

Four Cups of Duckweed: Which Resource Runs Out First?

Investigation question: When a real duckweed population gets light but no added nutrients, nutrients but no light, or everything it needs but a crowded start, how does it change over two weeks, and which resource limits each cup?

Classroom field investigation

Groups of 4

3 sessions

Setup 10 · Activity 75 · Cleanup 10 min

MS-LS2-1 · assesses

MS-LS1-5 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Cup keeper:** Sets up and labels the cups, measures water to the line, tops up evaporation on count days, and reads the thermometers in the light and inside the dark box.
- ☐ **Counter 1 (cups A and C):** Counts fronds with a toothpick and hand lens using the counting rule, and gives the color score and surface estimate for those two cups. Works fast on cup C so it spends as little time in the light as possible.
- ☐ **Counter 2 (cups B and D):** Counts the two fastest-growing cups, counting cup D one quarter at a time on the '+' paper, and gives their color scores and surface estimates.
- ☐ **Recorder and checker:** Fills the tables, recounts any cup whose number looks wrong, photographs the cups from above if a camera is allowed, and computes the growth factors.

Safety

- Fertilizer concentrate irritates eyes and skin and is harmful if swallowed. Only the teacher handles it, wearing goggles and gloves. The diluted nutrient water is still not for drinking; if it splashes in an eye, rinse with running water for several minutes and tell the teacher.
- Water that stands for two weeks grows bacteria and mold. Wash hands with soap after touching the cups, the water or the fronds. No food or drink at the lab table. Students with mold allergies can count from photographs instead of handling the cups at the end.
- Keep cups and water well away from the lamp, its cord, outlets and power strips. Dry your hands before touching the lamp switch.
- Spilled water is a slip hazard; wipe it up at once.
- Never pour duckweed down a drain or release it into a pond, creek or storm drain. It spreads quickly, and aquarium stock can carry snails, other plants or diseases into local water. Bag it and put it in the trash, or compost it at school.
- Cover each cup with the punched plastic wrap to keep out dust and insects; mosquitoes can breed in uncovered standing water.

Procedure

1. Session 1, day 0. Label four cups A, B, C and D. Measure 200 mL into each and draw the waterline with a marker: cup A gets aged tap water only; cups B, C and D get nutrient water.
2. Using a toothpick, lift healthy green fronds from the starter tub and float 10 fronds in cup A, 10 in cup B, 10 in cup C and 40 in cup D. Fronds often come joined in little clusters; count every frond in a cluster using the counting rule.
3. Record the day-0 count, color score and surface covered for each cup and the starting temperature. Then answer q1 and q2: predict how the cups will rank by growth and which resource might run short in each.
4. Cover each cup with punched plastic wrap. Set cups A, B and D side by side in the bright spot. Put cup C inside its box with the lid closed, right next to the others so it stays at the same temperature. Put one thermometer beside the cups and one inside the box.
5. Session 2, day 7. Read and record both thermometers. Count every cup (cup D one quarter at a time on the '+' paper), score color, estimate surface covered, and note roots, algae or anything unusual. Count cup C last and quickly, then return it to its box. Top every cup up to its line with plain aged water. If a camera is allowed, photograph each cup from directly above.
6. Session 3, day 14. Repeat every count and observation. Compute each cup's growth factor ($\text{day-14 count} \div \text{day-0 count}$), and for cups B and D the two weekly factors ($\text{day 7} \div \text{day 0}$ and $\text{day 14} \div \text{day 7}$).
7. Graph the number of fronds against day for all four cups on one set of axes, one color per cup, and draw a top view of each cup in the drawing box.
8. Add your four growth factors to the class table. When every group has reported, find the class median for each cup (list the values in order and take the middle one, or the average of the two middle ones).
9. Answer the analysis questions on your own.
10. Clean up: lift the fronds out with a spoon or pour each cup through a paper towel so no fronds reach the drain, bag the fronds for the trash or compost, pour the water into a sink, rinse the cups and wash your hands.

