3

SUPERVISOR'S USE ONLY

91605

916050

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Level 3 Biology, 2015

91605 Demonstrate understanding of evolutionary processes leading to speciation

2.00 p.m. Monday 23 November 2015
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.

Low Achievement

TOTAL 9

ASSESSOR'S USE ONLY

QUESTION ONE

'Land lobsters' are the common name of many species of large, flightless, ground-dwelling insects distributed in New Guinea, New Caledonia, and Lord Howe Island. Land lobsters have a stocky body form. Some males have enlarged and powerfully armed hind legs, and the females have an elongated ovipositor which they use to deposit eggs into the soil. Nuclear and mitochondrial DNA sequence analysis has shown that the different land lobsters species are unrelated to each other, and therefore have undergone convergent evolution.

Different 'land lobster' species, (a) to (f), compared with a winged, canopy-dwelling stick insect, (g).

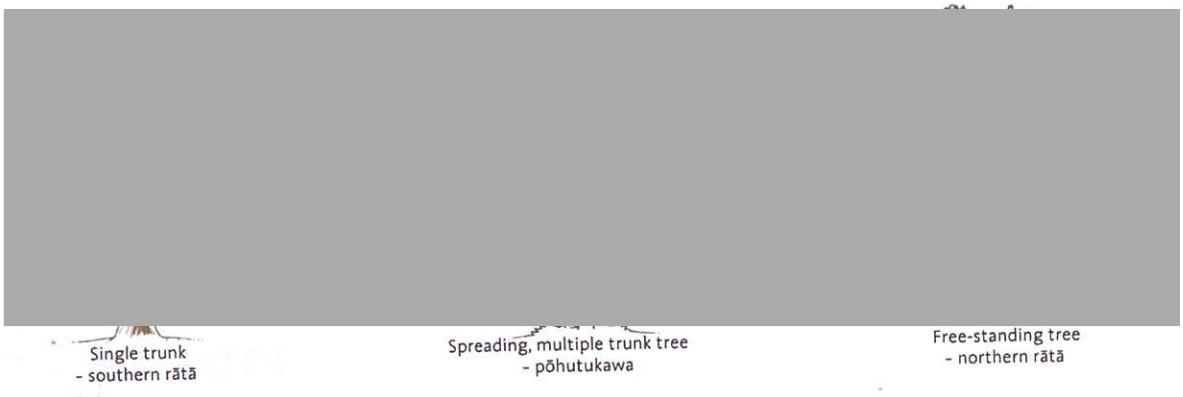
Adapted from Buckley, T.E. et al. (2009). Extreme convergence in stick insect evolution: phylogenetic placement of the Lord Howe Island tree lobster. Proc. R. Soc. 276, 1055–1062.

Pōhutukawa (*Metrosideros excelsa*), northern rātā (*Metrosideros robusta*), and southern rātā (*Metrosideros umbellata*) are all related species belonging to the same genus. These species have undergone divergent evolution during the ice age that occurred between one and two million years ago.

Pōhutukawa has a coastal distribution and is very salt-tolerant. It has multiple trunks, is a coloniser of coastal cliffs and bare volcanic larva, and is susceptible to light frosts.

Northern rātā usually begins life as an epiphyte perched high on another tree. From here it sends down roots to form a trunk that can grow into a 40 m tree. It has moderate frost tolerance.

Southern rātā usually grows from the ground to a 15 m high, single-trunked tree that can tolerate frost and colder climates.



Different forms of *Metrosideros*.

Adapted from: P. Simpson, *Pohutukawa and Rata*, (Wellington, Te Papa Press, 2005), p. 125.

Discuss the evolutionary patterns AND selection pressures that have contributed to these patterns for land lobsters and *Metrosideros*.

ASSESSOR'S USE ONLY

In your answer:

- describe convergent evolution and divergent evolution
- explain, using the evidence given above, how each of these patterns could arise
- explain, by giving examples from the resource material, which pattern is associated with homologous structures AND which pattern is associated with analogous structures
- discuss why land lobsters have a different evolutionary pattern to *Metrosideros*.

