How does Plant Richness Influence Arthropod Richness and Abundance?

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Grades: Middle and High School

Observations:

Many arthropods (invertebrate animals with an exoskeleton, such as insects, spiders, mites, centipedes, etc) use plants for food and shelter. Areas that have a greater number of species of plants, such as natural areas (Fig. 1) and gardens, seem to have more arthropods than areas that have few species of plants, such as agricultural fields (Fig. 2) and grass lawns.

Question: Does the number of plant species in an area influence the number of arthropod species and their abundance?

Hints to form the hypothesis:

Herbivorous arthropods may eat one plant species (specialists) or eat a variety of plant species (generalists). Areas that have a diversity of plants may provide more food for specialist and generalist herbivores. Arthropod predators often prey on insect herbivores, so predators may be more abundant where there are many herbivores. Arthropods also find shelter in a variety of plant parts.

Hypothesis:

Arthropod richness (the number of species) and abundance (number of individuals of each species) will be higher in diverse plant communities because of the availability of a greater variety of food and shelter.

Materials:

- At least three plastic yellow bowls (Yellow is attractive to many types of insects and other arthropods and they are drawn to the bowls)
- A one meter long piece of string
- An instruction and plant data sheet (Table 1)
- At least three plastic containers with lids (use peanut butter jars or other containers from home)
- Water, table salt, dish detergent
- A hand lens or dissection microscope (Fig. 3 shows a sample packet of materials).

The Experiment:

Student fills each plastic yellow bowl with one cup of water. Stir two teaspoons of salt and a couple drops of dish detergent into the water. Student places their bowls outside in areas with a low number of plant species, medium number of plant species, and a high number of plant species. With the help of a parent, measure how many plant species are within one string-length of the bowl. Parents hold one end of the string at the bowl and the student holds the other end. Holding the string taunt, students walked in a circle around the bowl and count the number of plant species the string passes over. Record data on the instruction and data sheet (Table 1). Leave bowl in place for 24 hours. After 24 hours, pour the contents of the bowl into a plastic container with a screw lid.

Once inside, student pours a small amount of sample back into their yellow bowl. Using a hand-lens or microscope, count the number of different kinds of arthropods (for older students, group arthropods by major categories, as in Table 2) and the total abundance of arthropods (i.e., number of individuals of all species or taxa), empty the yellow bowl, and pour more sample into their bowl. Continue this process until the entire sample is sorted. Enter all data into a computer program with graphing capabilities, or hand draw a figure showing the richness and total abundance of arthropods versus plant richness. The data can be graphed as a bar chart showing the number of arthropods in each habitat, or if you sample a large number of habitats, use an xy scatter graph, as shown in Fig. 4 (the regression line is not necessary, but does show the general trend in the data – Microsoft Excel provides an option in their graphing tools to insert this line).

Results: Present the results in a chart (Fig. 4)

Discussion:

Discuss whether the data do or do not support the hypothesis, focusing on whether species richness and abundance of arthropods increases or decreases with species richness of plants. Formulate follow-up questions and hypotheses if possible. For example, how do you think modifying habitat for human uses (agricultural and urban areas) influence arthropod richness and abundance? What can we do in human-modified areas to increase arthropod richness? Were there any specific types of arthropods most attracted to the yellow bowls? Are there certain kinds of arthropods that we may not catch with yellow bowls (such as those that live in leaf litter)? What methods can we use to sample a greater variety of arthropods?

Expanding the project for older students:

1) Plants from a larger area than a one-meter string length around the bowl will likely affect arthropods, so you can expand the area that is sampled by lengthening the string.

2) Arthropods can be grouped in numerous ways depending on the level of specificity desired. One way to group arthropods is into orders based on morphology (Table 2). A morphological grouping exercise would be suitable for high school students to learn how to distinguish among arthropod orders. Consult your local extension agent for help.

3) Advanced secondary classes can also sample a broader array of insects if they used yellow sticky cards, pitfall traps, or Berlese funnels in conjunction with the yellow bowls.

References:

A quick way to identify common insect orders:
http://gk12calbio.berkeley.edu/lessons/less_quickinsect_id.html

Easy key to insect orders: http://www.sci.sdsu.edu/classes/bio462/easykey.html

Estimated time required: Two to three 43-minute class periods

Cost: Less than $1.00 per student

Contact: For questions concerning the project please contact the author- Matthew Richardson at Matthew.Richardson@ARS.USDA.GOV

Table 1. Instruction and data sheet.

1. Fill each bowl with one cup of water and add a couple drops of dish detergent and 2 teaspoons of salt.
2. Place bowl(s) anywhere outside of your house.
3. With the help of a parent, measure how many plant species are within a string-length of the bowl. Parents hold one end of the string at the bowl and students will hold the other end. Holding the string taunt, students will walk in a circle around the bowl and count the number of plant species the string passes over. Record data below.
4. Leave the bowl outside overnight.
5. Pour the water, salt and insects into the plastic container and bring the container, bowl, string, and this instruction sheet to school.
How many different kinds of plants are there? _____

Table 2. Common Arthropods caught with Yellow Bowls.

Common Name	**Order**	**Description**
Spiders	Araneae	Eight legs, no wings
Beetles	Coleoptera	Hard elytra
Springtails	Collembola	Minute & wingless
Earwigs	Dermaptera	“Pincer”-like cerci
Flies, gnats, mosquitoes	Diptera	Only order with 2 wings
Leafhoppers, planthoppers	Hemiptera	Wings half hard, half membranous
Aphids	Homoptera	Small, with cornicles
Wasps (many small parasitoids), bees, ants	Hymenoptera	Usually with a constricted “waist”
Moths, butterflies	Lepidoptera	Scale-covered wings
Lacewings	Neuroptera	Clear, vein-filled wings
Harvestmen	Opiliones	Like spiders, often called daddy longlegs
Crickets, grasshoppers, katydids	Orthoptera	Long hind legs for jumping

Figure 1. A natural area with a high species richness of plants.

Figure 2. An agricultural area with a low species richness of plants (soybeans in foreground, corn in background).

Figure 3. Packet of materials sent home with student to collect arthropods (yellow bowl, plastic container with lid, instruction and data sheet, a 1-m long piece of string, and a plastic bag to carry the materials).

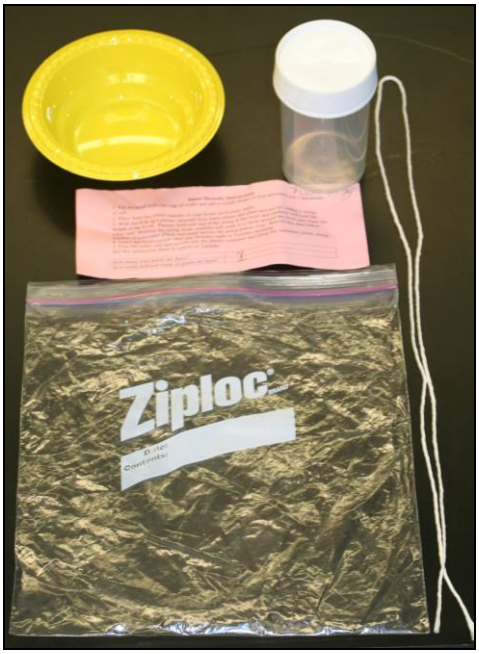
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Figure 4. Sample Student Graphs
a, Arthropod Richness versus Plant Richness **b,** Arthropod Abundance versus Plant Richness.