**Q1.**Species richness and an index of diversity can be used to measure biodiversity within a community.

(a)     What is the difference between these two measures of biodiversity?

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**(1)**

Scientists investigated the biodiversity of butterflies in a rainforest. Their investigation lasted several months.

The scientists set one canopy trap and one understorey trap at five sites.

•        The canopy traps were set among the leaves of the trees 16–27 m above ground level.

•        The understorey traps were set under trees at 1.0–1.5 m above ground level.

The scientists recorded the number of each species of butterfly caught in the traps. The table below summarises their results.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Species of butterfly** | **Mean number of butterflies** | | **P value** |
|  | **In canopy** | **In understorey** |
|  | *Prepona laertes* | 15 | 0 | < 0.001 |
|  | *Archaeoprepona demophon* | 14 | 37 | < 0.001 |
|  | *Zaretis itys* | 25 | 11 | > 0.05 |
|  | *Memphis arachne* | 89 | 23 | < 0.001 |
|  | *Memphis offa* | 21 | 3 | < 0.001 |
|  | *Memphis xenocles* | 32 | 8 | < 0.001 |

(b)     The traps in the canopy were set at 16–27 m above ground level. Suggest why there was such great variation in the height of the traps.

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**(1)**

(c)     By how many times is the species diversity in the canopy greater than in the understorey? Show your working.

Use the following formula to calculate species diversity.

*d* = 

where *N* is the total number of organisms of all species and *n* is the total number of organisms of each species.

Answer = ...................................

**(3)**

(d)     The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in the table.

Explain what the results of these statistical tests show.

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**(Extra space)** ................................................................................................

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**(3)**

**(Total 8 marks)**

**Q2.**Scientists investigated the effect of a mycorrhizal fungus on the growth of pea plants with a nitrate fertiliser or an ammonium fertiliser. The fertilisers were identical, except for nitrate or ammonium.

The scientists took pea seeds and sterilised their surfaces. They planted the seeds in soil that had been heated to 85 °C for 2 days before use. The soil was sand that contained no mineral ions useful to the plants.

(a)     Explain why the scientists sterilised the surfaces of the seeds and grew them in soil that had been heated to 85 °C for 2 days.

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**(2)**

(b)     Explain why it was important that the soil contained no mineral ions useful to the plants.

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**(1)**

The pea plants were divided into four groups, **A**, **B**, **C** and **D**.

•        **Group A** – heat-treated mycorrhizal fungus added, nitrate fertiliser

•        **Group B** – mycorrhizal fungus added, nitrate fertiliser

•        **Group C** – heat-treated mycorrhizal fungus added, ammonium fertiliser

•        **Group D** – mycorrhizal fungus added, ammonium fertiliser

The heat-treated fungus had been heated to 120 °C for 1 hour.

(c)     Explain how groups **A** and **C** act as controls.

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**(2)**

After 6 weeks, the scientists removed the plants from the soil and cut the roots from the shoots. They dried the plant material in an oven at 90 °C for 3 days. They then determined the mean dry masses of the roots and shoots of each group of pea plants.

(d)     Suggest what the scientists should have done during the drying process to be sure that all of the water had been removed from the plant samples.

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**(2)**

The scientists’ results are shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Treatment** | **Mean dry mass / g per plant ( standard deviation)** | |
|  | **Root** | **Shoot** |
|  | **A** – heat-treated fungus  and nitrate fertiliser | 0.40 (±0.05) | 1.01 (±0.12) |
|  | **B** – fungus and nitrate  fertiliser | 1.61 (±0.28) | 9.81 (±0.33) |
|  | **C** – heat-treated fungus  and ammonium fertiliser | 0.34 (±0.03) | 0.96 (±0.26) |
|  | **D** – fungus and  ammonium fertiliser | 0.96 (±0.18) | 4.01 (±0.47) |

(e)     What conclusions can be drawn from the data in the table about the following?

The effects of the fungus on growth of the pea plants.

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The effects of nitrate fertiliser and ammonium fertiliser on growth of the pea plants.

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**(4)**

The scientists determined the dry mass of the roots and shoots separately. The reason for this was they were interested in the ratio of shoot to root growth of pea plants. It is the shoot of the pea plant that is harvested for commercial purposes.

(f)     Explain why determination of dry mass was an appropriate method to use in this investigation.

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**(2)**

(g)     Which treatment gave the best result in commercial terms? Justify your answer.

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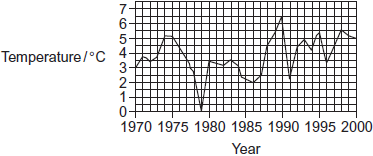
**(2)**

**(Total 15 marks)**

**Q3.**During the last 50 years, there have been changes in the climate of the UK. One of the main changes is temperature. The data in the following resources all relate to southern England.

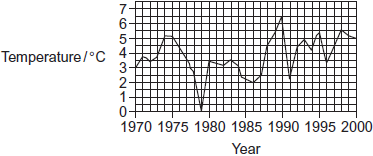
**Figure 1** shows the mean temperatures for January and February combined.

**Figure 1**



**Figure 2** shows the mean temperatures for March.

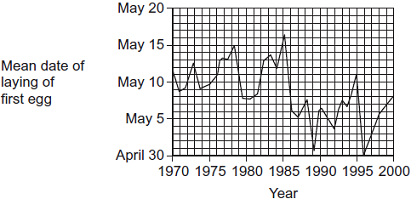
**Figure 2**



Birds, such as chaffinches, have been recorded as breeding earlier. Chaffinches build nests. When the nest is complete, the female lays eggs until she has produced a full clutch of 4 to 6 eggs. After the eggs hatch, the parent birds feed the young on insects.

