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Level 3 Biology, 2016

91605 Demonstrate understanding of evolutionary processes leading to speciation

2.00 p.m. Thursday 10 November 2016
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 and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

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

Merit

TOTAL 15

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QUESTION ONE: MEXICAN SPADEFOOT TOAD

The Mexican spadefoot toad (*Spea multiplicata*) is found in southwestern United States and Mexico. In ponds with low abundance of food resources and high density levels of tadpoles, two populations predominate. One population (called the omnivore morph) has a round body with a long intestine, small jaw muscles, smooth mouth parts, and has a generalist omnivorous diet of algae and small crustaceans found on the bottom of the pond. The other population (called the carnivore morph) has a narrow body with a short intestine, enlarged jaw muscles, teeth-like mouthparts, and has a specialist carnivorous diet of fairy shrimps found in the water column.

On the other hand, in ponds of high abundance of food resources and low density levels of tadpoles, only one population, of intermediate phenotype, is found.

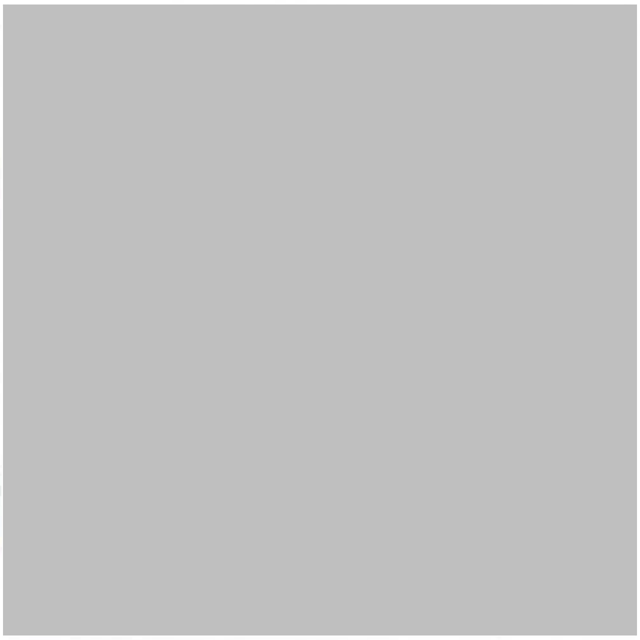

Figure 1: Mexican spadefoot toad tadpoles from a high density, low food resource pond. *Top:* the omnivore morph. *Bottom:* the carnivore morph.
http://labs.bio.unc.edu/pfennig/LabSite/Photos.html

Compare and contrast the impact of disruptive and stabilising selection on genetic diversity AND discuss how speciation could occur in the Mexican spadefoot toad.

In your answer you should:

- describe genetic variation
- describe the terms disruptive and stabilising selection, and describe which population(s) of Mexican spadefoot toad tadpole is associated with each type of selection
- explain the selection pressures that promote disruptive selection, AND the selection pressures that promote stabilising selection in the Mexican spadefoot toad tadpole.

Well labelled diagrams can be used to support your answer.

Genetic variation is the differences of genetic material in a gene pool. A population with greater genetic diversity/variation is more likely to thrive in an environment compared to a population that has less variation. The term disruptive selection is when both extremes of a species phenotype are selected for, in turn leading to sympatric speciation. disruptive selection is associated with the omnivourous morph and

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Carnivourous morph in the population's with low abundance of food, Where ~~the~~ either morph has developed to have different behavoural traits in the form of it's diet. The ~~scarce~~ less abundant ponds have greater selection preassures than that of high abundant populations. Selection preassures can be biotic and abiotic factors. In the less abundant ponds there is greater competition for food and space in the pond's. This ~~has lead to~~ can lead to sympatric speciation as the omnivourous tadpole's populate the sedimentary level of the water collumn wheras the habitat of the carnivourous morph is a specialist feeder on fairy shrimps which have no specified location within the water collumn. These dietary requirments for both carnivore morph and omnivore have had positive feedback on their structure, which with time natural selection ~~selects~~ gravitates further to either extreme untill sympatric speciation occurrs. However in abundant ponds, where there is higher density of available food and less tadpoles, Stabilising selection occurrs. Stabilising selection is where the average

There is more space for your answer to this question on the following page.

sequential

phenotype's are selected for. This has resulted in there only being one morph thath is intermediate and would be expected to have 50/50 structural feautures as the omnivore and carnivore tadpole's. The type of evolution expeted in this case would be sequential, and change over time as one specie.

