	
NLD	0.76	0.72	0.83	0.88	0.88	3.67

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.76								
CHE	0.85	11.13							
DEA	0.85	0.94	14.21						
NLD	0.86	0.88	0.85	3.38					
NZL	0.60	0.65	0.68	0.60	10.36				
USA	0.85	0.86	0.85	0.85	0.62	3.33			
GBR	0.76	0.76	0.75	0.81	0.64	0.83	3.95		
FRA	0.86	0.96	0.93	0.91	0.61	0.87	0.80	1.75	
ITA	0.85	0.85	0.85	0.86	0.69	0.85	0.80	0.87	19.85

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.49						
CHE	0.76	11.87					
DEA	0.73	0.97	10.93				
NLD	0.69	0.69	0.67	3.75			
USA	0.74	0.68	0.67	0.90	2.86		
GBR	0.66	0.82	0.78	0.67	0.67	0.04	
FRA	0.66	0.69	0.67	0.81	0.91	0.65	0.94

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.64								
CHE	0.69	11.07							
DEA	0.81	0.93	11.67						
NLD	0.85	0.83	0.85	3.47					
NZL	0.58	0.55	0.62	0.58	7.07				
USA	0.85	0.82	0.85	0.89	0.64	2.39			
GBR	0.76	0.77	0.85	0.79	0.68	0.84	3.95		
FRA	0.78	0.87	0.85	0.77	0.54	0.85	0.77	0.94	
ITA	0.85	0.73	0.85	0.84	0.66	0.88	0.86	0.85	24.54

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.35						
DEA	0.88	13.54					
NLD	0.87	0.87	3.20				
NZL	0.59	0.60	0.62	7.07			
USA	0.89	0.87	0.87	0.58	2.39		
GBR	0.86	0.88	0.89	0.64	0.87	3.95	
ITA	0.87	0.93	0.88	0.65	0.89	0.88	18.11

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	6.74				
GBR	0.74	4.57			
NZL	0.59	0.64	11.54		
USA	0.84	0.86	0.62	3.38	
AUS	0.72	0.86	0.69	0.74	7.02

GUE cc1

	CAN	GBR	USA
CAN	6.83		
GBR	0.69	0.03	
USA	0.80	0.74	3.45

GUE cc2

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.82					
GBR	0.77	4.57				
NZL	0.55	0.68	7.73			
USA	0.85	0.85	0.65	2.73		
ZAF	0.74	0.83	0.69	0.84	13.78	
AUS	0.70	0.79	0.75	0.80	0.85	7.16

GUE int

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.26					
GBR	0.86	4.57				
NZL	0.57	0.64	7.73			
USA	0.89	0.87	0.60	2.73		
ZAF	0.86	0.87	0.65	0.87	13.78	
AUS	0.86	0.86	0.73	0.87	0.88	7.16

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	FRR	CHE	NLD
CAN	7.37									
CZE	0.74	17.90								
DEU	0.88	0.80	14.57							
DFS	0.89	0.86	0.93	16.12						
FRA	0.75	0.85	0.81	0.83	0.85					
USA	0.77	0.89	0.87	0.86	0.91	2.42				
POL	0.73	0.61	0.77	0.72	0.60	0.68	18.37			
FRR	0.71	0.74	0.61	0.65	0.76	0.78	0.62	0.78		
CHE	0.94	0.83	0.93	0.93	0.85	0.88	0.71	0.72	13.70	
NLD	0.78	0.82	0.79	0.77	0.85	0.88	0.67	0.77	0.82	4.14

