

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 were computed. Brown Swiss, Guernsey, Holstein, Jersey, Red Dairy Cattle and Simmental breed data were included in this evaluation.

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

- T1 (HC): Maiden (H)eifer's ability to (C)onceive. A measure of confirmed conception, such as conception rate (CR), will be considered for this trait group. In the absence of confirmed conception an alternative measure, such as interval first-last insemination (FL), interval first insemination-conception (FC), number of inseminations (NI), or non-return rate (NR,preferably NR56) can be submitted;
- T2 (CR): Lactating (C)ow's ability to (R)ecycle after calving. The interval calving-first insemination (CF) is an example for this ability. In the absence of such a trait, a measure of the interval calving-conception, such as says oprn (DO) or calving interval (CI) can be submitted;
- T3 (C1): Lactating (C)ow's ability to conceive (1), expressed as a rate trait. Traits like conception rate (CR) and non-return rate (NR, preferably NR56) will be considered for this trait group;
- T4 (C2): Lactating (C)ow's ability to conceive (2), expressed as an interval trait. The interval first insemination-conception (FC) or interval first-last insemination (FL) will be considered for this trait group. As an alternative, number of inseminations (NI) can be submitted. In the absence of any of these traits, a measure of interval calving-conception such as days open (DO), or calving interval (CI) can be submitted. All countries are expected to submit data for this trait group, and as a last resort the trait submitted under T3 can be submitted for T4 as well.
- T5 (IT): Lactating cow's measurements of (I)nterval (T)raits calving-conception, such as days open (DO) and calving interval (CI).

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

| Country | Traits | Submitted traits and their definitions |
|---------|---|--|
| AUS | T4=C2 T5=IT | 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 | CR=Heifers' Conception rate CF=Interval from Calving to First Service (ICF), days 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) |
| | T3=C1 | Conception rate |
| | T4=C2 | Interval from first to last insemination (IFL) |
| | T5=IT | Sum of Interval to first to last insemination and interval from calving to first service (IFL+ICF) |
| 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 | NR=Non-return rate at 56 days (%) |
| | T4=C2 | FL=Interval from first to last insemination cows (days) |
| | T5=IT | DO=days open (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 | 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 | PC=Lactating cow's ability to conceive (CR42) |
| | T5=IT | PC=Lactating cow's ability to conceive (CR42) |

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

CHANGES IN NATIONAL PROCEDURES

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

AUS (HOL,RDC,JER) Some decrease in daughters and EDC due to data editing
JPN (HOL) Some changes in proofs caused by additional records and in EDCs caused by modification of pedigree.
DEA (BSW) Minor changes in number of daughters for some bulls
POL (HOL) Small decrease in number of herds and daughters due to edits caused decrease of EDC.
DFS (ALL) Changes in number of information mainly caused by the fact that each single observation is checked with informations coming from calvings. If there is a conflict the observation is dropped. For JER, inclusion of data from Finland, France and Norway
DEU (HOL,RDC) Herd-years with uninformative NonReturn56, i.e., 100% NR56 are excluded. Some traits are verified with the subsequent calving, e.g. interval first to last insemination, insemination dates must match with calving dates and result in reasonable gestation length. Thus there are always some bulls having number of herds/daughters/EDC decreased, being not publishable anymore or in case number of herds drop below 10 herds, bulls are even not sent anymore.
NZL (ALL) Drops in information due to continuous DNA parenting testing
GBR (BSW) Base change for ccl, now on the same base as the other fertility traits.
USA (ALL) Drops in herds/daughters/EDCs are because for the latest partial year, the previous year's statistics are used. Then, as the full year data arrives some herds that did not pass previously pass this year and others that previously qualified are dropped.
ESP (HOL) Changes in data extraction and edits causing drop of information, base change
URY (HOL) Change in data editing causing drops of information
NOR (RDC) The rolling definition of hys (random) and herdX4yr (fixed) is causing the daughters to distribute somewhat differently over classes at each evaluation. Therefore some bulls occasionally may loose edc and reliability although number of daughters remain the same. If the oldest herdX4yr class is small, the data gets dropped. This cause a random loss of 1 to 2 daughters for old bulls, somewhat more if the daughter group was large.
CZE (HOL) Made changes in herd book related to bulls category. No foreign information for BVs are used therefore all previous ToP "21" appear now as 11 or 12 as all information comes from domestic daughters.

INTERBULL CHANGES COMPARED TO THE PREVIOUS ROUTINE RUN

Subsetting:

As decided by the ITC in Orlando, new subsetting was introduced in the september test run. Sub-setting is necessary for operational purposes and restrictions of time scales. To minimize the effect of subsetting, larger subsets with 10-12 countries and with 4 link providing countries have been applied.

Window:

According to the decision taken by ITC in Orlando, the following changes have been introduced in regards to the windows used for post processing:

The upper bounds have been set to 0.99 as these were judged to have very little effect on evaluations. The lower values have been set to about the 25% percentile value. The largest changes are for the lower values for conformation traits, with the lowest window being 40% for OFL otherwise it is about 50% for all other confirmation traits. It is anticipated that these low values may not have large impact on evaluations since there were very few countries combinations whose estimated correlations fell between the old limit of 0.30 and these new limits.

The window so far applied for MAS evaluation have been found too high compared to the within-country genetic correlation between mastitis and SCS available from the literature. It has been an ITC recommendation to adjust the windows for MAS in this test run to make them more in line with the values available from the literature. The recommendation has been approved by the Steering committee. Also, according to the decision taken by ITC in Orlando (2015) to review all windows every five (5) years, an overall review of the windows for all traits will take place during the first half of 2020 with the aim of implementation set for the September 2020 test run.

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 (August Routine Evaluation 2020).
Number of records for lactating cow's ability to conceive (cc2) by breed

| Country | BSW | GUE | HOL | JER | RDC | SIM |
|---------|------|-----|-------|------|-------|-----|
| AUS | | 142 | 8186 | 1773 | 739 | |
| BEL | | | 1892 | | | |
| CAN | 161 | 47 | 9397 | 548 | 550 | |
| CHE | 2828 | | 3406 | | | |
| CZE | | | 3887 | | | |
| DEA | 5526 | | | | | |
| DEU | | | 23906 | | 288 | |
| DFS | | | 16301 | 2446 | 10091 | |
| ESP | | | 5581 | | | |
| EST | | | | | | |

| | | | | | |
|-----|------|-----|-------|------|------|
| FRA | 389 | | 16541 | | |
| FRM | | | | | |
| GBR | 97 | 239 | 6899 | 566 | 407 |
| HUN | | | | | |
| IRL | | | 2944 | 195 | 64 |
| ISR | | | 1461 | | |
| ITA | 1813 | | 9622 | | |
| JPN | | | 6002 | | |
| KOR | | | | | |
| LTU | | | | | |
| LVA | | | | | |
| NLD | 195 | | 15621 | 173 | 82 |
| NOR | | | | | 2983 |
| NZL | 59 | 58 | 7991 | 4724 | 1369 |
| POL | | | 7701 | | |
| PRT | | | | | |
| SVK | | | | | |
| SVN | | | | | |
| URY | | | 1640 | | |
| USA | 1112 | 765 | 39497 | 4818 | 722 |
| ZAF | | | 1256 | 710 | 151 |
| HRV | | | | | |
| MEX | | | | | |
| CAM | | | | | |

| | | | | | | |
|-------------|-------|------|--------|-------|-------|---|
| No. Records | 12180 | 1251 | 189731 | 15953 | 17446 | |
| Pub. Proofs | 11187 | 1026 | 152577 | 13403 | 17354 | 0 |

