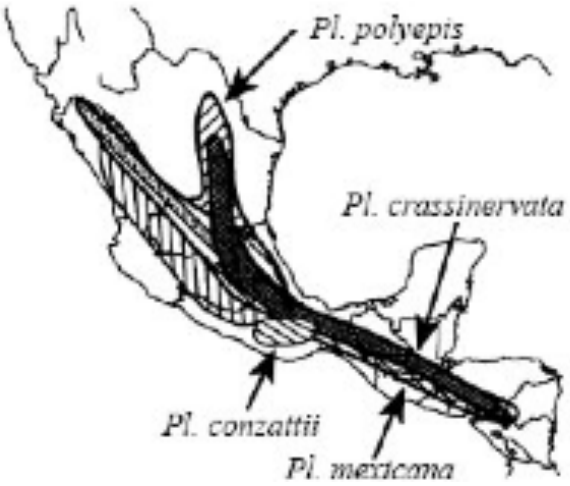
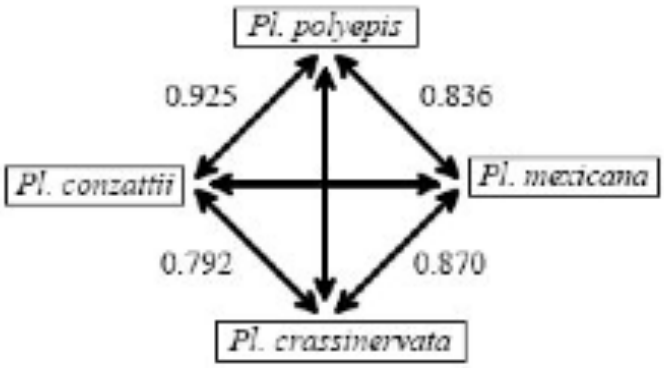
Speciation (6 marks)

The mechanisms of speciation in ferns have been studied in temperate and tropical habitats. One group of three species from the genus *Polypodium* lives in rocky areas in temperate forests in North America. Members of this group have similar morphology. Another group of four species from the genus *Pleopeltis* live at different altitudes in tropical mountains in Mexico and Central America. Members of this group are morphologically distinct. Data from the different species within each group was compared to study the mechanisms of speciation. Genetic identity was determined by comparing the similarities of certain proteins and genes in each species. Values between 0 and 1 were assigned to pairs of species to indicate the degree of genetic similarity. A value of 1 would mean that all the genetic factors were identical between the species.

Fig. 1:
The approximate distribution in North America of the three species of *Polypodium (Po.)* and a summary of genetic identity.





a. Compare the geographic distributions of the two groups. *(1 mark)*

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b. Identify, giving a reason, which group, *Polypodium* or *Pleopeltis*, is most genetically diverse. *(1 mark)*

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c. Identify the **two** species that are most similar genetically. *(1 mark)*

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d. Suggest how the process of speciation could have occurred in *Polypodium*. *(1 mark)*

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e. Explain which of the two groups has most probably been genetically isolated for the longest period of time. *(2 marks)*

