Frequencies of alleles in a population | experiment

Population Genetics and Evolution

Purpose

Before doing this laboratory you should understand:

1. How natural selection can alter allelic frequencies in a population;
2. The Hardy- Weinberg equation and its use in determining the frequencies of alleles in a population; and
3. The effects on allelic frequencies of selection against the homozygous recessive or other genotypes

Afterdoing this laboratory you should be able to:

4. Calculate the frequencies of alleles and genotypes in the gene pool of a population using the Hardy-Weinberg formula, and
5. Discuss natural selection and other causes of microevolution as deviations from the conditions required to maintain Hardy-Weinberg equilibrium.

Introduction

Hardy-Weinberg is very significant to evolution because he came up with the theory that the frequencies of genes in a gene pool of a non-evolving population will stay and remain constant, unless some other agent acts on the gene pool. Hardy-Weinberg also came up with equations to prove his equilibrium theorem by the equations $p+q= 1$ (Allele Frequencies) and $p^2+2pq+q^2 = 1$ (Genotype Frequencies). Where, p is the dominant allele frequency, q represents the recessive allele frequency, p^2 is the homozygous dominant, 2pq is the heterozygous, and q^2 represents the homozygous recessive. Therefore, to keep and maintain Hardy Weinberg equilibrium there is 5 conditions:

1. The population has to be really large
2. There cannot be any migration
3. There are no mutation in the population
4. Mating is completely random in the population
5. There is no natural selection

With the help of these equations it can help determine if a population gene pool is changing and the approximate rate by calculating allele frequencies. Therefore, if Hardy Weinberg equilibrium is in the population then the frequencies will remain constant as well as the percent of the population with each genotype. However, if the frequencies change then evolution is happening in the population.

Hypothesis

Case I: If Hardy Weinberg independently suggested evolution is seen as changes in the alleles frequency in a population of organisms, they also state that if five H-W conditions are met, the alleles and genotypes frequencies of the population will remain constant: the five conditions are the population is huge, mating is completely random, no mutation, no migration, and no selection; then when the class simulates a randomly mating heterozygous individuals in a population, the class will have an initial gene frequency of 0. 5 for, Big A, the dominant allele A and genotype frequencies of 0. 25 AA, 0. 5 Aa, 0. 25aa, then when each student has 4 cards two students will randomly choose 2 cards to create offspring, records, and changes the 4 cards the populations allele and genotype frequencies will remain constant because it meets the 5 conditions of Hardy Weinberg.

Case II: If sickle cell anemia is a illness caused by a mutation on a allele, homozygous recessive individuals often don't survive, if Hardy Weinberg suggested a method where evolution is seen as alter in allele frequency in a populations of organisms, they also state that if all H-W five conditions are complete, the alleles and genotypes frequencies of the population will remain constant: the five conditions are the population is huge, mating is completely random, no mutation, no migration, and no selection; then when the class simulation is more realistic by having different chances of survival, then when the class starts again with the initial genotype as in case I, however the offspring aa does not reproduce and the parents must try again; therefore, the aa recessive genotype will slowly disappear from the population and the frequency and the genotype will decease 20% each generation.

Case III: If from many human population show an sudden elevated frequency of the sickle cell allele therefore, heterozygous individuals are a little extra resistant to a form of malaria than individuals that are homozygous dominant, hence there is a light selection against homozygous dominant as compared to heterozygous, then when we start with the original genotype from case I: the genotype aa never survives and reproduce, and individuals that are homozygous dominant only stay alive if a coin toss comes up tails, therefore the frequency of genotype aa continues to decrease while the frequency of AA also begins to decrease frequency by 10% because they are not resistant to the deadly form of malaria, while Aa genotype frequency will continue to increase.

Case IV: If genetic drift is a change in a gene pool of a small population due to chance there could possibly be two effects the bottleneck effect and founder effect, the bottleneck is only a small portion of the population is able to survive and reproduce and founder effect is due to migration, then when the class is divided into smaller populations so individuals from each remote population don’t intermingle with each other individuals from other populations the frequencies of p and q and genotypes will not remain the same because the first rule of The Hardy Weinberg does not meet the condition that it is a large population; therefore since genic drift is a change in gene pool due to chance p and q will not stay constant but will decrease or increase by 15%.

Data

Topics for discussion pg. 241 #1 and #2

% of heterozygous tasters(2pq) in class= 2(. 532)(. 468)= . 497952

% of heterozygous tasters in North America= 2(. 329)(. 671)= . 441518

Calculations for gene frequencies

The Hardy Weinberg equation will expect that the new p and q will remain the same and constant as the initial generation after generation; therefore, because this case is a Hardy Weinberg the gene frequency for the dominant and recessive allele should be . 5(which is the same as the initial gene frequency). Hence, the genotype frequencies for this case should also be constant to the initial frequencies (0. 25AA, 0. 50Aa, 0. 25aa).

The results of the simulation do agree with H-W prediction because the frequencies of the allele and genotype did remain the same or constant. However, the 5 conditions are not being met during the simulation such as not having a large enough population.

