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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

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

Scholarship 2021
Biology

Time allowed: Three hours
Total score: 24

QUESTION BOOKLET

There are THREE questions in this booklet. Answer all questions.

Write your answers in Answer Booklet 93101A.

Check that this booklet has pages 2–7 in the correct order and that none of these pages is blank.

YOU MAY KEEP THIS BOOKLET AT THE END OF THE EXAMINATION.

QUESTION ONE: THE EVOLUTION OF CAMELIDS

Camelids are a group of living and extinct mammals that are currently represented by at least six species. Fossil and genetic evidence is shedding light on the evolutionary relationships between these species, and the role of adaptation and human influence on their evolution.

Camelids are divided into two main groups:

- Camelinae are Old World species native to Africa, Asia, and recently introduced into Australia and are represented by the dromedary or Arabian camel (*Camelus dromedarius*) and the Bactrian camel (*C. bactrianus*). These two species have been domesticated by humans for thousands of years.
- Laminae are New World species native to South America. These include the llama (*Lama glama*) and alpaca (*Vicugna pacos*), which were domesticated around 6000 years ago, and their wild ancestors, the guanaco (*L. guanicoe*) and vicuña (*V. vicugna*).

The domestication of camelids was vital in allowing humans to survive in marginal environments. Camelids provide transportation, meat, wool, and milk, and their dried dung can be burnt for fuel.

Camelids originated in North America around 45 million years ago (mya). The ancestral camelid was a short (30-cm-tall) herbivore that browsed on low-growing vegetation. It quickly diverged into a number of species that occupied a wide range of niches, including a now extinct 3-metre-tall giraffe-like species that browsed leaves high up in the trees.

Around 6 mya, a temporary land bridge between North America and Asia formed, allowing for dispersal of camelids into Asia, Europe, and Africa. Similarly, the formation of a land bridge between North and South America around 3 mya allowed for their dispersal into South America.

Camelids in North America became extinct around 10–12 000 years ago, corresponding to a changing climate, and the reappearance of land bridges from Asia that allowed for the migration of humans into North America.

Old World camelids often live in hot, sandy environments with limited water supplies and vegetation. In contrast to this, the New World camelids live in cooler, high altitude regions in the South American Andes mountains. Camelids have a range of adaptations and corresponding genetic changes to help them thrive in their environments. These traits have been further modified through selective breeding and hybridisation between the species.

Old World camelids possess large fat deposits in the form of one or two humps on their backs, which can be metabolised for energy and a source of water. They have long legs, a thick coat, and efficient kidneys. Their blood is hyperglycemic, they can tolerate a wide range of internal body temperature, and can survive up to 10 days without drinking. Studies into their genetics have shown rapid, recent changes in a large number of genes, including:

Genes	Function
ACC2, DGKZ, GDPD4	Insulin responses, fat metabolism, mitochondrial function
ERP44, NFE2G2, MGST2	Heat stress and water loss
NR3C2, IRS1	Kidney function
AQP1, AQP2, AQP3	Water reabsorption
NFAT5, GLUT	Blood glucose levels

New World camelids are smaller and lack the humps of their Old World relatives. Studies of New World camelids compared the genomes of the domesticated species with those of their wild ancestors. Changes were found in genes responsible for coat fibre characteristics, coat colour, milk production, reproduction, social behaviours, and response to low oxygen levels.

