Chapter 13

Investigations of Relationships among Wetland Organisms Using Pickle Jar Aquaria

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Contents

Introduction

A field trip to a local marsh and a semester-long study of aquaria in the laboratory introduce beginning biology students to some wetland organisms, basic ecological concepts, and the process of scientific inquiry. This project also incorporates a library research project that introduces students to basic biological reference sources and information search strategies.

The aquaria are one-gallon pickle jars filled with samples of water, sediment, and organisms collected at the marsh. They become model ecosystems which give students the opportunity to witness changing spatial and temporal relationships. As students become familiar with their pickle jar ecosystem they must find something which piques their curiosity, form a question, and conduct and report the results of an investigation to answer that question. They work in teams of three and must decide what constitutes an appropriate question for investigation, devise appropriate sampling and data collection techniques, draw conclusions from data, and communicate their ideas and conclusions (supported by evidence) in class discussions and in a written report. In the process they experience some of the same problems and frustrations ecologists and other scientists experience during an investigation. For example, poorly formed questions or the untimely death of a key organism in the investigation lead to dead ends. Limited access to the system in terms of time or equipment available places practical constraints on the types of questions they can ask and how much information they can collect. As the semester progresses they understand more about ecological relationships. Subsequently, their view of the model system changes and leads to the "if-I-knew-then-what-I-know-now" sentiment about their investigations. Another result of this process is that students gain some sense of the collegial nature of science. In addition to working as a member of a research team, students conduct a library research project on one of the key genera in their investigation. Each student then has the opportunity to become the class expert on a particular genus. Students are encouraged to consult one another as questions arise.

The staff function primarily as guides and resource people in the process. Students tend to be intimidated by the expectation that they must ask their own questions and find their own answers. Though most have no specific experience with ecological investigations, common sense and prior knowledge should help them recognize that there are physical, chemical, and biological factors which affect what happens in their pickle jars. We lead brainstorming sessions to help elicit questions that result when they consider such factors. Students tend to believe that their personal observations have little value. We try to give students confidence that they can learn much from information gathered directly with their own senses (smell and touch as well as sight). We also try to help them value the learning that occurs when they experience the inevitable dead ends, mis-starts, ecological catastrophes, or dumb mistakes. Finally, we encourage them to consider the larger implications of their results, to see differences between the pickle jar environment in the lab and the natural environment, and to consider how their findings relate to the pickle jar system as a whole and to the wetland from which the organisms were collected.

The project occupies two 1-hour discussion sections and two 3-hour laboratories at the beginning of the semester. They also spend approximately 20 minutes per week during subsequent weeks recording observations, ideas, and new questions. These are submitted to teaching assistants and checked off as completed. Early in the semester they are occasionally reviewed for progress. Students submit interim reports half-way through the semester which are peer reviewed and then graded by the teaching assistants. An additional 3-hour laboratory period is devoted to sharing information and preparing for the final paper.

Materials

For the whole class:

Plankton net
Trowel or small shovel for getting bottom mud
A collection of sampling devices, such as tiny strainers made from 95 μm mesh, zooplankton counting wheel, 10 ml Pipetman, turkey baster
Well-lit environment in which to store the jars, either sunny windows or a bank of fluorescent lights. (It is desirable, but not essential, to be able to maintain the temperature at 15°C.)
30 cm forceps (3)
5 gallon plastic carboy for extra marsh water

For each team of three students:

Chest waders (optional)
Aquatic net
Plastic pail
Various sizes of jars for holding organisms in the field
One gallon glass jar to use as aquarium
150 mm plastic petri dish to use as a jar cover
White enamel or plastic tray
Dissecting microscope
Depression slides, watch glasses, and/or small petri dishes for observing organisms with microscope
Hand lens
Clear plastic ruler

Student Outline

Overview

We begin this project with a field trip, which has two purposes. The first is to observe some of the habitats along the shallow water zone of Lake Mendota and a nearby marsh and to become acquainted with the communities of organisms within them. The second is to collect material for establishing aquaria which you and fellow team members will observe throughout the semester. After spending a few weeks getting to know your ecosystem and the organisms within it, you will investigate some aspect of the relationship between two or more of the organisms. This is a major project for this course and we will spend a lot of time trying to understand what is happening in these model ecosystems.

