Ecology and Evolutionary Biology 2245/2245W

Exam 3

April 5, 2012

Print your complete name clearly at the top of each page. This exam should have 6 pages – count the pages in your copy to make sure.

Answer all of the following questions. Points out of the total of 100 are assigned as follows:

Multiple choice .... 2.5 points each.

True/False .... 2 points each.

Circle the correct choice .... 2 points each.

All other questions...................... as specified in the question.

You will have 75 minutes to complete the exam. Mathematical formulas to jog your memory are given below.

$$t = 4N \qquad \text{(time } t \text{ in number of generations)}$$

$$p^2 + 2pq + q^2 = 1$$

$$N_e = \frac{4N_f N_m}{(N_f + N_m)}$$

$$Nm \approx \frac{\left(\dfrac{1}{F_{ST}}\right) - 1}{4}$$

$$p = \frac{1}{2N_e} \qquad \text{(}p \text{ for fixation of allele)}$$

Multiple Choice (2.5 points each). Choose the best answer out of the choices given:

1. Assume that a population of 17 breeding individuals is unaffected by selection, mutation, or migration. If an allele in that population has an initial frequency of $p = 0.50$, it will be fixed or lost in
    (a) 136 generations.
    (b) 68 generations.
    (c) 17 generations.
    (d) an indeterminate number of generations.

2. The University of Illinois' long-term artificial selection experiment on corn shows
    (a) there is a lot of hidden genetic variation in most populations.
    (b) selection (artificial or natural) soon exhausts available genetic variation in populations.
    (c) it's easier to increase the oil content in corn than it is to increase the protein content.
    (d) being a crop plant, corn is a bad choice for investigations of variation.

3. In all organisms, the onset of senescence begins
    (a) when the organism is first born.
    (b) when the organism can first reproduce.
    (c) when the organism reaches its reproductive peak.
    (d) in post-reproductive life.

4. Phylogenetic factors must be separated from ecological factors if we are to understand the role of adaptation in the evolution of animals or plants. This can be achieved by
    (a) applying the comparative method.
    (b) assessing the complexity of a trait.
    (c) doing an experiment.
    (d) formulating a new hypothesis.

5. Under natural selection, the frequency of an allele will change most rapidly in a population when that allele starts off
    (a) rare.
    (b) common.
    (c) at an intermediate frequency.
    (d) none of the above.

6. The "isolation by distance" model of gene flow requires
    (a) that two subpopulations be separated by a large distance, with no other subpopulations in between.
    (b) that several subpopulations be arranged in a row across geographical distance.
    (c) that individuals be very poor dispersers (i.e., can't migrate very far).
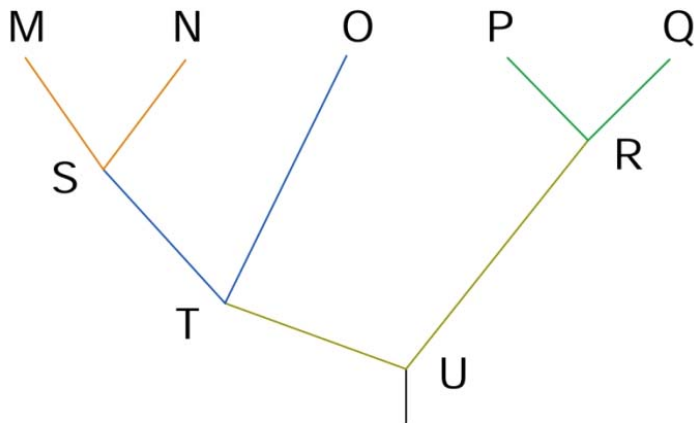   (d) that gene flow is highest among adjacent (neighboring) populations.

7. Microevolution is
    (a) the evolution of new species from existing species.
    (b) changes in allele frequencies in populations.
    (c) phenotypic change from one generation to the next.
    (d) the origin of a new allele at a locus through mutation.

8. All insects have 6 legs. This is an example of
    (a) an evolutionary trade-off.
    (b) an exaptation.
    (c) a phylogenetic constraint.
    (d) an adaptation.

