

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 absence 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 absence of any of these traits, a measure of interval calving-conception such as days open (DO), or calving interval (CI) can be submitted. All countries are expected to submit data for this trait group, and as a last resort the trait submitted under T3 can be submitted for T4 as well.
- T5 (IT): Lactating cow's measurements of (I)nterval (T)raits calving-conception, such as days open (DO) and calving interval (CI).

Based on the above trait definitions the following traits have been submitted for international genetic evaluation of female fertility traits.

Country	Traits	Submitted traits and their definitions
AUS	T2=CY T4=C2 T5=IT	Calving interval converted to 42 days pregnancy rate Calving interval converted to 42 days pregnancy rate Calving interval converted to 42 days pregnancy rate
BEL	T2=CY T4=C2 T5=IT	PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)} \times 100$, with DO=days open) PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)} \times 100$, with DO=days open) PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)} \times 100$, with DO=days open)
CAN	T1=HC T2=CY T3=C1 T4=C2 T5=IT	NR=Non Return Rate after 56 Days in heifers (NRR), % CF=Interval from Calving to First Service in cows (CF) NR=Non Return Rate after 56 Days in cows (NRR), % FC=Interval first insemination-conception in cows DO=Days open
CHE	T1=HC T2=CR T3=C1 T4=C2	CR=Heifers' Conception rate CF=Interval from Calving to First Service (ICF), days NR=Non Return Rate after 56 Days (NRR), % FL=Interval from first to last insemination cows
CZE	T1=HC	CR=Heifers' Conception rate (pregnant or not after 3 months)

	T3=C1	CR=Cows' Conception rate (pregnant or not after 3 months)
	T4=C2	CR=Cows' Conception rate (pregnant or not after 3 months)
AUT/DEU	T1=HC	NR=Heifers' Non Return Rate after 56 days
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	NR=Cows' Non Return Rate after 56 days
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
DFS	T1=HC	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:

ITA BSW Base change, changed procedure to estimate reliabilities and EDC, parentage correction. Changed formula to standardized the ebv

ITA HOL Base change and one year cut off of data

NOR RDC Standard deviation changed from 10 to 12

FRA ALL Base change

ISR HOL Base change

CAN ALL Base change

DEU HOL/RDC Herd-years with uninformative NonReturn56 were 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.

NZL BSW/JER New organization providing data
HOL/RDC New Zealand has continuous DNA parentage testing so herds/daughters/edc will always
GUE change, herd count corrected for some bulls

CHE BSW Changed the deduction of type of proofs for all traits. Implemented new rules for the publication of proofs

IRL HOL/RDC New base
JER

URY HOL First participation for CC2

DEA BSW new data preparation - model change: multitrait evaluation with 7 traits (old: 5) early fertility disorders and ovarian cysts are now included. New genetic parameters Many animals changing from official to unofficial due to a new calculation of the reliabilities.

ZAF HOL/JER Data since 2012 on 18 ARC herds were added, which influenced the breeding values of certain birth years bulls

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 (April 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	7240	1484	610	
BEL			1048			
CAN	121	37	7424	376	442	
CHE	2492		2827			
CZE			3348			
DEA	5098					
DEU			23899		321	
DFS			14587	2082	8984	
ESP			2778			
EST						
FRA	329		14885			
FRM						
FRR			168			
GBR	75	208	5761	483	312	
HUN						
IRL			2382	133	50	
ISR			1214			
ITA	1602		8677			
JPN						
KOR						
LTU						
LVA						
NLD	152		13785	116	59	
NOR					3615	
NZL	50	59	6833	4196	1248	
POL			5781			
PRT						
SVK						
SVN						
URY			1201			
USA	981	720	33976	3901	620	
ZAF		31	1166	635	137	
HRV						
No. Records	10900	1173	158980	13406	16398	
Pub. Proofs	10116	971	135957	11412	15408	0

