Problem Set # 2 – Hardy-Weinberg Equilibrium -- Due September 26th

Probability, Genetic Variation, Finding Equilibria, HWE

Instructions:

This is the second of **six** problem sets that will count towards your final grade. The problem set is due **at the start of lecture** on Thursday, September 26th. You may work in groups of up to three people. Please hand in one sheet per group with **up to three names** listed. Late assignments will not be accepted. **Please show your work!** Incorrect answers with correct work will receive part marks; correct answers with no work shown will not receive full marks.

1) Among a sample of 1000 Canadian geese, the number of individuals with each of the LZ blood group phenotypes was as follows *LL*: 320, *LZ*: 460, *ZZ*: 220. What is the *L* allele frequency? What is the *Z* allele frequency? What number of each of the genotypes would be expected under Hardy-Weinberg? Use the chi-square chart (found on Virtual Campus in Assignments) to determine whether the genotype frequencies are in Hardy-Weinberg Equilibrium. (4 marks)

p = 320/1000 + ½(460/1000) = 0.55
q = 1-p = 0.45

Genotype	Obs	Exp	O-E	(O-E)^2/E
LL	320	302.5	17.5	1.012
LZ	460	495	-35	2.475
ZZ	220	202.5	17.5	1.512
Total	1000	1000		4.999

$X^2 = 4.999$, df = 3-2 = 1, $X^2_{crit} = 3.84$
$X^2 > X^2_{crit}$, so $p < 0.05$. We reject the null hypothesis that this population is in HWE at this locus.

2) At one locus, p = 0.3. At another, p = 0.7. What is the probability of choosing an individual at random who is a double hetrozygote? (2 marks)

1st locus: 2pq = 2(0.3)(0.7) = 0.42
2nd locus: 2pq = 2(0.7)(0.3) = 0.42
0.42 x 0.42 = 0.176

3) A locus with three alleles (A1, A2, A3) in mice controls coat colour. When A1 is present, the mouse is always black. When A2 is present, the mouse is black, unless it is in the presence of A3 (A2A3), when it is brown. Homozygous A3 individuals are white. A population has 200 black mice, 100 brown mice, and 50 white mice.

a) Assuming Hardy Weinberg, find the estimated number of individuals with each of the 6 genotypes. (4 marks)

$p_3 = \sqrt{(50/350)} = 0.378$
$2p_2p_3 = 100/350 = 0.286$
$p_2 = 0.286/2p_3 = 0.286/\ 2(0.378) = 0.378$
$p_1 = 1\text{-}0.378\text{-}0.378 = 0.244$

A1A1 = p_1^2 N = $(0.244)^2$ (350) = 21
A1A2 = $2p_1p_2$ N = 2(0.244)(0.378)(350) = 65
A1A3 = $2p_1p_3$ N = 2(0.244)(0.378)(350) = 65
A2A2: p_2^2 N = $(0.378)^2$ (350) = 50
A2A3: 100
A3A3: 50

b) Test whether this population differs significantly from the predictions under Hardy-Weinberg equilibrium. (1 mark)

We can not test this, because we assumed HWE to estimate the allelic frequencies.

4) A population with 100 males and 100 females, and p = 0.1, is invaded by 100 males originating from a population with p = 0.7. Assuming random mating of this new larger population, calculate the genotypic frequencies for the next three generations. When does p_m equalize with p_f? After how many generations is Hardy-Weinberg equilibrium re-established? (4 marks)

pf = 0.1, qf = 0.9
pm = (100/200)(0.1) + (100/200)(0.7) = 0.4, qm = 0.6
pave = 0.25

Generation 1:
AA: pmpf = (0.4)(0.1) = 0.04
Aa: pmqf + pfqm = (0.4)(0.9) + (0.1)(0.6) = 0.42
aa: qmqf = (0.6)(0.9) = 0.54

p = 0.04 + ½(0.42) = 0.25, q = 1-0.25 = 0.75

Sexes are equalized after 1 generation, can use HWE subsequently.

Generation 2:
AA: $p^2 = (0.25)^2 = 0.06$
Aa: 2pq = 2(0.25)(0.75) = 0.38
aa: $q^2 = (0.75)^2 = 0.56$

HWE is restored after two generations.
Genotypic frequencies are the same for generation 3.

5) In birds, males are the homogametic sex (ZZ), while females are the heterogametic sex (ZW). This is referred to as the ZW system, which is opposite to the XY system seen in mammals and fruit flies, where females are homogametic (XX) and males are

heterogametic (XY). Lutino (l) is a recessive Z-linked feather colour mutation in parakeets. Wild type parakeets (genotype +/+, +/l, or +/) have green feathers, while those with the lutino (genotype l/l or l/) phenotype have yellow feathers.

a) If 20% of males have yellow feathers, what percentage of females are expected to have yellow feathers, assuming Hardy-Weinberg? (1 mark)

$p = \sqrt{p^2} = \sqrt{(0.20)} = 0.45$
Approximately 45% of females are expected to be yellow.

b) Given the observed male genotypic numbers below, determine whether these parakeets fit Hardy-Weinberg expectations. (4 marks)

	Phenotype	Genotype	Observed Number
males	green	++	149
	green	+l	186
	yellow	ll	70
Total			405

$p = (149/405) + 1/2\ (186/405) = 0.6$
$q = 1 - 0.6 = 0.4$

Genotype	Obs	Exp	O-E	(O-E)^2/E
Male++	149	145.8	3.2	0.07
Male+b	186	194.4	-8.4	0.36
malebb	70	64.8	5.2	0.42
Total	405	405		0.85

df = 3-2 = 1, Xcrit = 3.84
$X^2 < Xcrit$, so $p > 0.05$. Therefore we fail to reject the null hypothesis that this population is in HWE at this locus.