18. Classification, Biodiversity and Conservation

18.2 Biodiversity

Paper 4

Question Paper

1 Bears are several species of mammal in the family Ursidae.

Climate change and loss of habitats due to human activity have reduced the size of some bear populations in recent years.

(c) (i) Human activity has disturbed the habitat of many populations of spectacled bear, *Tremarctos ornatus*. The spectacled bear feeds on a variety of plant and animal species.

Scientists compared the diversity of the food eaten by two populations of spectacled bear by analysing their faeces. One population lived in an undisturbed habitat and the other population lived in a habitat that had been disturbed by road building.

The scientists analysed the faeces from 60 bears in each population. They identified the species present and the number of individuals of each species in the faeces.

The scientists calculated the diversity of species in the faeces of the two populations using Simpson's Index of Diversity.

The formula for Simpson's Index of Diversity is:

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

n = number of individuals of each species present in the sample
N = total number of all individuals of all species

Table 8.1 shows the results and some of the steps for calculating the D value for the disturbed population.

Table 8.1

species eaten by bear	**number of individuals**	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
Gracilinanus aceramarcae	3	0.048	0.002
Oligorizomys sp.	5	0.081	0.007
Hesperomeles cuneata	4	0.065	0.004
Puya atra	28	0.452	0.204
Vaccinium floribundum	2	0.032	0.001
Pernettya prostrata	8	0.129	0.017
Gaultheria hapalotricha	12	.....	.....
total	62		.....

Calculate Simpson's Index of Diversity by completing Table 8.1 in the spaces provided.

Write the value for Simpson's Index of Diversity on the dotted line.

Simpson's Index of Diversity (D) = ... [3]

(ii) The scientists calculated a D value of 0.833 for the undisturbed population.

Explain what is shown by the difference in the D values between the two populations of bear.

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..... [1]

2 Lichens are found growing on trees, walls, rocks and soil.

Fig. 9.1 shows a lichen of the genus *Usnea. Usnea* can tolerate only low concentrations of sulfur dioxide and does not grow in places where the air is polluted with sulfur dioxide.

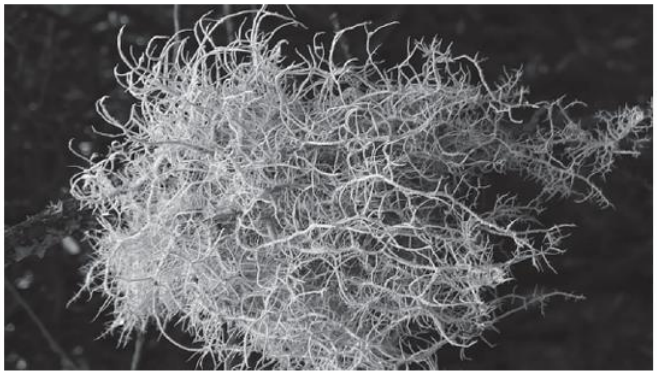


Fig. 9.1

Usnea is composed of a mixture of two types of cell:

- photosynthetic cells that are classified in the kingdom Protoctista
- fungal cells that are classified in the kingdom Fungi.

(b) *Xanthoria* is a lichen that can grow in places where there is a high concentration of sulfur dioxide in the air, for example in towns where homes, factories and vehicles burn fuels.

Fig. 9.2 shows a lichen of the genus *Xanthoria*.

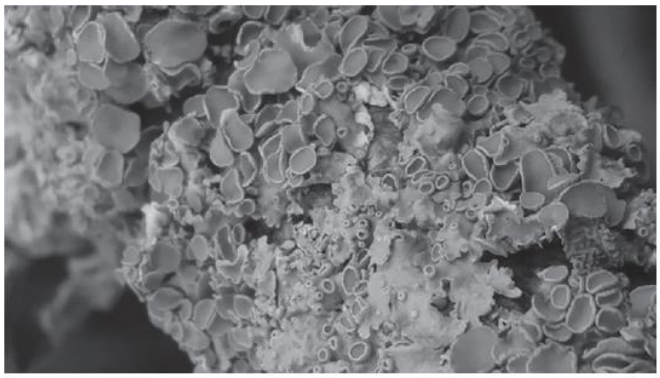


Fig. 9.2

(i) A student planned a method to measure the relative abundance of *Usnea* and *Xanthoria* on trees along a transect from the town centre at 0 km to unpolluted countryside at 4 km.

Suggest why measuring the relative abundance of the two types of lichen gives information that is useful for conservation.

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..... [3]

3 Populations of the moth *Biston betularia* live in Europe and in North America. The most common phenotype on both continents is a pale wing colour with light-grey shading (the typical form).

A moth phenotype with dark wing colour (the melanic form) also occurs on both continents.

Fig. 10.1 shows the typical form of the moth.

