

Introduction

The latest routine international evaluation for udder traits took place as scheduled at the Interbull Centre. Data from thirty-three (33) countries were included in this evaluation.

International genetic evaluations for udder health traits of bulls from Australia, Austria-Germany, Belgium, Canada, Croatia, Czech Republic, Denmark-Finland-Sweden, Estonia, France, Hungary, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, South Africa, Slovak Republic, Spain, Switzerland, the United Kingdom, the United States of America, Poland, Lithuania, Latvia, Croatia, Slovenia, Portugal and Uruguay were computed. Brown Swiss, Holstein, Red Dairy Cattle, Guernsey, Jersey and Simmental breed data were included in this evaluation.

Countries sending real MAS data (other countries participate to the MAS evaluation using SCS data as predictor):

HOL : DFS, NLD, FRA, CAN, ITA, CHE, USA, DEU, GBR, AUS
RDC : DFS, NLD, CAN, GBR, AUS
BSW : NLD, FRA, CHE, GBR
JER : DFS, NLD, CAN, GBR, AUS, USA
SIM : NLD, CHE, GBR
GUE : No evaluation for MAS yet

Changes in national procedures

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

ISR (HOL) Slight reductions for a few bulls in number of daughters due to edits and paternity corrections
SVN (ALL) Some changes in information due to changes in data base related to the pedigree completeness and phenotypic data improvement
FRA (ALL) Some drops in information due to corrections made in pedigree
AUS (ALL) Decrease in information as a result of data clean up such as pedigree changes, causing also changes in type of proofs. Change of status of bull which leads to a good number of bulls no longer being qualified. Decreases in EDC due to rounding.
AUS (RDC) Completely different analysis for the red breeds which are now analysed separately from the other breeds holsteins and Jersey
DEA (BSW,SIM) Base change. Some drops in reliability due to pedigree changes. For SIM few bulls show slight decrease in number of herds/EDC with same number of daughters. This could be expected with herd changes regarding to the movement of cows from alpine pasturing back to herds in the valleys.
POL (HOL) Test data submission as a result of a new software application. Computational technologies we used so far seems not to be able to deal with still growing data amount in near future. Software upgrade based on new libraries and compilers implementation, improved data workflow without changing mathematical model itself.
JPN (HOL) Drops in information due to parentage checks
BEL (HOL) Some decrease in information due to pedigree correction
CHE (HOL) In-depth corrections and renewal of the database table containing bull information by one of our breeding associations lead to changes in status of bulls and type of proof as well as a fewer number of EBV delivered. Slight changes in number of daughters, number of herds and EDC are due to manual edits in the database.
CHE (SIM) In-depth corrections and renewal of the database table containing bull information by one of our breeding associations lead to changes in status of bulls and type of proof as well as a fewer number of EBV delivered. Slight changes in number of daughters, number of herds and EDC are due to manual edits in the database.
ITA (SIM) Small decrease in information due to pedigree correction
GBR (HOL) Loss of information due to data changes that occurred in one of the major data providers providing highest proportion of the HOL data, it affects more SCS/mas as such traits are recorded by farmers voluntarily and suffered more from data changes
NZL (ALL) Daughter counts ≥ 200 affects all traits. New Zealand has continuous DNA parentage testing so daughters will always change
Herd Count ≥ 200 affects all traits. Affected by continuous DNA parentage testing.
EDCs ≥ 200 affects all traits. Affected by continuous DNA parentage testing and a bug was found in the EDC calculation so a fix was applied
NZL (ALL) same model as what used before but running on Bolt software. Wrong heritability was used in the calculation of EDC which has now been corrected.

IRL (HOL)

SCC: we have developed a whole new test-day model for SCS - the current model is a 305day lactation model - heritability is slightly higher 0.14 compare to the current 0.11. The TDM for SCC is a 3 parity trait model - the published breeding value is a composite of the 3 parity PTAs (as opposed to 1 heifer parity equivalent PTA).

INTERBULL CHANGES COMPARED TO THE PREVIOUS ROUTINE RUN

Post-processing Windows:

According to the decision taken by ITC in Orlando (2015) to review the post-processing windows every 5 years, during the 2020 the relative working group has been re-activated and new windows have been identified.

As before, the upper bounds have been set to 0.99 as these were judged to have very little effect on evaluations while the lower values have been reduced to the 10th percentile. This reduction would provide post-processed correlations to be closer to the real estimated ones. Over the past five years, in fact, the previous adopted lower value (25th percentile) had been found too high causing estimated and post-processed correlations to differ significantly from each other. The new lower values have been applied to all breeds and traits.

The weight assigned to the magnitude of the changes tested by each country has also been revised. The new weight will allow post-processed correlations to take more in consideration the value of the new estimated ones even when no changes are applied by the countries.

