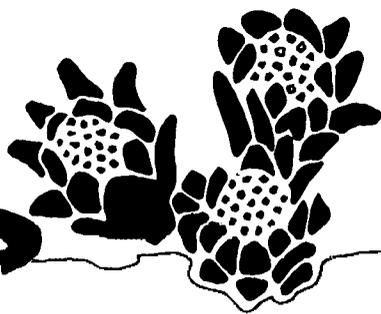
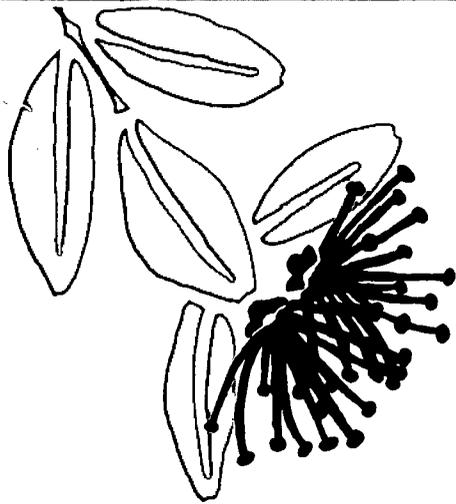


ECOLOGICAL MANAGEMENT



Department of Conservation
Te Papa Atawhai

Number 2
July 1994

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DEPARTMENT OF CONSERVATION
THREATENED SPECIES UNIT

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The contents of the bulletin are intended as a description of field results obtained in different parts of the country and at different times. They do not necessarily reflect current Department of Conservation policy on materials and methods.

The editorial board for this issue was Alan Tennyson, Mary Cresswell, Kaye Green, and Don Newman.

Views expressed in this publication are not necessarily those of the Department of Conservation.

Address all comments to the Editor, Threatened Species Unit, Department of Conservation, P.O. Box 10-420, Wellington. When submitting material for **ECOLOGICAL MANAGEMENT**, please send unformatted material, either as an attachment on the DoC internal communication system or on a floppy disk (WordPerfect 5.1), and we will format material at this end. Please include a hard copy as well.

Cover designed by Cathy Jones

FOREWORD

Issue Number One of ECOLOGICAL MANAGEMENT received much good feedback from conservation workers throughout the country. Thank you to those of you who took the time to write or talk with us about your ideas or opinions.

Number Two continues in the same vein by giving reports of specific field operations (e.g. transfer of Mohua to Centre Island, stoat control on Maud Island), but contains more overview papers on management techniques (e.g. disease management, lizard survey techniques, translocation techniques). In Number One we had some problems with clarity of photographs (i.e. most of the islands looked like meatloaves, showing little detail). In Number Two we've only used photos with clearer definition. We've also introduced a new category called 'Short Notes' for articles two pages or shorter. These notes will not have abstracts.

ECOLOGICAL MANAGEMENT fills a unique niche in New Zealand's array of publications. It is particularly for those conservation field workers (both within and outside the Department of Conservation) who may not like writing for or reading more 'scientific' journals (there are many other journals available for publishing research results). However, contributions from 'scientists' and others are still more than welcome. We have tried to accommodate the varied format of submitted articles by using a flexible style from one article to the next - all articles need not be fully referenced for example.

We will continue to actively seek out articles on conservation projects that have never been documented. In my opinion if a project has not been written up then it is not complete. Unexpected successes and failures are an inevitable part of innovative conservation work and we must share those successes but also we cannot afford to let others repeat our mistakes.

We aim for ECOLOGICAL MANAGEMENT to reach all those actively involved or with an interest in practical conservation. I hope ECOLOGICAL MANAGEMENT can continue to provide a forum for communicating novel management techniques. We can only do this with your continued support - so please keep sending in articles, and suggestions you have for improving ECOLOGICAL MANAGEMENT, and make sure that you are on our mailing list.