Fig. 10.2 shows the melanic form of the moth.



Fig. 10.1

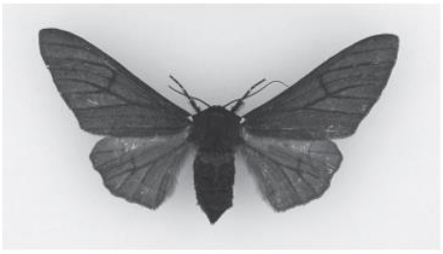


Fig. 10.2

(d) A light trap was used to estimate the total size of a population of *B. betularia* in a woodland. On night one, 24 moths were captured. These were marked with a small spot of harmless paint. On night two, 29 moths were captured, and 8 of these showed a spot of paint.

Use the Lincoln index formula provided to calculate the size of the population.

Show your working.

$$N = \frac{n_1 \times n_2}{m_2}$$

Key to symbols:
N = estimate of population size
n_1 = number of individuals captured in first sample
n_2 = number of individuals (both marked and unmarked) captured in second sample
m_2 = number of marked individuals recaptured in second sample

population size = ... [2]

4 The natural **ecosystem** on Hawadax Island in Alaska was disrupted in the 1780s when brown rats, *Rattus norvegicus*, swam to the island from a sinking ship and then rapidly increased their population size.

The rats occupied a new **niche** on the island as predators. The rats ate the eggs and chicks of birds such as the black oystercatcher, *Haematopus bachmani*, and the glaucous-winged gull, *Larus glaucescens*. These birds make nests, lay eggs and rear their chicks on the beaches of the island.

(a) Define the terms ecosystem and niche.

(i) ecosystem

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..... [2]

(ii) niche

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..... [1]

Conservation ecologists carried out a project to try to restore the natural ecosystem of Hawadax Island. In 2008, they removed all rats from the island.

Before removing the rats, the ecologists measured the abundance of birds, invertebrates and seaweeds on eight of the island's beaches. Seaweeds are large algae that grow attached to rocks on the beach. The ecologists repeated these measurements in 2013 and in 2019, so that they could calculate the percentage change in abundance from 2008.

(b) To measure the abundance of invertebrates and seaweeds, the ecologists used this method:

- They laid 30 m tapes from high-tide mark to low-tide mark on the beach.
- They placed quadrats at 5 metre intervals next to the tapes.
- They took a photograph of each quadrat.
- They analysed the photographs to calculate the percentage cover of seaweeds and the percentage cover of invertebrates such as mussels and sea snails.

(i) State the name of the sampling technique used.

..... [1]

(ii) Biodiversity can be assessed at a number of different levels.

Identify the levels of biodiversity:

- that were assessed by this sampling technique
- that were **not** assessed by this sampling technique.

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..... [3]

5 **(a)** The passage outlines one method of estimating the size of an animal population.

Complete the passage by using the most appropriate scientific terms.

The size of a population of animals can be estimated using the mark-release-recapture method. A sample of animals is captured using a humane (harmless) trap and is counted. The animals are marked using a method that does not harm them. This can be done using a small tag or ..... . The marked animals are released into the area where they were captured. Time is allowed for the marked animals to mix into the population. This period of time must be short so that emigration, immigration, migration or ..... do not occur.

A second sample of animals is then captured and the number of marked and unmarked animals is counted. The population size can be estimated using the ..... Index. For reliability, the method should be ..... .

[4]

6 Biodiversity can be assessed at three different levels. One of these is the genetic variation within each species.

(a) Outline **two** other levels at which biodiversity can be measured.

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..... [2]

(c) Table 2.1 shows the mean number of nucleotide differences per site of some species.

Table 2.1

species	mean number of nucleotide differences per site
Drosophila melanogaster, fruit fly	0.0087
Anopheles gambiae, mosquito vector of malaria	0.0301
Plasmodium falciparum, malarial pathogen	0.0015
Zea mays, wild maize	0.0139

(i) State the **genus** name of the species that shows the most genetic variation.

..... [1]

(ii) State how many kingdoms of organisms are represented in Table 2.1.

..... [1]

7 **(a)** Over the past 200 years, many species of animals and plants have become extinct.

Fig. 8.1 shows the changes between the years 1800 and 2000 in:

- the number of species becoming extinct
- the size of the world human population.

