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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.

Excellencet

TOTAL 21

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 ^{— Winter} 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. ^{— Feeding}

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 ^{predation}
- an advantage and a disadvantage of being active at night for the kauri snail ^{food resources, more mates, nocturnal predators, hard to see}
- 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. ^{survive & successfully reproduce}
^{food source → energy} ^{unfavourable temp}

The relationship between the kauri snail and the possum is ~~mutualism~~, where both organisms benefit from their association. The is predation, which is an exploitation relationship where the possum benefits by feeding and praying on the Kauri snail (The snail is thus harmed).

Due to both the snail and possum being nocturnal, the possum can easily find the snails as they slowly move along from the trees in which they reside in. The relationship between the possum and the hedgehog is interspecific competition, in which these two different species are competing for the same food resource; the kauri snail.

There are many advantages and disadvantages of ^{the} Kauri Snail's ^(KS) nocturnal behaviour. Firstly, these snails are able to find a greater amount of food resources such as earthworms and other small snails that are also active in the same period of the day as the KS. More food resources provide the KS with greater energy to carry on with their activities such as reproduction and growth. Also, by being nocturnal, KS are able to access more mates, thus increasing the amount of genetic mixing and therefore increasing the genetic variation of the KS species. Such increased allele frequency

thus enhancing ^{their} success

Via genetic variation, ~~ensures~~ that increases the likelihood in which the KS population can survive environmental change. On the other hand, however, a noticeable disadvantage of the KS's nocturnal behaviour is that it is active in the same time regime as its predators; the possum & hedgehog. This means that there's a higher likelihood the Kauri gnat is spotted by a possum in a tree, or by a hedgehog (ground-dwelling) and get eaten, thus the KS is negatively impacted and thus their survival & reproductive success is declined as the KS gene pool reduces in size. However, the Kauri gnat carries on with its activity as the benefit of gaining more mates & food outweighs the cost of predation.

By laying six eggs each, 3 times a year, the KS most definitely enhances survival. This is because, the rapid scale of predation by possums & hedgehogs could result in a massive reduction in KS numbers. By ensuring to lay ~~one~~ eggs 3 times a year, the KS gene pool numbers are restored, and will not result in extinction. Thus, ^{due to massive decline in} the survival of the KS is increased overall.
and reproductive success

By hibernating for a few months when temperatures get lower than 11°C , the hedgehog ensures that it lives in favourable warm temperatures, and thus wouldn't require to waste energy that could be otherwise used for important activities such as reproduction. Also, by hibernating, the hedgehog isn't active when food resources are scarce, and hard to find as winter months often involve heavy rainfall. Therefore, the survival

of the hedgehog is increased as they hibernate and store energy within the cold winter months until conditions start to get warmer. Therefore hibernation of hedgehogs increases their survival.

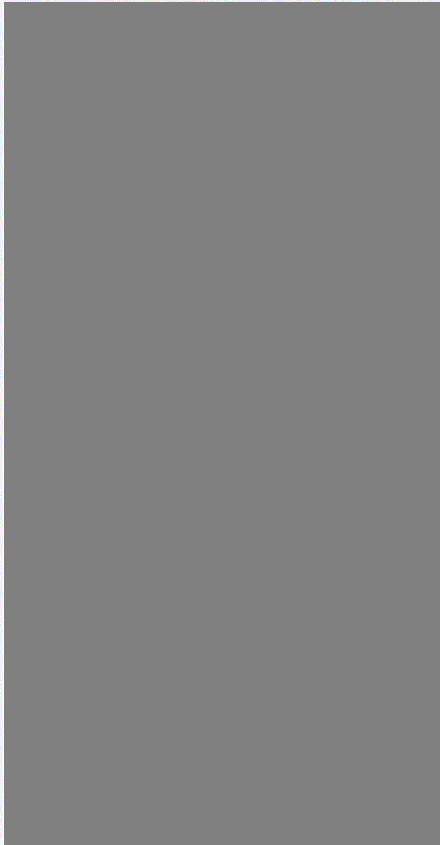
The nocturnal behaviour of the possum provides it with more food resources, as Kaori snails are also nocturnal. The possums are thus provided with more energy to survive and successfully reproduce.

