S

93101Q

931012

NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2023
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 2–8 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 IBERIAN LYNX

The Iberian lynx (*Lynx pardinus*) is one of the world's most endangered feline species. It prefers heterogeneous environments of open grassland mixed with dense shrubs such as strawberry tree, mastic, juniper, and trees such as holm oak and cork oak. Adult lynx live in territories of up to 20 km², which they scent-mark and defend from each other, although male and female territories may overlap. The home ranges of adults are stable over many years.

The Iberian lynx feeds mostly on European rabbits (*Oryctolagus cuniculus*), but it will also eat ducks, partridges, and even young deer if rabbit densities are low. An adult lynx can survive on one rabbit a day, however, a mother raising her young needs to catch about three rabbits per day to meet the total energy demands of her young.

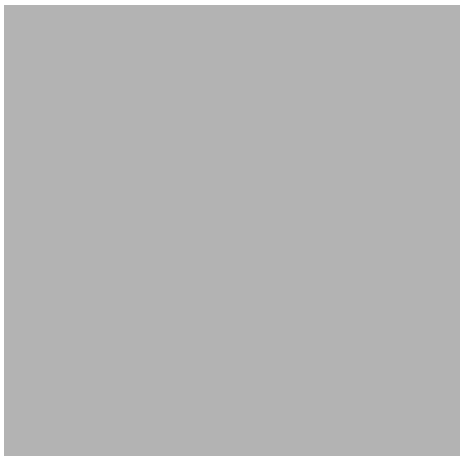

Figure 1: Iberian lynx

Litters of lynx are born in the Northern Hemisphere spring (between March and April). The average number of young (kits) is three, with rarely more than two young surviving weaning. Kits are born with fur, but they are helpless. The kits become independent at 7 to 10 months old but remain with the mother until around 20 months old. Survival of the young depends heavily on the availability of prey species. Very high rates of mortality have been observed when the kits leave the den. The average age of sexual maturity for males and females is around one year though, in practice, females rarely breed until a territory becomes vacant, sometimes taking up to five years.

The maps show the distribution of the Iberian lynx in the early 19th century and early 21st century (Figure 2). In the early 19th century, the Iberian lynx was widely distributed in Spain and Portugal. Distribution declined steadily during the 20th century and, at the beginning of the 21st century, only two isolated breeding populations remained in the world, located in southern Spain in Doñana National Park and the Sierra Morena mountains. These populations totalled less than 100 adult animals, with only 25 breeding females.

Figure 2: Distribution of the Iberian lynx

Multiple factors contributed to the decline of the Iberian lynx, the main one being hunting. The species was regarded both as an attractive hunting trophy, and as vermin or pests. The Iberian lynx was legally protected against hunting from the early 1970s, but they are still the victims of guns, traps, and snares, particularly those set for other animals. Additional factors include fragmentation of suitable habitats, deaths from vehicle strike due to the construction of high-speed roads and highways, and the population decline of its main prey species, the rabbit, due to epidemics such as myxomatosis and haemorrhagic fever. In 2013, it was reported that the Iberian lynx possesses environmentally acquired, antibiotic-resistant bacteria within its digestive tract, which may lead to more dangerous and difficult-to-treat infections, and so decrease its fitness. Another factor is the difficulty in finding mates, which has led to inbreeding, resulting in fewer kits and higher death rates due to genetic defects.

The Iberian lynx is now fully protected. Since 2014 it has been listed as 'Endangered' on the International Union for the Conservation of Nature (IUCN) Red List, which classifies species at high risk of global extinction. Conservation measures have been implemented since the beginning of this century, and have included: creating protected areas, wildlife corridors, and highway tunnels; restocking of rabbits; translocation of animals between different populations; reintroduction to previously inhabited areas / countries; and monitoring of the lynx. It has also included a captive breeding programme and, in March 2013, it was reported that Iberian lynx embryos and oocytes had been collected and stored in liquid nitrogen for possible future breeding.

