Introduction

The latest routine international evaluation for females fertility traits took place as scheduled at the Interbull Centre. Data from seventeen (18) countries were included in this evaluation.

International genetic evaluations for female fertility traits of bulls from Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Netherlands, New Zealand, Norway, Poland, Spain, Sweden, Switzerland, South Africa, the United Kingdom and the United States of America were computed. Brown Swiss, Guernsey, Holstein, Jersey, Red Dairy Cattle and Simmental breed data were included in this evaluation.

Based on a decision made by Interbull Steering committee in August 2007, female fertility traits are classified as follows:

T1 (HC): Maiden (H)eifer's ability to (C)onceive. A measure of confirmed conception, such as conception rate (CR), will be considered for this trait group. In the absence of confirmed conception an alternative measure, such as interval first-last insemination (FL), interval first insemination-conception (FC), number of inseminations (NI), or non-return rate (NR,preferably NR56) can be submitted;

T2 (CR): Lactating (C)ow's ability to (R)ecycle after calving. The interval calving-first insemination (CF) is an example for this ability. In the abscence of such a trait, a measure of the interval calving-conception, such as says oprn (DO) or calving interval (CI) can be submitted;

T3 (C1): Lactating (C)ow's ability to conceive (1), expressed as a rate trait. Traits like conception rate (CR) and non-return rate (NR, preferably NR56) will be considered for this trait group;

T4 (C2): Lactating (C)ow's ability to conceive (2), expressed as an interval trait. The interval first insemination-conception (FC) or interval first-last insemination (FL) will be considered for this trait group. As an alternative, number of inseminations (NI) can be submitted. In the abscence of any of these traits, a measure of interval calving-conception such as days open (DO), or calving interval (CI) can be submitted. All countries are expected to submit data for this trait group, and as a last resort the trait submitted under T3 can be submitted for T4 as well.

T5 (IT): Lactating cow's measurements of (I)nterval (T)raits calving-conception, such as days open (DO) and calving interval (CI).

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

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

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

CHANGES IN NATIONAL PROCEDURES

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

BEL (HOL) : Definition of genetic groups were updated/improved. Genetic groups are always based on selection path, type of breed, degree of Holsteinisation,

origin (North-America vs Europe) and time. Periods of time were updated and improved. Genetic reference base was changed on cows with records born in 2010.

CHE (HOL) : The formerly separate genetic evaluations of HOL-CHR/SIM-CHE and HOL-CHE have been joined to one single evaluation. The main differences are: Use of pooled data, Various changes in data edits, New genetic parameters, first submission of HCO, new definition for CC2 (interval between first and last insemination).

DEA (BSW) Base change

DEU (HOL,RDC) Changed EBV from natural scale to relative breeding values which are now published. For the HCO and CC1, the correlations between the old and new proofs are 1, while for CRC, CC2 and INT the correlations are -1, because our relative breeding values have large values designed as biologically favourable.

DFS (ALL) : New genetic parameters have been recalculated. Model changed from a multitrait Sire model with repeated lactations to a multitrait, multi-lactation Animal Model.

FRA (HOL) : New trait for CC2

GBR (ALL) The major changes are mostly data clean up and correction, so few bulls have become unofficial as herds/daughters have dropped.

ITA (HOL) Base change + delete birthyear=1999

NLD (ALL) Base changed: cow base is now 2010 and bull base is 2008.Re-testing the changes tested in September: First time participation for hco, Conception rate for heifers is sent. For cc1, conception rate is sent instead of non-return56. Parameters are updated for all the traits.

USA (ALL) : Inclusion of young bulls that have daughters measured for HCO but not yet yield, and converted Milking Shorthorns to RDC base. For CC1 and CC2 improved the precision of adjustments for heterosis and inbreeding, and converted Milking Shorthorns to RDC base. For INT improved the precision of adjustments for heterosis and inbreeding.

INTERBULL CHANGES COMPARED TO THE DECEMBER ROUTINE RUN

1) Data submission for pedigree, EBV/PTA, and parameters is possible only through uploading of the data to the Interbull Data Exchange Area (IDEA);
2) Interbull Centre has moved to a completely new MACE evaluation software called "Dairy System for International Evaluation (DAISIE)", partly because of the extended use of IDEA for EBV/PTA, and partly because of our continuous efforts to make the system more effective than before;
3) All trait groups (including conformation traits) are now evaluated in-house.
4) The file containing heritability values now contain more decimal places for heritability, and one extra field for the definition of reference base population;
5) The file containing genetic correlations has changed name from rG_columns_all to cor{RUNID}.csv, and also contains one extra field for the number of common bulls;
6) The file containing sire genetic standard deviations has changed name from sire_std_columns_all to std{RUNID}.csv;
7) Sire-MGS based pedigree files are not distributed anymore;
8) Parent averages in the "ipa" format are not distributed anymore;
9) An import AI bull (type of proof = 21) with official publication status 'Y' from a given country is included in the distribution file if the bull has a first country proof included from a different country OR a second country proof is included with minimum required number of daughters or EDC (20, 10, 150, 20, 20, and 80) and herds (20, 10, 150, 20, 20, and 80) for different breeds (BSW, GUE, HOL, JER, RDC and SIM), respectively;
10) Bulls with some missing pedigree information (sires and/or dam and/or birthdate) are excluded from evaluations;
11) Standardization factors are not used anymore;
12) Post-processing of genetic correlation are now applied to all trait groups.