Background

An *ecosystem* is a higher order biological system made up of a number of different species of organisms, each represented by a population of given size and density, living together and interacting in a setting of certain underlying physical and chemical conditions (the inorganic environment). Lake Mendota can be considered an ecosystem; it is a natural basin of particular dimensions, lined with mineral materials of particular composition and filled with fresh water. It is exposed to a particular regime of temperature-change and sunlight. In this setting lives a *community*, a system of interacting populations of a large number of species of organisms. The Lake Mendota community is comprised of at least several hundred different species (rooted aquatic plants, microscopic algae and crustaceans, insects and other invertebrates, fish, turtles, and other vertebrates) which possess specific adaptations to the properties of fresh water. Other ecosystems may be much more or less extensive than the lake. The entire biosphere is an ecosystem, as is a single rotting log on the floor of a Wisconsin woodlot with its constituent populations of bacteria, fungi, wood-boring insects, mites, centipedes, and salamanders, as is the pickle jar aquarium you will set up with water, mud, and organisms collected during the field trip to the marsh.

The community of organisms in any ecosystem has a particular structure in time and space. It consists of a particular number of particular species, each represented by a population of particular size, all in a more or less stable configuration. If the community is disturbed in some way, it will respond to the disturbance either by returning to its previous state or, if the disturbance is great enough, by shifting to a new stable configuration. Keep these ideas in mind to help you make sense of your pickle jar observations during the next few weeks.

Observations in the Field (Week 1)

From a human perspective the lake may look like one uniform habitat. To organisms residing there it is not. For example, the area of shallow water close to shore, known as the *littoral* zone, is characterized by rapid changes in water depth with distance from shore. Other factors, such as strength of wave-action, intensity of light at the bottom, and water temperature, are correspondingly quite variable. Such variation in the physical character of this area offers a wide range of different living conditions for organisms. It supports a wide variety of species, grouped into zones in water of different depths: a zone of *emergent* vegetation (cattails, sedges, bulrushes), of vegetation with floating leaves (water lilies, lotus), of *completely submerged* rooted vegetation (pond weeds, wild celery), each of these areas with its own numerous characteristic species of animals. Our explorations and collecting activities will be limited to the shallow shoreline waters in University Bay and the marsh. Take a few minutes and try to identify the zones of emergent, floating, and submerged vegetation in the bay and the marsh. How are the zones arranged in relation to the shoreline?

Assignment

After reading the above descriptions and some further background information in your text, you should have a sense of what we are referring to when we speak of an ecological community. While in the field this week, make notes and diagrams to define the community we visit. We will follow up on this in discussion sections next week.

Procedure for Collecting Materials and Setting Up Your Own Ecosystem (Week 1)

Work in teams of three.

In the Field

There will be an assortment of containers and nets available to take samples of many different kinds of biological materials. The entire class will act as a unit to collect the following materials to be used back at the lab to set up an aquarium for each team:

1. lake water
2. plankton, obtained by towing a fine-meshed net through the water
3. aquatic plants and the organisms attached to them, both free-floating kinds, such as duckweeds and coontails, and rooted kinds, such as pondweeds, wild celery, and water lilies
4. samples of mud, sand, and small stones
5. other organisms obtained by using nets or hands, such as aquatic insects and snails.

Certain precautions should be taken to keep materials in good condition:

1. Don't crowd things; don't pack too much in any one container; use plenty of water.
2. Keep things wet.
3. Avoid overheating the material; keep it in a cool and shady place.
4. Provide some light and oxygen. Do not close containers tightly; allow free exposure to air.

Back at the Lab

Set up your team's aquarium as soon as you return to the laboratory. This will allow you to start with material that should still be in good shape. What you choose to include in the aquarium is up to you and your team members, but keep in mind the hints below for maintaining the organisms in good condition. Although there will not be sufficient time for you to analyze the starting materials the first week, you should try to make enough notes so that the following week when you do analyze the organisms present you have a good idea of what you put in. Note the temperature and lighting conditions as well as the appearance of your ecosystem so that you can compare this with how it looks next week.

Strategies for Success

While every one of the pickle jar ecosystems is unique and we cannot guarantee a particular outcome, we have found over the years that certain approaches keep more organisms alive longer.

