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NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Biology 2024

91605 Demonstrate understanding of evolutionary processes leading to speciation

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of evolutionary processes leading to speciation.	Demonstrate in-depth understanding of evolutionary processes leading to speciation.	Demonstrate comprehensive understanding of evolutionary processes leading to speciation.

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

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in the margins (////). 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.

Merit

TOTAL 15

QUESTION ONE: Kōura

Kōura (freshwater crayfish) have inhabited New Zealand for millions of years. Their exoskeletons are dark and blend into the environment (e.g. between logs and in mud), giving them good camouflage to protect them from predators. They often live in small populations, where mating among relatives leads to inbreeding. At night, they search for food, finding fish, plants, and snails.

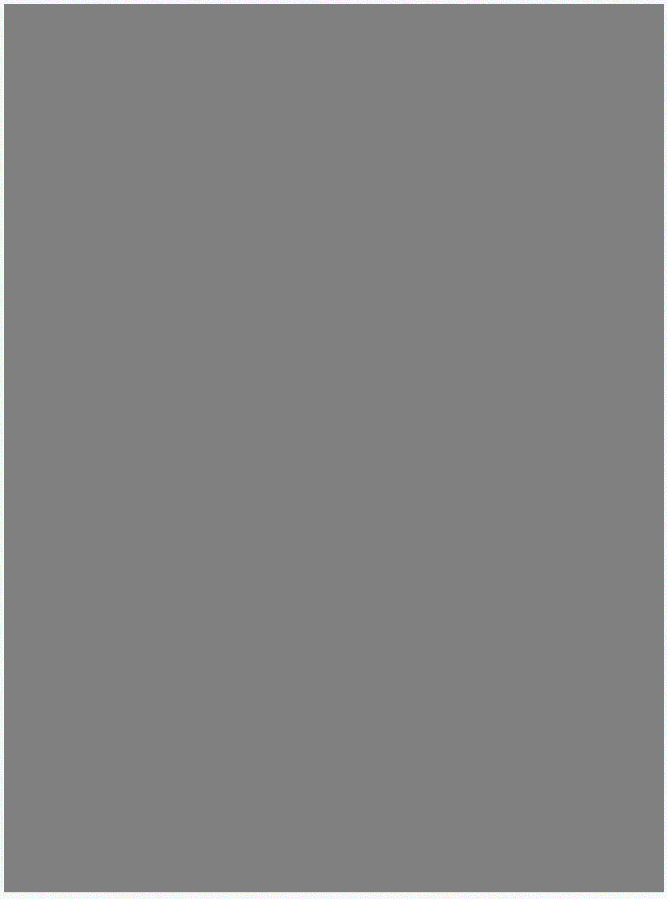
Kōura are a species valued by Māori as kai. In the past, they were also traded for other food items. Māori used to move some kōura between areas, and this was found to help with the success of each of the populations.

When looking at mitochondrial DNA (mtDNA), scientists found three major groups, indicated on the map below. The West Coast group (green) is more closely related to the southern group (yellow) than the northern group (purple). The groups were thought to diverge around the time of mountain building that formed the Southern Alps and before the formation of the Cook Strait.

Although there are two named species (*Paranephrops planifrons* and *P. zealandicus*), there are three distinct groups shown by genetic evidence. This suggests that the morphology used to classify the two species could be misleading.

In 2016, scientists at the University of Canterbury measured the genetic diversity of kōura populations. Results showed low genetic diversity **within** kōura populations but high genetic diversity **between** populations. This means populations were highly inbred but had strong genetic differences between the populations.

An adult kōura from Lake Rotomā.



Distribution of the three major mtDNA groups.

Discuss factors affecting the evolution of kōura. In your answer, include discussion of:

- the terms founder population and gene flow
- how the formation of the Southern Alps may have helped lead to divergent evolution by allopatric speciation
- why moving kōura between areas prevents speciation.