Alan Tennyson
Threatened Species Unit

NEW ZEALAND LIZARDS: THEIR ECOLOGY AND CONSERVATION

Tony Whitaker
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ABSTRACT: The origins, evolution, ecology and conservation of the New Zealand lizard fauna are described and briefly discussed.

Lizards are represented in New Zealand by two families only – the geckos and the skinks. To put these families in context, it is important to understand the relationship of the different reptile orders. There are four, and each has representatives in New Zealand or has been recorded in New Zealand waters.

CHELONIA – turtles and tortoises; ≈244 species worldwide, terrestrial and marine.

SPHENODONTIDA – tuatara; two species – only in New Zealand, terrestrial.

CROCODYLIA – crocodiles, alligators; tropical, 22 species, freshwater and marine.

SQUAMATA – lizards, snakes, worm lizards.

Squamata, in turn, are divided into three sub-orders:

AMPHISBAENA – worm lizards; 140 species, tropical, terrestrial.

SERPENTES – snakes; ≈2400 species, worldwide, terrestrial and marine.

SAURIA – lizards; ≈3800 species, worldwide, terrestrial.

The Sauria contain 16 families. The two largest are the cosmopolitan families SCINCIDAE – the skinks, with ≈1300 species, and the GEKKONIDAE – the geckos – with ≈800 species. So in effect, in New Zealand we are dealing

with the most successful of the extant reptiles – the most numerous, the most diverse, the most widespread and those that occupy the widest range of habitats.

So how can you distinguish geckos from skinks? Geckos have a chunky body with broad head and distinct neck, loose velvety skin of small granules which they shed whole or in large pieces, wide flat toes for climbing, large eyes with vertical slit pupil and they cannot shut their eyes. In contrast skinks have a streamlined body with a pointed head and no neck, a tight skin of overlapping fish-like scales shed scale by scale, thin round toes for running, small eyes with a round pupil, and moveable eyelids.

Both geckos and skinks have been in New Zealand for a very long time. The geckos are regarded as amongst the most primitive in the world. They probably originated in Gondwanaland, the ancient southern continent, and have been in the New Zealand region before it separated from that land mass around 80 million years ago. They are grouped with some geckos from New Caledonia and Australia into the subfamily Diplodactylinae.

The skinks, although not as ancient as the geckos, are believed to have been in the New Zealand region for at least 40 million years. This presumed antiquity is based on genetic diver-

gence rates (the time it takes for genera/species to evolve), differentiation from their overseas relatives (all New Zealand genera are endemic) and some show very distinctive characteristics e.g. with just one exception, in New Caledonia, the New Zealand geckos are the only ones in the world that do not lay eggs), and the diversity of lizard species that occurs within New Zealand.

Note that the New Zealand species currently included in *Leiolopisma* form a distinct grouping, differing at the generic level from species assigned to *Leiolopisma* elsewhere. The New Zealand species are soon to be allocated a new generic name.

Diversity

One aspect of the New Zealand lizard fauna that is remarkable is the diversity. Plants and animals adapt to their environment and gradually change, over a long period of time, to form different species and genera.

In New Zealand the lizards have evolved into many kinds, living in virtually all habitats, and with a wide range of habits. This diversity is unparalleled in temperate regions elsewhere – compared to other countries of similar size and latitude, New Zealand has three times the diversity of lizards of Japan, 4.5 times the diversity of Italy and five times the diversity of Spain. More surprisingly, in relation to land area we have three times the diversity of the Australian lizard fauna!

So how is this diversity manifest? First, the geckos and skinks have evolved into four groups that roughly correlate to the genera:

- Geckos that are active by day, generally green, and live in trees (*Naultinus*, seven species);

- Geckos that are active at night, generally brown, and live on the ground or in trees (*Hoplodactylus*, ≈22 species);
- Skinks that are active by day and live in open places (*Leiolopisma*, 22 species);
- Skinks that are active at night and live mostly in forested places (*Cyclodina*, nine species).