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

BSW hco

	CAN	DEA	FRA	USA	CHE	NLD
CAN	8.05					
DEA	0.80	9.76				
FRA	0.69	0.81	0.93			
USA	0.75	0.86	0.90	2.72		
CHE	0.81	0.94	0.88	0.88	12.95	
NLD	0.76	0.72	0.83	0.88	0.88	3.65

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.96								
CHE	0.85	11.12							
DEA	0.85	0.94	14.18						
NLD	0.86	0.88	0.85	3.42					
NZL	0.60	0.65	0.68	0.60	10.49				
USA	0.85	0.86	0.85	0.85	0.62	3.32			
GBR	0.76	0.76	0.75	0.81	0.64	0.83	3.90		
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	20.10

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.47						
CHE	0.76	11.93					
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	2.89		
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	0.95

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.57								
CHE	0.69	11.11							
DEA	0.81	0.93	11.65						
NLD	0.85	0.83	0.85	3.48					
NZL	0.58	0.55	0.62	0.58	7.04				
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	3.90		
FRA	0.78	0.87	0.85	0.77	0.54	0.85	0.77	0.95	
ITA	0.85	0.73	0.85	0.84	0.66	0.88	0.86	0.85	24.75

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.41						
DEA	0.88	13.54					
NLD	0.87	0.87	3.24				
NZL	0.59	0.60	0.62	6.76			
USA	0.89	0.87	0.87	0.58	2.39		
GBR	0.86	0.88	0.89	0.64	0.87	3.90	
ITA	0.87	0.93	0.88	0.65	0.89	0.88	18.26

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.14				
GBR	0.74	4.34			
NZL	0.59	0.64	11.53		
USA	0.84	0.86	0.62	3.38	
AUS	0.72	0.86	0.69	0.74	6.96

GUE cc1

	CAN	GBR	USA
CAN	6.71		
GBR	0.69	0.03	
USA	0.80	0.74	3.45

GUE cc2

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.77					
GBR	0.77	4.34				
NZL	0.55	0.68	7.69			
USA	0.85	0.85	0.65	2.71		
ZAF	0.74	0.83	0.69	0.84	13.75	
AUS	0.70	0.79	0.75	0.80	0.85	6.94

GUE int

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.36					
GBR	0.86	4.34				
NZL	0.57	0.64	7.69			
USA	0.89	0.87	0.60	2.71		
ZAF	0.86	0.87	0.65	0.87	13.75	
AUS	0.86	0.86	0.73	0.87	0.88	6.94

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	FRR	CHE	NLD
CAN	7.39									
CZE	0.74	17.57								
DEU	0.88	0.80	14.64							
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	18.44			
FRR	0.71	0.74	0.61	0.65	0.76	0.78	0.62	0.79		
CHE	0.94	0.83	0.93	0.93	0.85	0.88	0.71	0.72	13.74	
NLD	0.78	0.82	0.79	0.77	0.85	0.88	0.67	0.77	0.82	4.12

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA
NLD	NZL	USA	POL	ZAF	FRR	AUS	URY					
BEL	4.65											
CAN	0.75	6.15										
CHE	0.78	0.85	11.12									
CZE	0.64	0.80	0.85	18.07								
DEU	0.80	0.88	0.89	0.88	12.12							
DFS	0.82	0.84	0.86	0.79	0.92	13.01						
ESP	0.86	0.76	0.73	0.65	0.80	0.80	11.27					
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	4.72			
IRL	0.84	0.76	0.78	0.65	0.78	0.78	0.85	0.79	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	3.10	
ITA	0.84	0.78	0.77	0.74	0.83	0.84	0.94	0.76	0.87	0.84	0.56	17.99
NLD	0.79	0.85	0.87	0.82	0.91	0.90	0.79	0.82	0.79	0.80	0.64	0.82
4.63												
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	5.65											
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	2.32										
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	13.01									
ZAF	0.74	0.72	0.79	0.71	0.82	0.79	0.87	0.80	0.79	0.86	0.59	0.90
0.80	0.70	0.87	0.74	15.75								
FRR	0.44	0.39	0.39	0.39	0.62	0.45	0.36	0.37	0.35	0.35	0.31	0.35
0.55	0.27	0.38	0.55	0.37	1.11							
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	5.02						
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	1.46					