By 2012, the population of Iberian lynx had increased to approximately 325 individuals, then to 855 in 2020, and to 1110 in 2021. According to estimates by the World Wide Fund for Nature (WWF), numbers would need to reach 3000–3500 individuals, including around 750 reproductive females, to be considered as being in a "favourable State of Conservation" according to European regulations.

Analyse the information provided in this resource material and integrate it with your knowledge of biology to discuss:

- the different factors that have led to the decline and endangered status of the Iberian lynx
- how the different interventions already undertaken have helped to avoid the extinction of the species
- management strategies that may ensure the long-term viability of the species and achieving a favourable conservation status.

QUESTION TWO: THE LANCEWOOD / HOROEKA AND THE MOA

Many of the adaptations of modern plant species are a result of evolutionary pressures caused by interactions with herbivorous animals. In most parts of the world, the herbivore niches were occupied by mammals, e.g. cattle, sheep, and deer, but New Zealand lacked this type of terrestrial mammal. All of New Zealand's native herbivores are birds, e.g. takahē, kōkako, kererū. One of New Zealand's most significant herbivores was the moa (Figure 3), a now-extinct bird which comprised several species ranging in size from that of a turkey to up to 3 metres in height. Once common across both the North and South Islands, the moa became extinct around 600 years ago.

Figure 3: Little Bush Moa illustration

Puzzling features of plants are sometimes explained as legacies of co-evolution with extinct herbivores. One of the more interesting features seen in some New Zealand plants is heteroblasty, a significant and abrupt change in form and function during the life cycle.

One of the most extreme examples of heteroblasty is found in the New Zealand lancewood / horoeka (*Pseudopanax crassifolius*). It is thought that the changes in the form and function of this plant species were adaptations to protect the plant from browsing moa. The changes across the sequence of growth were so striking that early botanists initially mistook them as two different species.

Defensive colouration is an adaptation which can reduce the risk of herbivory. When the lancewood / horoeka first sprouts, the seedling's leaves are brown and mottled, and it appears like a relatively nondescript plant on the forest floor (Figure 4a). As the plant grows, the leaves acquire brightly coloured spots next to each spike on the leaf (Figure 4b).

A 2009 study tested the moa-browsing, colouration hypothesis by analysing the different wavelengths of light reflected by lancewood / horoeka grown in a garden. The study showed that moa would have had difficulty distinguishing seedling leaves against a background of leaf litter. Conversely, the brightly coloured spots which flank the spine on sapling leaves are highly conspicuous to birds. Overall, the results indicated that *P. crassifolius* goes through a remarkable series of colour changes during development, from cryptically coloured seedlings to aposematically (warning) coloured saplings, forming a defensive strategy which protected against giant browsing birds.

The nutritional content of lancewood / horoeka leaves varies throughout the plant's life cycle. When mature, the leaves contain approximately 5 times as much protein, and 1.25 times as much soluble carbohydrate as a seedling. It is hypothesised that the low nutritional value of the young leaves reduces their attractiveness to browsers.

As the plant grows taller, the leaves of the juvenile lancewood / horoeka develop into metre-long rigid, barbed spears, slanting downward toward the forest floor. Large birds, such as the moa, eat by approaching leaves end-on and taking the leaves whole down into their throats. After the juvenile lancewood / horoeka reaches a height of about 3 metres, which can take 10–15 years, it changes shape again. The dagger-like leaves begin to point upward to form the top of the tree, and a tall straight trunk develops until its appearance is like that of most other trees in a forest, growing up to 20 metres high, and its leaves resemble those of other forest trees. All the previous features are now gone (Figures 4c and 4d).

