

## 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 days open (DO) or calving interval (CI) can be submitted;
- T3 (C1): Lactating (C)ow's ability to conceive (1), expressed as a rate trait. Traits like conception rate (CR) and non-return rate (NR, preferably NR56) will be considered for this trait group;
- T4 (C2): Lactating (C)ow's ability to conceive (2), expressed as an interval trait. The interval first insemination-conception (FC) or interval first-last insemination (FL) will be considered for this trait group. As an alternative, number of inseminations (NI) can be submitted. In the absence of any of these traits, a measure of interval calving-conception such as days open (DO), or calving interval (CI) can be submitted. All countries are expected to submit data for this trait group, and as a last resort the trait submitted under T3 can be submitted for T4 as well.
- T5 (IT): Lactating cow's measurements of (I)nterval (T)raits calving-conception, such as days open (DO) and calving interval (CI).

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

Country	Traits	Submitted traits and their definitions
AUS	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	CR=Heifers' Conception rate for maiden heifers
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	CR=Cows' conception rate for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
ESP	T2=CY	DO=Days open
	T4=C2	DO=Days open
	T5=IT	DO=Days open
FRA	T1=HC	CR=Heifers' Conception rate (binary trait) for maiden heifers
	T2=CY	Interval between calving and first AI
	T3=C1	CR=Cows' Conception rate (binary trait) for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
GBR	T2=CY	CI=days between 1st and 2nd calvings
	T3=C1	NR=1st lactation non return at 56 days
	T4=C2	CI=days between 1st and 2nd calvings
	T5=IT	CI=days between 1st and 2nd calvings
IRL	T2=CY	CI=Calving interval
	T4=C2	CI=Calving interval
	T5=IT	CI=Calving interval
ISR	T3=C1	CR=Inverse of the number of insemination to conception (%)
	T4=C2	CR=Inverse of the number of insemination to conception (%)
ITA	T2=CY	CF=Days to first service
	T3=C1	NR=Non-return rate at 56 days (%)
	T4=C2	CI=Calving Interval (days)
	T5=IT	CI=Calving interval (days)
ITA (BSW)	T2=CY	CF=Interval calving to first insemination
	T4=C2	Days Open
	T5=IT	CI=Calving interval
NLD	T1=HC	CR=Heifers' Conception rate
	T2=CY	CF=Interval calving to first insemination (days)
	T3=C1	CR=Cows' Conception rate (binary trait) for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	CI=Calving Interval (days)
NOR	T1=HC	NR=NR=Non-return rate 56 days (heifers)
	T2=CY	CF=Interval calving to first insemination (days)
	T3=C1	NR=NR=Non-return rate 56 days (cows)
	T4=C2	CI=Calving Interval (days)
	T5=IT	CI=Calving Interval (days)
NZL	T2=CY	PM=Lactating cow's ability to start cycling
	T4=C2	PC=Lactating cow's ability to conceive (CR42)
	T5=IT	PC=Lactating cow's ability to conceive (CR42)
POL	T1=HC	Non return rate at 56 days for heifer
	T2=CR	Interval from calving to first insemination
	T3=C1	Non return rate at 56 days for cows
	T4=IT	Days open
	T5=IT	Days open
URY	T4=C2	Days open expressed as Daughter Pregnancy Rate
	T5=IT	Days open expressed as Daughter Pregnancy Rate

USA T1=HC CR=Conception rate (heifer)  
T2=CY CF=Interval from calving to first insemination  
T3=C1 CR=Conception rate (cow)  
T4=C2 DP=Daughter Pregnancy Rate  
T5=IT DP=Daughter Pregnancy Rate

ZAF T4=IT CI=Calving Interval  
T5=IT CI=Calving Interval

-----

CHANGES IN NATIONAL PROCEDURES

-----

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

DFS HOL HOL and RED HOL (RED) have merged. Cows with min 87 % HOL genes and and bulls with min 93 % HOL genes have been converted to HOL. Animals with less % HOL genes will no longer be a part of the evaluation.

NOR RDC Some decrease in EDC/REL due to the rolling definition of hys.

DEU HOL Excluded herd-years with uninformative NonReturn56.