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL
ZAF	AUS	FRA	URY									
BEL	4.65											
CAN	0.86	6.10										
DEU	0.86	0.86	10.41									
DFS	0.90	0.87	0.93	12.95								
ESP	0.86	0.86	0.88	0.86	11.27							
GBR	0.88	0.86	0.86	0.90	0.91	4.72						
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	17.99				
NLD	0.91	0.86	0.91	0.94	0.87	0.90	0.86	0.89	4.49			
NZL	0.68	0.56	0.60	0.59	0.67	0.66	0.66	0.65	0.61	5.65		
USA	0.87	0.89	0.87	0.89	0.87	0.87	0.87	0.92	0.87	0.60	2.32	
POL	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.88	0.86	0.65	0.87	13.02
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
15.75												
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	5.02											
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	1.46									

JER hco

	CAN	DFS	USA	NLD
CAN	7.44			
DFS	0.85	18.86		
USA	0.82	0.86	2.65	
NLD	0.77	0.76	0.88	4.30

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.46							
DFS	0.87	13.89						
GBR	0.73	0.87	4.07					
NLD	0.86	0.91	0.77	3.92				
NZL	0.58	0.66	0.67	0.59	6.94			
USA	0.84	0.85	0.83	0.85	0.65	3.77		
AUS	0.71	0.72	0.86	0.72	0.61	0.73	3.67	
IRL	0.73	0.72	0.86	0.72	0.61	0.76	0.87	1.94

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.60				
DFS	0.73	14.36			
GBR	0.68	0.68	0.03		
NLD	0.70	0.64	0.66	3.53	
USA	0.71	0.73	0.69	0.91	2.88

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.61								
DFS	0.85	16.10							
GBR	0.77	0.79	4.06						
NLD	0.86	0.89	0.79	3.70					
NZL	0.60	0.59	0.70	0.59	4.46				
USA	0.85	0.87	0.85	0.88	0.69	2.60			
ZAF	0.67	0.72	0.76	0.78	0.71	0.86	11.07		
AUS	0.69	0.71	0.77	0.71	0.69	0.71	0.78	3.66	
IRL	0.78	0.79	0.85	0.80	0.66	0.85	0.76	0.83	1.94

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.34								
DFS	0.87	15.82							
GBR	0.86	0.88	4.06						
NLD	0.87	0.90	0.88	3.65					
NZL	0.58	0.64	0.68	0.61	4.46				
USA	0.88	0.88	0.87	0.87	0.67	2.60			
ZAF	0.87	0.87	0.87	0.87	0.70	0.87	11.07		
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	0.56	0.87	0.87	0.87	1.94

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.05					
DEU	0.86	13.35				
DFS	0.83	0.84	15.72			
NOR	0.87	0.83	0.80	15.17		
USA	0.82	0.85	0.89	0.84	2.68	
NLD	0.78	0.79	0.73	0.72	0.88	4.75

RDC crc										
	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	6.23									
DEU	0.86	9.60								
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	14.93					
NZL	0.59	0.60	0.58	0.63	0.66	10.60				
USA	0.84	0.84	0.84	0.84	0.85	0.70	3.51			
NLD	0.86	0.91	0.93	0.80	0.86	0.60	0.85	2.94		
AUS	0.72	0.72	0.72	0.86	0.75	0.67	0.74	0.72	4.70	
IRL	0.72	0.71	0.72	0.86	0.74	0.62	0.78	0.72	0.88	2.47