	Omnivore	vs Carnivore
Structural	• Round body • long intestine • Small jaw muscles • smooth mouth parts	• Narrow body • Short intestine • enlarged jaw muscles • Teeth like mouthparts
behavioural	• Algae + crustacean eaters. • Bottom dwelling	• Specialist fairy Shrimp diet.

The abundance of food and space promotes stabilisng selection in the more abundant ponds. Wheras the less abundant and crowded ponds undergo disruptive selection due to increased preassures which could result in sympatric speciation which is where a new species is formed in the same environment to mechanisms such as behavioural, structural, temporal and gametic.

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QUESTION TWO: THREE-SPINED STICKLEBACK

hooks

The three-spined stickleback (*Gasterosteus aculeatus*) is a small (30 – 90 mm) fish found in the Northern Hemisphere. Some populations live in coastal marine habitats, while other populations live in freshwater.

Three-spined sticklebacks lack the scales typical of most fishes; instead they possess (protective) bony plates and spines. Three-spined stickleback populations living in a marine habitat have high numbers of bony plates and long spines, whereas freshwater populations typically have low numbers of bony plates and short spines. Genetic evidence suggests that a mutation in the Ectodysplasin (EDA) gene causes variation in plate number, and a mutation in the PITX1 gene causes variation in spine length.

Figure 2. *Top:* Typical three-spined stickleback from a marine population. *Bottom:* Typical three-spined stickleback from a freshwater population. Fish have been stained with alizarin red to highlight bony plates and spines.

http://unews.utah.edu/wp-content/uploads/sticklebackfigure1.jpg

likely to get eaten as adult.

The main predators of three-spined stickleback in marine habitats are larger fish. In freshwater habitats, grasping insects (such as dragonfly larvae) are the main predators, especially of juvenile three-spined stickleback. Marine habitats typically have low amounts of shelter suitable for the three-spined stickleback, whereas freshwater habitats have high amounts of shelter. The growth rate and acceleration / burst speed of three-spined sticklebacks is highest when the bony plate number is lowest.

Figure 3. Typical three-spined stickleback predators in ocean and freshwater habitats.

http://learn.genetics.utah.edu/content/selection/stickleback/

Discuss how EDA and PITX1 gene mutations AND natural selection have affected evolution in three-spined stickleback.

In your answer you should:

- describe the terms mutation AND natural selection
- explain how selection pressures in marine AND freshwater habitats act differently on bony plate number and spine length
- discuss the roles of mutation AND natural selection on three-spined stickleback evolution.

A mutation is the permanent change in the base sequence of DNA, The term natural selection is where the best suited phenotype is selected for in an environment.

There is more space for your answer to this question on the following page.

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There ~~are~~ ~~less~~ is less protection from the environment in which the marine stickle-back inhabits, and larger predators such as other / larger fish. These fish tend to have larger mouth's and hunt by swallowing stickle backs (marine). This has resulted in the EDA and PITX1 to be selected for in the marine environment. Giving the marine strickle-backs more spines / more plated armor and more length. The added protection from the bony plates potentially prevent the sticklebacks from being crushed in a fishes mouth. The spines work as a hook and can retract whilst swimming however when being hunted, if swallowed these ~~hoot~~ spines lodge into the predators mouth and the marine Stickleback cannot be swallowed as a result. Over time the EDA and PITX1 mutations have ~~become~~ of higher frequency in the marine population as it is a benefitial phenotypic mutation. However this isn't the same scenarios for freshwater Stickle backs. Freshwater Stickle backs are predated upon by insect larvae such as dragonfly larvae. In this case <u>speed</u> and <u>accelleration</u> is selected for over having bony plates as the clawing grasp from the larvae is more deadly. Freshwater

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Stickleback population's select against EDA and PITX1 as it benefits more from growing faster as juveniles are targeted over matured sticklebacks. This has caused the fresh water Stickleback's to make the mutation's redundant as they do not increase their chance of survival. It is more beneficial to the Freshwater Sticklebacks to be able to swim out of the larvaes grip.