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

BSW hco

| | | | | | | |
|-----|------|------|------|------|-------|------|
| | CAN | DEA | FRA | USA | CHE | NLD |
| CAN | 8.62 | | | | | |
| DEA | 0.85 | 9.82 | | | | |
| FRA | 0.78 | 0.84 | 0.90 | | | |
| USA | 0.79 | 0.78 | 0.89 | 2.76 | | |
| CHE | 0.92 | 0.95 | 0.88 | 0.88 | 13.15 | |
| NLD | 0.75 | 0.70 | 0.88 | 0.88 | 0.87 | 4.00 |

BSW crc

| | | | | | | | | | |
|-----|------|-------|-------|------|------|------|------|------|-------|
| | CAN | CHE | DEA | NLD | NZL | USA | GBR | FRA | ITA |
| CAN | 6.95 | | | | | | | | |
| CHE | 0.85 | 11.37 | | | | | | | |
| DEA | 0.85 | 0.94 | 14.33 | | | | | | |
| NLD | 0.87 | 0.88 | 0.87 | 3.94 | | | | | |
| NZL | 0.62 | 0.64 | 0.75 | 0.64 | 0.09 | | | | |
| USA | 0.85 | 0.86 | 0.84 | 0.85 | 0.62 | 3.34 | | | |
| GBR | 0.74 | 0.76 | 0.75 | 0.79 | 0.64 | 0.84 | 3.86 | | |
| FRA | 0.86 | 0.96 | 0.94 | 0.91 | 0.64 | 0.86 | 0.78 | 1.81 | |
| ITA | 0.85 | 0.85 | 0.84 | 0.85 | 0.69 | 0.84 | 0.79 | 0.86 | 17.59 |

BSW ccl

| | | | | | | | |
|-----|------|-------|-------|------|------|-----|-----|
| | CAN | CHE | DEA | NLD | USA | GBR | FRA |
| CAN | 8.03 | | | | | | |
| CHE | 0.79 | 11.74 | | | | | |
| DEA | 0.79 | 0.95 | 11.05 | | | | |
| NLD | 0.75 | 0.71 | 0.67 | 4.13 | | | |
| USA | 0.75 | 0.68 | 0.67 | 0.89 | 2.87 | | |

| | | | | | | | | | |
|-----|------|------|------|------|------|------|------|--|--|
| GBR | 0.72 | 0.79 | 0.75 | 0.71 | 0.67 | 0.03 | | | |
| FRA | 0.72 | 0.69 | 0.67 | 0.92 | 0.91 | 0.70 | 0.96 | | |

BSW cc2

| | CAN | CHE | DEA | NLD | NZL | USA | GBR | FRA | ITA |
|-----|------|-------|-------|------|------|------|------|------|-------|
| CAN | 6.89 | | | | | | | | |
| CHE | 0.74 | 11.11 | | | | | | | |
| DEA | 0.84 | 0.91 | 11.75 | | | | | | |
| NLD | 0.88 | 0.82 | 0.85 | 3.54 | | | | | |
| NZL | 0.67 | 0.57 | 0.67 | 0.65 | 7.67 | | | | |
| USA | 0.86 | 0.84 | 0.85 | 0.85 | 0.67 | 2.41 | | | |
| GBR | 0.84 | 0.79 | 0.86 | 0.84 | 0.71 | 0.85 | 3.86 | | |
| FRA | 0.86 | 0.86 | 0.88 | 0.88 | 0.65 | 0.86 | 0.85 | 0.96 | |
| ITA | 0.85 | 0.69 | 0.85 | 0.85 | 0.60 | 0.88 | 0.81 | 0.85 | 22.93 |

BSW int

| | CAN | DEA | NLD | NZL | USA | GBR | ITA |
|-----|------|-------|------|------|------|------|-------|
| CAN | 7.32 | | | | | | |
| DEA | 0.88 | 13.68 | | | | | |
| NLD | 0.89 | 0.87 | 3.60 | | | | |
| NZL | 0.64 | 0.71 | 0.67 | 7.41 | | | |
| USA | 0.93 | 0.87 | 0.87 | 0.63 | 2.41 | | |
| GBR | 0.87 | 0.88 | 0.89 | 0.69 | 0.87 | 3.86 | |
| ITA | 0.88 | 0.93 | 0.88 | 0.68 | 0.89 | 0.88 | 17.91 |

GUE crc

| | CAN | GBR | NZL | USA | AUS |
|-----|------|------|------|------|------|
| CAN | 7.55 | | | | |
| GBR | 0.75 | 5.09 | | | |
| NZL | 0.61 | 0.64 | 0.11 | | |
| USA | 0.84 | 0.88 | 0.62 | 3.23 | |
| AUS | 0.78 | 0.88 | 0.91 | 0.77 | 6.96 |

GUE cc1

| | CAN | GBR | USA |
|-----|------|------|------|
| CAN | 7.58 | | |
| GBR | 0.72 | 0.03 | |
| USA | 0.80 | 0.72 | 3.41 |

GUE cc2

| | CAN | GBR | NZL | USA | AUS |
|-----|------|------|------|------|------|
| CAN | 6.90 | | | | |
| GBR | 0.84 | 5.09 | | | |
| NZL | 0.65 | 0.71 | 7.68 | | |
| USA | 0.86 | 0.85 | 0.67 | 2.67 | |
| AUS | 0.70 | 0.70 | 0.75 | 0.75 | 9.78 |