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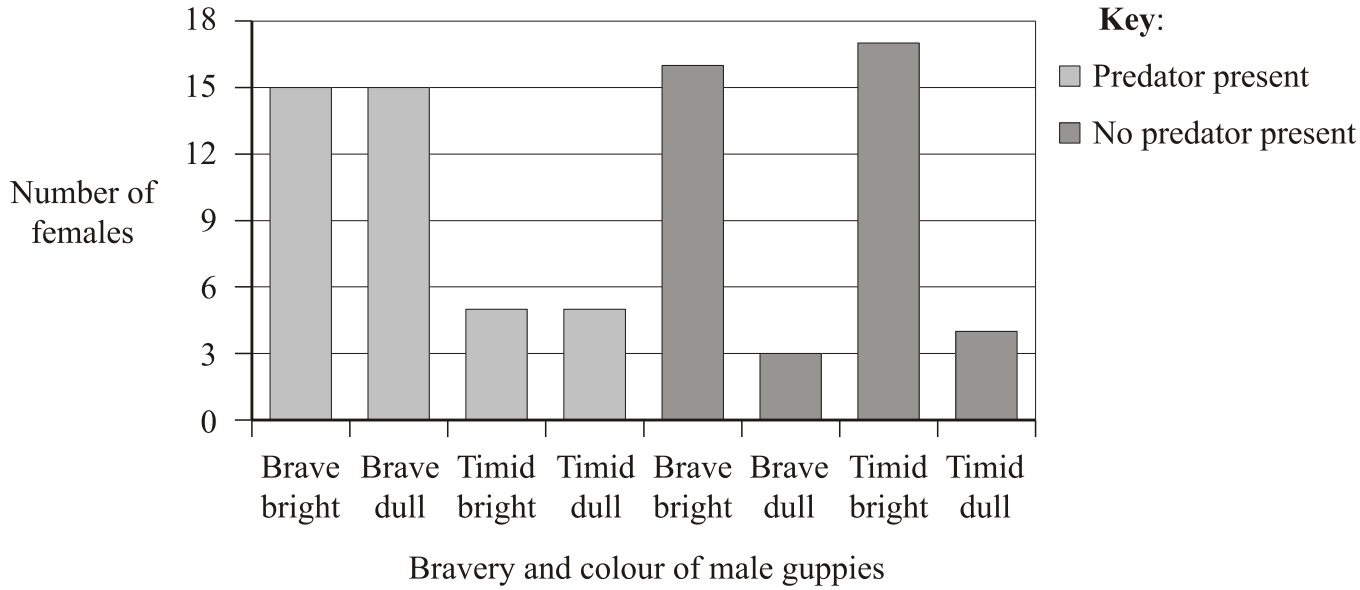
Guppies (8 marks)

The guppy (*Poecilia reticulata*) is a small fish found in Trinidad. In an experiment, male guppies were divided into those with a lot of colour (bright) and those with little colour (dull). They were also exposed to a predator to see if they approached it (brave) or swam away from it (timid). Female guppies were allowed to select males to mate with, in the presence or absence of predators. A bar chart summarizes their choice of males.



a. State how many females chose dull male guppies with a predator present. *(1 mark)*

