

## QUANTITATIVE EVOLUTIONARY GENETICS ASSIGNMENT

**Due:** Tuesday 25th November 2008

**Worth:** 50 pts.

### Objective

The purpose of this exercise is to manipulate raw data to understand, in a quantitative manner, how natural selection can act to change phenotype through time.

### Background

Red deer (called Elk in California) lived throughout Western Europe during the Pleistocene. A population of red deer living on a peninsula of northwestern France became isolated as sea-levels rose during the last Interglacial (~ 120,000 years ago). The high ground that preserved this subpopulation is now called Jersey, one of the English Channel Islands. The deer were too large to survive comfortably on such a small island; natural selection favored smaller offspring (which need less food) and led to a progressive size reduction through time. The ultimate result was a population of dwarf deer.



### The Question

How quickly might the population have responded to isolation and become dwarfed? A hundred years? A thousand? Ten thousand? The data presented here are hypothetical; the phenomenon is real.

### **The Theory.**

The “response to selection” i.e. the change in the morphology of an organism, is defined as:

$$R = HS$$

Where H is the heritability and S is the selection differential.

Note that S, the selection differential, is a measure of the mean *selected* parent size expressed in standard deviations from the overall population mean. Note also that S is not the same parameter as s, the selection coefficient.

H, the heritability, is a measure of how much of a character is inherited from the parents. When H=1, the offspring match the “mid-parent” (i.e the average of the two parents) exactly. If H=0.5, half the phenotypic effect is inherited, and half is random or environmentally determined.

If we plot the character values of the mid-parents against the values for their offspring, the slope of the line is equal to the heritability. Thus, a perfectly inherited character will produce a 45 degree line (slope = 1).

The slope of the best fit straight line through a scatter plot is given by a statistical technique known as simple linear regression, where  $y = a + bX$  (y is the offspring value, X is the mid-parent value, a is the intercept and b is the slope). The spreadsheet program Excel provides a convenient way to compute regression statistics (see example).

## Data

### Fore-limb length for red deer (cms)

Mid-parents	Offspring
104	104
105	100
108	140
111	107
115	114
119	108
126	126
127	142
131	132
135	132
139	140
140	133
149	155
151	151
170	158

1] Plot offspring (y-axis) against midparent (x-axis). Obtain the regression coefficient,  $b$ , for the relationship ( $b = \text{slope}$ ).

2] Assume that natural selection selects for parents that are, on average, 0.2 standard deviations smaller than the population mean., so that  $S = 0.2$

Plot the population response to natural selection ( $R$ ) in the form of a graph showing average deer size through time, assuming 4 years per generation.

Remember that  $R$  is calculated in standard deviations; you will need to convert back to cms to track changes in body size.

Also, assume that the standard deviation is a constant proportion of the mean.

**How long would it take for the population to evolve to one-half its starting body size?**

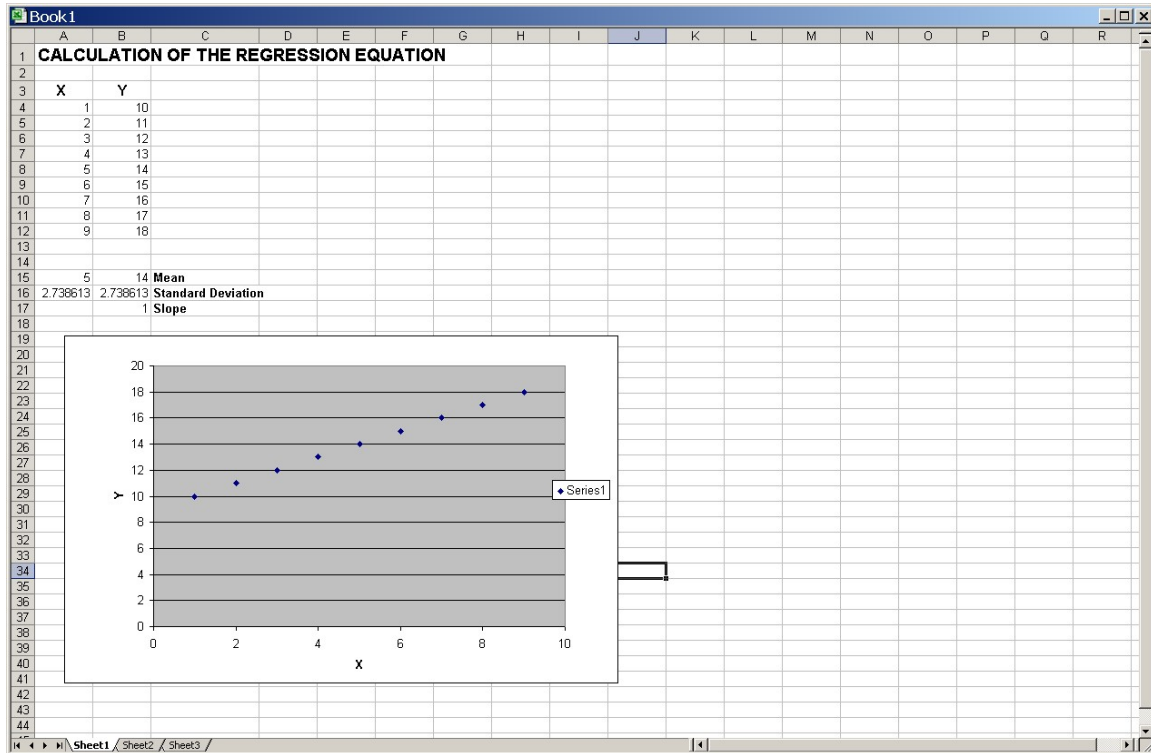
**In reality, we can never know the parent-offspring data for a collection of fossil bones in a cave. Assuming that you excavate such a cave and find two distinct strata yielding bones from 140,000 years ago and 120,000 years ago, what information could you derive from this material?**



**Further Reading:**

**Lister, A. M. 1989. Rapid dwarfing of red deer on Jersey in the last interglacial. *Nature*. 342(6249):539-542.**

## A Brief Primer on using Excel.



The statistics above are obtained using Excel functions. To compute a function in any given cell, start with an “=”. For example, to calculate the mean of a range of values (data in cells a4 through a12), choose a convenient empty cell and type:

**=AVERAGE(a4:a12)**

When you press <ENTER>, the cell will return the mean of your data.

The Standard deviation would be calculated as:

**=STDEV(a4:a12)**

The slope of the regression of Y on X, (where the x data are in a4 to a12 and the Y data are in b4 to b12) is given by:

**=SLOPE(b4:b12,a4:a12)**