BISC 300: EVOLUTION
MIDTERM EXAMINATION 1
October 10, 2012

Total
/36

Name:_____

Student #:_____

Tutorial Time/Day_____

You have 50min to complete this exam. The number in brackets indicates the mark for the question. The formula sheet is on the projector screen at the front of the room.
Please answer all questions in the spaces provided and show all your work!
You may use a scientific calculator, but absolutely no cell phones or programmable calculators!

1. Indicate whether each of the following statements is true or false. Include a brief explanation to support your reasoning.
    a) Gene flow from mainland to Island populations always results in maladaptation. (2m)
    False – gene flow is non-adaptive process; it can increase, decrease or have no effect on the fit between organisms and their environment

    b) Inbreeding increases the frequency of deleterious recessive alleles in a population. (2m)
    False – inbreeding does not change allele frequency, it increases homozygotes which increases the proportion of recessive alleles upon which selection can act

    c) Genetic drift increases genetic differentiation between isolated populations. (2m)
    True – drift results in the random fixation of alleles within a population, isolated populations are unlikely to have the same alleles go to fixation

    d) If the selection differential for a quantitative trait is positive, the mean value of that trait will always increase in the next generation. (2m)
    False – the trait will only increase in the next generation if it is also heritable
    Part marks for true if they specify that they are assuming heritability

2. A local vineyard has hired you to study a population of insects that feed on the leaves of their grape vines. They have avoided using pesticides in the past, but the level of leaf damage has increased beyond a threshold limit and the reduction in crop yield is beginning to have a serious economic impact on the grower's operation. Although they have not treated their crops with pesticides in the past, they are aware that neighbouring vineyards routinely spray their crops with a common insecticide. Resistance to this insecticide is controlled by a single gene with two alleles. The A allele is dominant to the recessive resistance allele, a.

a) You sample the population and find the genotype frequencies shown below. Use this data to calculate the information you would need to determine if your population is in Hardy-Weinberg equilibrium at the loci controlling insecticide resistance. Show all of your work for full marks. (4m)

AA	***Aa***	***aa***	***f(A) = 0.40 + 0.35/2 =0.575***
0.40	***0.35***	***0.25***	***f(a) = 0.25 + 0.35/2 = 0.425 (1m)***
p^2	***2pq***	***q^2***	
0.331	***0.489***	***0.181 (1m each correct genotype)***	

b) Based on your calculations in part b, your research partner calculates a Chi Square value of 8.11. Is the population in Hardy-Weinberg equilibrium? Show your reasoning. (1m)

No because 8.11>3.84 (must show reasoning, deduct 0.5 if they just say no)

c) Based on the data you have, can you determine if the population is evolving? Why or why not? (2m)

No. It is not possible to tell which assumption has been violated. Non-random mating leads to change in genotype frequencies without change in allele frequencies

d) The growers decide to spray their crops with the commonly used insecticide. Individuals with the AA genotype are at a 40% survival disadvantage compared to the other genotypes. Calculate the frequency of the resistance allele after spraying. (4m)

	AA	***Aa***	***aa***	
Freq	***0.40***	***0.35***	***0.25***	
Fitness	***0.60***	***1***	***1***	***(1m)***
Rel freq	***0.24***	***0.35***	***0.25***	***mean = 0.84 (1m)***
New freq	***0.286***	***0.416***	***0.298***	***(1m)***

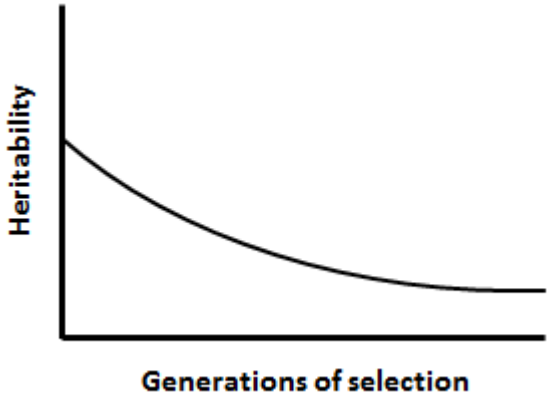
F(a) = 0.298 + 0.416/2 = 0.506 (1m)

Note: A few students picked up on my mistake in writing this question and observed that if the trait is truly recessive, the fitness for the heterozygote should be the same as the fitness for the homozygous dominant genotype. Well spotted! We also gave full marks if you did the calculations using a fitness of 0.6 for both the dominant homozygote and the heterozygote.

e) The growers are concerned that their spraying methodology will select for insecticide resistance. Suggest a strategy that will reduce the likelihood of resistance evolving in the pest population. (2m)

They could spray with three different pesticides simultaneously. Mutations providing resistance to all three are unlikely to arise simultaneously.

