Introduction

The latest routine international evaluation for females fertility traits took place as scheduled at the Interbull Centre. Data from twentyone (21) countries were included in this evaluation.

International genetic evaluations for female fertility traits of bulls from Australia, Austria, Belgium, Canada, Czech Republic, Denmark-Finland-Sweden, France, Germany, Ireland, Israel, Italy, Netherlands, New Zealand, Norway, Poland, Spain, Switzerland, South Africa, the United Kingdom, Uruguay, Japan and the United States of America and Slovenia 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	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	T1=HC	CR=Heifers' Conception rate
	T2=CR	CF=Interval from Calving to First Service (ICF), days
	T3=C1	NR=Non Return Rate after 56 Days (NRR), %
	T4=C2	FL=Interval from first to last insemination cows
CZE	T1=HC	CR=Heifers' Conception rate (pregnant or not after 3 months)

	T3=C1	CR=Cows' Conception rate (pregnant or not after 3 months)
	T4=C2	CR=Cows' Conception rate (pregnant or not after 3 months)
AUT/DEU	T1=HC	NR=Heifers' Non Return Rate after 56 days
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	NR=Cows' Non Return Rate after 56 days
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
DFS	T1=HC	CR=Heifers' Conception rate for maiden heifers
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	CR=Cows' conception rate for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
ESP	T2=CY	Interval from Calving to First Service (ICF)
	T4=C2	Interval first insemination to conception
	T5=IT	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)
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	FL=Interval from first to last insemination cows (days)
GBR	T2=CY	CI=days between 1st and 2nd calvings
	T3=C1	NR=1st lactation non return at 56 days
	T4=C2	CI=days between 1st and 2nd calvings
	T5=IT	CI=days between 1st and 2nd calvings
IRL	T2=CY	CI=Calving interval
	T4=C2	CI=Calving interval
	T5=IT	CI=Calving interval
ISR	T3=C1	CR=Inverse of the number of insemination to conception (%)
	T4=C2	CR=Inverse of the number of insemination to conception (%)
ITA	T1=HC	NR= non-return rate 56 days (heifers)
	T2=CY	CF=Days to first service
	T3=C1	CR=Conception rate at first service
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=days open (days)
ITA(BSW)	T1=HC	CR=Conception rate
	T2=CY	CF=Interval calving to first insemination
	T3=C1	CR=Conception rate
	T4=C2	DO=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=Days Open
NOR	T1=HC	NI=Number of inseminations (heifers)
	T2=CY	CF=Days from calving to first insemination (days)
	T3=C1	NI=Number of inseminations (cows)
	T4=C2	NI=Number of inseminations (cows)
	T5=IT	CF=Days from calving to first insemination (days)
NZL	T2=CY	PM=Lactating cow's ability to start cycling
	T4=C2	PR42: confirmed pregnant within 6 weeks of planned start of mating (PSM), (in days)
	T5=IT	PR42: confirmed pregnant within 6 weeks of planned start of mating (PSM), (in days)
POL	T1=HC	CR=Conception Rate (heifer)
	T2=CR	CF=Interval from calving to first insemination
	T3=C1	CR=Conception Rate (cow)
	T4=IT	DO=Days open

	T5=IT	DO=Days open
URY	T4=C2	Days open expressed as Daughter Pregnancy Rate
	T5=IT	Days open expressed as Daughter Pregnancy Rate
USA	T1=HC	CR=Conception rate (heifer)
	T2=CY	CF=Interval from calving to first insemination
	T3=C1	CR=Conception rate (cow)
	T4=C2	DP=Daughter Pregnancy Rate
	T5=IT	DP=Daughter Pregnancy Rate
ZAF	T4=IT	CI=Calving Interval
	T5=IT	CI=Calving Interval
JPN	T1=HC	CR=Heifers'Conception rate
	T3=C1	CR=Cows'Conception rate
	T4=C2	DO=Days open
	T5=IT	DO=Days open
SVN	T5=IT	CI=Calving interval (days)

