Cambridge Assessment International Education

Cambridge International AS & A Level

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1624630727

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

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1 A student investigated the effect of wind speed on the rate of transpiration. The student used the flowering plant Japanese spiraea, *Spiraea japonica*.

The student used the apparatus shown in Fig. 1.1 to measure the rate of transpiration.

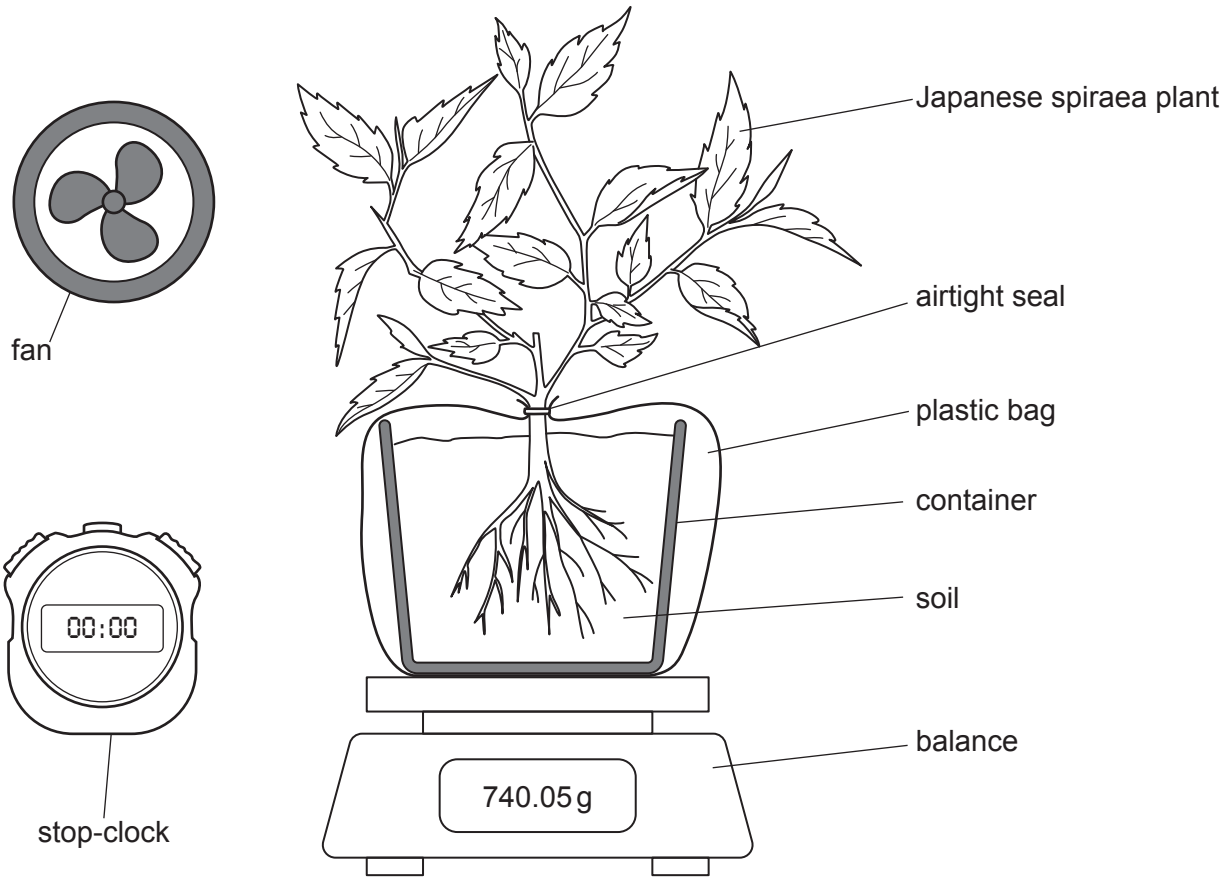

Fig. 1.1

To set up the apparatus the student:

- obtained a Japanese spiraea plant growing in a container of soil
- added 200 cm^3 of water to the soil
- placed a plastic bag around the container of soil to prevent water loss from the soil
- placed the plant and container on the balance
- switched on the fan to a low setting.

The roots of the Japanese spiraea plant absorbed water from the soil. Water was carried in the xylem and water vapour was lost by transpiration from the leaves of the plant. This caused the reading on the balance to decrease during the investigation.

(a) (i) Identify the **independent** variable in this investigation.

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..... [1]

(ii) The student carried out the investigation in a laboratory with standard laboratory apparatus.