Convergent evolution is where species who do not have a recent common ancestor, have similar features and traits due to the species all having similar selection pressures, which cause them to evolve in a similar direction. This can be seen in the Land Lobsters as they have extremely similar traits and physical features. Land lobsters have a different evolutionary pattern to that of Metrosideros because Metrosideros species are all related and come from one common ancestor and due to individuals of this common ancestor having different selection pressures over many generations, they evolved in different directions to the point that they're now separate species. The Land lobsters have always been separate species. The Landlobsters pattern of convergent evolution is associated with homologous structures as the different species have similar structures such as the females all having an elongated ovipositer. The pattern of divergent evolution shown in the Metrosideros is associated with analogous structures as the species have noticable

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

differences in their structures such as single trunk, spreading multiple trunk and tall standing tree. These patterns of evolution could have arose in the Metrosideros because of individuals of the common ancestor becoming isolated from other ~~trees~~ Metrosideros' and having a completely different environment and ~~the~~ this selection pressures which allowed it to evolve in a different direction and become a new species. This is also what divergent evolution is. Because ~~the~~ all the three species have different frost tolerances this tells us that they all evolved in different climates with the Southern ranker in the coldest and Rohutakawa in the warmest. //

ASSESSOR'S USE ONLY

A4

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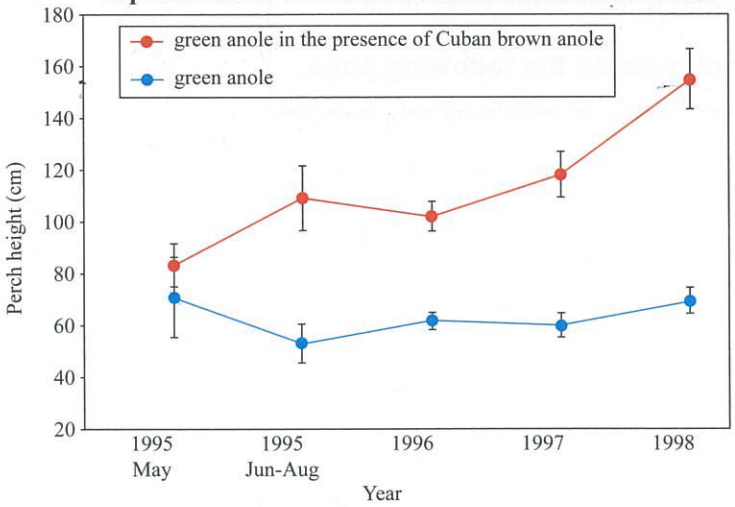
The examination continues on the following page.

QUESTION TWO

The green anole lizard (*Anolis carolinensis*) is the only native anole in the United States. However, since 1940, the Cuban brown anole lizard (*Anolis sagrei*) has been invading the southeastern United States so that both species exist sympatrically in this area. Both species have adhesive scales on their toe pads called lamellae, and are very similar in habitat use, ecology, and dietary preferences. Biologists studying these anole compared the height at which the green anole perched in trees in the presence AND absence of the Cuban brown anole, and their results are shown in Figure 1. Biologists also measured toe pad area and lamella number in the green anole in the presence AND absence of the Cuban brown anole, and their results are shown in Figure 2a and Figure 2b.

Figure 1: Perch height of green anole lizard in presence and absence of Cuban brown anole lizard



Adapted from: Stuart, Y. E., et al. (2014), 'Rapid evolution of a native species following invasion by a cogener', *Science* 346 (6208): 463–466

Green anole and Cuban brown anole lizards.

http://davewelling.photoshelter.com/image/I0000HVzOE-fE2lmQ

Green anole hind foot showing toe pads.

www.utexas.edu/mews/2014/10/23/anole-lizards-evolution-florida/

Figure 2a: Toe pad area in green anole lizard in absence and presence of Cuban brown anole lizard

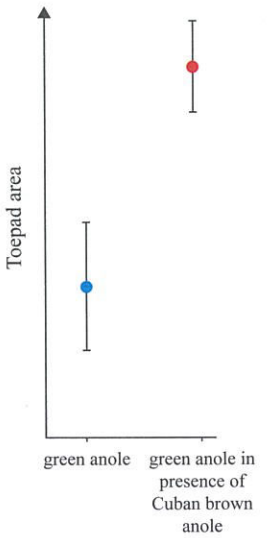
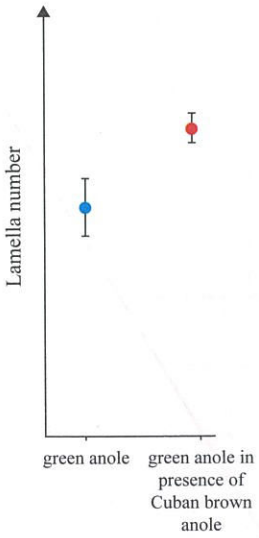


Figure 2b: Lamella number in green anole lizard in absence and presence of Cuban brown anole lizard



Adapted from: Stuart, Y. E., et al. (2014), 'Rapid evolution of a native species following invasion by a cogener', *Science* 346 (6208): 463–466

Discuss the natural selection pressures that have affected evolution in the green anole.