The new weights are as follows:

No changes :: 2
Small changes:: 1
Big changes :: 0

More information can be read on https://interbull.org/ib/rg_procedure

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 ROUTINE RUN

Results were distributed by the Interbull Centre to designated representatives in each country. The international evaluation file comprised international proofs expressed on the base and unit of each country included in the analysis. Such records readily provide more information on bull performance in various countries, thereby minimizing the need to resort to conversions.

At the same time, all recipients of Interbull results are expected to honor the agreed code of practice, decided by the Interbull Steering Committee, and only publish international evaluations on their own country scale. Evaluations expressed on another country scale are confidential and may only be used internally for research and review purposes.

PUBLICATION OF INTERBULL TEST RUN

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

^aTable 1. National evaluation data considered in the Interbull evaluation for udder health (December Routine Evaluation 2021).
Number of records for milk somatic cells by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		146	8597	1719	801	
BEL			2193			
CAN	269	103	13379	832	855	
CHE	3102		3232	96		3461
CZE			4549			
DEA	5882				23911	
DEU		23354		284		

DFS		13955	2274	8048					
ESP		4324							
EST		1277		467					
FRA	423	17731			490				
FRM					4603				
GBR	139	294	7274	743	552	85			
HUN			3163			190			
IRL			3003						
ISR			1606						
ITA	2059		9755	76		1684			
JPN			6644						
KOR			1523						
LTU			1269		435				
LVA			527		564				
NLD	214		16586	215	95	468			
NOR					4260				
NZL	69	57	8593	4942	1406				
POL			11784						
PRT			2491						
SVK			1149						
SVN	408		664		714				
URY			1974						
USA	1140	718	40779	5020	732	84			
ZAF			1211	602	125				
HRV			893			1002			
CAM					44				
<hr/>									
No. Records	13705	1318	213479	16519	18668	36692			
Pub. Proofs	11032	1021	156591	13479	17678	32954			

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

BSW	SCS	CAN	FRA	NLD	USA	CHE	DEA	NZL	ITA	GBR	SVN
CAN	6.43										
FRA	0.92	1.04									
NLD	0.89	0.92	3.97								
USA	0.90	0.90	0.86	0.21							
CHE	0.91	0.94	0.93	0.83	10.51						
DEA	0.91	0.96	0.92	0.86	0.97	11.95					
NZL	0.71	0.78	0.81	0.67	0.77	0.72	0.36				
ITA	0.89	0.89	0.88	0.85	0.95	0.91	0.69	15.99			
GBR	0.92	0.96	0.95	0.91	0.93	0.94	0.82	0.89	11.85		
SVN	0.84	0.83	0.84	0.83	0.83	0.83	0.68	0.83	0.85	10.35	

BSW	MAS	CAN	FRA	NLD	USA	CHE	DEA	NZL	ITA	GBR	SVN
CAN	6.43										
FRA	0.84	1.04									
NLD	0.82	0.78	3.95								
USA	0.84	0.79	0.83	0.21							
CHE	0.89	0.84	0.88	0.80	11.42						
DEA	0.92	0.75	0.88	0.84	0.91	11.95					
NZL	0.69	0.64	0.72	0.68	0.70	0.74	0.36				
ITA	0.86	0.77	0.82	0.78	0.88	0.92	0.69	15.99			
GBR	0.85	0.86	0.83	0.80	0.88	0.78	0.64	0.79	2.25		
SVN	0.81	0.75	0.76	0.79	0.75	0.80	0.75	0.82	0.79	10.35	

