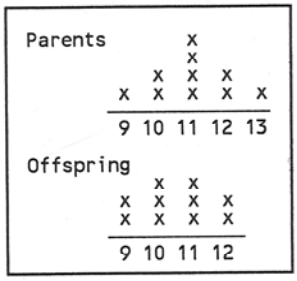
Some quantitative genetics problems

1 Pig farmers in Illinois would like to reduce the average number of offspring per litter, because pigs from larger litters tend to be of lesser quality. One way to do this is to select for smaller litter sizes. The distribution of litter sizes in a parental population is shown at the right (above). All individuals with litter sizes of 10 or fewer were mated at random among themselves; the resulting distribution of litter sizes among their offspring is shown below the parental distribution. Calculate the mean and variance of litter size for the parental and offspring populations. Determine the selection differential (S), the response to selection (R), and the heritability. Is this *broad-sense* or *narrow-sense* heritability? Which *variance components* can we estimate from these data, and what are their values?



2 A population of *asexually* reproducing slugs shows genetic variance for fecundity (egg number, which translates directly into fitness) in a certain back yard in Seattle. There are, at the moment, three *equally frequent* genotypes in this population, with distributions of fecundity (lifetime egg number) as given in the table. These samples of four individuals are representative of the population as a whole. What is the mean fecundity in *this* generation? What will it be *next* generation? (*Hints:* You must find the heritability and the selection gradient or differential; there are *several* ways to find the heritability; for example, you could figure out the parent-offspring regression by noting that these slugs are *asexual*; what other approaches could you use?) What will the *equilibrium* fecundity be in this population? (Assume that there is no significant immigration or mutation for many generations.) At equilibrium, what is the additive genetic variance? The phenotypic variance?

Genotype	Fecundities
1	150, 170, 190, 210
2	170, 190, 210, 230
3	190, 210, 230, 250

3 Five generations of selection for decreased plasma cholesterol in mice changed the mean from 2.15 mg/100 ml to 2.01 mg/100 ml. The selection differential was -0.07 mg/100 ml. What is the realized heritability?

4 Two inbred varieties of tobacco are crossed and the variance of leaf number among F_1 plants is 1.5. In the F_2 generation the variance is 6.0. What are the genotypic and environmental variance components and the broad-sense heritability in the F_2 generation?

5 In a population of the flour beetle *Tribolium* the mean weight of pupae is 2 mg (2000 μg). The phenotypic variance is 400 μg^2 and the additive genetic variance is 100 μg^2. If individuals with a *mean* pupal weight that is *two phenotypic standard deviations* above the mean are selected as parents, what is the expected average pupal weight among the progeny?

6 How many generations of selection with a selection differential of 20 would be required to increase the average number of eggs laid per hen per year from 180 to 220, given a heritability of 0.20?

7 After a lengthy study of flower-size variation in a population of wild poppies growing in southwestern Utah, you find that flower diameters (equivalent to a measure of petal lengths) are distributed *bimodally*, as shown below. The gap between the two main peaks is real: you measured several flowers on each of hundreds of individual plants. The flowers on any given plant tend to be similar in size, relative to the variation among plants. The bimodality does not result from a sex difference, because all individuals in this species are hermaphrodites. Nor is it some strange effect of the environment, because you get similar distributions when you harvest seeds from adults and grow them up to mature plants in the greenhouse. What's going on here? There are several possibilities. Describe as many as you can think of, and explain how you would *test* them.

8 "In general, we expect the heritabilities of quantitative traits to be *lower* in *small* populations than in large ones." Critically evaluate this assertion. Whether you agree or disagree, *explain your reasoning*.