Bio Factsheet

April 2000 Number 68

Fieldwork Techniques

By studying this factsheet the student should gain a knowledge of:

- **the uses and limitations of sampling methods of plant populations, such as frame quadrats, point quadrats, line transects and belt transects.**
- **the uses of netting and trapping in the measurement of population size by the mark-release-recapture technique.**
- **how ecological results can be displayed and the use of the χ^2 test in reporting results of ecological studies.**

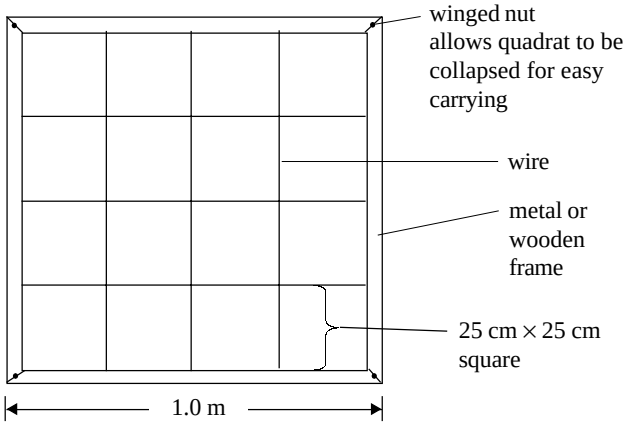
Exam Hint - *questions may test a candidate's knowledge of the application of sampling techniques, or involve calculations about population size, or involve statistical analysis and interpretation of data.*

Sampling of plant communities

To standardise the areas where biotic and abiotic components of ecosystems are investigated, quadrats and/or transects are usually used and sampling is restricted to the areas of the quadrats or transects.

Frame quadrats are metal or wooden frames which form a square of known area, usually 0.25 m^2, 0.5 m^2, or 1.0 m^2. They are often subdivided by crosswires into smaller squares to facilitate counting of plants. They can be used to sample areas of vegetation which appear fairly uniform, for instance, to compare the frequencies of daisies in regularly cut lawns and in infrequently cut lawns, or to determine whether two species of plant grow together in a pasture more frequently than they grow separately. The quadrats should be placed randomly in the areas to be sampled. Throwing the quadrats over the shoulder is not recommended to give randomness. Random numbers should be obtained from tables or computer generated and used as co-ordinates to determine quadrat positions in an area to be sampled, marked at the sides with measuring tapes. The plant species in each quadrat should be recorded, and if necessary the plant numbers counted. A standard technique should be adopted for plants which touch the quadrat sides. Usually plants which touch either of two sides are counted and plants touching either of the other two sides are not. Generally, if a habitat is uniform, valid results can be obtained by recording five quadrats. Fig 1 shows the structure of a quadrat.

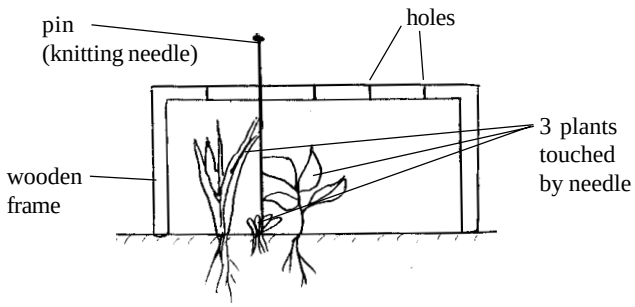
Fig 1. A 1.0 m^2 quadrat with wire sub-quadrats



In long term ecological studies, **permanent quadrats** may be established. The quadrat areas can be marked out permanently using pegs and rope, and periodic sampling of biotic and abiotic factors can be performed.

A **point quadrat** consists of a frame which has a number of holes through which long pins can be passed. Any species which touch the pin are recorded for each of the holes. Point quadrats are very useful for assessing overgrown habitats where plant species overlap. A pin quadrat is shown in Fig 2.

