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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Biology 2024

91603 Demonstrate understanding of the responses of plants and animals to their external environment

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of the responses of plants and animals to their external environment.	Demonstrate in-depth understanding of the responses of plants and animals to their external environment.	Demonstrate comprehensive understanding of the responses of plants and animals to their external environment.

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 16

QUESTION ONE: Relationships in the forest

Kauri snails/pūpū-rangi (*Paryphanta spp.*) belong to the group of northern giant land snails, which evolved in New Zealand before the introduction of the nocturnal predator species: possums and hedgehogs. The snails live in areas of fertile soil, rich with earthworms, and may live to 20 years or more. The snails are most active at night. They usually spend the day under leaf litter or vegetation.

Faecal analysis shows their diet is mainly earthworms and some small snails, with the small snails' shells being a source of dietary calcium.

Snail mating occurs mostly between April and July, and appears to be triggered by climatic conditions, such as rainfall. The kauri snail lays about six eggs, three times a year. The eggs are protected by a hole dug by the snails or under leaf litter at the base of a tree.

Like the kauri snails, hedgehogs (*Erinaceus europaeus*) are also active at night; however, in cold areas they can hibernate for a few months per year if the ground temperature is below 11 degrees Celsius. Their diet includes kauri snails.

Nocturnal brushtail possums (*Trichosurus vulpecula*) also eat kauri snails and, from a position in trees, they can spot the large invertebrate as it slowly moves along.



Adult pūpū-rangi.



Pūpū-rangi shell.



A hedgehog eating a snail.



Brushtail possum.

Evaluate reasons for the coexistence and survival of these species in Northland.

In your answer, include discussion of:

- the relationships between the kauri snail and the possum, AND between the possum and hedgehog
- an advantage and a disadvantage of being active at night for the kauri snail
- how each of the behaviours of these animals support survival, such as frequency of egg laying three times a year for the kauri snail, hibernation for the hedgehog, and nocturnal behaviour for the possum.

the relationship between the kauri snail and the possum is parasitic because one species benefits while the other species is harmed. In this case the possum is a predator of the kauri snail and eat them to sustain their necessary life processes including reproduction. The kauri snail is harmed because they are hunted for food. This can make scavenging for their own diet of earthworms and other small snails difficult because possums prey on them from trees, where they can see the snails move. The relationship between the possum and hedgehog is an ^{interspecific} competitive relationship as both species share a resource, the kauri snail ~~for~~ as a food source. Because they compete for the same resource it is likely that their territory or other components of their individual ecological niche are similar. ~~There are at~~ the ecological niche of an organism is an overview of what it eats, its mating habits, habitat needs and other resources required for successful reproduction and survival. Part of the kauri snail's ecological niche is that it is mostly active at night. This means that the kauri has a nocturnal behaviour pattern and spends the daylight hours under leaf litter or vegetation. This has advantages for the kauri snail

As their prey, earthworms and other small snails may also be nocturnal, allowing more food opportunities. Another advantage of the nocturnal biological clock of the snail is that the snail may be avoiding worse predators during the daylight ~~at~~ hours that are a larger threat to the snail's population size. This however, is also a disadvantage as the snail is now most active when two predators are also most active. This increases the kauri's chance of predation and decreases the likelihood of reproduction and survival for the species. Kauri snails have another biological clock pattern that aids their survival. This is its act of laying 6 eggs, 3 times between April and November. This mating season is triggered by climate conditions ~~and~~ ^{or} rainfall, this increases the snail offspring's survival as they must require damp conditions to develop properly into fertile adults. By laying eggs 3 different times it decreases the chance of them being eaten by predators as they will be in different places as well as protecting them from floods or environmental events that could damage one set of eggs. Hedgehogs ~~to~~ hibernate in winter when the ground temp. is below 11°C . This supports survival of the hedgehog as it reduces the amount of energy spent by the organism when food supply is potentially at a minimum. Hedgehogs may also be able to maintain a warmer temperature while not expending energy on anything but that, increasing its chance of survival through the winter. Possums are nocturnal because ~~it~~ that is when it's food source, the kauri, is most active and its predators, humans in NZ, are not. ~~This means~~

QUESTION TWO: Bumblebees and kōwhai

The kōwhai (*Sophora spp.*) is a New Zealand native tree. The brightly coloured flowers bloom in late winter or early spring. Auxins are essential at each stage in the life cycle, including root development, growth, and flowering. Once the plant flowers, pollination occurs via animals such as the bumblebee (*Bombus terrestris*).

In New Zealand, the bumblebee forages for food during daylight hours, but is more active in the cooler times of the day. Bumblebees also live in the Arctic. During the Arctic summer, there is constant 24-hour daylight. An experiment was conducted in the Arctic to observe the foraging behaviour of a bumblebee colony under constant light conditions. Results for two bumblebees are shown in Figure 1 below.



A bumblebee foraging in kōwhai blossom.



Figure 1: Double-plotted actograms showing foraging times of two individual worker bees from a colony under constant light conditions.

Discuss how the control of life processes through biological clocks results in kōwhai success.

In your answer, include discussion of:

- whether the kōwhai is a long-day plant or a short-day plant, including evidence
- the mechanism for the geotropic response of the kōwhai shoots
- the type of movement response of the bumblebee to the kōwhai nectar
- whether the New Zealand bumblebee and the kōwhai have biological clocks that are entrained to environmental factors.

