

Introduction

The latest routine international evaluation for females fertility traits took place as scheduled at the Interbull Centre. Data from seventeen (17) 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 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 ($=\frac{21}{(DO-45+11)}*100$, with DO=days open) PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)}*100$, with DO=days open) PR=Pregnancy Rate ($=\frac{21}{(DO-45+11)}*100$, with DO=days open)
CAN	T1=HC T2=CY T3=C1 T4=C2 T5=IT	NR=Non Return Rate after 56 Days in heifers (NRR), % CF=Interval from Calving to First Service in cows(CF) NR=Non Return Rate after 56 Days in cows(NRR), % FC=Interval first insemination-conception in cows DO=Days open
CHE	T1=HC T2=CR T3=C1 T4=C2	CR=Heifers' Conception rate CF=Interval from Calving to First Service (ICF), days NR=Non Return Rate after 56 Days (NRR), % FL=Interval from first to last insemination cows
CZE	T1=HC	CR=Heifers' Conception rate (pregnant or not after 3 months)

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

AUS (HOL,JER): pedigree changes

DEU (HOL): HOL-RED changes for 14 bulls

DFS: The new Nordic fertility model tested in January was implemented.

ESP: An update of genetic base

FRA: some changes from official to unofficial, and some reductions in herds/daughters/edc

ITA: some bulls lost info because of pedigree corrections

NLD: reliability/edc reduction due to changes in rel/edc calculation and some herds being discarded from the data

USA: drop in the number of herds/daughters due to data edits removing records from some herd-years

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 0lx-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 (August 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	7082	1446	594	
BEL			1000			
CAN	116	36	7192	356	427	
CHE	2517		2736			
CZE			3294			
DEA	4977					
DEU			23376		311	
DFS			14393	2057	8903	
ESP			2707			
EST						
FRA	314		14589			
FRM						
FRR			163			
GBR	69	203	5577	471	305	
HUN						
IRL			2193	111	45	
ISR			1149			
ITA	1437		8634			
JPN						
KOR						
LTU						
LVA						
NLD	145		13543	114	55	
NOR					3551	
NZL	41	55	6488	3994	1161	
POL			5473			
PRT						
SVK						
SVN						
URY						
USA	960	707	33169	3776	599	
ZAF		31	1128	613	134	
HRV						
No. Records	10576	1147	153886	12938	16085	
Pub. Proofs	10054	952	133604	11043	15167	0

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

BSW	hco					
	CAN	DEA	FRA	USA	CHE	NLD
CAN	8.19					
DEA	0.83	11.84				
FRA	0.65	0.67	0.93			
USA	0.69	0.80	0.83	2.66		
CHE	0.77	0.91	0.86	0.80	12.94	
NLD	0.77	0.73	0.78	0.76	0.75	3.59

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.90								
CHE	0.86	11.06							
DEA	0.86	0.94	14.70						
NLD	0.87	0.88	0.86	3.58					
NZL	0.56	0.59	0.55	0.56	9.60				
USA	0.85	0.87	0.85	0.86	0.54	3.29			
GBR	0.78	0.81	0.86	0.81	0.62	0.87	3.92		
FRA	0.86	0.96	0.91	0.91	0.58	0.88	0.82	1.69	
ITA	0.86	0.86	0.85	0.87	0.63	0.86	0.84	0.88	14.31

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.37						
CHE	0.74	11.89					
DEA	0.79	0.96	11.57				
NLD	0.67	0.65	0.56	3.91			
USA	0.73	0.64	0.63	0.87	2.92		
GBR	0.62	0.80	0.78	0.66	0.59	0.04	
FRA	0.63	0.62	0.57	0.73	0.89	0.64	0.93

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.56								
CHE	0.66	10.97							
DEA	0.84	0.81	13.55						
NLD	0.84	0.71	0.85	3.62					
NZL	0.48	0.36	0.46	0.47	6.84				
USA	0.77	0.80	0.83	0.83	0.60	2.37			
GBR	0.70	0.58	0.77	0.74	0.65	0.85	3.92		
FRA	0.74	0.77	0.82	0.71	0.39	0.77	0.70	0.93	
ITA	0.73	0.52	0.82	0.76	0.60	0.88	0.86	0.62	16.37