Fig 2. A point quadrat (pin frame)



A **line transect** can be used to sample a uniform area or an area in which there is a transition in habitats and populations. A measuring tape or string is run along the ground in a straight line between two poles and only species actually touching the line are recorded and counted. A similar set up is used in a **belt transect**, but two tapes may be used 0.5 or 1.0 m apart. All the plants species between the tapes are recorded and counted if necessary. Alternatively only one tape may be used and quadrats placed along its length to enable species to be recorded and counted. Sometimes height variations are also recorded along the belt or line transect which may then be referred to as a **profile transect**.

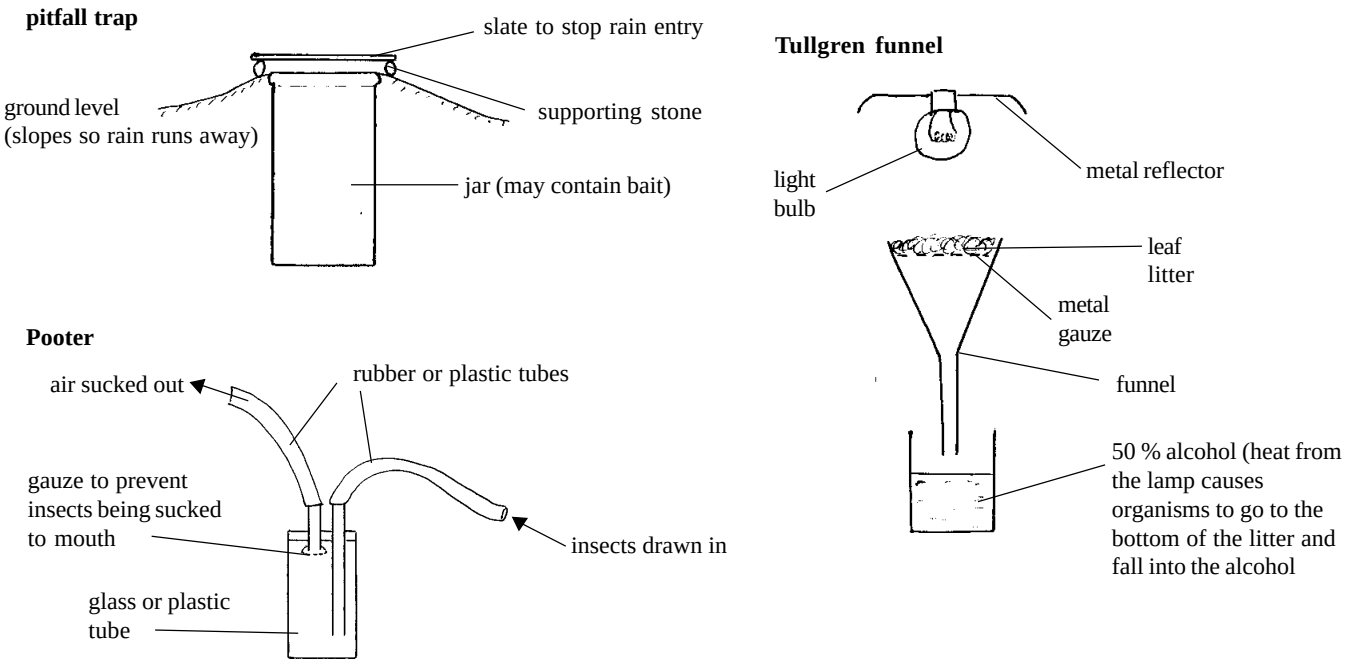
Using quadrats and transects are known as **direct counting methods**. If the number of organisms found in a certain number of quadrats is known, and these represent a known fraction of a given area, then the total number of organisms in the whole area can be calculated. Species density, species frequency and species cover can be determined. The **species density** is the number of individuals of a species within a given area. The **species frequency** is a measure of the probability of finding a given species (rooted) within a randomly placed quadrat in a given area. Thus, if a species only occurs in 1 in 10 quadrats it is said to have a frequency of 10%. (But the quadrat size should be stated since it will have an effect on the frequency). The **species cover** is a measure of the proportion of ground covered by the species and is a useful measurement when dealing with large numbers of small plants (in a quadrat) which are too numerous or time consuming to count.

