Name_____

Bumblebee Mark-Recapture Lab

Objectives

1. Learn how to use the mark-recapture method, used by wildlife biologists to estimate population size of wild animals.
2. Use the mark-recapture method to estimate the number of bumblebees on a school campus or community garden.

1. **Background Question** Why might a scientist want to estimate the population size for a wild animal?

Introduction

Ecologists interested in questions about populations and communities frequently face a very basic question: how best to estimate the size of a population of organisms in the field? However, it usually is not possible to obtain a complete count or census of a natural population of animals (and it is often difficult even for plants!). For this reason, ecologists generally have to rely on some kind of estimate of abundance or density.

At one extreme is a complete census of individually identifiable organisms. This approach might involve tagging all trees in a forest plot, or marking all the animals of a species living in an area at a particular time. Techniques for individually identifying animals include: Compiling a catalog of photographs or drawings that show unique markings of individuals (e.g., fin shape and markings on whales; spot patterns on African wild dogs).

2. **Question** Why is it hard to determine the *exact* number of organisms in most populations of wild animals?

At the other extreme are 'quick & dirty' methods that give crude estimates of abundance. Examples include counting the number of monarch butterflies passing a point such during migration, counting the number of bird songs one hears during a morning in the spring, or counting animal tracks along a trail. Or one may count the individuals in a sample area and then extrapolate to the larger area in which the whole population is assumed to live. Each method has different assumptions and hence, different strengths and weaknesses.

3. **Question** What is a disadvantage of using a 'quick & dirty' method to estimate a population size?

The Mark and Recapture Technique

By far the most popular way to measure the size of a population of animals is called the Mark and Recapture Technique. This technique is commonly used by fish and wildlife managers to estimate population sizes before fishing or hunting seasons. For invertebrates, it is possible to use this technique with bees because they are larger. The mark and recapture method involves marking a number of individuals in a natural population, returning them to that population, and subsequently recapturing some of them as a basis for estimating the size of the population at the time of marking and release.

It is based on the principle that if part of the population was marked in some way, returned to the original population and then, after complete mixing, a second sample was taken, the proportion of marked individuals in the second sample would be the same as was marked initially in the total population. That is,

$$\frac{\textbf{R}\text{ (marked recaptures)}}{\textbf{T}\text{ (total in second sample)}} = \frac{\textbf{M}\text{ (marked initially)}}{\textbf{N}\text{ (total pop. size)}}$$

By rearrangement we can estimate the population size, N, to be,

$$N = \frac{M \times T}{R}$$

For example, suppose you took 200 mice out of a forest having an unknown number of mice, put leg bands on them, return them to the forest and let them mix thoroughly.

If you then take 250 mice from the forest and find 50 of them to be have leg bands, then M = 200, T = 250, R = 50, and the unknown total number of mice (N) could be estimated as:
N = M*T/R = (200)(250)/50 = 1000 mice

4. **Sample problem**: A pest control technician captures and applies ear tags to 23 brown rats, which he then releases. A week later he traps 29 brown rats, 11 of which have ear tags. What is the estimate of the total population of brown rats?

Assumptions

The accuracy of this mark-recapture method rests on a number of assumptions.

Assumption 1.

During the time between the first marking period and the recapture period, nothing has happened to upset the proportions of marked to unmarked animals

5. **Question** What could happen that would make assumption #1 not true?

Assumption 2.

The chance for each individual in the population to be caught are equal and constant for both the initial marking period and the recapture period. That is, marked individuals must not become either easier or more difficult to catch.

6. **Question** What could happen that would make assumption #2 not true?

Assumption 3.

Sufficient time must be allowed between the initial marking period and the recapture period for all marked individuals to be randomly dispersed throughout the population (so that assumption 2 above holds). However, the time period must not be so long that Assumption 1 breaks down.

Assumption 4.

Animals do not lose their marks. This is an important factor for animals that shed or molt as they grow or as they respond to seasonal factors. All these assumptions must be considered very carefully and play a strong role in the techniques used to perform the study.

