Population Genetics Calculations

Using Hardv-Weinberg Equations

1. A population of hamsters has a gene consisting of 90 % M alleles (black) and 10 % m alleles (grey). Mating is random . Determine the proportion of offspring that will be black and the proportion that will be grey.

recessive phenotype mm q^2 = .1 x .1 = .01 → 1% → grey (1%)
recessive allele m q= 10% = .1
dominant allele M p= 90% = .9
homozygous MM p2 = .9 x .9 = .81 → 81%
heterozygous Mm 2pq = 2 x .9 x .1 = .18 → 18% → Black (99%)

2. You are working with pea plants and found 36 plants out of 400 were dwarf, which is the recessive phenotype.
a.) Calculate the frequency of the tall gene (Report your answer as a decimal.)
b.) Determine the number of heterozygous pea plants. (Record your answer as a whole number.)

Gene ⇒ allele is a form of a gene in this case tall or dwarf

recessive phenotype tt q^2 = 36/400 = .09
recessive allele t q= √.09 = .3
dominant allele T p= 1 - .3 = .7 ← tall
homozygous TT p2 = .7 x .7 = .49
heterozygous Tt 2pq = 2 x .3 x .7 = .42

.42 x 400 = 168

3. A type of deformity appears in 4 % of a large herd of cattle. Assume the deformity was caused by a recessive allele. Calculate the percentage of the herd that are carriers of the gene.

deformity = 4% = recessive = "dd"

recessive phenotype q^2 = 4% = .04
recessive allele q= √.04 = .2
dominant allele p= 1 - .2 = .8
homozygous p2 = .8 x .8 = .64
heterozygous (carrier) 2pq = 2 x .8 x .2 = .32

.32 x 100 = 32%

4. In Caucasians, 1 in every 2 000 are affected by cystic fibrosis, a genetic disorder caused by a recessive allele. Calculate the frequency of heterozygotes in a Caucasian population. Report your answer as value from 0 to 1, rounded to two decimal places.

1/2000 = recessive = "cc"

recessive phenotype cc q^2 = 1/2000 = .0005
recessive allele q= √.0005 = .0223
dominant allele p= 1 - .0223 = .9777
homozygous p2 = .9777 x .9777 = .9559
heterozygous 2pq = 2 x .0223 x .9777 = .0436 ⇒ .04

5. Sickle -cell anemia is caused by a recessive mutant of the hemoglobin gene. Sickle -cell anemia is most common among people of African descent and, to a lesser degree, among people of Mediterranean descent. In the early 1970s, nationwide screening programs were set up in the United States. Many states made the testing of African -American compulsory. The screen programs were not supported with counselling, however, and many people who were carriers assumed they had the disease. Furthermore, some carriers were denied health insurance after the results of their tests were not kept confidential. Racial tensions developed, and the compulsory screening programs were abandoned. If 150 in 100000 African -Americans suffer from sickle -cell anemia, then how many individuals are carriers? What percentage is this?

recessive genotype "ss" → q^2 = 150/100,000 = .0015
s → q = √.0015 = .0387
S → p = 1 - .0387 = .9613
SS → p^2 = .9613 X .9613 = .924
Ss 2pq = 2 x .9613 x .0387 = .0744 → = .0744 x 100,000 = 7440
carriers

Hardy-Weinberg REVIEW PROBLEMS

6. The dominant allele T controls the ability to taste the chemical (PTe) phenylthiocarbamide. Individuals with the T allele find PTe bitter while "tt" individuals find the chemical tasteless. In a sample of 16 students in Biology 30, 5 were tasters and 11 were non-tasters. Using this information, calculate the:

"tt" tasteless $q^2 = 11/16 = .6875$
$q = \sqrt{.6875} = .8292$
$p = 1 - .8292 = .1708$
"TT" taste $p^2 = .1708 \times .1708 = .02917$
"Tt" taste $2pq = 2 \times .8292 \times .1708 = .2833$

a. Frequency of the recessive allele .8292

b. Frequency of the dominant allele .1708

c. Genotype frequencies of the original sample of students

"tt" or tasteless = .6875
"TT" or taster = .02917
"Tt" or taster = .2833

Check: Tasters will be BOTH Tt or TT, so .02917 + .2833 = .31247
.31247 x 16 = 5 → which is # of tasters... so the check works

7. In a population of birds, the dominant beak color is brown. A recessive allele for blue beak color occurs in a frequency of 0.4.

recessive trait → q^2 : .4 x .4 = .16
recessive allele → q : .4
p : 1 − .4 = .6
p^2 :
$2pq$: 2 x .4 x .6

a. What is the genotype frequency of the blue beaked trait?

.4 x .4 = .16

b. What is the genotype frequency of the heterozygous condition?