Thus, all 3 organisms are able to coexist due to the benefits they gain & because these benefits outweigh all costs.

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.

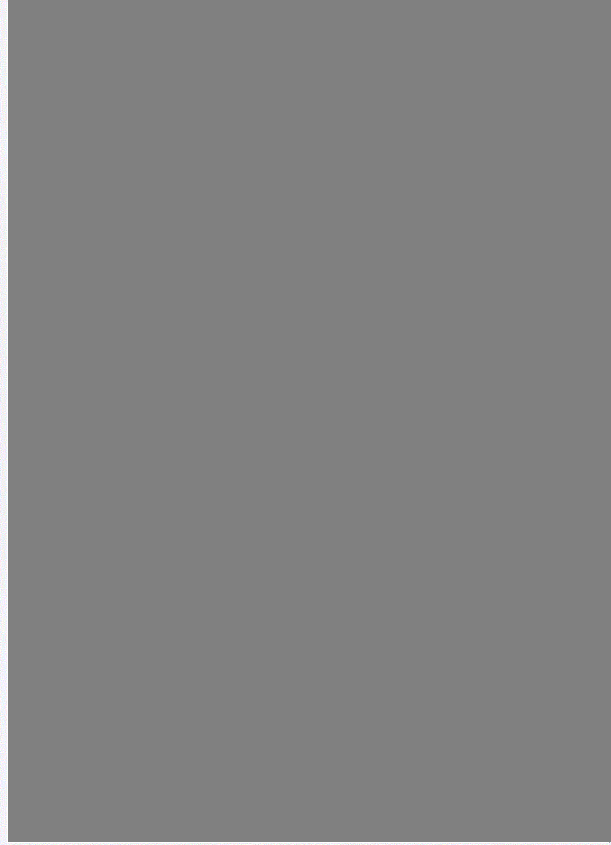


Figure 1: Double-plotted actograms showing foraging times of two individual worker bees from a colony under constant light conditions.

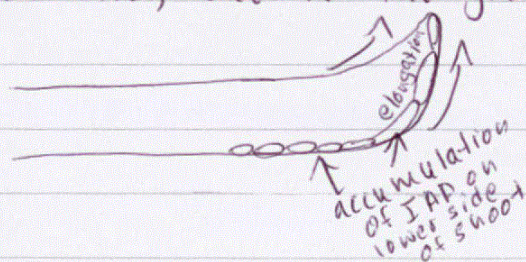
Discuss how the control of life processes through biological clocks results in kōwhai success.

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 — -ve geo-
- ✓ 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.

- Kōwhai is a short day plant (SDP), this can be understood as its brightly coloured flowers tend to bloom in late winter or early spring, in which day lengths tend to be shorter than critical day length & night (dark) regimes are longer. Also, since its main pollinator, bumblebees are active in the cooler times of the day, it is shown that the Kōwhai has adapted to flower during late winter or early spring, when temperatures are relatively lower.

The geotropic response of the Kōwhai shoots is negative geotropism. Negative geotropism is the directional growth response of the Kōwhai shoot away from the direction of gravity (The gravitational force goes downwards). This response of the Kōwhai shoots is controlled via the plant hormone named Auxin (IAA). IAA is a plant growth hormone that promotes cell elongation in shoots. IAA tends to accumulate on the lower side of the Kōwhai shoot which is initially horizontal, due to the gravitational force. Due to the accumulation



of IAA on the base, the cells on the base of the shoot elongate, ~~they~~ if they elongate more rapidly than on the top surface

of the shoot. Such unequal cell elongation causes the Kōwhai shoot to bend upwards, in the direction opposite to the ~~up~~ downwards gravitational force. Thus, Kōwhai shoots display negative geotropism.

The movement response of the bumblebee towards the Kōwhai nectar is positive chemotropism. The bumblebee moves in

the direction of the stimulus of the chemical excreted by the Kowhai nectar. While the brightly coloured yellow Kowhai flowers may initially attract the bumblebee, it seems that the bee continuously pollinates the Kowhai flowers due to the nectar it receives. As a result the bee constantly is attracted to the chemicals excreted by the Kowhai nectar and thus moves in its direction.