DATA AND METHOD OF ANALYSIS

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

National proofs were first de-regressed within country and then analysed

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

Table 2 presents the date of evaluation as supplied by each country in the 01x-proof file.

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

SCIENTIFIC LITERATURE

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

International genetic evaluation computation:
- Schaeffer. 1994. J. Dairy Sci. 77:2671-2678
- Klei, 1998. Interbull Bulletin 17:3-7

Verification and Genetic trend validation:
- Klei et al., 2002. Interbull Bulletin 29:178-182.
- Boichard et al., 1995. J. Dairy Sci. 78:431-437

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

De-regression:
- Sigurdsson and G. Banos. 1995. Acta Agric. Scand. 45:207-219
- Jairath et al. 1998. J. Dairy Sci. Vol. 81:550-562

Genetic parameter estimation:
- Klei and Weigel, 1998, Interbull Bulletin 17:8-14
- Sullivan, 1999. Interbull Bulletin 22:146-148

Post-processing of estimated genetic correlations:
- Mark et al., 2003, Interbull Bulletin 30:126-135
- Jorjani et al., 2003. J. Dairy Sci. 86:677-679
- https://wiki.interbull.org/public/rG%20procedure?action=print

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

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

NEXT ROUTINE INTERNATIONAL EVALUATION

Dates for the next routine evaluation can be found on http://www.interbull.org/ib/servicecalendar.

NEXT TEST INTERNATIONAL EVALUATION

Dates for the next test run can be found on http://www.interbull.org/ib/servicecalendar.

PUBLICATION OF INTERBULL TEST RUN

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

^LTable 1. National evaluation data considered in the Interbull
evaluation for fertility (April Routine Evaluation 2015).
Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
ARG						
AUS		115	7012	1434	589	
BEL			982			
CAN	115	35	7048	345	415	
CHE	2479		2675			
CZE			3238			
DEA	4934					
DEU			23121		310	
DFS			14170	2035	8765	
ESP			2582			
EST						
FRA	310		14470			
FRM						
FRR			161			
GBR	68	201	5493	459	293	
HUN						
IRL			2137	103	45	
ISR			1149			
ITA	1425		8537			
JPN						
KOR						
LTU						
LVA						
NLD	144		13330	112	53	
NOR					3497	
NZL	41	55	6481	3978	1156	
POL			5304			
PRT						
SVK						
SVN						
URY						
USA	950	702	32752	3714	590	
ZAF		31	1128	613	134	
HRV						
No.Records	10466	1139	151770	12793	15847	
Pub. Proofs	9972	947	132143	10934	14976	0

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

BSW hco

	CAN	CHE	DEA	FRA	NLD	USA
CAN	8.22					
CHE	0.77	12.94				
DEA	0.83	0.91	11.84			
FRA	0.65	0.86	0.67	0.94		
NLD	0.77	0.75	0.73	0.78	3.60	
USA	0.69	0.80	0.80	0.83	0.76	2.73

BSW crc

	CAN	CHE	DEA	FRA	GBR	ITA	NLD	NZL	USA
CAN	6.80								
CHE	0.86	11.07							
DEA	0.86	0.94	14.67						
FRA	0.86	0.96	0.91	1.70					
GBR	0.78	0.81	0.86	0.82	3.96				
ITA	0.86	0.86	0.85	0.88	0.84	14.42			
NLD	0.87	0.88	0.86	0.91	0.81	0.87	3.69		
NZL	0.56	0.59	0.55	0.58	0.62	0.63	0.56	9.32	
USA	0.85	0.87	0.85	0.88	0.87	0.86	0.86	0.54	3.35

BSW cc1

	CAN	CHE	DEA	FRA	GBR	NLD	USA
CAN	7.37						
CHE	0.74	11.92					
DEA	0.79	0.96	11.57				
FRA	0.63	0.62	0.57	0.94			
GBR	0.62	0.80	0.78	0.64	0.04		
NLD	0.67	0.65	0.56	0.73	0.66	3.93	
USA	0.73	0.64	0.63	0.89	0.59	0.87	2.95

BSW cc2

	CAN	CHE	DEA	FRA	GBR	ITA	NLD	NZL	USA
CAN	6.54								
CHE	0.66	10.99							
DEA	0.84	0.81	13.54						
FRA	0.74	0.77	0.82	0.94					
GBR	0.70	0.58	0.77	0.70	3.96				
ITA	0.73	0.52	0.82	0.62	0.86	16.37			
NLD	0.84	0.71	0.85	0.71	0.74	0.76	3.73		
NZL	0.48	0.36	0.46	0.39	0.65	0.60	0.47	6.67	
USA	0.77	0.80	0.83	0.77	0.85	0.88	0.83	0.60	2.41

