

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	CR=Heifers' Conception rate CF=Interval from Calving to First Service (ICF), days

	T3=C1	NR=Non Return Rate after 56 Days (NRR), %
	T4=C2	FL=Interval from first to last insemination cows
CZE	T1=HC	CR=Heifers' Conception rate (pregnant or not after 3 months)
	T3=C1	CR=Cows' Conception rate (pregnant or not after 3 months)
	T4=C2	CR=Cows' Conception rate (pregnant or not after 3 months)
AUT/DEU	T1=HC	NR=Heifers' Non Return Rate after 56 days
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	NR=Cows' Non Return Rate after 56 days
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
DFS	T1=HC	CR=Heifers' Conception rate for maiden heifers
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	CR=Cows' conception rate for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
ESP	T2=CY	DO=Days open
	T4=C2	DO=Days open
	T5=IT	DO=Days open
FRA	T1=HC	CR=Heifers' Conception rate (binary trait) for maiden heifers
	T2=CY	Interval between calving and first AI
	T3=C1	CR=Cows' Conception rate (binary trait) for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	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:

NOR RDC Some EDC/Rel changes due to the rolling definition of hys

AUS ALL Some pedigree changes leading to a type of proof change for some bulls

POL HOL Data edits causing some decrease in information for some bulls

DEU HOL/RDC Change in publication rules

ITA HOL Decrease in information due to editing system applied

GBR ALL Some decrease in information due to changes applied by data providers

CHE ALL Base change
Some decrease in information due to the continuous work on the raw data
by herd-book organizations and to the merge of two data bases (HOL-CHE and SIM-CHE)

ESP HOL Base change

CZE HOL Cut off one year of data

USA ALL Fertility edits accept or reject data for each herd-year base on the properties of that year.
In August, stats from the current year become available and cause some herds and daughters to
be dropped if the herd is no longer sending sufficient data for the given trait. Some missing
bulls for HOL as they have fallen below the treshold of 10 herds.

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 (August Routine Evaluation 2018).
 Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		122	7741	1568	660	
BEL			1740			
CAN	135	40	8653	483	511	
CHE	2665		3132			
CZE			3717			
DEA	5314					
DEU			26053		357	
DFS			15642	2330	9702	
ESP			4955			
EST						
FRA	363		15894			
FRM						
GBR	85	219	6368	529	372	
HUN						
IRL			2680	170	60	
ISR			1336			
ITA	1712		8922			
JPN						
KOR						
LTU						
LVA						
NLD	180		14812	133	71	
NOR					3921	
NZL	52	58	7348	4499	1294	
POL			6912			
PRT						
SVK						
SVN						
URY			1420			
USA	1056	744	37329	4417	683	
ZAF			1213	671	143	
HRV						
MEX						
CAM						
=====						
No. Records	11562	1183	175867	14800	17774	
Pub. Proofs	10692	979	144354	12524	16589	0

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

BSW hco

	CAN	DEA	FRA	USA	CHE	NLD			
CAN	9.07								
DEA	0.87	9.75							
FRA	0.81	0.83	0.91						
USA	0.80	0.84	0.90	2.76					
CHE	0.93	0.94	0.88	0.88	13.07				
NLD	0.79	0.72	0.87	0.88	0.88	3.55			

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	7.24								
CHE	0.85	11.24							
DEA	0.85	0.94	14.26						
NLD	0.87	0.88	0.85	3.57					
NZL	0.62	0.66	0.76	0.64	10.84				
USA	0.85	0.85	0.85	0.85	0.62	3.23			
GBR	0.75	0.76	0.75	0.80	0.65	0.83	3.91		
FRA	0.86	0.96	0.93	0.91	0.65	0.86	0.79	1.78	
ITA	0.85	0.85	0.84	0.86	0.69	0.85	0.80	0.87	18.64

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA		
CAN	7.55								
CHE	0.78	11.82							
DEA	0.79	0.96	11.01						
NLD	0.73	0.69	0.67	3.56					
USA	0.74	0.67	0.67	0.91	2.81				
GBR	0.73	0.82	0.79	0.68	0.67	0.04			
FRA	0.71	0.69	0.67	0.89	0.92	0.68	0.96		

