MID-TERM BIOL 434: October 2008

1. A lab population of *Drosophila* starts with an allele frequency at an autosomal locus of 0.2 for a particular allele **B**. Artificial selection on that locus allows 90% of **BB** individuals to survive, while only 65% of **Bb** individuals and 35% of **bb** individuals are allowed to survive. This artificial selection is applied for two generations only, and then the locus evolves neutrally for a very large number of generations.

a. *(8 points)* What is the frequency of the **B** allele immediately after the two generations of selection?

$$p' = \frac{p^2 w_{11} + pq w_{12}}{\overline{w}} = \frac{(0.2)^2(0.9) + (0.2)(0.8)(0.65)}{(0.2)^2(0.9) + 2(0.2)(0.8)(0.65) + (0.8)^2(0.35)} = 0.299$$

$$p'' = \frac{p^2 w_{11} + pq w_{12}}{\overline{w}} = \frac{(0.299)^2(0.9) + (0.299)(0.701)(0.65)}{(0.299)^2(0.9) + 2(0.299)(0.701)(0.65) + (0.701)^2(0.35)} = 0.413$$

b. *(6 points)* What is the probability that the **B** allele fixes in the population after the very large number of generations?

The probability of fixation of a neutral allele is equal to the allele frequency at the beginning of the drift process. When the allele becomes neutral (when selection stops) the frequency is 0.413, so the probability of fixation is 0.413.

2. *(4 points each)* For each case, say whether the **G** or **g** allele is likely to be higher in frequency after a very large number of generations. Assume that there is no migration or mutation. Please put your answer in the blank before the question:

___g___a. Starting allele frequency is p_G =0.2; $w_{GG} = w_{Gg} = w_{gg}$.

___G___b. Starting allele frequency is p_G =0.2; $w_{GG} > w_{Gg} > w_{gg}$.

___g___c. Starting allele frequency is p_G =0.2; $w_{GG} = 1$; $w_{Gg} = 1.5$; $w_{gg} = 1.2$

___G___d. Starting allele frequency is p_G =0.8; $w_{GG} = w_{Gg} = w_{gg}$.

___g___e. Starting allele frequency is p_G =0.8; $w_{GG} = 1$; $w_{Gg} = 1.5$; $w_{gg} = 1.2$

3. *(4 points each)* In each part below, there are two cases listed, and all other evolutionary parameters are assumed to be equal. Choose which of each pair would have the *higher* total genetic variance at equilibrium, and indicate your choice by circling the case with higher genetic variance.

a.	Positive frequency dependent selection	Negative frequency dependent selection (Increases frequency of alleles when rare)
b.	Variance in reproductive success is 4.	Variance in reproductive success is 2. (Would have a higher N_e .)
c.	High mutation rate (Brings more variation into the population.)	Low mutation rate
d.	Equal sex ratio (Would have a higher N_e .)	Unequal sex ratio
e.	Fitnesses equal to $w_{BB}=1$; $w_{Bb}=1.5$; $w_{bb}=1.2$ (This is overdominance (and the other is underdominance). Overdomiannce maintains variation, but underdominance causes the allele frequency to evolve to fixation or loss.)	Fitnesses equal to $w_{BB}=1$; $w_{Bb}=0.75$; $w_{bb}=1.2$

4. A diploid population starts with three alleles at a locus, with allele frequencies of the first two alleles equal to $p_1 = 0.2$ and $p_2 = 0.5$. The population is then maintained for five generations with 20 individuals and variance in reproductive success equal to 4.0. Assume that the mutation rate for this locus is zero, and there is no fitness difference between the alleles.

a. *(10 points)* What is the expected heterozygosity at this locus after these five generations?

$$H_0 = 1 - 0.2^2 - 0.5^2 - 0.3^2 = 0.62 \qquad N_e = \frac{4N-2}{V+2} = \frac{4(20)-2}{4.0+2} = 13$$

$$H_t = \left(1 - \frac{1}{2N}\right)^t H_0 = \left(1 - \frac{1}{2(13)}\right)^5 (0.62) = 0.5096$$

b. *(3 points)* Is it possible for the heterozygosity to drop to zero after the five generations? Explain.

Yes, by drift any allele frequency is possible as long as the population has multiple alleles a the locus. By chance, the allele frequency could drift to 0 in five generations.

c. *(3 points)* Is it possible for heterozygosity to be higher after the five generations than at the beginning? Explain.

Yes, allele frequency could by chance drift to a state that gives higher heterozygosity. For example, if the alleles by chance drifted to a frequency of $p_1 = 1/3$, $p_2 = 1/3$, and $p_3 = 1/3$, the heterozygosity would be higher.

5. *(15 points)* A population is maintained at effective population size of 10,000 for a very long time. A set of 20 diploid individuals from that population is taken into the lab, and this lab population is maintained for a total of 8 generations (including the generation in which they are sampled from the field) at effective population size 20. At the end of this process, how much heterozygosity should there be on average a locus with mutation rate 10^{-6} (and assume an infinite alleles model)?

$$H_0 = 1 - \hat{F} = \frac{4N\mu}{4N\mu + 1} = \frac{4(10{,}000)10^{-6}}{4(10{,}000)10^{-6} + 1} = 0.0385$$

$$H_t = \left(1 - \frac{1}{2N}\right)^t H_0 = \left(1 - \frac{1}{2(20)}\right)^8 (0.0385) = 0.0314$$

(Mutation is weak enough that it does not affect the change in heterozygosity much during the last 8 generations.)

6. A haploid population starts with five individuals with allele A_1 and five individuals with allele A_2 at the same locus. The probability of survival to adulthood of A_1 is 0.6 and for A_2 the probability of survival is 0.5. After the population reaches adulthood, it acts as an ideal population to create 10 offspring.

a. *(10 points)* What is the expected allele frequency of the A_1 allele of the offspring?

$$p' = \frac{pw_1}{\overline{w}} = \frac{0.5(0.6)}{0.5(0.5) + (0.5)(0.6)} = 0.5454$$

b. *(5 points)* What is the probability that the offspring generation will start with an A_1 allele frequency of 0.7?

$$P(7) = \binom{10}{7}(0.5454)^7(1 - 0.5454)^{10-7} = 0.162$$