CHANGES IN NATIONAL PROCEDURES

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

USA (ALL)	Separate groups for unknown foreign parents were removed because most such animals are now from countries with no domestic U.S. descendants. Drop in information due to the pedigree correction and herd-year minimum edits
AUS (ALL)	Some decrease in information due to pedigree, data updates and change in bulls' status which made bulls no longer qualifying for inclusion.
NLD (ALL)	Base change. Too many data were provided for the January test run, the error has been corrected resulting in drops of information especially for HOL.
ITA (BSW)	cc1, hco: First time participation. cc2,crc,int: new editing procedure, new variance components/heritability, a multitrait model has been applied. Base change
ITA (HOL)	Change in statistical model/new variance components and data editing (stricter criteria). Change in trait definition of cc1, from "non return rate at 56 days" to "conception rate at first service" . Change in trait definition of hco. Base change. Drop in information due to the yearly data cut-off for phenotypes
FRA (ALL)	Base change
DEA (BSW)	Base change due to the rolling base definition
IRL (HOL,JER)	Drop in information because ancestry errors are being corrected on an on-going basis as the genotypes come in.
JPN (HOL)	Drop in information due to the pedigree modification
DEU (ALL)	Base change. For HOL, drop in information causing some bulls to drops below the required threshold of 10 herds
CHE (ALL)	Drop of information due to changes in the groups of fixed effects regions and level (geographical) and edits in database. Base change.
CAN (ALL)	Base change
BEL (HOL)	Drop in information due to few pedigree correction
NZL (ALL)	Drop in information due to the DNA parentage testing.
CZE (HOL)	Drop in information due to the half a year data trimming (mainly cc1,cc2)
GBR (HOL,JER,BSW,RDC)	Drop in information due to the pedigree updates and clean up and data edits

INTERBULL CHANGES COMPARED TO THE PREVIOUS ROUTINE RUN

In 2020 new post-processing windowsâ\200\231 correlations for all breeds and traits have been applied: 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. The previoulsy lower value adopted (based on the 25th percentile) had been found too high causing estimated and post-processed correlations to differ significantly from each other. It is a recommendation from the Interbull Technical Committee to review such windows every 5 years. 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. More information can be read on https://interbull.org/ib/rg_procedure

Since 2021 a new trait group has been added to the MACE evaluation, called stcm (SNP Training for clinical mastitis) evaluating the trait cma (pure clinical mastitis). New trait group codes have been issued as follows: 041 for international ebv files (.itb), 071 for parent average (ipr).

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.

^LTable 1. National evaluation data considered in the Interbull evaluation for fertility (April Routine Evaluation 2024).
Number of records for lactating cow's ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		149	8820	1875	805	
BEL			2136			
CAN	186	50	10503	665	604	
CHE	3043		3317			
CZE			3495			
DEA	4997					
DEU			25840		320	
DFS			17518	2527	10667	
ESP			6714			
EST						
FRA	443		17401			
FRM						
GBR	114	256	7737	637	475	
HUN						
IRL			3361	241	75	
ISR			1700			
ITA	2007		7312			
JPN			6681			
KOR						
LTU						
LVA						
NLD	228		16814	266	100	
NOR					3146	
NZL	54	50	8740	5006	1338	
POL			9402			
PRT						
SVK						
SVN						
URY			2010			
USA	1215	803	42671	5417	803	
ZAF			1275	754	159	
HRV						
CAM						
No.Records	12287	1308	203447	17388	18492	
Pub. Proofs	10793	1080	160400	14446	18261	0

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

BSW hco							
	CAN	DEA	FRA	USA	CHE	NLD	ITA
CAN	9.31						

DEA	0.86	9.91					
FRA	0.76	0.90	0.76				
USA	0.79	0.80	0.86	2.62			
CHE	0.91	0.95	0.87	0.81	13.20		
NLD	0.83	0.72	0.80	0.81	0.77	4.46	
ITA	0.79	0.80	0.89	0.90	0.87	0.84	15.48

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	7.14								
CHE	0.80	11.38							
DEA	0.77	0.95	14.96						
NLD	0.82	0.85	0.83	3.52					
NZL	0.59	0.65	0.76	0.61	0.12				
USA	0.77	0.83	0.80	0.78	0.61	8.13			
GBR	0.70	0.69	0.62	0.73	0.65	0.73	3.99		
FRA	0.82	0.97	0.96	0.86	0.66	0.85	0.73	1.69	
ITA	0.82	0.84	0.86	0.81	0.61	0.79	0.72	0.87	17.02

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA	ITA
CAN	7.30							
CHE	0.83	11.78						
DEA	0.79	0.95	11.43					
NLD	0.76	0.70	0.67	3.78				
USA	0.75	0.67	0.67	0.80	2.85			
GBR	0.77	0.81	0.79	0.70	0.68	0.03		
FRA	0.73	0.69	0.67	0.82	0.86	0.71	0.88	
ITA	0.68	0.66	0.66	0.69	0.78	0.67	0.88	16.27

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.72								
CHE	0.77	11.16							
DEA	0.75	0.93	12.28						
NLD	0.83	0.79	0.75	3.20					
NZL	0.65	0.81	0.68	0.64	0.08				
USA	0.81	0.82	0.82	0.79	0.65	2.50			
GBR	0.70	0.80	0.79	0.73	0.67	0.81	3.99		
FRA	0.86	0.89	0.89	0.83	0.66	0.84	0.79	0.88	
ITA	0.85	0.85	0.85	0.76	0.74	0.77	0.74	0.90	19.27