GUE int

| | CAN | GBR | NZL | USA | AUS |
|-----|------|------|------|------|------|
| CAN | 7.75 | | | | |
| GBR | 0.87 | 5.09 | | | |
| NZL | 0.62 | 0.67 | 7.68 | | |
| USA | 0.92 | 0.87 | 0.63 | 2.67 | |
| AUS | 0.87 | 0.87 | 0.73 | 0.87 | 9.78 |

| | | | | | | | | | | | | | | | | | | | | |
|-----|------|------|------|------|------|------|------|------|------|------|------|-------|------|------|------|-------|-------|------|------|-------|
| GBR | 0.89 | 0.84 | 0.74 | 0.65 | 0.83 | 0.84 | 0.86 | 0.83 | 4.63 | | | | | | | | | | | |
| IRL | 0.84 | 0.83 | 0.81 | 0.67 | 0.83 | 0.83 | 0.85 | 0.84 | 0.85 | 3.48 | | | | | | | | | | |
| ISR | 0.55 | 0.64 | 0.65 | 0.83 | 0.76 | 0.71 | 0.70 | 0.67 | 0.58 | 0.62 | 3.18 | | | | | | | | | |
| ITA | 0.75 | 0.85 | 0.86 | 0.90 | 0.91 | 0.84 | 0.88 | 0.84 | 0.77 | 0.78 | 0.83 | 15.71 | | | | | | | | |
| NLD | 0.84 | 0.89 | 0.89 | 0.84 | 0.95 | 0.91 | 0.88 | 0.91 | 0.84 | 0.84 | 0.74 | 0.85 | 4.72 | | | | | | | |
| NZL | 0.74 | 0.64 | 0.53 | 0.48 | 0.64 | 0.64 | 0.66 | 0.64 | 0.71 | 0.74 | 0.47 | 0.57 | 0.64 | 5.02 | | | | | | |
| USA | 0.84 | 0.86 | 0.85 | 0.87 | 0.91 | 0.88 | 0.88 | 0.85 | 0.84 | 0.84 | 0.77 | 0.92 | 0.86 | 0.65 | 2.31 | | | | | |
| POL | 0.84 | 0.83 | 0.74 | 0.62 | 0.83 | 0.83 | 0.84 | 0.82 | 0.84 | 0.83 | 0.56 | 0.78 | 0.83 | 0.65 | 0.84 | 13.60 | | | | |
| ZAF | 0.76 | 0.78 | 0.81 | 0.71 | 0.82 | 0.77 | 0.82 | 0.80 | 0.80 | 0.87 | 0.58 | 0.84 | 0.78 | 0.71 | 0.87 | 0.78 | 15.85 | | | |
| AUS | 0.71 | 0.70 | 0.74 | 0.64 | 0.71 | 0.66 | 0.72 | 0.72 | 0.71 | 0.87 | 0.58 | 0.71 | 0.67 | 0.70 | 0.75 | 0.63 | 0.83 | 7.88 | | |
| URY | 0.84 | 0.81 | 0.68 | 0.60 | 0.81 | 0.81 | 0.82 | 0.81 | 0.85 | 0.84 | 0.49 | 0.65 | 0.82 | 0.76 | 0.83 | 0.86 | 0.77 | 0.68 | 1.44 | |
| JPN | 0.83 | 0.85 | 0.83 | 0.74 | 0.85 | 0.85 | 0.87 | 0.85 | 0.86 | 0.84 | 0.61 | 0.86 | 0.84 | 0.64 | 0.92 | 0.89 | 0.87 | 0.73 | 0.82 | 18.55 |

HOL int

| | BEL | CAN | DEU | DFS | ESP | GBR | IRL | ITA | NLD | NZL | USA | POL | ZAF | AUS | URY | FRA | JPN |
|-----|------|------|-------|-------|-------|------|------|-------|------|------|------|-------|-------|------|------|------|-------|
| BEL | 4.71 | | | | | | | | | | | | | | | | |
| CAN | 0.87 | 6.50 | | | | | | | | | | | | | | | |
| DEU | 0.87 | 0.89 | 12.31 | | | | | | | | | | | | | | |
| DFS | 0.90 | 0.91 | 0.94 | 12.85 | | | | | | | | | | | | | |
| ESP | 0.89 | 0.89 | 0.89 | 0.89 | 11.18 | | | | | | | | | | | | |
| GBR | 0.89 | 0.87 | 0.87 | 0.89 | 0.88 | 4.63 | | | | | | | | | | | |
| IRL | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 3.48 | | | | | | | | | | |
| ITA | 0.87 | 0.89 | 0.90 | 0.90 | 0.93 | 0.87 | 0.87 | 20.63 | | | | | | | | | |
| NLD | 0.93 | 0.90 | 0.91 | 0.95 | 0.88 | 0.90 | 0.87 | 0.87 | 4.76 | | | | | | | | |
| NZL | 0.75 | 0.61 | 0.59 | 0.59 | 0.63 | 0.72 | 0.74 | 0.66 | 0.64 | 5.02 | | | | | | | |
| USA | 0.87 | 0.93 | 0.91 | 0.89 | 0.91 | 0.87 | 0.87 | 0.93 | 0.87 | 0.60 | 2.31 | | | | | | |
| POL | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.90 | 0.87 | 0.68 | 0.87 | 13.60 | | | | | |
| ZAF | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.89 | 0.89 | 0.87 | 0.72 | 0.89 | 0.87 | 15.86 | | | | |
| AUS | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.88 | 0.87 | 0.87 | 0.68 | 0.87 | 0.87 | 0.87 | 7.88 | | | |
| URY | 0.87 | 0.86 | 0.87 | 0.86 | 0.86 | 0.87 | 0.87 | 0.87 | 0.87 | 0.77 | 0.87 | 0.87 | 0.87 | 1.44 | | | |
| FRA | 0.79 | 0.85 | 0.78 | 0.79 | 0.84 | 0.71 | 0.78 | 0.80 | 0.79 | 0.52 | 0.82 | 0.69 | 0.79 | 0.73 | 0.62 | 0.98 | |
| JPN | 0.87 | 0.93 | 0.90 | 0.90 | 0.90 | 0.87 | 0.87 | 0.94 | 0.87 | 0.63 | 0.92 | 0.91 | 0.89 | 0.87 | 0.87 | 0.77 | 18.55 |

JER hco

| | CAN | DFS | USA | NLD |
|-----|------|-------|------|------|
| CAN | 7.97 | | | |
| DFS | 0.76 | 17.42 | | |
| USA | 0.82 | 0.88 | 2.74 | |
| NLD | 0.76 | 0.87 | 0.88 | 4.47 |

JER crc

| | CAN | DFS | GBR | NLD | NZL | USA | IRL |
|-----|------|-------|------|------|------|------|------|
| CAN | 6.69 | | | | | | |
| DFS | 0.87 | 13.56 | | | | | |
| GBR | 0.73 | 0.85 | 4.03 | | | | |
| NLD | 0.87 | 0.91 | 0.77 | 4.10 | | | |
| NZL | 0.62 | 0.67 | 0.71 | 0.61 | 0.07 | | |
| USA | 0.84 | 0.84 | 0.84 | 0.84 | 0.64 | 3.71 | |
| IRL | 0.74 | 0.73 | 0.87 | 0.73 | 0.62 | 0.75 | 2.06 |