DEU RDC Type of proof corrected for some bulls resulting in few bulls being not publishable anymore.

ITA HOL Some changes in information due to data-flow and editing.

NZL BSW/GUE Continuous DNA parentage testing affecting daughters, herds, EDCs and reliabilities.  
HOL/JER  
RDC

CZE HOL Trimming old data. Thus there are old bulls (born ~90-94) decreasing in daughters/herds/Reliability

INTERBULL CHANGES COMPARED TO THE DECEMBER ROUTINE RUN

-----

Subsetting:

-----

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

Window:

-----

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

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

DATA AND METHOD OF ANALYSIS

-----

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

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

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

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

#### SCIENTIFIC LITERATURE

---

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

International genetic evaluation computation:

Schaeffer. 1994. J. Dairy Sci. 77:2671-2678

Klei, 1998. Interbull Bulletin 17:3-7

Verification and Genetic trend validation:

Klei et al., 2002. Interbull Bulletin 29:178-182.

Boichard et al., 1995. J. Dairy Sci. 78:431-437

Weighting factors:

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

De-regression:

Sigurdsson and G. Banos. 1995. Acta Agric. Scand. 45:207-219

Jairath et al. 1998. J. Dairy Sci. Vol. 81:550-562

Genetic parameter estimation:

Klei and Weigel, 1998, Interbull Bulletin 17:8-14

Sullivan, 1999. Interbull Bulletin 22:146-148

Post-processing of estimated genetic correlations:

Mark et al., 2003, Interbull Bulletin 30:126-135

Jorjani et al., 2003. J. Dairy Sci. 86:677-679

<https://wiki.interbull.org/public/rG%20procedure?action=print>

Time edits

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

International reliability estimation

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

#### NEXT ROUTINE INTERNATIONAL EVALUATION

---

Dates for the next routine evaluation can be found on

<http://www.interbull.org/ib/servicecalendar>.

#### NEXT TEST INTERNATIONAL EVALUATION

---

Dates for the next test run can be found on

<http://www.interbull.org/ib/servicecalendar>.

PUBLICATION OF INTERBULL TEST RUN

---

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

^LTable 1. National evaluation data considered in the Interbull evaluation for fertility (December Routine Evaluation 2017).  
 Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		124	7538	1542	637	
BEL			1148			
CAN	128	40	8296	452	489	
CHE	2612		3046			
CZE			3645			
DEA	5248					
DEU			24622		333	
DFS			15180	2289	9472	
ESP			4751			
EST						
FRA	357		15739			
FRM						
GBR	85	215	6191	515	363	
HUN						
IRL			2563	153	54	
ISR			1297			
ITA	1679		8993			
JPN						
KOR						
LTU						
LVA						
NLD	166		14508	126	63	
NOR					3830	
NZL	49	58	7016	4338	1252	
POL			6550			
PRT						
SVK						
SVN						
URY			1360			
USA	1041	737	35997	4289	671	
ZAF			1203	664	143	
HRV						
MEX						
CAM						
No. Records	11365	1174	169643	14368	17307	
Pub. Proofs	10528	969	141634	12184	16194	0

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

BSW	hco					
	CAN	DEA	FRA	USA	CHE	NLD
CAN	9.32					
DEA	0.86	9.76				
FRA	0.81	0.83	0.91			
USA	0.81	0.84	0.90	2.65		
CHE	0.93	0.94	0.88	0.88	13.08	
NLD	0.80	0.72	0.87	0.88	0.88	3.64

  

BSW	crc									
	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA	
CAN	7.05									
CHE	0.85	11.27								
DEA	0.85	0.94	14.19							
NLD	0.87	0.88	0.85	3.49						
NZL	0.62	0.65	0.73	0.62	11.01					
USA	0.85	0.86	0.85	0.85	0.62	3.37				
GBR	0.75	0.76	0.75	0.80	0.65	0.83	3.96			
FRA	0.86	0.96	0.93	0.91	0.63	0.86	0.79	1.77		

