BIOL 303: Estimating population size of Water Striders (*Gerris remigis*)

In today's lab we will attempt to estimate the population size of an insect, the Water Strider (*Gerris remigis*). We will estimate the population size using different techniques: enumeration, depletion, and mark and recapture. We will examine the assumptions of each method and their validity for this particular population. Many factors influence population size especially local environmental characteristics. Pay attention to the environment where we are sampling and make note of any factors that might affect the Water Strider population size.

Goals

1) Learn about various methods of estimating population size
2) Collect data on Water Striders using mark-recapture (capture/mark/recapture) methodology
3) Test different methods of estimating population size and evaluate your confidence in these estimates

Water Strider Biology

Water Striders are predatory insects that skate on the surface of slow-moving water. They eat both dead and live insects and spiders that fall on the water and get stuck on it from the water tension. They are attracted to food sources by ripples produced by their struggling prey. Their legs have tiny water-repellent hairs (called microsetae) on them that actually trap air bubbles. This allows them to stay buoyant and essentially "skate" on the surface of the water. They move by pushing with their middle legs using their back legs as a rudder to steer them. Their bodies are covered with tiny hairs that also help keep them buoyant. Water Striders communicate with each other by tapping the water surface and making ripples that are perceived by other Striders. They are capable of escaping underwater and can stay there for a period of time.

Water Striders are insects in the order Hemiptera, a group of roughly 80,000 species that includes assassin bugs, stink bugs, aphids, and plant hoppers. This group is often referred to as "true bugs". All hemipterans have a proboscis – an appendage designed to penetrate and suck juices from plants but also other insects – that is housed within a rostrum. Typically, the proboscis is positioned anteriorly on the insect. Water Striders use their proboscis to pierce the body cavity of other insects and extract the contents.

Estimating Population Size

In order to understand how biotic and abiotic factors influence the distribution and abundance of organisms, we need to measure changes in populations over time. As researchers, we are limited in our abilities to census populations – that is, we usually cannot count every individual in a given population. Instead, we typically rely on estimates of abundance or density that usually include some indication of certainty for the estimate (i.e., the estimate +/- X, where X is some measurement of error). For example, researchers may count the number of individuals in a given area and then extrapolate to a larger area in which the entire population lives. In another situation, a researcher may count the number of males in a population because they are very conspicuous (e.g., male songbirds can be quite conspicuous due to their boisterous calling advertising their territories) and then estimate total population size by assuming that for every male there is one female. Each method will have different strengths and weaknesses and thus it is usually best to use and compare at least two methods in any population study. In this lab, we will use three different methods to estimate the true population size of Water Striders along a segment of Town Run Creek, in downtown Shepherdstown. We will mark water striders with paint pens or nail polish.

Data Analysis

For this lab, we will use field-based collection techniques to estimate water strider population density in 2 ways. In practice, ecologists typically choose one estimation method (usually the most powerful and accurate method given the study organism) and then design their sampling regime to produce the data appropriate for that estimation method. We will estimate population density with the 1) enumeration (through depletion), and 2) capture mark recapture methods.

Enumeration (through depletion) Method

The simplest way to estimate population size is to capture and count all the individuals in the population. This can be accomplished by enumerating individuals captured over multiple sampling periods within a day (for our lab this will consist of 4 short 15-minute sampling bursts). Typically, this procedure is done by capturing all individuals (keeping them out of the population) and then repeatedly sampling adding new captures to the total removed from the population. However, it is possible that when you capture individuals and count them you may miss some that evade capture. Therefore, enumeration is often considered to provide a minimum estimate of population size and is sometimes referred to as the minimum number known to be alive.

The enumeration method is done by repeatedly sampling the population over a short period of time and a constant fraction of the remaining population will be taken in each sample. By using this fraction, we can estimate the population size using linear regression. By plotting the number of individuals captured in a given sample (*Y*) against the total captured in all previous samples (*X*), we calculate the **slope (m) of the best-fit line** through the data. With this **slope**, and the **y-intercept (*b*)** *w*e can calculate the **x-intercept**, i.e., **the estimate of the total population size**.

The line of best fit equation is **Y = mx + b**

where,

Y = the total number of individuals captured in a given sample

m = slope

x = the total number of individuals captured in all previous samples

b = y-intercept

Note: the **x-intercept** = the **population estimate**

To calculate an estimate using this method, you need to determine the values in the above equation for a line with the Y-axis = # of individuals captured in a given sample and the X-axis = # of individuals captured in all previous samples. Below I have provided a table with some hypothetical results of four consecutive depletion samples to show you how you might calculate the population estimate. *Note that for your data you may not have 4 sample periods.*

Table 1. Hypothetical data for estimating population size with the enumeration (through depletion) method.