GUE	SCS	CAN	GBR	USA	AUS	NZL
CAN	6.19					

GBR	0.92	13.51			
USA	0.93	0.90	0.25		
AUS	0.83	0.88	0.80	0.24	
NZL	0.79	0.82	0.74	0.89	0.63

HOL SCS

	CAN	CHE	DEU	DFS	EST	FRA	GBR	NLD	USA	ISR	ITA	AUS	HUN	BEL	JPN	ESP	ZAF	NZL	IRL	CZE	SVK	POL	LTU	LVA	PRT	KOR	SVN	HRV	URY				
CAN	5.69																																
CHE	0.90	10.75																															
DEU	0.94	0.95	12.90																														
DFS	0.93	0.92	0.97	11.73																													
EST	0.88	0.90	0.93	0.93	19.70																												
FRA	0.94	0.93	0.96	0.96	0.91	1.18																											
GBR	0.94	0.94	0.95	0.94	0.90	0.95	12.77																										
NLD	0.91	0.94	0.96	0.94	0.91	0.93	0.96	4.60																									
USA	0.94	0.86	0.89	0.88	0.90	0.90	0.91	0.87	0.20																								
ISR	0.85	0.85	0.86	0.83	0.86	0.84	0.82	0.81	0.87	0.24																							
ITA	0.90	0.89	0.95	0.93	0.93	0.93	0.90	0.89	0.89	0.84	5.82																						
AUS	0.82	0.86	0.83	0.83	0.79	0.84	0.87	0.85	0.79	0.70	0.81	0.25																					
HUN	0.88	0.89	0.93	0.90	0.91	0.90	0.89	0.88	0.91	0.89	0.94	0.79	1.36																				
BEL	0.92	0.93	0.97	0.96	0.96	0.95	0.94	0.94	0.89	0.84	0.95	0.82	0.92	0.52																			
JPN	0.87	0.84	0.86	0.87	0.85	0.90	0.87	0.85	0.87	0.79	0.84	0.79	0.83	0.85	0.42																		
ESP	0.93	0.91	0.96	0.94	0.93	0.96	0.93	0.91	0.91	0.88	0.96	0.81	0.93	0.96	0.85	11.63																	
ZAF	0.90	0.88	0.92	0.90	0.88	0.93	0.91	0.88	0.89	0.84	0.92	0.84	0.90	0.91	0.86	0.95	26.25																
NZL	0.78	0.83	0.81	0.81	0.77	0.82	0.84	0.83	0.74	0.69	0.77	0.89	0.73	0.79	0.81	0.78	0.82	0.41															
IRL	0.80	0.90	0.86	0.85	0.82	0.84	0.87	0.88	0.77	0.75	0.79	0.81	0.82	0.86	0.79	0.83	0.82	0.82	0.12														
CZE	0.87	0.84	0.90	0.89	0.87	0.89	0.87	0.86	0.87	0.81	0.90	0.76	0.89	0.90	0.85	0.92	0.89	0.74	0.75	16.00													
SVK	0.87	0.88	0.92	0.90	0.89	0.90	0.86	0.86	0.87	0.82	0.90	0.78	0.95	0.92	0.83	0.91	0.88	0.71	0.82	0.89	0.41												
POL	0.90	0.92	0.96	0.95	0.94	0.93	0.91	0.91	0.88	0.86	0.94	0.81	0.95	0.96	0.85	0.95	0.89	0.76	0.83	0.90	0.91	10.85											
LTU	0.84	0.88	0.90	0.89	0.92	0.87	0.86	0.86	0.83	0.82	0.87	0.79	0.87	0.92	0.82	0.89	0.86	0.75	0.79	0.85	0.87	0.91	0.36										
LVA	0.88	0.89	0.94	0.92	0.93	0.89	0.90	0.90	0.86	0.81	0.91	0.82	0.89	0.94	0.84	0.89	0.87	0.81	0.82	0.87	0.86	0.93	0.92	0.48									
PRT	0.81	0.81	0.83	0.82	0.81	0.81	0.82	0.81	0.81	0.78	0.82	0.73	0.82	0.83	0.81	0.83	0.83	0.72	0.74	0.81	0.81	0.83	0.82	0.46									
KOR	0.87	0.84	0.88	0.90	0.88	0.87	0.87	0.85	0.87	0.81	0.89	0.78	0.87	0.89	0.82	0.90	0.86	0.72	0.69	0.84	0.85	0.91	0.86	0.89	0.81	0.35							
SVN	0.82	0.84	0.87	0.88	0.84	0.85	0.85	0.84	0.82	0.80	0.85	0.80	0.85	0.88	0.82	0.86	0.83	0.73	0.84	0.83	0.83	0.88	0.85	0.87	0.81	0.83	10.50						
HRV	0.82	0.82	0.84	0.82	0.87	0.82	0.82	0.83	0.82	0.81	0.83	0.75	0.86	0.86	0.82	0.83	0.82	0.70	0.76	0.83	0.82	0.86	0.85	0.87	0.81	0.83	0.82	11.68					
URY	0.82	0.83	0.85	0.83	0.82	0.84	0.82	0.83	0.82	0.79	0.82	0.82	0.82	0.84	0.82	0.82	0.84	0.78	0.74	0.82	0.83	0.83	0.82	0.81	0.82	0.82	0.82	0.20					