ITA 0.85 0.85 0.85 0.86 0.69 0.85 0.80 0.87 18.92

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.53						
CHE	0.78	11.86					
DEA	0.79	0.96	10.97				
NLD	0.73	0.69	0.67	3.64			
USA	0.74	0.67	0.67	0.91	2.82		
GBR	0.73	0.82	0.78	0.68	0.67	0.04	
FRA	0.71	0.69	0.67	0.88	0.92	0.68	0.95

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.40								
CHE	0.73	11.08							
DEA	0.83	0.92	11.69						
NLD	0.88	0.84	0.85	3.38					
NZL	0.64	0.54	0.64	0.64	7.22				
USA	0.85	0.83	0.85	0.88	0.65	2.40			
GBR	0.82	0.77	0.85	0.82	0.70	0.85	3.96		
FRA	0.83	0.87	0.87	0.82	0.63	0.85	0.83	0.95	
ITA	0.85	0.71	0.85	0.85	0.66	0.88	0.86	0.85	23.89

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.94						
DEA	0.88	13.53					
NLD	0.89	0.87	3.20				
NZL	0.59	0.64	0.63	7.01			
USA	0.90	0.87	0.87	0.56	2.40		
GBR	0.87	0.88	0.90	0.66	0.87	3.96	
ITA	0.88	0.93	0.88	0.65	0.89	0.88	17.86

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.12				
GBR	0.75	4.78			
NZL	0.60	0.65	11.82		
USA	0.84	0.86	0.62	3.36	
AUS	0.73	0.87	0.70	0.74	6.96

GUE cc1

	CAN	GBR	USA
CAN	7.06		
GBR	0.71	0.03	
USA	0.80	0.74	3.40

GUE cc2

	CAN	GBR	NZL	USA	AUS
CAN	6.78				
GBR	0.83	4.78			
NZL	0.63	0.70	7.62		
USA	0.85	0.85	0.65	2.72	
AUS	0.71	0.72	0.76	0.79	7.15



HOL cc2

---

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR
ITA	NLD	NZL	USA	POL	ZAF	AUS	URY				
BEL	4.66										
CAN	0.84	6.13									
CHE	0.79	0.86	11.18								
CZE	0.65	0.84	0.87	15.98							
DEU	0.81	0.92	0.90	0.88	12.48						
DFS	0.83	0.85	0.86	0.81	0.93	13.21					
ESP	0.85	0.84	0.75	0.69	0.81	0.82	11.21				
FRA	0.82	0.86	0.91	0.79	0.88	0.84	0.79	0.98			
GBR	0.89	0.84	0.72	0.64	0.81	0.83	0.90	0.80	4.69		
IRL	0.84	0.83	0.80	0.66	0.81	0.82	0.85	0.82	0.85	3.49	
ISR	0.51	0.63	0.66	0.80	0.72	0.67	0.55	0.64	0.54	0.60	3.14
ITA	0.84	0.85	0.78	0.75	0.84	0.84	0.92	0.81	0.87	0.84	0.63
17.77											
NLD	0.82	0.91	0.88	0.84	0.93	0.91	0.82	0.85	0.82	0.83	0.70
0.83	4.51										
NZL	0.73	0.64	0.52	0.48	0.61	0.61	0.69	0.61	0.70	0.73	0.45
0.66	0.62	5.59									
USA	0.84	0.85	0.84	0.86	0.89	0.89	0.86	0.85	0.84	0.84	0.73
0.93	0.89	0.65	2.35								
POL	0.82	0.82	0.67	0.62	0.78	0.79	0.85	0.75	0.84	0.81	0.48
0.87	0.79	0.61	0.83	12.98							
ZAF	0.75	0.76	0.79	0.71	0.82	0.78	0.85	0.79	0.80	0.86	0.61
0.90	0.80	0.70	0.87	0.75	15.96						
AUS	0.78	0.72	0.79	0.67	0.72	0.70	0.76	0.79	0.75	0.88	0.58
0.78	0.71	0.70	0.79	0.67	0.84	5.08					
URY	0.84	0.81	0.68	0.58	0.79	0.81	0.84	0.81	0.85	0.84	0.50
0.82	0.81	0.75	0.83	0.86	0.78	0.73	1.44				