M6

QUESTION THREE: KAKARIKI

Kakariki are the most common species of parakeet in the genus *Cyanoramphus* and are distributed throughout the South Pacific (Figure 5). Aotearoa has the largest number of species. Kakariki live in a wide range of habitats, including subantarctic tussock (Antipodes Island kakariki and Reischek's kakariki), beech forests in mainland Aoteoroa (yellow-crowned kakariki and orange-fronted kakariki), and tropical rainforests (New Caledonian red-crowned kakariki).

Figure 4. Forbes' kakariki, Chatham Island.
www.nzbirdsonline.org.nz/species/forbes-parakeet

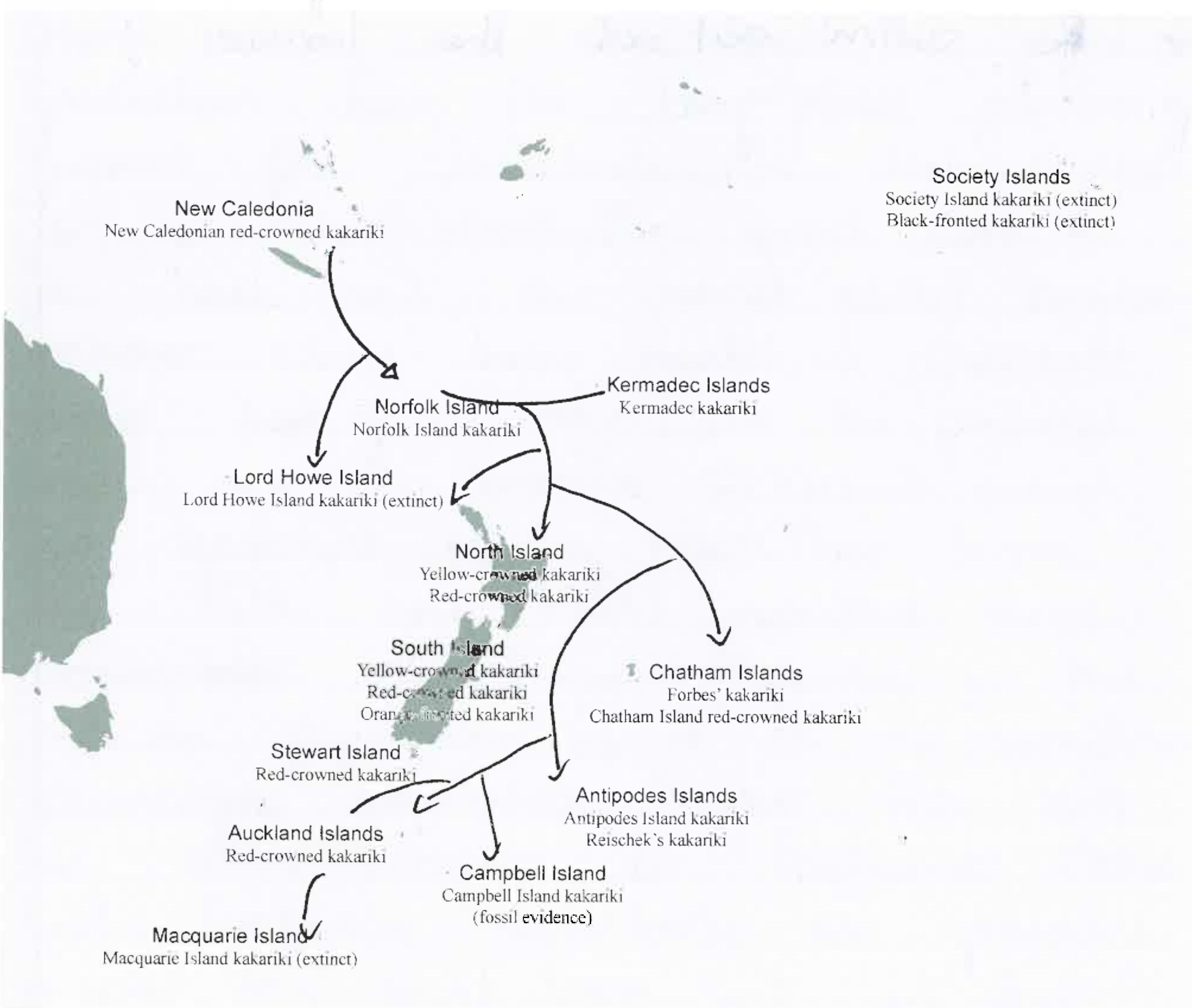

Figure 5: Kakariki distribution in the South Pacific.