1. Avoid crowding. The most common mistake students make is to put too much material into the jar. When plants are crowded, they cannot get enough light and soon die. Bacteria feeding on the decaying plant material use up a lot of the oxygen, which leads to animal death. One gallon is a very small volume and it cannot support more than two large (10 cm) or four small (3 cm) plants.
2. Add no more than one large carnivore. Top predators like fish and dragonfly larvae are voracious. Consider carefully whether you want one in your jar at all, and certainly add no more than one.

3. Limit the amount of mud added. While marsh mud is a good source of nutrients and organisms, too much can lead to a eutrophic system. A 2- to 3-cm layer is sufficient. If it seems to coat the plants in the initial set up, be sure to shake it off them so that it doesn't block their light.
4. Maintain your ecosystem at 15°C. In previous years, we have given students a choice of a "summer" (23°C) or a "fall" (15°C) temperature. Jars at the cooler temperature generally maintained a higher diversity of organisms, so this year we are strongly recommending that you keep your jar in the 15°C room.
5. Give the plants plenty of light. Be sure your jar is positioned directly under a light and that jar covers are transparent.
6. Cover your jar with a petri dish. This cuts down on evaporation, keeps organisms in the jar, and allows exposure to fresh air and light.

Observations and Questions (Week 2)

One of our objectives with this project is to help you understand how much you can learn by carefully observing, thinking, and questioning. We also encourage you to have confidence that your observations can yield meaningful information. When you come back to the lab the second week, begin by spending some time observing and discussing your jar with your team members. We want you to enjoy this experience and to have some time just to wonder about what is going on in your jar. If questions arise at this time, jot them down in your notebook. You may want to return to them later when we spend some time as a large group brainstorming questions which we might be able to answer by observing life in the pickle jar.

After observing and discussing your ecosystem, record descriptions and make diagrams in your lab notebook of the starting conditions (physical and biological) in your pickle jar. Incorporate information noted last week when you set up the ecosystem. Who are the community members of your pickle jar? A hand lens and microscope will help you observe some of the organisms. The staff will help you use the *Key to the Common Aquatic Invertebrates of University Bay* (Appendix B) and other reference materials to identify and help you prepare an inventory of the organisms in your jar. (See the *Further Reading* section below for a list of references.)

You will have approximately two hours to analyze the contents of your pickle jar. Then we will spend a short time brainstorming questions which might be interesting to answer over the next few weeks. Remember that the focus is relationships; therefore your questions should involve more than one organism. After the brainstorming session, you will get together with your team to discuss those questions that most interest you and to think about ways that you could set about answering them. Begin thinking about methods for counting or measuring the numbers of individuals or growth of the organisms upon which you would like to focus. Keep track of all your questions and ideas in your lab notebook. It is important to have several ideas because you may find that some questions cannot be answered with this system or with the time and resources available.

Subsequent Observations and Assignments (Weeks 3–9)

Although we will be beginning other projects by week 3, you must continue to spend some time on your ecosystem each lab period. By week 4 you should be in a position to begin your investigation of relationships among some of the organisms which comprise the ecosystem.

Ecosystem reconnaissance (weeks 2–4)

Devise measurement and sampling procedures and get to know what is present in your system. You should develop a sense of the variation occurring with repeated observations of the same organisms. In order to do this you must make careful quantitative observations of as many of the organisms as you can detect. By the end of the 4th week, your team must pose a specific question to investigate and hand this in. Each project must include at least two organisms which interact with each other.

Acquisition of data to investigate your specific question (weeks 5–9)

After the weeks spent getting to know your ecosystem, you will focus on a specific question and the observations and data you need in order to explore it.

Weekly Pickle Jar Notes (due at the end of each week's lab)

Pickle jar notes are on-going records of your observations and ideas. There will be time during the normal lab period to meet with your team and to observe and discuss your ecosystem. Record your observations and ideas and try to figure out what is going on. Compare your observations with those of the preceding weeks. Note any new questions that come to mind. Keep the original in your notebook and turn the carbon copy in to your TA at the end of the lab.

Interim Report (due in discussion week 6) and Final Report (due in lab week 11)

The interim report is intended to summarize your progress in making observations and collecting data that allow you to understand relationships within your ecosystem. It should help you focus on a particular question or relationship and can serve as a draft for your final report. The format is described below and closely follows that used by scientific journals. We encourage you to use discussions with your lab partners and your TA to develop and critique your ideas, but you must write your reports on your own. Please turn in two copies of your interim report, one for your TA and one for a peer reviewer.

