

**QUANTITATIVE GENETICS PROBLEMS- EVOLUTIONARY BIOLOGY FALL 2017**  
**(20 points total)(due October 27<sup>th</sup> 2017)**

- 1) Cichlid fishes in the African Rift lakes form one of the most iconic adaptive radiations. Male Cichlids are challenged by predators and competition from other males for mates. Males of many species have wildly colored fins and engage in elaborate courtship displays. Use the data below from 10 male fish showing a performance trait related to escape ability (swim burst speed), two morphological traits (body size, and an index of color intensity), and a measure of relative fitness (probability of mating success) to estimate quantitative genetic parameters related to these traits. (You can use Excel to calculate means, variances and covariances, or you can calculate these by hand given the formulas from lecture) (7 points)

| Male | Trait                  |                      |                       |                                |                                  |
|------|------------------------|----------------------|-----------------------|--------------------------------|----------------------------------|
|      | Burst Speed<br>(M/sec) | Body<br>Size<br>(mm) | Intensity<br>of color | Intensity<br>of son's<br>color | Probability of<br>mating success |
| 1    | 22                     | 180                  | 6.8                   | 5.5                            | 0.89                             |
| 2    | 32                     | 152                  | 5.3                   | 7.7                            | 0.67                             |
| 3    | 22                     | 168                  | 5.7                   | 3.8                            | 0.75                             |
| 4    | 9                      | 144                  | 4.8                   | 1.2                            | 0.34                             |
| 5    | 20                     | 148                  | 3.2                   | 4.2                            | 0.43                             |
| 6    | 8                      | 160                  | 7.1                   | 4.2                            | 0.79                             |
| 7    | 17                     | 184                  | 6.9                   | 2.5                            | 0.92                             |
| 8    | 16                     | 136                  | 0.6                   | 4.6                            | 0.14                             |
| 9    | 10                     | 176                  | 8.7                   | 9.3                            | 0.96                             |
| 10   | 20                     | 164                  | 3.7                   | 5.5                            | 0.55                             |

- Compute the phenotypic mean and variance of Burst Speed, Body Size, and Intensity of Color in this set of males. (1 pt)
- Use Price's Rule to estimate the Selection Differential (**S**) for these performance and morphological traits. Which of the three traits is under the strongest directional selection? (2 pts)
- What is the heritability of the trait Intensity of Color (**h<sup>2</sup>**) in this population? (1 pt)
- From a different experiment, you have an estimate of heritability (**h<sup>2</sup>**) generated from a set of full-sib brothers. This estimate is 0.65. Explain why is the estimate generated from fathers and sons is different than the estimate generated from full-sibs pairs. (1 pt)
- Assuming that the mean trait value of the males in this table is a good estimate of the mean in the population, and that selection via mating success is the only selection on body size, if the heritability of body size is 0.42, what would you expect the body size to be in the next generation? (1 pt)
- Will relative fitness increase or decrease in the next generation? (1 pt)

- 2) Suppose that in a population of African Cichlids the phenotypic variance for Burst Speed is 40.0 and the slope of a parent – offspring regression for this trait is **0.2 (Adjusted 10/23/17)**. You also have data from a long-term captive population with a line of completely inbred individuals. In this line the phenotypic variance for Burst Speed is 20. Assume that there are no shared environmental effects ( $V_{es}$ ) and no epistatic variance ( $V_i$ ) for this trait. (Note that these questions are not given in the order that you need to solve them)( 6 points)
- What is the total genetic variance ( $V_G$ ) for Burst Speed? (1 pt)
  - What is the additive genetic variance ( $V_A$ )? (1 pt)
  - What is the dominance genetic variance ( $V_D$ )? (1 pt)
  - What is the environmental variance ( $V_E$ )? (1 pt)
  - What is the heritability ( $h^2$ )? (1 pt)
  - What is the expected phenotypic covariance among full-sibs? (1 pt)
- 3) One classic example of phenotypic evolution from the fossil record is evolutionary change in Woolly Mammoths. Towards the end of their era there was a dramatic decrease in body size. In addition to these changes in body size, there was also a decrease in Tusk length. Tusk length decreased from an average of approximately **300 cm** to **150 cm** over a period of 500,000 years. Assume that Mammoths have an average generation time of 10 years and that the slope of the midparent-offspring regression for Tusk length is 0.40. (3 points)
- If this evolutionary change is a consequence of natural selection (and only natural selection) operating directly on tusk length, what average **directional selection differential** per generation (**S**) is necessary to account for the observed change? (1 pt)
  - Starting at 150 cm, how many additional years would be required for the average tusk length of Mammoths to reach 50 cm<sup>3</sup>? (Assume the heritability remains constant). (2 pts)
- 4) On a recent trip to the Galapagos Islands some of your classmates were able to collect data on Darwin's finches. They measured data on beak size in a set of related individuals. Consider the following data on beak size. These quantitative trait values (in mm) are given for the mother, father and one of their offspring. (4 points)

| Mother | Father | Offspring |
|--------|--------|-----------|
| 8      | 11     | 10        |
| 7      | 13     | 11        |
| 14     | 9      | 10        |
| 9      | 11     | 10        |
| 11     | 10     | 13        |
| 14     | 15     | 14        |
| 8      | 12     | 11        |
| 9      | 10     | 8         |
| 11     | 6      | 10        |
| 13     | 7      | 12        |
| 8      | 9      | 11        |

- Calculate the **midparent** values for each parent pair and use a midparent-offspring regression approach to calculate the **heritability ( $h^2$ )** of this trait. There is more than one way to do this, but it will be easiest if you use Microsoft Excel. You can use the **VARP** function to calculate the necessary variances and the **COVAR** function to calculate the covariance. Remember that the slope of the regression line is the  $Cov(\text{Midparent}, \text{Offspring}) / \text{Var}(\text{Midparent})$ . You can also calculate these by hand given the formulas from lecture, or use Excel to plot offspring value as a function of midparent value, and then fit a regression line. (1 pt)

- b) Now calculate the heritability ( $h^2$ ) for the trait using a **mother-offspring regression** and a **father-offspring regression**. Are they the same? (1 pt)
- c) Maternal effects are nongenetic effects of the mother on the phenotype of the offspring, caused by things like the brooding environment, cytoplasmic factors and nutritional state of the mother. Do you see any evidence for maternal effects with respect to this trait? Explain your reasoning. (1 pt)
- d) If the only individuals that could get sufficient resources to breed successfully are the five males and five females with the largest beak sizes what is the selection differential (**S**) on beak size? Assume there is no sexual dimorphism and that the mean of the sample of all the parents above represents the mean of the whole population of finches. (1 pt)