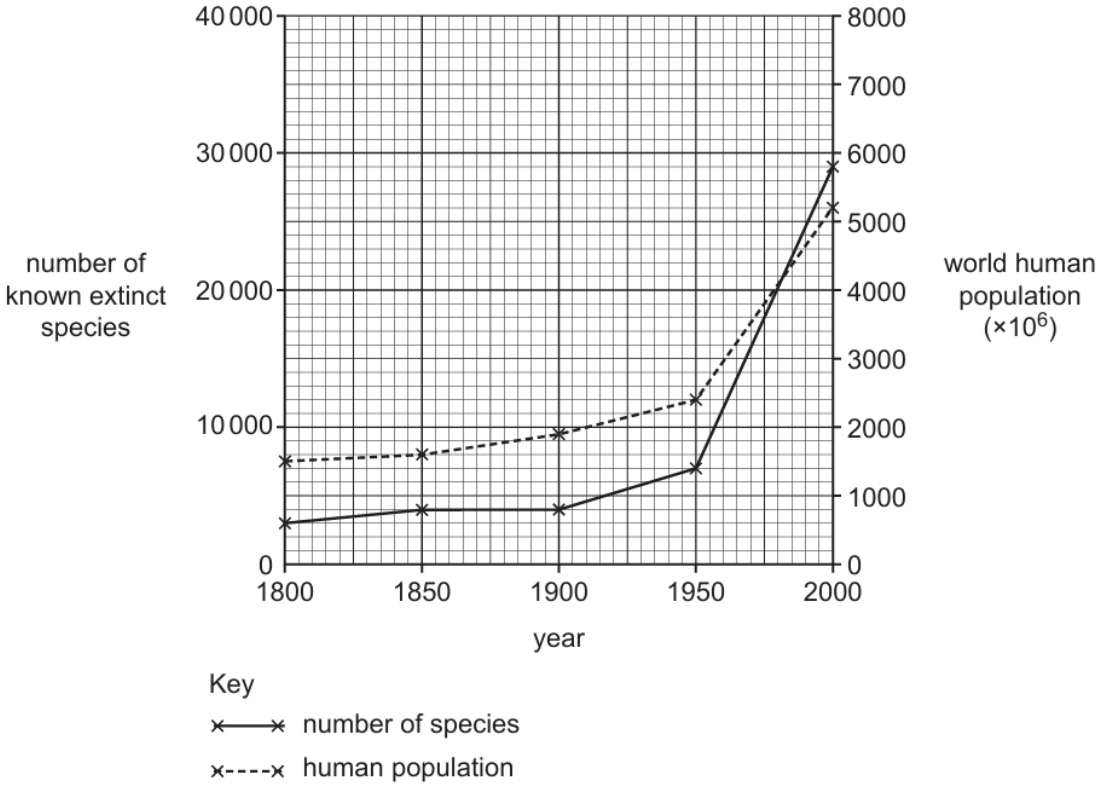


Fig. 8.1

(ii) Calculate the rate of species extinction per year between 1950 and 2000.

Show your working.

answer = ... [2]

8 The African penguin, *Spheniscus demersus*, lives along the coast of South Africa.

Fig. 10.1 shows two African penguins.



Fig. 10.1

(a) One way of estimating the size of a population of African penguins is to use the mark-release-recapture method.

Suggest **three** assumptions that must be made for the mark-release-recapture method to be valid.

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..... [3]

9 **(a)** One way to measure global biodiversity is to count the number of species of organisms.

Table 3.1 shows estimates for 2009 of the number of species in some taxa of animals.

The numbers in brackets are the numbers that were updated in 2019 from the International Union for Conservation of Nature and Natural Resources (IUCN) for three intensively studied taxa.

Table 3.1

number of species in each taxon		
kingdom	**phylum**	**class**
animals 1 438 805	arthropods 1 191 770	arachnids 102 248
		crustaceans 47 000
		myriapods 16 072
		insects 1 024 945
		other arthropod classes 1505
	chordates 63 543	fish 31 269
		amphibians 6515 (6722)
		birds 9990 (11 126)
		reptiles 8734
		mammals 5487 (5692)
	molluscs 85 000	
	other animal phyla 98 492	

(iv) With reference to Table 3.1, identify the class of animals that is most diverse then calculate the percentage of animal species that belongs to this class.

Show your working and give your answer to two significant figures.

answer = ... % [2]

10 Biodiversity can be considered at three different levels.

Fig. 5.1, Fig. 5.2 and Fig. 5.3 are images that show these three different levels of biodiversity.



Fig. 5.1



Fig. 5.2



Fig. 5.3

(a) Describe the level of biodiversity most clearly visible in each image.

Fig. 5.1 .....

Fig. 5.2 .....

Fig. 5.3 .....

[3]

(b) Prairie strips are restored habitat areas planted with native grasses and wildflowers. Prairie strips are usually located between or around the edges of fields of maize or soy bean.

Students in North America wanted to investigate biodiversity along a prairie strip.

(i) Outline how the students could measure the biodiversity of plants and insects along a prairie strip.

plants .....

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insects .....

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[4]

(ii) Mathematical methods and statistical tests help to summarise and compare biodiversity data.

