Process of Evolution: Population Genetics

Useful Formulae

$t = 4N$

$p^2 + 2pq + q^2 = 1$

$N_e = \frac{4N_f N_m}{N_f + N_m}$

$Nm \approx \frac{\left[\frac{1}{F_{ST}}\right]-1}{4}$ (*Nm* is number of migrants)

$p = \frac{1}{2N_e}$ (*p* for fixation of allele)

$R = h_2 S$

$R = \bar{x}_o - \bar{x}_p$

Practice Questions

1. A pride of lions consists of 8 females and only 2 males. Calculate the effective population size (N_e) for this pride?

2. A new allele arises in single individual in population of 50 individuals. Assuming that this population is not being acted on by evolutionary forces, what is the probability that this allele will eventually become fixed in the population?

3. In large, randomly mating population of 1000 daisies there are two Mendelian phenotypes present. Homozygous dominant and heterozygous individuals have red petals, while homozygous recessive individuals have yellow petals. We know that there are 700 homozygous dominant individuals in the population. Assuming the population is

in Hardy-Weinberg Equilibrium, calculate the number heterozygous and homozygous recessive individuals.

4. A population of *Heliconius* butterflies is subdivided into small subpopulations that exchange migrants at a rate of *m* migrants per generation. Given that the number of migrants a subpopulation receives (*Nm*) is 10, calculate the approximate fixation index (F_{ST}).

5. A botanist growing peas in a green house wants to select for larger plants. To do this, he only allows the largest plants he has to breed.

    a. If the mean height of his parent plants ($\bar{x}_p$) is 80cm, and the mean height of the offspring plants ($\bar{x}_o$) is 95cm, calculate the response to selection, R.

    b. Given that narrow sense heritability for height in peas (h^2) is 0.8, calculate the selection differential, S.

6. Scientists are studying two very different populations. The first is a laboratory population of 1,000 crickets, the genotypes at a locus coding for coloration are given below.

AA	Aa	aa
200	500	300

The second population is a pack of 10 wolves in Yellowstone National Park. The genotypes at a locus coding for coat color are given below.

AA	Aa	aa
2	5	3

While closing the cricket's cage, a scientist accidently squishes a homozygous recessive individual between the lid and the cage. In a second unlucky accident, a falling tree branch kills a homozygous recessive wolf in the Yellowstone pack. Using this information, respond to parts a-c below.

a. What are the original allele frequencies and what are the new allele frequencies (after the random deaths) for the populations of wolves and crickets?

b. Which evolutionary force results in the differences in allele frequency?

c. Is this force stronger in the wolf or in the cricket population? Why?

7. In a population of 100,000 flour beetles there exists a recessive genetic disease that causes antennae to develop in a "Z" shape when in the homozygous condition. You find 10 individuals with Z-shaped antennae. Calculate the genotype and allele frequencies for this population of flour beetles.

8. Water fleas, *Daphnia* species, can develop 2 possible phenotypes: when hatching in the presence of fish mucus, the water fleas grow large armored structure that makes them more difficult to be eaten by fish predators; when in the absence of fish mucus, they do

not develop armored structures. An undergraduate working on their honors thesis is experimenting on *Daphnia*. She grows *Daphnia* in a beaker with fish mucus, and another population in a beaker without mucus. Then she switches some individuals from each beaker to the other. She finds that after the switch their phenotypes do not change, but the phenotypes of their offspring does! Is this a course-grained or fine-grained response? How can you tell?

Use the table of genotypes of a population of salamanders to answer the following questions.

AA	Aa	aa
40	40	20

a.) Calculate the allele frequencies

b.) Use the Hardy-Weinberg equilibrium equation to calculate the predicted genotype frequencies based on the allele frequencies you calculated in part 1.

c.) Based on your answer in b, how many individuals if each genotype would you expect to see if this population were in Hardy-Weinberg equilibrium?

d.) In the next generation, a research finds the following genotype frequencies. Is the population in Hardy-Weinberg equilibrium? If not, which assumptions of Hardy-Weinberg have likely been violated?

AA	Aa	aa
40	60	0