Bio Factsheet

September 1997 Number 6

Tackling Data Interpretation Questions - Ecology

It is important that A-level students understand the abilities which they are expected to have developed during their study of Biology since these will be tested in their final examinations. In this regard, the actual syllabus which is being pursued is irrelevant since the assessment objectives of all of the boards are essentially the same (Table 1).

Table 1. Examination Board Assessment Objectives

Ability	Explanation
Recall	Facts, concepts, principles and relationships. For example, Can the candidate define the term "community"
Apply	Can the candidate apply this knowledge to new situations?
Describe, interpret and translate	Can the candidate describe graphs accurately, interpret information presented in graphs, kite diagrams and tables etc. and translate information e.g. draw a graph using information in a table or vice versa?
Formulate hypotheses and plan suitable investigations	Can the candidate formulate a hypothesis and devise an investigation if they are told that lichen species change as the distance from urban centres increases?
Analyse and evaluate	Can the candidate analyse data from investigations and assess its validity?
Select and present	Can the candidate choose ideas, facts and arguments which support a particular case and present them in an appropriate manner?

Ecology is an essential component of all A-level syllabuses and provides Chief Examiners with an easy opportunity to set questions testing all of these assessment objectives. This Factsheet will illustrate how these assessment objectives are tested in ecological questions and will suggest techniques which candidates can use to maximise their marks on such questions. For illustration, this Factsheet will focus on four types of commonly examined topics:

1. Predator-Prey graphs
2. Sigmoid growth curves
3. Questions about the flow of energy
4. Questions about the factors affecting the distribution of organisms

1. Predator-Prey graphs

Candidates are often asked to draw or interpret predator-prey graphs. Table 2 shows the populations of two species, *x* and *y*, which form part of a grassland community in Canada. Often candidates will be asked to plot the data graphically. Such questions usually attract four marks, as follows :

- *One mark* for choosing appropriate scale - the candidate should use at least half the paper in each direction.
- *One mark* for correctly labelling the axes.
- *One mark* for correctly plotting the points.
- *One mark* for labelling the lines or providing a key.

Commonly, candidates are then asked to:

(i) *Suggest which line represents the predator and which line represents the prey.*

The prey usually reach higher population peaks than predators.

Table 2. Population of species x and y

Year	1955	1960	1965	1970	1975	1980
Species x	1200	800	920	1170	1310	1000
Species y	170	150	155	160	180	160

(ii) Describe and explain the fluctuations shown.

The basic principles are simple. An increase in the number of prey represents an increase in food availability for the predator, whose numbers **subsequently** increase. As the number of predators increase, the number of prey decreases because they are being eaten. Eventually, the number of prey will decline to the point where some of the predators are unable to find or catch food and they die. It is also likely to be the case that the few remaining prey are the fastest or healthiest and those best able to escape from the predators. The predator population thus falls, predation decrease and the prey population may increase again.

However, Examiners require candidates to focus in a little more closely. In **describe** questions candidates should comment on:

(a) *The periodicity of the predator and prey curves i.e. the average time between peaks (or troughs) for each of the organisms.*

(b) *The magnitude of the population booms of each of the predator and prey.*

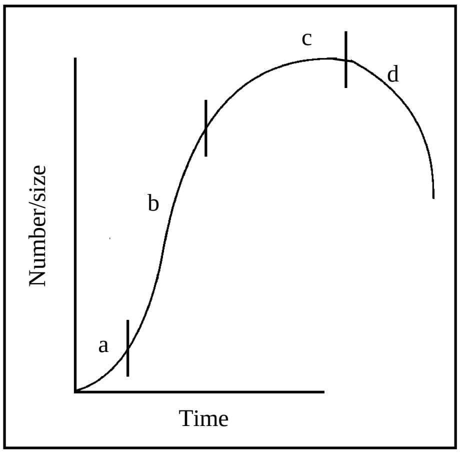
Candidates frequently imply that the recovery of the number of prey is an instantaneous consequence of the decline of the predators. But this is not the whole story. The prey population will not increase merely as a result of less predation; rather it will stop decreasing so quickly. Prey populations will only increase after mating, gestation and birth have occurred and this explains - for both the predator and the prey - why there is a time lag between population decline and ascent.

In questions which focus on analysis, the strongest candidates will mention that predators very rarely feed on just one prey species so decline in one prey may not result in the dramatic fluctuation of the predator at all.

2. The sigmoid growth curve

Sigmoid curves crop up everywhere in A-level Biology! The sigmoid curve is shown in Fig 1. The graph describes:

Fig 1. The sigmoid growth curve



(i) The growth of yeast or bacterial cultures.

(ii) The growth in the average size of leaves on a tree.

(iii) The growth of an animal population introduced into a new habitat.

Commonly, questions on the sigmoid growth curve will test candidates' ability to describe, interpret and translate data on population growth. Most candidates understand the significance of the shape of the curve and are able to explain each of the stages:

(a) Population increasing slowly - adapting to new environment.

