Answers Assignment 2 Monday January 30 2017

1. Plot the average reaction norm (i.e., before any selection has taken place).
   This is simply a line P(x) = x, where P(x) is yield on the y-axis, and x is the mean yield in an environment on the x-axis. By construction, in Finlay-Wilkinson regression, the average phenotype is always equal to the average environmental value. This is because the "environment" is defined as the mean performance in an environment.

2. Plot the phenotypic and genetic variance (or sd) and the heritability as a function of the environment *x*, where *x* ranges from 5,000 to 11,000kg. Observe that the linear reaction norm enforces the variances to take a quadratic function of the environment. *See R-code.*

3. Magnitude of GxE-interaction: Calculate the genetic correlation between the trait in the average environment (*x* = 8000) and in the highest (11,000kg) and lowest (5000kg) environments. Change the genetic variance in slope to see how the degree of GxE is affected.
   See R-code. Increasing the variance in slope decreases the genetic correlation between environments. More variance in slope means more GxE. Hence, in the RN-Model, the variance in slope is a measure of the degree of GxE. If the variance in slope is zero, then there is no GxE-interaction (r_g = 1).

4. Calculate the degree of GxE-interaction (*i.e.*, the genetic correlation) between the lowest and the highest environment. What do you observe when you strongly increase the genetic variance in the slope?
   See R-code. If you sufficiently increase the variance in slope, then the correlation becomes negative.

5. Set values back to their defaults. Calculate response to selection in level and slope, when selecting in: 1. The average environment, 2. The lowest environment, 3. The highest environment. How does the change in environmental sensitivity depend on the selection environment?
   See R-code. Selection in the high environment increases environmental sensitivity, while selection in the low environment decreases environmental sensitivity. Selection in the average environment increases environmental sensitivity a little, because the correlation between level and slope is positive.

6. Calculate the average reaction norm when you would select 5 generations in the high environment, and also when you would select 5 generations in the low environment. Does the difference between average milk yield in the high and low environment change?
   High environment: response = 243.5 kg in level, and 0.032 in slope. Hence, in five generation this is 1217.5 kg in level, and 0.16 in slope. Hence, after selection, the reaction norm is given by $\bar{z}(x) = \bar{z}_0 + \bar{z}_1(x - \bar{x}) = 9217.5 + 1.16(x - 8000)$ *. Mean yield in the high environment equals* $\bar{z}(11{,}000) = 9217.5 + 1.16(11{,}000 - 8000)$ *= 12,697.5 kg. Hence, an increase by 1,697.5 kg. Mean yield in the low environment equals* $\bar{z}(5{,}000) = 9217.5 + 1.16(5{,}000 - 8000)$ *= 5737.5 kg. Hence, an increase by only 737.5 kg. Thus the difference between the high and low environment has increased by 960kg, indicating that environmental sensitivity has increased.*

Low environment: response = 193.5 in level and -0.010 in slope. Hence, in five generation this is 967.5 kg in level, and -0.05 in slope. Hence, after selection, the reaction norm is given by $\bar{z}(x) = \bar{z}_0 + \bar{z}_1(x - \bar{x}) = 8967.5 + 0.95(x - 8000)$. *Mean yield in the high environment equals* $\bar{z}(11{,}000) = 8967.5 + 0.95(11{,}000 - 8000)$ *= 11,817.5 kg. Hence, an increase by 817.5 kg. Mean yield in the low environment equals* $\bar{z}(5{,}000) = 8967.5 + 0.95(5{,}000 - 8000)$ *= 6117.5 kg. Hence, an increase by 1117.5 kg. Thus the difference between the high and low environment has decreased by 300kg, indicating that environmental sensitivity has decreased.*

7. Calculate response to selection in milk yield in the low environment when either: 1. Selection is in the low environment, 2. Selection is in the high environment.
   See R-code.

8. Calculate correlated response in the low environment when selecting in the high environment, using the genetic correlation (i.e., rather than the above equations) and compare with results of the above equation.
   Correlated response is given by $\Delta G = i_s h_s r_{g,sr} \sigma_{A_r}$, where subscript s indicates the selection trait and subscript *r* the response trait. From question 4, the genetic correlation between the low and the high environment equals $r_{g,sr}$ = 0.56. From question 2, heritability in the high environment equals h_s^2 = 0.235 and additive genetic standard deviation in the low environment equals σ_{A_r} = 541.8 kg. Hence, response equals $1 \times \sqrt{0.235} \times 0.56 \times 541.8 = 147 kg.$ This agrees with the result calculated from the reaction-norm approach, indicating that the multitrait model and the RN-model are consistent.