Effects of Nitrates on Duckweed Populations

Topic

The size of a duckweed population is affected by levels of nitrates in water.

Introduction

Grassy parks, green lawns, and neatly clipped golf courses owe their vigor and rich color to fertilizers, nutrients that help plants grow. Most fertilizers contain three primary nutrients: nitrogen, phosphorus, and potassium. After a rain, fertilizer that has not been taken up by plants washes into nearby streams, rivers, lakes, and ponds. In these waterways, fertilizer has the same effects on water plants as it did on those terrestrial plants for which it was designed. However, fertilizer levels can accumulate in waterways and cause plant growth to become excessive.

One water plant that responds well to fertilizer is duckweed, or *Lemna minor*, one of the smallest flowering plants. These plants live in still or slow-moving warm water across the globe. A duckweed plant does not look much like a typical plant. It is a single lobe or frond (a leaf-like structure). Fronds often grow in clumps with roots hanging below (see Figure 1). In this experiment, you will raise duckweed in the laboratory and find out how different levels of nitrogen affect its growth.

Time Required

2 weeks

Materials

- 80 duckweed fronds
- 4 petri dishes
- 25 milliliters (ml) of nitrogen solution B

- 25 ml of nitrogen solution C
- 25 ml of nitrogen solution D
- 25 ml of tap water
- inoculating loop
- magnifying glass or stereomicroscope
- permanent marker or pen
- colored pencils
- graph paper
- grow lights or access to a sunny window
- science notebook

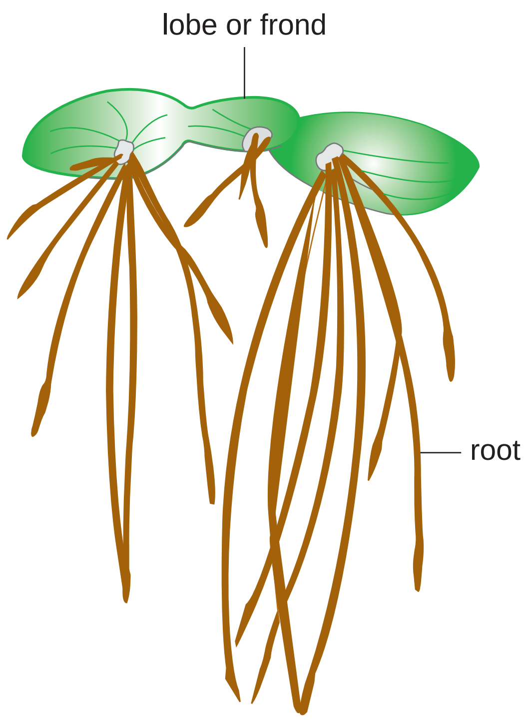

Figure 1

Duckweed plants

Safety Note **Please review and follow the safety guidelines at the beginning of this volume.**

Procedure

1. Label the four petri dishes as "A," "B," "C," and "D."
2. To dish A, add 25 ml of tap water. This will serve as the control in your experiment.
3. To dish B, add 25 ml of nitrogen solution B, which contains nitrogen at the recommend concentration for lawns and gardens.
4. To dish C, add 25 ml of nitrogen solution C, which contains nitrogen at half the recommended rate for lawns and gardens.
5. To dish D, add 25 ml of nitrogen solution D, which contains nitrogen at twice the recommended rate for lawns and gardens.
6. Use an inoculating loop to transfer 20 lobes or fronds of duckweed to each petri dish. A lobe is one plant, although lobes may be growing in clumps.
7. Place the tops on the petri dishes and set the dishes under grow lights or in a window where they receive plenty of light.
8. Each day for two weeks count the number of duckweed lobes in each dish. Record your counts on the data table. To count lobes:
   a. Use a magnifying glass or a stereomicroscope to view the plants.
   b. Count every visible lobe, even the tiny ones that are just beginning to grow from another lobe. The clump of plants that is made up of four lobes, shown in Figure 2, will give you some idea of how to count plants.
   c. If plant populations are extremely high, draw a four-quadrant grid on a piece of paper and place the grid under the petri dish (see Figure 3). Count the lobes in only one grid, then multiply your count by four.

