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SCHOLARSHIP EXEMPLAR



Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2024 Biology

Time allowed: Three hours
Total score: 24

ANSWER BOOKLET

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

Write your answers to all THREE questions in this booklet.

Start your answer to each question on a new page. Carefully number each question.

Check that this booklet has pages 2–27 in the correct order and that none of these pages is blank.

Do not write in the margins (XXXX). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

PLANNING

Hector's dolphin

Behaviour of dolphins and external threats

- Seasonal movement (migration)
- Diet?
- 50 km home range (small)
- Single-sex groups, nursery groups, mixed-sex group for breeding
- polygyny / Sexual maturity, gestation period
- Single calf 2-3 years, K-strategy
- Fishing nylon nets, human influenced
- disease
- other human induced threats
- ↓ allele frequency, gene pool, genetic drift.

interventions:

regulations, fishing distances

- mortality limit.
- captive breeding programme and translocation

PLANNING

evolutionary patterns and processes:

- punctuated equilibrium and gradualism
- divergent evolution
- Allopatric and sympatric speciation

DNA analysis and acceptance.

fossil evidence, mt dna, nuclear DNA

PLANNING

ecological niche of woolly mammoths

- colder climates
- Mammoth - steppe:
- seasonal diet
- Body structure
- ice age

hominins way of life:

nomadic, hunter-gatherer lifestyle

- Homo Neanderthalensis
- Archaic Homo Sapiens.

Question One: Hector's dolphin

— Various behaviours of the Hector's dolphin and ~~multiple~~ ^{multiple} external threats contribute to the current small population sizes of all Hector dolphins.

They show seasonal movement from shallow waters in spring ^{and summer} to deeper waters in Autumn and winter, returning to the same ~~sight~~ sites in each summer. Hector's dolphins navigate within a relatively small home range of 50km, which is shared with others of the same species. This small home range means that resources are limited as they only have access to the resources such as food within their home range, therefore increasing competition for resources which could lead to starvation, decreasing survival of the population.

— During their lifetime all Hector's dolphins live primarily in single-sex groups of similar age, limiting their contact with other dolphins. Individuals within groups don't form strong bonds, leading to groups being susceptible to change as they may exchange members. During the breeding season the small groups combine to form larger, mixed-sex groups. ~~After~~ Mating occurs randomly, therefore not requiring behavioural or

courtship cues or displays. By mating randomly it ~~increases the chances~~ more fit male dolphins don't have an adaptive advantage, resulting in the frequency of alleles they ~~contribution~~ contribute to the gene pool not changing. However each male ~~attempts~~ displays polygyny where they attempt to mate with multiple females, while displaying no aggression to other males indicating no form of hierarchy in Hector dolphins. By mating with many females it increases the chances of a male to contribute to ~~g~~ the gene pool. However if a male with unfavourable alleles breeds with many females, contributing the unfavourable alleles to the gene ~~flow~~ pool, decreasing the survival of future offspring.

Male dolphins reach sexual maturity from 6-9 years old and females from 7-9 years old. Where the gestation period lasts 10-11 months. It takes a lot of time and energy for Hector dolphins to breed as females also tend to birth a single calf every 2-3 years in late spring or summer. By following a K-strategy Hector's dolphins mothers spend 1-2 years of their time and energy to raise young, making the parents more vulnerable. there is a population growth rate of 2% while the estimated mortality rate is 36%. therefore all these behaviours result in not enough offspring being born compared to those that are dying, contributing to the

Small population sizes of the Hector's dolphin.

Many human-influenced threats have contributed to the current small populations. In the 1970s nylon nets were introduced by the fishing industry, which were difficult for the dolphins to detect. Hector dolphins are attracted to these trawling nets as the "invisible" nets catch a lot of fish species that match with the dolphins diet therefore they dive down to the nets thinking that they are catching food but end up suffocating after becoming entangled or captured by the nets. A "bycatch". Other human-induced threats are seismic acoustic survey, a geographical survey that uses ~~that~~ pressure waves to measure the reflected signals, this could affect the dolphins echolocation which they use to catch prey and communicate. Sea bed mining, oil spills and run-off, sewage, and storm water discharge alongside plastic pollution, pollute the ocean and ~~are~~ areas where the Hector dolphins live, ~~plastic~~ the toxic materials are accidentally ingested, injuring and killing the dolphins. which decreases the survival, resulting

Another threat of the Hector's in small populations.