Format for Aquatic Ecosystem Laboratory Reports

We want you to organize your report following the format used by scientific journals. Each of the headings below (except for Title) should head that particular section of your report.

Title (a clear statement of the subject of your report)

The title should be specific and descriptive. (Aquatic Report is not a good title.) Here are a few examples taken from the ecological literature:

How Honeybees Find a Home
A Quantitative Study of the Larger Aquatic Plants of Lake Mendota
The Effect of Fire on Woody Plants in the Tall Grass Prairie
Gap Phase Replacement in a Maple-Basswood Forest
Comparison of Prairie Species in Glaciated and Unglaciated Regions of Ohio
Demonstration of the Antagonistic Action of Large Aquatic Plants on Algae in a Florida Lake

Introduction (framework)

Introduce the project in general as well as the topic upon which you will focus. List the major players. Give details about the wetland from which your samples were collected. Include other information a biology student not taking this course would need to know to understand the rationale behind the project and your results. Since you will focus your report on one or more organisms or themes, it would be appropriate to introduce relevant background information about them here. Your experience with the computerized card catalog, reference sources in the biological sciences, and search strategies should help you locate any additional background information needed for this section.

Methods (what you did)

Briefly describe the methods you used for collecting organisms and setting up the jar. Relate the conditions under which your jar was maintained and explain the methods you used to make observations, sample the ecosystem, and collect data. There should be enough details that the reader could repeat what you did.

Results (what you saw)

Present quantitative data from your weekly notes in tables and graphs. Each table and graph should be clearly labeled with a number and a descriptive title. Prepare a narrative overview of relevant information contained in your weekly notes. Refer to the tables and graphs in the text and alert the reader to key trends or specific results which will provide supporting evidence for conclusions you present in the discussion section. What have you learned about the issue and the organisms involved? Be as specific as you can. Perhaps, in thinking about the project for your interim report, you realize that there are particular data you wished you would have kept track of. Mention that here. Where appropriate, begin collecting such data now even though you will not have records for the first part of the semester. Under no circumstances should you even consider making up the missing data. That is scientific fraud and academic misconduct.

Discussion (what it means)

In the Introduction, you raised an issue or question. In the Discussion you should tell the reader what you conclude from the results and explain the how the evidence lead you to a particular conclusion. This section is the place to include speculations about why things happened the way they did, but be sure to distinguish between things that you know and speculation about what you think may have happened. It is all right if you are not completely certain about a relationship. Tell the reader what you think is happening and give the evidence that led you to conclude this. If you included any data about physical factors in your observations, discuss how they relate to what happened. Discuss how your observations relate to the ecosystem from which the organisms were collected. Knowing what you know now about making observations and the pickle jar project, discuss any ideas you have about ways to approach the project or different questions you would like to ask if you were just starting it now.

Try to conclude with some general summary statement.

References (list of sources that you used for information)

Use the format shown below.

For books

Author's last name, Initials. year of publication. Book title. Publishing company, City, State.
Example: Raven, P. H. and E. B. Johnson. 1992. Biology, Third ed. Mosby-Year Book, St. Louis.

For journal articles

Author's last name, initials. year of publication. Article title. Journal title volume: pages.
Example: Van der Zouwen, W. J. 1982. Vegetational changes in University Bay 1966–1980. Wis. Acad. Sci., Arts , and Lett. 70: 42–51.

Notes for the Instructor

Week 1: Field Trip

We use the discussion section which meets before the lab to make sure everyone knows the logistics of the trip and also to go over field guides and how to use a key. As soon as the groups arrive at the marsh, team members pick up jars, buckets, nets, and waders. We give a brief overview of the marsh and point out some adaptations shown by wetland organisms, such as the spongy tissue in cattails which allows oxygen to get to root cells. Students spend most of the time there exploring and collecting organisms. We point out good places to look and how to sweep the nets along the vegetation just under the water surface to catch insects.

Back at the lab, students assemble their pickle jars, putting in whatever they choose. It is important that they do not to put in too much, which will result in a lot of death due to overcrowding. (See *Strategies for Success* above.)

Week 2: Analysis of Aquatic Material

Students spend the first part of the lab observing, identifying (usually to level of family), and wondering about the plants and animals in their jars. Useful keys and field guides are listed in the *Further Reading* section. They then brainstorm questions about the organisms and their relationships, first as a team and then as a large group. Each team must then come up with questions that they wish to investigate over the next eight weeks and decide on the data they need to collect or observations they need to make to help them answer these questions. They may decide to change their focus as they gather data, but we want them to begin posing questions right away.