The diversity exhibited by *Leiolopisma* and *Hoplodactylus* exceeds that of all other vertebrate genera in the New Zealand region.

Within these groups, *Cyclodina* is confined to the North Island and relatively low elevations (<500 m), *Naultinus* is throughout New Zealand but does not extend to very high elevations (<1000 m), *Hoplodactylus* and *Leiolopisma* are throughout New Zealand and to high elevations (≈1800 m).

Habitat

Lizards have evolved to occupy every habitat from tiny rocky islets through to mountain tops – to at least 2200 m. Basically you can expect to find lizards anywhere (except very high alpine areas) – islands, rocky shores, coastal scrub, and so on. Some species are very flexible in their habitat requirements and occupy a wide variety of habitats. For example, the forest gecko (*Hoplodactylus granulatus*) occurs in any wooded environment from coastal forest through lowland scrub, broadleaf forest, montane beech forest to subalpine scrub.

Other species are incredibly precise in their habitat requirements – the egg-laying skink (*Leiolopisma suteri*) only lives close to the tide line on rocky shores; the scree skink (*Leiolopisma waimatense*) occurs on active scree in the South Island mountains. Lizards

also occupy some apparently harsh environments. The Fiordland skink (*Leiolopisma acrinasum*) only occurs on exposed Fiordland coastlines where it frequently encounters the full fury of the south Tasman Sea. The black-eyed gecko (*Hoplodactylus kahutarae*) lives on alpine bluffs between 1100-2200 m in the Seaward and Inland Kaikoura Ranges where snow cover exists 4-6 months of each year.

The process of speciation in New Zealand has been aided by the changing nature of the landforms in this region over the last 30-40 million years. As sea-levels have fluctuated and the land has been distorted by movement of the tectonic plates, so 'New Zealand' has been a changing archipelago. This has meant the lizard fauna has been fragmented from time to time and the process of speciation accelerated.

More recently the Pleistocene Ice Ages (10-15,000 years ago) isolated many populations of lizards, especially in the South Island. This is believed to be the primary cause of the diversity in the green geckos (*Naultinus*, with two species in the North Island, five in the South Island).

When the broad ice cover isolated South Island green gecko populations to small coastal remnants of forest, they evolved slight differences in colour and shape. As the climate warmed and the ice retreated, the gecko populations gradually spread out again until they occurred throughout the islands.

However, the differences evolved in isolation remained, and although these geckos can interbreed in captivity they are distinctively different from one district to another.

Geographical distribution

The number of lizard species is greatest

in the north – as many as 12 species occurring sympatrically – and the proportion of nocturnal species is also greatest there. However, lizards occur as far south as southern Stewart Island, where they are amongst the southernmost species in the world.

So how can so many sympatric lizard species survive together? This is achieved by a variety of factors, including:

- Occupying a different microhabitat,
- Being active at different times of day,
- Eating different kinds of food, or
- Growing to a different size.

The Central Otago lizard fauna illustrates this, where eight lizard species occur often at the same site (*Hoplodactylus maculatus*, *Naultinus gemmeus*, *Leiolopisma otagense*, *L. grande*, *L. maccanni*, *L. nigriplantare polychroma*, *L. inconspicuum*, *L. chloronoton*). They can survive because they use slightly different parts of the environment and in slightly different ways:

- One is nocturnal, the others diurnal.
- Two are arboreal, the others terrestrial.
- Four live on rocks, the others on the ground.
- Two prefer wet sites, the others dry sites.
- The three largest are about five times bigger than the smallest.
- All have a slightly different diet.

Population density

People are often unaware of lizards,

except when their cat drags one inside, but it always surprises me how those with an interest in the New Zealand biota underestimate the density/biomass of the lizard fauna. To some extent this is understandable because over most of the New Zealand mainland the lizard populations are severely depleted by habitat loss and predation.