RDC cc1							
	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	6.68						
DEU	0.82	12.05					
DFS	0.81	0.89	14.07				
GBR	0.68	0.76	0.83	0.03			
NOR	0.86	0.75	0.77	0.75	14.52		
NLD	0.72	0.69	0.66	0.68	0.70	4.23	
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	6.40										
DEU	0.88	9.97									
DFS	0.85	0.93	13.09								
GBR	0.77	0.79	0.80	4.32							
NOR	0.89	0.87	0.85	0.87	16.47						
NZL	0.59	0.59	0.58	0.67	0.66	6.92					
USA	0.85	0.89	0.87	0.86	0.86	0.68	2.42				
ZAF	0.67	0.82	0.80	0.73	0.70	0.72	0.85	18.30			
NLD	0.86	0.91	0.87	0.80	0.86	0.59	0.89	0.79	3.87		
AUS	0.69	0.71	0.69	0.78	0.66	0.69	0.72	0.77	0.72	4.56	
IRL	0.77	0.79	0.79	0.85	0.86	0.71	0.85	0.84	0.81	0.86	2.47

RDC int											
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.34										
DEU	0.86	9.16									
DFS	0.87	0.93	13.37								
GBR	0.86	0.87	0.88	4.32							
NOR	0.90	0.90	0.87	0.89	16.47						
NZL	0.60	0.59	0.58	0.65	0.49	6.92					
USA	0.88	0.87	0.88	0.88	0.88	0.67	2.42				
ZAF	0.88	0.87	0.87	0.88	0.90	0.68	0.89	18.30			
NLD	0.87	0.91	0.92	0.89	0.89	0.61	0.87	0.87	3.24		
AUS	0.86	0.86	0.86	0.86	0.88	0.66	0.87	0.88	0.86	4.56	
IRL	0.86	0.86	0.86	0.86	0.88	0.64	0.87	0.87	0.86	0.88	2.47

 ^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	64	43	70	69	23
DEA	52	0	170	138	494	108
FRA	38	126	0	64	140	64
USA	61	100	48	0	164	36
CHE	55	398	106	138	0	70
NLD	20	98	53	32	66	0

BSW

common bulls below diagonal
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	90	83	32	16	98	40	59	83
CHE	72	0	486	79	22	233	50	138	355
DEA	69	386	0	120	29	185	50	170	482
NLD	27	70	108	0	20	44	32	69	99
NZL	15	17	22	13	0	17	15	18	24
USA	93	202	140	39	15	0	49	85	144
GBR	36	37	34	24	11	46	0	40	54
FRA	51	102	126	55	14	57	31	0	149
ITA	71	300	364	77	17	99	37	112	0

BSW

common bulls below diagonal
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	91	82	32	99	41	61
CHE	73	0	484	79	233	52	145
DEA	68	381	0	119	185	53	181
NLD	27	70	108	0	44	32	74
USA	94	202	140	39	0	51	88
GBR	37	39	36	24	48	0	43
FRA	53	109	138	61	61	35	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	74	29	14	94	38	56	76
CHE	62	0	474	79	22	289	50	145	355
DEA	61	377	0	119	29	282	49	180	473
NLD	25	70	108	0	20	67	32	74	99
NZL	13	17	22	13	0	26	15	19	24
USA	85	271	250	54	23	0	60	109	194
GBR	34	37	34	24	11	56	0	41	54
FRA	48	109	138	61	15	75	33	0	159
ITA	63	300	358	77	17	133	37	123	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	74	30	14	94	38	76
DEA	61	0	121	29	282	49	581
NLD	26	110	0	20	68	32	107
NZL	13	22	13	0	26	15	24
USA	85	250	57	23	0	60	211
GBR	34	34	24	11	56	0	55
ITA	64	480	85	17	147	37	0