JER cc1

| | CAN | DFS | GBR | NLD | USA |
|-----|------|-------|------|------|------|
| CAN | 6.87 | | | | |
| DFS | 0.72 | 15.50 | | | |
| GBR | 0.76 | 0.68 | 0.03 | | |
| NLD | 0.76 | 0.91 | 0.70 | 3.95 | |
| USA | 0.74 | 0.89 | 0.67 | 0.89 | 2.91 |

| ----- | | | | | | | | | |
|-------|------|-------|------|------|------|------|-------|------|------|
| JER | cc2 | | | | | | | | |
| | CAN | DFS | GBR | NLD | NZL | USA | ZAF | AUS | IRL |
| CAN | 6.68 | | | | | | | | |
| DFS | 0.86 | 15.72 | | | | | | | |
| GBR | 0.85 | 0.85 | 4.04 | | | | | | |
| NLD | 0.89 | 0.89 | 0.85 | 3.50 | | | | | |
| NZL | 0.65 | 0.65 | 0.76 | 0.65 | 4.06 | | | | |
| USA | 0.86 | 0.86 | 0.85 | 0.86 | 0.67 | 2.59 | | | |
| ZAF | 0.69 | 0.69 | 0.75 | 0.72 | 0.76 | 0.86 | 11.11 | | |
| AUS | 0.67 | 0.66 | 0.67 | 0.67 | 0.70 | 0.69 | 0.75 | 6.02 | |
| IRL | 0.84 | 0.85 | 0.85 | 0.85 | 0.67 | 0.85 | 0.73 | 0.75 | 2.06 |

| ----- | | | | | | | | | |
|-------|------|-------|------|------|------|------|-------|------|------|
| JER | int | | | | | | | | |
| | CAN | DFS | GBR | NLD | NZL | USA | ZAF | AUS | IRL |
| CAN | 6.44 | | | | | | | | |
| DFS | 0.89 | 15.43 | | | | | | | |
| GBR | 0.87 | 0.88 | 4.04 | | | | | | |
| NLD | 0.89 | 0.91 | 0.88 | 3.60 | | | | | |
| NZL | 0.63 | 0.60 | 0.75 | 0.60 | 4.06 | | | | |
| USA | 0.89 | 0.88 | 0.87 | 0.87 | 0.65 | 2.59 | | | |
| ZAF | 0.87 | 0.87 | 0.87 | 0.86 | 0.73 | 0.87 | 11.11 | | |
| AUS | 0.87 | 0.87 | 0.87 | 0.87 | 0.60 | 0.87 | 0.87 | 6.02 | |
| IRL | 0.86 | 0.86 | 0.85 | 0.87 | 0.46 | 0.86 | 0.84 | 0.87 | 2.06 |

| ----- | | | | | | | | | |
|-------|------|-------|-------|-------|------|------|--|--|--|
| RDC | hco | | | | | | | | |
| | CAN | DEU | DFS | NOR | USA | NLD | | | |
| CAN | 7.59 | | | | | | | | |
| DEU | 0.91 | 14.17 | | | | | | | |
| DFS | 0.79 | 0.80 | 12.34 | | | | | | |
| NOR | 0.86 | 0.87 | 0.86 | 16.56 | | | | | |
| USA | 0.84 | 0.83 | 0.89 | 0.74 | 2.77 | | | | |
| NLD | 0.75 | 0.77 | 0.88 | 0.72 | 0.88 | 5.04 | | | |

| ----- | | | | | | | | | |
|-------|------|------|-------|------|-------|------|------|------|------|
| RDC | crc | | | | | | | | |
| | CAN | DEU | DFS | GBR | NOR | NZL | USA | NLD | IRL |
| CAN | 6.40 | | | | | | | | |
| DEU | 0.85 | 9.95 | | | | | | | |
| DFS | 0.87 | 0.90 | 12.67 | | | | | | |
| GBR | 0.76 | 0.74 | 0.76 | 4.13 | | | | | |
| NOR | 0.89 | 0.87 | 0.86 | 0.74 | 13.77 | | | | |
| NZL | 0.63 | 0.62 | 0.61 | 0.65 | 0.65 | 0.11 | | | |
| USA | 0.84 | 0.84 | 0.84 | 0.82 | 0.85 | 0.76 | 3.42 | | |
| NLD | 0.87 | 0.90 | 0.92 | 0.79 | 0.86 | 0.62 | 0.84 | 3.59 | |
| IRL | 0.73 | 0.73 | 0.74 | 0.87 | 0.74 | 0.63 | 0.76 | 0.73 | 2.72 |

| ----- | | | | | | | | | |
|-------|------|-------|-------|------|-------|------|------|--|--|
| RDC | cc1 | | | | | | | | |
| | CAN | DEU | DFS | GBR | NOR | NLD | USA | | |
| CAN | 7.12 | | | | | | | | |
| DEU | 0.90 | 13.56 | | | | | | | |
| DFS | 0.76 | 0.77 | 13.10 | | | | | | |
| GBR | 0.72 | 0.78 | 0.72 | 0.03 | | | | | |
| NOR | 0.79 | 0.87 | 0.93 | 0.72 | 13.95 | | | | |
| NLD | 0.78 | 0.78 | 0.91 | 0.71 | 0.78 | 4.30 | | | |
| USA | 0.84 | 0.74 | 0.88 | 0.67 | 0.77 | 0.89 | 2.70 | | |

| RDC | cc2 | CAN | DEU | DFS | GBR | NOR | NZL | USA | ZAF | NLD | AUS | IRL |
|-----|------|-------|-------|------|-------|------|------|-------|------|------|------|-----|
| CAN | 6.80 | | | | | | | | | | | |
| DEU | 0.92 | 10.97 | | | | | | | | | | |
| DFS | 0.85 | 0.94 | 12.85 | | | | | | | | | |
| GBR | 0.85 | 0.84 | 0.85 | 4.14 | | | | | | | | |
| NOR | 0.88 | 0.87 | 0.90 | 0.86 | 13.95 | | | | | | | |
| NZL | 0.65 | 0.65 | 0.65 | 0.69 | 0.66 | 6.76 | | | | | | |
| USA | 0.88 | 0.90 | 0.86 | 0.85 | 0.86 | 0.72 | 2.40 | | | | | |
| ZAF | 0.70 | 0.82 | 0.74 | 0.72 | 0.70 | 0.73 | 0.85 | 17.52 | | | | |
| NLD | 0.89 | 0.95 | 0.90 | 0.85 | 0.86 | 0.65 | 0.86 | 0.77 | 3.76 | | | |
| AUS | 0.68 | 0.70 | 0.66 | 0.70 | 0.66 | 0.70 | 0.71 | 0.76 | 0.67 | 7.26 | | |
| IRL | 0.84 | 0.84 | 0.85 | 0.85 | 0.86 | 0.72 | 0.85 | 0.84 | 0.85 | 0.82 | 2.72 | |

