ESTIMATING POPULATION SIZE USING CAPTURE AND RECAPTURE:

A GYPSY MOTH STUDY INCLUDING SIMULATIONS

TEACHER LAB TEMPLATE

Susan Wells Rollinson
Jackson River Governor's School
Dabney S. Lancaster Community College
Clifton Forge, Virginia

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Objectives

At the end of this lab you will be able to:

- Perform a simple capture/recapture population study
- Estimate the population from capture/mark/release/recapture data

Correlations

AP Environmental Science Course Description (May 2004, May 2005)

I.E.2. Populations and Communities
V.A.3. Biota: Introduced Exotics

Virginia Standards of Learning

BIO.1 a, d, e, f, g, i (Investigations)
BIO.9 a, d, e (Ecology)

National Science Education Standards, Grades 9-12

A (Inquiry)
B (Life Science), especially 3 (interdependence), 4 (behavior)
F (Social Perspectives), especially 2 (population), 3 (natural resources), 5 (hazards)

Why Use This Lab in the APES Course?

Estimating populations is a necessary, but difficult, procedure in ecology. Performing a population count gives students insight into the difficulty and reliability of these measurements. Quantitative data seem to have more validity, regardless of their source or reliability. Most students are just developing an awareness of the errors inherent in any measurement, and they frequently fail to stop to consider the reasonableness of media and interest-group pronouncements.

Furthermore, the introduction of nonnative species and their impact on the local environment is a continuing global problem. Whether it's kudzu or killer bees, rarely does a week go by without some introduced species making the news. Gypsy moths are a great example for the northeastern United States in late spring/early summer. You may be able to adapt this lab to your locality. Certainly the simulations offer easy substitution of organisms that may be more relevant to your situation.

Introduction

Leopold Trouvelot introduced gypsy moths to the United States in 1869 in an effort to develop a domestic silk industry in Massachusetts. The silk business never materialized, but the moths escaped and have wreaked havoc on local ecosystems ever since, slowly expanding their range, which now reaches from Canada to North Carolina and west to Wisconsin.

The eggs hatch in midspring and pass through five (male) or six (female) instars before pupating in early summer. The moths hatch about two weeks later to mate and lay eggs for the next year.

As with most insects, it is the larval (caterpillar) stage that does the greatest damage. While preferring oaks, gypsy moth caterpillars are capable of feeding on almost any tree. In their last two instars, they are capable of defoliating trees overnight. During a large infestation, the dropping frass (excrement) sounds like a light rain.

Until their final feeding frenzy, gypsy moth caterpillars prefer to munch leaves at night and retreat to shelter during the day. This makes it possible to trap the caterpillars by providing a convenient daytime hiding place in a burlap band tied around a tree.

Population estimates are necessary for both monitoring the spread of the gypsy moth and implementing effective control measures in infested areas. In the winter, population estimates are based on counts of egg masses on trees. After the moths have matured, pheromone traps are used to arrive at a population estimate. The method used in this exercise is appropriate for population estimates of the destructive larval (caterpillar) stage.

The references give a lot more information on the gypsy moth life cycle and management.

The laboratory exercises described here include performing a gypsy moth population assessment in the field and two simulations that can substitute if a field study is not possible.

Materials and Equipment

Each student should have a laboratory notebook or data sheet and pen or pencil to record data.

Part A1:

Per student:

- One piece of burlap (2 feet by 3 feet)
- 6 feet of twine
- One bottle of correcting fluid ("white-out"). As long as the bottle is kept tightly closed, it will last a number of years.
- Optional: gloves

Optional per student pair:

- Tree identification book
- Instruments to measure tree diameter and height (biltmore stick, dbh tape, clinometer)

Part A2:

Per student pair:

- Shoe box
- 10-30 stickers: 1-2 inches in diameter or side
- 200 paperclips: 100 each of two different colors
- Two snack- or sandwich-size resealable bags to hold paperclips

Part A3:

Per student group:

- Microsoft Excel running on a suitable computer. The simulation works on both Windows (Excel XP/2002) and Macintosh (Excel MX).

Part B:

- Calculator with square root function

Suppliers

Part A1:

- Burlap and twine can be purchased at most fabric and craft stores. We got ours from Wal-Mart.
- Optional forestry equipment is available from Forestry Suppliers, Inc. (www.forestry-suppliers.com).

Part A2:

- Multicolored paperclips are available from most office supply stores and catalogs. All paperclips used by a team must be of the same size.
- The stickers used to prepare the shoe boxes can come from a variety of sources. I use "freebies" from my junk mail. The National Wildlife Federation even has stickers that match the environmental science theme!
- Shoe boxes: no teacher should ever throw out a shoe box! With advance notice, your students can also add to the supply. Other boxes can also be used, but you may need to scale the number of paperclips you use.

Safety and Disposal

All materials can be reused. There are no disposal problems (other than to destroy gypsy moths on recapture day).

Some students may want to wear gloves when handling caterpillars.

As in all field experiences, everyone should thoroughly wash their hands when they return to the classroom.

Group Size

I have students work in teams of two. Each team studies two trees in Part A1.

Part A2 can be done in groups of one to four students.

Part A3 can be done individually.

Lab Length

Part A1 takes place over three days. Once you are in the field, the actual experiment takes about 30 minutes each day.

Part A2 takes about 30 minutes.

Part A3 can take as long as you want — each round of data collection takes only a few seconds.

Calculations, regardless of data source, take about 30 minutes.

Preparation and Prep Time

Part A1:

Cut burlap into 2-foot lengths using the full width of the burlap. Cut twine into 6-foot lengths. We fold each piece of burlap and wrap a piece of twine around it to make a convenient package.