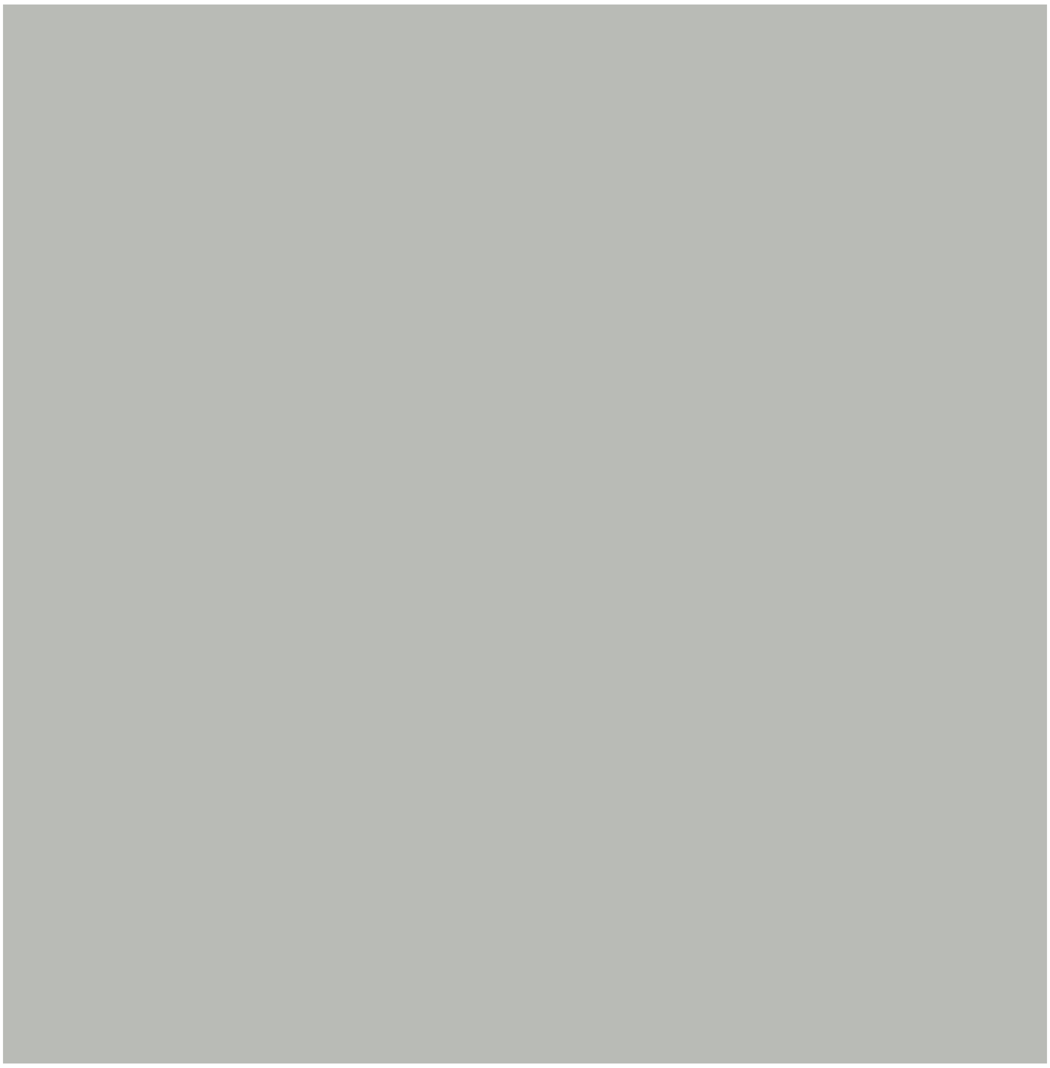

Figure 1. Classification and distribution of camel species

Source: https://www frontiersin.org/articles/10.3389/fgene.2019.00588/full

Analyse the information provided in the resource material, and integrate it with your biological knowledge to:

- discuss the ecological and evolutionary processes and patterns that have led to the diversity of the camelidae family
- discuss the impact of genetic changes in the evolution of camelids
- evaluate the role humans have played in the evolution of camelids.

QUESTION TWO: NEW ZEALAND SEA LION (*Phocarctos hookeri*)

The New Zealand Hooker's sea lion or whakahao (*Phocarctos hookeri*) was once found along the coastline of New Zealand but, due to human impacts such as hunting and fishing, the colonies of sea lions disappeared from the New Zealand mainland. Now major colonies occur on two groups of New Zealand's subantarctic islands – Campbell Island and the Auckland Islands. In recent years, a small population of sea lions started breeding on the Otago coast when, in 1993, a female from Enderby Island had the first pup to be born on the mainland in 200 years.

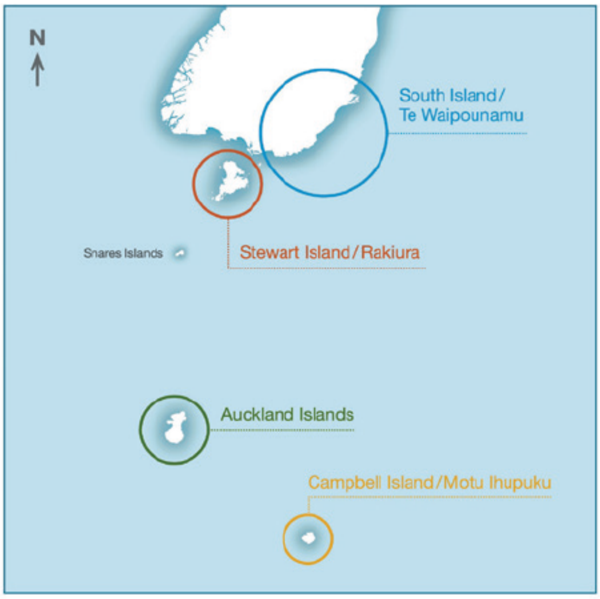

Figure 2. Current New Zealand sea lion breeding sites.

