Student design of class experiments facilitates problem-based learning

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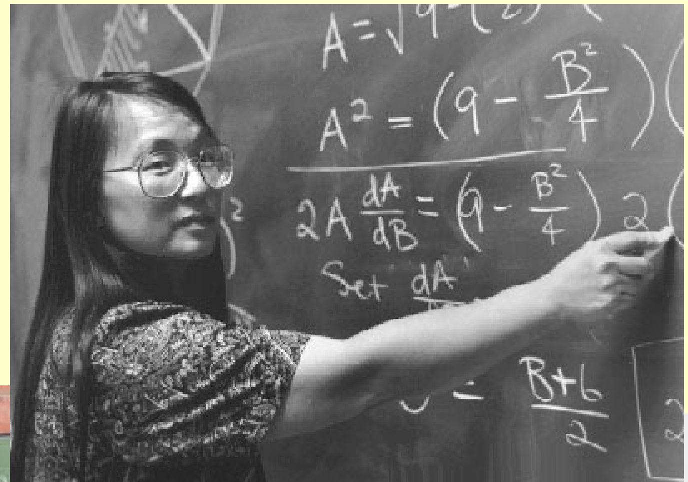
Students have little or no ownership in course structure or content



pcc.edu

paul-hummel.suite101.com

ehow.com

This is especially true when it comes to class experiments

Lab Experiment: How Do Different Host Plants Affect Population Growth of and Damage from the Twospotted Mite?

Background and Rationale: Different species and varieties of plants respond differently to the same pest species. For any given plant, there are two responses – both of which indicate its level of genetic resistance: (1) impact on pest population growth; and (2) plant susceptibility to injury (expressed as damage). Some plants are highly resistant; others are quite susceptible. The more susceptible a plant is, the greater the damage that results. Damage may be a combination of sensitivity to pest injury and numbers of pests that survive to feed on the plant. When dealing with a *polyphagous* pest like the twospotted spider mite (*Tetranychus urticae*), which is able to develop on hundreds of taxonomically unrelated plants, it is easy to assume that the damage caused by mites is equal -- that is, its *pest status* is the same. However, this may not be true because, even with pests that have a wide range of host plants, there will be differences in resistance. In our class experiment, we will test the hypotheses that twospotted spider mite populations respond the same to different plants, and that damage caused will be the same across all plant species.

Objectives of Experiment: To determine whether (1) population growth of the twospotted spider mite differs depending on plant type; (2) plant damage differs among plant species and cultivars; and (3) if plant damage is correlated with twospotted mite population numbers.

Materials and Methods: Five to six plants of each species (number and kind to be determined) will be planted during August and September with planting dates selected according to the germination and growth rates of the different plants. This may include lima beans (*Phaseolus lunatus*), on which the colony of pest mites is maintained. Each plant will be infested at the same time with 15 adult female twospotted mites. Thereafter, the class will take two kinds of data: (1) Weekly, *plant damage ratings* will be made by having pairs of students look at each plant and assign a **visual damage rating** numerically as follows: 1 = "no symptoms", 3 = "light infestation", 5 = "medium infestation", 7 = "heavy infestation". (2) At the end of the experiment (on or about October 11), leaves will be cut by a technician and **counts of spider mites** will be made. As soon as all the data are collected, we will distribute the mite count and plant damage data and answer questions about how to use the data to write up your lab report.

Results: Describe the important findings of the experiment. Do this by writing out answers to each of the following questions (write the question and then answer it):

1. Were there differences in plant damage among plant species?
2. If so, what was the order of damage, from least to greatest, among the plant species tested?
3. Were there differences in twospotted mite numbers among plant species and cultivars?
4. What was the rank order of mite numbers from fewest to most among the different plants?
5. How did plant damage correlate with mite numbers? That is, did the plant species/cultivar with the greatest damage also have the most mites? And, did the one with the fewest mites have the least damage?