(b) Population increasing exponentially - no limiting factors.

(c) Population growth slows and then stops. birth rate = death rate at the plateau.

(d) Death rate exceeds birth rate.

However, many candidates provide inaccurate statements in their descriptions. Exponential growth is **only** being achieved when the time taken for the population to double is the same over a number of generations. Exponential growth is unsustainable because of density dependent limiting factors such as food supply, space and predation. Often however, intraspecific competition is more significant then interspecific competition in limiting population size and this is largely because members of the same species are competing for exactly the same factors.

Candidates may also incorrectly describe the relationship between birth rate and death rate at the plateau stage. Even though the population is not increasing at the plateau the birth rate is unlikely to be zero. It is however the case that the birth rate = death rate.

The interpretion of such curves also requires care. Part a of the curve represents slow population growth but the explanation of this must be tailored to the organism concerned. In yeast, it is quite acceptable to state that slow population growth is a result of the need of the organism to synthesise appropriate enzymes for the substrate it finds itself in. This is not an appropriate explanation however for the slow growth in population of, for example, rabbits.

3. The flow of energy

All A-level syllabuses require candidates to understand how energy flows through ecosystems. By far the most common type of question focuses on the loss of energy at each trophic level since this limits the size of food chains and explains why numbers and biomass of organisms at each trophic level usually decreases. This concept can be asked in a number of different ways, thus:

Why are there usually no more than five stages in the food chain?
Why do the number of organisms decrease at each stage of food chain?
Why does the biomass of organisms decrease at each stage of a food chain?
Why are big, fierce animals rare?

At every stage in the food chain, energy is lost because:

1. Energy is lost as heat during respiration and is therefore unavailable to the next organism.

2. Energy is lost in faeces which the next organism does not eat.

3. Not all of the preceding organism is eaten.

Thus, the amount of available energy decreases at each trophic level. This limits the number of stages which can be sustained in the food chain and usually means that the number and biomass of organisms at each trophic level declines.

Frequently, this topic also generates questions which test candidates' ability to demonstrate their critical awareness of social, economic and environmental issues.

Farmers attempt to minimise respiratory losses by minimising the movement of their animals (eg. battery farms) and by ensuring that homeotherms (birds and mammals which use energy trying to maintain a constant body temperature) do not have to waste energy doing this.

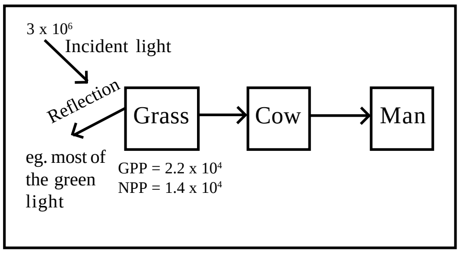
Modern agriculture is the cause of many environmental problems - nitrate pollution, eutrophication, organic pollution, pesticide contamination, habitat destruction, soil erosion etc. Many of these problems are made worse by livestock production systems and this topic may be tested in an application question. Annually, millions of human beings die because they are unable to satisfy energy requirements. In terms of the energy efficiency of our farming system, humans would be much better off trying to satisfy their energy requirements by eating vegetables and crops, rather than feeding them to cattle and eating the meat. By introducing another stage into the food chain (crop → cattle → humans, rather than crop → humans) a huge amount of energy is lost.

The second type of question on energy flow concerns the relationship between Gross Primary Productivity and Net Primary Productivity and frequently involves simple calculations. The key equation which candidates must be able to recall and use is:

GPP	=	NPP	+	R
Total amount of energy fixed by green plants		Net primary productivity		Respiration

NPP is the most useful concept since this represents the amount of energy or organic matter which is actually available to the next trophic level. Commonly, candidates are asked to calculate one of the three variables when they are given the other two. For example, Fig 2 below show the energy flow in a grassland ecosystem.

Fig 2. Energy flow in a grassland



Calculate:

(i) The respiratory loss of the grass plants.

Since GPP = NPP + R
GPP - NPP = R

$2.2 \times 10^4 - 1.4 \times 10^4 = 0.8 \times 10^4 kjm^{-2}yr^{-1}$
(Don't forget the units)

(ii) The percentage of sunlight energy which is fixed as GPP by the grass plants.

Candidates who are terrified of percentage calculations must grit their teeth, practise and think.

Not all of the light energy will be fixed - some will be reflected so the percentage must be less than 100%, so:

GPP = 2.2×10^4
Total available = 3×10^6

So the percentage is $\frac{2.2 \times 10^4}{3 \times 10^6} \times 100\,\% = 0.7\%$

The factors affecting productivity confuse many candidates and sometimes it helps merely to substitute in the word photosynthesis. Hence **"Why is tropical rainforest more productive than temperate coniferous woodland?"** becomes **"Why is the rate of photosynthesis faster in the tropics than in temperate areas?"**

Productivity and photosynthesis are influenced by temperature, carbon dioxide concentration, water and nutrient availability, light intensity and wavelength and pollution. The tropics are hot and wet, hence productivity is high.