Source: www mpi.govt nz/dmsdocument/18788-New-Zealand-sea-lion- threat-management-plan

Figure 3. Dive profiles of representative juvenile female New Zealand sea lions at Auckland Islands and Otago. Juvenile females: A) 2-years-old Auckland Islands, B) 2-years-old Otago, C) 3-years-old Auckland Islands and D) 3-years-old Otago.

Source: Elaine S. Leung, Amelie A. Auge, B. Louise Chilvers, Antoni B. Moore, Bruce C. Robertson, Foraging Behaviour of Juvenile Female New Zealand Sea Lions (*Phocarctos hookeri*) in Contrasting Environments, PLoS ONE, May 2013, p. 8

There is a population of approximately 10 000 sea lions in the Auckland Island colonies, compared to approximately 170 sea lions at Otago. Their natural predators are orca and great white sharks.

Auckland Island sea lions mainly target arrow squid, while Otago sea lions largely target prey such as barracouta and jack mackerel.

Adult males are 240–350 cm long and weigh 320–450 kg, and adult females are 180–200 cm long and weigh 90–165 kg. Males live at least 23 years and females to at least 26 years. Males become sexually mature at the age of five years. The age of maturity for females is 3–4 years.

The breeding season for the New Zealand sea lion begins in late November, when adult males return and establish themselves on territories. One dominant male will occupy a beach in late November, and harems of up to 25 females will gather in December. Other bulls will remain on the perimeter of the territory, occasionally challenging the dominant male through displays, vocalising, and fighting. The bulls are frequently challenged by newly arriving males and neighbours, and turn-over of males is a regular occurrence. Many territorial bulls depart the rookery in mid-January at the end of the pupping period. By late January, the harems will break up and the bulls will disperse.

Breeding colonies occupy the same sites every year, and the gestation period is 11 months. Females move to a breeding beach about two days before giving birth. They usually have only one pup at a time, and give birth every one or two years. During their first year, the pups are completely dependent on the mother for food and protection.

Figure 4. Mean and maximum dive depths for juvenile female New Zealand sea lions at Auckland Islands and Otago. Mean ± standard error of mean.

Source: Leung *et al*, 2013, p. 7

Figure 5. Mean mass of juvenile and adult female New Zealand sea lions at Auckland Islands and Otago.

Source: Leung *et al*, 2013, p. 5

Body reserves for pups are relatively low at birth. Suckling occurs for eight to nine days before the mother's first foraging trip, which tends to last for only two days. A direct influence on pup mortality is male harassment; females move pups to inland vegetation six weeks after birth, presumably to protect them from adult males.

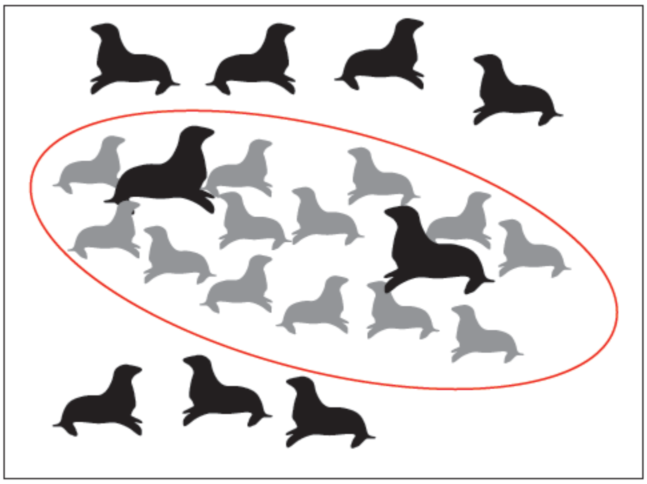

Figure 6. Diagram of a New Zealand sea lion breeding colony where males are represented in black and females in grey. The red circle outlines the breeding harem, with territorial (reproductive) males associating with females inside, and non-territorial (reproductively unsuccessful) males outside the harem.

Analyse the information provided in the resource material, and integrate it with your biological knowledge to discuss:

- reasons for the difference in mean mass between the colonies on the Auckland Islands and the Otago Peninsula
- the breeding behaviours of the sea lions and the impacts they may have on the different colonies.

QUESTION THREE: BIOLOGICAL CONTROL

Honeydew is produced by small scale insects (*Ultracoelostoma spp*.) that live within the bark of beech trees (*Nothofagus spp*.). These insects are very simple in body structure, and are related to aphids. They are described as looking like a little flattened sac with no wings or legs. They are just mouthparts with a very long anal tube, which is the one part of the insect that you can see protruding as a thin waxy stem from the bark of the tree. The tube often has a small drop of sweet sugary honeydew on the end.