GUE

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	13	3	31	18
GBR	10	0	13	39	28
NZL	2	11	0	9	26
USA	30	37	7	0	19
AUS	13	22	24	16	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	USA
CAN	0	13	31
GBR	10	0	41
USA	30	39	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	10	2	28	1	15
GBR	7	0	13	70	5	29
NZL	2	11	0	29	3	26
USA	26	72	29	0	10	52
ZAF	1	4	1	6	0	5
AUS	11	23	25	49	4	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	10	2	28	1	15
GBR	7	0	13	70	5	29
NZL	2	11	0	29	3	26
USA	26	72	29	0	10	52
ZAF	1	4	1	6	0	5
AUS	11	23	25	49	4	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	791	1632	857	952	1857	705	0	598	882
CZE	518	0	1463	907	967	1037	721	9	379	1088
DEU	1032	993	0	2158	2005	2065	1226	67	909	2503
DFS	694	503	1198	0	1327	1083	767	14	534	1565
FRA	656	523	965	639	0	1282	853	2	503	1509
USA	1910	731	1253	804	658	0	993	3	594	1218
POL	495	461	817	499	409	819	0	48	309	862
FRR	0	3	44	2	0	0	54	0	6	40
CHE	483	245	762	455	450	514	220	3	0	685
NLD	753	870	1877	1147	868	897	607	9	652	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	390	349	666	480	369	492	325	463	701	314	407	222	535	11	399
CAN	346	0	620	1705	938	878	1114	413	1272	974	547	1957	615	998	2	763
CHE	313	508	0	928	548	426	554	329	568	707	328	652	272	504	12	407
DEU	586	1044	769	0	2251	1178	1740	767	2197	2754	853	2277	1079	2102	77	1211
DFS	388	751	464	1243	0	766	1234	628	1297	1570	694	1237	681	1334	14	891
ESP	327	515	320	690	513	0	831	413	951	813	427	958	440	853	2	594
GBR	422	1090	504	1144	820	628	0	789	1295	1407	776	1364	573	1285	6	988
IRL	293	400	324	650	494	381	800	0	574	763	615	495	238	633	2	558
ITA	359	876	489	1215	818	643	858	476	0	1428	678	1758	736	1557	1	883
NLD	728	856	669	2208	1188	670	1126	693	999	0	887	1427	775	1590	42	1054
NZL	230	499	276	628	462	314	646	521	476	794	0	638	279	695	0	962
USA	341	1986	575	1346	888	546	1148	466	1015	1092	551	0	885	1448	3	870
POL	145	427	184	655	418	207	311	149	421	516	171	676	0	767	43	346
FRA	480	672	437	948	611	574	736	494	713	871	384	707	327	0	3	935
FRR	7	1	4	50	3	0	1	1	1	10	0	0	48	0	0	4
AUS	301	625	331	719	498	394	751	446	521	807	912	700	158	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	622	812	1699	942	1000	1156	69	1275	982	1982	649	2
CHE	511	0	386	926	549	518	557	42	568	707	652	300	12
CZE	539	251	0	1458	898	957	790	75	978	1098	1108	695	10
DEU	1042	767	1000	0	2246	2096	1783	110	2185	2718	2246	1140	76
DFS	760	464	506	1233	0	1344	1256	100	1297	1568	1237	733	13
FRA	695	448	510	965	629	0	1315	92	1562	1608	1435	803	3
GBR	1139	507	446	1164	837	759	0	94	1318	1436	1412	612	6
ISR	50	27	54	89	79	50	64	0	98	106	88	55	0
ITA	880	489	572	1208	817	736	876	71	0	1428	1756	775	1
NLD	867	669	872	2165	1188	894	1151	87	996	0	1428	830	42
USA	2038	575	762	1310	888	723	1209	72	1015	1092	0	931	3
POL	452	207	447	739	481	357	342	35	461	576	714	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	381	349	322	655	480	369	534	492	326	42	463	701	314	518	220	222	11	444