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA	SVN
CAN	7.63							
DEA	0.79	14.29						
NLD	0.84	0.86	3.06					
NZL	0.66	0.67	0.65	0.08				
USA	0.90	0.81	0.78	0.61	2.50			
GBR	0.82	0.70	0.82	0.68	0.82	3.99		
ITA	0.86	0.88	0.79	0.67	0.74	0.80	19.33	
SVN	0.72	0.68	0.72	0.68	0.70	0.75	0.71	19.61

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.73				
GBR	0.73	4.78			
NZL	0.59	0.65	0.11		
USA	0.77	0.76	0.60	6.94	

AUS	0.67	0.78	0.90	0.66	6.97

GUE cc1

	CAN	GBR	USA
CAN	7.62		
GBR	0.77	0.03	
USA	0.81	0.73	3.45

GUE cc2

	CAN	GBR	NZL	USA	AUS
CAN	7.34				
GBR	0.70	4.78			
NZL	0.64	0.68	0.07		
USA	0.84	0.80	0.68	2.83	
AUS	0.68	0.68	0.70	0.72	10.31

GUE int

	CAN	GBR	NZL	USA	AUS
CAN	8.01				
GBR	0.82	4.78			
NZL	0.64	0.67	0.07		
USA	0.90	0.80	0.64	2.83	
AUS	0.71	0.69	0.70	0.72	10.31

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD	ITA	JPN
CAN	7.84										
CZE	0.76	17.59									
DEU	0.90	0.79	15.15								
DFS	0.78	0.84	0.84	13.54							
FRA	0.76	0.77	0.80	0.88	0.71						
USA	0.83	0.84	0.84	0.86	0.84	2.38					
POL	0.63	0.50	0.63	0.50	0.47	0.55	19.50				
CHE	0.96	0.78	0.93	0.78	0.78	0.86	0.52	13.63			
NLD	0.84	0.80	0.87	0.89	0.85	0.87	0.50	0.83	5.11		
ITA	0.82	0.85	0.88	0.91	0.92	0.93	0.57	0.86	0.91	1.95	
JPN	0.85	0.71	0.85	0.71	0.70	0.83	0.63	0.84	0.77	0.82	6.23

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA
BEL	4.64													
CAN	0.75	7.40												
CHE	0.80	0.83	12.27											
DEU	0.71	0.83	0.87	10.93										
DFS	0.79	0.86	0.94	0.91	11.60									
ESP	0.77	0.81	0.85	0.82	0.83	10.93								
GBR	0.89	0.73	0.77	0.71	0.79	0.76	4.58							
IRL	0.85	0.59	0.66	0.59	0.61	0.69	0.82	3.57						
ITA	0.80	0.87	0.89	0.89	0.90	0.87	0.79	0.64	1.38					
NLD	0.78	0.84	0.90	0.86	0.93	0.81	0.76	0.59	0.86	4.43				
NZL	0.62	0.59	0.62	0.58	0.63	0.63	0.65	0.58	0.64	0.56	0.09			
USA	0.73	0.77	0.81	0.82	0.85	0.79	0.78	0.59	0.82	0.78	0.60	6.84		
POL	0.73	0.90	0.89	0.84	0.83	0.84	0.72	0.64	0.90	0.78	0.66	0.76	13.36	
FRA	0.77	0.85	0.94	0.92	0.94	0.85	0.79	0.64	0.90	0.90	0.64	0.83	0.88	1.13

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	JPN

CAN	6.72																		
CHE	0.93	10.84																	
CZE	0.82	0.73	17.31																
DEU	0.91	0.91	0.80	14.67															
DFS	0.75	0.68	0.86	0.79	13.16														
FRA	0.77	0.74	0.89	0.76	0.87	0.96													
GBR	0.77	0.77	0.68	0.79	0.66	0.73	0.03												
ISR	0.79	0.70	0.93	0.78	0.88	0.89	0.76	3.30											
ITA	0.70	0.66	0.89	0.68	0.80	0.88	0.66	0.90	1.30										
NLD	0.78	0.74	0.88	0.80	0.91	0.92	0.70	0.88	0.82	4.56									
USA	0.80	0.71	0.95	0.75	0.83	0.85	0.68	0.93	0.87	0.84	2.82								
POL	0.72	0.72	0.71	0.74	0.58	0.56	0.66	0.67	0.58	0.59	0.65	19.64							
JPN	0.79	0.77	0.90	0.77	0.83	0.83	0.77	0.86	0.82	0.81	0.92	0.66	7.58						