Name the mathematical method **or** statistical test that the students can use:

to estimate the total biodiversity of a prairie strip

.....

to test whether plant biodiversity is associated with insect biodiversity.

.....

[2]

(c) Prairie strips have environmental and economic effects.

Scientists have made long-term measurements of the environmental effects of prairie strips.

The scientists found that when prairie strips formed 10% of a crop-field:
- soil erosion decreased by 95%
- mineral loss from the field decreased by 90% for phosphorus compounds
- mineral loss from the field decreased by 85% for nitrogen compounds.

Crop plants need phosphorus (P) and nitrogen (N) to grow.

Evaluate the **economic** effects of prairie strips on farming.

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..... [3]

11 Ecological surveys are conducted before conservation decisions are made. For example, surveys can be carried out before deciding whether to reintroduce a species to its former habitat.

(a) Outline how an ecological survey can measure the biodiversity of a terrestrial habitat.

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..... [4]

12 **(a)** Sampling is used to find out the variety of species in an ecosystem and the size of the population of each species.

A study was carried out to investigate the biodiversity of two fields, **A** and **B**.

Field **A** had **not** been used for growing crops for 10 years. Field **B** had been used for growing crops until one year before the study. Random sampling was carried out.

Describe how random sampling could be carried out on plant species in the two fields.

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..... [4]

(b) Table 8.1 shows the results of the sampling of field **A**.

Table 8.1

species	number of individuals (n)
Scabiosa columbaria	13
Centaurea centaurium	15
Primula veris	26
Trifolium pratense	36
Leucanthemum vulgare	11
Silybum marianum	5
Anacamptis morio	8
total number of individuals (N)	114

Simpson's Index of Diversity (D) is a value of the species diversity in an area.

The formula for this is:

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

Σ = sum of
n = number of individuals of a species
N = number of individuals of all species

(i) Complete Table 8.2 for *Primula veris*.

Table 8.2

species	n	$\frac{n}{N}$	$\left[\frac{n}{N}\right]^2$
Scabiosa columbaria	13	0.11	0.01
Centaurea centaurium	15	0.13	0.02
Primula veris	26	.....	.....
Trifolium pratense	36	0.32	0.10
Leucanthemum vulgare	11	0.10	0.01
Silybum marianum	5	0.04	0.00
Anacamptis morio	8	0.07	0.00

[1]

(ii) Use the data in Table 8.2 to calculate Simpson's Index of Diversity (D) for field **A**.

Show your working and write your answer to **two** decimal places.

D = ... [2]

(iii) The value of D for field **B** was 0.45.

Comment on the values of D for both fields.

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..... [1]

13 **(a)** Describe a method that could be used to estimate the population size of a mobile animal, such as a brown rat.

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..... [5]

(b) The soft rush plant, *Juncus effusus*, grows in many habitats in Northern Europe. An investigation was carried out to assess whether there was a relationship between the height of soft rush plants and the altitude at which they grow on exposed hillsides.

The mean height of 10 soft rush plants was calculated at each of eight different altitudes.

The results are shown in Table 8.1.

Table 8.1

altitude / m	mean height of soft rush plants / cm
100	85
150	86
200	83
250	79
300	72
350	74
400	68
450	63

The statistical test, Spearman's rank correlation (r_s), was applied to find out if there was a relationship between the altitude and the mean height of the soft rush plants.

(i) The formula for calculating Spearman's rank correlation is:

$$r_s = 1 - \left(\frac{6 \times \Sigma D^2}{n^3 - n}\right)$$

- ΣD^2 is the sum of the differences between the ranks of the two samples
- n is the number of samples.

In this investigation the value of ΣD^2 is 164.

Calculate the value of r_s.

Show your working and write your answer to **two** decimal places.

r_s = ... [2]

(ii) Use your value for r_s to evaluate the relationship between the altitude and the mean height of the soft rush plants.

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..... [2]

14 **(a)** Define the term *ecosystem*.

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..... [3]

(b) State the term used to describe:

the functional role of a species within an ecosystem

.....

a reproductively isolated group of organisms that interbreed to produce fertile offspring

.....

physical factors in the environment such as temperature and soil pH.

.....
[3]

15 Table 8.1 shows the total number of plant species, the total number of insect species and the number of habitats in three areas, **A**, **B** and **C**.

Table 8.1

area	total number of plant species	total number of insect species	number of habitats
A	6	5	1
B	15	23	4
C	362	70	12

(a) Identify the area with the highest biodiversity.

Give reasons for your choice of area.

area .....

reasons .....

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..... [3]

(b) Identify the area that is likely to be affected the most if the environment changes.

Give a reason for your choice of area.

area .....

reason .....

.....

[1]

(c) State **one** reason why it is important to conserve biodiversity in **all** three areas.

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..... [1]