Describe a method, using the apparatus shown in Fig. 1.1, that the student could use to investigate the effect of wind speed on the rate of transpiration by Japanese spiraea.

Your method should be set out in a logical order and be detailed enough to allow another person to follow it.

Details of how to set up the apparatus shown in Fig. 1.1 should **not** be included.

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(iii) Predict the effect of wind speed on the results of the investigation using the method you have given in **(a)(ii)**.

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(b) The student used a different method to measure the rate of transpiration of Japanese spiraea.

Fig. 1.2 shows the apparatus used. The leaf remained attached to the plant during the investigation.

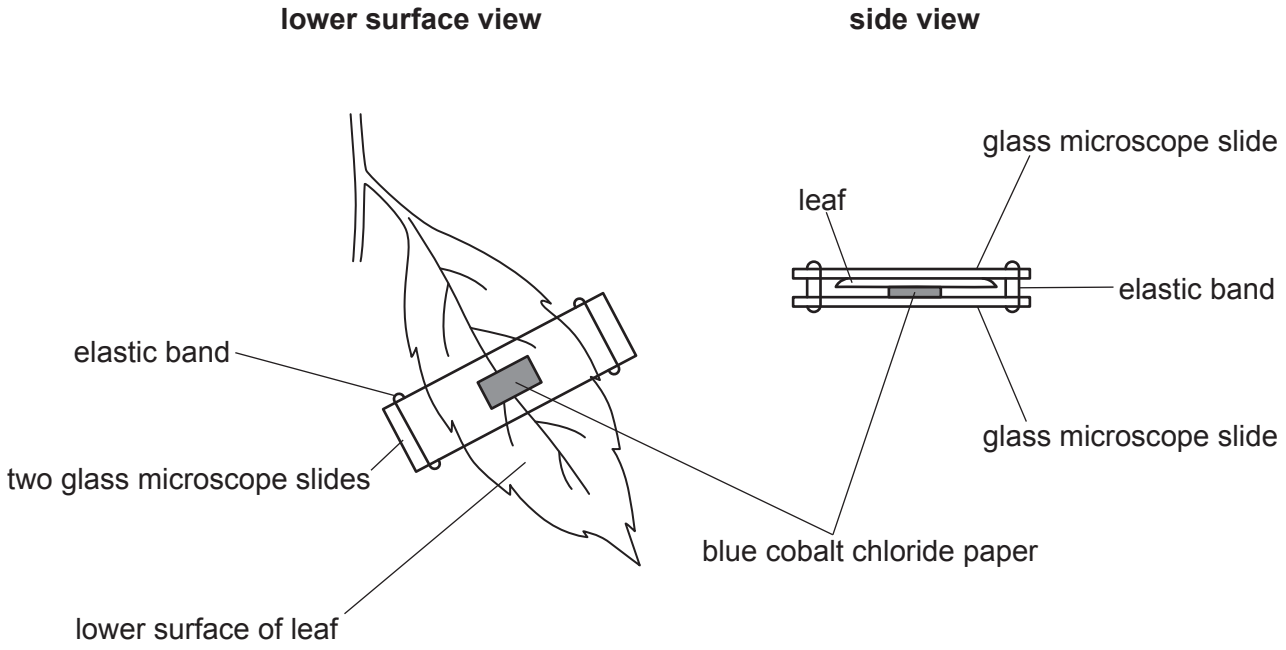

Fig. 1.2

A piece of blue cobalt chloride paper was attached to the lower surface of a leaf, as shown in Fig. 1.2. Blue cobalt chloride paper changes colour to pink if water is added.

The student measured the time taken for the blue cobalt chloride paper to change colour.

This procedure was repeated with two more leaves of the Japanese spiraea plant. The plant was kept in controlled conditions at all times.

Table 1.1 shows the results obtained using blue cobalt chloride paper.

Table 1.1

leaf tested	time taken for blue cobalt chloride paper to change colour / s
1	122
2	137
3	74

Fig. 1.3 shows the formula the student used to calculate the rate of transpiration in units of h^{-1}.

$$\text{rate of transpiration} = \frac{3600}{\text{time taken in seconds}}$$

Fig. 1.3

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(i) Using the information given in Table 1.1 and Fig. 1.3, calculate the rate of transpiration for leaf **2** of the Japanese spiraea plant.

Give your answer to **three** significant figures.

rate of transpiration = ... h^{-1}

[1]

(ii) To improve the validity of the results, the student decided to measure the time taken for blue cobalt chloride paper to change colour on a greater number of leaves of the Japanese spiraea plant.

State **one** other change the student could make to the method to improve the validity of the results.