---

HOL int

---

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA
POL	ZAF	AUS	URY								
BEL	4.66										
CAN	0.88	6.53									
DEU	0.86	0.87	10.61								
DFS	0.90	0.90	0.93	13.11							
ESP	0.87	0.87	0.88	0.87	11.24						
GBR	0.88	0.87	0.87	0.90	0.91	4.69					
IRL	0.87	0.87	0.86	0.87	0.87	0.87	3.48				
ITA	0.87	0.89	0.90	0.89	0.95	0.88	0.87	17.77			
NLD	0.91	0.91	0.92	0.94	0.87	0.90	0.87	0.89	4.42		
NZL	0.71	0.58	0.59	0.59	0.69	0.68	0.69	0.67	0.61	5.59	
USA	0.87	0.92	0.88	0.88	0.87	0.87	0.87	0.92	0.87	0.60	2.35
POL	0.87	0.87	0.86	0.86	0.87	0.87	0.87	0.89	0.86	0.66	0.87
12.97											
ZAF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.92	0.87	0.66	0.87
0.87	15.98										
AUS	0.87	0.87	0.86	0.87	0.87	0.87	0.88	0.87	0.87	0.69	0.87
0.87	0.87	5.07									
URY	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.73	0.87
0.87	0.87	0.87	1.44								

---

JER hco

---

	CAN	DFS	USA	NLD
CAN	7.78			
DFS	0.82	17.38		
USA	0.85	0.87	2.68	
NLD	0.79	0.81	0.88	4.33

---



JER      crc

---

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.80							
DFS	0.87	13.98						
GBR	0.73	0.87	4.10					
NLD	0.87	0.91	0.78	3.81				
NZL	0.60	0.66	0.67	0.60	6.95			
USA	0.84	0.84	0.84	0.85	0.64	3.82		
AUS	0.72	0.73	0.87	0.73	0.61	0.73	3.67	
IRL	0.73	0.73	0.87	0.73	0.62	0.76	0.88	1.89

---

JER      cc1

---

	CAN	DFS	GBR	NLD	USA
CAN	6.65				
DFS	0.73	15.52			
GBR	0.73	0.71	0.03		
NLD	0.73	0.89	0.67	3.51	
USA	0.75	0.87	0.67	0.91	2.90

---

JER      cc2

---

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.57								
DFS	0.85	16.08							
GBR	0.85	0.83	4.10						
NLD	0.90	0.89	0.83	3.67					
NZL	0.65	0.63	0.71	0.63	4.44				
USA	0.85	0.87	0.85	0.88	0.67	2.64			
ZAF	0.71	0.73	0.77	0.79	0.71	0.86	10.98		
AUS	0.67	0.72	0.71	0.70	0.70	0.69	0.77	3.67	
IRL	0.84	0.84	0.85	0.84	0.67	0.85	0.74	0.77	1.89

---

JER      int

---

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.35								
DFS	0.88	15.83							
GBR	0.87	0.88	4.10						
NLD	0.89	0.91	0.89	3.62					
NZL	0.60	0.64	0.70	0.60	4.44				
USA	0.89	0.88	0.87	0.87	0.65	2.64			
ZAF	0.87	0.87	0.87	0.87	0.68	0.87	10.98		
AUS	0.87	0.87	0.87	0.87	0.66	0.87	0.87	3.67	
IRL	0.87	0.86	0.86	0.87	0.48	0.87	0.86	0.87	1.89

---

RDC      hco

---

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.15					
DEU	0.91	14.22				
DFS	0.83	0.83	12.33			
NOR	0.85	0.83	0.80	15.50		
USA	0.86	0.85	0.90	0.76	2.61	
NLD	0.81	0.78	0.81	0.72	0.88	4.63

---

RDC		crc									
	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL	
CAN	6.25										
DEU	0.86	9.98									
DFS	0.86	0.90	12.89								
GBR	0.74	0.74	0.77	4.39							
NOR	0.90	0.87	0.90	0.76	15.00						
NZL	0.61	0.62	0.61	0.66	0.65	10.61					
USA	0.84	0.84	0.84	0.83	0.85	0.70	3.53				
NLD	0.87	0.91	0.92	0.80	0.86	0.61	0.85	3.08			
AUS	0.73	0.73	0.72	0.87	0.75	0.68	0.73	0.73	4.70		
IRL	0.73	0.72	0.73	0.87	0.74	0.63	0.76	0.73	0.88	2.45	