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	FRR	AUS
BEL	4.62															
CAN	0.73	6.68														
CHE	0.79	0.85	12.29													
DEU	0.71	0.86	0.89	10.87												
DFS	0.81	0.88	0.94	0.91	12.05											
ESP	0.86	0.73	0.76	0.75	0.76	11.26										
GBR	0.88	0.73	0.76	0.74	0.81	0.91	4.72									
IRL	0.86	0.71	0.71	0.71	0.71	0.86	0.86	3.46								
ITA	0.78	0.85	0.89	0.90	0.92	0.86	0.83	0.71	8.03							
NLD	0.82	0.86	0.92	0.92	0.96	0.76	0.80	0.71	0.88	4.62						
NZL	0.65	0.59	0.62	0.59	0.61	0.63	0.63	0.61	0.69	0.59	8.78					
USA	0.83	0.84	0.84	0.84	0.84	0.88	0.87	0.77	0.84	0.84	0.60	3.27				
POL	0.74	0.88	0.90	0.87	0.89	0.76	0.71	0.70	0.90	0.86	0.60	0.84	13.92			
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	0.87	1.19		
FRR	0.72	0.79	0.77	0.90	0.80	0.69	0.68	0.68	0.79	0.88	0.58	0.75	0.83	0.82	1.54	
AUS	0.85	0.71	0.71	0.71	0.71	0.85	0.86	0.88	0.71	0.71	0.61	0.73	0.70	0.71	0.69	4.94

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	FRR
CAN	6.60												
CHE	0.87	10.96											
CZE	0.79	0.75	18.06										
DEU	0.82	0.93	0.72	13.64									
DFS	0.80	0.90	0.68	0.90	13.49								
FRA	0.71	0.75	0.87	0.66	0.64	1.01							
GBR	0.67	0.76	0.66	0.76	0.75	0.67	0.03						
ISR	0.69	0.65	0.83	0.67	0.70	0.81	0.71	3.09					
ITA	0.77	0.88	0.70	0.93	0.87	0.63	0.74	0.70	0.05				
NLD	0.71	0.71	0.83	0.68	0.68	0.86	0.67	0.82	0.66	4.57			
USA	0.78	0.71	0.95	0.68	0.68	0.89	0.66	0.87	0.70	0.91	2.82		
POL	0.70	0.76	0.58	0.83	0.76	0.57	0.64	0.58	0.84	0.61	0.65	17.44	
FRR	0.53	0.53	0.60	0.57	0.49	0.58	0.50	0.61	0.50	0.75	0.67	0.58	1.10

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD
NZL	USA	POL	ZAF	FRR	AUS	URY							
BEL	4.62												
CAN	0.75	6.13											
CHE	0.78	0.85	11.15										
CZE	0.64	0.80	0.85	18.07									
DEU	0.80	0.88	0.89	0.88	12.07								
DFS	0.82	0.84	0.86	0.79	0.92	13.00							
ESP	0.86	0.76	0.73	0.65	0.80	0.80	11.25						
FRA	0.80	0.83	0.91	0.77	0.86	0.82	0.74	0.98					
GBR	0.89	0.76	0.71	0.61	0.79	0.82	0.92	0.75	4.71				
IRL	0.84	0.77	0.79	0.65	0.79	0.79	0.85	0.80	0.85	3.46			
ISR	0.45	0.58	0.58	0.75	0.67	0.58	0.48	0.61	0.49	0.56	3.09		
ITA	0.84	0.78	0.77	0.74	0.83	0.84	0.94	0.76	0.87	0.84	0.56	17.94	
NLD	0.79	0.85	0.87	0.82	0.91	0.90	0.79	0.82	0.79	0.81	0.64	0.82	4.59
NZL	0.73	0.55	0.53	0.47	0.58	0.57	0.70	0.57	0.69	0.72	0.40	0.66	0.58
5.64													
USA	0.84	0.85	0.84	0.86	0.89	0.89	0.87	0.85	0.84	0.84	0.67	0.94	0.89
0.65	2.33												
POL	0.82	0.73	0.65	0.59	0.75	0.75	0.85	0.68	0.83	0.79	0.42	0.86	0.75
0.60	0.83	12.92											
ZAF	0.74	0.72	0.79	0.71	0.82	0.79	0.87	0.80	0.79	0.85	0.59	0.90	0.80
0.70	0.87	0.74	15.81										
FRR	0.44	0.39	0.39	0.39	0.62	0.45	0.36	0.37	0.35	0.36	0.31	0.35	0.55
0.27	0.38	0.55	0.37	1.10									
AUS	0.80	0.69	0.78	0.66	0.71	0.69	0.80	0.78	0.79	0.87	0.53	0.81	0.71
0.71	0.79	0.71	0.83	0.23	5.03								
URY	0.83	0.81	0.69	0.58	0.79	0.82	0.84	0.80	0.85	0.84	0.46	0.82	0.81
0.77	0.83	0.86	0.78	0.45	0.73	1.44							