However, at some mainland sites and on predator-free islands the density of lizards (as once occurred over most of New Zealand) can be determined. Lizard numbers often reach 1/m² (equivalent to 50 kg/ha) but can locally reach numbers of >10/m². At these densities they are a significant component of the New Zealand ecology, both as consumers and as prey, and in the reproduction of some plants (pollination and seed dispersal).

Diet

Most New Zealand lizards are primarily insectivorous, eating a wide variety of invertebrates. Studies on different species have shown that many species have quite specialised diets – some eat lots of fruit and nectar, others do not; some eat more insects, some more spiders, and yet others prefer crustaceans; some will eat carrion. Extremes of diet specialisation are shown by some species, e.g. the egg-laying skink (*Leiopisma suteri*), which feeds in and around rock pools and in the intertidal zone.

Lizards have an important role in seed dispersal, and in late summer fleshy fruits form the major component of the diet of many species. Seeds are voided intact often many tens of metres from the parent plant, and trials show that the seeds of many species have enhanced viability after passing through lizard guts.

It has been calculated that at some sites

over a million seeds per hectare per year pass through lizard guts to be deposited in favourable sites for germination. Some plants with densely tangled branches and white or colourless fruit appear to be specifically adapted by dispersal by lizards.

Geckos swarm over some plants' flowers in search of the nectar and in doing so become covered in pollen. As they move from plant to plant, pollen is transferred from one to another.

Predation and protection

Lizards are important items of prey for a variety of indigenous birds (harriers, falcons, rails, owls, cuckoos, kingfishers, etc. – they have even been recorded in the diet of kakapo and takahe); tuatara readily consume lizards, big lizards eat small lizards, and lizards are also eaten by a variety of invertebrates including beetles, centipedes and spiders. I know of two instances where fish have been recorded taking lizards.

Apart from secure hiding places and secretive habits, the greatest protection that lizards have is their cryptic colouration. Even apparently boldly coloured species blend extremely well with their natural surroundings. If their camouflage lets them down lizards (especially skinks) usually rely on their speed for escape.

Failing that, green geckos will try bluff – a threat display with accompanying loud calls. If all else fails and they are attacked, all New Zealand lizards can shed their tails to escape. A new tail soon grows to replace the old but it is never as long and is always marked differently in pattern and size.

The present depleted state of the herpetofauna in New Zealand can be directly attributed to the presence of humans in

this country – first Maori and later Pakeha. Widespread habitat destruction and the impact of introduced predators (cats, rats, stoats, etc.) over the past 1000 years has led to the extinction of at least three lizard species and many others have disappeared from large parts of their range, some of them only surviving on predator-free offshore islands. The survival of many species is now seriously threatened.

Subfossil remains show that many of the lizard species became extinct on the mainland before the Pakeha arrived, and the most likely cause of this extinction is predation by kiore (Polynesian rats) and competition by the rats for invertebrate food species. The lizards most vulnerable are large, nocturnal, terrestrial and egg-laying as these species are active at night when the rats are active, cannot climb to evade capture, are too large to fit into rat-proof shelter, and their eggs are at risk of being dug up and eaten.

The impact of rats is best illustrated by comparing the faunas of adjacent islands which are inhabited by rats and rat-free. When kiore are present there are fewer lizard species and fewer individuals (e.g. islands in the Mercury group). Confirmation of this impact came a few years ago when kiore accidentally invaded an island in the Mokohinau group which had thriving populations of five lizard species. Within two years two species had become extinct and the other three were decimated.

The predators that arrived with Pakeha are just as serious. Ship rats and Norway rats are efficient lizard predators (e.g. Whenuakura Island); stoats and ferrets include large numbers of lizards in their diet, especially when rabbit numbers are low; and cats consume

huge numbers of lizards each year. In one hunting foray (i.e. 4-6 hours) a cat can take 15-20 lizards, and because they hunt by day they usually take species not accessible to rats. Many introduced birds are also lizard predators (e.g. blackbirds, starlings, mynas).