RDC		cc1							
	CAN	DEU	DFS	GBR	NOR	NLD	USA		
CAN	6.95								
DEU	0.89	12.57							
DFS	0.77	0.73	12.98						
GBR	0.72	0.77	0.77	0.03					
NOR	0.84	0.76	0.76	0.73	14.58				
NLD	0.74	0.69	0.85	0.68	0.70	4.27			
USA	0.83	0.71	0.83	0.67	0.71	0.91	2.66		

RDC		cc2										
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL	
CAN	6.77											
DEU	0.91	10.05										
DFS	0.85	0.93	13.02									
GBR	0.85	0.82	0.85	4.37								
NOR	0.89	0.86	0.85	0.86	16.16							
NZL	0.65	0.63	0.65	0.69	0.66	6.90						
USA	0.87	0.89	0.86	0.85	0.86	0.69	2.43					
ZAF	0.70	0.81	0.75	0.72	0.70	0.72	0.85	17.96				
NLD	0.91	0.93	0.89	0.84	0.86	0.64	0.88	0.79	3.88			
AUS	0.69	0.71	0.67	0.71	0.66	0.70	0.72	0.77	0.71	4.61		
IRL	0.84	0.83	0.85	0.85	0.86	0.72	0.85	0.84	0.84	0.83	2.45	

RDC		int										
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL	
CAN	6.68											
DEU	0.88	9.40										
DFS	0.88	0.93	13.32									
GBR	0.87	0.87	0.88	4.37								
NOR	0.89	0.89	0.87	0.88	16.16							
NZL	0.63	0.58	0.58	0.67	0.53	6.90						
USA	0.89	0.88	0.88	0.87	0.88	0.68	2.42					
ZAF	0.88	0.87	0.88	0.88	0.90	0.67	0.89	17.96				
NLD	0.90	0.92	0.92	0.90	0.89	0.60	0.87	0.87	3.28			
AUS	0.87	0.87	0.87	0.87	0.88	0.68	0.87	0.88	0.87	4.61		
IRL	0.87	0.87	0.87	0.87	0.88	0.66	0.87	0.87	0.87	0.88	2.45	

^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	74	44	83	77	26
DEA	58	0	180	158	526	113
FRA	38	133	0	67	145	67
USA	71	115	51	0	179	39
CHE	61	432	111	150	0	75
NLD	23	104	55	35	70	0

BSW

common bulls below diagonal  
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	96	89	33	16	109	43	63	86
CHE	75	0	506	83	22	241	53	146	375
DEA	70	403	0	127	29	195	53	179	500
NLD	29	74	115	0	21	46	33	72	104
NZL	14	17	22	15	0	17	15	18	24
USA	98	212	147	40	15	0	52	87	149
GBR	36	38	36	25	11	48	0	43	58
FRA	51	109	133	57	14	60	32	0	159
ITA	69	315	382	83	18	103	39	122	0

BSW

common bulls below diagonal  
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	99	90	33	114	44	66
CHE	77	0	505	82	241	56	153
DEA	71	401	0	125	195	57	190
NLD	29	74	115	0	46	34	77
USA	103	212	147	40	0	55	91
GBR	37	40	38	25	50	0	47
FRA	55	116	146	64	65	37	0

BSW

common bulls below diagonal  
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	83	76	30	15	98	38	58	76
CHE	64	0	497	83	22	298	53	153	375
DEA	60	396	0	126	29	291	52	189	490
NLD	26	74	115	0	21	69	33	77	104
NZL	13	17	22	15	0	26	15	19	24
USA	85	280	254	57	23	0	63	112	198
GBR	32	38	36	25	11	58	0	45	58
FRA	50	116	146	64	15	79	35	0	170
ITA	63	315	377	83	18	137	39	134	0

BSW

-----  
common bulls below diagonal  
common three quarter sib group above diagonal  
CAN DEA NLD NZL USA GBR ITA