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..... [1]

[Total: 10]

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2 The responses of plant species to water stress can be classified as either isohydric or anisohydric.

- Isohydric plant species close stomata during times of water stress. This behaviour minimises water loss by transpiration but also reduces carbon dioxide uptake for photosynthesis.

- Anisohydric plant species do not close stomata during times of water stress. This behaviour maximises carbon dioxide uptake for photosynthesis but also increases water loss by transpiration.

A biologist studied 10 tree species from Australia. The biologist studied the effect of water stress **and** high environmental temperatures on five isohydric tree species and five anisohydric tree species.

For each tree species studied:

- The biologist obtained 20 young trees.
- The young trees were grown in containers of soil in controlled conditions in a glasshouse.
- The environmental conditions in the glasshouse were chosen to represent summer conditions in Australia. The mean glasshouse temperature was 28 °C.
- All the young trees were given a good supply of water for 10 weeks, so that the young trees acclimatised to the environmental conditions in the glasshouse.

(a) State **three** environmental conditions in the glasshouse that should be standardised in the 10-week period of acclimatisation, **other than** the temperature of the glasshouse.

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After the 10-week period of acclimatisation, the biologist divided the young trees from each species into four groups of five trees.

Table 2.1 shows the experimental conditions used by the biologist for the next five weeks.

Table 2.1

group	experimental conditions
1	The young trees were given a good supply of water for five weeks. The mean glasshouse temperature during weeks 1 to 5 was 28 °C.
2	The young trees were given a good supply of water for five weeks. The mean glasshouse temperature during weeks 1 to 4 was 28 °C. During week 5, the mean glasshouse temperature was increased to 35 °C.
3	The young trees were given a reduced supply of water for five weeks (water stress). The mean glasshouse temperature during weeks 1 to 5 was 28 °C.
4	The young trees were given a reduced supply of water for five weeks (water stress). The mean glasshouse temperature during weeks 1 to 4 was 28 °C. During week 5, the mean glasshouse temperature was increased to 35 °C.

At the end of week 5, the biologist measured the stomatal conductance of three leaves from each young tree at 12:00 (midday).

Stomatal conductance is a measure of water vapour loss from the intercellular air spaces of leaves to the atmosphere through the stomata.

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The biologist processed the data to compare the results from the isohydric and anisohydric tree species in the four experimental conditions, as shown in Table 2.1.

The results are shown in Fig. 2.1.