BSW int

	CAN	DEA	GBR	ITA	NLD	NZL	USA
CAN	6.40						
DEA	0.86	11.45					
GBR	0.86	0.87	3.96				
ITA	0.86	0.92	0.88	15.62			
NLD	0.86	0.86	0.89	0.87	3.49		
NZL	0.62	0.61	0.62	0.62	0.61	6.67	
USA	0.88	0.85	0.85	0.88	0.85	0.60	2.41

GUE crc

	AUS	CAN	GBR	NZL	USA
AUS	6.96				
CAN	0.71	7.25			
GBR	0.85	0.74	4.41		
NZL	0.68	0.57	0.62	11.48	
USA	0.71	0.85	0.85	0.54	3.37

GUE cc1

	CAN	GBR	USA
CAN	6.62		
GBR	0.67	0.03	
USA	0.78	0.72	3.42

GUE cc2

	AUS	CAN	GBR	NZL	USA	ZAF
AUS	6.96					
CAN	0.71	6.53				
GBR	0.85	0.70	4.41			
NZL	0.72	0.41	0.66	8.19		
USA	0.86	0.81	0.85	0.61	2.68	
ZAF	0.86	0.77	0.87	0.65	0.90	13.75

GUE int

	AUS	CAN	GBR	NZL	USA	ZAF
AUS	6.96					
CAN	0.86	6.20				
GBR	0.86	0.85	4.41			
NZL	0.69	0.60	0.62	8.19		
USA	0.87	0.89	0.85	0.60	2.68	
ZAF	0.88	0.86	0.87	0.64	0.91	13.75

HOL hco

	CAN	CHE	CZE	DEU	DFS	FRA	FRR	NLD	POL	USA
CAN	7.32									
CHE	0.95	13.73								
CZE	0.75	0.77	17.59							
DEU	0.88	0.94	0.80	14.82						
DFS	0.89	0.93	0.85	0.93	16.00					
FRA	0.74	0.81	0.83	0.81	0.83	0.85				
FRR	0.71	0.67	0.70	0.54	0.63	0.73	0.79			
NLD	0.79	0.73	0.78	0.80	0.77	0.82	0.71	4.12		
POL	0.69	0.72	0.55	0.75	0.67	0.54	0.57	0.66	18.32	
USA	0.77	0.84	0.90	0.85	0.84	0.91	0.73	0.80	0.52	2.41

HOL crc

	AUS	BEL	CAN	CHE	DEU	DFS	ESP	FRA	FRR	GBR	IRL	ITA	NLD
NZL	POL	USA											
AUS	4.93												
BEL	0.85	4.63											
CAN	0.70	0.72	6.65										
CHE	0.70	0.79	0.85	12.29									
DEU	0.70	0.70	0.86	0.88	11.06								
DFS	0.70	0.81	0.88	0.93	0.90	11.98							
ESP	0.85	0.85	0.74	0.76	0.76	0.76	11.32						
FRA	0.70	0.75	0.87	0.93	0.92	0.93	0.79	1.18					
FRR	0.70	0.73	0.83	0.80	0.91	0.82	0.72	0.85	1.49				
GBR	0.85	0.87	0.74	0.76	0.74	0.81	0.91	0.80	0.71	4.75			
IRL	0.88	0.85	0.70	0.70	0.70	0.70	0.85	0.70	0.70	0.85	3.70		
ITA	0.70	0.78	0.85	0.89	0.90	0.92	0.86	0.92	0.82	0.83	0.70	8.16	
NLD	0.70	0.81	0.86	0.91	0.91	0.95	0.76	0.95	0.90	0.80	0.70	0.88	4.76
NZL	0.60	0.66	0.56	0.62	0.56	0.61	0.63	0.59	0.57	0.63	0.60	0.68	0.56
8.35													
POL	0.69	0.73	0.88	0.90	0.86	0.89	0.75	0.87	0.84	0.71	0.70	0.89	0.85
0.59	13.85												
USA	0.70	0.81	0.85	0.85	0.85	0.85	0.89	0.85	0.80	0.87	0.77	0.85	0.85
0.54	0.84	3.25											

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	FRR	GBR	ISR	ITA	NLD	POL	USA
CAN	6.58												
CHE	0.89	10.98											
CZE	0.77	0.74	18.16										
DEU	0.81	0.93	0.72	13.78									
DFS	0.80	0.91	0.67	0.90	13.41								
FRA	0.71	0.72	0.87	0.65	0.63	1.00							
FRR	0.54	0.48	0.51	0.52	0.49	0.54	1.09						
GBR	0.65	0.75	0.65	0.76	0.75	0.67	0.50	0.03					
ISR	0.65	0.62	0.80	0.64	0.68	0.79	0.56	0.69	3.11				
ITA	0.76	0.87	0.69	0.93	0.87	0.61	0.47	0.73	0.68	0.05			
NLD	0.71	0.68	0.78	0.69	0.66	0.80	0.69	0.68	0.77	0.66	4.64		
POL	0.70	0.76	0.50	0.83	0.76	0.51	0.53	0.60	0.53	0.81	0.57	17.67	
USA	0.77	0.70	0.95	0.67	0.66	0.87	0.58	0.62	0.85	0.69	0.88	0.50	2.79