According to figure one, it seems that the bumblebee's diurnal circadian rhythm continues even in the constant light conditions. This means that the bees' rhythm is endogenous and thus is entrained into a regular rhythm via its internal biological clock. However, ~~its~~ its endogenous rhythm does require external environmental cues and a zeitgeber to reset its rhythm ^{within} every 12 hours of light regime its active in. Otherwise, its rhythm will be free running and eventually result in a phase shift where its activity has occurred slightly earlier each day as shown in the diagram (fig. 1).

The life processes of the Kowhai are also endogenous, however, they are circannual, as they flower ever late winter and early spring annually. The Kowhai is an SDP and its biological clock is regulated via the hormone 'Phytochrome' system. This system is regulated by the photoperiod and ensures that the Kowhai grow and develop to flower when its pollinator's bumblebees are active. By having a regulated biological clock the Kowhai is able to be pollinated at a greater amount

by the bumblebees and increases likelihood of cross pollination thus increasing genetic diversity and ensures the allele frequency is high enough to survive environmental change. Also, by being active in daytime it can maximise exposure to sun, enhancing its photosynthetic rate and thus gaining more energy for life processes. Overall, while there are costs, the Komhal's behaviours advantages outweigh them, therefore making them more successful.

thus increasing survival & reproductive success

QUESTION THREE: Cooperative breeding

Australian chestnut-crowned babbler (*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. *cooperative breeding*

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 *only relate to* 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. *offspring safeguarded*

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.

The social behavior of the babblers involves upto groups of 25 individuals living withⁱⁿ a breeding territory. A territory is an actively defended region in which organisms may breed and rear young. Their activity is cooperative, where they all help to build one nest and care for their young collectively. However, females tend to carry out kin selection and thus prefer to use up their energy towards ~~young~~ caring for young and developing young that are genetically related to them. Kin selection is the process in which organisms choose to care for the development of young that are genetically related to them.

An advantage of being involved in a social group such as the chestnut babblers is that these birds have higher efficiency in the activities they carry out. ~~By~~ By finding food in a group, the likelihood of being successful is greater as all individuals collectively forage a variety of resources within a short ~~be~~ period of time. Also, this means that individuals in the social group aren't wasting a great amount of energy ~~to~~ themselves, and the excess energy saved by each of the ~~the~~ individuals can be used for reproduction and rearing of young. Further, by being in such a social group where they preen together, parental care has been shared and therefore such social behaviour ensures that a greater number of offspring are protected from predators and are successfully able to survive until they reach a reproductive age. This means that overall, the babblers' social behaviour ensures successful survival & reproduction.

Since male babblers tend to be stronger and is rather large in size, a greater number of males can help with ^(rather than all of them simply breeding) the group's activity, such as defending the breeding territory from intruders. Upto 12 non-breeding males can successfully carry out territorial displays and behaviours to ensure that their social group is safeguarded and they have sole access to all the resources within their territory. While the helper males defend, the other babblers can successfully safeguard their offspring and grow them to be mature and eventually reproduce. Thus, the helper males' behaviour can ensure successful reproduction and ensure their population remains unchanged.

Rearing young is a very energy expensive process, ~~for~~ in which female babblers use a great amount of their lifetime for. The main purpose of reproduction for female babblers is to ensure that their own genes, and the 'best genes' of their kind are successfully passed on to the next generation. Therefore females engage in kin selection, to ensure that offspring that are blood related to them are who they support the care and development of. By supporting young that are related to them, the females are supporting her own genes and are ensuring that her genes are carried to the next generation.
 → rather than wasting further energy in addition to rearing young on other young that aren't related to them.

Therefore, the female babblers carrying out kin selection ensures that the juveniles are successfully & safeguarded

Excellence

Subject: Biology

Standard: 91603

Total score: 21

Q	Grade score	Marker commentary
One	E7	This response addresses most of the key points in a logical and progressive manner. It effectively links the multiple laying of the kauri snail and the hibernation of the hedgehog to increased reproductive success.
Two	E7	This response demonstrates a comprehensive understanding of flowers blooming when pollinators are active and provides evidence that bumblebees also rely on a biological (endogenous) clock.
Three	E7	Although this response does not include all the expected elements, it serves as a good example of how an Excellence grade can be achieved when the logical argument is fully developed and connected to reproductive success, particularly in the context of social behaviour.