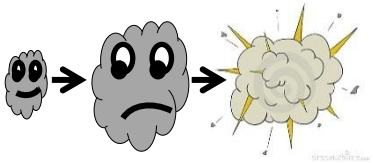
3. The figure below shows the heritability for oil content in corn plants that have had strong selection imposed on them for over a century.
   a) Why do we see the trend shown in the figure below? (2m)
   Heritability decreases over time because selection decreases additive genetic variation. Heritability is a measure of additive genetic variation as a proportion of total phenotypic variation. If you reduce additive variation, you reduce heritability.



   b) What effect will this have on the population's response to selection over time? (1m)
   The response to selection will decrease over time.

4. Imagine a mutation arises in a sexually reproducing population that allows individuals with the mutation to reproduce asexually. Explain why asexuals have an immediate fitness advantage and briefly describe one hypothesis for why sexual reproduction may be favoured. (4m)
   (2m) Asexual advantage due to twofold cost of sex. Sexuals produce half the reproductive offspring (females) and only half their alleles are passed on to each. (2m)
   (2m) Sexual advantage = recombination of current genotypes allows fast response to selection due to temporal or spatial variation
   Red queen hypothesis – evolutionary arms race with parasite or pathogen
   Genetic Lottery hypothesis – diversity of offsping increases likelihood one is successful

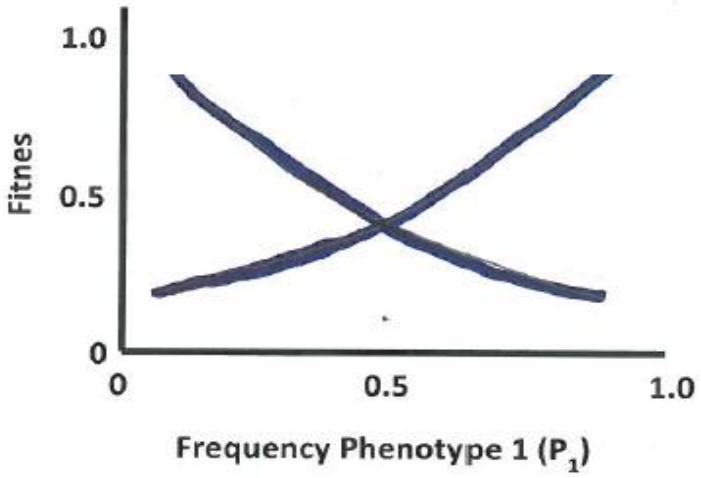
5. A recessive disease occurs in our good friends the puffballs. Individuals with this disease continue growing past the normal adult size and just keep puffing up until they reach about three times the size of a normal adult puffball. At this point they explode (poof). Explosions are the fatal end for individuals afflicted with this terrible disease. Afflicted puffballs have an estimated fitness of 0.15. The frequency of the recessive allele is 0.03 in the population. The rate of mutation of the dominant to recessive allele is 4.2×10^{-5}. Use this information to help you provide an explanation for why the deleterious allele persists at such a high rate in the puffball population. (4m)



S= 1-w = 0.85
q-hat = sqr root (0.000042/0.85) = 0.007
Mutation selection balance alone cannot explain the relatively high frequency of this deleterious allele. There may be a fitness advantage to heterozygotes contributing to the maintenance of this allele at 0.03.

6. Consider a population where there are two phenotypes (P_1 and P_2) which are subject to negative frequency-dependant selection. These phenotypes result from the expression of a single gene with two alleles.

    a) On the axis below, draw curves to represent the relative fitness of P_1 and P_2 as a function of the frequency of P_1 in the population. Be sure to label your curves!



    b) How will selection affect genetic diversity in this population over time? (2m)
    Genetic diversity will be maintained over time because as the frequency of an allele decreases, its fitness increases preventing either allele from being lost from the population.A