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF
AUS	FRA	URY											
BEL	4.62												
CAN	0.86	6.06											
DEU	0.86	0.86	10.34										
DFS	0.90	0.87	0.93	12.94									
ESP	0.86	0.86	0.88	0.86	11.25								
GBR	0.88	0.86	0.86	0.90	0.91	4.71							
IRL	0.86	0.86	0.86	0.86	0.86	0.86	3.46						
ITA	0.86	0.86	0.90	0.90	0.95	0.88	0.86	17.94					
NLD	0.91	0.86	0.91	0.94	0.87	0.90	0.86	0.89	4.47				
NZL	0.68	0.56	0.60	0.59	0.67	0.66	0.67	0.65	0.61	5.64			
USA	0.87	0.89	0.87	0.89	0.87	0.87	0.87	0.92	0.87	0.60	2.33		
POL	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.88	0.86	0.65	0.87	12.93	
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	15.82
AUS	0.86	0.86	0.86	0.86	0.86	0.86	0.88	0.86	0.86	0.68	0.87	0.86	0.87
5.03													
FRA	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.51	0.87	0.86	0.87
0.86	0.97												
URY	0.88	0.86	0.87	0.86	0.87	0.87	0.87	0.87	0.87	0.75	0.87	0.87	0.87
0.87	0.86	1.44											

JER hco

	CAN	DFS	USA	NLD
CAN	7.36			
DFS	0.85	18.78		
USA	0.82	0.86	2.68	
NLD	0.77	0.76	0.88	4.37

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.56							
DFS	0.87	13.82						
GBR	0.73	0.87	4.07					
NLD	0.86	0.91	0.77	3.94				
NZL	0.58	0.66	0.67	0.59	6.95			
USA	0.84	0.85	0.83	0.85	0.65	3.79		
AUS	0.71	0.72	0.86	0.72	0.61	0.73	3.68	
IRL	0.73	0.73	0.86	0.72	0.62	0.76	0.88	1.93

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.55				
DFS	0.73	14.37			
GBR	0.68	0.68	0.03		
NLD	0.70	0.64	0.66	3.62	
USA	0.71	0.73	0.69	0.91	2.89

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.63								
DFS	0.85	16.04							
GBR	0.77	0.79	4.07						
NLD	0.86	0.89	0.79	3.75					
NZL	0.60	0.59	0.70	0.59	4.45				
USA	0.85	0.87	0.85	0.88	0.69	2.62			
ZAF	0.67	0.72	0.76	0.78	0.71	0.86	11.04		
AUS	0.69	0.71	0.77	0.71	0.69	0.71	0.78	3.66	
IRL	0.79	0.80	0.85	0.81	0.66	0.85	0.75	0.82	1.93

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.44								
DFS	0.87	15.73							
GBR	0.86	0.88	4.07						
NLD	0.87	0.90	0.88	3.67					
NZL	0.58	0.64	0.68	0.61	4.45				
USA	0.88	0.88	0.87	0.87	0.67	2.62			
ZAF	0.87	0.87	0.87	0.87	0.70	0.87	11.04		
AUS	0.86	0.86	0.86	0.86	0.66	0.87	0.87	3.66	
IRL	0.86	0.86	0.86	0.86	0.55	0.87	0.86	0.87	1.93

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.01					
DEU	0.86	13.26				
DFS	0.83	0.84	15.70			
NOR	0.87	0.83	0.80	15.18		
USA	0.82	0.85	0.89	0.84	2.69	
NLD	0.78	0.79	0.73	0.72	0.88	4.79