Prep time is minimal once the burlap and twine have been cut.

Part A2:

Prepare shoe boxes by placing several stickers/labels on the bottom of the box. Covering one-fourth to one-third of the bottom surface is optimal.

Paperclips should be presorted into groups of 100 of the same color and placed in resealable bags.

Prep time is minimal once the shoe boxes and paperclips have been assembled for the first time.

Part A3:

No prep time other than to have computers available.

Teaching Tips

If at all possible, perform the "real thing." However, this limits the investigation to the Northeast and Mid-Atlantic states in late May/early June.

Part A1:

Day 1: At least one night must intervene between capture/recapture days. It is possible to leave trees "burlapped" over a weekend. We usually start the study on a Friday or Saturday, mark on Monday, and recapture on Tuesday.

Day 2: Have students mark caterpillars as they count them. This greatly simplifies the problem of "Have I counted that caterpillar yet?"

Their pairs of blue and red spots and hairy appearance easily identify gypsy moth caterpillars.

You don't have to remove the burlap or the caterpillars from the tree to count and mark.

Other interesting critters also take refuge in the burlap. Be on the alert for teachable moments! You might want to have an insect field guide on hand to identify non-gypsy moth larvae. A good online source of caterpillar information for the eastern U.S. is: "Caterpillars of Eastern Forests" (www.npwrc.usgs.gov/resource/2000/cateast/cateast.htm).

Day 3: The only reason we kill the larvae is because they are invasive, nonnative pests. In most population studies, you release all subjects at the end of the experiment.

If you have a variety of trees, the gypsy moth's preference for oaks is unmistakable.

The class pools data for calculations.

Part A3:

The simulation places 200 gypsy moth larvae over a 20 x 20 grid. If the location is a “tree,” the caterpillar is marked. If it lands on a tree a second time, it becomes a “marked recaptured,” while if it is only on a tree the second time, it is a second-day capture. All this is accomplished by formulas in columns D, G, and H on the “Larvae” sheet, included as part of the GypsyMoth.xls Excel file on AP Central. The numbers are summarized on the “Map” sheet. The calculations are also found there.

Calculations:

The basic calculation of population size is easy to understand. The ratio of the number of marked “recaptured” on day 2 to the number marked on day 2 gives an estimate of what proportion of the total population you captured the first day. When divided into (or equivalently, multiplied by the reciprocal) the total number of caterpillars captured on day 3, you get an estimate of population size.

The calculation of standard error is more difficult to understand. The students who do the “live” study have no exposure to statistics, so we treat the formula as a “black box” calculation. In the simulation, it is useful to compare this to the “true” population, which is known — sometimes the true number does not lie within the 95 percent confidence interval. Of course, in a “real world” population count, the true value is not known. The results can be used to discuss the variability and reliability of measurements.

Discussion Starters:

Can the data we gathered here be generalized to other locations? Years? We did not sample every tree on campus. How might we expand this experiment to adequately assess the gypsy moth population on our 100-plus acre campus? What additional information would we need to know?

Extensions:

If you collected data on tree species and tree size, you can draw conclusions about which tree species are preferred by gypsy moths. (Obviously, this is not possible in the simulations.) You could also look for correlations between tree size and population count.

Part A1 can be continued in subsequent years. Can you see a change in population over time?

Use Web resources to follow the spread of the gypsy moth over the past 20 years. How would you expect the gypsy moth range to change over the next 20 years?

Investigate the control measures being used to retard the spread of the gypsy moth. Which measures would you recommend for:

(a) a homeowner with five oak trees on the property?

(b) a homeowner with five maple trees on the property?

(c) a tree farmer with a 50-acre loblolly pine plantation?

(d) a tree farmer with 50 acres of mixed hardwoods?

(e) a large tract (e.g., 50,000 acres or more) of federal or state mixed hardwood forest?

Possible Assessments

Formal lab report

Lab notebook

Oral and/or PowerPoint presentation

References (all Internet sources were accessed March 2004)

Gypsy Moth Internet Resources

The Gypsy Moth in Virginia
www.gypsymoth.ento.vt.edu/vagm/

USDA Gypsy Moth Handbook
www.fs.fed.us/na/morgantown/fhp/gm/gmhb.htm

Pest Alert — Gypsy Moth
www.na.fs.fed.us/spfo/pubs/pest_al/gm/gm.htm

Gypsy Moth Informational Guide
www.gypsy-moth.com

Ecology of the Gypsy Moth

Botkin, Daniel B., and Edward A. Keller. "Case Study: The Acorn Connection." In *Environmental Science*. 3rd ed. John Wiley and Sons, Inc., 2000, pp. 97-98 (pp. 95-96 in 4th ed., 2003).

Field Ecology Methods

Smith, Robert Leo. "Capture-Recapture Sampling." In *Ecology and Field Biology*. 5th ed. Benjamin Cummings, 1996, pp. 707-08.

Caterpillar Identification and Information

Caterpillars of Eastern Forests

www.npwrc.usgs.gov/resource/2000/cateast/cateast.htm

Tree Identification and Information

Tree Fact Sheets
www.cnr.vt.edu/dendro/dendrology/factsheets.cfm

Tree ID Key
www.cnr.vt.edu/dendro/dendrology/idit.htm

www.oplin.lib.oh.us/products/tree/

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Glossary

dbh (diameter at breast height)

The diameter of a tree 54 inches (4.5 feet, 1.4 meters) above the ground.

instar

A stage between molts (shedding of the exoskeleton to accommodate growth) of insect larvae.

pheromone

A chemical released in minute amounts by one animal that stimulates a response in another member of the same species. Insect sex attractants are probably the best-known examples of pheromones.