```
INTRODUCTION
--------------------------------------------------------------------------------
The latest genomic test international evaluation for females fertility traits took place
as scheduled at the Interbull Centre. Data from 20 countries were
included in this evaluation.

International genetic evaluations for fertility traits of bulls were computed from:
AUS BEL CAN CHE CZE DEU DFS ESP FRA GBR IRL ISR ITA NLD NZL POL USA ZAF URY JPN
Holstein data were included in this evaluation.

BEL, CAN, DEU, FRA, GBR, ITA, NLD, POL submitted GEBVs.

cc1:      CAN, DEU,    , FRA,      GBR, ITA, NLD, POL
cc2: BEL, CAN, DEU, ESP,    ,      GBR, ITA, NLD, POL
crc: BEL, CAN, DEU, ESP, FRA,      GBR, ITA, NLD, POL
hco:      CAN, DEU,    , FRA,         , ITA, NLD, POL
int: BEL, CAN, DEU, ESP,    ,      GBR, ITA, NLD, POL

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      T2=CY   Calving interval converted to 42 days pregnancy rate
         T4=C2   Calving interval converted to 42 days pregnancy rate
         T5=IT   Calving interval converted to 42 days pregnancy rate

BEL      T2=CY   PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
         T4=C2   PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
         T5=IT   PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)

CAN      T1=HC   NR=Non Return Rate after 56 Days in heifers (NRR), %
         T2=CY   CF=Interval from Calving to First Service in cows(CF)
         T3=C1   NR=Non Return Rate after 56 Days in cows(NRR), %
         T4=C2   FC=Interval first insemination-conception in cows
         T5=IT   DO=Days open
```

```
CHE        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    NR=Non Return Rate after 56 Days (NRR), %


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    DO=Days open
           T4=C2    DO=Days open
           T5=IT    DO=Days open


FRA        T1=HC    CR=Heifers' Conception rate (binary trait) for maiden heifers
           T2=CY    Interval between calving and first AI
           T3=C1    CR=Cows' Conception rate (binary trait) for cows
           T4=C2    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    NR=NR=Non-return rate 56 days (heifers)
           T2=CY    CF=Interval calving to first insemination (days)
           T3=C1    NR=NR=Non-return rate 56 days (cows)
           T4=C2    CI=Calving Interval (days)
           T5=IT    CI=Calving Interval (days)


NZL        T2=CY    PM=Lactating cow's ability to start cycling
           T4=C2    CSD= Calving Season Day (CDS123) calculated as calving season day – number of days from the planned start of calving date to calving
           T5=IT    CSD= Calving Season Day (CDS123) calculated as calving season day – number of days from the planned start of calving date to calving


POL        T1=HC    CR=Conception rate for heifers
```

```
        T2=CR   Interval from calving to first insemination
        T3=C1   CR=Conception rate for cows
        T4=IT   Days open
        T5=IT   Days open

USA     T1=HC   CR=Conception rate (heifer)
        T2=CY   CF=Interval from calving to first insemination
        T3=C1   CR=Conception rate (cow)
        T4=C2   DP=Daughter Pregnancy Rate
        T5=IT   DP=Daughter Pregnancy Rate

ZAF     T4=IT   CI=Calving Interval
        T5=IT   CI=Calving Interval

JPN     T1=HC   CR=Heifers'Conception rate
        T2=CY   DO=Days open
        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 fertility traits are as follows:

GBR (HOL)    Loss of about 300 bulls in this run compared to previous run. Due to improved QA with such that all clones are removed, removal of animals failing
             parentage check, removal of some invalid genotypes, some identities have been updated from Herd book numbers to eartags between the runs
DFS (HOL)    New gebv submitted in line with MACE proofs

INTERBULL CHANGES COMPARED TO THE DECEMBER ROUTINE RUN
-------------------------------------------------------------
No changes in Interbull procedures

DATA AND METHOD OF ANALYSIS
--------------------------------------------------------------------------------
Thirteen Holstein populations sent GEBV data for up to 38 traits, while
classical EBVs for the same traits were used in the analyses. Young bull
GEBVs from the GEBV providers have been converted to the scales of all
countries participating in classical MACE. A bull will get a MACE EBV or
a GMACE EBV but not both.
From those thirteen countries, National GEBVs of bulls less than seven years of age and with no
classical MACE proofs were included for the breeding value prediction
with a further requirement of either a MACE-PA or a GMACE-PA (for young
genomic bulls with young genomic sires) being available.

The parameter-space approach is used for the GMACE genetic evaluations (Sullivan, 2016)


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

Sullivan, P.G. 2016. Defining a Parameter Space for GMACE. Interbull Bulletin 50, p 85-93.

VanRaden, P.M. and Sullivan, P.G. 2010. International genomic evaluation methods for dairy cattle. Gen. Sel. Evol. 42:7

Sullivan, P.G. and Jakobsen, J.H. 2012. Robust GMACE for young bulls methodology. Interbull Bulletin 45, Article 1.

Sullivan, P.G. 2012a. GMACE reliability approximation. Report to the GMACE working group of Interbull. GMACE_rels 2013

Sullivan, P.G. 2012b. GMACE variance estimation. Report to the GMACE working group of Interbull. GMACE_vce 2013

Sullivan, P.G. 2012c. GMACE Weighting Factors. Report to the GMACE working group of Interbull. GMACE_gedcs 2013

Jakobsen, J.H. and Sullivan, P.G. 2013. Trait specific computation of shared reference population. Reference sharing Nov 2013

