POPULATION GENETICS: Allele and Genotype Frequencies

As we have seen, population genetics is concerned with the changes in genetic composition (which control the trait) from one generation to next. This involves the examination and modelling changes in the frequencies of genes and alleles in populations. The allele and genotype frequencies are defined as:

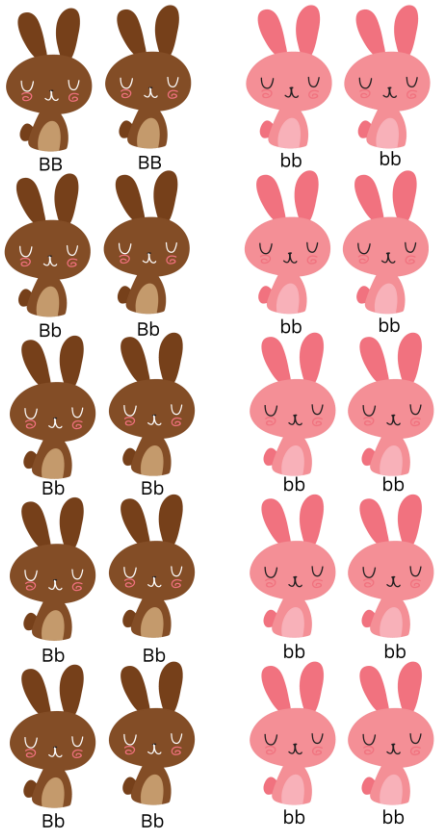
$$\text{Allele Frequency} = \frac{\text{Number of copies of particular allele in a population}}{\text{Total number of all the alleles of that particular gene in a population}}$$

$$\text{Genotype Frequency} = \frac{\text{Number of individuals with a particular genotype in a population}}{\text{Total number of all the individuals in a population}}$$

Though these two frequencies are related, a clear distinction between them must be kept in mind.

Finding Allele Frequency

For example, let us look at a sample population of 20 rabbits. Each rabbit has two copies of the fur color gene.



B= Brown (dominant)
b= pink (recessive)

Allele frequencies are a comparison of how many "**B**" vs. "**b**" there are in a population.

If we look at the two gene copies in each rabbit and count up how many **B** copies are present, we find there are 12. If we count up how many **b** copies are present, we find that there are 28. The total number of gene copies in the whole population is 12 +28 = 40.

We can divide the number of copies of each allele by the total number of copies to get the allele frequency.

Frequency of **B** = 12/40 = 0.3
Frequency of **b** = 28/40 = 0.7

These results tell us that the allele frequency of B is 30% and b is 70%.

Finding Genotype Frequency

Well, what is a genotype? A genotype is two alleles. By using the same example, let's now calculate the genotype frequency of the rabbits.

Frequency of **BB** = 2/20 = 0.1
Frequency of **Bb** = 8/20 = 0.4
Frequency of **bb** = 10/20 = 0.5

Both the allele and genotype frequencies always sum to one (equal to 100%).

In our rabbit example, the allele frequency of the dominant allele **B** equals to 0.3 and the frequency of the recessive allele **b** is 0.7. If we add the two together, we obtain value of 0.3 + 0.7 = 1.0.

For genotype frequencies: Freq. of **BB** + Freq. of **Bb** + Freq. of **bb**
= 0.1 + 0.4 + 0.5
= 1.0

Phenotypes			
Genotypes	BB	Bb	bb
Number of Rabbits (Total = 20)	2	8	10
Genotype Frequencies	$\frac{2}{20} = 0.1\ BB$	$\frac{8}{20} = 0.4\ Bb$	$\frac{10}{20} = 0.5\ bb$
Number of alleles in gene pool (Total = 40)	X 2 ↓ 4 B	8 B 8 b	X 2 ↓ 20 b
Allele Frequencies	$\frac{12}{40} = 0.3\ B$		$\frac{28}{40} = 0.7\ b$

Now it's your turn to practice. Suppose in a population of 100 students, 60 are tongue rollers with genotype RR, 35 are tongue rollers with genotype Rr and the last 5 are non-rollers with genotype rr. Determine the allelic and genotype frequencies of the population.

Answer:

Frequency of R = $\frac{2(60)+35}{2(100)} = 0.775\ R$

Frequency of r = $\frac{2(5)+35}{2(100)} = 0.225\ r$

Frequency of RR = $\frac{60}{100} = 0.6\ RR$

Frequency of Rr = $\frac{35}{100} = 0.35\ Rr$

Frequency of rr = $\frac{5}{100} = 0.05\ rr$

Practice Questions

1. A hypothetical population consists of 600 individuals. A particular gene with alleles **M** and **m** was studied. It was found out that 175 individuals had **MM** genotype, 250 had **Mm** genotype and 175 had **mm** genotype.
   i. What is the frequency for allele **m**?
   ii. What is the genotype frequency for **Mm**?

2. If a particular gene has two alleles and the frequency of allele **B** is 0.4m what is the frequency of allele **b**?

References:

Brooker, R. J. (2012). *Concepts of Genetics.* Mc Graw Hill.

Tor Sion Hoon, Sudani Sudin, Kamaludin A. Rashid, Nor Alina Anb Aziz, Fariza Zakaria and Haliza Hamzah. (2015). *Q & A for Matriculation Biology Semester 1 Second Edition Updated.* Oxford Fajar Sdn. Bhd.

Answers: Practical Questions

1. A hypothetical population consists of 600 individuals. A particular gene with alleles **M** and **m** was studied. It was found out that 175 individuals had **MM** genotype, 250 had **Mm** genotype and 175 had **mm** genotype.
   i. What is the frequency for allele **m**?

   Total number of alleles in the population = 600 x 2 = 1200
   There are 2 copies of allele **m** in **mm** individuals, so = 175 x 2 = 350
   There are 1 copy of allele **m** in **Mm** individuals, so = 250 x 1 = 250
   Total number of allele **m** = 350 + 250 = 600

   Frequency of m = $\frac{600}{1200} = 0.5\ m$

   ii. What is the genotype frequency for **Mm**?

   Frequency of Mm = $\frac{250}{600} = 0.42\ Mm$

2. If a particular gene has two alleles and the frequency of allele **B** is 0.4m what is the frequency of allele **b**?

   The frequency of allele **B** = 0.4
   The frequency of allele **b** = 1 – 0.4
   = 0.6