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	6.19									
DEU	0.86	9.46								
DFS	0.86	0.90	12.97							
GBR	0.73	0.74	0.77	4.33						
NOR	0.90	0.87	0.90	0.77	14.58					
NZL	0.59	0.60	0.58	0.63	0.66	10.62				
USA	0.84	0.84	0.84	0.84	0.85	0.70	3.50			
NLD	0.86	0.91	0.93	0.80	0.86	0.60	0.85	2.92		
AUS	0.72	0.72	0.72	0.86	0.75	0.67	0.74	0.72	4.69	
IRL	0.72	0.72	0.72	0.86	0.74	0.62	0.77	0.72	0.88	2.38

RDC cc1

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	6.64						
DEU	0.82	12.06					
DFS	0.81	0.89	14.06				
GBR	0.68	0.76	0.83	0.03			
NOR	0.86	0.75	0.77	0.75	14.47		
NLD	0.72	0.69	0.66	0.68	0.70	4.25	
USA	0.82	0.70	0.69	0.67	0.75	0.92	2.77

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.34										
DEU	0.88	9.91									
DFS	0.85	0.93	13.09								
GBR	0.77	0.79	0.80	4.33							
NOR	0.89	0.87	0.85	0.87	15.87						
NZL	0.59	0.59	0.58	0.67	0.66	6.88					
USA	0.85	0.89	0.87	0.86	0.86	0.68	2.43				
ZAF	0.67	0.82	0.80	0.73	0.70	0.72	0.85	18.25			
NLD	0.86	0.91	0.87	0.80	0.86	0.59	0.89	0.79	3.84		
AUS	0.69	0.71	0.69	0.78	0.66	0.69	0.72	0.77	0.72	4.61	
IRL	0.78	0.80	0.80	0.85	0.86	0.72	0.85	0.83	0.82	0.85	2.38

RDC int

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.30										
DEU	0.86	9.09									
DFS	0.87	0.93	13.36								
GBR	0.86	0.87	0.88	4.33							
NOR	0.90	0.90	0.87	0.89	15.87						
NZL	0.60	0.59	0.58	0.65	0.49	6.88					
USA	0.88	0.87	0.88	0.88	0.88	0.67	2.43				
ZAF	0.88	0.87	0.87	0.88	0.90	0.68	0.89	18.25			
NLD	0.87	0.91	0.92	0.89	0.89	0.61	0.87	0.87	3.12		
AUS	0.86	0.86	0.86	0.86	0.88	0.66	0.87	0.88	0.86	4.61	
IRL	0.86	0.86	0.87	0.86	0.88	0.64	0.87	0.87	0.86	0.88	2.38