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	JPN
BEL	4.64																			
CAN	0.74	6.35																		
CHE	0.82	0.90	10.94																	
CZE	0.66	0.86	0.88	17.31																
DEU	0.79	0.93	0.92	0.91	13.47															
DFS	0.80	0.84	0.88	0.82	0.94	12.86														
ESP	0.76	0.80	0.87	0.88	0.85	0.80	10.92													
FRA	0.81	0.90	0.93	0.85	0.95	0.88	0.85	0.92												
GBR	0.88	0.70	0.74	0.65	0.76	0.79	0.73	0.75	4.58											
IRL	0.83	0.75	0.84	0.70	0.79	0.76	0.77	0.82	0.82	3.57										
ISR	0.61	0.72	0.72	0.87	0.81	0.77	0.82	0.74	0.64	0.65	3.29									
ITA	0.78	0.85	0.89	0.90	0.90	0.86	0.90	0.88	0.75	0.78	0.83	1.36								
NLD	0.79	0.86	0.88	0.83	0.94	0.90	0.83	0.91	0.73	0.78	0.79	0.85	4.30							
NZL	0.69	0.63	0.76	0.76	0.65	0.63	0.78	0.65	0.67	0.72	0.72	0.79	0.63	0.06						
USA	0.79	0.86	0.84	0.88	0.91	0.85	0.82	0.84	0.82	0.81	0.80	0.89	0.82	0.65	2.36					
POL	0.79	0.70	0.73	0.62	0.70	0.70	0.69	0.72	0.80	0.75	0.63	0.75	0.69	0.66	0.77	12.28				
ZAF	0.78	0.77	0.81	0.71	0.81	0.75	0.75	0.81	0.78	0.85	0.59	0.78	0.75	0.67	0.86	0.79	15.61			
AUS	0.69	0.68	0.73	0.62	0.70	0.64	0.68	0.74	0.68	0.83	0.59	0.68	0.65	0.64	0.72	0.61	0.78	8.48		
URY	0.72	0.69	0.67	0.64	0.68	0.68	0.65	0.66	0.70	0.70	0.57	0.64	0.68	0.75	0.69	0.69	0.77	0.65	1.40	
JPN	0.83	0.82	0.86	0.78	0.85	0.84	0.77	0.84	0.86	0.85	0.69	0.86	0.79	0.66	0.92	0.89	0.87	0.70	0.69	18.26

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN	SVN
BEL	4.64																	
CAN	0.88	6.87																
DEU	0.86	0.91	12.31															
DFS	0.90	0.91	0.95	12.77														
ESP	0.88	0.84	0.84	0.85	10.92													
GBR	0.89	0.83	0.86	0.89	0.83	4.58												
IRL	0.84	0.82	0.82	0.80	0.85	0.82	3.57											
ITA	0.88	0.90	0.90	0.92	0.89	0.86	0.79	2.53										
NLD	0.90	0.88	0.90	0.94	0.84	0.85	0.80	0.89	4.25									
NZL	0.70	0.64	0.62	0.60	0.64	0.67	0.73	0.69	0.61	0.06								
USA	0.80	0.92	0.91	0.86	0.86	0.82	0.81	0.87	0.81	0.60	2.36							
POL	0.79	0.86	0.78	0.80	0.75	0.81	0.76	0.89	0.78	0.66	0.77	12.29						
ZAF	0.80	0.84	0.85	0.80	0.84	0.80	0.87	0.81	0.80	0.68	0.86	0.83	15.61					
AUS	0.71	0.72	0.70	0.67	0.73	0.69	0.84	0.66	0.67	0.64	0.73	0.67	0.80	8.48				
URY	0.73	0.68	0.67	0.67	0.69	0.68	0.71	0.69	0.67	0.80	0.67	0.70	0.79	0.68	1.40			
FRA	0.81	0.89	0.84	0.83	0.84	0.75	0.81	0.81	0.80	0.59	0.83	0.70	0.81	0.74	0.66	0.92		
JPN	0.85	0.93	0.90	0.90	0.85	0.87	0.83	0.91	0.86	0.62	0.92	0.89	0.89	0.72	0.71	0.82	18.26	
SVN	0.88	0.75	0.76	0.83	0.79	0.79	0.74	0.84	0.81	0.65	0.70	0.69	0.65	0.68	0.67	0.75	0.77	19.85

JER hco

	CAN	DFS	USA	NLD
CAN	7.95			
DFS	0.73	17.34		
USA	0.75	0.83	2.72	

NLD	0.85	0.84	0.74	4.67

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	7.01						
DFS	0.81	13.40					
GBR	0.65	0.81	3.84				
NLD	0.82	0.84	0.69	3.37			
NZL	0.58	0.65	0.63	0.55	0.07		
USA	0.77	0.81	0.78	0.77	0.63	8.33	
IRL	0.61	0.61	0.79	0.60	0.57	0.60	2.41

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	6.89				
DFS	0.71	15.43			
GBR	0.78	0.67	0.03		
NLD	0.75	0.76	0.69	3.55	
USA	0.75	0.80	0.67	0.71	2.90