Note: When you answer your questions, you need to explain why you said "yes" or "no" using data that you will organize in tables and/or graphs!

Biological Control
ENTOM. 820

Why do class experiments?

- Demonstrate where scientific knowledge comes from

- Increase students' ability to think logically and critically

- Preparation for graduate school

How well do we accomplish these goals?

- Demonstrate where scientific knowledge comes from **Yes**
- Increase students' ability to think logically and critically **No**
- Preparation for graduate school **No**

Sequence of steps for experiments

1. Observation/ideas
2. Hypotheses/predictions
3. Objectives
4. Experimental design (essential part of materials & methods)
5. Data collection and analysis
6. Summarization and presentation of results
7. Interpretation, conclusions, relevance to literature (discussion)

Most student experiments limited to:

1. Observation/ideas
2. Hypotheses/predictions
3. Objectives
4. Experimental design (essential part of materials & methods)
5. **Data collection and analysis**
6. **Summarization and presentation of results**
7. **Interpretation, conclusions, relevance to literature (discussion)**

Student-designed experiments add missing steps

1. **Observation/ideas**
2. **Hypotheses/predictions**
3. **Objectives**
4. **Experimental design (essential part of materials & methods)**
5. Data collection and analysis
6. Summarization and presentation of results
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Student-designed experiment

Topic and background

Biological Control
Entom. 820

Spring, 2009
J. R. Nechols

1

Designing an experiment to test factors affecting foraging efficiency of a predatory mite

Background: Key questions to consider when releasing predators in an augmentative biological control program are: how many to release (in relation to the pest density)? when to release them? and where to make the releases? All three questions relate directly or indirectly to a consideration of the *foraging efficiency* of the predator which, in turn, may be affected by a number of biotic environmental factors including (1) **prey density and/or distribution**, (2) ***plant* density and/or distribution,** and (3) **plant architecture** (macro and micro).

All of these factors have **spatial characteristics** and they can usually be manipulated experimentally to determine their impact on foraging (prey-finding) so that adjustments can be made to improve effectiveness of biological control. These modifications often involve altering the numbers of predators or parasitoids released, or their distribution pattern taking into account plant spacing patterns (which vary dynamically during plant growth). **Your assignment is to design an experiment to evaluate if/how *prey distribution* and/or *plant density/distribution* affects predator foraging efficiency.**

We will use the predatory mite, *Phytoseiulus persimilis*, an important biological control agent of its principal prey, the twospotted mite, *Tetranychus urticae*. We will use lima bean as the host plant. Choosing among the available resources, and using the constraints and guidelines below, each of the two class groups will (1) independently develop an experimental design, (2) prepare a PowerPoint, and (3) present it on **FEB. 25.** As a class we will discuss and critique each proposal and then decide on which one (or possibly a merger of the two) to do for our experiment.

Groups:

- German, Ian, Poornima, Paola, Nick
- Altair, Wendy, Predeesh, Shannon

Resources available, constraints, and schedule:

- A small greenhouse (208 sq. feet) that contains *one* long bench, ca. 45 x 240 inches (114 x 610 cm).
- Lima bean plants (3-4-leaf stage) grown in 6-inch diameter (~15-cm) pots will be available.
- Depending on how you space the plants, you will be able to fit between 24 and 36 plants on the bench. (This is important because it restricts the number of treatments and replications in your design!)

