

Population size in two areas using quadrats

investigate the population size of an organism in two different areas using quadrats

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. Teacher answers start on a new page.

Name

Date

Aim

To compare the population size of a plant species in two different areas by sampling with quadrats.

Background

A **population** is all the organisms of one species living in an area. It is usually impossible to count every individual, so ecologists take a **sample** and use it to estimate the whole population.

A **quadrat** is a square frame that marks out a small, known area. To avoid **bias**, quadrats are placed at random, for example by using random numbers as coordinates on a grid made from two tape measures. Counting in many quadrats and calculating a **mean** makes the estimate more reliable.

The number of a plant in an area depends on abiotic factors such as light intensity and water, and on biotic factors such as competition. Comparing two areas that differ in one factor, such as a shaded area under a tree and an open, sunny area, shows how that factor may affect the population size.

Population size can be estimated using: $\text{population size} = \text{mean number per quadrat} \div \text{area of one quadrat} \times \text{total area of the habitat}$.

Hypothesis

There will be more daisies in the open, sunny area than in the shaded area, because daisies need light for photosynthesis.

Variables

Independent	The area sampled (shaded area under a tree or open sunny area)
Dependent	The number of daisies in each quadrat, used to calculate the mean number per quadrat
Control	• Size of the quadrat (0.5 m × 0.5 m) • Number of quadrats in each area (10) • The species counted (daisies) • The person counting • Time of year and day • Both areas on the same lawn, with similar mowing and soil

Equipment

- Quadrat, 0.5 m × 0.5 m (area 0.25 m²)
- 2 tape measures (10 m or longer)
- Random number table, or a calculator or phone random number generator
- Identification chart or key for the species
- Clipboard, pencil and recording table
- Calculator

Risk assessment

Hazard	Risk	Precaution
Uneven or wet ground and tape measures	Tripping or slipping	Wear suitable footwear, look where you are walking and keep tape measures tidy.
Soil, plants and animal droppings	Infection or skin irritation	Do not touch plants you cannot identify, do not put hands near the mouth, and wash hands after the fieldwork.
Weather and sun	Sunburn or getting cold	Wear suitable clothing and sun cream if needed, and follow the teacher's instructions.

Method

1. Choose the two areas to compare, for example a shaded area under a tree and an open, sunny area of the same lawn. Measure the size of each area (in this example each is 10 m × 10 m, or 100 m²).
2. In the first area, lay one tape measure along one side and another at right angles along an adjacent side to make a grid.
3. Use a random number generator or table to choose two numbers, one for each tape measure, for example 4.0 m and 7.5 m. These are your coordinates.
4. Place the quadrat on the ground with its corner at that point.
5. Count the number of daisies inside the quadrat. Count a plant only if more than half of it is inside the frame.
6. Record the number in the results table.
7. Repeat steps 3 to 6 until you have 10 quadrats in the first area.
8. Repeat the whole procedure in the second area, using the same size of quadrat, the same number of quadrats and the same species.
9. Add up the counts for each area and calculate the mean number of daisies per quadrat.
10. Calculate the estimated population size in each area using: population size = mean per quadrat ÷ 0.25 × total area (m²).
11. Compare the two areas. Wash your hands.

Results

Results table: number of daisies in each 0.25 m² quadrat		
Quadrat number	Number of daisies in shaded area	Number of daisies in open area
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Total		
Mean per quadrat		
Estimated population in 100 m²		

Graph

Bar chart of the mean number of daisies per quadrat (y-axis, from 0, labelled ‘Mean number of daisies per quadrat’) for each of the two areas (x-axis, categoric), with gaps between the bars.



Exam questions 10 questions · 27 marks

1 Explain why the quadrats were placed at random. **[2 marks]**

2 The numbers of dandelions in five quadrats were 3, 5, 4, 6 and 2. Calculate the mean number of dandelions per quadrat. **[2 marks]**

Answer =

3 A field has an area of 400 m². Each quadrat has an area of 0.25 m². The mean number of dandelions per quadrat was 4. Estimate the number of dandelions in the field. **[3 marks]**

4 Explain why 10 quadrats were used in each area instead of one. **[2 marks]**

5 Give three variables that must be kept the same when comparing the number of daisies in two areas. **[3 marks]**

6 The shaded area had fewer daisies than the open area. Suggest an explanation for this. **[3 marks]**

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7 Suggest one abiotic factor, other than light intensity, that could differ between the two areas and describe how you would measure it. **[2 marks]**

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8 Where plants are very small and close together they are difficult to count. Suggest another way of measuring the abundance of the plants in a quadrat. **[2 marks]**

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9 The mean number of daisies per quadrat was 1.2 in the shaded area and 4.8 in the open area. Calculate how many times greater the mean was in the open area. **[2 marks]**

Answer =

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10 A student wants to compare the number of dandelions in two fields. Describe how the student could use quadrats to do this. **[6 marks]**

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Teacher answers

Practical 12: Population size in two areas using quadrats. The example results are practice data, not real measurements.