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.62								
DFS	0.80	15.66							
GBR	0.70	0.74	3.85						
NLD	0.82	0.80	0.72	3.16					
NZL	0.64	0.64	0.64	0.64	0.05				
USA	0.80	0.78	0.77	0.77	0.68	2.64			
ZAF	0.66	0.66	0.73	0.67	0.74	0.84	11.34		
AUS	0.64	0.64	0.64	0.64	0.63	0.65	0.70	6.48	
IRL	0.75	0.73	0.76	0.75	0.66	0.76	0.78	0.72	2.41

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.55								
DFS	0.83	15.36							
GBR	0.75	0.82	3.85						
NLD	0.82	0.82	0.77	3.08					
NZL	0.62	0.61	0.64	0.61	0.05				
USA	0.83	0.80	0.77	0.75	0.67	2.64			
ZAF	0.71	0.72	0.74	0.71	0.75	0.84	11.34		
AUS	0.68	0.67	0.68	0.67	0.63	0.68	0.71	6.48	
IRL	0.79	0.73	0.75	0.75	0.63	0.76	0.80	0.75	2.41

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.89					
DEU	0.90	14.41				
DFS	0.71	0.82	12.23			
NOR	0.83	0.87	0.87	16.55		
USA	0.83	0.83	0.82	0.73	2.80	
NLD	0.84	0.86	0.81	0.66	0.82	5.73

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	6.68								
DEU	0.83	10.14							

DFS	0.84	0.89	12.67						
GBR	0.77	0.71	0.69	4.17					
NOR	0.83	0.81	0.85	0.61	14.20				
NZL	0.66	0.58	0.55	0.67	0.58	0.11			
USA	0.77	0.82	0.80	0.75	0.77	0.66	8.56		
NLD	0.83	0.84	0.88	0.72	0.79	0.56	0.77	3.29	
IRL	0.60	0.60	0.62	0.81	0.61	0.60	0.62	0.60	2.84

RDC cc1

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	7.51						
DEU	0.90	13.90					
DFS	0.70	0.81	12.99				
GBR	0.77	0.79	0.67	0.03			
NOR	0.78	0.86	0.93	0.77	14.09		
NLD	0.77	0.79	0.84	0.70	0.69	3.91	
USA	0.82	0.75	0.77	0.68	0.73	0.82	2.78

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.98										
DEU	0.92	11.45									
DFS	0.80	0.93	12.85								
GBR	0.70	0.76	0.75	4.17							
NOR	0.78	0.81	0.89	0.72	14.09						
NZL	0.64	0.67	0.64	0.66	0.66	0.07					
USA	0.87	0.89	0.79	0.79	0.72	0.65	2.57				
ZAF	0.69	0.81	0.73	0.70	0.78	0.65	0.80	17.04			
NLD	0.86	0.94	0.87	0.73	0.75	0.67	0.81	0.75	3.38		
AUS	0.66	0.68	0.63	0.67	0.65	0.64	0.68	0.66	0.65	7.63	
IRL	0.75	0.79	0.76	0.80	0.72	0.72	0.78	0.83	0.78	0.79	2.84

RDC int

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.69										
DEU	0.90	11.26									
DFS	0.87	0.94	13.17								
GBR	0.82	0.85	0.80	4.17							
NOR	0.77	0.74	0.68	0.69	14.20						
NZL	0.69	0.63	0.60	0.66	0.63	0.07					
USA	0.91	0.89	0.76	0.80	0.69	0.63	2.57				
ZAF	0.79	0.84	0.76	0.74	0.81	0.65	0.81	17.04			
NLD	0.87	0.90	0.92	0.82	0.73	0.62	0.79	0.80	3.13		
AUS	0.70	0.70	0.68	0.69	0.69	0.64	0.70	0.73	0.67	7.63	
IRL	0.81	0.81	0.78	0.80	0.69	0.71	0.77	0.85	0.79	0.80	2.84