Habitat loss

Despite the impact of predation, one of the most serious problems facing the lizard fauna is habitat loss. Half the forests were burned off before Pakeha arrived but the insatiable demands of the Europeans for agricultural land and timber mean that nowadays over 95% of lowland forest has been lost. The consequences for this on the lizard fauna are immense.

But it is not only forest loss – the conversion of tussock grasslands to pasture are also severely impacting on the lizard fauna and placing some of our rarest lizards at risk (e.g. Otago skink (*Leiolopisma otagense*) and grand skink (*Leiolopisma grande*)).

Conservation and the future

What of the future? Eleven species of lizard are listed in the *Red Data Book* of endangered species, and 19 are listed by the Department of Conservation as threatened species. Fortunately in recent years people have become more aware of the New Zealand lizard fauna, its uniqueness, diversity and importance in the ecology of the country.

Most lizards are now covered by the Wildlife Act as protected species, and for many of the rarer ones there are recovery programmes in place. Nevertheless, there is still much to be done. A number of species occur only on the mainland, and they are still subjected to the impact of predators, competitors and frequently to further habitat degradation.

It is important that suitable areas of habitat be protected for all threatened lizards and that research into the management of their habitat be undertaken.

For many species, the best hope for continued survival exists on predator-free islands. With the recent spectacular successes in rat eradication from islands the future for many species is really looking bright. Following removal of rats from Korapuki Island, in the Mercury group, the lizard species present not only increased in numbers and occupied new habitats, but for some there was also a dramatic increase in average size.

Transfers of several very rare species have already taken place and the oldest (28 *Cyclodina whitakeri* moved to Korapuki Island six years ago) appears to have been successful. Other transfers have included Fiordland skinks (*Leiopisma acrinasum*) to Hawea Island, which has been spectacularly successful, and robust skinks (*Cyclodina alani*), marbled skinks (*Cyclodina oliveri*) and egg-laying skinks to Korapuki Island. More transfers are planned following the removal of rats and mice from several other islands around New Zealand.

Conservation and the past

I would like to end with a story about one of the lizard species we appear to have lost. When the early European naturalists talked with the Maori inhabitants they were told of several large reptiles that lived in New Zealand forests. Kumi and ngarara are believed to be mythical, tuatara we now know to be the ancient reptiles scientists call *Sphenodon*, but what was the creature they called kawekaweau?

Kawekaweau were reported from widespread sites in northern New Zealand. Although variously described as being

amphibious, terrestrial or even able to fly, the most common description was of an arboreal species about 60 cm long. Some early Pakeha did claim to have seen kawekaweau but no description was ever written and no specimens were known.

The last reported sighting was in 1870 when one was caught beneath the bark of a rata tree near Whakatane and killed. It was said to be 60 cm long, as thick as a man's wrist and coloured brown with reddish stripes. Nothing more was heard of the beast until 1984 when a specimen of a huge gecko was discovered in the basement of the Marseille Museum. At 62 cm it is half as big again as the next largest gecko (from New Caledonia) and its morphology and remaining bits of skeleton clearly showed it was a species of *Hoplodactylus*. Interestingly its size and colour exactly match the description of the lizard from Whakatane.

There is no data with the specimen and no indication of how it got to France. All efforts to prove a connection to New Zealand sadly failed despite some sophisticated tests. Nor has any subfossil material turned up in cave or dune deposits – none unless a tiny bone from a Central Otago cave is in fact the hemipenal bone of a large gecko.

This bone, collected over 100 years ago, together with a pleurodont reptile jawbone, was originally described as the rib of a kumi (or mythical lizard). Recent re-examination suggests it might be the hemipenal bone (paired bones that occur in the sex organs) of a large gecko and a detailed comparison of the bone with X-rays of the Marseille specimen indicate this is definitely possible.