In your answer:

- describe natural selection and the trends shown by the resource material
- explain the type of natural selection occurring in the green anole
- evaluate the impact of competition on the evolution of the green anole.

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Natural Selection is the process in which individuals with the best genes and mutations that are beneficaial are allowed to survive and reproduce. Those who have poor genes or harmful mutations ~~are not~~ do not reproduce and die. Because the cuban brown anole has come into the area that the Green anole occupies and both species occupy almost exactly the same niche the green anole's selection pressures have changed as there is now more competition for resources. The perching height has dramatically increased to approx 152cm ~~from~~ in the presense of the cuban brown anole. from approx 70cm when the green anole was not in presense of the brown anole. The same & large increase can be said about the green anole's toe pad area and lamellar area. This is because the bigger the green anole gets, the greater his ability to out compete the cuban brown anole, as it is impossible for two species in the same ecosystem to occupy the same niche for a long sustainable period of time.

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

one will out compete the other. In the presense of the Cuban brown anole, the green anoles that are bigger ~~in~~ are being naturaly selected for as it increases their chance of survival making larger ~~green~~ green anoles more successful than smaller individuals. due to ~~competi~~ interspecific competition between the Green anole and the Cuban brown anole. //

ASSESSOR'S USE ONLY

A3

QUESTION THREE

ASSESSOR'S USE ONLY

The four-wing saltbush (*Atriplex canescens*) is a shrub that has undergone polyploidy. It has a haploid number of nine chromosomes ($n = 9$). Biologists studied four-wing saltbushes with different numbers of chromosomes. Each type of saltbush lives in a slightly different habitat depending on how much water is available. Biologists measured the width of the water transport system (called the xylem) in each type of saltbush, and the results are shown in the table below. The xylem can be blocked by air bubbles in drought conditions.

Type of saltbush	Habitat (relative soil water availability)	Relative Xylem width	Resistance to air bubble blockage
Diploid ($2n = 18$)	High	Low	Low
Tetraploid ($4n = 36$)	Moderate	Moderate	Moderate
Hexaploid ($6n = 54$)	Low	High	High

Source: Hao, G et al. 'Polyploidy enhances the occupation of heterogeneous environments through hydraulic related trade-offs in *Atriplex canescens* (Chenopodiaceae)', *New Phytologist* (2013) 197: 970–978.

Polyploid plants also tend to have lower guard cell density and a thicker epidermal layer in their leaves.

Discuss the implications of polyploidy on the evolution of the four-wing saltbush.

In your answer:

- describe polyploidy and describe why the four-wing saltbush polyploids are fertile
- explain how polyploid formation could occur in the four-wing saltbush
- discuss what processes need to occur for the polyploids to become separate species
- discuss how the change in structure of the polyploids may lead to speciation.

polyploidy is the result of a hybrid. when two different species ~~reproduce~~ are similar enough to, and do reproduce, ~~it can have~~ the offspring can have ~~4~~ an odd number of chromosomes, making it unfertile with members of the species of it's parents. however a hybrid can successfully reproduce with another hybrid as if it has 9 chromosomes and breeds with another 9 chromosomes, there will be 18 chromosomes which is an even number so two hybrids offspring is fertile.

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

ASSESSOR'S USE ONLY

In order for the polyploids to become a seperate species they need to ~~become~~ evolve to become different enough to be ~~consi~~ reproductivly isolated for from other saltbush's. The change in structure in the four winged saltbush could lead to speciation because the structures could be so different to other saltbush structures that they can no longer reproduce with each other. //

ASSESSOR'S USE ONLY

N2

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

QUESTION NUMBER

ASSESSOR'S USE ONLY

91605

Annotated Exemplar Template – Achieved (Low)

exemplar for 91605 - 2015		Total score	9
Q	**Grade score**	**Annotation**	
1	4	Although this candidate has given some good definitions and stated that selection pressures where important in both convergent and divergent evolution, they have not gone on to explain what those selections pressures were. They have also confused analogous and homologous structures. There actions limited the grade to an Achieved only.	
2	3	The candidate is able to interpret data from the graphs provided. Although they were able to state that change in perch height was because of competition, they did not give a named resource that was being competed for, nor link the increased pad size as a requirement for the increased perch height, thus limiting their grade to an Achieved only.	
3	2	The candidates answer was very general without much biological knowledge being demonstrated. Partial points were given but not elaborated on. They have shown that they know the requirements for a fertile polyploid, but not what a polyploid is, how it is formed and that it is an example of instant / sympatric speciation.	