^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	66	44	74	73	24
DEA	52	0	170	143	496	110
FRA	38	126	0	66	140	65
USA	65	103	50	0	170	38
CHE	58	401	106	143	0	72
NLD	21	100	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	15	99	40	61	83
CHE	72	0	489	79	19	233	50	141	359
DEA	68	385	0	122	26	186	50	173	484
NLD	27	70	109	0	18	44	32	69	101
NZL	14	14	19	12	0	15	13	16	22
USA	96	202	140	39	13	0	49	85	144
GBR	36	37	34	24	10	46	0	40	54
FRA	53	105	129	55	12	57	31	0	151
ITA	70	303	363	79	16	99	37	114	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	99	41	65
CHE	72	0	486	79	233	52	149
DEA	68	382	0	121	186	53	185
NLD	27	70	109	0	44	32	75
USA	96	202	140	39	0	51	90
GBR	37	39	36	24	48	0	45
FRA	57	112	142	62	63	36	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	84	78	30	14	97	39	60	77
CHE	64	0	479	79	19	290	50	149	359
DEA	63	379	0	120	26	282	49	184	475
NLD	26	70	108	0	18	67	32	75	101
NZL	13	14	19	12	0	24	13	17	22
USA	88	272	250	55	21	0	60	112	194
GBR	34	37	34	24	10	56	0	43	54
FRA	52	112	142	62	13	78	34	0	162
ITA	63	303	359	79	16	133	37	126	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	78	31	14	97	39	78
DEA	63	0	122	26	282	49	585
NLD	27	110	0	18	68	32	108
NZL	13	19	12	0	24	13	22
USA	88	250	58	21	0	60	211
GBR	34	34	24	10	56	0	55
ITA	65	483	87	16	147	37	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	12	3	30	17
GBR	9	0	13	41	27
NZL	1	11	0	9	26
USA	29	38	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	27	0	15
GBR	6	0	13	71	4	28
NZL	1	11	0	29	3	26
USA	25	72	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	27	0	15
GBR	6	0	13	71	4	28
NZL	1	11	0	29	3	26
USA	25	72	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	FRR	CHE	NLD
CAN	0	819	1593	905	972	1909	734	0	621	911
CZE	547	0	1451	937	977	1072	755	9	391	1111
DEU	882	953	0	2180	1986	1998	1230	67	895	2443
DFS	736	527	1183	0	1349	1136	806	14	553	1615
FRA	668	535	921	658	0	1293	879	2	517	1530
USA	1979	766	1071	859	670	0	1036	3	616	1243
POL	523	488	790	525	429	874	0	49	318	891
FRR	0	3	44	2	0	0	56	0	6	40
CHE	507	252	722	475	467	535	231	3	0	702
NLD	788	904	1737	1201	885	930	636	9	669	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	FRR	AUS
BEL	0	402	361	673	495	385	502	334	474	716	315	417	234	547	11	402
CAN	357	0	641	1710	973	910	1138	425	1299	1005	529	1999	639	1026	2	763
CHE	324	528	0	930	568	441	571	339	584	723	327	669	287	522	12	409
DEU	590	1029	765	0	2267	1202	1746	769	2205	2704	812	2273	1094	2113	76	1198
DFS	400	794	483	1252	0	790	1260	640	1322	1621	685	1270	706	1358	14	894
ESP	338	550	338	702	536	0	855	426	983	842	429	994	469	880	2	597
GBR	431	1122	526	1144	847	653	0	804	1317	1430	775	1390	586	1302	6	989
IRL	300	409	336	645	507	394	818	0	588	774	616	505	249	646	3	563
ITA	369	905	512	1206	844	668	886	490	0	1452	660	1795	756	1578	1	883
NLD	748	900	687	2121	1243	695	1153	706	1023	0	861	1460	796	1621	42	1055
NZL	229	486	272	585	458	313	647	523	464	770	0	618	273	686	0	946
USA	346	2072	591	1305	932	580	1184	477	1047	1136	534	0	919	1466	3	871
POL	154	445	197	677	438	225	330	159	440	542	170	707	0	793	43	350
FRA	494	700	457	950	637	599	760	503	733	906	382	737	347	0	3	937
FRR	7	1	4	50	3	0	1	1	1	10	0	0	49	0	0	4