^LAPPENDIX II. Number of common bulls

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	FRA	USA	CHE	NLD	ITA
CAN	0	106	55	110	109	33	96
DEA	92	0	201	201	624	145	522
FRA	47	155	0	73	170	76	179
USA	99	160	56	0	210	55	142
CHE	91	526	131	174	0	106	454
NLD	29	135	63	51	100	0	123
ITA	83	407	139	102	395	97	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	125	122	40	20	138	48	74	117
CHE	106	0	626	109	31	277	63	170	480
DEA	109	519	0	161	44	248	59	209	648
NLD	35	100	147	0	28	66	34	80	134
NZL	19	24	38	21	0	21	15	22	36
USA	135	243	198	60	18	0	66	95	182
GBR	44	48	43	29	11	64	0	47	68
FRA	63	129	160	65	17	66	37	0	189
ITA	103	418	528	111	30	130	48	146	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA	ITA
CAN	0	128	124	41	140	47	78	118
CHE	107	0	625	109	277	67	177	483
DEA	110	516	0	162	248	64	221	651
NLD	36	100	147	0	66	36	84	135
USA	136	243	198	60	0	68	100	183
GBR	44	52	47	31	67	0	53	73
FRA	67	135	171	70	72	44	0	202
ITA	104	423	529	110	131	51	159	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	113	109	36	15	133	45	71	102
CHE	94	0	618	109	26	334	63	177	453
DEA	97	513	0	162	35	324	59	220	595
NLD	32	100	147	0	22	89	34	84	133
NZL	14	21	32	17	0	24	12	19	26
USA	125	311	281	77	21	0	76	120	228
GBR	40	48	43	29	8	73	0	50	65
FRA	62	135	170	70	15	86	41	0	200
ITA	90	388	468	107	22	157	45	154	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	NLD	NZL	USA	GBR	ITA	SVN
CAN	0	114	38	15	138	47	113	28
DEA	101	0	161	35	323	59	710	84
NLD	34	147	0	22	89	34	140	38
NZL	14	32	17	0	24	12	29	9
USA	130	281	77	21	0	76	253	34
GBR	42	43	29	8	73	0	70	16
ITA	99	629	115	25	180	51	0	82
SVN	26	79	38	9	30	13	79	0

GUE

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS

CAN	0	18	3	43	18
GBR	15	0	14	56	28
NZL	2	12	0	10	26
USA	42	53	7	0	19
AUS	13	22	23	16	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	USA
CAN	0	19	43
GBR	15	0	59
USA	42	56	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	14	1	41	25
GBR	11	0	12	87	36
NZL	1	10	0	24	22
USA	39	88	23	0	69
AUS	21	29	21	66	0

GUE

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	GBR	NZL	USA	AUS
CAN	0	14	1	41	25
GBR	11	0	12	87	36
NZL	1	10	0	24	22
USA	39	88	23	0	69
AUS	21	29	21	66	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD	ITA	JPN
CAN	0	1145	2380	1483	1344	3159	1486	875	1516	1714	1202
CZE	859	0	1909	1301	1240	1559	1278	503	1553	1233	845
DEU	1978	1472	0	2767	2416	3132	2501	1182	3277	2407	1375
DFS	1416	891	2164	0	1733	1867	1561	759	2329	1462	1019
FRA	1034	776	1415	1046	0	1728	1578	732	2009	1485	1156
USA	3653	1289	2569	1741	1069	0	2177	930	2035	2327	1535
POL	1389	1046	2271	1337	1119	2330	0	580	1769	1578	881
CHE	799	353	1108	714	679	859	482	0	937	641	477
NLD	1508	1351	2956	2068	1361	1850	1631	931	0	1564	1110
ITA	1368	840	1497	1077	774	1810	1264	547	1164	0	1056
JPN	705	387	647	555	441	846	499	310	589	495	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
BEL	0	822	638	1288	918	962	923	551	640	1318	537	884	627	1011
CAN	827	0	907	2548	1566	1702	1764	607	1601	1673	760	3371	1382	1448
CHE	646	839	0	1220	771	768	799	457	607	993	451	990	554	749
DEU	1322	2070	1157	0	2957	2451	2402	993	2125	3787	1094	3424	2280	2662