Hot mas

	CAN	CHE	DEU	DFS	EST	FRA	GBR	NLD	USA	ISR	ITA	AUS	HUN	BEL	JPN	ESP	ZAF	NZL	IRL	CZE	SVK	POL	LTU	LVA	PRT	KOR
CAN	7.48																									
CHE	0.92	10.68																								
DEU	0.92	0.88	9.79																							
DFS	0.94	0.88	0.91	12.57																						
EST	0.81	0.85	0.83	0.85	19.71																					
FRA	0.96	0.92	0.92	0.94	0.83	1.19																				
GBR	0.88	0.89	0.83	0.84	0.78	0.88	2.41																			
NLD	0.85	0.90	0.82	0.86	0.85	0.86	0.82	4.98																		
USA	0.84	0.80	0.85	0.81	0.76	0.86	0.80	0.80	2.35																	
ISR	0.75	0.76	0.74	0.78	0.84	0.75	0.71	0.76	0.71	0.24																
ITA	0.81	0.88	0.77	0.80	0.84	0.82	0.80	0.88	0.71	0.79	6.03															
AUS	0.71	0.70	0.71	0.71	0.70	0.71	0.71	0.69	0.71	0.66	0.71	0.12														
HUN	0.83	0.86	0.78	0.82	0.90	0.81	0.82	0.87	0.73	0.87	0.90	0.70	1.36													
BEL	0.87	0.93	0.86	0.88	0.93	0.87	0.84	0.89	0.74	0.82	0.88	0.71	0.93	0.52												
JPN	0.75	0.83	0.72	0.75	0.79	0.74	0.73	0.80	0.70	0.77	0.84	0.70	0.81	0.85	0.42											
ESP	0.86	0.91	0.81	0.86	0.90	0.86	0.84	0.87	0.72	0.86	0.87	0.70	0.93	0.96	0.86	11.62										
ZAF	0.83	0.87	0.78	0.78	0.83	0.82	0.79	0.84	0.72	0.81	0.85	0.70	0.90	0.93	0.86	0.94	25.98									
NZL	0.63	0.70	0.64	0.63	0.71	0.63	0.63	0.64	0.62	0.71	0.67	0.67	0.71	0.78	0.80	0.77	0.81	0.41								
IRL	0.73	0.75	0.77	0.79	0.76	0.72	0.77	0.75	0.68	0.69	0.72	0.68	0.80	0.80	0.71	0.75	0.73	0.71	0.11							
CZE	0.84	0.86	0.76	0.82	0.86	0.83	0.80	0.84	0.71	0.79	0.88	0.70	0.90	0.91	0.85	0.92	0.90	0.72	0.71	16.00						
SVK	0.83	0.85	0.80	0.80	0.88	0.84	0.81	0.86	0.76	0.81	0.88	0.70	0.94	0.91	0.80	0.90	0.89	0.71	0.76	0.89	0.40					
POL	0.86	0.89	0.82	0.86	0.93	0.84	0.84	0.87	0.72	0.84	0.85	0.70	0.95	0.97	0.84	0.95	0.89	0.74	0.78	0.91	0.90	10.81				
LTU	0.81	0.79	0.80	0.82	0.88	0.82	0.78	0.76	0.70	0.76	0.78	0.70	0.87	0.91	0.79	0.87	0.82	0.71	0.80	0.83	0.86	0.90	0.35			
LVA	0.77	0.79	0.75	0.80	0.91	0.78	0.76	0.82	0.71	0.77	0.83	0.70	0.88	0.92	0.80	0.87	0.85	0.77	0.78	0.85	0.84	0.92	0.89	0.48		
PRT	0.73	0.80	0.71	0.74	0.79	0.74	0.71	0.76	0.70	0.76	0.74	0.70	0.81	0.85	0.78	0.83	0.82	0.71	0.75	0.82	0.78	0.81	0.82	0.45		
KOR	0.83	0.83	0.74	0.84	0.84	0.83	0.80	0.79	0.73	0.76	0.78	0.70	0.86	0.89	0.81	0.90	0.83	0.71	0.70	0.85	0.84	0.92	0.84	0.86	0.78	

SVN	0.78	0.81	0.77	0.83	0.81	0.79	0.79	0.69	0.76	0.78	0.70	0.82	0.89	0.79	0.86	0.81	0.71	0.80	0.83	0.80	0.88	0.84	0.83	0.82	0.80	10.49		
HRV	0.73	0.74	0.72	0.74	0.84	0.73	0.76	0.78	0.70	0.78	0.77	0.70	0.84	0.85	0.79	0.83	0.80	0.71	0.70	0.82	0.80	0.84	0.85	0.87	0.78	0.79	0.80	11.41
URY	0.74	0.75	0.76	0.74	0.80	0.74	0.74	0.72	0.70	0.77	0.75	0.70	0.79	0.84	0.80	0.81	0.82	0.77	0.71	0.80	0.82	0.80	0.80	0.78	0.79	0.80	0.20	

JER SCS

	CAN	DFS	GBR	NLD	USA	AUS	ZAF	NZL	CHE	ITA
CAN	6.08									
DFS	0.91	12.41								
GBR	0.92	0.91	11.37							
NLD	0.91	0.95	0.94	4.26						
USA	0.90	0.84	0.89	0.86	0.17					
AUS	0.80	0.84	0.84	0.86	0.76	0.24				
ZAF	0.86	0.87	0.86	0.88	0.84	0.82	21.28			
NZL	0.72	0.74	0.79	0.80	0.71	0.89	0.78	0.39		
CHE	0.89	0.87	0.87	0.90	0.83	0.78	0.84	0.72	12.48	
ITA	0.87	0.92	0.86	0.87	0.85	0.71	0.83	0.65	0.85	6.86

JER mas

	CAN	DFS	GBR	NLD	USA	AUS	ZAF	NZL	CHE	ITA
CAN	7.46									
DFS	0.93	12.22								
GBR	0.82	0.86	1.87							
NLD	0.85	0.83	0.79	4.10						
USA	0.78	0.77	0.75	0.76	2.45					
AUS	0.70	0.70	0.70	0.70	0.70	0.11				
ZAF	0.74	0.72	0.72	0.79	0.71	0.70	21.27			
NZL	0.63	0.63	0.63	0.64	0.63	0.63	0.77	0.39		
CHE	0.85	0.81	0.74	0.78	0.76	0.72	0.81	0.73	12.40	
ITA	0.76	0.74	0.73	0.78	0.67	0.67	0.80	0.70	0.81	6.86