Sampling of animal communities

Many techniques are available for sampling animal populations. Some examples are listed below:

- a **sweep net** is a nylon net attached to a metal ring and handle which can be swept through grass, foliage, ponds or streams.
- a **beating tray** is a fabric sheet of known area attached to a collapsible metal or wood frame. It is held under foliage which is shaken. Organisms fall into the sheet and can be collected.
- a **kite net** is a muslin net attached to a handle which is swept through the air to sample flying insects. It must be used in a standard way, for example, ten figure of eight sweeps per sample.
- a **plankton net** is a fabric net attached to a metal ring and rope harness which is towed through the water. A small container is attached to the end of the net to catch the accumulated specimens.
- **kick sampling** may be used for collecting in streams or rivers. An open plankton or sweep net is held just downstream of the sampling area where the organisms are dislodged by kicking the stones on the stream bed, or by turning them over by hand. The dislodged organisms are caught in the net.
- a **light trap** consists of a mercury vapour lamp which attracts moths and other nocturnal flying insects, These fly into the trap, hit baffles, fall to the base and become trapped in a cardboard box.
- a **pitfall trap** can be used to trap walking or crawling invertebrates. It consists of a jam jar buried in the soil with its rim at ground level. A pitfall trap is shown in Fig 3.
- a **Tullgren funnel** is used to sample invertebrates in soil and leaf litter. A Tullgren funnel is shown in Fig 3. Invertebrates in leaf litter can also be sampled by **hand-sorting** when the organisms can be collected with a **pooter**. A pooter is shown in Fig 3.
- **mustard** solution or **formaldehyde** solution can be used to water a square metre of lawn or field in order to drive earthworms to the surface. They should be washed immediately to remove the formaldehyde or mustard. 50 cm^3 of 0.4% formaldehyde should be used per square metre.
- **flotation** can be used to sample soil organisms. The weighed soil sample is added to a beaker of saturated salt solution and vigorously stirred. Organisms float to the top and can be collected, killed in 70% alcohol if necessary, sorted, identified and counted.

Fig 3. Apparatus for collecting invertebrates



Measurement of an animal population size

This can be done by the **mark-release-recapture** technique. Unlike using quadrats which is a direct counting method, this technique is an **indirect counting method**. It involves capturing organisms from the population, counting them, then marking them in some harmless way and releasing them back into the population. At a later stage, organisms in the population are trapped again and the marked and unmarked organisms counted (and then released again). The population size can be calculated using the **Lincoln Index** formula:

$$\text{Estimated total population} = \frac{\text{number of organisms initially caught} \times \text{number of organisms in second sample}}{\text{number of marked organisms recaptured}}$$

The technique assumes that the organisms mix randomly back into the population in the time allowed between samplings, and that the organisms disperse evenly within the sampled geographical area. It is assumed also that changes due to immigration, emigration, births, deaths and predation are negligible, and that the marking does not make the organism more conspicuous to predators.

Invertebrates can be marked with dots of paint, fish can be netted and have their operculum tagged with aluminium or plastic discs, birds can be netted and have rings placed around their legs and mammals can have their ears tagged or clipped.

Display of ecological results

This can be done in many ways. For example, data may be presented in tabular form, or shown in graphs, histograms, profiles, kite diagrams or in any form that presents the data in a clear and concise way. Some ways of displaying data are shown in the specimen questions and mark schemes below.