Continued next page

- At the time the experiment begins, we can arrange for some plants to be inoculated with twospotted mites and others to have no mites. (This will depend on your experimental design.) Mites will be placed on plants early enough to establish a population that will be moderately small when the experiment begins (March 11).
- The predatory mite will be purchased and released at the beginning of the experiment. Based on previous research, predators will be released at a 1:10 predator-to-prey ratio.
- We will *collect data* on March 23 (just after spring break) and possibly earlier. We may conclude the experiment by March 25 or decide to extend it depending on how things proceed. Question for you: *What kind of data should be collected to evaluate predator foraging efficiency?*

Proposal: Your proposal should include the following:

- Title
- Objectives *and* hypotheses
- Treatments and control(s)
- Experimental design and/or proposed spatial layout
- Procedures (including data to be collected) & additional materials needed
- Expected results

*Each group should meet one or more times, and you may wish to communicate electronically using a **K-State Online Group.** Come up with a proposal to present and discuss during lab on Feb. 25. You can present the proposal in any format you would like – PowerPoint (preferred), transparencies, etc., as long as it can be viewed by everyone.*

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I would like a copy of each group's PowerPoint proposal. It is worth 60 points.

Student-designed experiment

Resources, constraints, schedule

Biological Control
Entom. 820

Spring, 2009
J. R. Nechols

Designing an experiment to test factors affecting foraging efficiency of a predatory mite

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Student-designed experiment

Groups assigned

Biological Control
Entom. 820

Spring, 2009
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Groups develop proposals

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Effect of prey distribution and predator-to-prey ratio on the foraging efficiency of *Phytoseiulus persimilis*

Group Presentation by:

Altair, Predeesh, Wendy and Shannon

Class Experiment

- **Objective:** To evaluate how the prey distribution and predator-to-prey ratio affects the foraging efficiency of the predatory mite *Phytoseiulus persimilis.*

Background

- Few studies have successfully shown the stability of predator-prey systems in relation to spatial variation in prey density patches (Berstein 1984).

- This study is important for enhancing the role of predatory mites in biologic control by assessing the capacity for individual or small numbers of predatory mites to stabilize pest populations.

Hypothesis

- *P. persimilis* will consume different number of prey according to their distribution;
- Change in the predator-to-prey ratio will eliminate, or at least, modify the rate of prey consumption in the different levels of prey distribution.

Experimental Design

- Treatments: four treatment groups, three plants in each group, arranged with touching foliage