RDC SCS

	CAN	DFS	GBR	NOR	USA	DEU	AUS	EST	ZAF	NZL	LTU	LVA	NLD	CAM
CAN	5.70													
DFS	0.94	12.91												
GBR	0.93	0.92	11.37											
NOR	0.89	0.91	0.85	14.21										
USA	0.92	0.87	0.89	0.84	0.23									
DEU	0.94	0.96	0.95	0.90	0.89	14.11								
AUS	0.82	0.85	0.87	0.84	0.76	0.84	0.27							
EST	0.89	0.90	0.90	0.87	0.87	0.94	0.82	19.60						
ZAF	0.85	0.86	0.87	0.91	0.87	0.92	0.78	0.89	25.30					
NZL	0.79	0.81	0.82	0.83	0.75	0.82	0.89	0.81	0.80	0.43				
LTU	0.86	0.90	0.88	0.90	0.84	0.90	0.79	0.90	0.88	0.79	0.34			
LVA	0.87	0.87	0.89	0.87	0.86	0.92	0.82	0.96	0.88	0.83	0.90	0.44		
NLD	0.91	0.95	0.95	0.89	0.87	0.96	0.86	0.90	0.88	0.83	0.87	0.89	4.26	
CAM	0.90	0.90	0.91	0.91	0.84	0.91	0.89	0.90	0.90	0.87	0.90	0.90	0.91	6.35

RDC mas

	CAN	DFS	GBR	NOR	USA	AUS	EST	ZAF	NZL	LTU	LVA	NLD	CAM
CAN	7.82												
DFS	0.90	13.62											
GBR	0.86	0.86	2.06										
NOR	0.85	0.76	0.78	14.21									
USA	0.80	0.75	0.79	0.82	0.23								
AUS	0.72	0.72	0.72	0.75	0.71	0.12							
EST	0.82	0.76	0.81	0.84	0.81	0.73	19.60						
ZAF	0.84	0.83	0.82	0.89	0.79	0.72	0.85	25.34					
NZL	0.65	0.64	0.68	0.79	0.70	0.70	0.81	0.77	0.43				
LTU	0.80	0.76	0.82	0.88	0.81	0.74	0.90	0.86	0.79	0.34			
LVA	0.80	0.76	0.81	0.86	0.80	0.74	0.95	0.86	0.84	0.91	0.44		
NLD	0.85	0.81	0.84	0.86	0.84	0.73	0.87	0.86	0.73	0.84	0.85	4.51	

CAM 0.86 0.86 0.86 0.90 0.83 0.85 0.89 0.89 0.88 0.90 0.90 0.87 6.35

SIM scs

	FRM	FRA	ITA	NLD	CHE	DEA	HUN	SVN	GBR	HRV	USA
FRM	1.10										
FRA	0.90	1.01									
ITA	0.88	0.88	12.66								
NLD	0.91	0.93	0.86	4.30							
CHE	0.93	0.93	0.88	0.93	10.40						
DEA	0.91	0.93	0.86	0.91	0.89	12.27					
HUN	0.90	0.90	0.92	0.88	0.89	0.91	16.37				
SVN	0.89	0.84	0.84	0.84	0.86	0.83	0.86	9.09			
GBR	0.91	0.95	0.88	0.95	0.90	0.93	0.89	0.85	11.60		
HRV	0.87	0.81	0.82	0.81	0.82	0.81	0.85	0.82	0.82	9.84	
USA	0.85	0.90	0.88	0.87	0.86	0.84	0.91	0.83	0.90	0.82	0.20

SIM mas

	FRM	FRA	ITA	NLD	CHE	DEA	HUN	SVN	GBR	HRV	USA
FRM	1.08										
FRA	0.88	1.00									
ITA	0.91	0.82	12.65								
NLD	0.86	0.86	0.79	4.14							
CHE	0.85	0.89	0.88	0.86	9.63						
DEA	0.92	0.92	0.85	0.87	0.77	12.27					
HUN	0.88	0.83	0.89	0.87	0.86	0.90	16.37				
SVN	0.88	0.82	0.82	0.79	0.82	0.82	0.84	9.09			
GBR	0.79	0.88	0.78	0.82	0.89	0.81	0.83	0.80	2.73		
HRV	0.85	0.79	0.80	0.73	0.79	0.80	0.83	0.81	0.76	9.84	
USA	0.81	0.86	0.74	0.84	0.81	0.81	0.75	0.72	0.80	0.74	0.20

