1.11 Biology: Genetics, Populations and Evolution: 30-minute Pack

AQA 7402 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Three scenarios below describe natural selection acting on continuously variable traits in different populations. For each scenario, name the type of natural selection taking place and describe its expected effect on the distribution of the trait in the population.

(a) Scenario 1: In a population of human babies, data collected over many years show that babies born with a birth mass close to the population mean (around 3.2 kg) have consistently had the highest survival rate to one year old, while babies with much lower or much higher birth mass have a lower survival rate. This pattern has remained stable over many decades. Name the type of selection and describe its effect on the distribution of birth mass in the population. **(3)**

(b) Scenario 2: In a population of a moth species living near a town, most individuals historically had pale-coloured wings, closely matching the colour of the lichen-covered tree bark on which they rested, making them well camouflaged from predatory birds. After nearby factories began releasing soot that darkened the tree bark over several decades, the proportion of dark-coloured (melanic) moths in the population increased substantially, generation after generation. Name the type of selection and describe its effect on the distribution of wing colour in the population. **(3)**

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(c) Scenario 3: A population of finches on an island feeds only on seeds from two plant species: one produces small, soft seeds and the other produces large, hard seeds; no plants producing seeds of intermediate hardness grow on the island. Finches with small, shallow beaks can only feed efficiently on the soft seeds, and finches with large, deep beaks can only feed efficiently on the hard seeds; finches with intermediate beak depth feed inefficiently on both food sources. Name the type of selection and predict its effect on the distribution of beak depth in the population over time. **(3)**

(Total for Question 1 is 9 marks)

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2 A researcher at Fenwick Down nature reserve is investigating the inheritance of shell banding pattern in the grove snail, Cepaea nemoralis. For the purposes of this question, assume shell pattern is controlled by a single gene with two alleles: U (unbanded shell, dominant) and u (banded shell, recessive). The researcher crosses two snails that are both heterozygous (Uu) and rears 200 offspring to hatching.

(a) Complete a genetic diagram to show the expected genotype ratio of the offspring from this cross, and state the expected phenotype ratio. **(2)**

(b) State a suitable null hypothesis for a chi-squared test on these data. **(1)**

(c) Using the 3:1 ratio and the total sample of 200 offspring, calculate the expected number of unbanded offspring and the expected number of banded offspring. **(2)**

(d) The researcher actually observed 155 unbanded and 45 banded offspring. Using the formula $chi^2 = sum[(O - E)^2 / E]$, calculate the chi-squared value for these data. Show your working. **(3)**

(e) The critical value of chi-squared at the 5% ($p = 0.05$) significance level with 1 degree of freedom is 3.84. Compare your calculated value with this critical value and state a conclusion about the null hypothesis. **(2)**

(Total for Question 2 is 10 marks)

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Mark scheme · 1.11 Biology: Genetics, Populations and Evolution: 30-minute Pack

Question 1

(a) stabilising selection **B1**

(a) individuals with the mean/intermediate value of the trait are favoured (have highest fitness/survival) and those at both extremes are selected against **B1**

(a) over time this reduces the variance/spread of the distribution around the mean, without shifting the mean itself **B1**

(a) Answer: Stabilising selection; the distribution becomes narrower (reduced variance) around the same mean, as both extremes are selected against.

(b) directional selection **B1**

(b) pale moths became more conspicuous to predators against the darkened bark and were preferentially eaten, while melanic moths were now better camouflaged and more likely to survive and reproduce **B1**

(b) the mean phenotype/allele frequency shifts progressively towards one extreme (darker colouration) over successive generations, and the whole distribution curve moves in that direction **B1**

(b) Answer: Directional selection; the distribution shifts progressively towards the darker (melanic) phenotype over generations as the mean moves towards one extreme.

(c) disruptive selection **B1**

(c) individuals with intermediate beak depth are selected against (lower fitness, feeding inefficiently on both food sources), while both extremes (shallow and deep beaks) are favoured **B1**

(c) over time this produces a bimodal distribution (two separate peaks, around small and large beak depths) with a reduced frequency of the intermediate phenotype, increasing overall variance **B1**

(c) Answer: Disruptive selection; the distribution becomes bimodal, with two peaks corresponding to shallow and deep beak depths and a trough at the intermediate depth, increasing overall variance.

Question 2

(a) correct gametes (U, u) from each parent combined correctly to give offspring genotypes UU : Uu : uU : uu = 1 : 2 : 1 **M1**

(a) expected phenotype ratio of unbanded : banded = 3 : 1 **A1**

(a) Answer: 3 : 1 (unbanded : banded)

(b) there is no significant difference between the observed numbers of unbanded and banded offspring and the numbers expected from a 3:1 ratio oe **B1**

(b) Answer: There is no significant difference between the observed and expected numbers of unbanded and banded offspring.

(c) 200 x 3/4 = 150 (unbanded) **M1**

(c) 200 x 1/4 = 50 (banded), both correct **A1**

(c) Answer: Expected unbanded = 150; expected banded = 50.

(d) $(155 - 150)^2 / 150 = 25/150 (= 0.17)$ **M1**

(d) $(45 - 50)^2 / 50 = 25/50 (= 0.5)$ **M1**

(d) $chi^2 = 0.67$ (2 dp) (allow 0.667 or 2/3) cao **A1**

(d) Answer: $chi^2 = 0.67$ (awrt)

(e) the calculated chi-squared value (0.67, or ecf from part (d)) is less than the critical value of 3.84 **M1**

(e) the null hypothesis is accepted; there is no significant difference between observed and expected numbers, so the data are consistent with a 3:1 ratio and simple monohybrid inheritance with complete dominance **A1**

(e) Answer: 0.67 < 3.84, so the null hypothesis is accepted; the data are consistent with a 3:1 ratio.

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