FREE SAMPLE: THE FIRST QUESTION

Question One (8 marks)

The island parakeet (a fictional species written for this paper; all data are invented for practice) is a ground-feeding parrot that once lived throughout the forests of the North Island. Introduced stoats, cats and rats killed adults and chicks, and by 1998 only a small remnant survived on the mainland. In 2000, conservation staff moved 22 birds to Kōhatu Island, a 600 ha island from which all mammalian predators had been removed. The birds nest in tree cavities and feed mainly on the fruit of two native trees, which produce heavy crops only every second or third year. Each pair rears at most one or two chicks a year, and birds first breed at about five years old (a generation is about five years). The island's forest can support about 250 birds, based on the number of nest cavities and the food supply. The founders came from a single source population whose genetic diversity had already been reduced.

Table 1 shows the island population. Table 2 shows genetic diversity, measured as mean heterozygosity at 12 microsatellite loci (the source population before translocation had a value of 0.62). Table 3 shows hatching success in 150 monitored nests, grouped by the inbreeding coefficient (F) of the chicks, calculated from a pedigree.

Analyse the information in the resource material, and integrate it with your biological knowledge to discuss:

- the ecological factors that explain the pattern of population change in Table 1, and what limits the population now
- the genetic consequences of the way this population was founded, using Tables 2 and 3
- whether conservation staff should now add birds from a different, genetically distinct population to the island, giving your justified opinion.

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Table 1

Year	2000	2005	2010	2015	2020	2025
Birds on the island	22	41	87	160	231	248

Table 2

Year	Mean heterozygosity
2000	0.55
2010	0.48
2025	0.41

Table 3

Inbreeding coefficient of chicks	Hatching success (%)
F below 0.05	86
F 0.05 to 0.15	74
F above 0.15	52

[8 marks]

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THE WORKED ANSWER TO THAT QUESTION

Question 1 (8 marks) [Conservation biology: a bottlenecked island population]

The island parakeet (a fictional species written for this paper; all data are invented for practice) is a ground-feeding parrot that once lived throughout the forests of the North Island. Introduced stoats, cats and rats killed adults and chicks, and by 1998 only a small remnant survived on the mainland. In 2000, conservation staff moved 22 birds to Kōhatu Island, a 600 ha island from which all mammalian predators had been removed. The birds nest in tree cavities and feed mainly on the fruit of two native trees, which produce heavy crops only every second or third year. Each pair rears at most one or two chicks a year, and birds first breed at about five years old (a generation is about five years). The island's forest can support about 250 birds, based on the number of nest cavities and the food supply. The founders came from a single source population whose genetic diversity had already been reduced. Table 1 shows the island population. Table 2 shows genetic diversity, measured as mean heterozygosity at 12 microsatellite loci (the source population before translocation had a value of 0.62). Table 3 shows hatching success in 150 monitored nests, grouped by the inbreeding coefficient (F) of the chicks, calculated from a pedigree. Analyse the information in the resource material, and integrate it with your biological knowledge to discuss: • the ecological factors that explain the pattern of population change in Table 1, and what limits the population now • the genetic consequences of the way this population was founded, using Tables 2 and 3 • whether conservation staff should now add birds from a different, genetically distinct population to the island, giving your justified opinion.

Answer: Integrated extended answer (8 marks); see the rubric and sample answers below.

- How the 8 marks are awarded (TPH rubric, 2 marks per row):
- Use of the resource data (accurate reading, calculation or comparison of the figures supplied). Reads Table 1 correctly (growth from 22 to 248 birds, fastest per bird in the early years and largest in absolute numbers between 2010 and 2020, then levelling near the carrying capacity of about 250) and quantifies it, for example r ≈ 0.137 per year in 2000–2010 against r ≈ 0.044 per year in 2015–2025. [2 marks]
- Accuracy and depth of biological knowledge (correct terms and mechanisms). Explains exponential then logistic growth, density-dependent limits (nest cavities, food), release from predators, the founder effect, a genetic bottleneck, genetic drift and inbreeding depression; mast-fruiting as a source of variation in breeding. [2 marks]
- Integration (links ecology, genetics and evolution and ties the data to the biology). Links ecology to genetics: a small founder number and slow breeding mean a small effective population size even when the census size is 248; the same low N that makes the population vulnerable to drift is reflected in Tables 2 and 3. [2 marks]
- Evaluation (a justified judgement or opinion, with a limitation or alternative considered). Judges the genetic-rescue option: benefits (new alleles, higher heterozygosity and hatching success) against risks (outbreeding depression, loss of local adaptation, disease), and states a reasoned decision with a condition or monitoring plan. [2 marks]
- SAMPLE ANSWER aimed at Scholarship (5-6 out of 8): The population grew quickly at first because there were no predators and plenty of food, then slowed as it came close to the carrying capacity of about 250 (Table 1). Growth changed from about 0.14 per year to 0.04 per year because limited nest cavities and food (density-dependent factors) stopped further increase. The 22 founders carried only a small part of the species' alleles (founder effect), and heterozygosity fell from 0.55 to 0.41 (Table 2), a loss of about 25%, because genetic drift is strong in small populations. Table 3 shows that chicks with higher inbreeding had lower hatching success (86% down to 52%), so there is inbreeding depression. I think birds from a different population should be added because it would bring in new alleles and

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raise hatching success.

• SAMPLE ANSWER aimed at Outstanding Scholarship (7-8 out of 8): Table 1 shows two phases. From 2000 to 2010 the population grew almost exponentially (r ≈ 0.14 per year) because predators were absent and the food supply exceeded demand; from 2015 to 2025 r fell to about 0.04 per year as numbers approached the carrying capacity of about 250 set by nest cavities and the mast-fruiting trees. This is logistic growth with density-dependent limits. The fall in heterozygosity from 0.55 to 0.41 in five generations (a loss of 25%) is much faster than the loss of only about 4% to 5% that the harmonic-mean census size of about 54 birds (2000 to 2020) would predict over five generations. Solving H(t) = H(0)(1 − 1/2Ne)^t gives an effective size of only about 9, because only a few of the 22 founders bred successfully and breeding success is uneven, so drift and inbreeding are strong although the island looks 'full'. Table 3 shows the cost: hatching success falls from 86% to 52% as F rises, a drop of 34 percentage points, so inbreeding depression reduces recruitment and could slow recovery or make it fail when a poor mast year occurs. Adding unrelated birds (genetic rescue) would raise heterozygosity and, by masking deleterious recessive alleles, hatching success; the risks are outbreeding depression if the donor is adapted to different conditions and the arrival of disease, but with a close relative population and a quarantine and monitoring plan the benefit outweighs the risk. I would therefore translocate a small number (say 5–10) of birds and monitor hatching success and heterozygosity over the next generation. A limitation is that the table gives only three years of heterozygosity data, and the simple formula assumes constant Ne.

KEY TAKEAWAY

Combine the growth curve (ecology) with heterozygosity and fitness data (genetics) to decide on conservation action, and always state a judgement with its limits.

LOS: Conservation biology: a bottlenecked island population (93101)

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