| RDC | int | CAN | DEU | DFS | GBR | NOR | NZL | USA | ZAF | NLD | AUS | IRL |
|-----|------|-------|-------|------|-------|------|------|-------|------|------|------|-----|
| CAN | 6.67 | | | | | | | | | | | |
| DEU | 0.89 | 10.82 | | | | | | | | | | |
| DFS | 0.89 | 0.94 | 13.14 | | | | | | | | | |
| GBR | 0.87 | 0.87 | 0.88 | 4.14 | | | | | | | | |
| NOR | 0.89 | 0.89 | 0.87 | 0.88 | 13.77 | | | | | | | |
| NZL | 0.68 | 0.58 | 0.59 | 0.68 | 0.63 | 6.76 | | | | | | |
| USA | 0.92 | 0.90 | 0.88 | 0.87 | 0.87 | 0.71 | 2.40 | | | | | |
| ZAF | 0.87 | 0.87 | 0.87 | 0.87 | 0.90 | 0.71 | 0.88 | 17.52 | | | | |
| NLD | 0.90 | 0.91 | 0.93 | 0.89 | 0.88 | 0.62 | 0.87 | 0.87 | 3.60 | | | |
| AUS | 0.87 | 0.87 | 0.87 | 0.87 | 0.88 | 0.69 | 0.87 | 0.88 | 0.87 | 7.26 | | |
| IRL | 0.87 | 0.87 | 0.87 | 0.87 | 0.88 | 0.68 | 0.87 | 0.89 | 0.88 | 0.88 | 2.72 | |

^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 | 89 | 52 | 99 | 92 | 29 |
| DEA | 75 | 0 | 197 | 176 | 579 | 131 |
| FRA | 43 | 141 | 0 | 70 | 156 | 71 |
| USA | 89 | 134 | 52 | 0 | 195 | 47 |
| CHE | 76 | 484 | 114 | 160 | 0 | 84 |
| NLD | 26 | 123 | 58 | 43 | 79 | 0 |

BSW

common bulls below diagonal
 common three quarter sib group above diagonal

| | CAN | CHE | DEA | NLD | NZL | USA | GBR | FRA | ITA |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 108 | 103 | 36 | 20 | 128 | 44 | 68 | 99 |
| CHE | 87 | 0 | 561 | 92 | 27 | 259 | 57 | 157 | 417 |
| DEA | 86 | 460 | 0 | 146 | 35 | 215 | 56 | 200 | 564 |
| NLD | 32 | 84 | 135 | 0 | 25 | 56 | 36 | 77 | 117 |
| NZL | 18 | 22 | 29 | 20 | 0 | 21 | 17 | 21 | 29 |
| USA | 120 | 225 | 167 | 51 | 18 | 0 | 58 | 92 | 163 |
| GBR | 38 | 40 | 38 | 27 | 13 | 50 | 0 | 44 | 62 |
| FRA | 57 | 114 | 145 | 62 | 17 | 62 | 34 | 0 | 175 |
| ITA | 83 | 353 | 434 | 94 | 22 | 115 | 41 | 130 | 0 |

BSW

common bulls below diagonal

common three quarter sib group above diagonal

| | CAN | CHE | DEA | NLD | USA | GBR | FRA |
|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 109 | 103 | 36 | 129 | 44 | 72 |
| CHE | 89 | 0 | 556 | 91 | 259 | 58 | 165 |
| DEA | 86 | 456 | 0 | 144 | 214 | 59 | 210 |
| NLD | 32 | 84 | 135 | 0 | 56 | 36 | 82 |
| USA | 121 | 225 | 166 | 51 | 0 | 60 | 97 |
| GBR | 39 | 42 | 40 | 27 | 52 | 0 | 48 |
| FRA | 61 | 121 | 156 | 68 | 68 | 39 | 0 |

BSW

common bulls below diagonal

common three quarter sib group above diagonal

| | CAN | CHE | DEA | NLD | NZL | USA | GBR | FRA | ITA |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 96 | 91 | 35 | 19 | 121 | 41 | 66 | 90 |
| CHE | 75 | 0 | 551 | 92 | 27 | 315 | 57 | 165 | 417 |
| DEA | 75 | 453 | 0 | 145 | 36 | 308 | 55 | 208 | 553 |
| NLD | 31 | 84 | 135 | 0 | 26 | 79 | 36 | 82 | 117 |
| NZL | 17 | 22 | 29 | 20 | 0 | 30 | 17 | 22 | 29 |
| USA | 109 | 292 | 271 | 68 | 26 | 0 | 68 | 117 | 210 |
| GBR | 34 | 40 | 38 | 27 | 13 | 60 | 0 | 46 | 62 |
| FRA | 57 | 121 | 155 | 68 | 18 | 82 | 37 | 0 | 187 |
| ITA | 74 | 353 | 428 | 94 | 22 | 147 | 41 | 141 | 0 |

BSW

common bulls below diagonal

common three quarter sib group above diagonal

| | CAN | DEA | NLD | NZL | USA | GBR | ITA |
|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 95 | 37 | 20 | 125 | 43 | 95 |
| DEA | 78 | 0 | 146 | 36 | 307 | 55 | 664 |
| NLD | 34 | 137 | 0 | 26 | 80 | 36 | 123 |
| NZL | 18 | 29 | 20 | 0 | 30 | 17 | 30 |
| USA | 113 | 271 | 71 | 26 | 0 | 68 | 228 |
| GBR | 36 | 38 | 27 | 13 | 60 | 0 | 63 |
| ITA | 79 | 561 | 102 | 23 | 163 | 41 | 0 |

GUE

GUE

common bulls below diagonal

common three quarter sib group above diagonal

| | CAN | GBR | NZL | USA | AUS |
|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 15 | 3 | 38 | 18 |
| GBR | 12 | 0 | 13 | 52 | 28 |
| NZL | 2 | 11 | 0 | 9 | 26 |
| USA | 37 | 49 | 7 | 0 | 19 |
| AUS | 13 | 22 | 24 | 16 | 0 |

GUE

common bulls below diagonal

common three quarter sib group above diagonal

| | CAN | GBR | USA |
|-----|-----|-----|-----|
| CAN | 0 | 15 | 38 |
| GBR | 12 | 0 | 53 |
| USA | 37 | 50 | 0 |

GUE

```

-----
common bulls below diagonal
common three quarter sib group above diagonal
  CAN  GBR  NZL  USA  AUS
-----
CAN   0   11   2   38   22
GBR   8   0   13   83   32
NZL   2   11   0   29   26
USA  36  84  28   0   62
AUS  18  26  26  58   0
-----