  Treatment1: clustered prey release distally to 1 predator

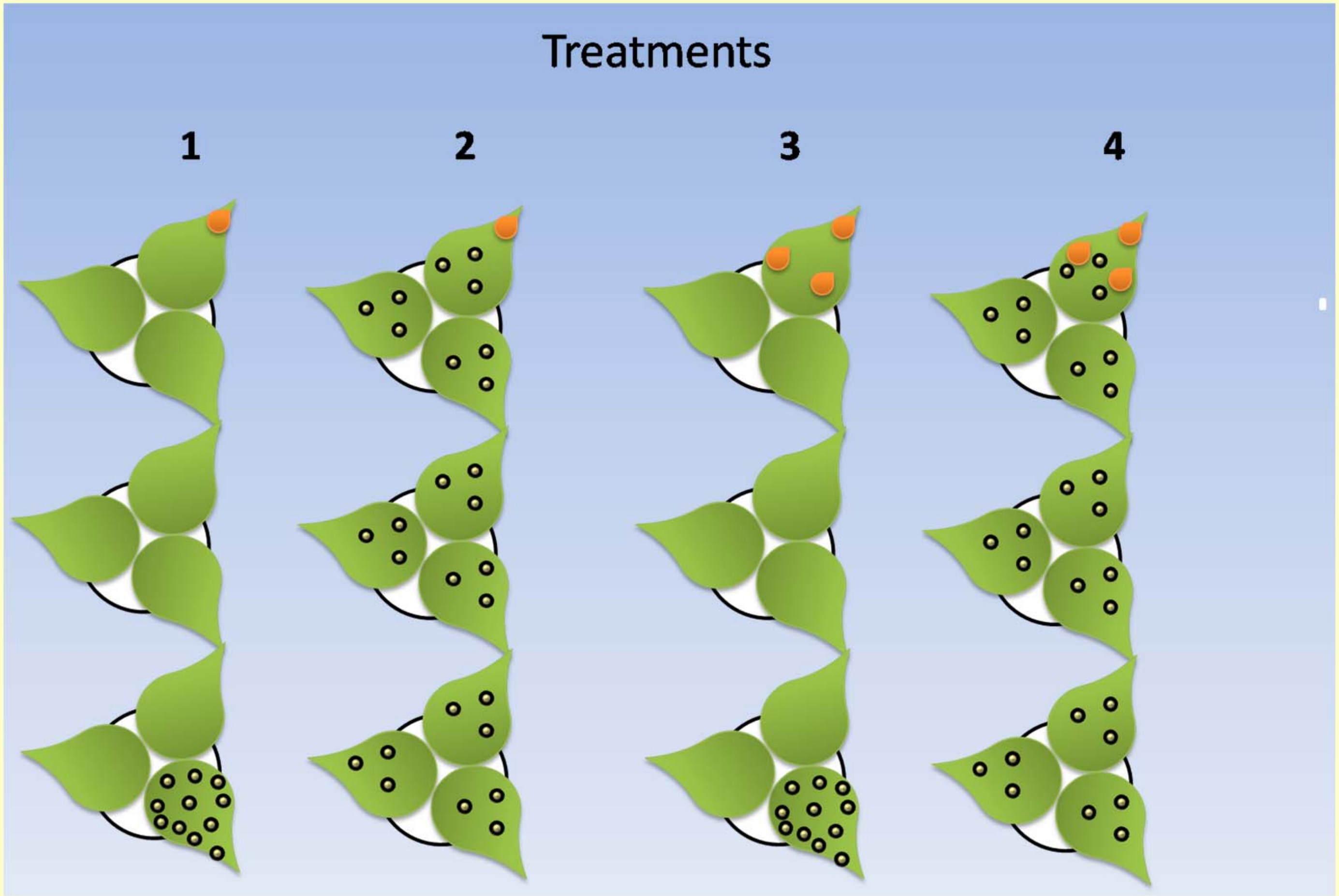
  Treatment2: uniform prey release with 1 predator

  Treatment3: clustered prey release distally to 3 predators

  Treatment4: uniform prey release with 3 predators

- Measure prey remaining at two time points over 12 day (day 3, day 12) experiment

Experimental Design



Experiment Evaluation

- Data collection: prey remaining at end of 12 days will describe how well predators suppress variable prey densities
- Data analysis includes ANOVA on treatment groups and can separate means from sampling time points for each treatment with REPEATED MEASURES model to account for difference in time

Expected Results

- We expect that, the number of prey remaining in each treatment will be different. More prey will be consumed when they are close together (clustered distribution), but when the predator-to-prey ratio is reduced this effect will be reduced or even canceled.

Student-designed experiment

Presentations and peer review

- Groups critique each other’s designs, ask questions
- Instructor facilitates discussion

Student-designed experiment

One experiment chosen

- Groups critique each other's designs, ask questions
- Instructor facilitates discussion
- Often, predictions, treatments, data to be collected, etc. merger of different proposals

Student-designed experiment

Class experiment done

- Groups critique each other's designs, ask questions
- Instructor facilitates discussion
- Often, predictions, treatments, data to be collected, etc. merger of different proposals
- Data shared; individual student reports written

What are the benefits of student-designed experiments?

providence.edu

What are the benefits of student-designed experiments?

- Challenges thinking about underlying questions and predictions

- Sharpens problem-solving skills:

  How to design an experiment capable of testing your predictions
  (What treatments and controls? What responses should be measured?)

  How to compose a good *technical* design

- Actual outcomes (results) are compared to your own predictions
  vs. someone else's

Benefits of team approach

- Experience working collaboratively

- Shared ideas (stimulates thinking)

Challenges for undergraduate classes

queensjournal.ca

- Adequate student preparation (scientific method)
- Academic maturity (foundational knowledge to ask questions and develop experimental design)

Questions?