Proof the Marseille specimen did come

from New Zealand would be very exciting but what concerns me most is to ensure that none of our other lizard species go the way of the kawekawea – species like the spectacular chevron skink (*Leiopisma homalonotum*), our largest surviving lizard and one of the rarest, is known only from Great and Little Barrier Islands and from fewer than 100 records.

THIS PAPER IS A SUMMARY OF A TALK ORIGINALLY PRESENTED TO DEPARTMENT OF CONSERVATION STAFF AND THE PUBLIC AT TE ANAU, 1 MARCH 1993.

SURVEY METHODS FOR LIZARDS

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ABSTRACT: Essential points to consider when surveying for lizards: planning, techniques for day and night surveying, capturing, handling, and sources for identification.

Careful preparation is important and can save a lot of time and money in the field. Make full use of *all* sources of information and training opportunities. Get permits – be systematic – record data.

Background

Find out what is already known about the species and location. Review the literature. Talk to people; use the media.

Training

Familiarise yourself with the species and habitat/habits by viewing animals elsewhere or in captivity. Practise techniques with someone who knows the species.

Information sources

Talk with landowners and those who work in or use the habitat you are surveying (farmers, loggers, hunters, etc.). Always carry a collection of photos or book of illustrations. Don't ask leading questions – let the interviewee set the scene to avoid later confusion. Don't put people off by being prejudicial over their activities (e.g., logging!).

Project design

Carefully design your project so that (if possible) it gives you what you want; be systematic and objective; think 'laterally'.

Examine scientific method (especially if you are collecting data for later 'number-crunching') – some survey

techniques are appropriate for catch-per-unit-effort (CPUE) analysis but this has drawbacks of operator bias, lack of contemporaneous samples, low repeatability and is often imprecise.

Standardised trapping techniques overcome some of the problems of CPUE but tend to be more time consuming, more selective of species, etc.

Monitoring methodologies require special care to detect real differences or changes (e.g., mark/recapture and mark/re-sight).

Get permits from DoC to capture and handle lizards and to enter reserves. Get permission from the DoC Ethics Committee for projects requiring manipulation (e.g. marking).

Data recording

Take notes and photographs, make drawings – **DO NOT RELY ON YOUR MEMORY.**

Record details of everything – including the area surveyed (location name, description, grid reference, altitude, aspect, etc.), date, time, duration, searcher's names, effort (start and stop times), weather (temperature, cloud, sun, wind, rain, etc.), habitat (including dominant plant species), available cover, details of species found (number, behaviour, microsite, how located, etc.).

SEARCHING BY DAY

Lizards are incredibly cryptic, even the boldly coloured species when in their proper habitat, so search carefully when checking retreats or looking for basking or active lizards both by day and at night.

The best strategy is to scan a potential site with binoculars to try and see basking or foraging lizards, move closer to look for basking or active lizards, move on the site taking care to see if you can hear or see disturbed lizards, check for lizard sign, then finally check retreats for inactive lizards.

Retreats

SITES: Logs, stones, crevices, loose bark, dense vegetation.

EQUIPMENT: Small focusing torch (e.g. Maglite®), good to examine cracks or crevices; "winkle" wire.

TECHNIQUES: Move stones/logs quickly and cleanly. Be prepared to move very quickly as animal's response (especially hot skinks) can be extremely rapid. Use wire (or substitute) to work animals out of tight crevices. You can often find arboreal geckos in retreats on the ground during winter or prolonged bad weather.

CAUTIONS: Searching can destroy habitat; it can injure or kill animals if not done carefully, and it can leave them exposed to predation. Return logs, stones, etc. to original position, THEN release animal.

Basking animals

Animals will only be out in sunny weather. When air temperatures are very low they will bask in sheltered sites (even surrounded by snow!).

EQUIPMENT: Binoculars; must focus to close range (<4 m), and preferably have high light gathering qualities (i.e.,

big lenses 7-8 x 50 are good but heavy).