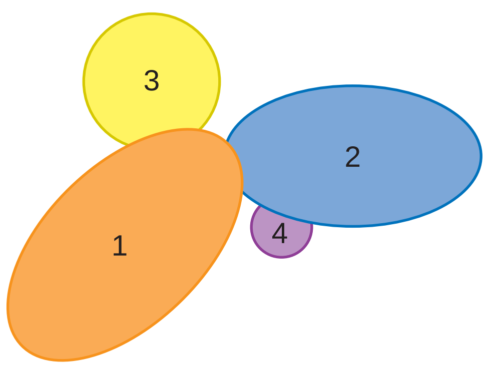

Figure 2
How to count duckweed lobes

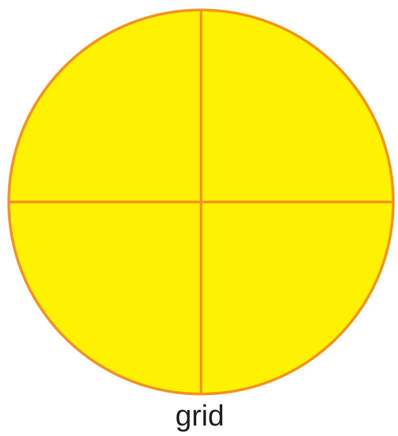

Figure 3
To be placed under petri dish

9. Graph your experimental findings. Place time (number of days) on the X-axis and number of lobes on the Y-axis. Use a different color pencil for each petri dish.

Data Table

	Number of Plants in Each Petri Dish			
	A	**B**	**C**	**D**
Day 1	20	20	20	20
Day 2				
Day 3				
Day 4				
Day 5				
Day 6				
Day 7				
Day 8				
Day 9				
Day 10				
Day 11				
Day 12				
Day 13				
Day 14				

Analysis

1. What nutrients are found in most fertilizers?
2. How do fertilizers enter waterways?
3. Describe the structure of one duckweed plant.
4. In this experiment, in which petri dish was duckweed growth the greatest?
5. How do you think that fertilizer runoff into waterways affects duckweed populations? Explain your answer.
6. Suggest some ways to reduce the problem of fertilizer runoff.

What's Going On?

Addition of nitrogen compounds to waterways increases the rate of plant growth. Duckweed is an *invasive species*, one that is not native to the United States and therefore has few natural consumers and diseases. Consequently, duckweed populations grow more aggressively than the native species. When nutrients and sunlight are available and the temperatures are warm, duckweed doubles its mass every two days. The plants quickly spread over the tops of ponds and streams, blocking the light and preventing it from reaching native species below. Such rapid overgrowth of any type of plant or alga in a waterway is known as *eutrophication.*

Even in locales that do not support duckweed, nitrogen in waterways causes problem. Since nitrogen increases the rate of plant growth, it causes water plants to grow rapidly until they form thick mats at the water's surface. When mats become too dense for sunlight and oxygen to penetrate, the plants die and sink to the bottom where they are broken down by oxygen-consuming bacteria. Fast-growing bacterial populations can quickly use up all the available oxygen in the water, depriving other living things of the oxygen they need to survive.

Connections

Natural eutrophication is a gradual process that occurs over decades as waterways age. However, problematic eutrophication occurs because of human activities that create runoff containing nutrients like nitrogen and phosphorus. Some of the primary sources of nutrients in waterways include farmland, sewage treatment plants, and erosion from farmlands and building sites. In a short time, nutrients accumulating in a body of water can destroy the ecosystem within it.

A classic case of eutrophication occurred in Lake Erie in the 1960s, when homes, shopping centers, and expanding farms developed quickly on the land surrounding the lake. With this development came increased runoff, which carried a heavy load of nutrients, especially nitrogen and phosphorus. In a short time, thick layers of water plants and algae developed in the lake then died and sank to the bottom, leading to the depletion of the oxygen in the water. Without this vital gas, animals and plants died. When putrid masses of dead organisms washed onto the shore, communities around the lake decided to make a change. Public concern led to the passage of the 1972 Great Lakes Water Quality Agreement between Canada and the United States. Controls on land use reduced the amount of nutrients reaching the lake, and the lake began to recover. Today, Lake Erie still has problems, but it is in much better condition.

Want to Know More?

See Our Findings.