```

```

GUE
-----
common bulls below diagonal
common three quarter sib group above diagonal
  CAN  GBR  NZL  USA  AUS
-----
CAN   0   11   2   38   22
GBR   8   0   13   83   32
NZL   2   11   0   29   26
USA  36  84  28   0   62
AUS  18  26  26  58   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  990 2015 1172 1205 2578 1080  793 1214 1642 1055
CZE  712   0 1695 1127 1166 1329 1013  482 1377 1233  761
DEU 1551 1266   0 2317 2189 2671 1845 1093 2764 2469 1237
DFS 1070  727 1677   0 1565 1468 1145  695 1973 1576  899
FRA  875  700 1176  861   0 1580 1271  678 1839 1710 1082
USA 2937 1042 1989 1265  912   0 1522  832 1648 2181 1355
POL  918  770 1530  883  791 1498   0  474 1309 1273  737
CHE  677  325  964  610  604  746  359   0  862  737  446
NLD 1170 1191 2365 1669 1173 1415 1114  833   0 1676  980
ITA 1364  852 1643 1200  956 1701  923  661 1371   0 1140
JPN  566  316  514  441  379  674  372  270  470  489   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  697  571 1120  786  831  800  494  777 1153  478  749  479  890
CAN  699   0  825 2169 1262 1407 1451  517 1707 1353  645 2720  976 1298
CHE  575  710   0 1126  695  680  702  402  735  888  398  893  427  688
DEU 1146 1616  997   0 2508 2067 2033  879 2571 3211  947 2925 1609 2422
DFS  727 1153  613 1757   0 1369 1484  728 1560 1995  792 1614 1029 1582
ESP  892 1169  618 1780 1156   0 1371  680 1600 1548  696 1641  965 1561
GBR  789 1503  638 1499 1120 1247   0  952 1564 1713  905 1818  860 1527
IRL  490  516  409  769  605  701  992   0  652  881  716  623  348  737
ITA  751 1431  661 1719 1198 1404 1202  579   0 1733  730 2329 1118 1713
NLD 1313 1324  862 2871 1743 1608 1476  832 1444   0 1011 1891 1162 1944
NZL  392  602  334  725  562  582  783  622  553  917   0  766  390  791
USA  711 3112  798 2071 1352 1376 1718  609 1753 1652  702   0 1382 1775
POL  385  807  313 1244  766  733  608  260  776  951  283 1311   0 1160
FRA  876  959  601 1303  850 1455  963  598  946 1217  478 1010  687   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 | 827 | 1025 | 2159 | 1267 | 1295 | 1519 | 99 | 1705 | 1357 | 2763 | 1019 | 1190 |
| CHE | 711 | 0 | 470 | 1124 | 695 | 687 | 717 | 54 | 732 | 888 | 893 | 452 | 475 |
| CZE | 770 | 320 | 0 | 1690 | 1081 | 1141 | 954 | 97 | 1208 | 1352 | 1408 | 990 | 754 |
| DEU | 1601 | 994 | 1284 | 0 | 2503 | 2427 | 2097 | 142 | 2553 | 3191 | 2893 | 1741 | 1414 |
| DFS | 1157 | 613 | 729 | 1748 | 0 | 1587 | 1523 | 128 | 1560 | 1994 | 1619 | 1105 | 944 |
| FRA | 971 | 611 | 702 | 1319 | 866 | 0 | 1556 | 112 | 1715 | 1955 | 1770 | 1218 | 1204 |
| GBR | 1588 | 654 | 640 | 1559 | 1152 | 989 | 0 | 119 | 1622 | 1773 | 1911 | 917 | 1043 |
| ISR | 73 | 33 | 75 | 119 | 101 | 63 | 86 | 0 | 127 | 133 | 129 | 87 | 93 |
| ITA | 1428 | 659 | 852 | 1702 | 1197 | 963 | 1266 | 100 | 0 | 1730 | 2321 | 1177 | 1182 |
| NLD | 1331 | 862 | 1202 | 2848 | 1742 | 1241 | 1544 | 110 | 1439 | 0 | 1891 | 1271 | 1037 |
| USA | 3171 | 798 | 1104 | 2034 | 1352 | 1026 | 1840 | 121 | 1746 | 1652 | 0 | 1439 | 1540 |
| POL | 863 | 345 | 758 | 1445 | 863 | 744 | 669 | 64 | 838 | 1093 | 1383 | 0 | 724 |
| JPN | 671 | 305 | 346 | 599 | 503 | 441 | 536 | 42 | 552 | 550 | 814 | 390 | 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 | 687 | 571 | 548 | 1115 | 787 | 831 | 887 | 802 | 496 | 68 | 777 | 1155 | 478 | 900 | 475 | 326 | 702 | 321 | 493 |
| CAN | 687 | 0 | 816 | 1005 | 2096 | 1239 | 1394 | 1254 | 1424 | 505 | 96 | 1656 | 1323 | 629 | 2877 | 947 | 436 | 1168 | 643 | 1103 |
| CHE | 575 | 694 | 0 | 470 | 1118 | 696 | 680 | 675 | 702 | 402 | 55 | 728 | 888 | 398 | 1008 | 414 | 270 | 603 | 292 | 442 |
| CZE | 421 | 738 | 320 | 0 | 1686 | 1081 | 1025 | 1132 | 937 | 445 | 97 | 1202 | 1352 | 512 | 1515 | 916 | 317 | 732 | 442 | 721 |
| DEU | 1137 | 1529 | 984 | 1277 | 0 | 2496 | 2073 | 2395 | 2025 | 876 | 143 | 2530 | 3167 | 945 | 3449 | 1562 | 547 | 1586 | 707 | 1342 |
| DFS | 727 | 1124 | 614 | 729 | 1737 | 0 | 1377 | 1575 | 1487 | 728 | 130 | 1556 | 1998 | 797 | 2005 | 1006 | 500 | 1208 | 586 | 894 |
| ESP | 892 | 1143 | 618 | 809 | 1777 | 1163 | 0 | 1565 | 1374 | 681 | 119 | 1601 | 1554 | 700 | 1961 | 950 | 510 | 1116 | 595 | 1038 |
| FRA | 869 | 914 | 596 | 693 | 1264 | 836 | 1448 | 0 | 1519 | 739 | 115 | 1688 | 1928 | 795 | 2456 | 1137 | 475 | 1239 | 557 | 1146 |
| GBR | 789 | 1468 | 638 | 627 | 1487 | 1120 | 1248 | 954 | 0 | 953 | 120 | 1557 | 1715 | 907 | 2194 | 844 | 494 | 1341 | 603 | 986 |
| IRL | 490 | 496 | 409 | 324 | 762 | 605 | 701 | 594 | 992 | 0 | 91 | 650 | 884 | 718 | 786 | 342 | 333 | 723 | 352 | 432 |
