INTRODUCTION TO CALCULATING POPULATION SIZE THROUGH "MARK AND RECAPTURE"

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Abstract

An important part of environmental biology is determining the **size** of **populations**. However, animal populations are often too large and/or scattered to count directly. Therefore, scientists try to capture **some** of the animals, let them go, then recapture animals of the same species after the marked ones have mixed in with the general population. Obviously, when scientists try to catch animals the second time, they may get many which were NOT marked the first time. This is important because it allows them to make a good guess at how many animals in that species are really out there. Knowledge of a species' population size, then, is important for conservation scientists to make necessary decisions.

Introduction

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Objectives

In this laboratory activity students will be able to:

- estimate the number of individuals in each of two populations by mark and "recapture".
- use class data from the "mark and recapture" activity to compare the success of two closely related species in a community.

Scenario

Imagine that two species of fish are found in a pond. These species have similar niches and are closely related. They eat the same foods, reproduce once a year, and compete with each other for resources. One is **native** and one is **alien**. Your job is to determine which is more successful in the pond.

HYPOTHESIS:

NULL HYPOTHESIS:

Strategy 16 PAIRS, 60 - 90 MINUTES

Materials for each pair, you will need

- 1 beaker of dry kidney beans
- 1 beaker of black-eyed peas
- 1 flat tray
- 1 black permanent marker or white-out

Procedure

1. Choose a partner. Decide who is "A" and who is "B".

2. One of you should get the materials as instructed by your teacher.

3. Person "A" gets beans, "B" gets peas.

4. "A" should pick out 25 beans, and mark them clearly with the marker or white-out. Mark each with a nice big spot! "B" should do the same with the peas.

5. Once you have marked your beans or peas, put them back into the beaker from which they came and shake them gently to assure thorough mixing.

6. Person "A" should now close his/her eyes. Person "B" should place the flat tray in front of "A" and pour the beans out upon it.

7. Keeping **eyes closed**, "A" should now pick out 25 of his beans at random, one at a time, handing each one to his partner.

8. How many of these beans were recaptured (had a mark on them)? Write this number down here. **# of beans recaptured (marked)** = _____

9. Switch positions and repeat steps 3 and 4 with the peas. (Person "B" should be picking the peas with her eyes closed). **# of beans recaptured (marked)** = _____

10. Record the class data in the data chart.

Calculations

1. Use the MARK AND RECAPTURE equation discussed in the prelab to determine the number of individuals in the population according to **YOUR DATA**. Show your work!

$$\text{population total} = \frac{\text{total \# of marked individuals} \times \text{total \# captured}}{\text{\# of marked individuals (recaptured)}}$$

Calculated Bean Population = _____ Calculated Pea Population = _____

2. The teacher will now tell you how many beans there really were in the bean and pea populations.
   Actual Bean Population = _____
   Actual Pea Population = _____

3. What was your % error for each population?

$$\%\ \text{Error} = \frac{|\text{Actual - Calculated}|}{\text{Actual}} \times 100\%$$

% Error For Beans = _____ %
% Error For Peas = _____ %

CLASS DATA:

PAIR	Calculated Bean Population	Calculated Pea Population	SIGN TEST
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
CLASS AVERAGE			
CLASS ERROR			

CALCULATIONS II BASED ON CLASS DATA

1. Calculate and record the class averages for bean and pea populations.
2. Calculate and record class error for each actual population.
3. Remember that these represent two species of fish in a pond. Is there really a significant difference between the numbers of the two populations?

USE THE SIGN TEST TO DETERMINE IF THEY ARE SERIOUSLY DIFFERENT. (IT SHOULD BE OBVIOUS IN THIS CASE).

FOLLOW UP QUESTIONS:

1. How did the class average compare with each **actual** population value? Was it better or worse than your pair's calculation? EXPLAIN!

2. What did each beaker represent in our model or "scenario"?

3. What did the peas and beans represent?

4. 4) According to the **sign test**, was there a significant difference in the two populations? If so, which one dominated?

5. Do you think it was the peas or the beans which represented the alien species? Explain your reasoning.

6. List 5 environmental factors which could affect these fish in a real pond.

INTRODUCTION TO CALCULATING POPULATION SIZETHROUGH "MARK AND RECAPTURE"

(Teacher's Lesson Plan)

Background

This lesson would best be used with Honors or TAG High School Biology, General Ecology, or Environmental Science. At the time of presentation, students should probably have completed Algebra I. They should have been introduced to the ***sign test****, understand basic ecological interactions (relationships like predator-prey, parasite-host), and have mastered basic population dynamics (natality, mortality, immigration, emigration). The current unit would have included a discussion of the major causes of human-caused ecosystem disruption (habitat destruction, economic exploitation, pollution, introduction of non-native species). One of these is the introduction of non-native species. This lesson bridges population studies with the *potential* impact of alien species on an ecosystem.

*See Appendix

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DRILL: Copy and distribute so students can complete the following drill.

1. Solve for "*x*"

$$\frac{1}{6} = \frac{x}{150}$$

2. Solve the following analogies:

a) predator: prey :: parasite : _____
b) natality: immigration :: mortality: _____

Go over the drill by getting answers from students. At Eastern Technical H. S., we try to develop drills which are "SAT prep" oriented. The answers are as follows:

1. 25
2. a) host
   b) emigration

Students should be able to show work for #1 and explain metacognition in #2a & #2b.