HOL cc2

	AUS	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	FRR	GBR	IRL	ISR	ITA	NLD	NZL	POL	USA	ZAF
AUS	4.97																		
BEL	0.84	4.63																	
CAN	0.70	0.69	6.16																
CHE	0.74	0.74	0.88	11.13															
CZE	0.66	0.63	0.80	0.83	18.16														
DEU	0.71	0.76	0.87	0.91	0.88	12.18													
DFS	0.69	0.80	0.84	0.88	0.78	0.92	12.90												
ESP	0.84	0.86	0.69	0.72	0.64	0.77	0.76	11.31											
FRA	0.77	0.77	0.82	0.91	0.77	0.84	0.80	0.65	0.98										
FRR	0.22	0.39	0.37	0.36	0.38	0.61	0.42	0.30	0.33	1.09									
GBR	0.84	0.89	0.70	0.69	0.60	0.75	0.80	0.92	0.69	0.29	4.75								
IRL	0.87	0.84	0.71	0.74	0.64	0.75	0.73	0.84	0.75	0.30	0.84	3.70							
ISR	0.52	0.48	0.60	0.56	0.75	0.68	0.58	0.49	0.63	0.29	0.49	0.57	3.10						
ITA	0.84	0.85	0.74	0.75	0.74	0.82	0.84	0.94	0.69	0.32	0.88	0.85	0.58	18.09					
NLD	0.70	0.74	0.84	0.87	0.81	0.89	0.88	0.75	0.80	0.52	0.75	0.77	0.64	0.80	4.71				
NZL	0.70	0.71	0.39	0.47	0.46	0.47	0.46	0.67	0.44	0.18	0.66	0.70	0.30	0.62	0.47	5.63			
POL	0.80	0.82	0.67	0.60	0.57	0.69	0.70	0.84	0.57	0.45	0.83	0.77	0.44	0.86	0.69	0.61	13.04		
USA	0.84	0.83	0.82	0.85	0.87	0.88	0.88	0.86	0.79	0.32	0.84	0.84	0.73	0.93	0.86	0.60	0.83	2.30	
ZAF	0.88	0.84	0.75	0.79	0.74	0.85	0.84	0.91	0.79	0.32	0.86	0.88	0.62	0.94	0.82	0.64	0.78	0.91	18.47

HOL int

	AUS	BEL	CAN	DEU	DFS	ESP	FRA	GBR	IRL	ITA	NLD	NZL	POL	USA	ZAF
AUS	4.97														
BEL	0.85	4.63													
CAN	0.85	0.85	6.12												
DEU	0.85	0.85	0.85	10.47											
DFS	0.85	0.90	0.87	0.92	12.85										
ESP	0.85	0.85	0.85	0.88	0.85	11.31									
FRA	0.85	0.85	0.85	0.85	0.85	0.85	0.97								
GBR	0.85	0.88	0.85	0.86	0.90	0.91	0.85	4.75							
IRL	0.87	0.85	0.85	0.85	0.85	0.85	0.85	0.85	3.70						
ITA	0.85	0.85	0.86	0.90	0.90	0.95	0.85	0.88	0.85	18.09					
NLD	0.85	0.91	0.86	0.91	0.93	0.87	0.85	0.89	0.85	0.89	4.59				
NZL	0.63	0.63	0.60	0.60	0.60	0.62	0.60	0.62	0.64	0.62	0.60	5.63			
POL	0.85	0.85	0.85	0.85	0.85	0.86	0.85	0.85	0.86	0.88	0.85	0.62	13.05		
USA	0.85	0.85	0.89	0.86	0.88	0.85	0.85	0.85	0.85	0.92	0.85	0.60	0.85	2.30	
ZAF	0.87	0.85	0.85	0.86	0.86	0.92	0.85	0.85	0.88	0.95	0.86	0.62	0.88	0.91	18.48

JER hco

	CAN	DFS	NLD	USA
CAN	7.57			
DFS	0.84	18.76		
NLD	0.78	0.76	4.11	
USA	0.81	0.84	0.70	2.61

JER crc

	AUS	CAN	DFS	GBR	IRL	NLD	NZL	USA
AUS	3.67							
CAN	0.71	6.38						
DFS	0.71	0.87	13.87					
GBR	0.85	0.72	0.87	4.03				
IRL	0.87	0.72	0.71	0.85	2.05			
NLD	0.71	0.87	0.91	0.77	0.71	4.02		
NZL	0.60	0.52	0.61	0.62	0.60	0.54	6.67	
USA	0.70	0.85	0.85	0.82	0.75	0.86	0.62	3.74

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.70				
DFS	0.69	14.27			
GBR	0.66	0.64	0.03		
NLD	0.68	0.61	0.65	3.64	
USA	0.69	0.72	0.68	0.76	2.85