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	6.46						
DEA	0.86	11.47					
NLD	0.86	0.86	3.39				
NZL	0.62	0.61	0.61	6.84			
USA	0.88	0.85	0.85	0.60	2.37		
GBR	0.86	0.87	0.89	0.62	0.85	3.92	
ITA	0.86	0.92	0.87	0.62	0.88	0.88	15.61

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.22				
GBR	0.74	4.36			
NZL	0.57	0.62	11.38		
USA	0.85	0.85	0.54	3.30	
AUS	0.71	0.85	0.68	0.71	6.96

GUE cc1

	CAN	GBR	USA
CAN	6.61		
GBR	0.67	0.03	
USA	0.78	0.72	3.39

GUE cc2

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.48					
GBR	0.70	4.36				
NZL	0.41	0.66	7.95			
USA	0.81	0.85	0.61	2.65		
ZAF	0.77	0.87	0.65	0.90	13.75	
AUS	0.71	0.85	0.72	0.86	0.86	6.96

GUE int

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	6.13					
GBR	0.85	4.36				
NZL	0.60	0.62	7.95			
USA	0.89	0.85	0.60	2.65		
ZAF	0.86	0.87	0.64	0.91	13.75	
AUS	0.86	0.86	0.69	0.87	0.88	6.96

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	FRR	CHE	NLD
CAN	7.31									
CZE	0.75	17.56								
DEU	0.88	0.80	14.79							
DFS	0.89	0.85	0.93	16.12						
FRA	0.74	0.83	0.81	0.83	0.85					
USA	0.77	0.90	0.85	0.84	0.91	2.42				
POL	0.69	0.55	0.75	0.67	0.54	0.52	18.34			
FRR	0.71	0.70	0.54	0.63	0.73	0.73	0.57	0.80		
CHE	0.95	0.77	0.94	0.93	0.81	0.84	0.72	0.67	13.68	
NLD	0.79	0.78	0.80	0.77	0.82	0.80	0.66	0.71	0.73	4.13

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL
USA	POL	FRA	FRR	AUS							
BEL	4.68										
CAN	0.72	6.63									
CHE	0.79	0.85	12.25								
DEU	0.70	0.86	0.88	11.00							
DFS	0.81	0.88	0.93	0.90	12.02						
ESP	0.85	0.74	0.76	0.76	0.76	11.30					
GBR	0.87	0.74	0.76	0.74	0.81	0.91	4.75				
IRL	0.85	0.70	0.70	0.70	0.70	0.85	0.85	3.65			
ITA	0.78	0.85	0.89	0.90	0.92	0.86	0.83	0.70	8.12		
NLD	0.81	0.86	0.91	0.91	0.95	0.76	0.80	0.70	0.88	4.71	
NZL	0.66	0.56	0.62	0.56	0.61	0.63	0.63	0.60	0.68	0.56	8.35
USA	0.81	0.85	0.85	0.85	0.85	0.89	0.87	0.77	0.85	0.85	0.54
3.25											
POL	0.73	0.88	0.90	0.86	0.89	0.75	0.71	0.70	0.89	0.85	0.59
0.84	13.83										
FRA	0.75	0.87	0.93	0.92	0.93	0.79	0.80	0.70	0.92	0.95	0.59
0.85	0.87	1.18									
FRR	0.73	0.83	0.80	0.91	0.82	0.72	0.71	0.70	0.82	0.90	0.57
0.80	0.84	0.85	1.50								
AUS	0.85	0.70	0.70	0.70	0.70	0.85	0.85	0.88	0.70	0.70	0.60
0.70	0.69	0.70	0.70	4.93							