In this simulation not all 5 conditions of H-W are strictly met such as not having a very large population, the simulation restricted having a huge population in the class. Therefore, H-W equilibrium is not met and causes inconstant frequencies from the initial population.

Calculations for gene frequencies

The new/ initial p and q frequencies in Case II compared to the initial frequencies in Case I is the same initial population frequency of p and q. However, in Case II all aa offspring do not reproduce. As the generations keep going the frequencies of p and q compared to the frequencies in Case I after 5 generations is that in the Case II the p is larger when compared to Case I and the q was smaller when compared. Also, the genotype aa is no longer in the gene pool.

The allelic frequency of the populations has changed after the fifth generation the frequency of p is increasing and the frequency of q is decreasing because the aa offspring cannot reproduce. Therefore, not all offspring have a equal chance to survive.

If the class had simulated another 5 generations, the allele frequency of p would continue to increase and majority of the population would have the A allele, while little a will continue to decrease in the population. This is because in Case II the aa off spring does not reproduce and cannot continue to pass on the a allele generation after generation.

It cannot be possible to entirely eliminate a deleterious recessive allele in a large population because there are still heterozygous genotypes in the gene pool. The heterozygous genotypes will keep the recessive allele alive in population; however, the recessive allele will continue to decrease.

Calculations for gene frequencies

The frequencies of p and q in Case I and Case II compared illustrates that homozygous recessive genotype is no longer in the population because aa cannot produce offspring is the difference between Case I and Case II. When you compare Case II and Case III, in Case III the recessive allele(a) increased generation after generation because the Aa (heterozygous genotype) have a selection advantage because they are resistant to malaria than homozygous dominant. After the 5 th generation, the frequencies of the recessive allele are slowly increasing after each generation.

I do not think the recessive allele will be eliminated from Case II or Case III for the reason that heterozygous genotype in Case II will always be present in population; hence, the recessive allele will not disappear in Case II. In Case III the heterozygous genotype in the population have an advantage to a form of malaria; therefore, the heterozygous genotype in Case III will live on and reproduce to keep the recessive allele alive.

There is an extreme importance of heterozygous in maintain genetic variation in the populations because it causes heterozygous advantage; therefore, making sure that both the dominant and recessive allele are able to be passes on from generation to generation. As a result, because both alleles remain in the gene pool because it keeps the variation in the population by heterozygous advantage.

Calculations for gene Frequencies

The initial genotypic frequencies of each population for each Case are the same. The start genotype frequency for each Case's population is 0. 25 AA, 0. 50 Aa, and 0. 25 aa.

The results from the class indicate that the population size is very important because in Case IV by making the case smaller caused a bigger chance of a change in p and q because it does not follow the H-W 5 conditions. Therefore, as the population size decreases, there is an increase in evolutionary force because in a small population chance is a huge part in the population's genotypes.

Conclusion

In the first objective after doing the lab, to calculate the frequencies of genotypes and alleles in a gene pool of a population you must use the H-W formulas $p+q= 1$ for alleles and $p^{2} +2pq+q^{2} = 1$ for genotypes. Where p is the dominant allele and q is the recessive allele. When using the equation to calculate genotype frequencies: p^{2} represents the homogenous dominant, 2pq represents the heterozygous genotype, and q^{2} represents the recessive genotype in a population. To calculate p it is the total number of A alleles divided by the whole number of alleles in the population and to calculate the value of q is by total digit of a alleles divided by sum number alleles on the whole population.

In the second objective after doing the lab, as the population begins deviates from the 5 conditions of having a large population, random mating, no migration, no mutation, and no natural selection to maintain the Hardy-Weinberg; the causes of microevolution begin to increase. When microevolution begins to increase because it does not follow the H-W conditions it causes a change in the allele frequencies over time. There are four different aspects that cause microevolution such as gene flow, genetic drift, natural selection, and mutation. The first aspect that causes microevolution is gene flow which is the genetic switch or exchange because of migration of fertile individuals between each population and therefore usually reduces the differences between each population. The second aspect is genetic drift, which is a change in the population gene pool due to completely by chance causing the bottleneck effect and the founder effect (migration). The third and fourth aspects fall into each other by natural selection and mutation because it causes selective advantages or selective disadvantages of a genotype with respect to being able to survive and reproduce. However, some variation or mutation has no selective advantages or disadvantages called neutral variation. In Case I, the simulation was a test for an ideal H-W population where all the 5 conditions are met; therefore, the allele and genotype frequencies remain the same. However, Case II it has selection where not all of the genotypes have the same rate of survival causing the there to be no homogenous recessive because the off spring cannot reproduce. Hence, because the aa cannot reproduce the dominant allele will increase while the recessive will decrease. This is slowly drifting away from an H-W population to microevolution. In Case III, the population begins to have a heterozygous advantage because the heterozygous are resistant to deadly form of malaria than homozygous dominant. Therefore, it will allow both the dominant and recessive allele to be passed on because heterozygous individuals are desired. In Case IV, this simulation demonstrates genetic drift which breaks the condition of having a large population in H-W; therefore, microevolution is occurring in the population because smaller population are more prone to evolution. These cases show the effects of the four process that cause microevolution and a ideal Hardy-Weinberg population.