

What Limits the Water Fleas? A Claim-Evidence-Reasoning Case

Learning target: I can use data from three jars to make a claim about which resource limits a population, support it with specific numbers, and explain the reasoning that connects resource supply to carrying capacity.

Claim, evidence, reasoning

About 45 min

Individual

MS-LS2-1 · assesses

MS-LS2-4 · practice

writing

data analysis

Standards connections

MS-LS2-1 (assesses): Students interpret population counts under three food supplies and use them as evidence for the effect of resource availability on a population, including a period of scarcity after a resource is withdrawn. The written argument is direct evidence toward this PE.

MS-LS2-4 (practice): The CER asks for an argument from empirical evidence that a change to a component of the jar ecosystem (the food supply) changed the population. It builds the argumentation practice this PE assesses.

Purpose: practice · **Time:** about 45 minutes · **Format:** individual

Answers with reasoning

The scenario

Daphnia, often called water fleas, are tiny crustaceans about the size of a sesame seed that live in ponds and eat single-celled algae. A class set up three identical one-liter jars of filtered pond water, put ten Daphnia in each, and placed them side by side under the same lamp at the same temperature. The only difference was feeding. **Jar A** received 1 milliliter of green algae culture every day. **Jar B** received 3 milliliters every day. **Jar C** received 3 milliliters every day through Day 12 and then nothing. Every three days the class counted the Daphnia in each jar and measured the dissolved oxygen, which stayed above 7 milligrams per liter in every jar for the whole experiment (Daphnia are fine above about 3).

Daphnia counted in each jar (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Day	Jar A (1 mL algae/day)	Jar B (3 mL algae/day)	Jar C (3 mL/day, then none after Day 12)
0	10	10	10
3	16	18	18
6	24	32	33
9	32	55	54
12	38	85	86
15	41	110	92
18	42	122	70
21	41	126	44
24	42	125	25

Simulated data built to be realistic for Daphnia, which can reproduce every few days when well fed. Not from a real class.

Warm-up: organize the evidence

1. List everything that was kept the same across the three jars. Then explain why the oxygen measurement matters for deciding what limited the Daphnia.

Answer: Same: jar size and water (one liter of filtered pond water), starting number (10 Daphnia), lamp (light), temperature, and dissolved oxygen (above 7 mg/L everywhere). Oxygen matters because Daphnia need it; measuring it and finding it high in every jar rules out oxygen shortage as the reason any population stopped growing or declined.

Why: Students must recognize the controlled variables and the role of the oxygen check as a ruled-out alternative.

Also acceptable: Accept 'the only thing that changed was the food.'

- Lists the controlled variables
- Explains that high oxygen in every jar rules out oxygen as the limit

2. Jar B received three times as much food as Jar A. Divide Jar B's Day 24 count by Jar A's Day 24 count. How does the ratio of the populations compare with the ratio of the food supplies?

Answer: $125 \div 42 \approx 2.98$, about 3. The population ratio (about 3 to 1) matches the food ratio (3 mL to 1 mL), so the carrying capacity grew in proportion to the food supply.

Why: This near-exact proportion is strong evidence that food set the ceiling in both jars.

Also acceptable: Accept 3.0 or 'about three times.'

3. Jars B and C were treated the same until Day 12 and their counts match closely until then. On what day does Jar C's count first fall, and what does the gap between Day 12 and that day suggest?

Answer: Jar C's count first falls on Day 18 (from 92 on Day 15 to 70). The six-day gap suggests the Daphnia kept reproducing for a few days on algae still in the water and on food stored in their bodies, so the effect of stopping the food showed up with a delay.

Why: Day 15 (92) is still slightly above Day 12 (86), so the first decrease is at Day 18.

Also acceptable: Accept 'between Day 15 and Day 18.'

- Day 18
- Explains the delay with leftover or stored food

Your argument

Answer: Claim: The algae food supply was the limiting resource. Each jar's carrying capacity was set by how much algae it received each day: about 42 Daphnia for 1 mL per day, about 125 for 3 mL per day, and when the food stopped, the carrying capacity collapsed and the population fell. Evidence: (1) Jar A leveled off at 41-42 Daphnia from Day 15 on, while Jar B, with three times the food, leveled off at 122-126 from Day 18 on; $125 \div 42$ is about 3, matching the 3-to-1 food ratio. (2) Jars B and C matched closely through Day 12 (85 and 86); after feeding stopped in C on Day 12, C peaked at 92 on Day 15 and fell to 70, 44 and 25 on Days 18, 21 and 24, while B stayed near 125. (3) Oxygen stayed above 7 mg/L in every jar, and light, temperature, water and jar size were identical, so none of those can explain the differences. Reasoning: A population grows while each individual can get enough of every resource. In Jars A and B the Daphnia multiplied until the daily algae was spread so thin among them that competition for food left each one with just enough to survive and replace itself; births then matched deaths and the count leveled off at the carrying capacity. Because Jar B received three times the food, three times as many Daphnia could be fed before that point, which is why its carrying capacity was about three times higher. Food was the limiting resource because it was the only resource that differed and the populations tracked it exactly. Jar C shows the effect of scarcity: once the food stopped, the jar could support far fewer Daphnia, so deaths outnumbered births and the count fell toward a new, much lower carrying capacity, with a short delay while leftover algae and stored food were used up. The populations did not grow forever because a limited daily food supply cannot feed an unlimited number of mouths.

