Day 4 Genomic Prediction and Genomic Selection

Exercise 1 Accuracy of Genomic Predictions

Use the spreadsheet 'GS accuracy.xls' to investigate and explain the impact of the following parameters on the effective number of chromosome segments (M_e), the proportion of variance explained by markers (q^2), the accuracy with which marker effects are estimated ($r_Q$hat), and the accuracy of the genomic prediction or molecular breeding value, MBV (r_{MBV}):

- number of markers (M)
- Effective population size (N_e)
- Heritability of phenotypes (h^2)
- Number of training individuals (N)

Set L=1 and k=30 for a genome of 30 chromosomes of 1 Morgan

a) What is the minimum number of markers that is needed to achieve near maximum genome coverage (q^2=0.99) when N_e=100 versus 340 versus 1000 versus 10,000? Enter this in the table below.

b) Set the number of markers M = 1,000,000 to get nearly complete coverage regardless of N_e. Set h^2=0.9.
Now evaluate the size of the training set (N) needed to reach an MBV accuracy of 0.8 for N_e=100, versus 340 versus 1,000 versus 10,000. Enter the results in the table below.

c) Repeat b) for heritabilities equal to 0.5 and 0.2

	N_e = 100	**N_e = 340**	**N_e = 1000**	**N_e = 10,000**
Min. # markers	*125,000*	*350,000*	*900,000*	*6,500,000*
h^2 = 0.9	2,600	7,100	17,800	166,000
h^2 = 0.5	4,700	12,650	32,000	300,000
h^2 = 0.2	11,700	31,600	80,000	750,000

d) Test the genome scaling argument that if the size of the simulated genome is reduced by a factor C, then the size of the training population also has to be reduced by the same factor C in order to maintain the same accuracy of MBV.

Compared to scenario a) with Ne=340, to reach an accuracy of 0.8 for half the genome size (k=15; L=1), you only need 1,300 records for training.

Exercise 2 EBVs combining phenotype and GBV

Consider selection for an additive trait with (total) heritability 0.2 and phenotypic standard deviation equal to 50. For this trait, you have been able to derive genomic breeding values with accuracy (r_{MBV}) equal to 0.5. The following sources of information are available for selection:

- own MBV
- own phenotype
- MBV of the individual's sire
- Phenotype of the individual's sire

Assume the top 20% individuals are selected. The base scenario is having own phenotype and phenotype of the sire only (no genotypes). Evaluate the impact of the following on the accuracy of selection and the genetic superiority of the selected individuals, using the spreadsheet 'STEBVaccuracy.xls': for answers, see Day 4_answers.xls

a) Adding genotyping of the individual to the base information of own phenotype and phenotype of the sire.

Base	0.4820
Base+OwnGeno	0.6228

b) Adding genotyping of the sire to the information from question a).

A+SireGeno	0.6235

c) Derive the elements of the P matrix and the G vector for question b)

P-matrix	own	sire	own DNA	sire DNA
own	σ_P^2	$a*h^2$	$r_{MBV}^2*\sigma_G^2$	$a*r_{MBV}^2*\sigma_G^2$
sire	$a*h^2$	σ_P^2	$a*r_{MBV}^2*\sigma_G^2$	$r_{MBV}^2*\sigma_G^2$
own DNA	$r_{MBV}^2*\sigma_G^2$	$a*r_{MBV}^2*\sigma_G^2$	$r_{MBV}^2*\sigma_G^2$	$a*r_{MBV}^2*\sigma_G^2$
sire DNA	$a*r_{MBV}^2*\sigma_G^2$	$r_{MBV}^2*\sigma_G^2$	$a*r_{MBV}^2*\sigma_G^2$	$r_{MBV}^2*\sigma_G^2$

G-matrix	
own	σ_G^2
sire	$a*\sigma_G^2$
own DNA	$r_{MBV}^2*\sigma_G^2$
sire DNA	$a*r_{MBV}^2*\sigma_G^2$

P-matrix	own	sire	own DNA	sire DNA
own	1	0.1000	0.0500	0.0250
sire	0.1000	1	0.0250	0.0500
own DNA	0.05000000	0.0250	0.0500	0.0250
sire DNA	0.0250	0.0500	0.0250	0.0500

G-matrix	
own	0.2
sire	0.1
own DNA	0.050
sire DNA	0.025

d) Explain the weight on the MBV of the sire in question b)

b = The sire's phenotype is corrected for the sire's MBV

0.15261324
0.066898955
0.84738676
-0.066898955

e) Convert this MBV blending problem into a two-trait problem consisting of the original trait and the MBV as a correlated trait with heritability = 1. I.e. derive the genetic and phenotypic correlations between the two traits. Enter the results into MTindex.xls and check that it gives the same answers for question b).

Gen. Corr:	$r_{GQhat}=qr_{Qhat}=r_{MBV}=$	0.5
Phen. Corr:	$r_{PQhat}=hqr_{Qhat}=hr_{MBV}=$	0.22
sigmaMBV	$r_{MBV}\sigma_G=$	0.1