^APPENDIX II. Number of common bulls

BSW

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	FRA	NLD	USA	CHE	DEA	NZL	ITA	GBR	SVN
CAN	0	88	56	184	143	153	31	136	68	37
FRA	78	0	87	121	166	220	27	195	56	62
NLD	52	70	0	85	102	158	30	136	42	53
USA	182	81	76	0	322	331	35	233	95	47
CHE	122	122	95	299	0	606	33	475	77	90
DEA	138	163	151	296	503	0	46	675	80	119
NZL	31	21	23	32	26	41	0	37	23	14
ITA	120	154	113	163	415	573	30	0	80	110
GBR	69	48	36	94	61	56	21	60	0	24
SVN	34	60	54	38	86	111	13	108	21	0

BSW

common bulls below diagonal

common three quarter sib group above diagonal

	CAN	FRA	NLD	USA	CHE	DEA	NZL	ITA	GBR	SVN
CAN	0	81	52	184	68	153	31	136	31	37
FRA	73	0	71	106	69	206	23	184	28	62
NLD	46	60	0	76	44	142	29	125	21	49
USA	182	73	66	0	88	330	35	233	41	47
CHE	62	52	44	65	0	217	16	186	18	56
DEA	138	153	134	296	185	0	46	675	38	119
NZL	31	19	22	32	14	41	0	37	10	14
ITA	120	148	103	163	156	573	30	0	41	110
GBR	30	24	18	41	15	27	8	32	0	14

SVN 34 60 50 38 53 111 13 108 12 0

GUE

common bulls below diagonal

common three quarter sib group above diagonal

CAN GBR USA AUS NZL

CAN 0 30 73 51 14

GBR 25 0 87 38 13

USA 64 89 0 69 29

AUS 49 32 67 0 26

NZL 11 11 29 26 0

GUE

HOL

common bulls below diagonal

common three quarter sib group above diagonal

CAN CHE DEU DFS EST FRA GBR NLD USA ISR ITA AUS HUN BEL JPN ESP ZAF NZL IRL CZE SVK POL LTU LVA PRT KOR SVN HRV URY

CAN	0	892	2467	1599	285	1554	1708	1693	3718	145	1873	1545	1117	870	1435	1384	508	807	589	1207	445	1608	324	207	1060	726	238	333	839
CHE	809	0	1146	739	175	697	706	950	1026	67	764	651	448	623	490	589	261	421	394	542	240	727	187	132	498	276	152	211	328
DEU	1898	1077	0	2762	451	2438	2070	3467	3597	174	2674	1717	1314	1276	1478	1601	552	1014	860	1921	694	2755	642	299	1235	646	354	675	832
DFS	1398	690	2067	0	326	1709	1608	2298	2257	159	1691	1375	984	925	1047	1110	507	886	755	1348	423	1804	389	206	958	510	282	441	696
EST	174	97	326	203	0	278	269	401	375	53	303	231	219	212	225	226	110	148	139	288	122	365	125	87	205	130	103	135	154
FRA	1049	623	1295	936	135	0	1562	2063	2558	129	1699	1326	982	987	1251	1216	476	825	707	1285	434	1809	312	187	952	535	219	317	629
GBR	1936	673	1580	1243	156	980	0	1833	2283	155	1601	1462	920	898	1087	1122	510	947	946	1107	388	1453	329	180	953	515	228	355	710
NLD	1636	947	3250	2061	292	1304	1603	0	2695	172	1871	1565	1052	1355	1145	1224	518	1114	892	1622	562	2107	427	227	1083	510	295	482	726
USA	4202	957	2631	1782	258	1373	2047	2403	0	209	2744	2058	1426	1026	2057	1648	637	1149	809	1755	558	2357	436	260	1330	887	271	420	1206
ISR	105	39	135	118	33	67	107	130	198	0	153	123	123	87	115	118	65	120	100	139	53	158	60	28	109	65	51	72	99
ITA	1571	705	1871	1334	172	952	1253	1584	2046	104	0	1266	1108	866	1226	1357	469	755	650	1332	404	1830	358	221	1019	621	270	423	729
AUS	1570	576	1299	1012	118	893	1274	1376	2099	78	955	0	791	793	963	944	484	1261	727	917	320	1154	277	167	805	470	195	317	722
HUN	1057	378	1062	808	135	674	804	907	1414	84	972	602	0	583	775	842	397	535	447	992	327	1078	247	140	732	476	183	287	558
BEL	868	636	1312	871	133	972	886	1570	919	55	854	699	511	0	589	724	340	544	512	703	309	895	221	144	680	319	195	292	385
JPN	790	343	692	603	86	466	588	644	995	52	627	561	456	389	0	967	429	604	444	897	327	1083	241	149	732	584	187	250	624
ESP	933	489	1059	854	112	893	898	1111	1102	69	1022	683	687	718	487	0	451	573	499	929	331	1178	253	167	860	508	214	311	566
ZAF	469	219	431	392	56	338	447	441	624	42	372	423	323	290	301	402	0	368	307	408	181	420	118	99	439	266	101	156	328
NZL	808	354	776	634	77	495	817	1020	1100	97	566	1271	417	441	335	439	300	0	718	660	265	718	198	116	583	327	144	237	569
IRL	520	381	713	604	73	522	911	797	691	72	526	608	370	481	281	451	264	593	0	529	207	636	161	105	470	221	127	189	381
CZE	916	413	1506	942	183	815	808	1474	1414	104	985	627	917	568	439	687	289	493	393	0	515	1471	338	191	817	501	240	395	602
SVK	313	124	513	223	54	233	223	395	373	22	245	160	230	188	123	169	97	161	101	439	0	470	140	96	326	207	95	151	248
POL	1424	614	2522	1513	259	1202	1239	1985	2307	124	1476	891	988	824	608	854	318	552	506	1239	327	0	475	251	1048	604	293	512	708
LTU	174	86	594	226	64	120	171	271	298	29	198	124	152	118	84	110	48	96	79	228	73	369	0	101	246	159	86	178	186
LVA	131	78	204	126	62	87	103	149	208	20	151	79	100	91	66	95	58	56	58	126	47	186	73	0	189	99	43	115	122
PRT	1099	452	1126	853	140	801	879	1082	1391	77	946	647	727	684	456	825	394	476	399	680	224	1045	158	143	0	478	173	333	569
KOR	710	198	444	376	64	314	378	370	1013	38	507	346	385	234	364	358	198	238	147	363	125	505	68	59	399	0	111	158	405
SVN	174	109	342	226	60	152	169	256	210	36	228	137	137	156	106	160	73	102	98	182	50	264	45	26	136	67	0	126	119
HRV	196	138	699	347	98	197	251	441	320	50	326	197	209	236	118	239	107	141	128	294	75	459	125	91	270	71	97	0	197
URY	812	258	606	503	87	380	594	595	1498	56	544	570	454	307	372	454	292	462	292	441	150	593	107	82	503	323	66	120	0