— Another threat of the Hector's dolphin is

the unicellular ~~disea~~ parasite toxoplasma gondii, which causes death by forming lesions in the lungs, lymph nodes, liver and adrenal glands. Hector dolphins become infected due to exposure to ~~catch~~ cat faeces containing T. gondii oocysts. When cat faeces get into water ways they could be carried into the ocean and then picked up by the dolphins where the eggs hatch and infest the dolphin until its eventual death. ~~this contributes~~ this parasitic relationship contributes to the small populations of Hector's dolphins. ~~*~~^{seen}

These small populations are now more susceptible to genetic drift as alleles in the gene pool become lost or fixed. These populations have decreased by 70% indicating a bottleneck. The isolated populations now remaining have little gene flow resulting in the subspecies of C. m. mawi and C. h. hectori. It is likely that the Hector's populations lack genetic diversity. ~~✱~~

— As the two subspecies of Hector's dolphins were ~~labelled~~ declared critically endangered and nationally vulnerable, it lead to interventions being put in place as an attempt to increase and restore population sizes.

~~*~~^{seen} Another bacteria disease brucellosis can cause late term abortions in Hector's dolphins, which increases

mortality rate while decreasing the natality, which decreases survival and overall population size.

In the 1980s fishing regulations were introduced. These included: no trawling within 2 nautical miles of the coastline, and no gillnetting within 4 nautical miles of the coastline. By fishing from a greater distance from the coastline it meant that nets were not invading the home ranges of Hector dolphins. However the area protected from gill net and trawl-net fishing are relatively smaller than the areas occupied by the Hector and Maui dolphins. Therefore the dolphins are still at great risk of becoming entangled and stuck in nets leading to death.

The Ministry of Primary Industries proposed a fishing-related mortality limit in the South Island. The FRML calculated the relative size of Hector's dolphin subpopulation and if 75% of this limit is reached Fisheries NZ recommended actions to be taken including: banning fishing or a method of fishing until the next season. This in turn meant that if limits were reached the remaining Hector's dolphins would be safe from the threat of nets however, this was only proposed in the South Island, therefore the Hector's dolphins and Maui dolphins found on the North Island are still at risk by the threat of fishing nets.

Both a captive breeding programme and translocation of subspecies have been considered. A breeding programme would ensure the likelihood of offspring reaching adulthood as they are in a managed ecosystem where natural selection is not possible. However they are still at risk as when released back into the wild the dolphins are still susceptible to other threats. A Translocating programme ~~of~~ between the South island Hector's dolphins and Mavi dolphin will increase gene flow and help increase the population numbers of mavi dolphins as they are on the verge of extinction. //

Question two: Olive Shells

punctuated speciation indicates speciation that has ~~once~~ occurred, in which ~~long periods~~ prolonged morphological stasis through time follows an abrupt change in species associated with speciation. Whereas the ~~other~~ alternative model indicates the evolutionary pattern of gradualism, where over time it displays gradual changes as it experiences different selection pressures, resulting in speciation. However punctuated equilibrium best fits the evolutionary of the Amalda.

Speciation occurs when two or more populations become reproductively isolated and no longer share a common gene pool, as gene flow is stopped. Allopatric speciation is the most common speciation and is the result of populations becoming geographical isolated in which they experience different selection pressures. ~~In figure 4 the A. benthicola~~ Figure 4 displays the results of experiment carried out ~~by~~ in 2018 by a group of scientists at Massey University, where they collected Amalda marine gastropods in the western Pacific and Indian oceans.

Figure 4 shows that *A. benthicola* was only found on the Chatham islands. *A. optima* in Mozambique and *A. Northlandica* in Spirits Bay.

This indicates that species of the genus *Amalda* have ^{become} ~~been~~ geographically isolated and therefore will have experienced similar and different selection pressures, in which they adapted to their environments. There is no gene flow between species therefore they are reproductively isolated and allopatric speciation has occurred. ~~the~~ Adaptations to different environmental selection pressure, for example the *A. benthicola* is smaller than the *A. northlandica* which also has more colouration than the *A. benthicola*.

The experiment also shows that many species of the genus *Amalda* can be found in the same location. However as they are species their own species it indicates speciation. Sympatric speciation occurs without geographical barriers where populations ~~are~~ are separated by niche differentiation as they occupy different ecological niches. Which is supported by Darwin's law where no two species can occupy the same niche at the same time. For example the three species found in Golden Bay are *A. novaezelandiae*, *A. australis* and *A. mucronata*. These three species occupy separate ecological niches where they have each adapted to their niches. *A. mucronata* is large and has light brown colouration, while *A. australis* is almost half the size and darker in colouration, and *A. novaezelandiae* is even

Smaller in size and also has a dark colouration therefore the process of Sympatric speciation has played a big role in the speciation of New Zealand Olive shells, across the country.