The evolutionary relationships of kakariki species have been determined using mitochondrial DNA sequence analysis. The phylogenetic tree based on this analysis is shown in Figure 6. The climate during this period is shown in Figure 7, and the reconstructed vegetation cover at the height of the last glacial period is shown in Figure 8.

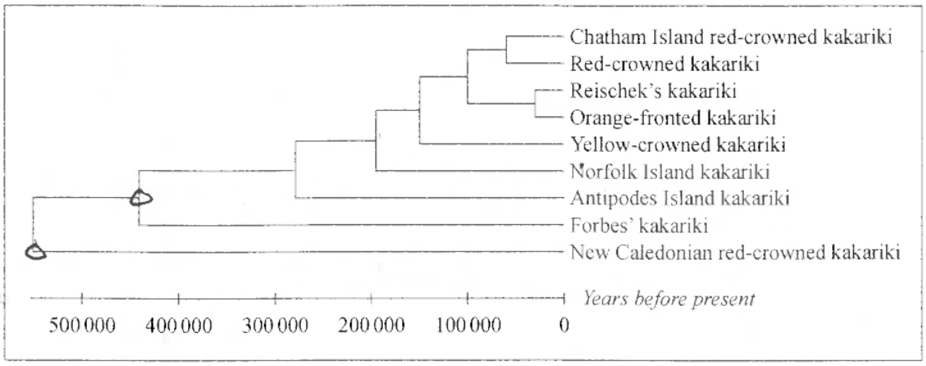

Figure 6. Phylogenetic tree for *Cyanoramphus*.
The time scale for evolutionary divergence is indicated above.

Adapted from Boon, W. M. *et al.* (2001). 'Molecular systematics and conservation of the kakariki (*Cyanoramphus* spp.)', *Science for Conservation*, 176 (Department of Conservation, Wellington).