Record your observations

Lab 2 recording sheet: Four cups of duckweed

The four cups

Cup	Water	Light	Fronds at start	Differs from cup B in
A	Aged tap water, no added nutrients	Bright	10	Nutrients
B	Nutrient water	Bright	10	(reference cup: everything supplied)
C	Nutrient water	Dark box	10	Light
D	Nutrient water	Bright	40	Crowding: room, light and nutrients per frond

Counting rule and scores — A **frond** is one small, flat, oval green body. Count a new frond as soon as its outline sticks out past the edge of the frond it is budding from. Use the same rule every time. **Color score:** 3 = deep green, 2 = light green, 1 = yellow-green or yellow, 0 = white, brown or see-through. **Surface covered:** estimate the percent of the water surface hidden by fronds, to the nearest 10 percent.

1. Prediction on day 0: rank the cups from the one you expect to grow the most (largest growth factor) to the one you expect to grow the least, and give a reason for your top and bottom choices.

2. For cups A, C and D, name the resource you think will run short first, and say which other cup you must compare it with to find out.

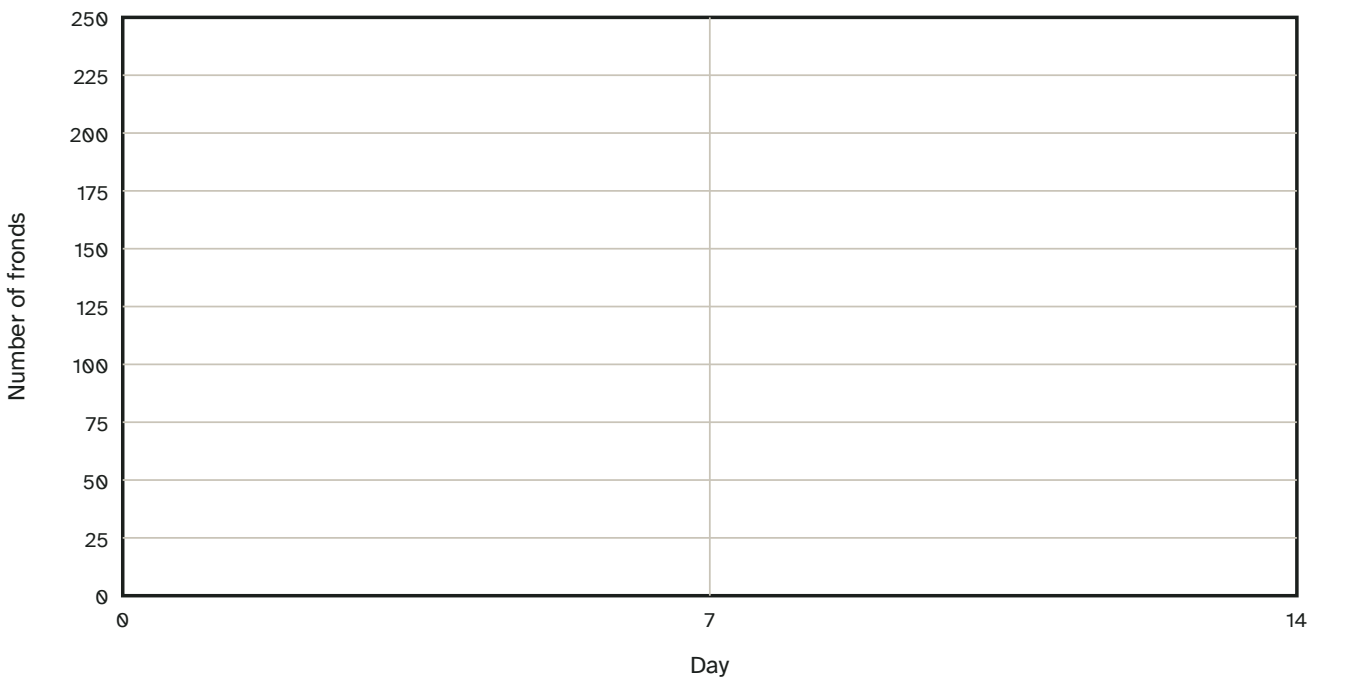
Counts and observations

Cup	Day 0 fronds	Day 7 fronds	Day 14 fronds	Growth factor (day 14 ÷ day 0)	Color score on day 14 (0-3)	Surface covered on day 14 (%)
A						
B						
C						
D						