```
NEXT ROUTINE INTERNATIONAL EVALUATION
-------------------------------------------------------------------------
Dates for next routine run can be found on http://www.interbull.org/ib/servicecalendar


NEXT TEST INTERNATIONAL EVALUATION
-------------------------------------------------------------------------
Dates for next routine 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 minimising the need to resort to
conversions.

At the same time, all recipients of Interbull results are expected to honour
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.

Table 1.  National evaluation dates in GMACE run December 2021
-----------------------------------------------------------
Country  Date
-----------------------------------------------------------
BEL      20201201
CAN      20211201
DEU      20211207
DFS      20211102
ESP      20211115
GBR      20211105
ITA      20211104
NLD      20211201
POL      20211207
FRA      20211208
===========================================================

Table 2.
-------------------------------------------------------
Number of bulls in reference population for        hco
-------------------------------------------------------
CAN 35562.0
DEU  8254.0 40727.0
DFS  4730.0 35082.0 35977.0
FRA  3815.0 32314.0 31756.0 33877.0
POL  4298.0 30136.0 29867.0 27837.0 31763.0
NLD  3904.0 33887.0 33241.0 31799.0 29065.0 34953.0
ITA 28635.0  6540.0  3585.0  3018.0  3126.0  3080.0 29464.0

-------------------------------------------------------
Number of bulls in reference population for        crc
-------------------------------------------------------
BEL  1459.0
CAN   704.0 35549.0
DEU   723.0  8605.0 43306.0
DFS   635.0  4907.0 37426.0 38382.0
ESP   700.0  5740.0 38517.0 37562.0 39581.0
GBR   671.0 31940.0  8859.0  5035.0  5871.0 34274.0
ITA   692.0 31169.0  6836.0  3744.0  4280.0 30267.0 32049.0
NLD   738.0  4104.0 36294.0 35675.0 36286.0  4421.0  3263.0 38026.0
POL   824.0  4327.0 32547.0 32320.0 32872.0  4453.0  3215.0 31565.0 33611.0
```

```
FRA    701.0   4040.0 34468.0 33921.0 34534.0   4113.0   3219.0 33978.0 30046.0 36141.0

---------------------------------------------------------
Number of bulls in reference population for        cc1
---------------------------------------------------------
CAN 38553.0
DEU  8485.0 41144.0
DFS  4768.0 35257.0 36132.0
FRA  3919.0 32537.0 31940.0 34174.0
GBR 31912.0  8716.0  4883.0  3985.0 33416.0
ITA 31146.0  6721.0  3627.0  3116.0 30175.0 31986.0
NLD  3987.0 34098.0 33421.0 31981.0  4203.0  3147.0 35262.0
POL  4330.0 30356.0 30075.0 28078.0  4384.0  3160.0 29310.0 31938.0

---------------------------------------------------------
Number of bulls in reference population for        cc2
---------------------------------------------------------
BEL  1653.0
CAN   727.0 41113.0
DEU   728.0  8693.0 43503.0
DFS   637.0  4960.0 37548.0 38510.0
ESP   703.0  5795.0 38642.0 37690.0 39715.0
GBR   687.0 34396.0  8933.0  5081.0  5925.0 36788.0
ITA   706.0 32900.0  6862.0  3759.0  4298.0 31966.0 33779.0
NLD   743.0  4190.0 36401.0 35778.0 36395.0  4467.0  3293.0 38345.0
POL   996.0  4514.0 32661.0 32431.0 32984.0  4570.0  3294.0 31684.0 34322.0

---------------------------------------------------------
Number of bulls in reference population for        int
---------------------------------------------------------
BEL  1341.0
CAN   579.0 39426.0
DEU   723.0  8595.0 43336.0
DFS   635.0  4913.0 37459.0 38411.0
ESP   700.0  5744.0 38549.0 37599.0 39611.0
GBR   671.0 34226.0  8888.0  5056.0  5897.0 36602.0
ITA   571.0 31707.0  6817.0  3750.0  4282.0 31880.0 32573.0
NLD   738.0  4125.0 36324.0 35706.0 36314.0  4446.0  3281.0 38201.0
POL   766.0  4251.0 32574.0 32347.0 32894.0  4461.0  3146.0 31592.0 33558.0
```