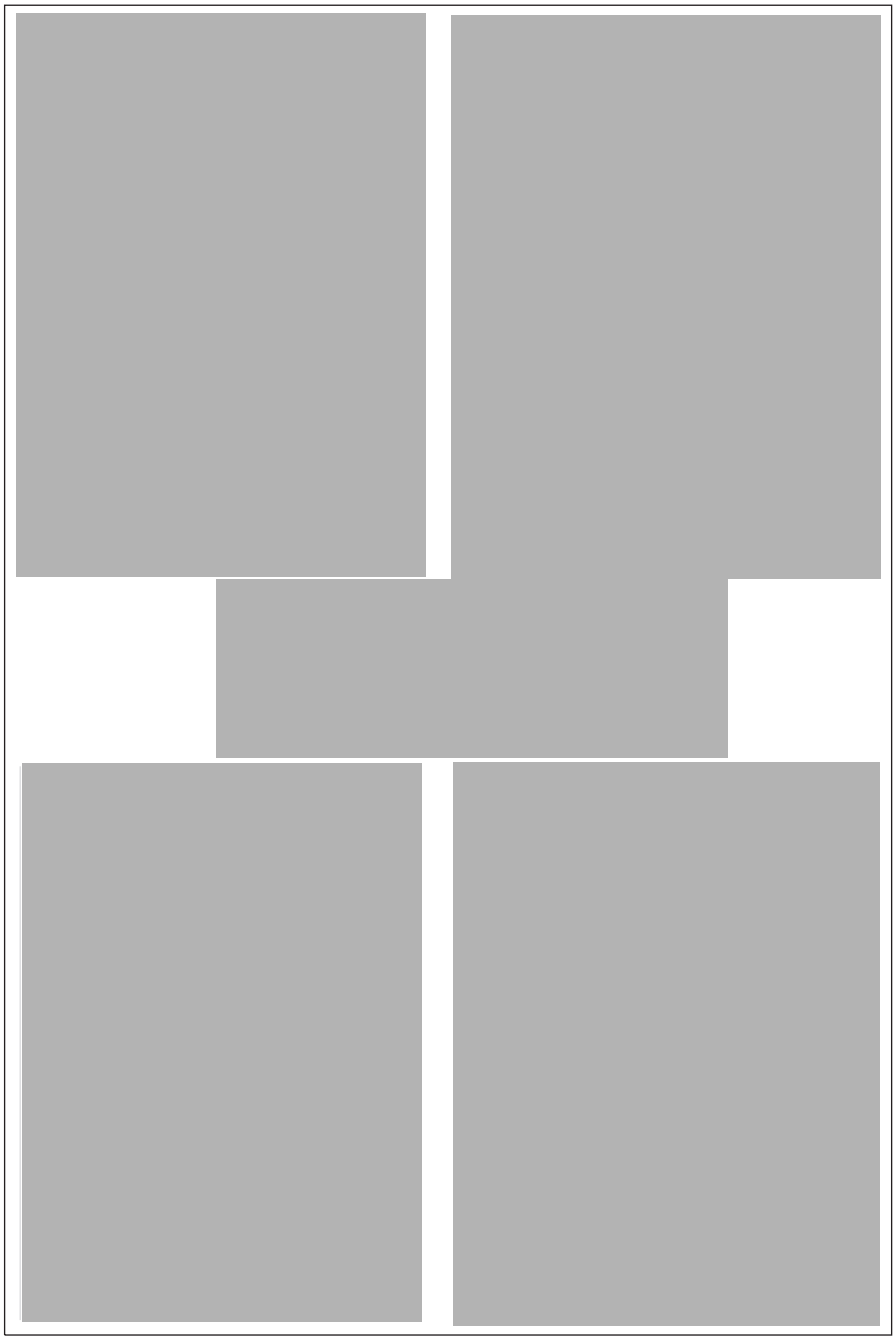

Figure 4: Lancewood / horoeka leaf – (a) seedling, (b) juvenile, (c) adult; (d) adult tree. Chatham Island lancewood – (e) adult tree.

This life cycle is unique to the New Zealand lancewood / horoeka. The Chatham Island lancewood (Figure 4e) shows very few of these adaptations; the leaves do not change colour as the plant develops, and the leaves of the juvenile do not point downwards or have spots and spines on them. The Chatham Islands has never had any flightless browsing birds.

Analyse the information provided in this resource material and integrate it with your knowledge of biology to discuss:

- the role of the moa in the evolution of heteroblasty in the life cycle of the New Zealand lancewood / horoeka
- the reasons the lancewood / horoeka has retained the heteroblastic life cycle despite the extinction of the moa.