DFS	866	1499	732	2263	0	1656	1736	821	1280	2390	915	2020	1430	1748
ESP	1032	1525	721	2181	1489	0	1616	758	1389	1901	780	2013	1361	1880
GBR	909	1851	767	1881	1400	1482	0	1077	1334	2039	1021	2242	1209	1679
IRL	543	604	469	877	697	777	1127	0	466	1000	806	743	455	798
ITA	627	1369	542	1434	1066	1151	1059	408	0	1441	498	2206	1379	1280
NLD	1504	1690	997	3559	2184	1998	1833	953	1230	0	1191	2313	1668	2150
NZL	438	697	375	847	665	648	885	704	403	1081	0	929	504	844
USA	846	3972	927	2719	1846	1822	2223	733	1781	2127	881	0	1978	1932
POL	539	1270	436	1973	1186	1153	978	355	1096	1499	386	2030	0	1489
FRA	999	1123	687	1556	1044	1807	1118	653	782	1445	521	1172	1018	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	JPN
CAN	0	906	1059	2542	1569	1457	1806	144	1606	1677	3409	1431	1351
CHE	839	0	433	1218	771	754	804	65	607	993	990	578	513
CZE	837	310	0	1597	1084	996	940	121	1079	1362	1454	1235	738
DEU	2063	1155	1297	0	2956	2678	2438	183	2119	3771	3405	2427	1572
DFS	1501	732	849	2258	0	1756	1761	163	1281	2388	2024	1534	1075
FRA	1140	695	644	1572	1055	0	1706	130	1287	2164	1945	1549	1292
GBR	1906	774	677	1912	1422	1141	0	167	1366	2074	2311	1272	1168
ISR	103	38	93	143	125	72	125	0	120	173	203	134	123
ITA	1373	542	826	1427	1066	789	1101	82	0	1441	2207	1433	981
NLD	1694	997	1270	3540	2184	1467	1876	137	1230	0	2314	1791	1185
USA	4023	927	1225	2695	1846	1191	2314	198	1781	2128	0	2047	1746
POL	1330	473	1044	2209	1314	1086	1056	100	1159	1664	2133	0	898
JPN	822	354	403	734	621	509	631	58	535	677	996	523	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	JPN
BEL	0	810	638	534	1279	919	962	1006	925	553	83	640	1320	526	1035	619	334	785	365	549
CAN	813	0	898	1038	2468	1543	1686	1421	1733	595	140	1578	1638	709	3520	1339	446	1404	789	1247
CHE	646	823	0	433	1210	772	768	747	799	457	66	607	993	437	1085	542	263	686	332	477
CZE	429	808	310	0	1592	1084	1060	988	926	414	121	1079	1362	469	1488	1152	265	692	475	703
DEU	1311	1971	1143	1287	0	2943	2452	2643	2391	989	183	2108	3742	1047	3946	2216	559	1828	871	1482
DFS	866	1464	733	849	2237	0	1664	1745	1741	822	165	1283	2394	888	2413	1405	512	1392	695	1013
ESP	1032	1490	721	865	2172	1497	0	1879	1619	759	144	1389	1906	762	2331	1340	517	1277	710	1166
FRA	990	1089	683	637	1519	1030	1794	0	1678	802	132	1271	2142	834	2631	1455	482	1369	627	1230
GBR	909	1812	767	668	1858	1400	1483	1112	0	1078	166	1334	2042	988	2618	1184	505	1562	745	1105
IRL	543	585	469	320	870	697	777	650	1127	0	113	466	1003	796	907	443	338	809	407	479
ISR	49	99	38	93	141	125	109	70	121	87	0	120	175	122	228	124	60	123	92	117
ITA	627	1336	542	826	1413	1066	1151	776	1059	408	82	0	1441	475	2238	1348	267	927	526	925
NLD	1506	1643	997	1270	3486	2186	2002	1430	1834	954	137	1230	0	1140	2876	1621	503	1594	744	1118
NZL	424	639	363	355	797	638	623	504	850	695	98	378	1029	0	1164	475	352	1267	562	582
USA	927	4058	1023	1246	2938	1984	2091	1466	2469	834	216	1801	2578	1110	0	1973	637	2132	1249	2035
POL	521	1207	420	928	1881	1153	1126	978	955	344	86	1060	1435	358	1990	0	230	860	526	819
ZAF	281	410	222	189	429	379	475	337	445	297	39	205	419	282	613	160	0	477	317	412
AUS	684	1436	612	496	1398	1038	1054	945	1388	703	80	732	1394	1258	2192	658	417	0	716	944
URY	263	737	249	323	619	480	614	361	600	315	51	371	583	459	1518	409	267	558	0	599
JPN	351	684	303	357	627	540	570	442	548	301	45	467	582	286	858	433	260	510	303	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN	SVN
BEL	0	812	1277	919	962	925	553	639	1320	526	1035	618	334	785	365	1006	549	158
CAN	817	0	2473	1550	1692	1742	601	1581	1647	714	3533	1342	450	1412	795	1429	1252	207
DEU	1310	1980	0	2939	2451	2391	989	2108	3740	1046	3941	2210	559	1827	871	2642	1482	330
DFS	866	1474	2234	0	1664	1740	821	1282	2391	888	2410	1403	512	1392	695	1745	1013	245
ESP	1032	1506	2172	1497	0	1619	759	1389	1904	762	2328	1340	517	1276	710	1878	1164	233