JER cc2

	AUS	CAN	DFS	GBR	IRL	NLD	NZL	USA	ZAF
AUS	3.63								
CAN	0.71	6.77							
DFS	0.71	0.86	15.99						
GBR	0.85	0.71	0.74	4.03					
IRL	0.87	0.73	0.73	0.85	2.05				
NLD	0.71	0.85	0.88	0.75	0.76	3.83			
NZL	0.66	0.51	0.49	0.68	0.64	0.49	4.45		
USA	0.85	0.76	0.84	0.85	0.86	0.81	0.65	2.58	
ZAF	0.86	0.72	0.75	0.86	0.88	0.76	0.71	0.88	12.78

JER int

	AUS	CAN	DFS	GBR	IRL	NLD	NZL	USA	ZAF
AUS	3.63								
CAN	0.85	6.47							
DFS	0.86	0.87	15.72						
GBR	0.85	0.85	0.88	4.03					
IRL	0.87	0.86	0.86	0.86	2.05				
NLD	0.86	0.86	0.90	0.88	0.86	3.77			
NZL	0.63	0.60	0.62	0.63	0.62	0.61	4.45		
USA	0.85	0.87	0.87	0.85	0.86	0.85	0.63	2.58	
ZAF	0.86	0.86	0.86	0.85	0.87	0.85	0.68	0.89	12.78

RDC hco

	CAN	DEU	DFS	NLD	NOR	USA
CAN	7.05					
DEU	0.86	13.79				
DFS	0.83	0.81	15.63			
NLD	0.80	0.80	0.71	4.71		
NOR	0.83	0.67	0.77	0.72	12.84	
USA	0.82	0.82	0.87	0.75	0.86	2.82

RDC crc

	AUS	CAN	DEU	DFS	GBR	IRL	NLD	NOR	NZL	USA
AUS	4.71									
CAN	0.71	6.28								
DEU	0.71	0.87	9.61							
DFS	0.71	0.86	0.90	12.90						
GBR	0.85	0.73	0.74	0.76	4.27					
IRL	0.88	0.71	0.70	0.71	0.85	2.70				
NLD	0.71	0.87	0.91	0.93	0.79	0.71	2.79			
NOR	0.72	0.90	0.88	0.89	0.74	0.72	0.87	12.24		
NZL	0.62	0.55	0.56	0.53	0.62	0.60	0.57	0.54	10.03	
USA	0.71	0.85	0.85	0.85	0.82	0.77	0.86	0.87	0.65	3.44

RDC cc1

	CAN	DEU	DFS	GBR	NLD	NOR	USA
CAN	6.60						
DEU	0.81	12.28					
DFS	0.81	0.90	14.01				
GBR	0.66	0.76	0.83	0.03			
NLD	0.71	0.70	0.63	0.67	4.33		
NOR	0.79	0.68	0.74	0.74	0.60	12.36	
USA	0.81	0.68	0.68	0.62	0.82	0.66	2.76

RDC cc2

	AUS	CAN	DEU	DFS	GBR	IRL	NLD	NOR	NZL	USA	ZAF
AUS	4.55										
CAN	0.71	6.37									
DEU	0.72	0.88	9.97								
DFS	0.70	0.85	0.93	13.03							
GBR	0.85	0.71	0.75	0.76	4.27						
IRL	0.88	0.72	0.76	0.74	0.85	2.70					
NLD	0.73	0.84	0.88	0.84	0.77	0.79	3.94				
NOR	0.87	0.76	0.74	0.71	0.87	0.86	0.87	13.46			
NZL	0.65	0.50	0.48	0.47	0.64	0.69	0.49	0.61	6.84		
USA	0.85	0.84	0.87	0.86	0.85	0.86	0.86	0.86	0.65	2.39	
ZAF	0.87	0.73	0.86	0.86	0.87	0.89	0.83	0.88	0.66	0.90	19.91

RDC int

	AUS	CAN	DEU	DFS	GBR	IRL	NLD	NOR	NZL	USA	ZAF
AUS	4.55										
CAN	0.86	6.23									
DEU	0.86	0.86	9.14								
DFS	0.85	0.86	0.92	13.29							
GBR	0.86	0.86	0.86	0.88	4.27						
IRL	0.88	0.86	0.85	0.86	0.85	2.70					
NLD	0.86	0.86	0.91	0.92	0.89	0.86	3.16				
NOR	0.87	0.90	0.89	0.86	0.88	0.86	0.87	13.46			
NZL	0.62	0.61	0.61	0.60	0.61	0.62	0.60	0.61	6.84		
USA	0.85	0.89	0.87	0.87	0.85	0.86	0.86	0.86	0.62	2.39	
ZAF	0.86	0.86	0.86	0.91	0.86	0.88	0.86	0.91	0.64	0.89	19.91