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b. Calculate the difference in timid bright males chosen by the females with and without the predator present. *(1 mark)*

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c. Compare mate selection by females in the presence and absence of a predator. *(2 marks)*

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d. Suggest reasons for this pattern of mate selection. *(2 marks)*

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e. Evaluate the hypothesis that bravery is more important than colour when selecting a mate. *(2 marks)*

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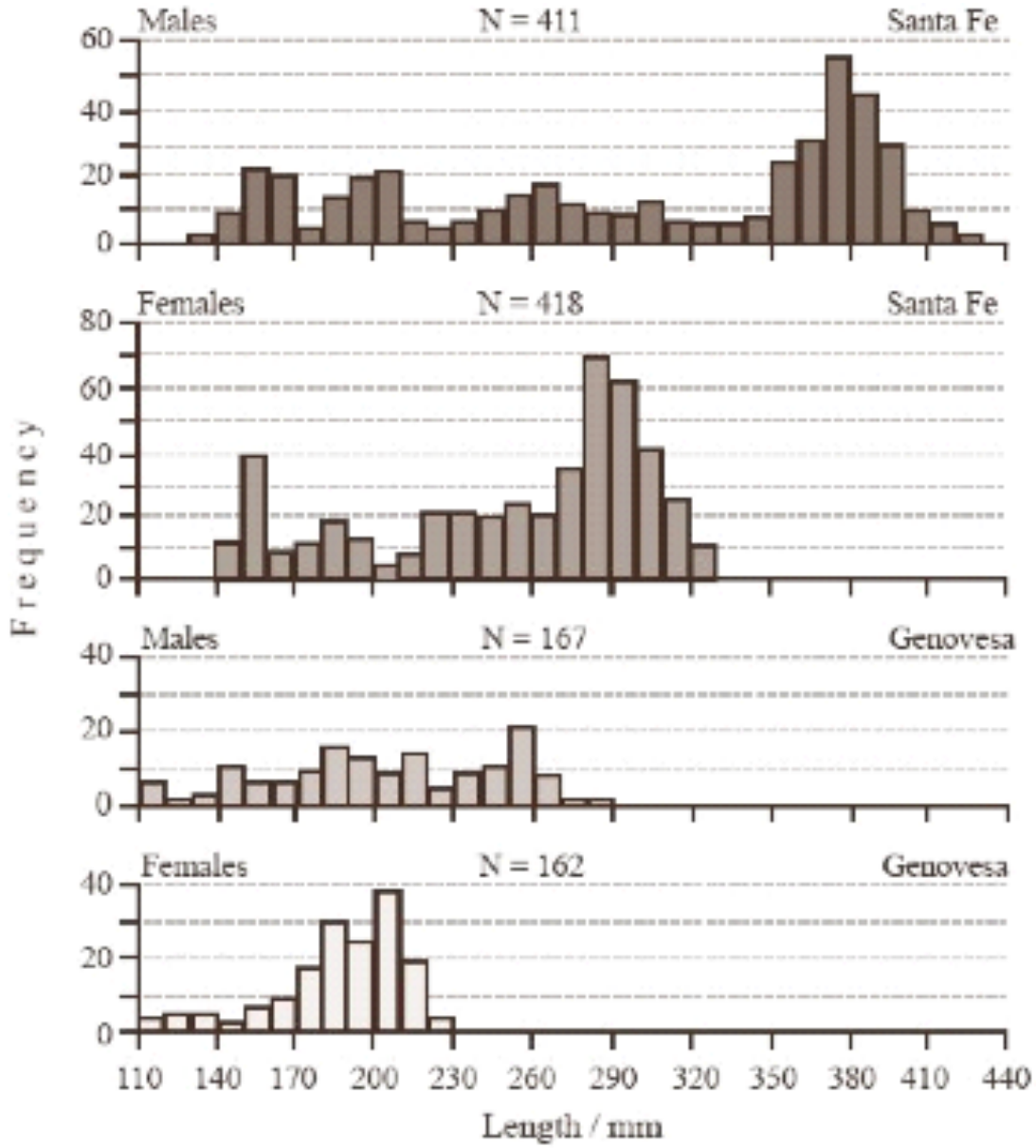
Iguana Body Size (6 marks)