Founder population is a group of individuals who separated from original population to be introduced to new area. This will result in fonders' effect where population will increase in numbers with less genetic variation. Gene flow is is caused by interbreeding or breeding between populations to share their genes in each other's gene pool to have similar genetic information.

Allopatric speciation is formation of new species with common ancestors due to geographical barriers preventing gene flow between original species. There are two different species of prawns which is caused by formation of geographical barrier, Southern alps between populations to prevent gene flow between them and as they are subjected with different selection pressures, they naturally selected for different phenotypes between populations to develop genetic difference that they further developed reproductive isolating mechanism such as structural leading to incompatibility of genitals to reproduce so unable to reproduce fertile offspring between original population thus, different species formed. This is divergent evolution as two named species has common ancestor but developed different phenotypes due to different selection pressure.

The distinct three groups of kowtow are distributed across different regions in New Zealand. This is likely due to Maori moving kowtow between areas for trading which would have introduced different ecological niches to kowtow to distribute; This is evident as each group of population tends to inbreed due to low genetic variation among the ~~population~~ populations as only few number of kowtow would have been moved to different area which would have caused founder's effect where the population grow in numbers but with small genetic variation. This lead to inbreeding, causing some characteristics to be fixed in the population. This contributed to low genetic variation within population. The distinct difference due to distinct difference in genetics between population would have been caused by different ecological niche with different phenotypes selection pressures favouring different phenotypes between population. This could lead to speciation between 3 populations due to possible development of reproductive isolating mechanisms but this is prevented by humans moving kowtow between areas as they would not interact with each other to breed and cause geneflow due to different ecological niches. However, as they are kept moving between areas of different population, there will be geneflow between 3 populations preventing speciation by preventing reproductive isolating mechanism to develop between groups.

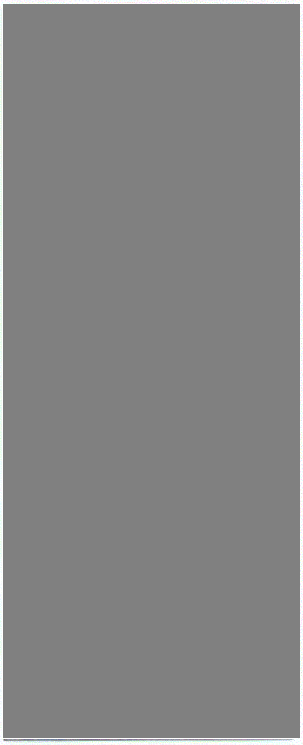
QUESTION TWO: Patterns of evolution in wallabies

In their native Australia, tammar (*Notamacropus eugenii*) and parma (*N. parma*) wallabies are allopatric and have very different habitat use, social structure, and mating times.

A tammar wallaby.

Parma wallabies grazing.

In New Zealand, they occur sympatrically on Kawau Island because of introductions in the late 19th century. Both species show differences, as seen in Australia. *N. parma* is more solitary and is frequently found in bush areas, while *N. eugenii* tend to be found in open grass areas. Genetic data shows no evidence of hybridisation despite living together in a new environment.



Kawau Island, 60 kms north of Auckland.

Figure 1: Phylogeny showing adaptive radiation of wallabies in Australia.

Discuss factors of the evolution of wallabies in Australia and New Zealand.

In your answer, include discussion of:

- the terms sympatric and species, including definitions
- the rate of evolution shown in Figure 1, identifying if it is either gradualism or punctuated equilibrium
- why adaptive radiation is seen in wallabies in Australia, but not in New Zealand
- TWO reproductive isolating mechanisms (RIMs) that may keep the wallabies from hybridising despite being sympatric on Kawau Island.

Sympatric species are species living in same area but separate species. Species are individuals who can breed with each other to form fertile offspring.

The rate of evolution shown is gradualism as there is constant changes in species through multiple species over time at constant rate.