HOL		cc1										
		CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA
POL	FRR											
CAN		6.57										
CHE		0.89	10.92									
CZE		0.77	0.74	18.09								
DEU		0.81	0.93	0.72	13.76							
DFS		0.80	0.91	0.67	0.90	13.52						
FRA		0.71	0.72	0.87	0.65	0.63	1.00					
GBR		0.65	0.75	0.65	0.76	0.75	0.67	0.03				
ISR		0.65	0.62	0.80	0.64	0.68	0.79	0.69	3.11			
ITA		0.76	0.87	0.69	0.93	0.87	0.61	0.73	0.68	0.05		
NLD		0.71	0.68	0.78	0.69	0.66	0.80	0.68	0.77	0.66	4.58	
USA		0.77	0.70	0.95	0.67	0.66	0.87	0.62	0.85	0.69	0.88	2.80
POL		0.70	0.76	0.50	0.83	0.76	0.51	0.60	0.53	0.81	0.57	0.50
17.61												
FRR		0.54	0.48	0.51	0.52	0.49	0.54	0.50	0.56	0.47	0.69	0.58
0.53	1.11											

HOL		cc2										
		BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR
		NLD	NZL	USA	POL	ZAF	FRR	AUS				
ITA												
BEL		4.68										
CAN		0.69	6.14									
CHE		0.74	0.88	11.14								
CZE		0.63	0.80	0.83	18.09							
DEU		0.76	0.87	0.91	0.88	12.17						
DFS		0.80	0.84	0.88	0.78	0.92	12.97					
ESP		0.86	0.69	0.72	0.64	0.77	0.76	11.30				
FRA		0.77	0.82	0.91	0.77	0.84	0.80	0.65	0.98			
GBR		0.89	0.70	0.69	0.60	0.75	0.80	0.92	0.69	4.74		
IRL		0.84	0.71	0.74	0.64	0.75	0.73	0.84	0.75	0.84	3.65	
ISR		0.48	0.60	0.56	0.75	0.68	0.58	0.49	0.63	0.49	0.57	3.10
ITA		0.85	0.74	0.75	0.74	0.82	0.84	0.94	0.69	0.88	0.85	0.58
18.00												
NLD		0.74	0.84	0.87	0.81	0.89	0.88	0.75	0.80	0.75	0.77	0.64
0.80	4.64											
NZL		0.71	0.39	0.47	0.46	0.47	0.46	0.67	0.44	0.66	0.70	0.30
0.62	0.47	5.62										
USA		0.83	0.82	0.85	0.87	0.88	0.88	0.86	0.79	0.84	0.84	0.73
0.93	0.86	0.60	2.31									
POL		0.82	0.67	0.60	0.57	0.69	0.70	0.84	0.57	0.83	0.77	0.44
0.86	0.69	0.61	0.83	12.94								
ZAF		0.84	0.75	0.79	0.74	0.85	0.84	0.91	0.79	0.86	0.88	0.62
0.94	0.82	0.64	0.91	0.78	18.47							
FRR		0.39	0.37	0.36	0.38	0.61	0.42	0.30	0.33	0.29	0.30	0.29
0.32	0.52	0.18	0.32	0.45	0.32	1.11						
AUS		0.84	0.70	0.74	0.66	0.71	0.69	0.84	0.77	0.84	0.87	0.52
0.84	0.70	0.70	0.84	0.80	0.88	0.22	4.97					

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA
POL	ZAF	AUS	FRA								
BEL	4.68										
CAN	0.85	6.09									
DEU	0.85	0.85	10.43								
DFS	0.90	0.87	0.92	12.90							
ESP	0.85	0.85	0.88	0.85	11.30						
GBR	0.88	0.85	0.86	0.90	0.91	4.74					
IRL	0.85	0.85	0.85	0.85	0.85	0.85	3.65				
ITA	0.85	0.86	0.90	0.90	0.95	0.88	0.85	18.00			
NLD	0.91	0.86	0.91	0.93	0.87	0.89	0.85	0.89	4.53		
NZL	0.63	0.60	0.60	0.60	0.62	0.62	0.64	0.62	0.60	5.62	
USA	0.85	0.89	0.86	0.88	0.85	0.85	0.85	0.92	0.85	0.60	2.31
POL	0.85	0.85	0.85	0.85	0.86	0.85	0.86	0.88	0.85	0.62	0.85
12.95											
ZAF	0.85	0.85	0.86	0.86	0.92	0.85	0.88	0.95	0.86	0.62	0.91
0.88	18.48										
AUS	0.85	0.85	0.85	0.85	0.85	0.85	0.87	0.85	0.85	0.63	0.85
0.85	0.87	4.97									
FRA	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.60	0.85
0.85	0.85	0.85	0.97								