QUESTION THREE: THE PĀRERA AND THE MALLARD

The biological species is the basic unit of classification, defined as a group of organisms that can successfully interbreed and produce fertile offspring. In many cases, however, the biological species concept is difficult or impossible to use. It can only be applied to sexually reproducing populations where clear reproductive isolation between groups can be observed.

One New Zealand example of where the biological species concept runs into problems is the 'hybrid swarm' which has occurred between the native pārera or grey duck (*Anas superciliosa superciliosa*) (Figure 5a) and the introduced mallard (*Anas platyrhynchos*) (Figure 5b). A hybrid swarm refers to a group of animals of mixed genetic heritage in which differentiation between one species and another is, without genetic analysis, no longer possible.

Pārera are an endemic New Zealand subspecies of the very closely related Pacific black duck (*Anas superciliosa*) found throughout the Pacific and Australia. The pārera were formerly found throughout New Zealand, including on all vegetated sub-Antarctic islands, the Chatham Islands, and the Kermadec Islands. They have disappeared from all sub-Antarctic islands, are now rare on the Chatham Islands, and are greatly diminished on mainland New Zealand.

Mallards were introduced to New Zealand early in the 20th century and were established by 1910, according to a 2011 study. It showed a minimum of 30 000 mallards were released by acclimatisation societies, groups which sought to naturalise new species to New Zealand, up until the 1970s. It also found that private releases were impossible to count but were considerable.

The New Zealand pārera population is believed to be extensively hybridised with introduced mallards, to such an extent that few pure pārera may now exist, hence its 'Critical' conservation status. While this presumption is based entirely on phenotype, as definitive genetic studies have yet to be undertaken, the diversity of soft-part and plumage characteristics of most grey, duck-like New Zealand birds (Figures 5c and 5d), compared to those in Australia, lends support to this belief. The hybridisation occurs very readily, and the hybrids are fertile, with no apparent significant loss in fitness. This results in 'extinction through hybridisation'.