91605

916050

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Level 3 Biology, 2015

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High Achievement

TOTAL 11

ASSESSOR'S USE ONLY

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In your answer:

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- discuss why land lobsters have a different evolutionary pattern to *Metrosideros*.

Convergant evolution is when two species are not related but have similar characteristics due to filling the same ecological niche. Divergant evolution is when the species are related but have developed different characteristics due to filling different ecological niches. Direrganf evolution could arise from the ice age that occured between one and two million years ago, and from being in different places such as on the coast (pōhutukawa). Convergant evolution could arise from there being ~~a large~~ many only one ecological niches to fill, which can accomodate for ~~more than one species~~ them. As there are several places, such as New Guinea, New Caledonia and Lord Howe Island each ~~with~~ has a slightly different species of land lobster. Land Lobsters have a different evolutionary pattern to Metrosideros because Metrosideros

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

started out as one species and as there were many ecological niches available after the ice age, the metro filled each of these niches and they each adapted to fit their chosen niche, such as the Pohutukawa being salt tolerant as it lives on the coast. However, the land lobsters started out as seperate species but due to there being only one available ecological niche all of the different species had to adapt to fit that one, therefore they all look relatively the same, with the same adaptations.

ASSESSOR'S USE ONLY

N1

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The examination continues on the following page.

QUESTION TWO

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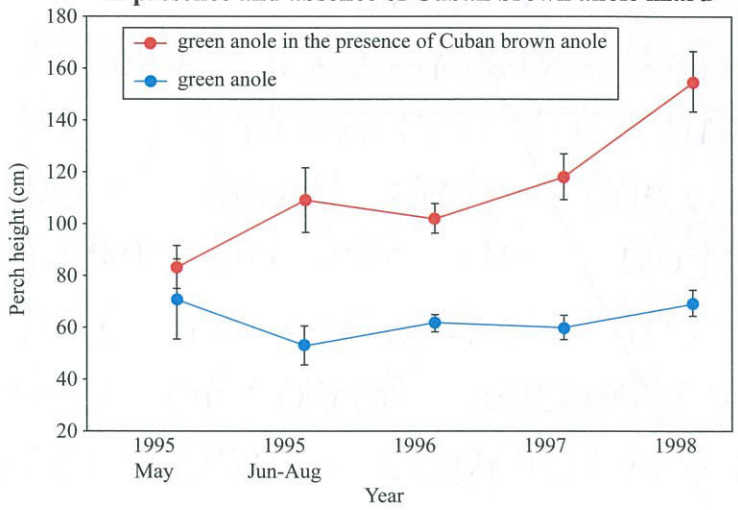

Adapted from: Stuart, Y. E., et al. (2014), 'Rapid evolution of a native species following invasion by a cogener', *Science* 346 (6208): 463–466

Green anole and Cuban brown anole lizards.

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Green anole hind foot showing toe pads.

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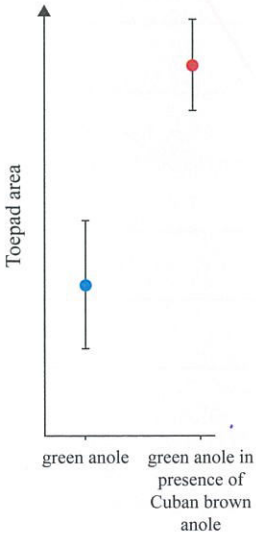
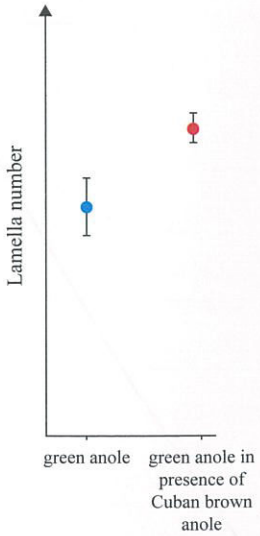


Figure 2b: Lamella number in green anole lizard in absence and presence of Cuban brown anole lizard



Adapted from: Stuart, Y. E., et al. (2014), 'Rapid evolution of a native species following invasion by a cogener', *Science* 346 (6208): 463–466

disruptive selection

Discuss the natural selection pressures that have affected evolution in the green anole.

