

Problem Set 4, Bio 4181: Due Oct. 13, 2009

1. A sample of 20 homologous genes from a tetraploid species is drawn at random from a large population with variance effective size of 1,000 and inbreeding effective size of 500. Assume all individuals are self-compatible hermaphrodites.

- a). What is the probability that two of the sampled genes coalesced in the previous generation?
- b). What is the probability that the first coalescent event occurs 4 generations ago?
- c). What is the expected time (in generations) between the second to last and ultimate coalescent event?
- d). What is the expected time to coalescence for a random pair of these genes?
- e). Chloroplast DNA is inherited as an effective haploid element in this species. Given a random sample of 20 chloroplast DNA molecules, redo calculations a) through d).

2. Two X-linked genes are randomly drawn from a population of variance effective size 500 and inbreeding effective size 1000. The neutral mutation rate at this locus is 10^{-5} per DNA replication. What is the probability that the two sampled genes are identical by descent, assuming that only neutral mutations occur?

3. A DNA region of 9 nucleotides is sequenced, with variable sites being found that define 5 haplotypes as follows:

1. A C C G T T G C A
2. A C C G T C G C A
3. A C G G T T G C A
4. A C C G T T A C A
5. A C G G T C G C A

- a. Construct a haplotype tree(s) assuming the least number of mutational events (maximum parsimony) and no recombination.
- b. Is there any ambiguity in this tree, and if so, how many distinct tree topologies are there under maximum parsimony?
- c. Is the tree consistent with the infinite sites model? Justify your answer.
- d. Is there any homoplasy in the maximum parsimony tree(s)? Justify your answer.
- e. What is the Jukes-Cantor genetic distance between haplotypes 4 and 5?

4. Two infinite-sized demes both have the A and a alleles at an autosomal locus, but with the frequency of A being 0.2 in population 1 and 0.7 in population 2. Suppose that now the two populations begin to symmetrically exchange gametes at a rate of 10% per generation.

a) What are the expected allele frequencies in demes 1 and 2 after two generations of gene flow?

b) What is the equilibrium frequency of A in demes 1 and 2?

5. Two copies of homologous genes from an autosomal locus are sampled at random from the same deme of inbreeding effective size 40 and variance effective size 50. The deme itself is just one deme of many that fit an island-model of subdivision with $m = .01$.

a). What is the probability that these two genes coalesce before either lineage experienced gene flow?

b). What is the ratio of expected coalescence times of a pair of genes sampled from the same local deme to the expected coalescence time of a pair of genes sampled at random from the total population?

6. Five populations are surveyed for genetic variation at an autosomal locus with the following results:

	AA	Aa	aa
Population 1	56	288	156
Population 2	156	288	56
Population 3	200	600	200
Population 4	608	384	8
Population 5	16	768	1216

What are f_{is} , f_{st} , and f_{it} ?

7. A species has a 1-dimensional stepping stone model of population structure with local inbreeding effective sizes of 100 and variance effective sizes of 50. 20% of the gametes are exchanged only among adjacent demes, and 0.1% are exchanged at random over all local demes.

a) What is the equilibrium f_{st} ?

b) Now suppose that the local exchange rate of gametes is doubled to 40%. What is the equilibrium f_{st} ?

c) Now suppose that the local exchange rate of gametes is restored to 20% but the long-distance exchange rate is doubled to 0.2%. What is the equilibrium f_{st} ?