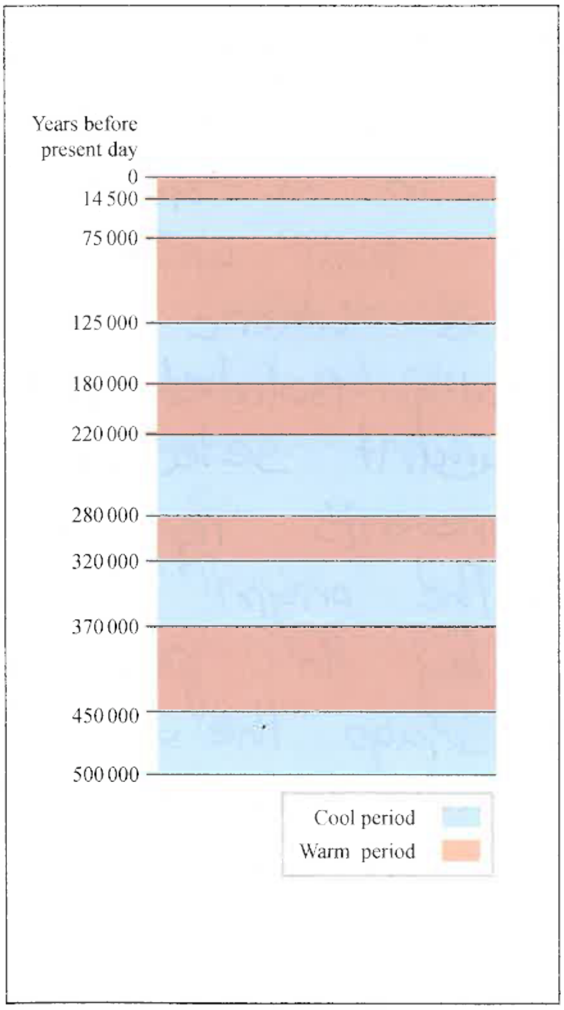

Figure 7. Glacial periods in Aotearoa.

Adapted from www.teara.govt.nz/en/diagram/10741/glacial-periods-in-new-zealand

Figure 8. Aotearoa vegetation cover 19 000 – 29 000 years b. p. as reconstructed from pollen, macrofossil, beetle and geographic evidence.

Adapted from: Newnham, R, *et al.* (2010). 'The vegetation cover of New Zealand during the last glacial maximum', *terra australis*, 32, p. 59 (ANU E Press, Canberra). http://press.anu.edu.au/wp-content/uploads/2011/02/ch0417.pdf

Discuss the pattern of evolution in kakariki, and the factors that have affected kakariki evolution.

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In your answer you should:

- describe the evolutionary pattern AND type of speciation indicated by the resource material
- explain the origin and distribution of kakariki in Aotearoa with reference to the phylogenetic tree
- using the information provided, discuss how biological and geographical factors have contributed to kakariki speciation.

The kakariki parakeet (Cyanoramphus) have undergon divergent evolution. divergent evolution is where a species has a common ancestor but evolves differently to be best suited phenotypically for the environment. In the case of the kakariki, adaptive radiation has occurred which is where a single ancestral species has diverged to fill multiple different niches in a short space of time. The kakariki has undergone allopatric speciation, which is where species become geographically isolated and exposed to new and variant selection preassures. This ~~over time~~ prevent's reproduction between species to occurr. The origin of the kakariki, indicated by the phylogenic tree, is that ~~500~~ 450,000 years ago the New Calendonian red-crowned kakariki migrated to nearby island's in which emerged the forbe's kakariki. In the past 200,000 founder effect must have taken place to induce adaptive radiation. Founder effect is where an individual or small percent of

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a population inhabit new ecological environments. These new environments for the kakariki were islands in the south-pacific. Where each Island's has unique selection preassure's. For example the tropical islands of newcaledonia, to ~~to~~ the Sub-tropic Kermadec's and upper north islands. The Kakariki radiated through Aoteroa with the formation of Orange crowned, Red crowned and yellow crowned ~~pre~~ sub-species The Kakariki that ~~speciated~~ migrated to the colder environments sush as the campbell islands and macqurie island could have migrated in warmer years between 125-000 to 75,000 years ago, but due to recent ice ages couldn't adapt fast enough to the ~~env~~ changing environment. Within New-Zealand there are Six main ecological environments (fig. 8) These home different crowned ~~ps~~ kakariki and the environment has lead to allopatric speciation.

M5

Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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Annotated Exemplar Template

Merit exemplar 2016

Subject:	**Biology**	**Standard:**	**91605**	**Total score:**	**15**

Q	**Grade score**	**Annotation**
1	4	Describes disruptive selection and describes an example of disruptive from the resource material. Describes stabilising selection and describes an example of stabilising selection.
2	6	Explains a selective biotic factor on plate number and spine length. Natural selection is explained in context of the question in relation to the survival of individuals that carry the EDA and PITX1 genes.
3	5	Describes allopatric speciation and explains the effect of different selection pressures in different areas that leads to speciation.