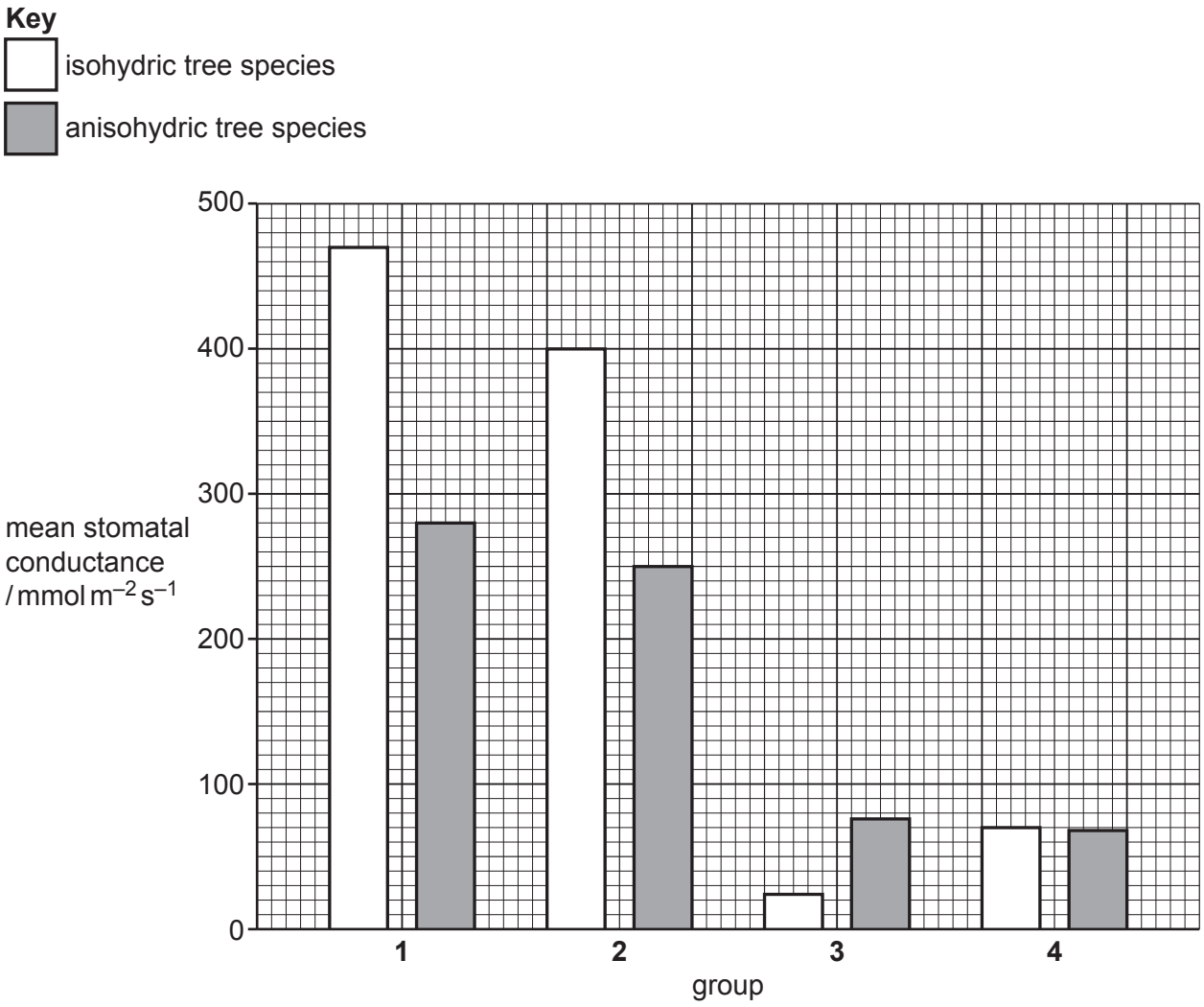

Fig. 2.1

(b) Using Fig. 2.1, state the effect of a high mean temperature on the mean stomatal conductance of young trees that were given a good supply of water.

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(c) The biologist then compared the young trees from group **3** and group **4** that were exposed to water stress.

The biologist carried out statistical tests on the data to see if the difference between the mean stomatal conductance of young trees in group **3** and the mean stomatal conductance of young trees in group **4** was significant.

Table 2.2 shows the probability values (*p*) from the results of the statistical tests.

Table 2.2

tree species	value of *p*	significance
isohydric tree species	0.046	significant
anisohydric tree species	0.788	not significant

With reference to Fig. 2.1 and Table 2.2, suggest **and** explain the conclusions that can be made about the effect of water stress **and** a high environmental temperature on isohydric **and** anisohydric tree species.

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Question 2 continues on page 12.

(d) The biologist noticed that the young trees in group **4** had some dead leaves at the end of week 5.

The biologist determined the percentage of leaves on the young trees that were dead at the end of week 5.

The results from the isohydric tree species and the anisohydric tree species are shown in Table 2.3.

Table 2.3

type of tree species	**group 4: water stress + high mean temperature**	
	mean percentage of leaves that were dead	**standard error (SE)**
isohydric	19.0	8.3
anisohydric	3.5	1.3

(i) The biologist then analysed these data using a *t*-test to compare the mean percentage of leaves that were dead on the young trees of the isohydric and anisohydric species.

State a null hypothesis for the *t*-test.

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(ii) The formula for the *t*-test is:

$$t = \frac{\left|\bar{x}_1 - \bar{x}_2\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

key to symbols:

$\bar{x}$ = mean
s = sample standard deviation
n = sample size (number of observations)

The biologist calculated $\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}$ = **8.231**

Use this value and Table 2.3 to calculate the value of *t* for these data.

Show your working.

t = ... [2]

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(iii) The degrees of freedom for this *t*-test are 48. Table 2.4 shows the probability table for the *t*-test.

Table 2.4

degrees of freedom	critical values		
	p = 0.10 (10%)	p = 0.05 (5%)	p = 0.01 (1%)
48	1.677	2.011	2.682

Using Table 2.4 and the calculated value of *t* from **(d)(ii)**, describe what the biologist can conclude from the results shown in Table 2.3.

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..... [3]

[Total: 14]

3 Female mosquitoes feed on human blood. Some species of mosquitoes are vectors of human pathogens. For example, female mosquitoes of the species *Aedes aegypti* transmit the pathogen that causes the disease yellow fever.

Mosquitoes have sensory receptors that can detect chemicals in the air. Mosquito repellents contain chemicals that are sprayed onto the skin of humans to prevent mosquitoes taking blood meals.

(a) Some scientists investigated the effectiveness of different mosquito repellents using a human volunteer. The scientists carried out the investigation on this person in a laboratory.