---

CAN	0	79	32	16	102	40	80
DEA	62	0	127	29	290	52	600
NLD	29	117	0	21	70	33	110
NZL	14	22	15	0	26	15	24
USA	89	254	60	23	0	63	217
GBR	34	36	25	11	58	0	59
ITA	66	505	90	18	152	39	0

---

GUE

-----  
GUE

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

---

CAN	0	13	3	32	18
GBR	10	0	13	45	28
NZL	2	11	0	9	26
USA	31	42	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	32
GBR	10	0	48
USA	31	45	0

---

GUE

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

---

CAN	0	10	2	31	19
GBR	7	0	13	75	30
NZL	2	11	0	29	27
USA	29	76	28	0	57
AUS	15	24	26	53	0

---

GUE

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

---

CAN	0	10	2	31	19
GBR	7	0	13	75	30
NZL	2	11	0	29	27
USA	29	76	28	0	57
AUS	15	24	26	53	0

---

HOL

-----  
common bulls below diagonal

common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD
CAN	0	850	1678	946	1037	2095	803	668	991
CZE	584	0	1518	979	1045	1140	819	422	1189
DEU	980	1032	0	2240	2163	2156	1345	960	2589
DFS	798	578	1291	0	1417	1199	876	587	1686
FRA	723	595	1062	720	0	1389	1014	579	1665
USA	2250	842	1234	950	749	0	1151	688	1377
POL	617	566	933	604	565	1058	0	359	987
CHE	557	278	785	517	521	613	266	0	754
NLD	892	980	1927	1312	991	1084	757	723	0

HOL

-----  
common bulls below diagonal

common three quarter sib group above diagonal

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	AUS
BEL	0	439	388	725	518	547	538	348	511	761	332	455	270	602	405
CAN	401	0	691	1842	1026	1197	1231	444	1408	1104	558	2209	753	1122	767
CHE	360	580	0	984	586	592	609	358	622	765	343	723	332	588	415
DEU	659	1190	825	0	2316	1864	1850	795	2285	2880	848	2444	1263	2315	1202
DFS	437	858	515	1360	0	1192	1315	657	1356	1693	714	1322	808	1427	891
ESP	542	934	543	1576	960	0	1209	616	1400	1351	615	1365	767	1342	799
GBR	480	1233	559	1251	916	1081	0	843	1390	1520	812	1500	666	1384	992
IRL	326	435	361	687	536	632	870	0	599	801	643	522	279	674	570
ITA	422	1040	547	1314	907	1160	972	511	0	1518	683	1923	867	1626	873
NLD	812	1020	739	2361	1354	1356	1251	749	1125	0	899	1583	910	1761	1058
NZL	249	511	292	622	481	505	686	552	491	806	0	650	312	722	953
USA	391	2371	650	1497	1006	1064	1324	503	1224	1282	564	0	1073	1565	874
POL	192	546	241	832	531	536	400	198	527	658	211	885	0	949	360
FRA	559	790	519	1119	711	1226	840	540	797	1022	411	834	496	0	947
AUS	305	628	337	711	493	588	753	454	526	812	902	702	164	545	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
CAN	0	691	906	1778	1029	1129	1281	80	1412	1113	2249	783
CHE	580	0	420	958	586	596	610	45	622	765	723	358
CZE	630	279	0	1522	971	1054	864	82	1079	1206	1227	808
DEU	1053	780	1028	0	2281	2288	1863	118	2229	2767	2347	1307
DFS	863	515	583	1279	0	1435	1336	112	1356	1692	1326	857
FRA	813	527	597	1090	725	0	1419	105	1632	1776	1570	985
GBR	1294	559	504	1185	931	862	0	102	1428	1560	1564	703
ISR	58	30	62	95	89	57	70	0	105	115	99	63
ITA	1045	547	674	1227	907	814	1003	77	0	1519	1921	906
NLD	1031	739	1004	2140	1353	1045	1283	97	1124	0	1584	971
USA	2428	650	886	1335	1006	848	1406	89	1224	1282	0	1114
POL	575	265	552	891	590	531	434	44	563	731	931	0