The adaptive radiation of wallabies are seen as adaptive radiation is multiple speciation occured due to different niche availability. As Australia is original population, it carries out of a genetic variation which allows them to adapt to multiple niche as they have variations of phenotypes genuine for multiple niches. However, my some individuals of wallabies from Australia population has established new population in New zealand thus it will not have high genetic variation to adapt to different niches due to founder's effect.

warblers and Parma in same area, leaves 'island did not interbreed as no hybrids are formed. This is due to different niche they occupy, habitat, .Therefore, pre-zygomatic reproductive isolating mechanism would have formed due to niche differentiation meaning, they are likely to not interact with each other as they live in different region of the island. ~~The~~ Thus, preventing reproduction between two species in same area, leaves island. Also, they have different ~~to~~ breeding ~~time~~ period so ~~can~~ temporal reproductive isolating mechanism could have developed as they will not breed each other during different breeding season. Parma occupy high areas mainly, warblers occupy open grass area. Also due to genetic difference, their gametes might not be compatible to form ~~fertile offspring~~ offspring.

QUESTION THREE: A case of convergent evolution

Flight has evolved numerous times in different animal groups, and those different groups have evolved different mechanisms for flight. For example, the honeybee wing is not made of bone, but it does serve the same function as the bird wing. The pattern of muscle attachments is different in the honeybee and the bird, and the way in which the wing is used to achieve lift is also different. However, due to the demanding nature of flight, there are distinct similarities between bee and bird wings.

Honeybee wing.

Bird wing.

A bird catching a beetle while both are in flight.

Discuss how convergent evolution is linked to selection pressures.

In your answer, include discussion of:

- selection pressures, including descriptions with examples
- how genetic data is used to show convergent evolution
- how the process of natural selection has resulted in analogous structures.

Convergent evolution is when two species without a common ancestor develops similar phenotypes due to similar selection pressures. There would have been a selection pressure such as ecological niche differentiation to reduce competition by changing its niche by developing a wing would have acted on birds and honey bee species.

As the wing phenotype brought adaptive advantage for their survival, this would have been selected for as it would have allowed them to exploit more resources in the new ecological niche. Thus, it was naturally selected.

The bird wing and honey bee wings are analogous structure, as they are similar but did not inherited from common ancestor. This support Convergent evolution as only similar selection pressures lead them to develop similar phenotype through evolution. This can be proven that they are not inherited from common ancestor by comparing its sequence which are different and analysing its genetic code. The DNA can be investigated to show that mutations which developed wings are completely different between them or it could have been similar mutation but occured in completely different part of DNA to show that the two species are not related thus, Convergent evolution developed wings. Mutation is permanent change in DNA sequence and source of new allele.

The two species of birds and honey bees would have favoured and selected for mutations that developed wing phenotypes as they would have provided adaptive advantage which increased their chance of survival in response to their similar selection pressure such as needing to avoid competition between species

on resources by moving into new ecological niche through having ability to fly so they had access to plenty of food and resources to increase their chance of survival, which allowed them to successfully reproduce offspring and pass on this alleles that gives wing to offspring and increase (favourable) its allele frequency in gene pool. Therefore directional selection or artificial selection favoured wings instead of walking legs or other phenotypes as they provided survival advantage. As they are not related, the structure of wing differs but the purpose of flying is the same. Therefore, this analogous structures of wing is developed between them through convergent evolution meeting similar selection pressure.

Merit

Subject: Biology

Standard: 91605

Total score: 15

Q	Grade score	Marker commentary
One	M5	This response explains how allopatric speciation works, i.e. that barriers and different environmental pressures are selective agents for different phenotypes. It also explains that the founder population will not have the full range of alleles as the main population, which may lead to the differences between them increasing over time.
Two	M5	This response explains how two RIMs act to prevent successful hybridisation between the two wallaby species in New Zealand / Kawau Island.
Three	M5	This response identifies that DNA / genetic differences can be used to show convergent evolution, with similar structures being formed by the action of different mutations. It also identifies that analogous structures are features of different species that are similar in function but not necessarily in structure, and which do not derive from a common ancestral feature.