Population genetics

Breeding population – a group of randomly mating individuals relatively isolated from the other members of the same species.

Breeding population – a group of individuals where one is the most likely to find a mate.

Population genetics is the study of the allele and genotype frequency distribution and change in a population.

Frequency - how often something occurs.

I have 80 cards, 8 white, 72 red.

What is the frequency of white cards?

fr(w) = 8/80 = 0.1
fr(R) = 72/80 = 0.9
fr(R) + fr(w) = 1
fr(R) = 1 – fr(w)

Genotype frequencies

In a population of 75 individuals:

#RR = 20
#RW = 10
#WW = 45

fr(RR) = #RR/total = 20/75 = 0.27
fr(RW) = #RW/total = 10/75 = 0.13
fr(WW) = #WW/total = 45/75 = 0.6

fr(RR) + fr(RW) + fr(WW) = 1

Find allele frequencies:

fr (R) = 2 x #RR + #RW / 2 x (total number of people) = 2 x 20 + 10 / 2 x 75 = 50 / 150 = 0.33
fr (W) = 1 – 0.33 = 0.67

Finding Allele frequencies from the genotype frequencies:

fr (A) = 2 x #AA + #Aa / 2 x N = 2 x #AA / 2 x N + #Aa / 2 x N = fr(AA) + 0.5fr(Aa)

fr (a) = 2 x #aa + #Aa / 2 x N = 2 x #aa / 2 x N + #Aa / 2 x N = fr(aa) + 0.5fr(Aa)

Find allele frequencies for each of the following sets of numbers:

1. #AA = 20
   # Aa = 40
   # aa = 140
   fr (AA) = 0.5
   fr (Aa) = 0.4
   fr (aa) = 0.1

2. fr(AA) = 0.5
   # Aa = 40
   # aa = 140
   fr (Aa) = 0.4

3. fr (bb) = 0.7
   fr (Bb) = 0.2
   fr (bb) = 0.1
True or False about a randomly mating population?
1. In a randomly mating population everyone is heterozygous
2. Dominant alleles are more common than recessive alleles in a randomly mating population
3. Frequency of heterozygotes tends to increase over time in a randomly mating population
4. Dominant phenotypes are more common than recessive phenotypes
5. Allele frequencies do not change from generation to generation
6. Genotype frequencies can be found from allele frequencies

Hardy-Weinberg theorem
If \( f_r(A) = p \); \( f_r(a) = q \)

Then
- \( f_r(AA) = p^2 \)
- \( f_r(aa) = q^2 \)
- \( f_r(Aa) = 2pq \)

\( p + q = 1 \), \( 0 < p < 1 \), \( 0 < q < 1 \)

1. population is infinitely large
2. population is randomly mating
3. there is no migration
4. no mutations
5. no selection

Godfrey Hardy and Wilhelm Weinberg

Hardy-Weinberg theorem: applications
1. Knowing frequency of one allele/genotype, estimate frequencies of the other alleles and genotypes

\[ f_r(B) = 0.7 = p \]  \[ f_r(b) = q = 1 - p = 1 - 0.7 = 0.3 \]

\( f_r(BB) = p^2 = 0.7^2 = 0.49 \)
\( f_r(Bb) = 2pq = 2 \times 0.7 \times 0.3 = 0.42 \)
\( f_r(bb) = q^2 = 0.3^2 = 0.09 \)

2. Testing if a population is a Hardy-Weinberg population (randomly mating, not affected by migration, selection, etc.)

3. Modeling evolutionary change

Test whether a population is at Hardy-Weinberg equilibrium (randomly mating, is not affected by migration, selection, etc.)

<table>
<thead>
<tr>
<th>RR</th>
<th>RW</th>
<th>WW</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>8</td>
<td>2</td>
<td>20</td>
</tr>
</tbody>
</table>

1) Find allele frequencies

\[ f_r(R) = \frac{2 \times \#RR + \#RW}{20 \times 2} = \frac{2 \times 10 + 8}{40} = 0.7 \]

\[ f_r(W) = 1 - 0.7 = 0.3 \]

Test whether a population is at Hardy-Weinberg equilibrium (randomly mating, is not affected by migration, selection, etc.)

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2) Find expected genotype frequencies for given allele frequencies

\[ f_r(RR) = 0.7 \times 0.7 = 0.49 \]
\[ f_r(RW) = 2 \times 0.7 \times 0.3 = 0.42 \]
\[ f_r(WW) = 0.3 \times 0.3 = 0.09 \]

1

3) Find expected number of individuals with each genotype

\[ \#(RR) = 0.49 \times 20 = 9.8 \]
\[ \#(RW) = 0.42 \times 20 = 8.4 \]
\[ \#(WW) = 0.09 \times 20 = 1.8 \]
Test whether a population is at Hardy-Weinberg equilibrium (randomly mating, is not affected by migration, selection, etc.)

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<th>RR</th>
<th>RW</th>
<th>WW</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>observed numbers</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>expected frequencies</td>
<td>fr(RR) = 0.09</td>
<td>fr(RW) = 0.42</td>
<td>fr(WW) = 0.49</td>
<td>1</td>
</tr>
<tr>
<td>expected numbers</td>
<td>9.8</td>
<td>8.4</td>
<td>1.8</td>
<td>20</td>
</tr>
</tbody>
</table>

4) compare OBSERVED and EXPECTED numbers