HOL

-----

common bulls below diagonal  
common three quarter sib group above diagonal

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS
URY																		
BEL	0	429	388	364	708	518	547	601	538	349	46	511	761	332	564	266	236	485
201																		
CAN	393	0	679	884	1710	1006	1183	1086	1202	434	77	1348	1065	540	2351	727	401	973
531																		
CHE	360	567	0	421	954	587	592	582	609	358	45	619	766	343	845	323	243	514
228																		
CZE	249	598	279	0	1520	972	892	1047	848	399	82	1067	1208	473	1373	754	295	678
359																		
DEU	633	1001	776	1025	0	2260	1834	2259	1811	781	119	2195	2738	832	3032	1193	523	1407
558																		
DFS	437	828	516	583	1268	0	1199	1426	1318	657	113	1343	1698	716	1716	787	468	1064
466																		
ESP	542	909	543	675	1509	966	0	1340	1211	617	101	1402	1356	617	1689	751	476	960
495																		
FRA	553	754	511	585	1048	701	1212	0	1376	674	106	1610	1753	724	2266	931	443	1125
456																		
GBR	480	1199	559	499	1167	917	1081	824	0	843	101	1380	1522	813	1882	651	461	1190
498																		
IRL	326	419	361	274	657	536	632	536	870	0	76	599	802	643	691	273	311	648
287																		
ISR	25	55	30	62	95	89	80	56	67	61	0	105	116	85	124	60	51	80
51																		
ITA	417	968	541	657	1197	892	1157	782	958	510	76	0	1497	678	2281	842	461	1054
534																		
NLD	812	977	739	1004	2103	1356	1359	1009	1252	749	97	1091	0	902	2152	882	463	1257
484																		
NZL	249	491	292	300	593	482	507	406	686	552	71	486	808	0	945	304	333	1062
386																		
USA	444	2445	752	957	1657	1136	1330	1125	1569	609	107	1332	1710	871	0	1082	590	1579
834																		
POL	184	512	230	486	744	515	517	475	389	190	39	502	625	205	858	0	186	495
289																		
ZAF	181	361	196	182	377	334	427	297	394	269	34	344	377	263	549	110	0	436
265																		
AUS	394	910	450	394	901	693	753	723	974	554	54	691	1041	1043	1454	295	367	0
480																		
URY	137	500	165	233	366	311	429	270	392	221	27	363	371	292	1037	212	221	361
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	URY
BEL	0	432	714	514	539	535	347	507	757	330	560	264	234	483	200
CAN	397	0	1762	1011	1181	1210	440	1359	1080	546	2364	729	403	979	534
DEU	647	1113	0	2287	1825	1834	790	2232	2819	842	3103	1210	526	1430	566
DFS	437	838	1333	0	1162	1316	654	1341	1697	714	1713	781	466	1059	462
ESP	540	924	1563	965	0	1190	604	1368	1313	603	1644	721	473	935	488
GBR	480	1212	1234	917	1080	0	840	1378	1526	813	1881	647	459	1189	497
IRL	326	427	679	536	622	868	0	597	800	642	689	269	311	647	284
ITA	417	983	1264	892	1155	957	509	0	1498	678	2278	833	460	1052	531
NLD	814	998	2265	1362	1349	1258	749	1096	0	901	2156	869	461	1256	483
NZL	249	496	613	482	504	686	552	486	809	0	945	304	332	1061	386
USA	444	2473	1794	1136	1326	1569	608	1332	1717	871	0	1074	587	1576	832
POL	184	518	781	515	499	389	189	502	620	205	858	0	184	488	285
ZAF	181	367	386	334	426	394	269	344	378	263	549	109	0	433	265
AUS	394	915	946	693	746	974	553	691	1045	1043	1454	293	366	0	479
URY	137	505	390	311	425	391	221	363	373	292	1037	212	221	361	0

JER

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

	CAN	DFS	USA	NLD
CAN	0	52	237	20
DFS	40	0	90	53
USA	220	69	0	42
NLD	15	50	42	0

-----

JER

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

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	0	56	114	25	129	268	119	8
DFS	41	0	122	74	113	103	93	30
GBR	115	111	0	65	172	165	142	48
NLD	20	67	61	0	60	57	47	24
NZL	131	85	178	52	0	222	325	93
USA	263	83	179	59	247	0	233	32
AUS	119	57	150	42	355	237	0	34
IRL	6	24	50	24	102	34	31	0