AUS	943	183	477	882	117	725	1162	413	1092	77	851	0	773	763	958	942	467	1230	670	906	292	1121	249	158	777	447	192	298	650
HUN	692	96	414	738	135	585	781	314	918	82	900	596	0	563	766	832	384	528	406	987	304	1053	230	136	708	457	179	274	498
BEL	580	183	539	767	131	802	848	532	537	55	769	690	507	0	568	708	333	529	472	687	279	861	202	135	658	310	193	282	356
JPN	588	123	304	544	86	406	574	250	767	52	593	559	456	389	0	967	426	595	419	897	303	1069	223	144	707	559	183	236	549
ESP	613	147	452	790	112	783	877	402	697	69	877	679	686	718	487	0	445	571	465	929	302	1162	235	161	844	495	209	299	515
ZAF	239	52	155	375	56	292	432	187	396	42	326	417	322	290	301	402	0	363	288	402	170	411	109	96	427	252	99	146	307
NZL	395	122	296	574	76	416	723	384	519	97	493	1235	416	438	335	439	298	0	681	658	252	698	182	111	567	315	143	226	522
IRL	321	116	271	497	65	429	794	311	396	65	412	544	335	449	261	422	239	559	0	486	185	573	145	91	420	208	116	172	331
CZE	571	107	494	831	183	655	793	627	849	104	870	616	917	568	439	687	289	493	353	0	484	1449	313	183	797	483	238	376	544
SVK	177	24	120	191	53	178	216	94	181	22	214	155	226	182	123	169	96	158	94	439	0	420	115	88	305	193	89	138	220
POL	1004	194	1170	1309	255	1052	1202	837	1479	123	1359	881	976	811	608	852	317	548	452	1239	312	0	439	236	1000	577	285	481	633
LTU	129	23	227	210	62	106	169	125	174	29	173	125	150	117	84	110	48	94	70	228	69	356	0	95	222	140	81	161	163
LVA	72	7	104	114	62	76	96	50	127	20	121	79	99	91	66	95	58	55	51	126	47	179	73	0	181	95	43	107	110
PRT	656	119	413	782	139	711	847	426	816	77	872	635	720	682	456	825	393	473	360	680	217	1021	154	142	0	458	170	311	518
KOR	504	79	198	345	64	277	364	129	667	38	488	335	381	234	364	358	197	234	143	363	123	495	64	59	396	0	110	144	361
SVN	129	41	226	202	60	141	168	126	153	35	206	136	136	155	106	160	73	102	89	182	50	261	45	26	136	67	0	121	111
HRV	143	37	371	314	98	183	249	247	179	50	261	193	209	233	118	239	107	141	117	294	74	451	124	89	267	70	96	0	179
URY	476	68	225	446	87	307	559	194	764	55	503	567	443	305	372	454	289	458	275	441	149	575	106	78	494	314	66	118	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