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.49								
CHE	0.73	11.06							
DEA	0.83	0.92	11.70						
NLD	0.88	0.85	0.85	3.33					
NZL	0.64	0.54	0.65	0.64	6.98				
USA	0.85	0.83	0.85	0.88	0.65	2.28			
GBR	0.82	0.78	0.85	0.83	0.69	0.85	3.91		
FRA	0.84	0.87	0.87	0.83	0.64	0.85	0.83	0.96	
ITA	0.85	0.70	0.85	0.85	0.65	0.88	0.86	0.85	23.66

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA		
CAN	7.08								
DEA	0.88	13.58							
NLD	0.89	0.87	3.27						
NZL	0.59	0.67	0.65	6.85					
USA	0.90	0.87	0.87	0.57	2.28				
GBR	0.87	0.88	0.90	0.66	0.87	3.91			
ITA	0.88	0.93	0.88	0.65	0.89	0.88	17.98		

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.16				
GBR	0.75	5.09			
NZL	0.61	0.65	11.72		
USA	0.84	0.86	0.62	3.31	
AUS	0.73	0.87	0.70	0.74	6.96

GUE ccl

	CAN	GBR	USA
CAN	7.15		
GBR	0.72	0.03	
USA	0.80	0.74	3.44

GUE cc2

	CAN	GBR	NZL	USA	AUS
CAN	6.79				
GBR	0.84	5.09			
NZL	0.64	0.70	7.51		
USA	0.85	0.85	0.65	2.55	
AUS	0.71	0.72	0.75	0.79	6.82

GUE int

	CAN	GBR	NZL	USA	AUS
CAN	7.20				
GBR	0.87	5.09			
NZL	0.59	0.65	7.51		
USA	0.91	0.87	0.61	2.55	
AUS	0.87	0.87	0.73	0.87	6.82

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD
CAN	7.82								
CZE	0.78	17.64							
DEU	0.93	0.80	15.10						
DFS	0.82	0.85	0.88	13.67					
FRA	0.82	0.87	0.82	0.87	0.84				
USA	0.84	0.88	0.87	0.89	0.91	2.39			
POL	0.79	0.67	0.78	0.78	0.67	0.68	19.08		
CHE	0.96	0.87	0.93	0.84	0.87	0.88	0.70	13.90	
NLD	0.81	0.87	0.78	0.83	0.87	0.88	0.68	0.86	4.13

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	AUS
BEL	4.72														
CAN	0.72	6.80													
CHE	0.79	0.84	12.37												
DEU	0.72	0.85	0.89	11.17											
DFS	0.80	0.89	0.95	0.90	11.99										
ESP	0.87	0.80	0.84	0.80	0.83	11.22									
GBR	0.88	0.74	0.77	0.74	0.81	0.89	4.69								
IRL	0.86	0.72	0.72	0.71	0.72	0.87	0.87	3.45							
ITA	0.79	0.85	0.89	0.88	0.91	0.86	0.83	0.72	7.75						
NLD	0.81	0.87	0.92	0.91	0.96	0.82	0.81	0.72	0.88	4.56					
NZL	0.65	0.60	0.62	0.59	0.62	0.63	0.64	0.61	0.70	0.60	8.53				
USA	0.82	0.84	0.84	0.84	0.84	0.83	0.87	0.77	0.84	0.84	0.60	3.25			

POL	0.75	0.89	0.89	0.87	0.89	0.80	0.74	0.71	0.91	0.87	0.62	0.84	14.09						
FRA	0.75	0.86	0.94	0.92	0.94	0.85	0.80	0.72	0.91	0.95	0.62	0.84	0.88	1.19					
AUS	0.86	0.72	0.72	0.71	0.72	0.87	0.86	0.88	0.72	0.72	0.61	0.72	0.71	0.72	4.94				

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL							
CAN	6.79																		
CHE	0.92	11.04																	
CZE	0.83	0.75	15.82																
DEU	0.90	0.94	0.75	14.38															
DFS	0.73	0.72	0.88	0.72	13.18														
FRA	0.73	0.74	0.89	0.68	0.85	1.01													
GBR	0.73	0.77	0.70	0.77	0.70	0.68	0.03												
ISR	0.78	0.71	0.91	0.71	0.84	0.86	0.75	3.16											
ITA	0.85	0.88	0.71	0.94	0.70	0.65	0.76	0.73	0.05										
NLD	0.74	0.71	0.89	0.68	0.93	0.91	0.68	0.88	0.66	4.50									
USA	0.78	0.70	0.95	0.70	0.86	0.89	0.66	0.91	0.71	0.91	2.81								
POL	0.80	0.81	0.65	0.85	0.70	0.64	0.70	0.66	0.87	0.65	0.66	17.17							