JER hco

	CAN	DFS	USA	NLD
CAN	7.66			
DFS	0.84	18.85		
USA	0.81	0.84	2.62	
NLD	0.78	0.76	0.70	4.08

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	6.37							
DFS	0.87	13.92						
GBR	0.72	0.87	4.05					
NLD	0.87	0.91	0.77	3.93				
NZL	0.52	0.61	0.62	0.54	6.67			
USA	0.85	0.85	0.82	0.86	0.62	3.80		
AUS	0.71	0.71	0.85	0.71	0.60	0.70	3.67	
IRL	0.72	0.71	0.85	0.71	0.60	0.75	0.87	2.08

JER ccl

	CAN	DFS	GBR	NLD	USA
CAN	6.75				
DFS	0.69	14.37			
GBR	0.66	0.64	0.03		
NLD	0.68	0.61	0.65	3.56	
USA	0.69	0.72	0.68	0.76	2.87

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.82								
DFS	0.86	16.03							
GBR	0.71	0.74	4.05						
NLD	0.85	0.88	0.75	3.71					
NZL	0.51	0.49	0.68	0.49	4.45				
USA	0.76	0.84	0.85	0.81	0.65	2.58			
ZAF	0.72	0.75	0.86	0.76	0.71	0.88	12.78		
AUS	0.71	0.71	0.85	0.71	0.66	0.85	0.86	3.64	
IRL	0.73	0.73	0.85	0.76	0.64	0.86	0.88	0.87	2.08

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.43								
DFS	0.87	15.75							
GBR	0.85	0.88	4.05						
NLD	0.86	0.90	0.88	3.68					
NZL	0.60	0.62	0.63	0.61	4.45				
USA	0.87	0.87	0.85	0.85	0.63	2.58			
ZAF	0.86	0.86	0.85	0.85	0.68	0.89	12.78		
AUS	0.85	0.86	0.85	0.86	0.63	0.85	0.86	3.64	
IRL	0.86	0.86	0.86	0.86	0.62	0.86	0.87	0.87	2.08

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.06					
DEU	0.86	13.61				
DFS	0.83	0.81	15.77			
NOR	0.83	0.67	0.77	12.91		
USA	0.82	0.82	0.87	0.86	2.77	
NLD	0.80	0.80	0.71	0.72	0.75	4.68

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	6.27									
DEU	0.87	9.67								
DFS	0.86	0.90	12.93							
GBR	0.73	0.74	0.76	4.30						
NOR	0.90	0.88	0.89	0.74	12.06					
NZL	0.55	0.56	0.53	0.62	0.54	10.00				
USA	0.85	0.85	0.85	0.82	0.87	0.65	3.50			
NLD	0.87	0.91	0.93	0.79	0.87	0.57	0.86	2.88		
AUS	0.71	0.71	0.71	0.85	0.72	0.62	0.71	0.71	4.70	
IRL	0.71	0.70	0.71	0.85	0.72	0.60	0.77	0.71	0.88	2.59

RDC ccl

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	6.58						
DEU	0.81	12.12					
DFS	0.81	0.90	14.07				
GBR	0.66	0.76	0.83	0.03			
NOR	0.79	0.68	0.74	0.74	12.37		
NLD	0.71	0.70	0.63	0.67	0.60	4.25	
USA	0.81	0.68	0.68	0.62	0.66	0.82	2.84