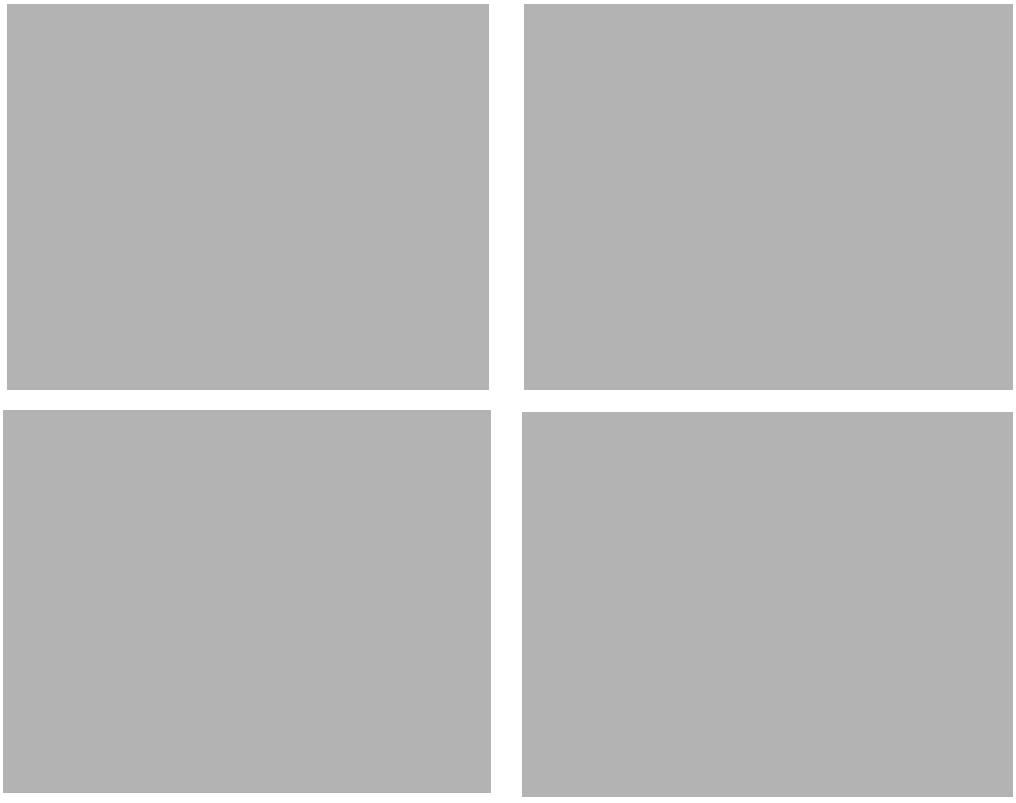

Figure 5: (a) Adult pārera (b) Male and female mallard
(c) Pārera and mallard hybrid (d) Pārera and mallard hybrid

Comparison of pārera and mallard

Feature	Pārera	Mallard
Average length	50–60 cm	50–70 cm
Average mass	900–1200 g	1050–1300 g
Clutch size	8–10	10–13
Breeding months	Aug–Dec	Jul–Dec
Egg laying dates	Aug–Oct	Jul–Oct
Incubation period	26–29 days	27–28 days
Flight range	Over 1500 km	Over 1500 km

Mallard come from an open, shallow, grassland region created during the retreat of the Northern Hemisphere ice sheets, and need an open landscape. The pārera evolved in wetlands where trees and bush cover dominated. In New Zealand, the clearing of the bush and creation of open farmland meant the mallard was already well adapted to the new conditions. Had mallard not been introduced to New Zealand, pārera would most likely have expanded their range of habitats to exploit the pastoral ponds and wetlands. This happened in Tasmania and many parts of southern Australia where mallard were not introduced, and are currently not as common as in other parts of Australia.

Currently, the mallard is a popular game bird and may be hunted and killed in all regions of New Zealand. Due to the difficulty of distinguishing pārera from mallards, both species may be legally killed by hunters during the game bird hunting season. The only exception is on Great Barrier Island where duck hunting is not permitted.

Preserving a population of pure-bred pārera would be very challenging. However, New Zealand does have expertise in using techniques such as captive breeding and offshore islands to protect endangered bird species. The techniques which have worked with other species would need to be modified for the pārera. The pārera is not, however, a conservation priority as very similar species are found in other parts of the world and funding is prioritised towards more uniquely endemic species, e.g. the kākāpō and kiwi.

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

- possible circumstances in which the biological species concept may be insufficient to distinguish species, as with the pārera and mallard, with examples from your own knowledge
- alternative evidence that could be used to distinguish the two duck species from one another
- how difficulties with the species concept, arising from hybridisation, may impact decisions regarding management of both the pārera and the mallard in New Zealand.

93101Q

Acknowledgements

Material from the following sources has been adapted for use in this assessment:

Figure 1 https://www.usatoday.com/story/news/world/2022/04/22/species-saved-from-extinction-gorilla-fox-crocodile/7371683001/

Figure 2 https://wwf.panda.org/discover/our_focus/wildlife_practice/profiles/mammals/iberian_lynx/
https://academic.oup.com/jmammal/article/92/5/1081/885349

Figure 3 https://collections.tepapa.govt.nz/object/710921

Figure 4 (a), (b): https://www.science.org/content/article/new-zealand-tree-stuck-time-warp

(c): https://www.nzplants.auckland.ac.nz/en/about/seed-plants-flowering/araliaceae/pseudopanax-crassifolius.html (Image 8)

(d): https://teara.govt.nz/en/interactive/13809/growth-forms-of-lancewood

(e): https://www.nzpcn.org.nz/flora/species/pseudopanax-chathamicus/

Figure 5 (a): https://nzbirdsonline.org.nz/species/grey-duck

(b): https://www.sciencelearn.org.nz/resources/2365-introducing-new-zealand-ducks

(c): https://www.zoochat.com/community/media/hybrid-grey-duck-x-mallard.138109/

(d): https://www.stuff.co.nz/science/107234405/native-grey-ducks-mating-to-extinction

Page 7 Table: https://nzbirdsonline.org.nz/species/grey-duck, https://nzbirdsonline.org.nz/species/mallard