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY
BEL	4.72																		
CAN	0.83	6.05																	
CHE	0.79	0.86	11.16																
CZE	0.65	0.84	0.87	15.82															
DEU	0.82	0.92	0.90	0.88	12.95														
DFS	0.83	0.85	0.86	0.81	0.93	13.20													
ESP	0.85	0.86	0.81	0.77	0.87	0.84	11.22												
FRA	0.83	0.86	0.91	0.79	0.88	0.84	0.86	0.98											
GBR	0.89	0.84	0.72	0.64	0.82	0.83	0.87	0.81	4.68										
IRL	0.84	0.83	0.80	0.66	0.82	0.82	0.84	0.82	0.85	3.45									
ISR	0.52	0.62	0.65	0.80	0.73	0.68	0.62	0.65	0.55	0.61	3.16								
ITA	0.84	0.86	0.81	0.81	0.88	0.85	0.92	0.83	0.86	0.84	0.70	17.65							
NLD	0.83	0.91	0.89	0.84	0.93	0.91	0.85	0.85	0.83	0.83	0.70	0.86	4.47						
NZL	0.73	0.64	0.52	0.48	0.62	0.62	0.67	0.61	0.70	0.73	0.46	0.65	0.62	5.41					
USA	0.84	0.85	0.84	0.86	0.89	0.88	0.87	0.85	0.84	0.84	0.73	0.93	0.88	0.65	2.30				
POL	0.83	0.82	0.68	0.62	0.79	0.79	0.85	0.76	0.84	0.81	0.49	0.87	0.80	0.62	0.83	12.99			
ZAF	0.75	0.77	0.79	0.71	0.82	0.78	0.83	0.79	0.80	0.87	0.60	0.87	0.80	0.70	0.87	0.75	16.02		
AUS	0.77	0.72	0.79	0.67	0.72	0.70	0.77	0.79	0.74	0.88	0.58	0.77	0.71	0.70	0.78	0.66	0.84	5.09	
URY	0.84	0.81	0.68	0.59	0.80	0.81	0.83	0.81	0.85	0.84	0.50	0.82	0.81	0.75	0.83	0.86	0.79	0.72	1.45

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA			
BEL	4.72																		
CAN	0.87	6.45																	
DEU	0.86	0.88	12.18																
DFS	0.89	0.90	0.93	13.09															
ESP	0.88	0.88	0.87	0.87	11.22														
GBR	0.88	0.87	0.87	0.90	0.89	4.68													
IRL	0.87	0.87	0.86	0.86	0.87	0.87	3.45												
ITA	0.87	0.89	0.90	0.89	0.95	0.88	0.87	17.65											
NLD	0.91	0.90	0.92	0.94	0.87	0.90	0.87	0.88	4.40										
NZL	0.71	0.58	0.59	0.59	0.64	0.69	0.70	0.67	0.62	5.41									
USA	0.87	0.92	0.88	0.88	0.88	0.87	0.87	0.91	0.87	0.60	2.30								
POL	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.89	0.86	0.66	0.87	12.99							
ZAF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.91	0.87	0.67	0.87	0.85	16.02						
AUS	0.87	0.87	0.86	0.87	0.87	0.86	0.88	0.86	0.86	0.69	0.87	0.86	0.87	5.09					
URY	0.87	0.86	0.86	0.86	0.85	0.87	0.87	0.87	0.87	0.72	0.87	0.87	0.86	0.86	1.45				
FRA	0.74	0.81	0.76	0.76	0.84	0.69	0.74	0.75	0.73	0.44	0.78	0.65	0.75	0.80	0.58	0.98			

JER hco				
	CAN	DFS	USA	NLD
CAN	7.94			
DFS	0.82	17.32		
USA	0.85	0.87	2.70	
NLD	0.79	0.81	0.88	4.30

JER crc								
	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.64							
DFS	0.87	13.99						
GBR	0.73	0.86	4.08					
NLD	0.87	0.91		3.87				
NZL	0.61	0.66	0.67	0.61	6.83			
USA	0.84	0.84	0.84	0.85	0.63	3.71		
AUS	0.72	0.73	0.87	0.73	0.61	0.73	3.68	
IRL	0.74	0.73	0.87	0.73	0.62	0.76	0.88	1.88