Marine iguanas (*Amblyrhynchus cristatus*) are found on the Galapagos islands of Genovesa and Santa Fe. Marine iguanas are unique among lizards in that they feed on algae in the intertidal zone. Between feeding they lie in the sun to warm themselves. Male iguanas establish territories on the rocks where females lie. Males provide no parental care of offspring while females guard the nest for a few days. Females mate once and use up 20% of their body mass in reproduction, while males try to mate more than once and do not use up much of their body mass. The graphs below show the lengths of males and females on the two different islands, sample size (N) is indicated for each graph.



a. State the most frequent range of body sizes of males on Santa Fe and males on Genovesa. *(1 mark)*

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b. Suggest **one** reason for the difference in size between male iguanas on Santa Fe and Genovesa. *(1 mark)*

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c. Compare the body size of males and females. *(2 marks)*

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d. Explain, using the theory of natural selection, the significance of size in males and females. *(2 marks)*

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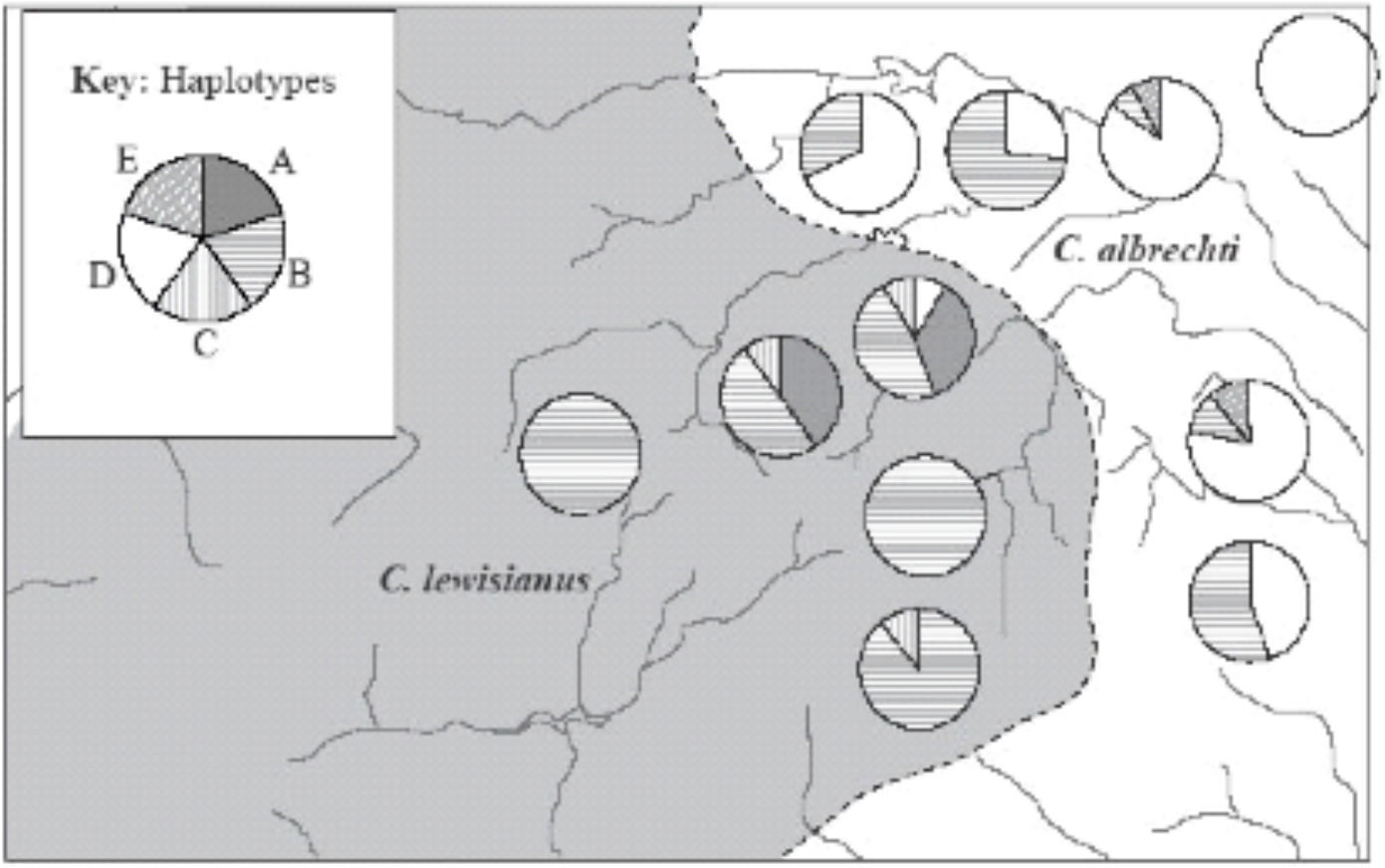
Beetle Haplotypes (6 marks)

Ecologists investigated two species of beetle, *Carabus lewisianus* and *Carabus albrechti*, which live in neighbouring areas in a mountainous region of Honshu, Japan. They analysed the genetic composition of a mitochondrial protein, called a haplotype, from beetles caught in different parts of their range. The results are shown below with each pie chart representing the sample site location.



a. State which haplotype is commonest in *C. albrechti*. *(1 mark)*

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b. Distinguish between the distribution of the haplotypes in the two species. *(2 marks)*

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c. Explain the hypothesis that these two species shared a common ancestor. *(3 marks)*