Guided Activity

1. Ask students how the U.S. government determines the population. Accept responses. Now ask students how one might determine the population of grasshoppers in a field or fish in a pond. Write responses on the board or overhead if possible.

2. Tell students this is just what we are going to do today in lab. We are going to suppose that there are two species of fish in a pond which are of interest to us. They are closely related, but one is native and one is alien. Our task is to try to closely estimate the population of each and compare their numbers to determine whether or not the alien species poses a threat to the native one. Ask students why the alien species might have an advantage over the native one. Answers may vary. Good answers would be as follows:
   a) The alien species has acquired immunity to a disease it carries while the native one has not been exposed.
   b) The alien species is more efficient at foraging.
   c) The alien species is more aggressive.
   d) The alien species is more tolerant to adverse conditions than the native species.

   You might also ask students why a native species might have an advantage over an alien one being introduced.

3. Getting back to the population study, tell students that fish are hard to catch and slimy to deal with, so we will substitute beans for fish. Have a student read aloud the introduction, objectives, and scenario on the lab sheet. Have them come up with a hypothesis regarding the greater success of one species or the other as determined by population size. Ex: "There will be significantly more native fish in the pond than alien fish" or "There will be significantly more alien fish in the pond than native ones." A null hypothesis would be "There is no significant difference in the sizes of the two populations".

4. Now is a good time to go over the transparencies with the students. Make sure each step is understood, although students can refer to the procedure on their lab sheets once the transparencies are down.

NOTE: THE TEACHER SHOULD COUNT OUT EXACTLY THE SAME POPULATION OF BEANS REPRESENTING A SINGLE SPECIES FOR EACH LAB GROUP'S BEAKER AHEAD OF TIME. THIS ALLOWS ALL GROUPS TO SAMPLE THE "POND" (BEAKER) SIMULTANEOUSLY. AN EXAMPLE MIGHT BE 120 NATIVE "PEAS" AND 200 ALIEN "BEANS" (or vice versa). IF YOU DON'T LIKE TO COUNT BEANS UNTIL YOUR BRAIN BEGINS TO FEEL LIKE ONE, HAVE STUDENTS **SECRETLY** COUNT THE BEANS/PEAS THEIR RESPECTIVE PARTNERS WILL USE.

Follow Up/Assessment

1. Get native and alien data from each lab group. Copy it onto a transparency or on the board. Students should copy this data as well. Since each group computed both alien and native population numbers, this can be considered "paired" data. Go over calculations with students if they are having difficulty. This is best done by using data really obtained by one of the groups.

2. Students should have enough prior knowledge to complete the analysis and follow up on their own. However, the follow up questions should be reviewed, either before papers are turned in, or after they are handed back (depending on the teacher's preference).

Answers for the follow up

1. Compare class data with actual bean counts.
2. The beaker represented THE POND.
3. Peas and beans represented FISH of the respective species.
4. OPEN ENDED
5. OPEN ENDED
6. OPEN ENDED

APPENDIX - USING THE SIGN TEST FOR STATISTICAL ANALYSIS

1. Examine data for each lab pair. Each pair will have two calculated populations - one for the native species (e.g; peas) and one for the alien species (e.g; beans).

2. With data side by side in the chart, evaluate it in the following way. Each time the native population is more than the alien population, place a "+" in the column to the right. Each time the alien population is greater than the native, place a "-" in the right. If they are calculated to be equal, place a "0" in the right column.

3. Tally the number of "+"s and "-"s. for the class or classes performing the activity.

4. Obtain a sign test graph and either include it with the lab packet given to each lab pair, or make a transparency of it if you wish to go over this part with the entire class, together.

5. Plot your coordinates (-,+) on the graph. The stair step divider will immediately indicate whether or not there is a significant difference between the two population sizes.

A **significant** difference is indicated by the coordinate positions between the divider and the x-axis or between the divider and the y-axis. If the coordinates fall in the middle of the graph, between the stair steps, the null hypothesis "There is **no significant** difference in the sizes of these two populations" is supported.

SAMPLE CLASS DATA

PAIR	Calculated Bean Population	Calculated Pea Population	SIGN TEST
1	625	208	+
2	156	104	+
3	208	89	+
4	208	89	+
5	625	156	+
6	156	104	+
7	125	156	-
8	156	125	+
9	208	89	+
10	208	78	+
11	156	89	+
12	208	125	+
13	313	208	+
14	313	313	0
15	313	208	+
16	104	156	-
CLASS AVERAGE	200	123	
CLASS ERROR	14 %	7 %	

ACTUAL POPULATIONS:

BEAN = 232 PEA = 132

SIGN TEST QUANTITIES:

13 (+) 2 (-)

CONCLUSION: THE HYPOTHESIS IS SUPPORTED. THERE IS A SIGNIFICANT DIFFERENCE BETWEEN THE SIZES OF THE TWO POPULATIONS, ACCORDING TO THE "MARK & RECAPTURE" METHOD.