GBR	909	1825	1858	1400	1483	0	1078	1334	2042	988	2618	1184	505	1562	744	1678	1105	203
IRL	543	593	870	697	777	1126	0	466	1002	796	907	443	338	809	407	802	479	111
ITA	627	1342	1413	1066	1151	1059	408	0	1441	475	2238	1346	267	927	526	1271	925	223
NLD	1506	1656	3485	2185	2002	1834	954	1230	0	1140	2875	1618	503	1594	744	2141	1117	263
NZL	424	643	797	638	623	849	694	378	1029	0	1164	475	352	1267	561	834	582	114
USA	927	4087	2938	1984	2091	2469	834	1801	2578	1110	0	1971	637	2132	1249	2631	2035	239
POL	521	1213	1876	1152	1126	955	344	1060	1435	358	1990	0	230	860	526	1455	818	246
ZAF	281	417	429	379	475	445	297	205	419	282	613	160	0	477	317	482	412	67
AUS	684	1441	1398	1038	1054	1388	703	732	1394	1258	2192	658	417	0	716	1369	944	155
URY	263	743	619	480	614	600	315	371	583	459	1518	409	267	558	0	627	599	91
FRA	990	1097	1519	1030	1794	1112	650	776	1430	504	1466	978	337	945	361	0	1230	195
JPN	351	687	627	540	570	548	301	467	582	286	858	433	260	510	303	442	0	151
SVN	123	160	323	193	206	148	86	187	226	77	194	204	47	108	46	142	80	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	107	353	37
DFS	103	0	159	96
USA	344	149	0	79
NLD	30	94	78	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	0	111	162	46	177	409	14
DFS	105	0	185	167	174	179	57
GBR	162	180	0	102	236	232	81
NLD	40	167	96	0	100	106	39
NZL	179	150	241	92	0	320	150
USA	413	169	252	108	345	0	46
IRL	13	53	84	38	167	48	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	112	163	47	414
DFS	106	0	187	166	178
GBR	162	182	0	104	233
NLD	41	166	99	0	105
USA	418	169	253	108	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	107	160	44	161	419	136	234	14
DFS	101	0	186	167	163	229	161	175	57
GBR	158	180	0	102	228	261	180	239	81
NLD	37	167	96	0	90	120	81	86	39
NZL	162	139	233	82	0	393	217	456	148
USA	424	207	288	125	465	0	327	530	53
ZAF	135	143	183	77	226	340	0	254	44
AUS	231	147	246	79	501	578	242	0	66
IRL	13	53	84	38	164	55	45	64	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	109	161	44	163	423	138	236	14
DFS	103	0	186	167	163	229	161	175	57
GBR	160	180	0	102	228	261	180	239	81
NLD	38	167	96	0	90	120	81	86	39
NZL	165	139	233	82	0	393	217	456	148
USA	430	207	288	125	465	0	327	530	53
ZAF	137	143	183	77	226	340	0	254	44
AUS	234	147	246	79	501	578	242	0	66
IRL	13	53	84	38	164	55	45	64	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	10	181	7	108	6
DEU	10	0	65	17	21	13
DFS	189	56	0	137	173	60
NOR	6	16	116	0	75	44
USA	102	19	165	75	0	39
NLD	6	13	57	44	37	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	0	13	182	81	7	73	151	6	4
DEU	12	0	70	15	17	22	23	17	5
DFS	190	58	0	123	153	193	200	62	20
GBR	82	14	119	0	69	83	109	42	26
NOR	6	16	126	73	0	54	83	51	62
NZL	74	22	187	81	53	0	110	25	16
USA	146	21	195	104	83	112	0	46	32
NLD	6	17	59	41	51	24	44	0	14
IRL	4	5	15	25	61	15	32	14	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	0	13	182	85	7	6	152
DEU	12	0	70	16	16	17	23
DFS	190	58	0	128	140	62	200
GBR	86	15	124	0	73	44	113
NOR	6	15	117	77	0	48	83
NLD	6	17	59	43	48	0	46
USA	147	21	195	108	83	44	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	13	181	76	7	68	174	77	6	77	4
DEU	12	0	68	15	16	20	24	3	17	46	5
DFS	189	57	0	123	140	177	221	62	62	232	20
GBR	76	14	119	0	68	76	122	47	42	91	26
NOR	6	15	117	72	0	44	87	0	48	73	62
NZL	68	20	173	73	43	0	120	40	22	151	15

USA	177	22	220	120	87	122	0	77	49	145	33
ZAF	81	3	59	44	0	38	72	0	3	46	3
NLD	6	17	59	41	48	22	47	3	0	39	14
AUS	79	44	209	89	62	151	147	48	37	0	21
IRL	4	5	15	25	61	15	33	3	14	20	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	13	181	78	7	68	175	77	6	77	4
DEU	12	0	68	15	17	20	24	3	17	46	5
DFS	189	57	0	123	153	177	221	62	62	232	20
GBR	78	14	119	0	69	76	122	47	42	91	26
NOR	6	16	126	73	0	45	87	0	51	77	62
NZL	68	20	173	73	44	0	120	40	22	151	15
USA	178	22	220	120	87	122	0	77	49	145	33
ZAF	81	3	59	44	0	38	72	0	3	46	3
NLD	6	17	59	41	51	22	47	3	0	39	14
AUS	79	44	209	89	66	151	147	48	37	0	21
IRL	4	5	15	25	61	15	33	3	14	20	0

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