179																			
CAN	340	0	610	787	1601	912	875	942	1090	403	67	1213	931	528	2072	592	382	2	875
471																			
CHE	313	493	0	387	914	549	426	497	554	329	42	563	708	328	771	268	225	12	473
202																			
CZE	209	512	251	0	1443	900	586	939	781	373	75	973	1100	464	1252	644	281	10	627
312																			
DEU	571	926	745	975	0	2211	1178	2046	1715	753	110	2135	2641	844	2921	1044	508	75	1350
528																			
DFS	388	722	465	506	1193	0	770	1324	1236	628	101	1289	1574	696	1634	671	446	13	1000
432																			
ESP	327	508	320	341	679	514	0	852	835	414	71	952	818	429	1158	438	380	2	652
354																			
FRA	475	619	424	488	893	589	566	0	1275	633	93	1523	1571	694	2114	750	415	3	1037
406																			
GBR	422	1058	504	441	1101	821	628	713	0	789	94	1285	1409	777	1749	566	443	6	1111
454																			
IRL	293	386	324	247	628	494	381	487	800	0	69	571	764	615	659	233	295	2	609
259																			
ISR	24	48	27	54	87	79	45	49	63	55	0	96	107	79	112	51	49	0	74
45																			
ITA	357	809	483	560	1142	799	639	682	845	471	68	0	1411	673	2167	720	444	1	990
481																			
NLD	728	811	669	872	2025	1190	671	838	1127	693	87	972	0	890	1992	757	439	42	1183
446																			
NZL	230	474	276	288	607	463	314	374	646	521	66	467	796	0	936	273	324	0	1029
354																			
USA	394	2030	675	831	1584	1020	686	979	1394	566	90	1144	1510	860	0	905	566	7	1484
757																			
POL	141	395	176	389	611	403	202	304	299	145	30	403	492	167	655	0	164	43	423
227																			
ZAF	168	348	180	174	366	314	320	271	374	250	34	321	355	252	525	93	0	2	415
249																			
FRR	7	1	4	3	50	3	0	0	1	1	0	1	10	0	1	48	1	0	5
1																			
AUS	343	779	399	338	838	619	434	626	887	509	51	614	947	1002	1318	223	344	1	0
428																			
URY	118	423	139	198	334	274	264	216	350	193	22	304	314	269	906	149	206	0	316
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	381	655	480	369	492	326	463	701	314	518	220	222	444	510	179
CAN	340	0	1599	912	874	1090	403	1213	934	528	2072	592	381	875	854	471
DEU	571	926	0	2214	1176	1718	759	2136	2659	849	2926	1045	507	1353	1933	529
DFS	388	722	1196	0	769	1236	628	1289	1577	696	1634	671	445	1000	1260	432
ESP	327	508	679	514	0	834	414	951	818	428	1156	437	379	650	811	354
GBR	422	1058	1105	821	628	0	789	1285	1411	777	1749	566	442	1111	1218	454
IRL	293	386	635	494	381	800	0	571	767	615	659	233	295	609	615	259
ITA	357	809	1144	799	639	845	471	0	1414	673	2167	720	444	990	1441	481
NLD	732	817	2050	1196	676	1131	696	978	0	891	1998	756	438	1186	1494	447
NZL	230	474	613	463	314	646	521	467	797	0	936	273	323	1029	670	354
USA	394	2030	1589	1020	686	1394	566	1144	1517	860	0	904	565	1484	2010	757
POL	141	395	614	403	202	299	145	403	492	167	655	0	164	423	692	227
ZAF	168	348	366	314	320	374	250	321	356	252	525	93	0	414	410	249
AUS	343	779	840	619	434	887	509	614	954	1002	1318	223	344	0	985	428