Students have a difficult time getting involved in this project because most of them have not previously tackled anything so open-ended. They want us to tell them what to do. While we don't tell them what to do, we do try to steer them away from questions that are not likely to help understand relationships among the organisms, *e.g.*, questions such as, "What will happen if I add chemical X to the jar?" We added the information concerning strategies for maintaining diversity in the system, the brain-storming session to stimulate their thinking, and the three weeks of "ecosystem reconnaissance" to build their confidence and observational and sampling skills. A certain amount of anxiety and frustration is likely to remain with students until they have more experience with posing questions and gain more confidence in their own observations and data.

Some examples of questions are listed below.

1. Do two particular species in the jar compete for light/nutrients/prey? How do you know? How could you test this?
2. What does a particular species of insect/crustacean/mollusk eat? How do you know? How could you test your idea?
3. The composition of the zooplankton community changes over time - how is this is influenced by some biotic or abiotic factor?
4. How do closely related species (e.g., two species of water beetles) partition the jar so that all can coexist?
5. Why are certain organisms usually found in particular places in the jar?
6. Species X and Y seem to associate with each other? Why?

Week 9: Sharing Ideas from Observations and Library Research

As part of this project, students participate in a library workshop where they learn basic reference sources in the biological sciences and strategies for finding information using the computerized card catalog. They focus on one of the genera central to their investigation and answer questions about its life cycle and ecology. We then take time for them to share the information they have learned from their library research and their own observations and encourage them to ask questions of each other and to use each other as resources.

Acknowledgments

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Further Reading

Buchsbaum, R. 1976. Animals without backbones. University of Chicago Press, Chicago, Illinois, 391 pages.

Fassett, N. C. 1957. A manual of aquatic plants. University of Wisconsin Press, Madison, Wisconsin, 405 pages.

Hotchkiss, N. 1972. Common marsh, underwater, and floating-leaved plants of the United States and Canada. Dover Publications, New York, 124 pages.

McCafferty, W. P. 1983. Aquatic entomology: the fishermen's and ecologists' illustrated guide to insects and their relatives. Jones and Bartlett, Boston, Massachusetts, 448 pages.

Needham, J. G. and P. R. Needham. 1962. A guide to the study of freshwater biology. Fifth edition. McGraw-Hill, New York, 107 pages.

Pennak, R. W. 1989. Freshwater invertebrates of the United States. Third edition. John Wiley, New York, 628 pages.

Reid, G. K. 1987. Pond life. Golden Press, New York, 160 pages.

Welsch, J. 1992. Guide to Wisconsin aquatic plants. Wisconsin Department of Natural Resources PUBL-WR-173 92 rev., Madison, Wisconsin, 38 pages.

APPENDIX A
Preparation of Materials and Addresses of Suppliers

Gallon glass jars to use as aquaria: If you need only a small number of pickle jars, you may be able to have a restaurant or delicatessen save them for you. They can also be ordered (in lots of 100 only) from Continental Glass and Plastic Co., 841 West Cermak, Chicago, IL 60608, (312) 666-2050): Catalog no. BR1872, $2.16 each.

Plankton net: Carolina Biological Supply Co., 2700 York Rd., Burlington, NC 27215, 1-800-334-5551. Catalog no. F6-65-2160, $89 each.

Tiny strainers to use as sampling devices: You can construct these from 95 μm mesh, which is appropriate for most zooplankton (Carolina Catalog no. F6-65-222M), and a ring to hold the mesh made from a short length of PVC pipe. Cut the pipe with a hacksaw and stretch the mesh over it and clamp it in place with an adjustable steel hose clamp. (Pipe and clamps are available from hardware stores.)

Zooplankton counting wheel: Wards, P.O. Box 92912, Rochester, NY 14692-9012, 1-800-962-2260. Catalog no. 21W1084, $83.50.

10 ml Pipetman and tips: These are available from Rainin Instrument Co., Box 4026 Mack Road, Woburn, MA 01888-4026, 1-800-4RAININ, Pipetman, $279.50; tips, $43.50/box 200. Cut off the end of the tip to create a 5 mm opening.