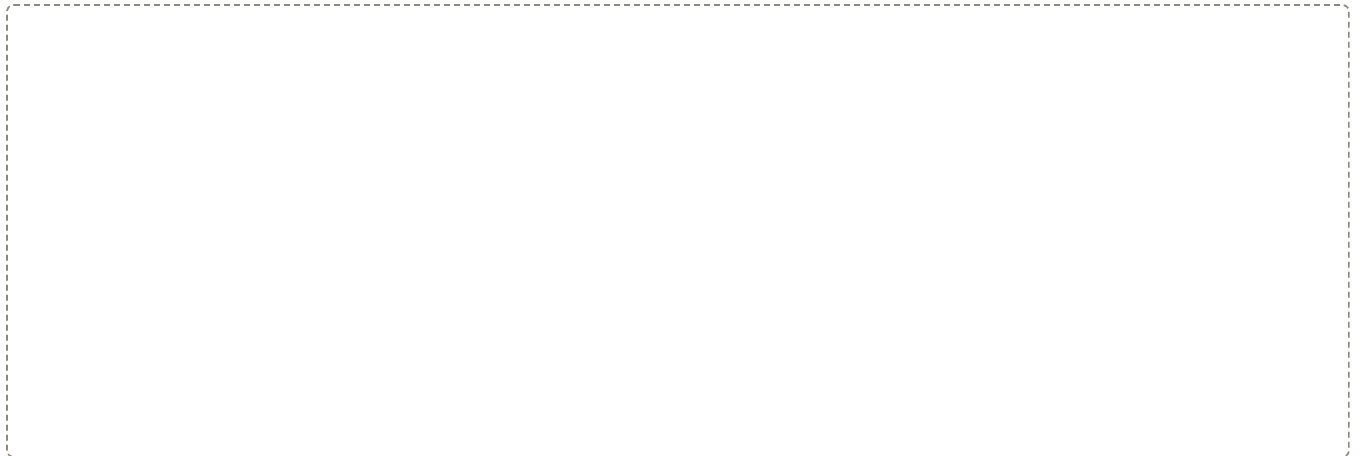
Conditions log

Day	Temperature beside the cups (°C)	Temperature inside the box (°C)	Water added at top-up (cup A, B, C, D)	Notes: roots, algae, color, anything unusual
0				
7				
14				

Duckweed fronds counted in each cup



-  Day 14: draw a top view of each cup as a circle, labeled A to D. Show roughly how much of the surface is covered, and use color or labels to show the frond color. Add one labeled detail you noticed in at least two cups (root length, frond size, algae, crowding).



Weekly growth factors for cups B and D

Cup	Week 1 (day 7 ÷ day 0)	Week 2 (day 14 ÷ day 7)
B		
D		

Class results: growth factors

Group	Cup A	Cup B	Cup C	Cup D
1				
2				
3				
4				
5				
6				
7				
8				
Class median				

3. Using the class medians, rank the cups from largest to smallest growth factor. Which part of your day-0 prediction was right, and which was not?

Analysis questions

4. Using your group's numbers, calculate the growth factors for cups A and B (show both divisions). Then divide B's growth factor by A's. How many times as much did the cup with added nutrients grow?

5. For cups A, C and D, name the limiting resource and give the evidence. Each answer must compare the cup with cup B and quote numbers.

6. Compare the week 1 and week 2 growth factors for cups B and D. Did either cup slow down in week 2? Explain what a slowdown means using the terms competition and carrying capacity.

7. Estimate how many fronds cup D could hold if its whole surface were covered: $\text{day-14 count} \div (\text{percent covered} \div 100)$. Show the calculation, then name one reason the real carrying capacity of the cup could be lower than your estimate.

- 8.** Resources affect individual organisms, not only how many there are. Describe how the fronds in cups A and C looked on day 14 compared with cup B, and explain what each resource was doing for the individual plants. Then connect this to the poison dart frogs: how can a missing resource change what an organism is like?

- 9.** Why did the class pool its results, and why use the median instead of a single group's numbers? Suppose one group's cup C grew a lot. What are two possible explanations, and how would you check?

- 10.** Name one thing that was supposed to stay the same for all four cups but might not have (look at your conditions log). Explain how it could have changed the results and how you would control it better next time.

- 11.** Write a claim, supported by the class data, about how the availability of light, nutrients and space affected the duckweed population. Include at least three numbers and explain the mechanism (what each resource does for a duckweed plant).