Amalda olive shells typically inhabit sandy, near-shore environments. The soft sediment, shoreline habitat increased Amalda's likelihood of fossilisation. The fossilised forms of ~~Amalda~~ Amalda dating back 45 mya have provided records of evidence that Amalda evolved through punctuated equilibrium. By using DNA analysis of the Amalda the punctuated equilibrium model has become the most accepted.

Scientists used DNA sequences and a molecular clock analysis to determine when lineage split, resulting in speciation. The mtDNA which is found in the mitochondria of the ovum can only be passed on through the maternal line. The mtDNA does not undergo recombination during meiosis and is unaffected by natural selection. Therefore the mtDNA can only be changed by random unpredictable mutations, this can be used as a molecular clock, comparing the base sequences of the DNA to one species to another. The similar the base sequence the more closely related they are. By analysing DNA sequences and the molecular clock it can determine the relationship of the

Amalda species and ~~when it~~ predict when they diverged from a common ancestor, by displaying it on phylogenetic tree.

DNA analysis estimated that the most recent common ancestor of the New Zealand species ~~was~~ lived 11.5 - 8 million years ago. This is significantly ~~greater~~ older than the oldest recorded *A. mucronata* fossil from 5.3 mya. This research indicates that the Amalda species formed a New Zealand clade descended from a common evolutionary ~~group or ancestor or group~~ group. With new species evolving from ancestors in the same region.

This supports the ~~acceptan~~ punctuated equilibrium model as rapid speciation of Amalda species from a common ancestor were followed by millions of years of stasis, where no evolutionary change occurred. This is supported by the left-hand model in figure 6 where the species would experience rapid morphological change associated with speciation. Therefore the alternate model can be rejected as its indication of gradual change alongside the invasion of other snail shell species is not supported by the findings of DNA analysis.

Question three

Fossil findings of the woolly rhinoceros are linked back to the end of the last ice age. They were well adapted to the ecological niche that they occupied during that time.

The woolly rhinoceros was widely distributed ranging from western Europe to Northe-eastern Siberia. They occupied a biome known as the mammoth-steppe: cold, dry grasslands ~~dominated~~ dominated by grasses, herbs and shrubs. All covered by thick snow in the winter. This environment indicates that the woolly rhinoceros became adapted to a cold ~~climate~~ dry climate as ~~into~~ their ecological niche.

Woolly rhinoceroses had ~~tege~~ long heads and bodies, but ~~smaller~~ covered ~~for~~ ^{by} long thick hair at the neck and ~~shoulders~~ shoulders. This long hair ensured that the woolly rhinoceros was warm and could survive the cold climate they lived in. This meant they had smaller ears and shorter tails and legs, this reduced exposure to the cold dry climate. While short hair on the legs would have increased efficient movement especially thick snow.

Sexual dimorphism ^{is} ~~was~~ ~~obvious~~ noticeably in the woolly rhinoceros. ~~as~~ Both females and males had two horns ~~made~~ made of

Keratin, however the long front horn was largest in males and a shorter horn between the eyes. the larger front horn in males ~~indicates~~ was an adaptive ~~adapt~~ advantage for digging through thick snow to find food resources. ~~seen~~

Isotope analysis of the horns indicates they had a seasonal diet, which was influenced by winter where the ground was covered in thick snow, resulting in scarce food. Therefore the woolly rhinoceros adapted a large hump extending from the shoulders and contained a fat reserve. The woolly rhinoceros would have spent the warmer seasons Spring, Summer, Autumn accumulating fat resources to ensure there was enough energy to survive the winters.

Females also had udders with two teats indicating that they most likely had 1-2 offspring at one time. ~~and it would have required~~ the female woolly rhinoceros would ~~have~~ likely have had to spend lots of time and energy on feeding and raising young.