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.32										
DEU	0.88	10.08									
DFS	0.85	0.93	13.07								
GBR	0.71	0.75	0.76	4.30							
NOR	0.76	0.74	0.71	0.87	13.35						
NZL	0.50	0.48	0.47	0.64	0.61	6.82					
USA	0.84	0.87	0.86	0.85	0.86	0.65	2.42				
ZAF	0.73	0.86	0.86	0.87	0.88	0.66	0.90	19.91			
NLD	0.84	0.88	0.84	0.77	0.87	0.49	0.86	0.83	3.81		
AUS	0.71	0.72	0.70	0.85	0.87	0.65	0.85	0.87	0.73	4.54	
IRL	0.72	0.76	0.74	0.85	0.86	0.69	0.86	0.89	0.79	0.88	2.59

RDC	int										
	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.24										
DEU	0.86	9.09									
DFS	0.86	0.92	13.33								
GBR	0.86	0.86	0.88	4.30							
NOR	0.90	0.89	0.86	0.88	13.35						
NZL	0.61	0.61	0.60	0.61	0.61	6.82					
USA	0.89	0.87	0.87	0.85	0.86	0.62	2.42				
ZAF	0.86	0.86	0.91	0.86	0.91	0.64	0.89	19.91			
NLD	0.86	0.91	0.92	0.89	0.87	0.60	0.86	0.86	3.15		
AUS	0.86	0.86	0.85	0.86	0.87	0.62	0.85	0.86	0.86	4.54	
IRL	0.86	0.85	0.86	0.85	0.86	0.62	0.86	0.88	0.86	0.88	2.59

^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	62	40	66	67	23
DEA	49	0	163	138	491	105
FRA	35	120	0	63	135	64
USA	58	97	46	0	161	35
CHE	53	392	98	134	0	69
NLD	20	97	53	31	63	0

BSW

common bulls below diagonal
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	85	80	31	15	95	38	55	71
CHE	68	0	488	73	17	224	47	129	316
DEA	65	387	0	114	24	185	45	159	408
NLD	26	65	104	0	16	41	27	64	88
NZL	14	13	18	10	0	14	12	15	18
USA	90	193	139	37	12	0	46	81	126
GBR	36	36	33	23	9	46	0	36	45
FRA	47	91	117	51	11	53	30	0	132
ITA	58	259	273	69	13	83	33	96	0