| ISR | 42 | 70 | 33 | 75 | 118 | 101 | 94 | 62 | 85 | 70 | 0 | 127 | 135 | 98 | 154 | 81 | 57 | 93 | 76 | 90 |
| ITA | 747 | 1361 | 654 | 846 | 1658 | 1178 | 1398 | 922 | 1191 | 576 | 97 | 0 | 1721 | 731 | 2600 | 1089 | 476 | 1156 | 627 | 1120 |
| NLD | 1315 | 1282 | 862 | 1202 | 2797 | 1744 | 1611 | 1195 | 1476 | 833 | 110 | 1423 | 0 | 1014 | 2455 | 1124 | 495 | 1407 | 604 | 982 |
| NZL | 392 | 579 | 334 | 362 | 716 | 563 | 585 | 472 | 783 | 623 | 83 | 554 | 920 | 0 | 1053 | 383 | 353 | 1164 | 467 | 535 |
| USA | 791 | 3203 | 893 | 1153 | 2298 | 1483 | 1640 | 1291 | 1960 | 708 | 138 | 1845 | 2087 | 996 | 0 | 1382 | 624 | 1812 | 1005 | 1849 |
| POL | 376 | 765 | 301 | 657 | 1176 | 743 | 717 | 659 | 592 | 251 | 55 | 747 | 902 | 275 | 1276 | 0 | 218 | 640 | 384 | 661 |
| ZAF | 268 | 397 | 218 | 206 | 417 | 362 | 462 | 325 | 429 | 288 | 38 | 374 | 409 | 283 | 595 | 145 | 0 | 467 | 304 | 399 |
| AUS | 600 | 1158 | 521 | 481 | 1144 | 849 | 888 | 822 | 1152 | 625 | 62 | 853 | 1199 | 1164 | 1767 | 439 | 405 | 0 | 598 | 839 |
| URY | 226 | 597 | 207 | 291 | 476 | 384 | 517 | 321 | 479 | 269 | 38 | 441 | 456 | 384 | 1230 | 289 | 251 | 456 | 0 | 513 |
| JPN | 298 | 552 | 262 | 302 | 504 | 432 | 472 | 379 | 460 | 262 | 34 | 467 | 469 | 252 | 694 | 316 | 249 | 419 | 242 | 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 |
|-----|------|------|------|------|------|------|-----|------|------|------|------|------|-----|------|------|------|------|
| BEL | 0 | 690 | 1113 | 787 | 831 | 802 | 496 | 776 | 1159 | 478 | 900 | 474 | 326 | 702 | 321 | 887 | 493 |
| CAN | 692 | 0 | 2101 | 1247 | 1401 | 1433 | 511 | 1664 | 1343 | 635 | 2891 | 949 | 438 | 1176 | 649 | 1263 | 1107 |
| DEU | 1136 | 1538 | 0 | 2492 | 2072 | 2025 | 876 | 2529 | 3190 | 945 | 3444 | 1554 | 546 | 1586 | 706 | 2394 | 1342 |
| DFS | 727 | 1134 | 1733 | 0 | 1377 | 1487 | 728 | 1556 | 2006 | 797 | 2003 | 1005 | 499 | 1208 | 585 | 1575 | 894 |
| ESP | 892 | 1159 | 1777 | 1163 | 0 | 1374 | 681 | 1600 | 1564 | 700 | 1958 | 950 | 509 | 1115 | 595 | 1564 | 1037 |
| GBR | 789 | 1481 | 1487 | 1120 | 1248 | 0 | 953 | 1557 | 1726 | 907 | 2194 | 844 | 493 | 1341 | 603 | 1519 | 986 |
| IRL | 490 | 504 | 762 | 605 | 701 | 992 | 0 | 650 | 888 | 718 | 786 | 342 | 333 | 723 | 352 | 739 | 432 |
| ITA | 747 | 1376 | 1659 | 1178 | 1397 | 1191 | 576 | 0 | 1733 | 731 | 2600 | 1086 | 476 | 1156 | 627 | 1688 | 1120 |
| NLD | 1326 | 1314 | 2835 | 1757 | 1633 | 1491 | 837 | 1442 | 0 | 1015 | 2470 | 1130 | 497 | 1412 | 609 | 1935 | 993 |
| NZL | 392 | 584 | 717 | 563 | 585 | 783 | 623 | 555 | 924 | 0 | 1053 | 383 | 352 | 1164 | 467 | 795 | 535 |
| USA | 791 | 3233 | 2298 | 1483 | 1640 | 1960 | 708 | 1845 | 2111 | 996 | 0 | 1379 | 623 | 1812 | 1005 | 2456 | 1849 |
| POL | 376 | 770 | 1173 | 742 | 717 | 592 | 251 | 746 | 911 | 275 | 1276 | 0 | 218 | 640 | 384 | 1137 | 661 |
| ZAF | 268 | 403 | 417 | 362 | 462 | 429 | 288 | 374 | 411 | 283 | 595 | 145 | 0 | 466 | 304 | 475 | 398 |
| AUS | 600 | 1163 | 1144 | 849 | 888 | 1152 | 625 | 853 | 1210 | 1164 | 1767 | 439 | 405 | 0 | 598 | 1239 | 839 |
| URY | 226 | 605 | 476 | 384 | 517 | 479 | 269 | 441 | 461 | 384 | 1230 | 289 | 251 | 456 | 0 | 557 | 513 |
| FRA | 869 | 923 | 1264 | 836 | 1448 | 954 | 594 | 922 | 1205 | 472 | 1291 | 659 | 325 | 822 | 321 | 0 | 1146 |
| JPN | 298 | 554 | 504 | 432 | 472 | 460 | 262 | 467 | 475 | 252 | 694 | 316 | 249 | 419 | 242 | 379 | 0 |

JER

common bulls below diagonal
common three quarter sib group above diagonal

| | CAN | DFS | USA | NLD |
|-----|-----|-----|-----|-----|
| CAN | 0 | 79 | 298 | 26 |
| DFS | 72 | 0 | 125 | 67 |
| USA | 283 | 110 | 0 | 55 |
| NLD | 20 | 64 | 54 | 0 |

JER

common bulls below diagonal
common three quarter sib group above diagonal

| | CAN | DFS | GBR | NLD | NZL | USA | IRL |
|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 83 | 132 | 30 | 146 | 336 | 10 |
| DFS | 74 | 0 | 152 | 109 | 133 | 139 | 47 |
| GBR | 129 | 144 | 0 | 76 | 200 | 193 | 68 |
| NLD | 26 | 105 | 69 | 0 | 67 | 71 | 29 |
| NZL | 146 | 112 | 202 | 60 | 0 | 257 | 119 |
| USA | 334 | 125 | 206 | 75 | 280 | 0 | 39 |
| IRL | 9 | 43 | 70 | 29 | 133 | 41 | 0 |

JER

common bulls below diagonal
common three quarter sib group above diagonal

| | CAN | DFS | GBR | NLD | USA |
|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 83 | 136 | 30 | 340 |
| DFS | 74 | 0 | 154 | 108 | 139 |
| GBR | 131 | 144 | 0 | 77 | 195 |
| NLD | 26 | 104 | 71 | 0 | 71 |
| USA | 338 | 125 | 207 | 75 | 0 |