In your answer:

- describe natural selection and the trends shown by the resource material
- explain the type of natural selection occurring in the green anole
- evaluate the impact of competition on the evolution of the green anole.

ASSESSOR'S USE ONLY

Natural selection is when only the "fittest" or best genes are chosen for reproduction, and to be passed down to the next generation. The trends show that in the prescence of the brown anole lizard the green anole perchs a lot higher in the tree than the ~~green~~ brown anole and that toe pad area and lamella number ~~are~~ are greatly increased as well. The type of natural selection occuring in the green anole is disruptive selection. This is where both extremes are selected for and can often result in the formation of a new species. Higher counts of toe pads and lamella are selected for in the presence of the brown anole because no two species can survive in the same ecological niche for long without one moving or becoming extinct. By selecting for both extremes the green anole will be able to survive higher in the

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

ASSESSOR'S USE ONLY

2

tree due to the increase in toe pads and lamella therefore there will be less competition from the brown anole. The impact of the brown anole on the evolution of the green anole is that the adaptations will begin to change with the green anoles with more toe pads and lamella being selected for and those lizards with less being selected against. The competition will cause the green anole to move higher into the trees and fill another ecological niche and will eventually evolve into a new species all together.//

M5

QUESTION THREE

ASSESSOR'S USE ONLY

The four-wing saltbush (*Atriplex canescens*) is a shrub that has undergone polyploidy. It has a haploid number of nine chromosomes ($n = 9$). Biologists studied four-wing saltbushes with different numbers of chromosomes. Each type of saltbush lives in a slightly different habitat depending on how much water is available. Biologists measured the width of the water transport system (called the xylem) in each type of saltbush, and the results are shown in the table below. The xylem can be blocked by air bubbles in drought conditions.

Type of saltbush	Habitat (relative soil water availability)	Relative Xylem width	Resistance to air bubble blockage
Diploid ($2n = 18$)	High	Low	Low
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Hexaploid ($6n = 54$)	Low	High	High

Source: Hao, G et al. 'Polyploidy enhances the occupation of heterogeneous environments through hydraulic related trade-offs in *Atriplex canescens* (Chenopodiaceae)', *New Phytologist* (2013) 197: 970–978.

Polyploid plants also tend to have lower guard cell density and a thicker epidermal layer in their leaves.

Discuss the implications of polyploidy on the evolution of the four-wing saltbush.

In your answer:

- ✓ describe polyploidy and describe why the four-wing saltbush polyploids are fertile
- ✓ explain how polyploid formation could occur in the four-wing saltbush
- ✗ discuss what processes need to occur for the polyploids to become separate species
- ✗ discuss how the change in structure of the polyploids may lead to speciation.

Polyploidy is a form of sympatric speciation and it is instant. Polyploids contains an extra set of chromosomes 3n or more. Four-wing saltbush are fertile because polyploids cannot undergo meiosis or independant assorment, crossing over or recombination. Speciation is the formation of a new species. Polyploidy could occur in the four-wing saltbush by during independent

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

ASSESSOR'S USE ONLY

assortment during meiosis when the sticky fibres come to seperate the chromosomes, one fails and so a pair of chromosomes is pulled to one side instead of just one causing there to be an extra set of chromosomes. //

ASSESSOR'S USE ONLY

A4

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

QUESTION NUMBER

ASSESSOR'S USE ONLY

91605

Annotated Exemplar Template – Achieved (High)

exemplar for 91605 - 2015		Total score	11
Q	**Grade score**	**Annotation**	
1	2	This candidate has given relevant examples of types of selection pressures for both divergent and convergent evolution, but has called them ecological niches. This mistake has cost the candidate a possible Merit grade for this answer. They have also described or explained homologous and analogous structures; this also limited their grade in this question.	
2	5	This candidate has explained that moving to higher perch heights selected for larger toe pads. Although this move will reduce competition (as indicated in the answer), there is no named resource that was being competed for. An explanation of the consequences of natural selection, or of directional selection, could have increased the grade for this answer.	
3	4	This is a good example of a High Achieved answer for this question. The candidate has provided a number of correct definitions related to polyploidy. To attain a higher grade, some explanations were required; how diploid gametes were formed (candidate needed to state 'gametes'); how a named feature of polyploids affected their survival; why hybrid vigour was an advantage to the plant.	