9. A person who formulated the idea of natural selection independently of Darwin was
    (a) Sir Charles Lyell
    (b) Thomas Robert Malthus
    (c) Gregor Johann Mendel
    (d) Alfred Russell Wallace

10. Environmental gradients can cause the frequency of an allele in a population to exhibit clinal variation across the gradient – e.g., going from $p = 0.8$ on one side of the gradient to $p = 0.2$ on the other side. The width (= steepness) of the cline depends on
    (a) the strength of natural selection.
    (b) the strength of gene flow.
    (c) the values of both natural selection and gene flow.
    (d) neither natural selection nor gene flow.

True or False / Circle the correct answer (2 points each):

11. (True or False) Sickle-cell anemia is an example of a multiple niche polymorphism.

12. (Circle the correct choice) Will severe but brief "bottlenecking" of a population have a <u>large</u>, <u>small</u>, or <u>no</u> effect on the heterozygosity of that population?

13. (Circle the correct choice) Perennial plant species invest <u>more</u>/<u>less</u> energy in yearly reproduction than do otherwise similar annual plant species.

14. (True or False) At this point in time, a full 153 years after publication of Darwin's *Origin of Species*, the theory of evolution by means of natural selection is accepted as fact by the majority of Americans.

15. (Circle the correct choice) Does higher heritability of a trait <u>increase </u>or <u>decrease a</u> population's response to selection at the locus determining the trait?

16. (True or False) If you have a "good genotype," you will live long and prosper.

Short-answer questions and problems (variable points):

17. (8 points) The phylogenetic tree below shows the relationships of five species to one another; the other letters (at the nodes of the tree) are reconstructed ancestral species. Assuming the method of independent contrasts, specify the four two-species contrasts (i.e., between sister-species) that must be calculated from this tree in order to remove phylogenetic effects from your analysis of adaptation (answer in space to the right of the tree).

M   N   O   P   Q

S

R

T

U

18. (3 points) As a rule, why is phenotypic plasticity higher in plants than in animals? (be brief)

19. (6 points) In a population of 500 elephant seals, 200 females but only 4 males contribute offspring to the next generation. What is the effective breeding size of this population?

20. (3 points) Name the island group in the Pacific Ocean that Darwin visited, that strongly affected his developing ideas on evolution and natural selection: _____

21. (3 points) Name the single process that can add new alleles to a locus in a population (assuming no immigration) _____.

22. (3 points) The origin of similar adaptations in phylogenetically distinct groups of organisms is called _____ evolution.

23. A population of sulfur butterflies shows the following number of field-collected individuals in each of three genotypes. *F* and *S* are the two alleles at the locus coding for these genotypes.

FF	*FS*	*SS*
10	60	30

(6 points) Determine the frequencies of the *F* allele and the *S* allele.

(8 points) If the population were in Hardy-Weinberg proportions, how many individuals of *FF*, *FS*, and *SS* would you expect to see?

(2 points, circle <u>Yes</u> or <u>No</u>) Based on your expectations, is this an example of heterozygote advantage (= heterozygote superiority)?

24. A species of spotted frog is distributed across western North America as an array of many partially isolated demes. F_{ST} among the southern demes has been measured at 0.40, while F_{ST} among the northern demes has been measured at 0.15. Natural selection has been shown to be unimportant in this system.

(4 points, circle the correct choice) Do demes in the <u>south</u> or in the <u>north</u> show the most genetic differentiation among demes?

(6 points) On average, how many migrants per generation move between **southern** demes?

25. Imagine that there are two populations, each bearing a locus with three genotypes A_1A_1, A_1A_2, and A_2A_2. Population I is increasing in size as the generations go by, while Population II is decreasing in size. In both populations, A_2A_2 has the highest fitness of the three genotypes.

    (2 points) What is the relative fitness (w) of genotype A_2A_2 in Population I?

    (2 points) What is the relative fitness (w) of genotype A_2A_2 in Population II?

    (2 points) What is the selection coefficient (s) of genotype A_2A_2 in Population I?

26. (5 points) Huntington's Disease is a neurodegenerative genetic disorder that causes acute psychosis and dementia, typically starting in middle age. Death soon follows. The disease is caused by a lethal dominant allele. Why is natural selection ineffective against this allele? (be brief!)

Bonus Questions:

27. (1 point) Which of the four famous Evolutionary Biologists who have visited class since the second exam did you find to be the most interesting (last name only is fine)? Justify your answer.

28. (2 point bonus question) Vladimir Putin (may have) poisoned Litvinenko by having a buddy add Polonium to Litvinenko's pub dinner. What type of radiation does Polonium produce?