The Fishy Frequencies Lab

Introduction to Hardy-Weinberg

The Hardy-Weinberg Principle states that allele frequencies in a population will remain constant unless one or more factors cause those frequencies to change. The situation in which allele frequencies remain constant is called genetic equilibrium. Five conditions are required to maintain genetic equilibrium from generation to generation: There must be random mating; the population must be large; and there can be no movement into and out of a population, no mutations, and no natural selection. In some populations, these conditions may be met or nearly met for long periods of time. If, however, the conditions are not met, the genetic equilibrium will be disrupted, and the population will change (i.e., evolve).

In 1908, G.H. Hardy, an English mathematician, and W.R. Weinberg, a German physician, independently determined the effects of random mating in successive generations in the frequencies of alleles in a population's gene pool. This is important for biologists because it is the basis of hypothetical stability from which real change in a population can be measured.

The Hardy- Weinberg equation states that:
$p^2 + 2pq + q^2 = 1$ (or 100%)
p= the frequency of a dominant allele in a gene pool for a given trait.
q= the frequency of a recessive allele in a gene pool for the same trait.
$p + q = 1$ (or 100%)

This means that the fraction of homozygous dominate (pp) individuals plus the fraction of heterozygous (pq) individuals plus the fraction of homozygous recessive (qq) individuals equals 1 (or 100% of the gene pool). Note that pq is multiplied by 2 because there are two ways to get that combination; that is, you can get p from the male and q from the female or q from the male and p from the female.

In this lab you will use little fishy crackers to help further your understanding of natural selection as it relates to genetics and gene frequencies in evolution. Here are the details:

1. The little fish in this study are the natural prey of the terrible fish eating sharks—YOU!

2. the fish come with two color – related phenotypes, gold, and Rainbow Color:

    a. Gold is a recessive trait (f); these fish happen to taste yummy and are easy to catch.

    b. Rainbow Color is a dominant trait (F); these fish aren't as yummy, are sneaky and are more difficult to catch.

3. You, the terrible fish eating sharks, much prefer to eat the yummy gold fish; you eat ONLY gold fish unless none are available in which case you resort to eating Rainbow fish in order to stay alive.

4. New fish are born every "year"; the birth rate equals the death rate. You will stimulate births by reaching into a container of "spare fish" and selecting randomly.

5. Since the gold trait is recessive, the gold fish are homozygous recessive (ff). Because the Rainbow trait is dominant, the Rainbow fish are either homozygous or heterozygous dominant (FF or ff).

For fishy crackers, you will assume that in the total population, you have the following genotypes, FF, Ff, and ff. You will also assume that the mating is RANDOM so that ff, Ff or Ff could mate with ff, Ff, or FF, etc. In addition, you assume that for gold and Rainbow traits there are only two alleles in the population—F and f. If you counted all the alleles for these traits, the fraction of "f" alleles plus the fraction of "F" alleles would add up to 1 (or 100%).

Here's an example: If you know that you have 16% homozygous recessive fish (ff), then your qq or q^2 value is .16, and q= the square root of .16 or .4; thus the frequency of your f allele is .4 and since the sum of the f and F alleles must be 1, the frequency of your F allele must be .6. Using Hardy Weinberg, you can

assume that in your population you have .36 FF (.6x.6) and .48 Ff (2x.4x.6) as well as the original .16 ff that you counted.

Procedure

1. Obtain a random population OF 10 fish from the "ocean" container.

2. Count gold and Rainbow fish and record in your data table; you will calculate frequencies later.

3. Eat 3 goldfish; if you do not have 3 goldfish, fill in the missing number by eating Rainbow fish.

4. Add 3 fish from the "ocean" (i.e., one fish for each one that died). Be sure to keep things random! Do NOT use artificial selection.

5. Now record the number of gold and Rainbow fish present in generation 2.

6. Again eat 3 fish, all GOLD if possible and add 3 randomly selected fish, on for each death. Count and record as generation 3.

7. Repeat the steps above in order to gather a total of five generations worth of data. Now add your team data to the spreadsheet provided.

8. Based on your counts, compute the gene frequencies based on the Hardy-Weinberg equation (review the example above).

9. When available, fill in the class results on your data table and compute the gene frequencies.

10. After your done with your calculations, move on to the analysis questions below. Good Luck

Analysis

1. What generalizations would you make about your team's results? How do they compare to the class results?
2. According to the Hardy-Weinberg Equilibrium, what conditions would have to exist for the gene frequencies in a population's gene pool to stay the same over time?
3. Why is it important to collect and analyze class data?

4. Explain which phenotype (gold or Rainbow) is NOT a favorable adaptation to the fish. Why?

5. Overall, what happened to the genotypic frequencies from generation 1 to generation 5?

6. What process is occurring when there is a change in genotypic frequencies over a period of time?

7. What would happen if it were more advantageous to be heterozygous (Ff)? Would there still be more homozygous fish? Explain.
8. What happens to the recessive genes over successive generations and why?

9. Why doesn't the recessive gene disappear from the population?

10. Explain what would happen if selective pressure changed and the dominant gene was selected for.