JER ccl					
	CAN	DFS	GBR	NLD	USA
CAN	6.61				
DFS	0.73	15.48			
GBR	0.73	0.71	0.03		
NLD	0.73	0.89	0.67	3.42	
USA	0.75	0.87	0.67	0.91	2.89

JER cc2									
	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.50								
DFS	0.85	16.10							
GBR	0.85	0.84	4.08						
NLD	0.90	0.89	0.83	3.58					
NZL	0.65	0.64	0.72	0.64	4.36				
USA	0.85	0.87	0.85	0.87	0.67	2.54			
ZAF	0.71	0.73	0.77	0.79	0.72	0.86	11.04		
AUS	0.67	0.72	0.70	0.70	0.70	0.69	0.77	3.70	
IRL	0.84	0.84	0.85	0.84	0.68	0.85	0.74	0.77	1.88

JER int									
	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.31								
DFS	0.88	15.87							
GBR	0.87	0.88	4.08						
NLD	0.89	0.91	0.89	3.61					
NZL	0.62	0.65	0.72	0.61	4.36				
USA	0.89	0.87	0.87	0.87	0.65	2.54			
ZAF	0.87	0.87	0.87	0.87	0.70	0.87	11.04		
AUS	0.87	0.87	0.87	0.87	0.66	0.87	0.87	3.70	
IRL	0.86	0.86	0.86	0.87	0.47	0.86	0.86	0.87	1.88

RDC hco						
	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.14					
DEU	0.91	14.51				

DFS	0.84	0.83	12.34			
NOR	0.86	0.83	0.80	15.77		
USA	0.86	0.85	0.90	0.75	2.56	
NLD	0.81	0.78	0.81	0.72	0.88	4.56

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	6.24									
DEU	0.85	9.98								
DFS	0.87	0.90	12.87							
GBR	0.75	0.75	0.77	4.40						
NOR	0.90	0.87	0.90	0.75	15.02					
NZL	0.61	0.62	0.61	0.65	0.64	10.57				
USA	0.84	0.84	0.84	0.82	0.85	0.70	3.39			
NLD	0.87	0.91	0.92	0.80	0.86	0.61	0.85	3.05		
AUS	0.73	0.73	0.73	0.87	0.75	0.68	0.74	0.73	4.70	
IRL	0.73	0.73	0.74	0.87	0.74	0.63	0.77	0.73	0.88	2.60

RDC ccl

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	6.85						
DEU	0.89	13.17					
DFS	0.77	0.74	12.99				
GBR	0.73	0.78	0.78	0.03			
NOR	0.84	0.78	0.76	0.74	14.78		
NLD	0.74	0.70	0.86	0.69	0.70	4.08	
USA	0.82	0.71	0.83	0.67	0.70	0.91	2.60

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.72										
DEU	0.91	10.54									
DFS	0.85	0.93	13.01								
GBR	0.85	0.83	0.85	4.38							
NOR	0.89	0.87	0.85	0.86	15.90						
NZL	0.65	0.64	0.65	0.68	0.66	6.81					
USA	0.87	0.89	0.86	0.85	0.86	0.70	2.31				
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	3.73		
AUS	0.69	0.71	0.67	0.70	0.66	0.70	0.72	0.77	0.71	4.60	
IRL	0.84	0.84	0.85	0.85	0.86	0.72	0.85	0.85	0.84	0.83	2.60

RDC int

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.69										
DEU	0.88	10.54									
DFS	0.88	0.94	13.31								
GBR	0.87	0.87	0.89	4.38							
NOR	0.89	0.89	0.87	0.88	15.90						
NZL	0.65	0.58	0.59	0.67	0.54	6.81					
USA	0.90	0.89	0.87	0.87	0.88	0.69	2.30				
ZAF	0.88	0.87	0.88	0.88	0.90	0.68	0.89	17.96			
NLD	0.90	0.92	0.92	0.90	0.89	0.61	0.87	0.87	3.27		
AUS	0.87	0.87	0.87	0.87	0.88	0.68	0.87	0.88	0.88	4.60	
IRL	0.87	0.87	0.87	0.87	0.88	0.66	0.87	0.88	0.87	0.88	2.60

