WJEC England Biology A Level

SP C2 06: Investigation of continuous variation in a species

Practical notes

Introduction

Continuous variation produces characteristics which **do not** fall into discrete categories, instead showing a **continuous range** e.g. height, weight. It can be represented by a **frequency histogram** which forms an approximately **normal** curve.

The **means** of two polygenic characteristics which show **continuous variation** can be compared using **Student's t-test** (**unpaired**).

Equipment

- Ruler
- 15 ivy leaves growing in bright conditions
- 15 ivy leaves growing in dark conditions

Risk assessment

Hazard	Risk	Precaution	Emergency
Ivy leaves	Allergic reaction	Use non-latex disposable gloves	Run the affected area under cold water; seek medical assistance
Berries	Poisonous	Do not ingest	Seek medical assistance

Method

1. Use a ruler to measure the **maximum width** of each leaf. Calculate the **mean width** of each sample of ivy leaves. Record your results in a suitable format.

2. Plot a **frequency histogram** for each data sample to confirm that the distribution is approximately **normal**.

3. Calculate each sample's **standard deviation** using:

$$s = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

4. Use **Student's t-test** to determine whether there is a **statistically significant difference** between the **means** of the two samples:

    a. Identify the null hypothesis
    b. Calculate t
    c. Work out the **degrees of freedom**
    d. Find the critical value and test the significance

$$t = \frac{|\overline{X_1} - \overline{X_2}|}{\sqrt{\left(\frac{S_1^2}{n_1}\right) + \left(\frac{S_2^2}{n_2}\right)}}$$

where…

$|\overline{X_1} - \overline{X_2}|$ is the difference between the two mean values

S_1^2 and S_2^2 are the squares of the samples' standard deviations

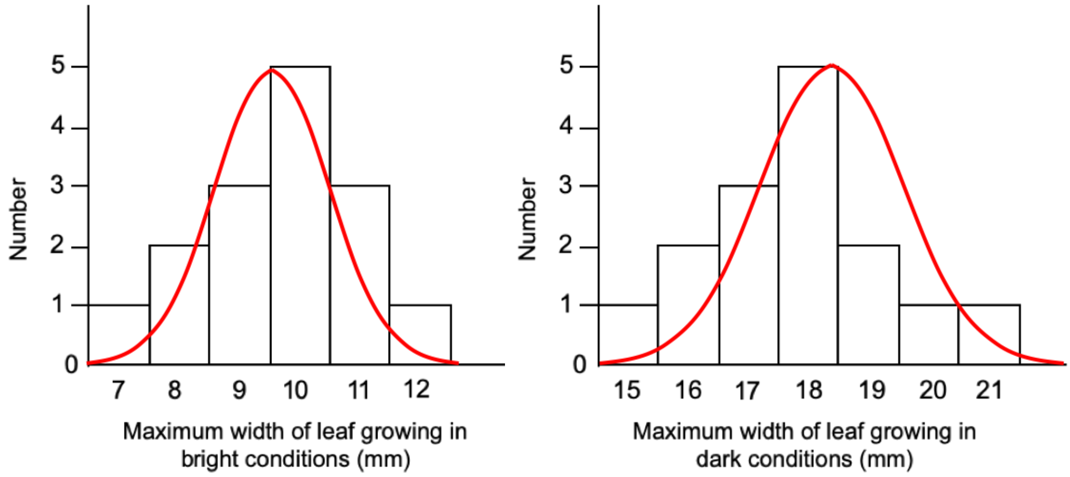
n_1 and n_2 are the total number of readings in each sample

Worked example

1. **Use a ruler to measure the maximum width of each leaf. Calculate the mean width of each sample of ivy leaves. Record your results in a suitable format.**

Maximum width of ivy leaf (mm)	
Bright conditions	Dark conditions
8	18
8	16
10	15
9	17
11	17
7	20
9	21
10	19
10	17
10	18
12	18
9	18
11	16
11	18
10	19
Mean = 9.67	Mean = 17.80

2. **Plot a frequency histogram for each data sample to confirm that the distribution is approximately normal.**



3. **Calculate each sample's standard deviation**

Leaves growing in bright conditions (1)	Width (mm)	$(x - \bar{x})$	$(x - \bar{x})^2$
1	8	-1.67	2.7889
2	8	-1.67	2.7889
3	10	0.33	0.1089
4	9	-0.67	0.4489
5	11	1.33	1.7689
6	7	-2.67	7.1289
7	9	-0.67	0.4489
8	10	0.33	0.1089
9	10	0.33	0.1089
10	10	0.33	0.1089
11	12	2.33	5.4289
12	9	-0.67	0.4489
13	11	1.33	1.7689
14	11	1.33	1.7689
15	10	0.33	0.1089
Mean	9.67		$\sum = 25.3335$

$$s_1 = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}} = \sqrt{\frac{25.3335}{14}} = 1.35$$

Leaves growing in dark conditions (2)	Width (mm)	$(x - \bar{x})$	$(x - \bar{x})^2$
1	18	0.2	0.04
2	16	-1.8	3.24
3	15	-2.8	7.84
4	17	-0.8	0.64
5	17	0.8	0.64
6	20	2.2	4.84
7	21	3.2	10.24
8	19	1.2	1.44
9	17	-0.8	0.64
10	18	0.2	0.04
11	18	0.2	0.04
12	18	0.2	0.04
13	16	-1.8	3.24
14	18	0.2	0.04
15	19	1.2	1.44
Mean	17.80		$\sum = 34.40$

$$s_2 = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}} = \sqrt{\frac{34.4}{14}} = 1.57$$

4. a. **Identify the null hypothesis**

H_0 - there is no statistically significant difference between the mean width of ivy leaves growing in bright conditions and the mean width of ivy leaves growing in dark conditions

b. **Calculate t**

$$t = \frac{|\bar{X}_1 - \bar{X}_2|}{\sqrt{\left(\frac{S_1^2}{n_1}\right) + \left(\frac{S_2^2}{n_2}\right)}} = \frac{8.13}{\sqrt{\left(\frac{1.8225}{15}\right) + \left(\frac{2.4649}{15}\right)}} = 15.20$$

c. **Work out the degrees of freedom** *(df = $n_1 + n_2 - 2$)*

df = 15 + 15 - 2 = 28

d. **Find the critical value and test the significance**

Probability of 0.05, df of 28, critical value for X^2 = 2.048

15.200 > 2.048
The null hypothesis is rejected.

There is a statistically significant difference between the mean width of ivy leaves growing in bright conditions and the mean width of ivy leaves growing in dark conditions.