4. Factors affecting the distribution of organisms

Questions are frequently set on the biotic and abiotic conditions which affect the distribution of organisms in or between different habitats. Zonation along rocky shores, the distribution of organisms in freshwater lakes or between polluted and non-polluted areas are common examples. In such questions, candidates are often asked to suggest explanations for a pattern or distribution which is often set in an unusual context. Many candidates omit to write any answers for such questions believing that they should be able to recall factual responses to everything. The examiners however will usually credit any sensible suggestions and the list of acceptable alternatives on mark schemes may be long. Candidates should try to stay calm and think about the underlying principles.
For example:

Fig 3. shows the distribution of seedlings of the capulin tree (*Prunus capuli*) on a wooded hillside in Mexico. Part of the hillside has been deforested.

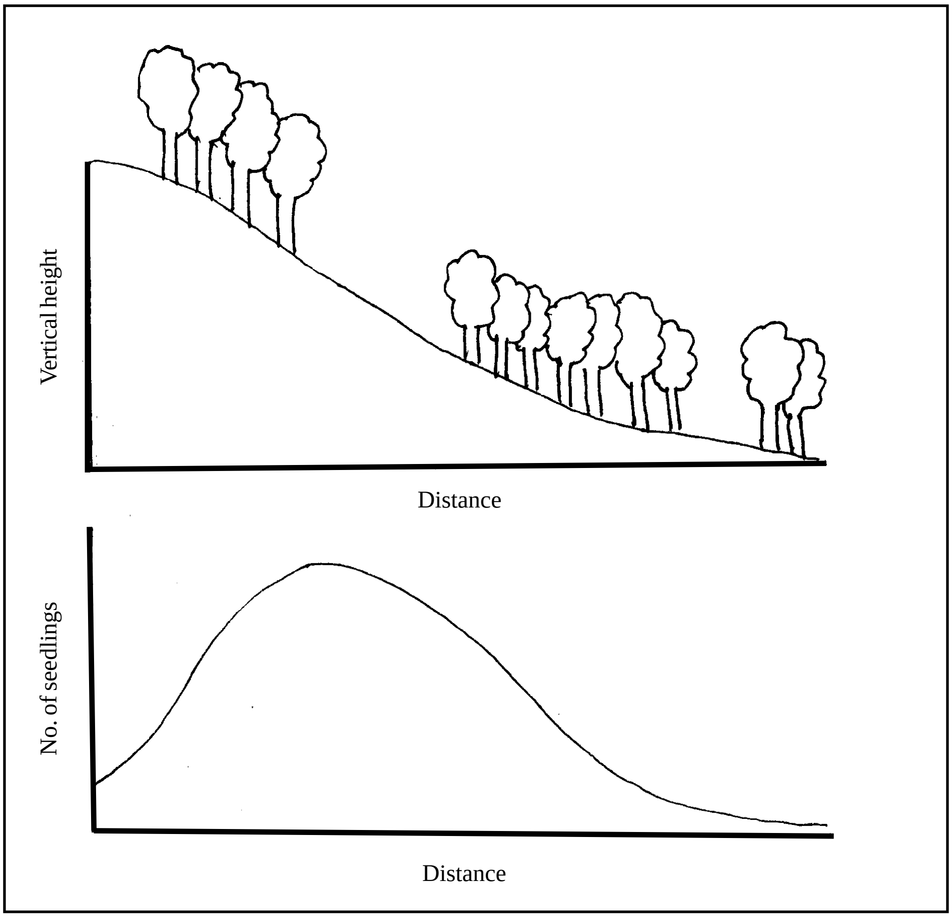
Suggest two reasons to account for the distribution of P.capulin seedlings.

Candidates should not be concerned that:

(a) They have not studied Mexico.

(b) They know nothing about P.capulin.

Fig 3. Distribution of P. capulin seedlings



The distribution of species is affected by biotic and abiotic factors. The deforested area has the highest number of seedlings. What biotic and abiotic factors could account for this? Even if candidates cannot recall the changes which deforestation causes to the immediate microclimate, it is relatively simple to **suggest** things.

For example, the soil in the clearing will receive more direct sunlight and therefore may be drier or warmer than soils beneath the canopy on either side. However, it could be argued that the soils on the top of the slope beneath the canopy might also be drier as they lose water through drainage so perhaps temperature - or the temperature range - may be more important than water availability. Then again, the soils in the cleared area will be subject to increased rain splash and erosion, increased leaching and increased frosts. These factors may all affect the distribution of P.capulin. We do not know, the Chief Examiner probably does not know and the key is to apply the biological basics to this new situation and to suggest things.

Acknowledgements:
This Factsheet was researched and written by Brian Taylor

Curriculum Press, Unit 305B, The Big Peg, 120 Vyse Street, Birmingham. B18 6NF

ISSN 1351-5136