-----

JER

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

	CAN	DFS	GBR	NLD	USA
CAN	0	56	115	25	275
DFS	41	0	121	74	102
GBR	115	110	0	64	166
NLD	20	67	61	0	56
USA	269	83	180	59	0

-----

JER

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

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	55	112	25	126	278	108	173	8
DFS	40	0	122	74	113	148	112	107	30
GBR	110	111	0	65	173	194	143	171	48
NLD	19	67	61	0	61	69	62	57	24
NZL	125	85	178	53	0	322	181	380	93
USA	269	115	214	73	395	0	264	431	39
ZAF	105	88	148	58	191	272	0	204	31
AUS	162	69	179	50	411	460	191	0	46
IRL	6	24	50	24	102	41	32	42	0

-----

JER

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

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	56	113	25	128	281	110	175	8
DFS	41	0	122	77	113	148	112	107	30
GBR	112	111	0	69	173	194	143	171	48
NLD	21	71	65	0	64	74	65	59	25
NZL	129	85	178	57	0	322	181	380	93
USA	275	115	214	79	395	0	264	431	39
ZAF	108	88	148	62	191	272	0	204	31
AUS	166	69	179	52	411	460	191	0	46
IRL	6	24	50	24	102	41	32	42	0

RDC

common bulls below diagonal  
common three quarter sib group above diagonal  
CAN DEU DFS NOR USA NLD

CAN	0	10	121	5	82	4
DEU	9	0	42	13	13	11
DFS	121	32	0	123	123	40
NOR	5	13	94	0	54	27
USA	77	13	114	55	0	26
NLD	4	11	38	26	24	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	11	117	61	5	56	112	5	54	3
DEU	10	0	48	12	14	13	15	11	20	4
DFS	118	38	0	85	108	153	134	40	137	13
GBR	62	11	82	0	37	58	74	24	48	16
NOR	5	14	79	38	0	39	61	27	34	45
NZL	57	13	148	56	37	0	75	13	101	8
USA	108	15	126	71	61	76	0	28	55	19
NLD	5	11	39	22	26	13	26	0	12	7
AUS	53	19	117	45	29	103	53	10	0	8
IRL	3	4	9	15	44	8	19	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	117	63	5	5	112
DEU	9	0	46	11	14	11	14
DFS	118	36	0	86	109	40	132
GBR	64	10	83	0	37	24	76
NOR	5	14	80	38	0	27	60
NLD	5	11	39	22	26	0	28
USA	108	14	125	72	60	26	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	113	57	4	54	135	67	4	59	3
DEU	7	0	45	11	13	12	15	1	11	35	4
DFS	114	35	0	85	104	153	155	52	40	170	13
GBR	57	10	82	0	37	59	87	38	24	65	16
NOR	4	13	75	38	0	39	63	0	26	51	45
NZL	55	12	148	57	37	0	102	35	13	122	8
USA	137	15	152	87	64	103	0	67	30	105	20
ZAF	72	1	51	36	0	33	62	0	2	37	2
NLD	4	11	39	22	25	13	28	2	0	21	7
AUS	58	34	145	62	42	124	104	37	19	0	11
IRL	3	4	9	15	44	8	20	2	6	10	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	113	58	4	54	135	67	5	59	3
DEU	8	0	48	12	13	13	16	2	11	36	4
DFS	114	38	0	85	104	153	155	52	40	170	13
GBR	58	11	82	0	37	59	87	38	24	65	16
NOR	4	13	75	38	0	39	63	0	28	51	45
NZL	55	13	148	57	37	0	102	35	13	122	8
USA	137	16	151	87	63	103	0	67	33	105	20
ZAF	72	2	51	36	0	33	62	0	2	37	2
NLD	5	11	39	22	27	13	30	2	0	21	7
AUS	58	35	145	62	42	124	104	37	19	0	11
IRL	3	4	9	15	44	8	20	2	6	10	0

-----