JER

common bulls below diagonal
common three quarter sib group above diagonal

| | CAN | DFS | GBR | NLD | NZL | USA | ZAF | AUS | IRL |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 79 | 129 | 30 | 141 | 342 | 124 | 199 | 10 |
| DFS | 70 | 0 | 153 | 109 | 137 | 185 | 142 | 145 | 47 |
| GBR | 124 | 144 | 0 | 76 | 202 | 219 | 162 | 203 | 68 |
| NLD | 25 | 105 | 69 | 0 | 68 | 84 | 69 | 66 | 29 |
| NZL | 138 | 114 | 202 | 61 | 0 | 358 | 200 | 425 | 119 |
| USA | 338 | 158 | 239 | 90 | 431 | 0 | 295 | 470 | 45 |
| ZAF | 122 | 122 | 162 | 65 | 209 | 306 | 0 | 230 | 39 |
| AUS | 192 | 114 | 208 | 61 | 459 | 512 | 219 | 0 | 54 |
| IRL | 9 | 43 | 70 | 29 | 133 | 47 | 40 | 52 | 0 |

JER

common bulls below diagonal
common three quarter sib group above diagonal

| | CAN | DFS | GBR | NLD | NZL | USA | ZAF | AUS | IRL |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 80 | 130 | 30 | 143 | 345 | 126 | 201 | 10 |
| DFS | 71 | 0 | 153 | 113 | 137 | 185 | 142 | 145 | 47 |
| GBR | 126 | 144 | 0 | 80 | 202 | 219 | 162 | 203 | 68 |
| NLD | 27 | 110 | 73 | 0 | 71 | 88 | 72 | 68 | 30 |
| NZL | 141 | 114 | 202 | 65 | 0 | 358 | 200 | 425 | 119 |
| USA | 343 | 158 | 239 | 95 | 431 | 0 | 295 | 470 | 45 |

| | | | | | | | | | |
|-----|-----|-----|-----|----|-----|-----|-----|-----|----|
| ZAF | 124 | 122 | 162 | 69 | 209 | 306 | 0 | 230 | 39 |
| AUS | 195 | 114 | 208 | 63 | 459 | 512 | 219 | 0 | 54 |
| IRL | 9 | 43 | 70 | 29 | 133 | 47 | 40 | 52 | 0 |

RDC

common bulls below diagonal
 common three quarter sib group above diagonal

| | CAN | DEU | DFS | NOR | USA | NLD |
|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 10 | 155 | 6 | 93 | 5 |
| DEU | 10 | 0 | 48 | 13 | 15 | 10 |
| DFS | 160 | 39 | 0 | 114 | 149 | 49 |
| NOR | 5 | 12 | 91 | 0 | 63 | 34 |
| USA | 88 | 14 | 142 | 62 | 0 | 31 |
| NLD | 5 | 10 | 46 | 34 | 29 | 0 |

RDC

common bulls below diagonal
 common three quarter sib group above diagonal

| | CAN | DEU | DFS | GBR | NOR | NZL | USA | NLD | IRL |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 12 | 155 | 67 | 6 | 66 | 131 | 6 | 4 |
| DEU | 11 | 0 | 52 | 14 | 14 | 15 | 17 | 13 | 5 |
| DFS | 161 | 40 | 0 | 97 | 136 | 165 | 165 | 51 | 18 |
| GBR | 67 | 13 | 91 | 0 | 50 | 71 | 86 | 31 | 21 |
| NOR | 6 | 13 | 107 | 53 | 0 | 40 | 71 | 39 | 53 |
| NZL | 66 | 15 | 161 | 67 | 39 | 0 | 90 | 18 | 12 |
| USA | 127 | 17 | 160 | 80 | 72 | 93 | 0 | 35 | 26 |
| NLD | 6 | 13 | 48 | 30 | 39 | 18 | 33 | 0 | 11 |
| IRL | 4 | 5 | 13 | 20 | 52 | 12 | 26 | 11 | 0 |

RDC

common bulls below diagonal
 common three quarter sib group above diagonal

| | CAN | DEU | DFS | GBR | NOR | NLD | USA |
|-----|-----|-----|-----|-----|-----|-----|-----|
| CAN | 0 | 12 | 156 | 69 | 6 | 6 | 131 |
| DEU | 11 | 0 | 52 | 14 | 14 | 13 | 17 |
| DFS | 162 | 40 | 0 | 99 | 123 | 51 | 164 |
| GBR | 68 | 13 | 92 | 0 | 51 | 31 | 88 |
| NOR | 6 | 13 | 98 | 54 | 0 | 37 | 71 |
| NLD | 6 | 13 | 48 | 30 | 37 | 0 | 35 |
| USA | 127 | 17 | 159 | 82 | 72 | 33 | 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 | 12 | 152 | 63 | 6 | 65 | 154 | 72 | 6 | 69 | 4 |
| DEU | 11 | 0 | 51 | 14 | 14 | 15 | 18 | 3 | 13 | 39 | 5 |
| DFS | 157 | 40 | 0 | 97 | 123 | 166 | 184 | 57 | 51 | 193 | 18 |
| GBR | 63 | 13 | 91 | 0 | 49 | 74 | 98 | 42 | 31 | 74 | 21 |
| NOR | 6 | 13 | 98 | 52 | 0 | 39 | 73 | 0 | 37 | 60 | 53 |
| NZL | 65 | 15 | 162 | 69 | 38 | 0 | 116 | 40 | 18 | 135 | 12 |
| USA | 155 | 18 | 182 | 94 | 74 | 119 | 0 | 72 | 38 | 118 | 28 |
| ZAF | 76 | 3 | 55 | 40 | 0 | 38 | 67 | 0 | 3 | 43 | 3 |
| NLD | 6 | 13 | 48 | 30 | 37 | 18 | 36 | 3 | 0 | 24 | 11 |
| AUS | 69 | 38 | 169 | 72 | 50 | 135 | 119 | 44 | 22 | 0 | 16 |
| IRL | 4 | 5 | 13 | 20 | 52 | 12 | 28 | 3 | 11 | 15 | 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 | 12 | 153 | 64 | 6 | 65 | 155 | 72 | 7 | 69 | 4 |
| DEU | 11 | 0 | 51 | 14 | 14 | 15 | 18 | 3 | 14 | 39 | 5 |
| DFS | 158 | 40 | 0 | 97 | 136 | 166 | 183 | 57 | 52 | 193 | 18 |
| GBR | 64 | 13 | 91 | 0 | 50 | 74 | 98 | 42 | 32 | 74 | 21 |
| NOR | 6 | 13 | 107 | 53 | 0 | 40 | 73 | 0 | 40 | 64 | 53 |
| NZL | 65 | 15 | 162 | 69 | 39 | 0 | 116 | 40 | 18 | 135 | 12 |
| USA | 156 | 18 | 180 | 94 | 73 | 118 | 0 | 72 | 40 | 118 | 28 |
| ZAF | 76 | 3 | 55 | 40 | 0 | 38 | 67 | 0 | 3 | 43 | 3 |
| NLD | 7 | 14 | 49 | 31 | 40 | 18 | 38 | 3 | 0 | 25 | 11 |
| AUS | 69 | 38 | 169 | 72 | 54 | 135 | 119 | 44 | 23 | 0 | 16 |
| IRL | 4 | 5 | 13 | 20 | 52 | 12 | 28 | 3 | 11 | 15 | 0 |

```

-----
SIM
-----
SIM
-----
SIM
-----
SIM
-----
SIM
-----
SIM
-----

```