Why: This is the solved model response. Full credit requires a claim naming food and linking it to carrying capacity, three evidence items with numbers (A versus B, B versus C, and the ruled-out alternatives), and reasoning that explains the leveling off through competition for a limited resource and the decline through the withdrawal of that resource.

Also acceptable: A student who claims that 'space' limited Jars A and B has not used the A-versus-B comparison (same jar, different ceilings); that response can earn partial credit for evidence but not for the claim. A student who notes the delay in Jar C's decline and explains it with stored food is giving a strong extra point.

- Claim names algae/food as the limiting resource and links it to carrying capacity
- Evidence compares Jar A and Jar B with counts and days
- Evidence compares Jar B and Jar C after Day 12 with counts and days
- Evidence rules out oxygen, light or temperature
- Reasoning uses limiting resource, carrying capacity and competition correctly
- Reasoning explains both the leveling off and the decline

4. What result in Jar C would have **contradicted** your claim? Describe the counts you would have expected to see if food were not the limiting resource.

Answer: If food were not the limiting resource, Jar C should have kept growing or leveled off near Jar B's number (around 120-126) after Day 12, because whatever was actually limiting (space, oxygen, waste) would not have changed when feeding stopped. A fall from 92 to 25 contradicts that expectation, which is why Jar C is such strong evidence.

Why: This item checks that the student can state what would disconfirm the claim, a mark of a testable argument.

Also acceptable: Accept 'Jar C would look like Jar B.'

- Describes Jar C staying level or continuing to grow
- Explains why that would mean something other than food was limiting

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	Names the food (algae) supply as the limiting resource and states that each jar's carrying capacity depended on the amount supplied, in one or two clear sentences.	Names food as the limiting resource but does not connect it to carrying capacity, or the connection is vague.	Names a resource that the data do not support (space, oxygen) or makes a claim without naming a resource.	No claim, or a restatement of the question.
Evidence	Three or more specific pieces of evidence with days and counts, including A versus B, B versus C after Day 12, and a fact that rules out oxygen, light or temperature.	Three pieces of evidence, but one lacks numbers or the ruled-out alternative is missing.	One or two pieces of evidence, or numbers listed without comparison.	Evidence missing, invented, or contradicts the table.
Reasoning	Explains the leveling off through competition for a limited daily food supply, explains Jar B's higher ceiling through its larger supply, explains Jar C's decline through the withdrawal of the resource, and uses the terms limiting resource, carrying capacity and competition correctly.	Explains the leveling off and the decline but the terms are used loosely or one link to the evidence is missing.	Restates the evidence without explaining why the counts leveled off or fell, or uses the terms incorrectly.	No reasoning, or reasoning unrelated to resources.
Scientific language and accuracy	Uses population, resource, limiting resource, carrying capacity and competition accurately; no scientific errors; describes the delay in Jar C or the proportion in q2 correctly if mentioned.	Terms mostly correct; one minor slip (for example, calling the ceiling a 'limit' without the term carrying capacity).	Several terms used loosely or interchangeably (limiting resource for carrying capacity).	Scientific language absent or consistently wrong.

Teacher notes

The dataset is simulated and shaped so that Jar A and Jar B level off in proportion to their food (42 versus 125; ratio about 3) and Jar C declines with a short delay after feeding stops (first drop at Day 18). *Daphnia* really do reproduce every few days when fed and really do need dissolved oxygen above roughly 3 mg/L; the 7 mg/L figure is comfortably safe and is included so students can rule oxygen out. Real *Daphnia* cultures

also crash from waste build-up or from their own filtering clearing the water, which is why the extension asks about other possible limits. If students argue that Jar B might have grown further with 6 mL per day, agree that the data cannot say, and point them to the extension. The three warm-ups map directly onto the three required evidence items; students who complete them should be able to fill the Evidence box by copying and polishing.

Scaffold offered to students: Evidence sentences with numbers in them

A piece of evidence is a sentence with at least one number and a comparison. Try these frames: 'By Day ___, Jar A had only ___ Daphnia while Jar B had ___.' 'Jar C peaked at ___ on Day ___ and fell to ___ by Day ___, after feeding stopped on Day 12.' 'Oxygen stayed above ___ mg/L in all jars, so ___.' Write three such sentences on scrap paper before filling in the Evidence box, then use the Reasoning box to say what each sentence proves.

Extension: Design Jar D

Design a fourth jar that would test whether Jar B's population could have grown even larger with more food, or whether some other resource (space, oxygen or waste build-up) would take over as the limiting resource at higher numbers. State the feeding rate, what you would measure besides the count, and sketch the two different curves you would expect depending on which answer is correct. Then write a sentence explaining why the limiting resource can change as a population grows.