**PCB 4674 Evolution**  June 6-8, 2016

**Lab # 5: Alleles, Genotypes and Phenotypes**

**ALLELES, GENOTYPES AND PHENOTYPES**

Reference chapters (in textbook): Ch. 5 and 6

**Lab objectives:**

* Familiar yourself about how to calculate phenotype, genotype and allele frequencies.
* Explore Hardy-Weinberg equilibrium.

We will be examining a sample data set from a population of banded snails and calculating the observed phenotypes, genotypes, and allele frequencies first, assuming that the snail population is in Hardy-Weinberg equilibrium and second, assuming the population is under selection with respect to shell banding pattern.

1. **Hardy-Weinberg equilibrium applied to banded snail shell phenotypes**

Given your population sample of snails, complete the following:

Population c, Shrub environment

**Characterize the phenotypes and score their frequencies.**

0 stripes = 3

1 stripe = 7

Multi-stripe = 20

Assuming the phenotype is controlled by a single locus, assign possible genotypes to each phenotype:

**Is there dominance at this locus?**

There is a co-dominance with shells having stripes because we see more multiple stripe shells compared to few 1 striped shells.

**For each phenotype you scored, what are the associated genotypes?**

rr= 0 stripe

Rr= 1 stripe

RR= multiple stripes

**What are the observed genotypic frequencies?**

rr=0.1

Rr= 0.23

RR= 0.66

**What are the allele frequencies (p (r ) and q ( R ))?**

r= 2 (0.1) + 1 (0.23) + 0 (0.66)

r= 0.2 +.23 + 0= 0.43

R= 1-0.43= 0.57

**What are the expected genotype frequencies?**

r^2 + 2rR + R^2 = 1

(0.43) ^2 + 2(0.43) (0.57) + (0.57) ^2= 1

0.18 + .49 +. 32= ~.99

Expected:

r= 0.18\*3= 0.54

rR= 0.24 \* 7= 1.71

RR= .32 \*20= 6.4

**Does your population sample suggest the population is in Hardy-Weinberg equilibrium?** (Hint: use a Chi-square test to evaluate this hypothesis, and note that when df = 1 the x2critical value = 3.84; Note: using expected individual numbers instead of expected frequencies)

The population sample suggest that the population is not in HWE.

3.84= ∑ (observed- expected) ^2 / expected

r:

3.84= (3-.54)^2/.54= 11.20

rR:

3.84= (7-1.71)^2/ 1.71 = 16.3

RR:

3.84= (20-6.4)^2/ 6.4 = 28.9

Assuming the requirements of Hardy-Weinberg equilibrium are maintained for 1 generation, **what genotypic and phenotypic frequencies would you expect?**

Phenotypic Frequency:

r = 0.43

R = 0.57

r + R = 1

Genotypic Frequency:

rr=0.1

Rr= 0.23

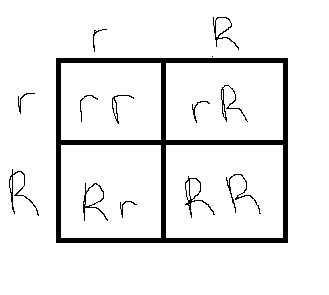
RR= 0.66

Expected Genotypic Frequency:

r= 0.18\*3= 0.54

rR= 0.24 \* 7= 1.71

RR= .32 \*20= 6.4



1. **Selection acts on banded snail shell coloration**

Song thrush predation creates selection on shell patterning based on habitat. More information about the system is available at <http://www.molluscs.at/gastropoda/terrestrial/banded_snails.html>

The selective pressures vary for snails depending on their habitat. In a shrubby habitat banding is particularly favored and very light and very dark snails are at a disadvantage while in woodland areas dark coloration is advantageous, so lighter forms survive less well. In grasslands light coloration and banding are advantageous. Variation in selection pressure across the 3 habitats leads to differential survivorship among snails with different banding patterns (see Table 1).

Table 1: Survivorship of different snail shell banding patterns in three habitats

|  |  |  |  |
| --- | --- | --- | --- |
| **Habitat** | **0 bands** | **1 band** | **Many bands** |
| Shrub | 0.60 | 0.85 | 1.00 |
| Woodland | 0.50 | 0.70 | 1.00 |
| Grassland | 0.95 | 1.00 | 0.80 |

Now, let’s assume that selection is acting on our populations of snails in different habitats.

**Calculate the selection coefficient(s) acting on each phenotype you’ve identified.**

Shrub Habitat:

0 bands = 1 -.60= .40

1 stripe = 1 - .85= .15

Multi-stripe = 1-1 = 0

Starting from your original observed population and assuming the population is under selection, you are then left with **a population of breeders**. Continue to assume selection is the only evolutionary force that is acting on this population and that the other assumptions of HWE still hold (e.g. random mating, infinite population size, no migration (gene flow) etc).

**What are the phenotypic frequencies of the breeders?**

Shrub Habitat:

0 bands= 3 \* 0.6= 1.8

1 band = 7 \* .85 = 5.95

Multi-stripe= 20 \* 1= 20

New population size = 27.75

**What are the genotypic frequencies of the breeders?**

r= 1.8/ 27.75 = 0.06

rR= 5.95/ 27.75= .21

RR= 20/ 27.75= .72

~ .99

**What are the allele frequencies of the breeders?**

r= 2 (0.06) + 1 (0.21) + 0 (0.72)

r= .33

R= 1-.33= .67

**What is the population mean fitness after selection (w-bar)?**

Fitness = expected per capita offspring contributed to the next generation

w/bar= (0.67)^ 2 \*0.60+2(0.67)(0.33)\*1.00+(0.33) ^2 \*0.85 = 0.89

**What are the offspring phenotypic and genotypic frequencies?**

r= r^2= 0.0036

rR= 2rR= 0.025

RR= R^2= 0.51

**What was the change in allele frequency (Δp and Δq) in 1 generation of selection?**

Original Breeders

Δr= 0.43- 0.33= 0.1 increase

ΔR=0.57- 0.67= -0.1 decrease

Repeat the above calculations for 2 more generations (Note: Use 40 individuals as your initial population starting size.)

40 Individuals, generation 1

p (t+1) = (p2 x w11 + pq x w12)/

= [(0.33)^2 (0.60) + (0.33)(0.67)(0.85)]/0.89

= 0.28

q (t+1) = (q2 x w22 + pq x w12)/

= [(0.67)^2 (1) +(0.33)(0.67)(0.85)]/0.89

= 0.71

Generation 2

p (t+2) = (p2 x w11 + pq x w12)/

= [(0.28)^2 (0.60) + (0.28)(0.71)(0.85)]/0.89

= 0.24

q (t+2) = (q2 x w22 + pq x w12)/

= [(0.71)^2 (1) +(0.28)(0.71)(0.85)]/0.89

= 0.76

**How is population mean fitness changing (w-bar)?**

The fitness is changing to select the r gene.

**What is the pattern of change in allele frequency (Δp and Δq)?**

From breeders to generation 1.

Δr= 0.33- 0.28= 0.05 increase

ΔR=0.67- 0.71= -.04 decrease

**What are your long term predictions about the fixation, loss or maintenance of the p and q alleles in this population?**

My prediction is that r will continue to decrease in the population while R will continue to increase in the population.