Example results

Example results (practice data)		
Quadrat number	Number of daisies in shaded area	Number of daisies in open area
1	1	4
2	0	6
3	2	3
4	1	5
5	3	7
6	0	4
7	1	5
8	2	6
9	1	3
10	1	5
Total	12	48
Mean per quadrat	1.2	4.8
Estimated population in 100 m ²	480	1920

Conclusion

The mean number of daisies per quadrat was 1.2 in the shaded area and 4.8 in the open area, so there were four times as many daisies in the open area. Estimated population in a 100 m² area: shaded = $1.2 \div 0.25 \times 100 = 480$; open = $4.8 \div 0.25 \times 100 = 1920$. This supports the hypothesis. Daisies in the open receive more light, so they can photosynthesise faster and grow and reproduce more. However, the areas may also differ in other factors such as soil moisture, which could also affect the number of daisies, so the investigation shows a link, not proof that light is the cause.

Errors and improvements

Error	Effect on the results	Improvement
Only 10 quadrats are used, so by chance they may land on unusually dense or sparse patches (random error)	The mean may not represent the whole area and the population estimate may be inaccurate	Use more quadrats and calculate a mean, or use a larger sample area.
Quadrats are placed by hand without using random numbers, for example on areas that look interesting (bias, systematic error)	The sample is not representative, so the results are biased	Use random numbers as coordinates on the grid for every quadrat.
Plants are hard to count or identify, for example small daisies hidden by grass or plants on the edge of the quadrat	Counts may be too low or inconsistent between people	Use the same person and a rule for plants on the edge, use an identification chart, and for dense plants estimate the percentage cover instead.
The two areas differ in more than one way, for example soil moisture and trampling as well as light	The difference in population size cannot be put down only to light, so the conclusion is less valid	Choose areas that are as similar as possible apart from the factor studied, and measure other factors such as light and soil moisture in each.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- to avoid bias (1)
- so that the sample is representative of the whole area (1)

2. [2]

- $3 + 5 + 4 + 6 + 2 = 20$ (1)
- $20 \div 5 = 4$ (1)

3. [3]

- $4 \div 0.25 = 16$ per m^2 (1)
- 16×400 (1)
- 6400 (1)

4. [2]

- to reduce the effect of chance / of one unusual quadrat (1)
- so that the mean is more reliable / representative of the area (1)

5. [3]

- size of quadrat (1)
- number of quadrats (1)
- the species counted (1)
- person counting / rule for plants on the edge / time of year (1)
- Max 3

6. [3]

- less light in the shade (1)
- so less photosynthesis (1)
- so less glucose for growth and reproduction / fewer seeds (1)

7. [2]

- soil moisture / soil pH / temperature (1)
- a suitable method, for example a moisture meter, pH probe or thermometer used in the same way in each area (1)

8. [2]

- estimate the percentage cover of the species in the quadrat (1)
- for example by counting the squares of a gridded quadrat that the plant covers (1)

9. [2]

- $4.8 \div 1.2$ (1)
- 4 (times) (1)

10. [6]

Level 3 5-6	A clear, ordered method including random placement of quadrats using coordinates, a suitable number of quadrats, counting, calculating a mean for each field and comparing them, with control of variables
Level 2 3-4	A method with random sampling and counting in both fields but with some steps, detail or ordering missing
Level 1 1-2	A simple or partial method, for example placing quadrats and counting with little detail

Indicative content

- mark out a grid with two tape measures in each field
- use random numbers as coordinates to place the quadrat
- count the number of dandelions in each quadrat
- use the same size of quadrat and the same number of quadrats (at least 10) in each field
- calculate the mean number per quadrat for each field
- compare the means, or estimate the population using $\text{mean} \div \text{area of quadrat} \times \text{area of field}$

Exam tips

- Always say that quadrats are placed randomly, and explain that this avoids bias. Name how: random numbers as coordinates on a grid.
- Use the same size and number of quadrats in each area. Without this the comparison is not fair.
- When you estimate a population, use the units carefully: divide the mean by the area of one quadrat (in m²), then multiply by the total area.
- Say that more quadrats make the mean more reliable and more representative of the whole area.
- A difference between two areas shows a link, not proof of cause, unless other factors are controlled.