The χ^2 test

The χ^2 test is frequently used to assess ecological data, particularly for tests of **association**, for instance, to determine whether two plants grow together in association more frequently than they grow separately, or to determine whether the colour of hydrangeas is associated with soil pH. An example of the use of the χ^2 test is given in the practice questions and answers below.

Remember – you will not have to recall the χ^2 test formula in an A-level Biology examination since it will be stated in the question. You will need to be able to state null and alternative hypotheses, use the formula to calculate the value of χ^2 and be able to interpret the value obtained. ***If the calculated value of χ^2 is less than the critical value at a 0.05 probability level (5%) then the null hypothesis is accepted (so the alternate hypothesis is rejected).***

Practice Questions

1. (a) Explain why 'throwing quadrats' is not an acceptable sampling technique. 2

   (b) Outline how you would use random sampling to estimate the number of dandelion plants in a square lawn. 5

   (c) A student required a 1% sample of a lawn measuring 25 m × 30 m The student used a quadrat measuring 50 cm × 50 cm Calculate the number of quadrats which would be required. Show your working. 3

   Total 10

2. A biologist suspected that two species of plant, dandelion (Taraxacum officianale) and ribwort (Plantago lanceolata) tended to grow in association with one another in a meadow. To investigate this, 200 quadrats were randomly placed in the meadow and the presence or absence of the two species was noted. The results are shown in the contingency table below:

		Dandelion		
		present	**absent**	**row total**
Ribwort	**present**	**O** 88 **E**	**O** 52 **E**	140
	absent	**O** 36 **E**	**O** 24 **E**	60
	column total	124	76	200 **(grand total)**

Perform a χ^2 test to assess whether the biologist's suspicions were confirmed by the results.

The formula for a χ^2 test is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$ where O = observed results, and E = expected results

(a) Propose a suitable null hypothesis for this investigation. 1

(b) The expected results can be calculated by the formula:

$$E = \frac{\text{Row total} \times \text{Column total}}{\text{Grand total}}$$

(i) Calculate the expected results and write them in the table above. 4

(ii) Calculate the value of χ^2. Show your working. 2

(iii) Calculate the degrees of freedom.
(degrees of fredom = (no of rows – 1) × (no of columns – 1) 1

(iv) With these degrees of freedom, the critical value for χ^2 at a 5% level of significance is 3.84. Does this enable you to accept or reject the null hypothesis? Explain your answer. 2

Total 10

3. The technique of mark-release-recapture was used to estimate the number of woodlice in a log pile. An initial sample of 66 woodlice were marked and released. The second sample of 54 woodlice contained 16 marked individuals.

   (a) Define the term 'population'. 1

   (b) Use the Lincoln Index formula below to estimate the population size of the woodlice. Show your working.

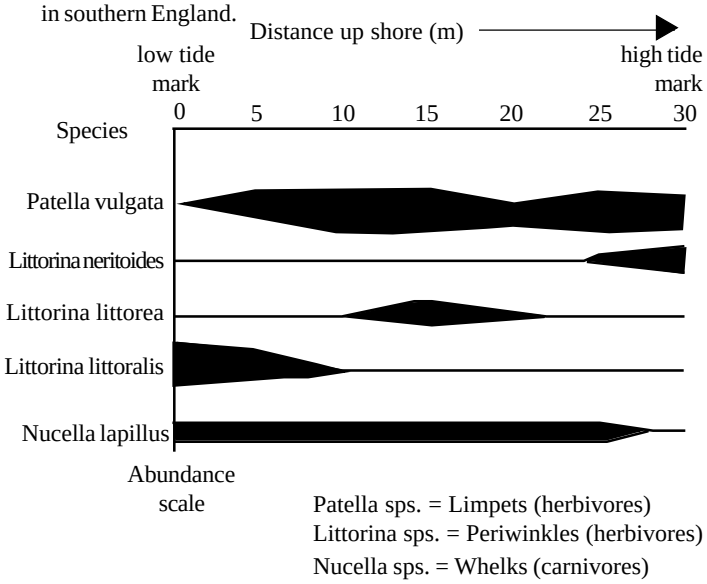
$$N = \frac{S_1 \times S_2}{R}$$

where N = population size,
S_1 = number of woodlice in first sample,
S_2 = number of woodlice in second sample and R = number of marked woodlice in second sample. 2

