Exercises Day 1
Part 1: EBV accuracy

Exercise 1.1 Effect of using relatives' information on selection accuracy

For single trait prediction of breeding value, write out the P-Matrix and the G-vector for the following cases:

1. One own performance record
2. Information known on own performance and performance of sire (1 record each)
3. Information known on own performance and an EBV of the sire (accuracy = 0.9)
4. Information known on own performance and an EBV of the sire (acc = 0.9) and dam (acc =0.5)
5. Information on own performance, EBV of the sire (acc = 0.9) and the mean of 25 half sibs
6. Information on own performance, mean of 25 half sibs and mean of 50 progeny

Use the symbols V_A for additive genetic variance and V_P for phenotypic variance.
Note that for a single trait prediction you can also substitute these by $V_P = 1$ and $V_A = h^2$

You can plug the formulas from above in Excel, R or Julia, and for these cases calculate the index weights and the accuracy, assuming a certain value for h^2. For some guidance on matrix calculation in Excel, see the end of this exercise sheet. You can check your answers with STEBVaccuracy.XLS (using the STSELIND tab).

Exercise 1.2 Correlations between relatives' EBV

Consider the following cases, and for each case, calculate the correlation between EBVs on full sibs and half sibs.
You can use STEBVaccuracy.XLS (using the STSELIND tab) and use the P-matrix and the index weights to work out this problem.

1. Information known on EBV of the sire (acc=0.9) and dam (acc=0.5)
2. One own performance record
3. Information known on own performance and an EBV of the sire (acc=0.9) and dam (acc=0.5)
4. Information on own performance, EBV of the sire (acc=0.9), dam (acc=0.5) and 50 progeny

Exercise 1.3 Pseudo BLUP

In real life, parents have not just their own records, but they have an estimated breeding value with certain accuracy, using BLUP. This accuracy is based on ancestor information, their own siblings and perhaps their offspring. Also, BLUP corrects for the records of the mates of sires, when their progeny are evaluated. The amount of ancestral information can be derived from a given population structure.

The STEBVaccuracy.XLS (using the PseudoBLUP tab) program does a full Pseudo-BLUP prediction of EBV accuracy, given genetic parameters, and a certain population structure (Half-sib and full-sib family size). You can follow the steps in more detail in BLUP_EBV.XLS.

For 2 cases:
h^2=0.25, c^2=0.15 FS family size =3, HS family size = 12 and
h^2=0.10, c^2=0.0 FS family size =4, HS family size = 80

1) explain the negative weight on EBV of mates;
2) vary h^2 and look at weights on parental EBV
3) compare Pseudo BLUP accuracy with that of a that simple selection index approach assuming just a single record for parents (STEBVaccuracy.XLS; using the STSELIND tab)

Exercises Day 1
Part 2: Selection response

Exercise 2.1

Consider an ongoing nucleus breeding program for trait with heritability equal to 0.25, a phenotypic standard deviation equal to 20, and a mean of 100. The trait is expressed in females only (sex-limited trait) when they are 1 year of age. Each round 10 sires are mated to 5 dams each, and each dam has 4 male and 4 female progeny.

1. Calculate the accuracy of BLUP EBV of young male and female selection candidates (use STEBVaccuracy without Bulmer)
2. Predict the genetic superiority of selected males and females, assuming selection of the top 10% of males and the top 50% of females. Use the SELINT.XLS (correlated EBV tab) to account for correlated EBVs.
3. Predict the expected phenotypic performance of the progeny generation (generation 1).

Exercise 2.2 Selection across age groups

Consider selection of females in dairy cattle for milk yield (heritability = 0.3, genetic SD = 550 kg). Three age groups of females are available, with numbers, ages, trait means, and accuracies of selection as given below. Our aim is to select a total of 50 females for breeding.

Age group	Age when progeny born (yr)	Number available candidates	Age group trait mean (kg)	Accuracy Of selection
1	2	500	12,000	0.55
2	3	300	11,700	0.68
3	4	200	11,400	0.72

Predict the genetic superiority and generation interval for the following two situations:

1. The 50 females are selected by selecting the best 10, 20, and 20 from age groups 1, 2, and 3
2. The 50 females are selected by truncation selection across age groups (use truncsel.xls)

Exercise 2.3

The response per year can be given by the formula of Rendel and Robertson: Ryr = S/L.
For simplicity assume equal selection intensities in males and females).
We can maximize selection response by truncation section across age classes, (assuming the selection criteria are comparable across age classes). Truncation selection across age classes maximizes the mean of the selected parents.
Show algebraically that maximizing the mean of selected parents results in maximizing the response per year (hence, optimizes selection across age classes)

Exercise 2.4

Using the Excel Spreadsheet 'Genetic_gain.xls', evaluate the impact of the percentage of cows inseminated by young bulls and progeny group size on genetic gain. Find the optimal combination of these two variables in order to maximize genetic gain

Exercises Day 1
Part 3: Change of Variance

Exercise 3.1 Response to selection with the Bulmer effect

Consider the problem of Exercise 2.1.

1. Calculate the genetic variance and heritability among the individuals produced in generation 1

2. Calculate accuracy of BLUP EBV of male and female selection candidates from generation 1. For the accuracy of sires and dams, use the accuracies of EBV you obtained in Exercise 2.1 (i.e. from an unselected population).

3. Predict the mean, genetic variance, and heritability of individuals produced in generation 2

4. Derive the asymptotic genetic variance, accuracy, heritability and response to selection for this breeding program.

5. Compare results from 4. to those you get from using the program SelAction.

Exercise 3.2 Pseudo BLUP EBV with the Bulmer effect

1. Use STEBVaccuracy.xls and compare accuracy and index weights of females of Exercise 2.1 with and without Bulmer. Do the same for males

2. Change the % selected and see how this changes index weights and accuracy of EBV.

3. Calculate the accuracy of a parental average EBV with and without selection (Bulmer correction) for different proportions selected. Look also at the variance of parental EBV.

   PA = ½ EBVsire + ½ EBVdam
   Var(PA) = ¼Var(EBVsire) + ¼Var(EBVdam)
   Accuracy = sqrt(Var(PA)/V_A)

4. Evaluate reduction in accuracy due to Bulmer with different heritabilities

Matrix calculations using Excel

You can do some basic matrix calculations with MS Excel.

First put in the values of your matrices

To multiply two matrices:
- select an area of the size of the resulting matrix
- type: =**MMULT(**
- select the area of the first matrix
- type a comma (,)
- select area of the second matrix
- type a close bracket)
- on Windows press: Ctrl_Shift_Enter on Mac press: Cmnd_Shift_Enter

To add or subtract a matrix (vector):
- select an area of the size of the resulting matrix
- type: = (
- select the area of the first matrix
- type a **+** or **-**
- select area of the second matrix
- type a close bracket)
- press: Ctrl_Shift_Enter

To invert a matrix:
- select an area of the size of the resulting matrix
- type: =**MINVERSE(**
- select the area of the first matrix
- type a close bracket)
- press: Ctrl_Shift_Enter

To transpose a matrix (vector):
- select an area of the size of the resulting matrix
- type: =**TRANSPOSE(**
- select the area of the first matrix
- type a close bracket)
- press: Ctrl_Shift_Enter

A more specialized matrix calculation program is MATLAB. It contains many more matrix functions and mathematical function than excel. MATLAB allows you to make and run programs, draw graphs, and run simulation). A MATLAB student version is very well suitable for animal breeding problems and quite easy to use.