OUR FINDINGS

EFFECTS OF NITRATES ON DUCKWEED POPULATIONS

Idea for class discussion: Discuss the concept of drainage basins with students. Explain how all of the land surrounding a body of water contributes to the runoff into that water. Have students suggest some problems that might originate in a waterway's drainage basin.

Notes to the teacher: Make three solutions of nitrogen fertilizer (ammonium nitrate is preferable) at different strengths. To prepare solutions, rinse out three 1-gallon jugs. Fill each with a gallon of water. Label the jugs "B," "C," and "D." To jug B, add the amount of fertilizer recommended on the box or bag. Mix the fertilizer with the water until completely dissolved. To jug C, add half the amount of fertilizer recommended. Mix the fertilizer with the water until completely dissolved. To jug D, add twice the amount of fertilizer recommended. Mix the fertilizer with the water until completely dissolved.

Analysis

1. nitrogen, phosphorus, and potassium
2. Fertilizers enter waterways through runoff from the drainage basin.
3. One duckweed plant is a single frond or lobe.
4. Answers will vary, but the best growth probably occurred in petri dish D.
5. Answers will vary. Increased levels of fertilizer will increase populations of duckweed.
6. Answers will vary but could include limiting the use of fertilizer near bodies of water and building erosion barriers to prevent materials from being carried to bodies of water.

SAFETY PRECAUTIONS

Review Before Starting Any Experment

Each experiment includes special safety precautions that are relevant to that particular project. These do not include all the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read and remain mindful of the General Safety Precautions that follow. Experimental science can be dangerous, and good laboratory procedure always includes following basic safety rules. Things can happen very quickly while you are performing an experiment. Materials can spill, break, or even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following the basic safety guidelines during the entire experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. For one reason, we want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical.

Read the safety precautions here and at the beginning of each experiment before performing each lab activity. It is difficult to remember a long set of general rules. By rereading these general precautions every time you set up an experiment, you will be reminding yourself that lab safety is critically important. In addition, use your good judgment and pay close attention when performing potentially dangerous procedures. Just because the book does not say “Be careful with hot liquids” or “Don’t cut yourself with a knife” does not mean that you can be careless when boiling water or using a knife to punch holes in plastic bottles. Notes in the text are special precautions to which you must pay special attention.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking an unnecessary risk can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone. When you are working off-site, keep in groups with a minimum of three students per groups, and follow school rules and state legal requirements for the number of supervisors required. Ask an adult supervisor with basic training in first aid to carry a small first-aid kit. Make sure everyone knows where this person will be during the experiment.

PREPARING

- Clear all surfaces before beginning experiments.
- Read the instructions before you start.
- Know the hazards of the experiments and anticipate dangers.

PROTECTING YOURSELF

- Follow the directions step by step.
- Do only one experiment at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure there is adequate ventilation.
- Do not horseplay.
- Keep floor and workspace neat, clean, and dry.
- Clean up spills immediately.
- If glassware breaks, do not clean it up; ask for teacher assistance.
- Tie back long hair.
- Never eat, drink, or smoke in the laboratory or workspace.
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult.

USING EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives or other sharp-pointed instruments with care.

- Pull plugs, not cords, when removing electrical plugs.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.
- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use alcohol-filled thermometers, not mercury-filled thermometers.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read labels carefully.
- Avoid chemical contact with skin and eyes (wear safety glasses, lab apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING SUBSTANCES

- Wear safety glasses, apron, and gloves when boiling water.
- Keep your face away from test tubes and beakers.
- Use test tubes, beakers, and other glassware made of Pyrex™ glass.
- Never leave apparatus unattended.
- Use safety tongs and heat-resistant gloves.
- If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it.
- Take care when lighting your Bunsen burner; light it with the airhole closed, and use a Bunsen burner lighter in preference to wooden matches.

- Turn off hot plates, Bunsen burners, and gas when you are done.
- Keep flammable substances away from flames and other sources of heat.
- Have a fire extinguisher on hand.

FINISHING UP

- Thoroughly clean your work area and any glassware used.
- Wash your hands.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Do not dispose of materials in the sink unless instructed to do so.
- Clean up all residues and put them in proper containers for disposal.
- Dispose of all chemicals according to all local, state, and federal laws.

BE SAFETY CONSCIOUS AT ALL TIMES!