^LAPPENDIX II. Number of common bulls

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	FRA	NLD	USA
CAN	0	64	59	39	23	63
CHE	51	0	486	131	67	157
DEA	48	385	0	160	101	134
FRA	34	96	118	0	62	62
NLD	20	63	94	51	0	33
USA	56	131	95	45	30	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	FRA	GBR	ITA	NLD	NZL	USA
CAN	0	81	76	53	38	67	30	15	90
CHE	65	0	485	124	46	311	69	16	221
DEA	64	382	0	155	44	405	112	23	183
FRA	45	89	115	0	35	130	63	15	79
GBR	36	36	33	29	0	44	27	12	46
ITA	56	255	268	95	33	0	85	17	126
NLD	25	63	102	50	23	67	0	16	41
NZL	14	13	18	11	9	13	10	0	14
USA	86	190	138	51	46	83	37	12	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	FRA	GBR	NLD	USA
CAN	0	83	78	60	38	31	93
CHE	67	0	483	135	49	68	221
DEA	65	380	0	169	48	111	183
FRA	52	100	130	0	38	70	87
GBR	36	37	34	33	0	26	49
NLD	26	62	102	58	22	0	41
USA	88	190	138	60	47	37	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	FRA	GBR	ITA	NLD	NZL	USA
CAN	0	75	70	55	38	64	28	14	91
CHE	60	0	474	135	46	311	69	16	280
DEA	59	375	0	168	43	398	111	23	278
FRA	47	100	130	0	37	140	70	16	108
GBR	34	36	33	32	0	44	27	12	56
ITA	53	255	266	106	33	0	85	17	171
NLD	24	63	102	58	23	67	0	16	64
NZL	13	13	18	12	9	13	10	0	22
USA	82	261	247	74	56	114	52	20	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	GBR	ITA	NLD	NZL	USA
CAN	0	70	38	63	29	14	91
DEA	59	0	43	434	112	23	278
GBR	34	33	0	44	27	12	56
ITA	53	283	33	0	86	17	179
NLD	25	104	23	68	0	16	64
NZL	13	18	9	13	10	0	22
USA	82	247	56	118	55	20	0

GUE

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	GBR	NZL	USA
AUS	0	18	28	23	18
CAN	13	0	13	1	30
GBR	22	10	0	13	34
NZL	22	0	11	0	8
USA	15	29	31	6	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	USA
CAN	0	13	30
GBR	10	0	36
USA	29	34	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	GBR	NZL	USA	ZAF
AUS	0	15	29	23	50	5
CAN	11	0	9	0	26	1
GBR	23	6	0	13	67	5
NZL	22	0	11	0	27	3
USA	47	24	68	29	0	10
ZAF	4	1	4	1	6	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	GBR	NZL	USA	ZAF
AUS	0	15	29	23	50	5
CAN	11	0	9	0	26	1
GBR	23	6	0	13	67	5
NZL	22	0	11	0	27	3
USA	47	24	68	29	0	10
ZAF	4	1	4	1	6	0

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HOL
--------
 common bulls below diagonal
 common three quarter sib group above diagonal
       CAN  CHE  CZE  DEU  DFS  FRA  FRR  NLD  POL  USA
 ------------------------------------------------------------------------
  CAN    0  528  753 1534  818  872    0  787  617 1698
  CHE  418    0  344  828  481  450    6  610  249  527
  CZE  487  221    0 1422  868  918    9 1018  651  991
  DEU  911  688  951    0 2105 1906   67 2325 1085 1934
  DFS  635  405  466 1116    0 1275   13 1461  685 1045
  FRA  563  405  479  880  580    0    2 1402  759 1196
  FRR    0    3    3   44    2    0    0   37   40    3
  NLD  616  558  774 1621 1017  719    7    0  749 1108
  POL  426  172  404  682  428  320   35  491    0  870
  USA 1685  454  677 1098  743  570    0  750  694    0
 ------------------------------------------------------------------------
HOL
--------
 common bulls below diagonal
 common three quarter sib group above diagonal
       AUS  BEL  CAN  CHE  DEU  DFS  ESP  FRA  FRR  GBR  IRL  ITA  NLD  NZL  POL  USA
 ------------------------------------------------------------------------------------
  AUS    0  390  761  395 1209  888  586  923    4  982  538  889 1049  942  332  869
  BEL  292    0  357  313  621  440  335  494   11  455  289  431  661  285  182  374
  CAN  624  310    0  565 1616  878  821  902    2 1054  364 1208  915  502  524 1830
  CHE  327  274  451    0  860  494  391  447   12  508  284  524  648  298  212  595
  DEU  717  525  936  706    0 2159 1098 1994   76 1652  697 2146 2637  789  941 2146
  DFS  495  343  674  413 1128    0  721 1262   13 1169  572 1249 1500  649  588 1163
  ESP  391  299  476  299  651  481    0  778    2  786  373  895  767  405  386  895
  FRA  524  428  565  386  840  529  521    0    3 1214  581 1505 1515  649  666 1344
  FRR    1    7    1    4   50    3    0    0    0    4    1    1   41    0   38    3
  GBR  747  382 1013  455 1053  754  598  659    1    0  723 1234 1332  731  490 1282
  IRL  428  257  344  282  574  431  347  425    1  713    0  525  685  544  179  438
  ITA  519  320  799  454 1144  757  612  643    1  799  414    0 1400  631  640 1680
  NLD  802  678  791  612 2066 1099  637  771   10 1041  607  953    0  834  676 1357
  NZL  892  205  459  243  562  420  289  340    0  603  443  430  732    0  227  587
  POL  152  109  352  145  528  333  173  255   35  249  102  347  427  136    0  774
  USA  698  303 1803  519 1188  798  506  601    0 1052  396  930 1009  495  554    0
 ------------------------------------------------------------------------------------
HOL
--------
 common bulls below diagonal
 common three quarter sib group above diagonal
       CAN  CHE  CZE  DEU  DFS  FRA  FRR  GBR  ISR  ITA  NLD  POL  USA
 ------------------------------------------------------------------------
  CAN    0  565  768 1616  881  903    2 1090   67 1212  922  556 1861
  CHE  453    0  352  856  494  455   12  514   39  524  648  238  595
  CZE  505  228    0 1402  851  889   10  756   70  938 1052  615 1060
  DEU  929  702  947    0 2156 1990   75 1704  105 2138 2602 1015 2132
  DFS  677  413  469 1118    0 1276   13 1195   94 1249 1499  634 1165
  FRA  588  397  454  863  555    0    3 1249   88 1505 1524  695 1337
  FRR    1    4    3   50    3    0    0    4    0    1   40   38    3
  GBR 1050  458  416 1075  768  679    1    0   91 1275 1371  528 1332
  ISR   49   26   53   85   75   48    0   63    0   95  103   47   85
  ITA  804  454  541 1135  757  664    1  818   68    0 1401  676 1678
  NLD  799  612  820 2028 1099  791   10 1067   83  951    0  734 1358
  POL  376  164  392  616  383  279   35  274   29  383  492    0  811
  USA 1841  519  719 1175  798  620    0 1094   70  930 1009  586    0
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HOL