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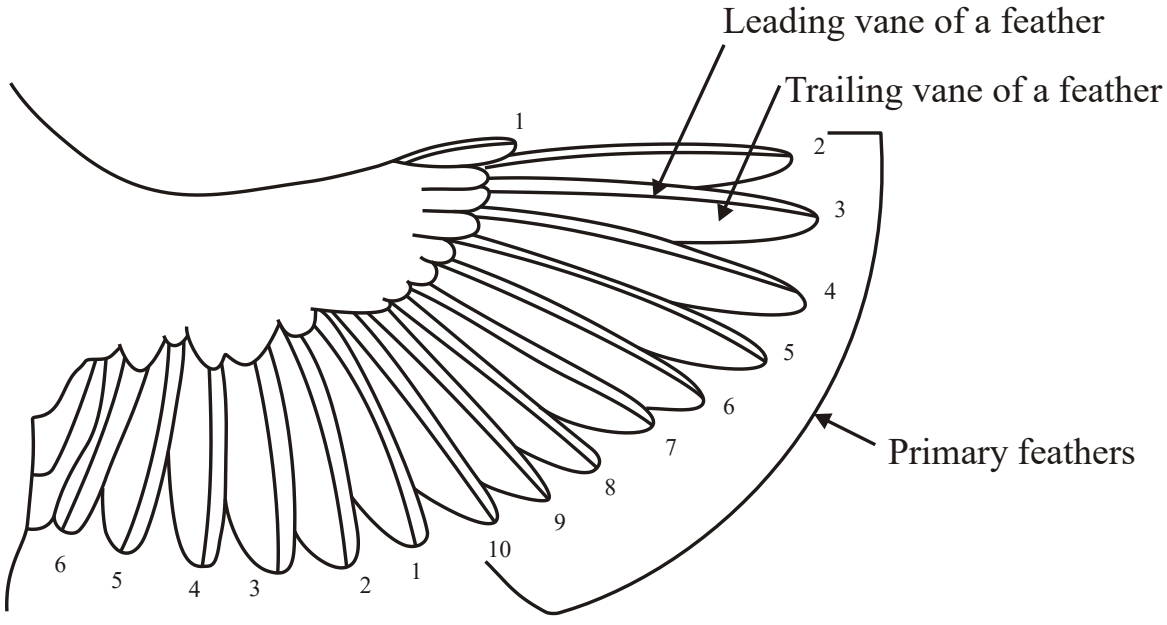
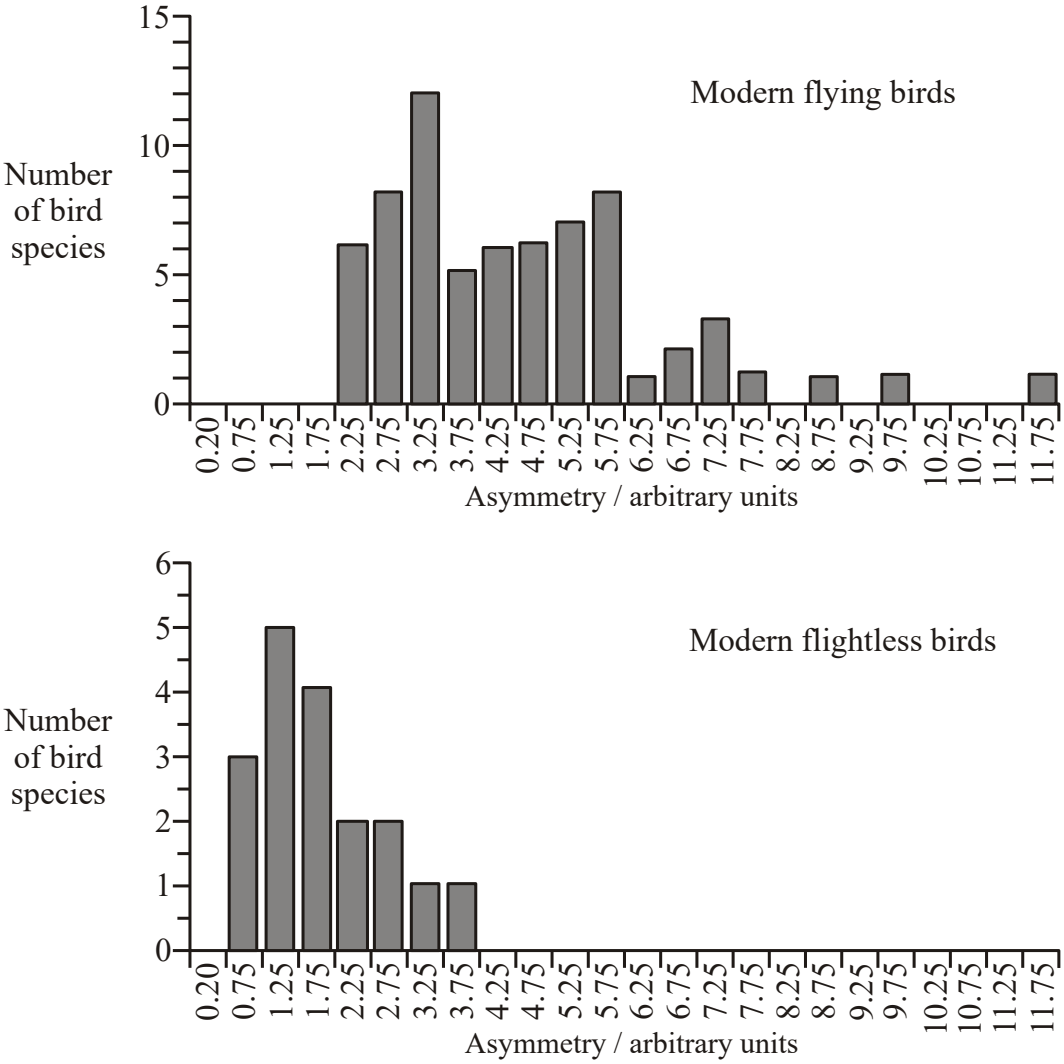
Bird Feathers (8 marks)

Birds have a series of flight feathers, which grow out from their hands called primaries. Each primary feather is shaped like an airplane wing, which provides the bird with lift during flight. The flat surfaces of the feather are called vanes and they are asymmetric (not equal in shape).