CAN DFS GBR NLD USA AUS ZAF NZL CHE ITA

CAN	0	119	167	43	465	273	154	189	40	37
DFS	111	0	177	145	208	165	156	159	59	41
GBR	171	172	0	93	244	228	169	225	72	48
NLD	39	147	86	0	98	78	78	84	40	29
USA	492	188	268	104	0	516	289	386	70	48
AUS	280	134	233	69	562	0	237	446	57	46
ZAF	150	138	170	74	305	227	0	201	56	44
NZL	196	136	233	79	459	494	211	0	54	39
CHE	34	58	69	34	71	48	49	46	0	33
ITA	32	41	48	24	47	40	39	36	33	0

JER

common bulls below diagonal

common three quarter sib group above diagonal

CAN DFS GBR NLD USA AUS ZAF NZL CHE ITA

CAN	0	44	79	19	87	124	69	87	24	24
DFS	39	0	115	113	59	131	131	133	57	38
GBR	75	107	0	68	83	165	130	159	64	43
NLD	12	107	64	0	34	74	74	77	37	29
USA	79	47	82	31	0	162	115	120	36	26
AUS	113	96	168	67	172	0	230	440	53	45
ZAF	63	109	131	71	126	226	0	197	53	44
NZL	79	106	163	72	122	487	208	0	50	39
CHE	22	54	61	32	30	47	48	45	0	32
ITA	20	36	42	24	25	39	39	36	33	0

RDC

common bulls below diagonal

common three quarter sib group above diagonal

CAN DFS GBR NOR USA DEU AUS EST ZAF NZL LTU LVA NLD CAM

CAN	0	180	83	7	212	14	103	3	70	92	17	7	7	0

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LTU	16	98	25	22	29	28	42	25	5	25	0	38	16	0
LVA	7	59	11	15	10	22	25	28	1	10	32	0	9	0
NLD	7	57	38	44	45	14	34	18	3	23	14	8	0	0
CAM	0	0	0	0	25	0	12	0	0	12	0	0	0	0

RDC

common bulls below diagonal														
common three quarter sib group above diagonal														
CAN	DFS	GBR	NOR	USA	AUS	EST	ZAF	NZL	LTU	LVA	NLD	CAM		
CAN	0	75	29	3	73	33	0	35	34	13	4	3	0	
DFS	74	0	74	136	197	216	118	46	173	110	92	56	0	
GBR	28	70	0	51	79	54	5	27	60	22	9	30	0	
NOR	3	109	54	0	79	73	24	0	46	26	17	40	0	
USA	73	194	78	80	0	129	23	54	126	35	14	44	25	
AUS	33	192	52	62	132	0	35	31	143	43	27	33	10	
EST	0	107	5	24	22	32	0	0	12	26	36	18	0	
ZAF	36	46	26	0	52	33	0	0	33	5	1	2	0	
NZL	34	168	59	46	131	144	11	30	0	29	13	21	12	
LTU	12	97	19	22	29	40	25	5	25	0	38	15	0	
LVA	4	59	9	15	10	25	28	1	10	32	0	8	0	
NLD	3	54	30	39	44	31	17	2	21	13	7	0	0	
CAM	0	0	0	0	25	10	0	0	12	0	0	0	0	

SIM

common bulls below diagonal														
common three quarter sib group above diagonal														
FRM	FRA	ITA	NLD	CHE	DEA	HUN	SVN	GBR	HRV	USA				
FRM	0	3	174	128	221	270	2	17	67	2	64			
FRA	1	0	153	78	12	276	6	60	0	110	3			
ITA	200	136	0	232	95	931	18	139	46	306	33			
NLD	153	75	229	0	91	353	8	67	49	150	28			
CHE	273	9	98	95	0	350	2	5	53	2	32			
DEA	315	234	843	373	316	0	37	246	49	678	34			
HUN	0	5	15	8	1	24	0	12	0	19	0			
SVN	17	57	132	64	5	227	11	0	0	121	1			
GBR	84	0	50	49	60	52	0	0	0	0	19			
HRV	1	100	293	148	2	710	17	110	0	0	0	4		
USA	79	3	39	30	31	40	0	1	26	4	0			

SIM

common bulls below diagonal														
common three quarter sib group above diagonal														
FRM	FRA	ITA	NLD	CHE	DEA	HUN	SVN	GBR	HRV	USA				
FRM	0	2	157	104	5	228	2	17	25	2	36			
FRA	1	0	85	31	1	161	3	34	0	59	1			
ITA	183	74	0	223	7	930	18	139	18	306	33			
NLD	127	30	219	0	6	325	8	64	18	144	25			
CHE	5	1	7	6	0	79	0	0	1	0	4			
DEA	276	124	843	344	71	0	37	246	20	678	34			
HUN	0	2	15	8	0	24	0	12	0	19	0			
SVN	17	29	132	61	0	227	11	0	0	121	1			
GBR	34	0	23	20	1	25	0	0	0	0	16			
HRV	1	51	293	143	0	710	17	110	0	0	0	4		
USA	51	1	39	27	4	40	0	1	22	4	0			