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	FRR	GBR	IRL	ISR	ITA	NLD	NZL	POL	USA	ZAF
AUS	0	414	829	433	600	1294	955	615	987	5	1057	555	72	956	1133	986	372	1421	397
BEL	308	0	350	313	292	609	440	335	495	11	455	290	40	431	661	285	180	485	206
CAN	712	302	0	558	739	1526	853	820	855	2	1030	355	64	1158	878	486	505	1975	359
CHE	364	274	442	0	353	839	495	391	439	12	508	284	39	520	649	298	210	714	211
CZE	316	187	482	228	0	1379	852	544	879	10	735	327	70	929	1054	431	566	1200	261
DEU	778	506	819	676	917	0	2118	1099	1939	75	1632	689	106	2074	2518	781	907	2810	486
DFS	566	343	650	414	469	1072	0	725	1255	13	1171	572	95	1243	1504	652	573	1556	426
ESP	410	299	471	299	323	642	482	0	783	2	790	374	70	896	772	407	386	1096	358
FRA	565	421	522	373	441	787	510	515	0	3	1206	582	89	1475	1499	647	651	2025	396
FRR	1	7	1	4	3	50	3	0	0	0	4	1	0	1	40	0	38	7	2
GBR	825	382	986	455	412	1014	755	598	633	1	0	723	90	1228	1334	731	484	1666	420
IRL	451	257	334	282	210	561	431	347	419	1	713	0	65	524	686	544	174	604	273
ISR	49	22	47	26	53	84	75	45	46	0	62	53	0	92	104	73	45	108	47
ITA	567	319	750	450	529	1077	745	612	616	1	787	413	65	0	1384	627	626	2131	430
NLD	888	678	748	612	820	1874	1101	638	735	10	1042	607	83	932	0	837	658	1918	420
NZL	950	205	441	243	263	540	421	289	332	0	603	443	63	425	734	0	222	881	305
POL	187	106	333	144	346	489	319	171	238	35	244	98	26	335	409	134	0	792	143
USA	1233	356	1868	618	784	1437	929	645	869	1	1300	496	87	1073	1423	796	538	0	540
ZAF	331	159	328	172	162	351	299	310	257	1	358	235	33	310	343	240	81	499	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	BEL	CAN	DEU	DFS	ESP	FRA	GBR	IRL	ITA	NLD	NZL	POL	USA	ZAF
AUS	0	414	829	1295	955	613	975	1057	555	956	1135	986	372	1421	396
BEL	308	0	350	609	440	335	491	455	290	431	661	285	180	485	206
CAN	712	302	0	1524	852	819	840	1030	355	1158	880	486	505	1975	358
DEU	779	506	819	0	2119	1097	1922	1632	690	2075	2530	781	905	2812	485
DFS	566	343	650	1073	0	723	1248	1170	571	1242	1505	652	572	1555	424
ESP	410	299	471	642	482	0	774	789	374	895	772	406	385	1094	357
FRA	558	419	505	774	501	510	0	1199	581	1458	1487	645	646	2007	395
GBR	825	382	986	1015	755	598	624	0	723	1228	1336	731	484	1666	419
IRL	451	257	334	562	431	347	417	713	0	524	688	544	174	604	273
ITA	567	319	750	1079	745	612	601	787	413	0	1386	627	626	2131	430
NLD	894	681	754	1893	1106	643	729	1046	610	937	0	837	657	1922	419
NZL	950	205	441	540	421	289	328	603	443	425	735	0	222	881	304
POL	187	106	333	490	319	171	230	244	98	335	409	134	0	791	143
USA	1233	356	1868	1440	929	645	850	1300	496	1073	1429	796	538	0	539
ZAF	331	159	328	351	299	310	256	358	235	310	344	240	81	499	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	NLD	USA
CAN	0	46	19	182
DFS	34	0	41	82
NLD	14	35	0	34
USA	168	62	33	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	DFS	GBR	IRL	NLD	NZL	USA
AUS	0	119	88	143	34	48	320	230