FRA	435	509	778	503	528	629	450	593	736	341	857	244	263	560	0	394
URY	118	423	334	274	264	350	193	304	316	269	906	149	206	316	205	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	48	201	19
DFS	36	0	86	48
USA	184	65	0	38
NLD	15	43	37	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	0	49	103	22	121	231	119	5
DFS	34	0	116	65	108	94	89	24
GBR	100	106	0	60	163	153	144	39
NLD	17	57	57	0	57	52	48	16
NZL	126	77	169	51	0	214	329	79
USA	227	72	163	55	241	0	233	24
AUS	117	51	146	43	358	237	0	34
IRL	4	19	40	16	88	26	30	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	49	105	22	236
DFS	34	0	116	65	93
GBR	103	105	0	61	155
NLD	17	57	57	0	52
USA	231	72	166	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	49	100	22	117	232	93	152	5
DFS	34	0	116	65	109	141	106	99	24
GBR	97	106	0	60	164	183	134	163	39
NLD	17	57	57	0	58	66	57	52	16
NZL	120	77	169	52	0	316	175	365	79
USA	228	105	199	71	391	0	245	406	33
ZAF	91	77	135	53	184	254	0	191	27
AUS	143	59	165	46	397	434	179	0	38
IRL	4	19	40	16	88	34	28	35	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	49	100	22	117	232	93	152	5
DFS	34	0	116	67	109	141	106	99	24
GBR	97	106	0	64	164	183	134	163	39
NLD	18	60	61	0	61	70	60	54	17
NZL	120	77	169	56	0	316	175	365	79
USA	228	105	199	76	391	0	245	406	33
ZAF	91	77	135	57	184	254	0	191	27
AUS	143	59	165	48	397	434	179	0	38
IRL	4	19	40	16	88	34	28	35	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	9	97	4	70	3
DEU	8	0	45	13	11	10
DFS	95	35	0	112	104	35
NOR	4	13	82	0	44	26
USA	66	11	98	44	0	23
NLD	3	10	34	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	101	50	4	54	100	3	54	2
DEU	9	0	51	4	15	15	17	12	21	3
DFS	99	42	0	49	100	147	121	37	135	11
GBR	51	4	49	0	17	41	52	13	36	9
NOR	4	15	75	18	0	37	49	25	34	44
NZL	54	15	142	40	36	0	71	10	103	7
USA	97	17	117	50	49	72	0	25	52	14
NLD	3	12	36	13	24	10	23	0	12	7
AUS	53	20	116	35	29	105	50	10	0	8
IRL	2	3	7	9	43	7	14	6	7	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	0	10	101	52	4	3	100
DEU	9	0	47	4	13	10	13
DFS	99	38	0	51	103	37	121
GBR	53	4	51	0	20	14	55
NOR	4	13	76	21	0	25	49
NLD	3	10	36	14	24	0	25
USA	97	13	117	52	49	23	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	97	48	4	53	121	65	3	57	2
DEU	8	0	44	4	11	12	13	1	10	30	3
DFS	94	35	0	49	90	147	136	48	37	159	11
GBR	49	4	49	0	16	42	64	34	13	44	9
NOR	4	11	68	17	0	37	51	0	25	46	44
NZL	53	12	142	41	36	0	96	34	10	119	7
USA	125	13	135	64	51	97	0	64	25	96	16
ZAF	69	1	46	32	0	31	59	0	2	35	2
NLD	3	10	36	13	24	10	23	2	0	19	7
AUS	56	29	136	43	38	121	96	35	17	0	9
IRL	2	3	7	9	43	7	16	2	6	8	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	97	48	4	53	121	65	4	57	2
DEU	8	0	48	4	13	14	17	1	12	33	3
DFS	94	39	0	49	90	147	136	48	37	159	11
GBR	49	4	49	0	16	42	64	34	13	44	9
NOR	4	13	68	17	0	37	51	0	26	46	44
NZL	53	14	142	41	36	0	96	34	10	119	7
USA	125	17	135	64	51	97	0	64	27	96	16
ZAF	69	1	46	32	0	31	59	0	2	35	2
NLD	4	12	36	13	25	10	24	2	0	19	7
AUS	56	32	136	43	38	121	96	35	17	0	9
IRL	2	3	7	9	43	7	16	2	6	8	0