Fig. 3.1 is a diagram of the experiment before the start of the investigation.

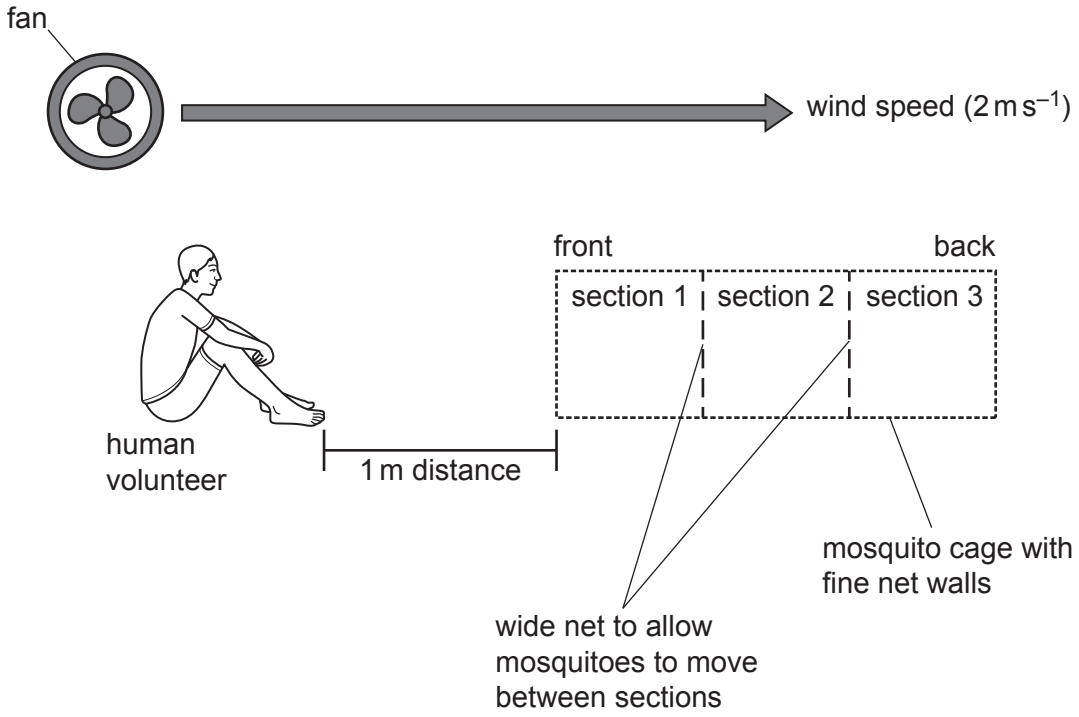

Fig. 3.1

The same procedure was used for each mosquito repellent studied.

- A human volunteer sat 1 m from a mosquito cage, as shown in Fig. 3.1.
- The person sprayed some mosquito repellent onto the skin of both arms.
- A fan was turned on so that air moved from the person towards the mosquito cage. The moving air carried chemicals, including the mosquito repellent, from the person into the mosquito cage.
- The scientists added 100 female mosquitoes of *A. aegypti* to section 2 of the mosquito cage.
- The mosquitoes were left in the mosquito cage for 15 minutes. The walls of the mosquito cage were made of fine net to prevent mosquitoes leaving the cage. The mosquitoes moved freely between sections 1, 2 and 3.
- After 15 minutes, the scientists counted the number of mosquitoes in each section of the mosquito cage. The percentage of mosquitoes in section 1 of the mosquito cage was calculated.
- This procedure was then repeated three times on different days, using the same person.

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(i) State a suitable control for this investigation.

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(ii) Suggest **one** risk to the **scientists** when carrying out this investigation **and** state a suitable precaution they should take.

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(b) Table 3.1 shows the results of the investigation.

Table 3.1

chemical in mosquito repellent	percentage concentration of chemical in mosquito repellent	percentage of mosquitoes in section 1 of the mosquito cage mean ± standard error (SE)
DEET	40	68.55 ± 6.42
DEET	98	33.70 ± 4.06
lemon eucalyptus oil	30	29.62 ± 6.31
picaridin	10	78.65 ± 6.00

The results of this investigation were published in a scientific paper.

A student who read this paper concluded that the most effective mosquito repellents contained DEET or lemon eucalyptus oil.

The student was planning to travel to a country where malaria is present. The student decided to use a mosquito repellent that contained DEET to prevent malaria infection.

Explain whether the procedure **and** the data in Table 3.1 support or do **not** support this decision to use a mosquito repellent that contained DEET.

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[Total: 6]

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