^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	77	45	87	81	27
DEA	62	0	183	158	541	120
FRA	39	134	0	67	148	68
USA	76	116	51	0	182	41
CHE	64	447	111	151	0	78
NLD	24	113	56	37	75	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	101	94	34	18	118	43	64	90
CHE	78	0	518	87	25	244	53	148	381
DEA	74	415	0	134	32	198	53	186	515
NLD	30	80	123	0	23	48	33	72	107
NZL	16	20	25	17	0	19	16	20	26
USA	106	213	151	44	16	0	52	87	150
GBR	37	39	37	26	13	49	0	43	58
FRA	53	111	136	58	16	60	33	0	161
ITA	72	319	396	85	19	104	40	124	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	100	94	35	119	44	67
CHE	78	0	513	85	245	56	154
DEA	75	410	0	132	198	57	197
NLD	31	79	123	0	48	34	78
USA	107	213	150	44	0	55	91
GBR	38	41	39	26	51	0	47
FRA	56	117	150	65	65	38	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	77	31	15	104	39	59	78
CHE	65	0	507	87	25	301	53	154	381
DEA	61	407	0	133	32	295	52	195	505
NLD	27	80	123	0	23	71	33	78	107
NZL	13	20	25	17	0	28	16	21	26
USA	90	281	258	60	24	0	63	112	200
GBR	33	39	37	26	13	59	0	45	58
FRA	51	117	149	65	17	79	36	0	173
ITA	64	319	390	85	19	137	40	136	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
--	-----	-----	-----	-----	-----	-----	-----

CAN	0	82	33	16	108	41	84
DEA	65	0	134	32	294	52	616
NLD	30	125	0	23	72	33	112
NZL	14	25	17	0	28	16	26
USA	94	258	63	24	0	63	218
GBR	35	37	26	13	59	0	59
ITA	69	518	92	19	152	40	0

GUE

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	13	3	33	18
GBR	10	0	13	47	28
NZL	2	11	0	9	26
USA	32	44	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	34
GBR	10	0	50
USA	33	47	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	77	30
NZL	2	11	0	29	26
USA	29	78	28	0	55
AUS	15	24	25	52	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	77	30
NZL	2	11	0	29	26
USA	29	78	28	0	55
AUS	15	24	25	52	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD
CAN	0	878	1870	1020	1079	2211	872	703	1042
CZE	616	0	1609	1016	1071	1182	861	428	1219
DEU	1341	1161	0	2401	2278	2430	1511	1045	2828
DFS	898	615	1511	0	1465	1277	956	618	1782

