Answers to Exercise 36

Heritability

1. Sometimes the slope does not exactly agree with the V_g/V_p value. This is simply due our finite population size. If you were to expand our population to 1000 individuals, you would find a closer agreement between the slope and the V_g/V_p value.

2. It is important to realize that heritability is defined by the *variation* in a trait and not by the trait itself. It makes no difference what the mean value of a trait is, as long as the variation in the trait remains constant. It may surprise you that the heritability remained 1 even when the parents mean was 10 and the offspring mean was 50.

   An example is the real-life situation of human height. Over several generations, the mean height of adults in the United States has been increasing due to more healthful environmental conditions and better diet. In particular, your parents are probably taller than your grandparents, and your grandparents are probably taller than your great-grandparents were as adults. Despite the fact that the environment is improving everyone's height, parents who are tall *relative to others in their generation* tend to have children who will also be tall relative to others in their generation. Likewise, parents who are short relative to other adults in their generation tend to have children who are short relative to other adults in their generation. Even though the means change from one generation to the next, the offspring heights are still predictable from the parents' heights, and thus the trait has high heritability.

3. As you raise the environmental variation, you raise the *E* values. As such, it becomes harder and harder to predict an offspring's phenotype by the parent's phenotype. Notice that you even sometimes get a negative slope for the parent offspring regression.* Likewise, the points on the graphs become more and more scattered. The V_e values becomes higher and higher, as you increase the environmental variation, yet the V_g stays the same. Consequently, V_g/V_p becomes smaller. Your values may differ from these due to the fact that our formulas include randomly generated numbers.

Trial	Heritability when environmental variation = 0.01	Heritability when environmental variation = 1	Heritability when environmental variation = 5	Heritability when environmental variation = 20
1	1 (0.95)	0.78 (0.84)	0.16 (0.12)	0.01 (0.01)
2	1 (1.01)	0.79 (0.82)	0.15 (0.17)	0.01 (–0.03)
3	1 (0.90)	0.76 (0.86)	0.14 (0.24)	0.01 (–0.08)
4	1 (1.03)	0.85 (0.82)	0.14 (0.16)	0.01 (–0.04)
5	1 (1.01)	0.80 (0.84)	0.12 (0.24)	0.01 (–0.07)

*** V_p/V_g is followed by the slope in parentheses.**

An important conclusion arises from this experiment: Even when you have populations with identical genetic make-up, heritability is defined only for a particular environment with a particular amount of variation within it. Environments that are homogeneous (provide the same conditions for each individual) will give rise to higher heritability estimates that environments that are heterogeneous (and provide different conditions for different individuals), even when individuals are genetically identical.

If we were to clone a population of plants and grow one set in a controlled greenhouse setting and another set in a natural field setting, heritability for the same trait will probably be higher in the greenhouse setting. Finally, if the parents have a different environmental variation than their offspring, the slope no longer accurately estimates heritability, and furthermore there is considerable variation in the slope.

4. Heritability approaches 0 as genetic variation is decreased even though the environmental heterogeneity is quite low. This is expected given the very low V_g value. Please note that our model actually becomes inaccurate when we change the allele frequencies because the G's will no longer add up to zero as they should.

5. If genotypes were not randomly assigned to environments, your estimate of heritability might be skewed. You might attribute some of the variation in phenotype to V_g when it was really part of V_e. (You can read more about this in Falconer 1989.)

6. Maternal effects can alter an offspring's phenotype, and can also skew estimates of heritability. Such maternal effects may results in an estimate of heritability that is higher than it should be. In fact, some scientists would argue that offspring-sire regressions are better for estimating heritability than offspring-midparent regressions. (You can read more about this in Falconer 1989.)