The large beech forests of New Zealand's national parks – Abel Tasman, Kahurangi, and Nelson Lakes – are swarmed every year by millions of wasps that were introduced. They are attracted to the honeydew – the filament with a sugary drop that hangs from the blackened bark of beech trees.

These droplets are a rich source of food for a number of organisms. For bats, tūī, kākā, and bellbirds, it is an easy and important energy source. Tūī have been observed working their way up and down beech trees, eating the small droplets of honeydew as they go. This food resource is available all year round, so in the winter months when nectar is scarce, the honeydew is an important food source for the birds.

Other native organisms also benefit from this sweet, sugary syrup. As the honeydew drops from the end of the anal tube, it covers the bark and ground surrounding the tree. This promotes the growth of black sooty mould fungi that eventually grow to cover the bark of the tree. These dense black fungi are an important food source for a range of animals, including several species of beetles and moths. These small insects also provide food for birds.

Prior to the introduction of wasps, the honeydew droplets that were not eaten by native birds and insects fell to the ground, contributing to the nutrient make-up of the soil.

The German wasp, *Vespula germanica*, and common wasp, *V. vulgaris* are wasps that live in multi-generational family groups that can form very large colonies of several thousand individuals. Both species nest in holes in the ground and are also found in rotten logs or stumps, in forest litter, and in trees. Colonies of both *Vespula* species have a caste system, with queens, workers, and males (drones). The workers collect food, water, and nesting material, caring for the brood and for nest defence. German wasps have the capacity to maintain large overwintering nests, whereas the common wasp colonies die in winter. In spring, fertile queen wasps emerge from winter hibernation to find a suitable place to build a nest.

Figure 7. Two species of wasp.

Source: www.stuff.co nz/environment/wasp-wipeout/85981172/ruthless-villains-dangerous-invaders-a-history-of-german-wasps-in-new-zealand

Figure 8. Common wasp obtaining honeydew from the anal tube of *Ultracoelostoma brittini*.

Source: www.stuff.co nz/environment/wasp-wipeout/88128289/the-hidden-impacts-of-invasive-wasps-on-our-native-forests--wasp-wipeout

The removal of honeydew by introduced wasps affects a wide range of species, including bellbirds, tūī, kākā, fungi, bacteria, beetles, mites, and other flora and fauna.

Recently, approval has been granted to release biological control agents of the wasp: the parasitoid hoverfly (*Volucella inanis*) and the wasp-nest beetle (*Metoecus paradoxus*). Both of these species have no known effect on the honey bee (*Apis mellifera*), bumble bee (*Bombus spp*.), or native bees (*Leioproctus fulvescens* and *Lasioglossum sordidum*).

Adults of the wasp-nest beetle, *Metoecus paradoxus*, are short-lived and do not feed. They lay eggs in wood and bark outside the wasp nest. Wasps forage for wood pulp to make their nest and the larvae of the wasp-nest beetle (who are living in the wood and bark) cling onto the wasp and get returned to the nest, where the beetles' larvae attack the wasp larvae. The beetle is a brood parasite of *Vespula* with one beetle larva requiring one wasp larva to complete its development.

Adult beetles smell like wasp queens and can enter and leave *Vespula* nests without being attacked. *Volucella inanis*, the hoverfly, is a brood parasite of *Vespula* wasps. One hoverfly larva requires at least two *Vespula* larvae to complete development. The adult hoverfly looks like a wasp and is complemented by chemical smell, so the hoverfly larvae are undetected by worker wasps in the nest.

Metoecus paradoxus – Wasp-nest beetle	*Volucella inanis* – Hoverfly
• Target mainly *Vespula vulgaris*. • Adults are short-lived and do not feed. • Female lays several hundred eggs. • One wasp larva per beetle.	• Target species in the subfamilies Vespinae. • Adults feed on pollen. • Female lays 300–660 eggs. • Two wasp larvae per hoverfly.

Figure 9. Wasp-nest beetle (*Metoecus paradoxus*)

Source: https://resources.stuff.co nz/content/dam/images/4/y/r/1/7/2/image related.StuffLandscapeSixteenByNine.1420x800.21zk4x.png/1613611350238.jpg

Figure 10. Parasitoid fly (*Volucella inanis*)

Source: https://live.staticflickr.com/65535/50183715902_0f5047c31a_n.jpg

Analyse the information provided in the resource material, and integrate it with your biological knowledge to discuss:

- the biological features that make *M. paradoxus* and *V. inanis* good biological control agents of *V. vulgaris* and *V. germanica*
- the possible positive and negative ecological impacts that scientists need to consider before releasing the biological control agents.