CAN	117	0	47	96	5	22	107	206
DFS	51	32	0	109	23	62	102	91
GBR	147	97	100	0	35	57	154	139
IRL	30	4	18	35	0	15	64	22
NLD	43	17	54	53	15	0	55	50
NZL	350	115	72	157	70	47	0	189
USA	237	203	68	152	24	52	216	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	47	99	22	212
DFS	32	0	110	62	90
GBR	98	100	0	57	147
NLD	17	54	53	0	50
USA	209	68	158	52	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	DFS	GBR	IRL	NLD	NZL	USA	ZAF
AUS	0	136	96	155	36	52	345	381	183
CAN	130	0	46	94	5	22	101	211	86
DFS	57	32	0	109	23	62	103	138	103
GBR	159	94	100	0	35	57	155	168	127
IRL	32	4	18	35	0	15	64	30	26
NLD	46	17	54	53	15	0	56	63	55
NZL	377	107	72	157	70	48	0	289	162
USA	412	209	102	187	32	67	364	0	229
ZAF	172	84	74	129	27	50	168	241	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	DFS	GBR	IRL	NLD	NZL	USA	ZAF
AUS	0	136	96	155	36	53	345	381	183
CAN	130	0	46	94	5	22	101	211	86
DFS	57	32	0	109	23	64	103	138	103
GBR	159	94	100	0	35	60	155	168	127
IRL	32	4	18	35	0	16	64	30	26
NLD	47	18	57	56	15	0	58	66	57
NZL	377	107	72	157	70	50	0	289	162
USA	412	209	102	187	32	71	364	0	229
ZAF	172	84	74	129	27	53	168	241	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NLD	NOR	USA
CAN	0	8	94	3	4	67
DEU	7	0	41	10	12	9
DFS	91	32	0	32	103	94
NLD	3	10	31	0	22	19
NOR	4	12	77	21	0	37
USA	62	9	89	17	37	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	DEU	DFS	GBR	IRL	NLD	NOR	NZL	USA
AUS	0	54	21	136	36	7	12	34	105	51
CAN	53	0	10	96	48	2	3	4	49	94
DEU	20	9	0	47	4	3	12	13	12	13
DFS	116	93	37	0	46	11	33	94	140	106
GBR	35	49	4	46	0	5	11	11	39	46
IRL	6	2	3	7	5	0	6	40	6	11
NLD	10	3	11	32	11	5	0	22	7	21
NOR	29	4	12	72	12	39	21	0	32	41
NZL	106	50	12	135	38	6	7	31	0	56
USA	49	91	13	103	44	11	19	41	57	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NLD	NOR	USA
CAN	0	9	96	49	3	4	94
DEU	8	0	44	4	10	12	10
DFS	93	34	0	46	33	95	106
GBR	50	4	46	0	11	12	47
NLD	3	9	32	11	0	22	21
NOR	4	11	73	13	21	0	41
USA	91	10	103	45	19	41	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	DEU	DFS	GBR	IRL	NLD	NOR	NZL	USA	ZAF
AUS	0	53	26	151	42	8	16	39	113	87	33
CAN	52	0	8	88	45	2	3	4	47	113	63
DEU	24	7	0	42	4	3	10	9	10	11	1
DFS	128	85	32	0	46	11	33	83	140	123	48
GBR	41	46	4	46	0	5	11	11	40	58	34
IRL	7	2	3	7	5	0	6	40	6	13	1
NLD	14	3	9	32	11	5	0	20	7	23	2
NOR	33	4	9	63	12	39	19	0	30	42	0
NZL	114	47	10	135	39	6	7	29	0	82	32
USA	88	116	10	124	58	13	21	42	83	0	61
ZAF	34	67	1	46	32	1	2	0	30	57	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	AUS	CAN	DEU	DFS	GBR	IRL	NLD	NOR	NZL	USA	ZAF
AUS	0	53	26	151	42	8	16	39	113	87	33
CAN	52	0	9	88	45	2	4	4	47	113	63
DEU	24	8	0	43	4	3	10	9	11	12	1
DFS	128	85	33	0	46	11	33	83	140	123	48
GBR	41	46	4	46	0	5	11	11	40	58	34
IRL	7	2	3	7	5	0	6	40	6	13	1
NLD	14	4	9	32	11	5	0	21	7	25	2
NOR	33	4	9	63	12	39	20	0	30	42	0
NZL	114	47	11	135	39	6	7	29	0	82	32
USA	88	116	11	124	58	13	22	42	83	0	61
ZAF	34	67	1	46	32	1	2	0	30	57	0