A long-day plant is a plant that requires night lengths shorter than the critical length in order to flower and a short-day plant is a plant that needs night lengths longer than the critical length in order to flower. The kōwhai flowers in late winter or early spring after a period of night lengths longer than the critical length. This indicates that kōwhai is a short-day plant. ~~Before flowers~~ As the kōwhai tree produces flowers it also grows roots into the earth to absorb water through osmosis. This is a positive geotropic response to a stimulus. A tropism is a ^{directional} growth response to an external stimulus, in this case, gravity. When the receptors in the roots of the kōwhai detect gravity there is a positive geotropic response where the roots move toward the gravity stimulus. This occurs by auxin gathering in the bottommost roots, stimulating growth and elongation, causing the roots to grow more rapidly downwards into the earth. Auxins ~~are a chemical~~ ^{are} hormones that plants produce to stimulate growth and they assist root development and flowering. Bumblebees pollinate the kōwhai flowers when they bloom. Bumblebees know the kōwhai have flowered because of the amount of ^{sup}light present. This is known as a photanastic response. A nastic response is a non-directional response that is proportional to the stimulus. When the amount of light during the day begins to increase, ~~the~~ receptors in the bees notice this and the bees begin to move and fly around more frequently. As the ~~the~~ amount of light increases, so does the bee's movement. Eventually, the bees will come into contact with the kōwhai flowers because of their increased movements, beginning pollination. The increase in daylight

Shows the bees that the SDP kowhai plants will be flowering and as the bees respond to an environmental cue, not the specific kowhai flowers, this ~~is~~ is not a directional response and rather a non-directional but proportional nastic response. This shows that bumblebees and kowhai plants both have biological clocks that are entrained to environmental factors. Both are annual biological rhythms as the kowhai plants only flower once annually. The kowhai relies on night lengths longer than the critical length and flowers when the night length begins to decrease as this gives the plant the best chance of reproduction. This is because the bumblebee also has an annual biological rhythm that tells them when the kowhai is flowering so they can have access to nectar for food. Individually, both organisms have biological clocks that respond to the presence of light to ensure their best chance at reproduction and survival. However, their individual biological clocks rely on the others. If, for some reason, the biological clock of the bumblebee changed then the kowhai plants would not be pollinated and reproduction of the plant would be in danger.

QUESTION THREE: Cooperative breeding

Australian chestnut-crowned babbblers (*Pomatostomus ruficeps*) are known for their social behaviour. They live in groups of up to approximately 25 individuals and participate in activities such as dust bathing, preening, and feeding. Together, they look for food, including insects, spiders, small amphibians, crustaceans, and reptiles, as well as fruit and seeds from plants.

At night, they crowd together in one large, central nest and, when alarmed, they may huddle together under dense foliage or fly up into the under-canopy of trees and shrubs, chattering noisily.

Breeding usually occurs between July and November with a single, large clutch of eggs (i.e. many eggs) from all the breeding pairs.

The entire group helps to build the one nest, feed the incubating females, and defend the breeding territory. Reproduction without support is rarely attempted. Researchers confirm there are often about 4 breeding males but up to 12 non-breeding, helper-males. Kin selection appears to be important, as females will not support the care and development of young with which they have no genetic relationship.



Adult babbler.



A babbler with an insect it has caught.



Babblers are social in their behaviour.



A babbler coming off its nest.

Examine how social behaviour can lead to successful reproduction.

In your answer, include discussion of:

- the terms territory and kin selection, including definitions
- an advantage of a group being involved in finding food together and of preening each other
- why the larger number of helper-males supports the population, and why the non-related females do not support the care and development of the young.

A territory is a place that adult individuals guard and protect where breeding occurs and all resources needed for ~~Survival~~ successful survival are contained. Kin selection is when non-breeding helper males are selected to help take care of the youth in a population. This is important because if some individuals are not fit and strong the whole population could be harmed. Babblers take their territory seriously by building one nest to which defend, where breeding occurs in the mid-winter to spring. The babblers also scavenge for food together and preen each other. This is important because the individuals are able to ~~preserve~~ ^{conserve} energy by hunting for food together and collect larger amounts to feed the young and incubating females. This is also an advantage as more food can be provided to the incubating females than would be in a single mating pair, leading to stronger offspring and survival of the species. If the babblers are predated while food scavenging numbers help to ensure that some birds survive to return food to the nest. Otherwise, youth may die as the single mating pair does not return with food for the offspring to grow and survive. Babblers also preen each other by helping to remove any bugs or parasites from the skin. This is beneficial to occur within a group as it establishes relationships between breeding males and females and can be seen as courtship behavior. It can also be used to establish hierarchies in a group between breeding and non-breeding males. By this can ensure no competitive behaviour occurs within the group. The youth are cared for by the helper-males and not the ~~for~~ non-related females of the group.

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because females may not have any energy left from incubation left to care for the young. Un-related females may also feel unconnected to the young so refuse to care for them. Having non-related helper males to assist in raising the offspring results in the most positive outcome in terms of the number of healthy, adult offspring, aiding the populations survival.

Merit

Subject: Biology

Standard: 91603

Total score: 16

Q	Grade score	Marker commentary
One	M5	This response addresses the main points of the question and effectively explains the vulnerability of the kauri snail, as well as the benefits of hibernation.
Two	M5	This response clearly demonstrates understanding that the kōwhai is a short-day plant, with supporting evidence. It explains how the synchronised biological clocks of both the kōwhai and the bumblebee ensure successful pollination and reproduction.
Three	M6	This response demonstrates a good understanding of the benefits of territory, group feeding, and grooming. Further development in the understanding of kin selection could have elevated this response.