FRA	764	618	1189	757	0	1441	1080	600	1709
USA	2417	897	1675	1042	797	0	1236	729	1439
POL	696	609	1147	683	625	1180	0	383	1057
CHE	593	282	909	542	540	653	286	0	774
NLD	964	1021	2287	1430	1035	1168	833	741	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	624	527	1065	709	759	739	458	705	1068	449	667	401	817	530
CAN	614	0	724	1964	1109	1248	1287	471	1477	1161	596	2352	801	1173	767
CHE	529	619	0	1044	618	611	628	370	639	793	367	770	353	607	415
DEU	1076	1384	898	0	2466	1943	1939	840	2361	3088	908	2643	1342	2400	1217
DFS	645	965	544	1532	0	1251	1367	681	1411	1806	751	1419	875	1483	896
ESP	808	989	561	1674	1008	0	1250	637	1434	1399	642	1446	817	1383	801
GBR	710	1310	576	1362	976	1117	0	877	1424	1570	852	1577	709	1424	995
IRL	450	463	374	735	562	653	908	0	618	825	674	552	305	697	573
ITA	655	1124	568	1420	984	1201	1013	531	0	1542	703	2018	923	1626	848
NLD	1204	1103	764	2670	1498	1414	1310	775	1182	0	944	1649	959	1807	1059
NZL	368	547	307	684	516	530	724	581	508	849	0	693	340	754	956
USA	618	2582	685	1750	1117	1131	1421	529	1331	1375	616	0	1147	1625	878
POL	321	607	259	922	594	578	440	223	568	707	238	993	0	991	364
FRA	794	838	537	1205	751	1269	868	560	822	1068	435	880	535	0	949
AUS	409	628	338	725	500	589	754	454	520	813	906	702	166	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	723	937	1968	1117	1164	1339	83	1481	1170	2396	830
CHE	619	0	432	1044	618	610	634	46	639	793	770	378
CZE	666	287	0	1614	1016	1077	897	86	1099	1247	1277	836
DEU	1370	895	1162	0	2470	2398	1996	126	2350	3080	2621	1433
DFS	970	544	628	1525	0	1480	1399	115	1413	1806	1424	923
FRA	850	543	620	1213	756	0	1448	105	1623	1811	1610	1030
GBR	1379	576	534	1400	1003	889	0	105	1464	1601	1653	743
ISR	63	31	68	107	92	60	74	0	108	119	103	65
ITA	1127	568	704	1414	984	835	1042	81	0	1543	2016	961
NLD	1114	764	1051	2659	1497	1084	1346	101	1181	0	1650	1022
USA	2639	685	939	1722	1117	887	1521	95	1331	1375	0	1186
POL	639	282	583	1049	653	576	472	46	608	788	1043	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	614	527	506	1057	710	759	807	739	459	60	701	1068	449	822	393	303	644	272
CAN	600	0	711	915	1902	1083	1233	1113	1259	458	80	1400	1129	578	2511	775	407	1046	561
CHE	529	601	0	433	1041	619	611	596	628	370	46	637	794	367	896	342	249	535	248
CZE	380	634	287	0	1612	1017	929	1071	883	419	86	1091	1250	501	1421	787	299	705	393
DEU	1065	1299	888	1151	0	2453	1948	2362	1932	840	128	2290	3053	904	3382	1309	542	1522	622
DFS	645	932	545	628	1511	0	1258	1469	1371	681	116	1391	1811	753	1814	853	477	1118	508
ESP	808	960	561	700	1669	1014	0	1382	1252	638	105	1435	1404	644	1773	805	482	1007	512
FRA	780	782	528	608	1163	726	1256	0	1413	699	107	1600	1785	752	2301	972	449	1154	486
GBR	710	1273	576	529	1349	977	1117	850	0	877	105	1410	1572	853	1958	694	469	1225	531
IRL	450	444	374	291	734	562	653	555	908	0	77	616	826	674	720	295	317	670	304
ISR	39	60	31	68	107	92	82	58	72	62	0	106	120	87	128	62	51	83	57
ITA	648	1040	565	689	1363	960	1200	798	998	528	78	0	1518	699	2306	894	458	1076	553
NLD	1204	1060	764	1051	2597	1500	1417	1039	1311	775	101	1145	0	947	2218	932	470	1299	517

NZL	368	526	307	329	677	517	532	429	724	581	73	500	851	0	989	330	339	1102	410
USA	703	2685	789	1008	2086	1252	1406	1152	1668	634	113	1411	1804	924	0	1155	595	1667	881
POL	308	568	247	520	874	571	565	514	426	212	41	541	671	230	959	0	191	530	316
ZAF	248	368	202	187	399	341	434	304	402	275	34	349	384	269	557	119	0	441	274
AUS	545	989	471	418	1033	742	785	746	1014	571	56	727	1080	1085	1566	324	374	0	519
URY	195	517	176	250	426	327	441	277	413	226	30	375	383	316	1080	228	223	388	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	FRA
BEL	0	617	1055	710	759	739	459	700	1069	449	822	392	303	644	272	807
CAN	605	0	1908	1089	1240	1268	465	1410	1145	584	2524	778	409	1053	566	1123
DEU	1064	1308	0	2451	1947	1932	840	2290	3060	904	3379	1305	541	1522	622	2361
DFS	645	942	1509	0	1257	1370	681	1390	1812	753	1813	853	476	1118	508	1469
ESP	808	976	1669	1014	0	1252	638	1435	1406	644	1771	805	481	1006	512	1381
GBR	710	1287	1349	977	1117	0	877	1410	1578	853	1958	694	468	1225	531	1413
IRL	450	453	734	562	653	908	0	616	829	674	720	295	317	670	304	699
ITA	648	1055	1363	960	1200	998	528	0	1521	699	2306	893	458	1076	553	1600
NLD	1209	1081	2611	1507	1426	1317	778	1150	0	947	2225	934	470	1301	519	1787
NZL	368	531	677	517	532	724	581	500	852	0	989	330	338	1102	410	752
USA	703	2714	2086	1252	1406	1668	634	1411	1811	924	0	1154	594	1667	881	2301
POL	308	573	872	571	565	426	212	541	672	230	959	0	191	530	316	972
ZAF	248	374	399	341	434	402	275	349	385	269	557	119	0	440	274	449
AUS	545	994	1033	742	785	1014	571	727	1086	1085	1566	324	374	0	519	1154
URY	195	523	426	327	441	413	226	375	386	316	1080	228	223	388	0	486
FRA	780	793	1163	726	1256	850	555	798	1045	429	1152	514	304	746	277	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	55	249	20
DFS	43	0	93	54
USA	232	72	0	43
NLD	14	51	43	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	0	60	117	27	132	288	119	10
DFS	46	0	125	78	115	108	94	37
GBR	117	115	0	68	181	170	142	57
NLD	21	72	63	0	62	60	47	29
NZL	134	88	187	54	0	229	326	104
USA	285	88	184	62	253	0	232	35
AUS	119	58	150	42	358	235	0	34
IRL	8	32	59	29	116	37	31	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	60	121	27	297
DFS	46	0	127	78	107
GBR	119	116	0	67	174
NLD	21	72	63	0	59