The primary feathers on the wings of 71 different bird species which can fly were measured for their asymmetry. The same measurements were carried out on 18 different species of flightless birds. These data are shown in the charts below.



a. Calculate the mean asymmetry for the modern flightless birds (Show your working). *(2 marks)*

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b. Compare the degree of asymmetry between the modern flying birds and the flightless birds. *(2 marks)*

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Archaeopteryx is a fossil bird whose wing feathers have been preserved. Primary feathers of two fossil *Archaeopteryx* specimens were measured. The mean asymmetry for this bird is 1.44.

c. On the basis of the data given, predict with a reason, whether *Archaeopteryx* could fly or not. *(2 marks)*

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d. Evaluate the evidence for your prediction in part c. *(2 marks)*

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Answers

1a *(1 mark)*

a. *Polypodium* are isolated in different parts of the continent **and** *Pleopeltis* much closer together / share same habitats

b. *Polypodium* grows in more northerly / temperate locations

*Award **[1]** for the comparison of both groups*.

1b *(1 mark)*

Polypodium as it has lower similarity / genetic identity values / *Pleopeltis* has higher similarity / genetic identity values

*Reason required to achieve **[1]**.*

1c *(1 mark)*

Pl. polylepis and *Pl. conzattii*

1d *(1 mark)*

geographic / ecological isolation / isolated by distance / by glacial periods / climatic changes; reproductive or genetic separation of gene pools (led to speciation) / adaptive radiation

1e *(2 marks)*

a. *Polypodium*; as more genetic difference between all three species than between the species of *Pleopeltis*

b. takes time to accumulate mutations / genetic changes; distance may have facilitated the process of reproduction isolation

*Award **[1]** for Polypodium and **[1]** for a reason.*

2a *(1 mark)*

20

2b *(1 mark)*

12

2c *(2 marks)*

a. with predator they choose brave (over timid)

b. without predator they chose bright (over dull)

2d *(2 marks)*

a. brave males will defend (females) against predator

b. brave males will pass on (genes for) bravery to offspring

c. bravery cannot be detected without a predator

d. bright males are attractive to females

2e *(2 marks)*

a. in the presence of a predator, bravery is more important than colour

b. in the absence of a predator, colour is more important than bravery

c. difference between brave and timid is less than the difference between bright and dull therefore, bright is more important

3a *(1 mark)*

Santa Fe 370–380 mm; (*units needed*) **AND** Genovesa 250–260 mm *(units needed*)

3b *(1 mark)*

food availability / predation / competition / territory size / different selection pressures. *(Any other valid suggestions)*

3c *(2 marks)*

a. males are generally bigger than females on both islands / females tend to be smaller

b. maximum size of males is greater than females on each island

c. range of male sizes greater than range of female sizes on each island

d. range of males and females sizes overlap

3d *(2 marks*)

a. males have to defend territory for mates
b. bigger males more successful mating
c. bigger males pass on their genes / size trait
d. longer length in females seems advantageous

Any other valid explanations.

4a *(1 mark)*

haplotype D

4b *(2 marks)*

a. D predominates in the *C. albrechti* population
b. D is only found in one sample of the *C. lewisianus* population
c. B predominates in the *C. lewisianus* population; B is common in both populations
d. *C. albrechti* contains only B, D, E / or A, C missing
e. E missing in *C. lewisianus*

4c *(3 marks)*

a. they both share haplotype B
b. common ancestor must have contained haplotype B
c. mutations (accumulating over time) could lead to differences in haplotype composition
d. the more geographically isolated have no overlapping haplotypes

5a *(2 marks)*

1.81

5b *(2 marks)*

a. flying birds have a higher degree of asymmetry than flightless birds
b. flying birds show more variation in their asymmetry than flightless birds

5c *(2 marks)*

a. *Archaeopteryx* (probably) could not fly
b. the mean asymmetry for *Archaeopteryx* is below the range for modern flying birds
c. within the range of modern flightless birds

5d *(2 marks)*

a. the evidence is weak
b. very few specimens of *Archaeopteryx* are available so they may not be representative
c. the specimens / feathers of *Archaeopteryx* may have been altered during fossilization