2 x .6 x .4 = .48

c. What is the genotype frequency of the homozygous dominant condition?

p^2 = .6 x .6 = .36

8. Suppose a population of lemmings has a dominant gene for white tooth enamel, while the recessive trait was yellow tooth enamel. If 23 lemmings in a population of 325 have the recessive trait

23/325 = q^2 = aa

a. What is the frequency of the recessive genotype in this population?

q^2 = .071

b. What is the frequency of the homozygous dominant condition?

p^2 = .539

q^2 : 23/325 = .071
q : $\sqrt{.071}$ = .266
p : 1 − .266 = .734
p^2 : .734 x .734 = .539
$2pq$:

Population Calculations

1. Calculate the population density if there were 300 birds in a 10 ha area in 1985 near Sylvan Lake. $D_p = \frac{N}{A}$

$D = \frac{N}{A} = \frac{300}{10} = 30$ birds/ha

2. Data from a sparrow population was collected over a year in Jan., 1999.

Original Population: 1000
Natality: 800
Mortality: 600
Immigration: 300
Emigration: 200

$gr = \frac{\Delta N}{\Delta t} = \frac{300 \text{ sparrows}}{1 \text{ yr}} = 300$

Calculate the population growth rate.

$\Delta N = (n+i) - (m+e) = (800+300) - (600+200) = 300$

3. In Canada, the population in 1986 was 25.0 million compared to 23.1 million in 1976. Calculate the annual per capita growth rate.

$cgr = ?$ $cgr = \frac{\Delta N}{N} = \frac{25.0 - 23.1}{23.1} = .0822$

4. On a range of 450 hectares, there are 1 275 jackrabbits. Studies indicate the following counts for this population:

a. Determine the change in population size.
b. Determine the per capita growth rate.

Mortality	2 225/year
Natality	3400/year
Emigration	775/year
Immigration	150/year

(a) $\Delta N = (n+i) - (m+e)$
$= (3400+150) - (2225+775)$
$= 550$

(b) $cgr = \frac{\Delta N}{N} = \frac{550}{1275} = .43$

5 . On October ~~15, 1992,~~ the beginning of the grouse hunting season that year, biologists counted 75 spruce grouse in a 30 hectare forest plot. On December 15, 1992, 42 spruce grouse were counted in the same area.

a. What was the density of the grouse population on October 15? On October 15?

$D = \frac{N}{A} = \frac{75}{30} = 2.5$ grouse/ha / $D = \frac{N}{A} = \frac{42}{30} = 1.4$ grouse/ha

6. In a certain year, the following observations were made of a mule -deer population in a 100 hectare island off the coast of British Columbia.

Number of does, January 1	90
Number of bucks, January 1	30
Number of deer, December 1	155
Births during the year	75
Deaths during the year	50

a.) What was the density of the population at the beginning of the year?
b.) What was the density of the population at the end of the year?
c.) What were the effects of immigration/ emigration on the population?

a) $D = \frac{N}{A} = \frac{120}{100} = 1.2$ deer/ha

b) $D = \frac{N}{A} = \frac{155}{100} = 1.6$ deer/ha

c) Jan. 1 Dec. 1
155 − 120 = 35 deer (the increase)
Births Deaths
75 − 50 = 25 deer (births more than deaths)
35 − 25 = +10 due to immigration

7. Data from a sparrow population was collected over a year, starting in January 1995. The study area was 4 000 ha.

Original population 200 000 (January 1995)
Natality 150 000
Mortality 130 000
Immigration 5 000
Emigration 2 000

a.) Calculate the original population density. Record your answer as a whole number.

$D_p = \frac{N}{A}$ $D = ?$ $N = 200\,000$ $A = 4000$ ha $= \frac{200000}{4000} =$ 50 squrils / ha

b.) Calculate the new population size. Record your answer as a whole number.

$\Delta N = (n+i) - (m+e)$

$(150000 + 5000) - (130\,000 + 2000) = 23000 + 200000$

223 000 sparrows

c.) Calculate the new population density. Record your answer as a whole number.

$D = \frac{N}{A}$ $\frac{223\,000}{4000 \text{ ha}} =$ 56 sparrows / ha

d.) Calculate the per capita growth rate (cgr) for the 1995 year.

$cgr = \frac{\Delta N}{N} = \frac{23\,000}{20000} =$ 0,115

Exercise # 1

There are two major kinds of factors that limit population growth. Density -dependent factors have a greater effect as the population grows. The effects of density -dependent factors are the same no matter how big or small the population is. State whether each of the following characteristic is an example of density -dependent (DO) or density -independent (DI) factor.

DI 1. Freezing weather
DD 2. Has a greater effect on a larger population
DI 3. A volcanic eruption
DD 4. Predation
DI 5. Floods
DD 6. Food supply
DI 7. May limit the population before it even gets close to carrying capacity
DD 8. Disease or parasites \
DD 9. Decreases when the population is below carrying capacity; increases when the population exceeds carrying capacity
DI 10. Fire
DI 11. Intensity of effect no greater for larger population, no less for smaller population
DD 12. May cause cyclical changes in lynx and hare populations
DI 13. Storms
DD 14. Tends to be a biotic factor
DI 15. Tends to be an abiotic factor

Exercise # 2

K -selected and r -selected life histories are the two ends of the spectrum of life -history patterns. State whether each of the following characteristic is an example of a K - selected life history pattern (K) or an r - selected life history pattern (r).

__r__ 1. Age at first reproduction younger

__r__ 2. Relative body size is small

__K__ 3. Stability of population near carrying capacity

__K__ 4. Low number of offspring

__r__ 5. Controlled mainly by abiotic factors

__r__ 6. Large number of offspring per reproduction

__K__ 7. Emphasis on quality and care of offspring

__K__ 8. Polar bears are an example

__r__ 9. Rapid population growth when conditions are favourable

__r__ 10. Dandelions and insects are examples