AUS	302	625	333	706	499	396	751	449	521	808	898	700	161	540	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	642	814	1656	976	1028	1176	70	1305	1010	2031	677	2
CHE	529	0	390	909	569	531	571	42	584	723	669	315	12
CZE	540	251	0	1422	909	966	794	75	982	1106	1107	714	10
DEU	910	724	937	0	2227	2077	1756	108	2151	2612	2183	1152	76
DFS	797	483	514	1177	0	1365	1283	101	1321	1619	1270	763	14
FRA	715	466	516	920	649	0	1332	93	1580	1634	1459	832	3
GBR	1164	526	450	1079	867	779	0	94	1339	1463	1437	629	6
ISR	51	27	54	85	80	50	64	0	99	106	89	57	0
ITA	906	512	574	1132	843	748	900	74	0	1451	1792	797	1
NLD	906	687	878	1930	1243	923	1181	89	1020	0	1461	863	42
USA	2110	591	763	1160	932	743	1233	76	1047	1136	0	968	3
POL	470	220	459	743	506	378	360	37	480	610	750	0	43
FRR	1	4	3	50	3	0	1	0	1	10	0	49	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	FRR	AUS	URY
BEL	0	391	361	330	659	495	385	545	502	335	42	473	716	315	527	232	222	11	454	187
CAN	347	0	627	794	1576	936	907	963	1109	417	68	1230	954	511	2109	611	383	2	893	488
CHE	324	511	0	391	904	569	441	512	571	339	42	579	724	327	793	279	230	12	481	215
CZE	215	518	251	0	1422	911	608	948	790	379	75	977	1108	449	1252	661	280	10	630	331
DEU	569	853	718	935	0	2208	1184	2040	1709	754	109	2109	2581	803	2881	1045	498	75	1329	533
DFS	400	752	484	514	1163	0	794	1342	1262	640	102	1306	1625	687	1664	692	446	14	1015	450
ESP	338	541	338	352	671	537	0	879	859	427	72	985	847	431	1195	466	383	2	676	373
FRA	487	642	440	496	867	606	591	0	1291	644	94	1543	1596	682	2137	772	416	3	1053	427
GBR	431	1090	526	449	1060	848	653	734	0	804	94	1300	1432	776	1774	578	443	6	1126	474
IRL	300	397	336	251	617	507	394	495	818	0	69	586	775	616	671	245	299	3	625	273
ISR	24	48	27	54	85	80	45	49	63	56	0	98	107	79	113	53	49	0	74	49
ITA	368	839	503	564	1103	821	667	703	864	484	72	0	1429	654	2179	736	446	1	995	501
NLD	748	839	687	878	1890	1245	696	866	1154	706	89	993	0	864	2026	780	440	42	1195	464
NZL	229	465	272	276	563	459	313	372	647	523	67	455	772	0	913	266	321	0	1014	365
USA	400	2093	693	833	1478	1063	720	996	1432	580	93	1164	1556	840	0	937	567	7	1502	782
POL	151	419	189	403	615	425	220	326	323	155	32	423	524	167	690	0	164	43	434	247
ZAF	168	349	182	173	356	315	325	273	375	254	34	324	356	251	527	94	0	2	415	254
FRR	7	1	4	3	50	3	0	0	1	1	0	1	10	0	1	49	1	0	5	1
AUS	351	811	410	342	809	640	456	644	913	525	51	626	967	990	1352	241	346	1	0	444
URY	123	437	147	212	323	289	278	231	363	203	24	321	332	276	938	165	212	0	326	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	391	665	495	385	502	335	473	716	315	527	232	222	454	513	187
CAN	347	0	1608	936	906	1109	417	1230	956	511	2109	611	382	893	855	488
DEU	580	928	0	2238	1203	1734	765	2139	2658	811	2936	1063	505	1355	1926	545
DFS	400	752	1221	0	793	1262	640	1306	1627	687	1664	692	445	1015	1266	450
ESP	338	541	698	537	0	858	427	984	847	430	1193	465	382	674	821	373
GBR	431	1090	1120	848	653	0	804	1300	1434	776	1774	578	442	1126	1222	474
IRL	300	397	637	507	394	818	0	586	778	616	671	245	299	625	621	273
ITA	368	839	1153	821	667	864	484	0	1431	654	2179	736	446	995	1444	501
NLD	751	845	2034	1251	701	1158	709	997	0	864	2030	779	439	1197	1496	465
NZL	229	465	581	459	313	647	523	455	773	0	913	266	320	1014	659	365