The woolly rhinoceros was well adapted to an ecological niche, ~~in which~~ the niche was most likely cold and dry with open grassland for the woolly rhinoceros to feed on. Woolly rhinoceros were predominantly

~~herbivorous~~ herbivorous, as gut morphology showed they were hindgut ~~feeders~~ fermenters with a single stomach. Allowing for the fermentation of dense herb plant material. they head had a ~~had a~~ ~~dew~~ downward-facing position, with wider upper lip, and enlarged temporals and neck muscles. This was an adaptive advantage for easily grazing on grasses, herbs and shrubs ~~etc~~ that grew close to the ground. ~~As~~ As they lived in a cold climate, the plant material would have been thick and dense to ensure their survival in the cold. Therefore on each side of the upper and lower jaws, there were three premolars and three molars, each with thick enamel. The woolly rhinoceroses teeth were adapting to chewing dense and thick raw plant material as part of their diet, which fit in with their ecological niche.

The woolly ~~rhino~~ rhinoceros coincides with the end of the ice age, which infers that they lived at the same time as the Homo Neanderthalensis and/or archaic Homo sapiens.

Homo Neanderthals lived a nomadic hunter-gatherer life style, and were located in primarily cold climates across Europe. ~~They would have~~ these hominins would have hunted the woolly rhinoceros as it provides a large food resource and the hides of the

Woolly mam rhinoceros could be used for clothing.

As hominins evolved they had controlled use of fire, advanced tools and a growing and more complex brain. This is supported by remains of woolly ~~rh~~ rhinoceros being found with evidence of trauma. Some bones have been found with consistent markings of stone weapons and butchery, this indicates how they were captured and killed with force to be used as a food resource by the homins. Charred bones indicate that the meat was cooked so that it was easier to eat and to kill any bacteria. ~~This was~~ This would have aided to the improvement of the hominin diet, which increased brain capacity, which lead to more abstract thought and planning, which improved ~~the~~ weapons and ability to find other food resources.

Abstract thought of the hominins was prominent as carvings were found in woolly rhinoceros rib bones, and their horns were used for making spears and spear throwing. Meaning that hominins had the ability to plan and imagine. Cave art depicting two woolly rhinoceros fighting shows that homins interacted with and experienced the strength of the woolly rhinoceros.

seen

* Broken and reformed bones and head damaged from rhinoceros horns indicates competition and aggression ~~the~~ most likely between two males. Other skulls indicate feline attack and that the woolly rhinoceros were exploited by other predator species.

Scholarship

Subject: Biology

Standard: 93101

Total score: 17

Q	Score	Marker commentary
1	05	This candidate discusses the K-selected reproductive strategy, the impact of having few offspring, which requires energy investment and results at a late age of sexual maturity, and how these factors contribute to small population sizes. The response discusses dolphins being killed by fishing trawlers, because they are attracted to their prey in the catch nets. This external threat, along with the effects of habitats polluted by oil spills and seismic surveying interference with echolocation and prey location, is discussed in terms of dolphin deaths and reduced population numbers. External threats contributing to a small population, which is more susceptible to genetic drift, are described in addition to the parasitic infection of <i>Toxoplasma gondii</i>, which kills dolphins and decreases population numbers. This candidate also describes the interventions of a captive breeding programme and the translocation of South Island Hector's dolphins to the Māui population to increase population size and reproductive success.
2	08	The response to the question regarding the speciation of New Zealand olive shells is comprehensive. The candidate integrates an understanding of allopatric and sympatric speciation to discuss olive shell speciation, providing examples, and describes the different selection pressures in each niche. DNA analysis and mitochondrial DNA as a molecular clock are discussed in terms of establishing relatedness and time of divergence. Acknowledgement is made of the very good fossil record of olive shells due to the soft sediment shoreline. This candidate discusses gradualism and describes punctuated equilibrium.
3	04	This response provides discussion about the cold adaptations of the woolly rhinoceros (long hair on the body compared to legs) related to its ecological niche. The response includes a description of the horn as showing sexual dimorphism with the males having had larger horns, along with the possible use of the horn to move snow or soil to access vegetation. The seasonal diet, which had differing types and quantities of plants available at different times of the year, is analysed; and the

Q	Score	Marker commentary
		function of the hump as a fat reserve to aid survival during food shortages in winter is discussed. Other aspects of the woolly rhinoceros' niche are described, such as the downward-facing head and teeth structure that indicate a herbivorous diet. There is discussion of the breeding behaviour, in terms of few calves produced and parental care invested (K-strategy), evidenced by the two teats on the udder of the female. Descriptions about the way of life of the hominins that interacted with the woolly rhinoceros include them making spears from the bones and creating art, some of which includes images of the woolly rhinoceros fighting.