USA 293 88 187 62 0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	59	115	27	129	298	112	180	10
DFS	45	0	125	78	115	153	115	112	37
GBR	113	115	0	68	182	199	145	176	57
NLD	20	72	63	0	63	73	64	59	29
NZL	129	88	187	55	0	330	182	395	104
USA	287	120	219	77	403	0	270	441	42
ZAF	109	92	149	59	193	277	0	209	33
AUS	169	76	185	51	428	471	197	0	50
IRL	8	32	59	29	116	44	34	47	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	60	116	27	131	301	114	182	10
DFS	46	0	125	82	115	153	115	112	37
GBR	115	115	0	72	182	199	145	176	57
NLD	22	77	67	0	66	78	67	61	30
NZL	132	88	187	59	0	330	182	395	104
USA	292	120	219	83	403	0	270	441	42
ZAF	111	92	149	63	193	277	0	209	33
AUS	172	76	185	53	428	471	197	0	50
IRL	8	32	59	29	116	44	34	47	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	13	128	5	83	4
DEU	12	0	57	17	19	12
DFS	129	46	0	129	130	42
NOR	5	16	100	0	55	29
USA	78	18	121	55	0	28
NLD	4	12	39	29	27	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	14	128	62	5	59	117	5	54	3
DEU	13	0	60	18	16	19	22	12	22	6
DFS	129	50	0	91	116	155	145	44	137	16
GBR	63	17	86	0	42	62	77	28	48	18
NOR	5	16	86	44	0	40	61	33	34	50
NZL	59	19	150	59	38	0	78	15	101	9
USA	113	22	136	73	61	79	0	30	54	23
NLD	5	12	42	27	33	15	29	0	12	9
AUS	53	21	117	45	29	103	52	10	0	8
IRL	3	6	11	17	49	9	23	9	7	0

RDC

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

CAN	0	14	129	64	5	5	118
DEU	13	0	60	18	16	12	22
DFS	130	50	0	92	118	44	144
GBR	65	17	87	0	42	28	78
NOR	5	16	88	44	0	33	61
NLD	5	12	42	27	33	0	30
USA	114	22	137	74	62	29	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	13	125	58	5	58	140	67	5	62	3
DEU	12	0	59	18	15	19	24	2	12	41	6
DFS	126	49	0	91	109	155	166	52	44	176	16
GBR	59	17	86	0	42	63	90	38	28	67	18
NOR	5	15	79	44	0	40	64	0	33	54	50
NZL	58	19	150	60	38	0	104	35	15	125	9
USA	143	24	160	88	64	105	0	67	32	107	25
ZAF	72	2	51	36	0	33	62	0	2	37	2
NLD	5	12	42	27	33	15	31	2	0	23	9
AUS	61	40	150	64	45	127	107	37	21	0	12
IRL	3	6	11	17	49	9	25	2	9	11	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	13	125	59	5	58	140	67	6	62	3
DEU	12	0	59	18	15	19	24	2	12	41	6
DFS	126	49	0	91	109	155	166	52	44	176	16
GBR	60	17	86	0	42	63	90	38	28	67	18
NOR	5	15	79	44	0	40	64	0	35	54	50
NZL	58	19	150	60	38	0	104	35	15	125	9
USA	143	24	161	88	65	105	0	67	35	107	25
ZAF	72	2	51	36	0	33	62	0	2	37	2
NLD	6	12	42	27	35	15	33	2	0	23	9
AUS	61	40	150	64	45	127	107	37	21	0	12
IRL	3	6	11	17	49	9	25	2	9	11	0

SIM

SIM

SIM

SIM

SIM