USA	400	2093	1586	1063	720	1432	580	1164	1561	840	0	936	566	1502	2009	782
POL	151	419	644	425	220	323	155	423	524	167	690	0	164	434	703	247
ZAF	168	349	365	315	325	375	254	324	357	251	527	94	0	414	410	254
AUS	351	811	850	640	456	913	525	626	973	990	1352	241	346	0	987	444
FRA	437	509	770	503	534	630	452	594	737	334	856	249	263	564	0	410
URY	123	437	344	289	278	363	203	321	334	276	938	165	212	326	214	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	48	207	20
DFS	36	0	86	50
USA	190	65	0	40
NLD	16	45	39	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	0	51	105	22	116	240	119	5
DFS	36	0	117	67	110	97	90	26
GBR	104	107	0	60	164	155	143	41
NLD	17	59	57	0	57	52	47	18
NZL	121	79	170	49	0	205	325	82
USA	237	75	166	55	229	0	232	25
AUS	118	52	146	42	354	235	0	34
IRL	4	21	42	18	91	28	31	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	51	109	22	244
DFS	36	0	119	67	96
GBR	106	107	0	61	159
NLD	17	59	57	0	52
USA	241	75	170	55	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	51	102	22	114	243	95	155	5
DFS	36	0	117	67	111	144	109	104	26
GBR	99	107	0	60	165	185	137	165	41
NLD	17	59	57	0	58	66	58	53	18
NZL	117	79	170	50	0	307	173	363	82
USA	238	108	202	71	380	0	249	410	33
ZAF	93	81	141	54	183	256	0	193	28
AUS	144	63	167	47	394	438	180	0	40
IRL	4	21	42	18	91	35	30	38	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	51	102	22	114	243	95	155	5
DFS	36	0	117	69	111	144	109	104	26
GBR	99	107	0	64	165	185	137	165	41
NLD	18	62	61	0	61	71	61	55	19
NZL	117	79	170	54	0	307	173	363	82
USA	238	108	202	77	380	0	249	410	33
ZAF	93	81	141	58	183	256	0	193	28
AUS	144	63	167	49	394	438	180	0	40
IRL	4	21	42	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	106	4	74	3
DEU	7	0	39	11	10	11
DFS	106	29	0	113	109	36
NOR	4	11	84	0	45	26
USA	70	10	104	45	0	23
NLD	3	11	35	25	21	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	106	50	4	51	102	4	54	2
DEU	9	0	45	4	12	11	12	10	20	4
DFS	105	35	0	52	107	145	122	38	136	13
GBR	51	4	51	0	21	42	52	16	36	9
NOR	4	12	78	22	0	36	51	26	34	45
NZL	52	11	140	41	34	0	66	11	101	7
USA	98	12	118	50	51	67	0	26	52	17
NLD	4	10	37	15	25	11	24	0	12	8
AUS	53	19	117	35	29	103	50	10	0	8
IRL	2	4	9	9	44	7	17	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	106	53	4	4	102
DEU	8	0	43	4	12	10	11
DFS	105	34	0	55	108	38	122
GBR	54	4	54	0	23	16	54
NOR	4	12	79	24	0	26	51
NLD	4	10	37	15	25	0	26
USA	98	11	119	51	52	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	101	48	4	50	125	66	4	58	2
DEU	7	0	42	4	11	10	12	1	10	29	4
DFS	99	32	0	52	93	145	141	50	38	163	13
GBR	49	4	51	0	20	43	66	34	16	46	9
NOR	4	10	71	21	0	35	53	0	25	48	45
NZL	51	10	140	42	33	0	92	34	11	117	7
USA	128	11	140	66	54	93	0	65	26	98	18
ZAF	71	1	49	32	0	32	60	0	2	36	2
NLD	4	9	37	15	24	11	24	2	0	20	8
AUS	57	27	140	45	39	119	98	36	18	0	10
IRL	2	4	9	9	44	7	18	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	101	48	4	50	125	66	5	58	2
DEU	8	0	44	4	11	11	13	2	10	30	4
DFS	99	35	0	52	93	145	141	50	38	163	13
GBR	49	4	51	0	20	43	66	34	16	46	9
NOR	4	11	71	21	0	35	53	0	26	48	45
NZL	51	11	140	42	33	0	92	34	11	117	7
USA	128	13	140	66	54	93	0	65	28	98	18
ZAF	71	2	49	32	0	32	60	0	2	36	2
NLD	5	10	37	15	25	11	25	2	0	20	8
AUS	57	29	140	45	39	119	98	36	18	0	10
IRL	2	4	9	9	44	7	18	2	7	9	0