BSc Degree Examinations 2018-9

Department:
BIOLOGY

Title of Exam:
Genes and Genomes in Populations and Evolution

Time Allowed:
1.5 hours

Marking Scheme:
Total marks available for this paper: 60
The marks available for each question are indicated on the paper

Instructions:
Answer all questions in the spaces provided on the examination paper

Materials Supplied:
CALCULATOR

For marker use only:  
Office use only: 

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DO NOT WRITE ON THIS BOOKLET BEFORE THE EXAM BEGINS
DO NOT TURN OVER THIS PAGE UNTIL INSTRUCTED TO DO SO BY AN INVIGILATOR
1. There are two adult females in a group: one older and one younger. When both are reproductive at the same time, all of their offspring are in competition with each other for resources, and thus each female has lower reproductive success than when they are not in competition. Dispersal is male-biased, where younger males move into an older female’s group to mate for life with that older female’s daughter. Any reproductive competition is between those two females.

The following reproductive strategies are possible:
Selfish: Both females reproduce throughout their lives: both lose on average 1.9 offspring overall compared to no-competition.
Altruist 1: Females stop reproducing from mid-life: here females lose an average of 3 offspring during that later stage of their life.
Altruist 2: Females do not reproduce until mid-life: here younger females lose an average of 3 offspring during that earlier stage of their life.

Use Hamilton’s rule to calculate whether females in this diploid system could be selected to not reproduce at either of the life stages (young / old). (8 marks)
The space above the line is sufficient for your answer.
2. Group-living howler monkeys use their howls in male-male competition over territory and females. The hyoid bone is enlarged in howler monkeys to increase the loudness of the howl. For 5 species of howler monkeys, male hyoid bone volume and testes volume are plotted against the mean number of males per group; the different species are denoted by letters A-E:
a) Using these graphs, compare the processes of sexual selection shaping male morphology in species A and species E.  

b) Monkeys with louder howls are better able to defend territories. What does this suggest about the evolution of female preference for louder howls?  

c) Howler monkeys calls are exceptionally low in pitch for their body size, compared to the calls of other monkeys. What does this suggest about the evolution of female preference for howls?
3.

a) Would you expect transposable elements to spread more easily in sexual or asexual organisms? Explain your reasoning. (4 marks)

b) Give an example of a sex chromosome system. In what way can the structure of sex chromosomes differ to autosomes? (2 marks)

c) Explain the process by which sex chromosomes diverge. (7 marks)
d) How might the development of sex-linked chromosomes lead to changes in the appearance or behaviour of an organism?  

(2 marks)

The space above the line is sufficient for your answer.
Imagine there are two closely related eukaryotic parasite species in one location (one city, for example).

a) List the main sample collection methods, laboratory methods and bioinformatics methods you would use to perform a population genomics study of these two parasite species? Include brief strategies for sample collection, DNA sequencing and bioinformatics methods. (4 marks)

b) Describe summary statistics and other analyses that would characterise the populations and evolutionary forces at play. (4 marks)

c) Describe what information the relationship $\Theta = 4N\mu$ would provide, if mutation rates could be assumed to be the same. (2 marks)
5.

a) What sequencing methods can be employed to study the diversity, composition and functioning of microbiomes? (5 marks)

b) You are planning to start an experimental evolution experiment to study adaptation of the bacterium *Pseudomonas aeruginosa* to glucose medium. You need to transfer a proportion of the evolved replicate bacterial populations to new fresh media everyday. How would your results be affected by transferring 1% or 80% of the populations? (5 marks)
6. The figure below shows, across a number of different shark species, how their diet breadth relates to the number of tapeworm (parasite) species identified inside them. For both axes, the numbers are residual values from the relationship between the number of tapeworm species or prey families counted, plotted against sampling effort. The straight line represents the linear regression through the data, and the slope is significantly different from zero.

Explain why this regression is problematic as a test of evolutionary association between shark diet breadth and tapeworm species richness; how you would more convincingly demonstrate if there was such an association; and speculate on why a positive evolutionary association might exist.

(10 marks)
The space above the line is sufficient for your answer.