**Figure 3** shows the mean date on which chaffinches laid their first egg.

**Figure 3**

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The data from which this graph was drawn were collected by volunteers. They used standard record cards. The volunteers used one record card for each nest they found. Each card was used to record

•        the geographical location

•        the habitat in which the nest site was situated

•        the date of each visit to the nest by the volunteer

•        the number of eggs present in the nest at each visit.

Visits were made to the nests at least once every 5 days.

(a)     Do the data in **Figure 1** and **Figure 2** support the idea that there has been a rise in the mean temperatures in southern England between 1970 and 2000? Explain your answer.

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**(2)**

(b)     Describe briefly how you would use a statistical test to find whether there is a significant correlation between mean March temperature and the date when chaffinches laid their first egg.

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(Extra space) .................................................................................................

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**(3)**

(c)     In chaffinches, the date of laying the first egg is determined by a number of factors. These include day length and temperature. What is the advantage to the bird of egglaying being determined by

(i)      daylength

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**(2)**

(ii)     temperature?

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**(2)**

(d)     Scientists found that there was a correlation between mean annual temperature and the date when chaffinches laid the first egg. Can you conclude that higher temperatures cause earlier laying of the first egg?  
Explain your answer.

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**(2)**

(e)     How does the way in which the data were collected affect the conclusions which can be drawn from **Figure 3**?

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**M1.**(a)     Species richness measures only number of (different) species / does not measure number of individuals.

**1**

(b)     Trees vary in height.

**1**

(c)     1.      Index for canopy is 3.73;

2.      Index for understorey is 3.30;

3.      Index in canopy is 1.13 times bigger;

*If either or both indices incorrect, allow correct calculation from student’s values.*

**3**

(d)     1.      For *Zaretis itys*, difference in distribution is probably due to chance / probability of being due to chance is more than 5%;

2.      For all species other than *Zaretis itys*, difference in distribution is (highly) unlikely to be due to chance;

3.      Because P < 0.001 which is highly significant / is much lower than 5%.

**3**

**[8]**

**M2.**(a)      1.      To kill any fungus / bacteria on surface of seeds or in soil;

2.      So only the added fungus has any effect.

**2**

(b)     So that only nitrate or ammonia / type of fertiliser affects growth.

**1**

(c)     1.      So that effects of nitrate or ammonium alone could be seen;

2.      So that effects of fungus can be seen.

**2**

(d)     1.      Weigh samples at intervals during drying;

2.      To see if weighings became constant (by 3 days).

**2**

(e)     With live fungus – showing effects of the fungus:

1.      Fungus increases growth of roots and shoots in both;

2.      Produces greater growth with nitrate.

With heat-treated fungus – showing effects of fertiliser:

3.      Similar dry masses for roots and shoots;

4.      (Probably) no significant difference because SDs overlap.

**4**

(f)     1.      Dry mass measures / determines increase in biological / organic material;

2.      Water content varies.

**2**

(g)     1.      Fungus with nitrate-containing fertiliser gave largest shoot: root ratio;

2.      And largest dry mass of shoot;

3.      6.09:1 compared with ammonium-containing fertiliser 4.18:1

**2 max**

**[15]**

**M3.**(a)     Shows trend of mean temperature rise;  
Higher temperatures more frequent since 1984 (in January and February);  
Considerable variation in temperature from year to year;  
Which may be due to chance;

*No mark for yes or no Do not penalise candidates who state there is no trend*

**2 max**

(b)     Construct null nypothesis;  
Use Spearman rank (and calculate test statistic);  
Look up in table (to find critical value of P = 0.05 / 5 %);  
Use figure (in table) to accept or reject null hypothesis;

**3 max**

(c)     (i)      (Particular daylength) always occurs at same time of year / valid example;  
Birds do not start laying eggs when period of warm weather occurs early in year;  
Synchronises breeding behaviour;  
Sufficient foraging time for food collection for young;

**2 max**

(ii)     Birds able to respond to changing climate;  
Food availability (mainly) determined by temperature;  
As insect / invertebrate development temperature-dependent;

**2 max**

(d)     A correlation does not indicate a causal relationship;  
As may be due to another factor / named factor;

**2**

(e)     Visits could be up to 5 days apart;  
Date of egg-laying may be inaccurate by 5+ days;

**2**

**[13]**

**E3.**(a)     Candidates recognised that temperatures were generally higher and also suggested that the temperature fluctuated. This question was usually marked at the correct level. It was less common for candidates to identify that the trend in the data may have been due to chance.

(b)     This was well understood with the vast majority scoring two or more marks. It was marked at the correct level by most centres. Most commonly the null hypothesis was absent in responses. Many accounts provided extensive unnecessary detail about calculating the test statistic. This was often incorrectly given credit.

(c)     (i)      Only a very small number of candidates established valid links between egg-laying and daylength. Very few candidates realised that daylength was related to a particular time of year. Too many answers which did not correspond to points on the marking guidelines were credited by centres. Credit was also often incorrectly given for synchronising egg-laying rather than breeding behaviour.

(ii)     Candidates had more success with the relationship of egg-laying and temperature. They established links with availability of food and an increase in insect numbers. Many candidates, however, discussed body temperature and survival of young and this was incorrectly credited by some centres. Others answered in terms of temperature affecting egg hatching.

(d)     This was well answered by the vast majority and marked at the correct level.

(e)     Many candidates were able to use the data supplied to suggest that the date of egg-laying would be imprecise. Many answers were linked to the collection of data by volunteers, candidates considering that as a consequence the data were unreliable and the conclusions that could be drawn were debatable. Again answers not meeting the requirements of those in the marking guidelines, such as ‘don’t know when the eggs were laid’, were credited.