Methods

Your goal is to estimate a population size using the mark-recapture method. The specific species we will be working with is the **yellow-faced bumblebee**. These bees are common, relatively easy to capture, have a fairly small range, and their population size is small enough that we should be able to get a reasonable estimate of the total number in our gardens.

Day 1: Initial Marking

Each group will need an insect net, a bug vacuum, and a collecting jar. During the collection time, groups will try to capture as many bumblebees as possible. Students will bring each captured bumblebee to the teacher for marking. First, they should be put in a cooler for a little while to slow them down, making it easier to mark them. The bees will be marked with a color dot on their thorax with a non-toxic paint pen. Special care should be taken not to harm the bees. We will record the number of total bees captured and marked for our class period, and the other classes will do the same. The total number of bees capture and marked by your entire class will be the 'M' in our population calculation.

Day 1 data:

Day 2: Recapture

Using the same groups, the same equipment, and spending the same amount of time, we will capture as many bumblebees as possible. For each bee that is captured, bring it to the instructor, and we will record whether or not the bees have previously been marked.

7. Question How can we avoid recapturing the same bee multiple times?

The total number of bees captured on day 2 will be 'T' in our calculations.
The number of bees that were previously marked (recaptures) will be the 'R' in our calculation.

Day 2 data:

Conclusion

8. Population estimate

Using the equation below, estimate the population of bees in our garden. Show your work.

$$N \text{ (total population)} = \frac{M \text{ (marked individuals day 1)} \times T \text{ (total number captured day 2)}}{R \text{ (marked individuals recaptured)}}$$

N =

9. Question Do you think that we were able to meet all four assumptions for this mark-recapture study? Explain why or why not?

10. Question How accurate do you think this population estimate is? What might be some factors that influenced our results? Explain.

11. Question Since we don't have any past data to compare this to, what is the value of doing this kind of population estimate?

12. Question What might be some factors that are influencing pollinator populations?

13. Question What are some ways that people can help maintain or increase pollinator populations?

Teacher Notes for Bumblebee Mark-Recapture Lab

Lab adapted with permission from *A Method of Population Estimation: Mark and Recapture* by John Kell, Radford University

Approximate time: Two class periods

- You will need an area with enough flowers to have a significant bumblebee population. Scout your schoolyard beforehand to see if there are areas that attract bees, such as gardens or landscaped flower beds. If your schoolyard doesn't work, there may be a community garden or greenspace near the school that will work for capturing enough bees.
- Students should use caution when capturing bees with bug vacs and insect nets. If used improperly there is the potential for stings, insect mortality, and equipment damage. I allow students to capture the bumblebees, but I do the tagging myself.
- It is recommended that you check for any sting allergies. I have never had a student get stung, but it is a possibility. Students with allergies could help record data, or help a group locate pollinators without actually capturing the insects themselves.

Equipment

All of the equipment for this activity can be ordered on-line.

- Backyard Safari makes a couple versions of the bug vacuum that can be ordered through Amazon or other online retailers.

https://www.amazon.com/Backyard-Safari-2450904-Bug-Vacuum/dp/B000YJMHLC

https://www.amazon.com/Backyard-Safari-Extreme-Bug-Vacuum/dp/B000302AFK

- My experience has been that the Bug Vacs are not durable, so students really need to be careful with them.
- Insect nets can be ordered through BioQuip, Amazon, or a variety of other retailers.

- Bumblebee marking tubes are inexpensive, and come in a variety of different sizes. The ones I use look like this and can be ordered for less than $5 on Amazon.

- I use Posca brand paint pens to do the actual marking. These can also be ordered on Amazon. Searching for “Bee Paint Pens” will give you several options. It is also possible to order the marking tube and paint pens together for about $25.
- Be careful not to press too hard with the pens, because sometimes too much paint will come out, which will be fatal to the bee.