BSW

common bulls below diagonal
 common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	85	80	31	95	41	60
CHE	69	0	486	72	223	52	136
DEA	65	384	0	113	185	52	171
NLD	26	64	104	0	41	30	70
USA	91	193	139	37	0	51	87
GBR	37	38	35	23	48	0	41
FRA	52	100	131	58	60	34	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	77	72	28	14	91	38	55	66
CHE	61	0	477	73	17	283	47	136	316
DEA	60	378	0	113	24	281	44	170	401
NLD	24	65	104	0	16	64	27	70	88
NZL	13	13	18	10	0	22	12	16	18
USA	82	264	248	52	20	0	56	108	171
GBR	34	36	33	23	9	56	0	37	45
FRA	47	100	131	58	12	74	32	0	141
ITA	54	259	270	69	13	114	33	106	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA
CAN	0	72	29	14	91	38	65
DEA	60	0	114	24	281	44	436
NLD	25	105	0	16	64	27	89
NZL	13	18	10	0	22	12	18
USA	82	248	55	20	0	56	179
GBR	34	33	23	9	56	0	45
ITA	54	286	70	13	118	33	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	13	1	30	18
GBR	10	0	13	37	28
NZL	0	11	0	8	23
USA	29	35	6	0	18
AUS	13	22	22	15	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	USA
CAN	0	13	30
GBR	10	0	39
USA	29	37	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	10	0	27	1	15
GBR	7	0	13	69	5	29
NZL	0	11	0	27	3	23
USA	25	71	29	0	10	51
ZAF	1	4	1	6	0	5
AUS	11	23	22	48	4	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	ZAF	AUS
CAN	0	10	0	27	1	15
GBR	7	0	13	69	5	29
NZL	0	11	0	27	3	23
USA	25	71	29	0	10	51
ZAF	1	4	1	6	0	5
AUS	11	23	22	48	4	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	FRR	CHE	NLD
CAN	0	769	1567	843	882	1756	648	0	546	806
CZE	503	0	1440	891	926	1012	676	9	353	1032
DEU	953	967	0	2136	1915	1978	1135	66	852	2355
DFS	673	489	1157	0	1286	1075	714	13	500	1486
FRA	577	489	887	591	0	1203	777	2	461	1411
USA	1767	703	1155	787	581	0	911	3	548	1130
POL	446	427	732	454	339	730	0	42	266	781
FRR	0	3	44	2	0	0	48	0	6	37
CHE	435	225	708	420	413	467	186	3	0	623
NLD	641	796	1656	1047	734	780	524	7	574	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA	FRR	AUS
BEL	0	366	323	635	452	347	466	297	441	676	291	383	195	504	11	393
CAN	319	0	585	1641	907	854	1072	374	1232	935	509	1872	558	923	2	762
CHE	283	469	0	887	508	412	524	297	544	667	305	617	233	460	12	399
DEU	544	981	728	0	2201	1151	1685	711	2177	2684	797	2196	996	2019	76	1210
DFS	355	712	426	1182	0	748	1191	586	1279	1529	654	1204	623	1286	13	888
ESP	308	500	312	678	504	0	812	384	932	798	414	925	419	813	2	593
GBR	391	1036	471	1086	778	617	0	741	1260	1359	741	1309	527	1231	4	984
IRL	265	360	296	592	450	360	735	0	537	715	562	450	196	592	1	546
ITA	330	829	468	1186	790	632	825	434	0	1421	641	1704	682	1520	1	890
NLD	693	815	629	2128	1135	658	1065	642	977	0	843	1386	723	1537	41	1054
NZL	205	464	246	569	423	297	610	461	441	740	0	593	243	655	0	943
USA	313	1866	535	1258	849	533	1080	417	964	1051	502	0	819	1357	3	873
POL	120	382	158	580	365	193	273	119	381	469	147	606	0	694	40	338
FRA	440	585	397	871	549	553	680	442	664	801	345	627	274	0	3	928
FRR	7	1	4	50	3	0	1	1	1	10	0	0	44	0	0	4
AUS	295	625	328	719	498	393	749	434	521	808	893	700	155	528	1	0