Sample # (e.g.)	Total taken in Previous sample (x)	Number taken in This sample (y)*	(x * y)
1 (12-12:10 pm)	0	60	0
2 (12:30-12:40 pm)	60	40	2400
3 (1:00-1:10 pm)	100	30	3000
4 (1:30-1:40 pm)	130	15	1950
	n=4	n=4	n=4
	Σx = 290	Σy = 145	Σ(x)(y) = 7350
	Mean x = 72.5	Mean y = 36.25	

*These are your new captures.

Mark and Recapture Method

The mark and recapture method is initiated by capturing, marking, and releasing a number of individuals from a population. At a later time, individuals from the same population are captured again (either individuals already marked from the previous sample or unmarked individuals that have never been caught previously). This sampling provides a basis for estimating the population size at the time of the marking and release. This method was used by two early population biologists Lincoln and Petersen. The procedure produces an estimate of population size referred to as the Lincoln Index or the Petersen Index. Using the mark and recapture method we assume that:

• All individuals have an equal chance of capture

• Marked individuals are randomly dispersed

• No migration occurred across sampling periods

• No births or deaths occurred across sampling periods

Equation: $$\mathbf{N = \frac{MC}{R}}$$

where,

N = population estimate
M = the total number of animals marked and released in the 1st sample
C = the total number of animals captured in the 2nd sample
R = the total number of marked animals recaptured in the 2nd sample

For the mark and recapture method, we can calculate confidence limits to represent how certain we are of the estimate. The confidence limits are calculated as follows,

$$SE_N = \sqrt{\frac{M^2(C+1)C+R)}{(R+1)^2(R+2)}}$$

As you might be able to see from the equation above, the precision with which the technique estimates population size is inversely proportional to the number of marked animals recaptured (R). That is, the greater the proportion of marked animals in your 2nd sample, the greater your precision. The standard error can be used to produce confidence intervals for the population estimate. A 95% confidence interval may be calculated using the following formula,

$$N \pm (1.96)(SE)$$

CALCULATIONS FOR THE ENUMERATION (THROUGH DEPLETION) ESTIMATE:

Mean X: see table above.

Mean Y: see table above.

Slope (m) = $\frac{\Sigma(x)(y) - (\Sigma x)(\Sigma y)}{n}$ = (7350 – (290)(145))/4 = -0.33

y-intercept (b) = Y bar – m * X bar = 36.25 - (-0.33 * 72.5) = 60.45 **rearrange slope equation**

x-intercept (population estimate) = -b/m = -60.45/-0.33 = 181

This is how many water striders you think there may be in this location, given the assumptions stated further below.

By plotting the number of individuals captured in a given sample (*Y*) against the total captured in all previous samples (*X*), we can calculate the **slope (m) of the best-fit line, and the y-intercept (b)** *we* can **estimate of the total water population size (i.e. the x-intercept) for a given locality. See Figure 1. For illustration.**

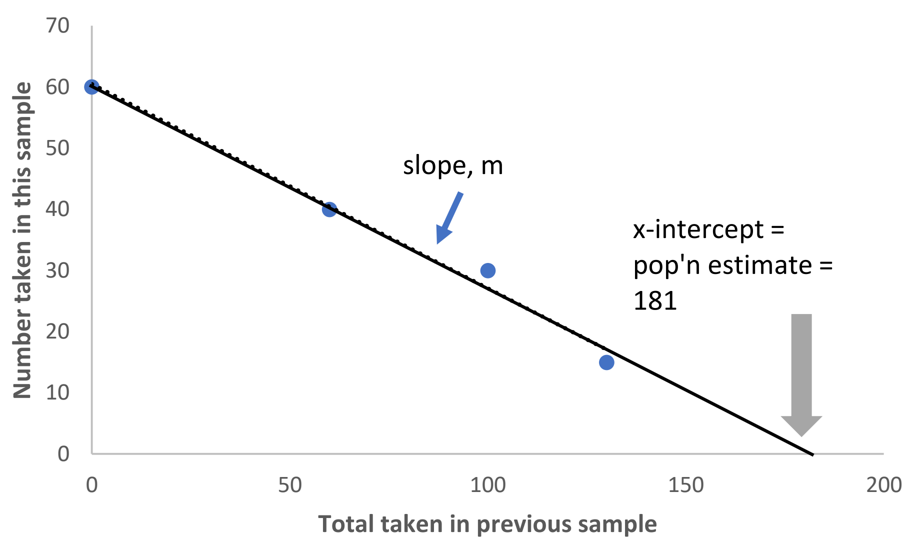

Figure 1. Estimation of population size (x-intercept) by calculating slope of the line of best fit and the y-intercept. See manual for details.

Using the enumeration (through depletion) method you must accept (and many cases test for) the following assumptions:

1. All individuals have an equal chance of capture

2. Capture probability does not change from one sampling period to the next

3. No migration occurred across sampling periods

4. No births or deaths occurred across sampling periods

Statistics need to be interpreted with these assumptions in mind.