Investigating Mosses and Lichens for Tardigrades: an exploration of an extremophile's ecological diversity

Jill Callahan, Brandy Garrett Kluthe, and Christina Mortellaro
Saint Peter's University, Jersey City, NJ

Abstract

This laboratory procedure uses an inquiry-based approach to give students experience developing a research protocol and hands-on practice with the scientific method. Student-designed, hypothesis-driven, research methods will allow students to develop their skills in project design, data collection, and analysis and allow for flexibility based on course content and academic level. This is ideal for a freshman level introductory biology course but can be scaled up to a higher-level course. The research organisms for this laboratory activity are tardigrades (water bears) which are ubiquitous organisms often found in the water layer that surrounds mosses and lichens. These hardy micro-invertebrates generally measure less than 0.5 mm in length and are extremophiles who survive a variety of environmental conditions making them excellent model organisms to study. The laboratory methods will give students practice in sample collections and introduce or reinforce their skills using a microscope to search for and view the organisms. This simple, inexpensive exercise focuses on developing a hypothesis and research method where students collect moss and lichen samples from a variety of locations. Instructors can also order specimens and set up several laboratory environments for student designed methods when outside collection is not feasible. Inquiry- based learning increases student engagement and has shown to have a positive impact on overall learning. This laboratory engages students in applying the scientific method to develop critical thinking skills and basic laboratory techniques.

Introduction

Tardigrades (also known as water bears) (Fig.1) are hardy micro-invertebrates within the phylum Tardigrada which generally measure less than 0.5 mm in length. They are excellent model organisms for students to study because they are extremophiles who can enter into cryptobiosis and survive a variety of unfavorable environmental conditions including lack of water, high and low temperatures, and radiation.(Carrero, 2019) There are approximately 1000 species of tardigrades. They are ubiquitous organisms found in most ecosystems. Tardigrades are often found in the water that surrounds mosses and lichens. (Garey, 2008)

In the outlined laboratory protocols, students will use iNaturalist and Google Earth to explore the global habitats of tardigrades and learn about their distribution. This will allow them to use that knowledge to help them plot areas for sampling. This approach will provide a high probability of finding tardigrades while using inquiry based discovery science to search for tardigrades in moss and lichen samples.

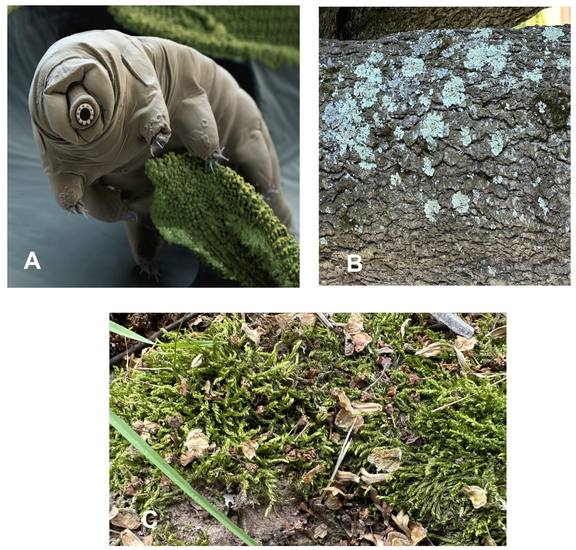

Figure 1a) Tardigrade SEM image b) Lichen on a Tree c) moss will serve as potential collection sites. (image A from https://www.nationalgeographic.com, image B and C were taken by J. Callahan)

Lab Objectives

In this lab you will investigate the microscopic world of mosses and lichens to search for Tardigrades. Tardigrades are tough micro-invertebrates found in many locations including your own backyard and on campus. They measure around 0.5 mm so you will need a microscope to view them. They can be found on the water layer surrounding mosses and lichens.
This lab will help you investigate these tiny creatures by learning about their global distribution, various ecosystems and through hands-on sampling at locations determined by the student through database analysis. Students will locate and and view prepared and collected samples through a microscope.

Objectives:

- To identify a variety of ecosystems that an extremophile could live in
- To utilize online databases to locate biological samples
- To identify geographical features of an ecosystem using online maps
- To develop a hypothesis and protocol based on ecological research
- Demonstrate proficiency in microscope techniques to locate organisms in a sample

Lab Part 1: Utilizing Digital Resources; iNaturalist and Google Earth

The first part of the lab will allow student to discover the diversity of habitats that tardigrades live in while also accessing and learning about a digital collection resource. They will begin by using iNaturalist to locate tardigrades in a defined area established by the instructor. From there they will determine some important factors about the sample location and add that to their data sheets. They will then dig in a litter deeper by taking the latitude and longitude coordinates and plugging them into Google Earth. This will allow them to visually see the type of area that the samples were collected from. Information like elevation, type of vegetation, distance from water will also be added to the data sheet. This will help them formulate and idea of where they could be successful in finding tardigrades themselves when they begin Part 2.

Figure2. . A) Lichen sample collection B) Isolated tardigrade

Lab Part 2: Isolation from Mosses and Lichens

Students will collect samples from mosses and lichens
1.Collect a small 5 cm square patch of moss or lichen from your sample and add to a plastic bag or other container..
2. Add 10 ml of spring or distilled water. Soak overnight (at least 12 hours) at room temperature.
3. The following day remove the patch of lichen or moss and squeeze out excess moisture.
4. Using a plastic pipette add a few drops of the mixture to a depression slide and view at 100X magnification
5.Photograph and/or videotape the tardigrades to examine shape and movement.

Resources

The resources for this lab will vary as it is modified but most things are likely already stocked in the laboratory with the exception of order tardigrade samples. Students will need a computer and internet access. The online database are free that are used in the first part. For the second part students will need to use a microscope, pipettes, distilled water, and plastic pipettes. Some students may prefer to wear gloves but that is optional as there are no harmful chemicals used in either protocol.

Discussion

The online database, iNaturalist, has been recognized as a valuable resource for biodiversity data and research, providing an active approach for students to engage with and learn about biodiversity (Niemiller et al., 2021) Online databases or data sets offer a flexible option for overcoming various challenges in incorporating inquiry-based learning into courses, have been previously utilized for examining a variety of biological data, and engage students in self-discovery, while developing observational and analytical skills.

In addition to online discovery, iNaturalist also encourages students to explore the natural world around them through inquiry (Eden, 2023). Outdoor field work has been shown to significantly improve students' attitude and knowledge towards biology, the natural environment, and persistence in the field. The unique experiences of outdoor field work through inquiry-based learning will provide an increased sense of belonging for students to their program of study and future careers.

References

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