HOL

common bulls below diagonal

common three quarter sib group above diagonal

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	FRA
BEL	0	357	622	452	347	466	298	439	676	291	493	194	206	421	495
CAN	313	0	1548	877	849	1052	365	1178	901	492	2007	538	358	847	847
DEU	523	857	0	2152	1148	1659	704	2100	2572	790	2842	950	485	1316	1927
DFS	355	682	1115	0	750	1192	585	1266	1534	656	1594	608	425	973	1253
ESP	308	494	668	505	0	815	385	931	803	415	1126	413	357	635	800
GBR	391	1010	1040	779	617	0	741	1254	1363	741	1691	515	420	1073	1204
IRL	265	350	580	450	360	735	0	537	719	562	617	190	277	568	591
ITA	327	764	1098	766	630	804	431	0	1401	634	2149	664	430	970	1461
NLD	696	777	1948	1142	664	1070	645	953	0	846	1952	701	419	1159	1493
NZL	205	445	550	424	297	610	461	431	743	0	886	237	304	991	648
USA	366	1929	1496	976	672	1326	518	1093	1468	801	0	833	539	1442	2009
POL	116	356	536	350	187	260	115	361	444	145	583	0	143	386	664
ZAF	159	328	351	300	310	359	239	310	344	239	499	81	0	396	395
AUS	315	738	800	588	426	847	464	579	919	955	1265	198	331	0	979
FRA	423	507	776	501	525	627	428	602	735	329	855	235	256	558	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	47	195	19
DFS	35	0	83	46
USA	180	63	0	37
NLD	14	40	36	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	AUS	IRL
CAN	0	49	99	22	111	214	119	5
DFS	34	0	114	64	104	92	88	24
GBR	99	104	0	58	158	146	144	39
NLD	17	56	54	0	55	51	48	16
NZL	120	75	162	47	0	196	321	67
USA	211	70	158	53	222	0	231	25
AUS	117	51	147	43	353	235	0	34
IRL	4	19	39	16	74	27	30	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	49	104	22	221
DFS	34	0	115	64	91
GBR	100	105	0	60	150
NLD	17	56	56	0	51
USA	217	70	159	53	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	48	97	22	108	218	88	143	5
DFS	34	0	114	64	105	141	104	97	24
GBR	97	104	0	58	159	175	130	158	39
NLD	17	56	54	0	56	66	55	52	16
NZL	115	75	162	48	0	295	165	347	67
USA	215	105	193	70	370	0	230	386	31
ZAF	86	75	131	50	172	242	0	183	26
AUS	137	58	162	46	382	418	173	0	37
IRL	4	19	39	16	74	33	27	33	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	48	97	22	108	218	88	143	5
DFS	34	0	114	66	105	141	104	97	24
GBR	97	104	0	62	159	175	130	158	39
NLD	18	59	58	0	59	70	57	54	17
NZL	115	75	162	52	0	295	165	347	67
USA	215	105	193	75	370	0	230	386	31
ZAF	86	75	131	53	172	242	0	183	26
AUS	137	58	162	48	382	418	173	0	37
IRL	4	19	39	16	74	33	27	33	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	8	98	4	67	3
DEU	7	0	41	12	9	10
DFS	95	32	0	110	99	33
NOR	4	12	81	0	39	23
USA	62	9	93	39	0	21
NLD	3	10	32	22	18	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	AUS	IRL
CAN	0	10	99	49	4	49	93	3	54	2
DEU	9	0	49	4	14	12	15	12	21	3
DFS	96	40	0	47	97	140	110	34	136	11
GBR	50	4	47	0	13	41	45	11	36	5
NOR	4	14	75	14	0	34	44	24	34	40
NZL	50	12	135	40	33	0	57	9	105	6
USA	90	15	106	43	44	58	0	24	52	12
NLD	3	12	33	11	23	8	21	0	12	6
AUS	53	20	116	35	29	106	50	10	0	7
IRL	2	3	7	5	39	6	12	5	6	0

RDC

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

CAN	0	9	99	51	4	3	93
DEU	8	0	44	4	12	10	11
DFS	96	35	0	48	99	34	110
GBR	52	4	48	0	17	12	48
NOR	4	12	76	18	0	24	44
NLD	3	10	33	12	23	0	24
USA	90	11	106	46	44	21	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	94	47	4	48	117	63	3	53	2
DEU	7	0	43	4	11	10	12	1	10	26	3
DFS	91	33	0	47	87	140	131	48	34	152	11
GBR	48	4	47	0	12	42	58	34	11	42	5
NOR	4	10	67	13	0	33	46	0	24	43	40
NZL	48	10	135	41	32	0	84	32	9	114	6
USA	120	11	131	58	46	85	0	61	24	90	13
ZAF	67	1	46	32	0	30	57	0	2	33	1
NLD	3	9	33	11	23	8	21	2	0	16	6
AUS	52	24	129	41	36	115	90	33	14	0	8
IRL	2	3	7	5	39	6	13	1	5	7	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	94	47	4	48	117	63	4	53	2
DEU	8	0	46	4	12	11	15	1	11	27	3
DFS	91	36	0	47	87	140	131	48	34	152	11
GBR	48	4	47	0	12	42	58	34	11	42	5
NOR	4	11	67	13	0	33	46	0	25	43	40
NZL	48	11	135	41	32	0	84	32	9	114	6
USA	120	14	131	58	46	85	0	61	26	90	13
ZAF	67	1	46	32	0	30	57	0	2	33	1
NLD	4	10	33	11	24	8	22	2	0	16	6
AUS	52	25	129	41	36	115	90	33	14	0	8
IRL	2	3	7	5	39	6	13	1	5	7	0