   (c) State <u>three</u> assumptions of the capture-recapture technique. 3

   Total 6

4. The kite diagram shows the distribution of molluscs on a rocky shore in southern England.



Patella sps. = Limpets (herbivores)
Littorina sps. = Periwinkles (herbivores)
Nucella sps. = Whelks (carnivores)

   (a) What does the width of the bars in this diagram represent? 1

   (b) Suggest <u>two</u> biotic and <u>two</u> abiotic factors which could account for the pattern of distribution shown. 4

   (c) Suggest reasons for the differences in distribution of:

   (i) Littorina neritoides and Littorina littoralis. 2

   (ii) Nucella lapillus and the Littorina species. 2

   Total 9

Answers

1. (a) will not provide a random sample;
because of 'handedness'/subjectivity/bias/differences between samplers' throwing ability; 2

(b) set up grid using tapes at right angles/along two sides of lawn;
generate random/numbers for use as co-ordinates;
using accurate technique e.g. computer/tables;
place quadrat at intersection;
count number of dandelions in the quadrat;
repeat at least 5 times and calculate the mean density per quadrat area;
calculate daisy population in total lawn area; max 5

(c) total area = $25 \times 30 = 750\ m^2$ **;**
1% sample = $7.5\ m^2$;
area of quadrat = $0.50 \times 0.50 = 0.25\ m^2$;
number of quadrats required = $\frac{7.5}{0.25} = 30$; max 3

Total 10

2. (a) there is no tendency for dandelion and ribwort to grow in association together in the meadow; 1

(b) (i)

		Dandelion		
		present	**absent**	**row total**
Ribwort	**present**	**O** 88 **E** **86.8;**	**O** 52 **E** **53.2;**	140
	absent	**O** 36 **E** **37.2;**	**O** 24 **E** **22.8;**	60
	column total	124	76	200 **(grand total)**

4

(ii) $\chi^2 = \frac{(88-86.8)^2}{86.8} + \frac{(52-53.2)^2}{53.2} + \frac{(36-37.2)^2}{37.2} + \frac{(24-22.8)^2}{22.8}$;

$= (0.0166 + 0.0271 + 0.0387 + 0.0632)$
$= 0.1456$; 2

(iii) 1; 1

(iv) accept the null hypothesis/there is no association between the two plants;
calculated value is smaller than the critical value; 2

Total 10

3. (a) the number of organisms of a species in one area at one time; 1

(b) $N = \frac{66 \times 54}{16}$; = 222.75; (accept 222 - 223) 2

(c) marking does not affect probability of recapture/organisms mix randomly back into population when released;
marking persists over trapping period/marks do not wear/wash off/the population
remains constant over the sampling period/no loses due to death/immigration/no gains due to birth/emigration;
the markings do not make the woodlice more noticeable to predators; max 3

Total 6

4. (a) relative abundance/population density; 1

(b) Biotic: predators; food supply; human activity; max 2

Abiotic: temperature changes; inundation/tidal covering;
exposure/turbulence/wave action;
varying salinity/dehydration; max 2

(c) (i) L. neritoides can withstand dessication/exposure to air/temperature changes;
L. littoralis requires constant cover by seawater/spray/cannot withstand dessication; 2

(ii) Nucella lapillus is found all over the shore since it can feed on all species of periwinkle/ limpet;
particular Littorina sps. are only found on specific areas of the shore; 2

Total 9

Acknowledgements;
This Factsheet was researched and written by Martin Griffin
Curriculum Press, Unit 305B, The Big Peg,
120 Vyse Street, Birmingham. B18 6NF

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