SITES: Nearly always facing directly to the sun, nearly always in sheltered/-protected position, frequently on a dark and/or heat-retaining surface. Diurnal species often bask with the whole of their body in sunlight, while nocturnal species usually bask with only a very small portion of the body showing.

TECHNIQUES: Search with the sun behind you; the angle of the sun is critical. "Shadow" to search vegetation – that is, wave arms around to stir animal into activity. Best time of day to search: early morning or late afternoon are equally effective. Best time of the year: spring. Best weather for searching: immediately after cold spell or when weather clears from rain.

Wait for elusive critters to return, as they usually return to the same basking site in a few minutes or use the same site each day. Use binoculars to search bigger areas and more distant sites.

Foraging animals

Strongly diurnal lizards are very unlikely to be active in anything but fine weather. Lizards will forage anywhere, but they rarely stay in the open. They are usually detected by their movement.

Use binoculars for distant sites – sit and watch potential sites. Look for visual anomalies such as dark shapes on light substrate and vice versa, shadows in unexpected places, different shapes or colours in foliage, etc. (This also applies to looking for basking animals.)

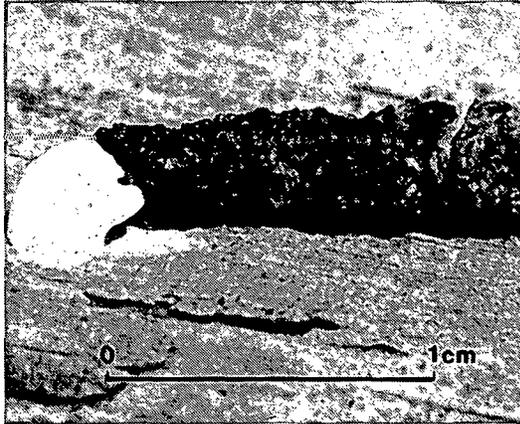


Figure 1 - Lizard droppings can be distinguished from bird droppings by the cap of uric acid on one end, the relatively large faecal fragments, their irregular shape, and the pointed end. Photo: T. Whitaker.

When disturbed, lizards usually run only a short distance (less than a metre) and then freeze, so wait quietly for them to move again. You can also try "shadowing". Arboreal geckos will creep away to hide on the side of trunk or branch away from you. Arboreal geckos can sometimes be knocked out of bushes by "beating"; they can also be located by bending the shrubs over, after which their movements to right themselves can be more easily seen.

Sign

DROPPINGS: Especially note differences from bird droppings – i.e. uric acid cap (rather than smeared along sides or splashed on substrate), larger fragments (rather than finely ground), irregular shape (rather than cylindrical and coiled, a function of fragment size), pointed end (rather than rounded); you don't get bird droppings under stones!! Uric acid lumps in dry crevices or beneath stones or logs can be very persistent. (See Fig. 1.)

SKIN: Scales or skin fragments; these can be small so look carefully. You can often find dead lizards in retreats.

ACTIVITY: Smooth, "polished" surfaces from frequent passage; lack of debris or lack of cobwebs in crevices; drag marks in dust.

Listen for noise

MOVEMENT: Rustling in vegetation.

CALLS: Geckos have two kinds of calls: alarm calls when disturbed (e.g. pushing through vegetation, track cutting) and communication calls (very soft but nevertheless distinctive).

SEARCHING AT NIGHT

The best strategy is to scan (from a distance) a potential site with a binocular-mounted spotlight to try to see reflected eye-shine or foraging lizards. Then move on the site to look directly for active lizards (taking care to listen for disturbed lizards). Then check retreats for inactive lizards.

Equipment

Good torch (preferably head torch) which throws a relatively tight uniform light without shadows or patches in the beam; binocular-mounted spotlight (the most effective combination is a good 6V light with 7x50 or 8x50 binoculars); small hand torch.

Techniques

FORAGING ANIMALS: Look everywhere; at night, active lizards (both geckos and skinks) will forage over open areas. Check potential food

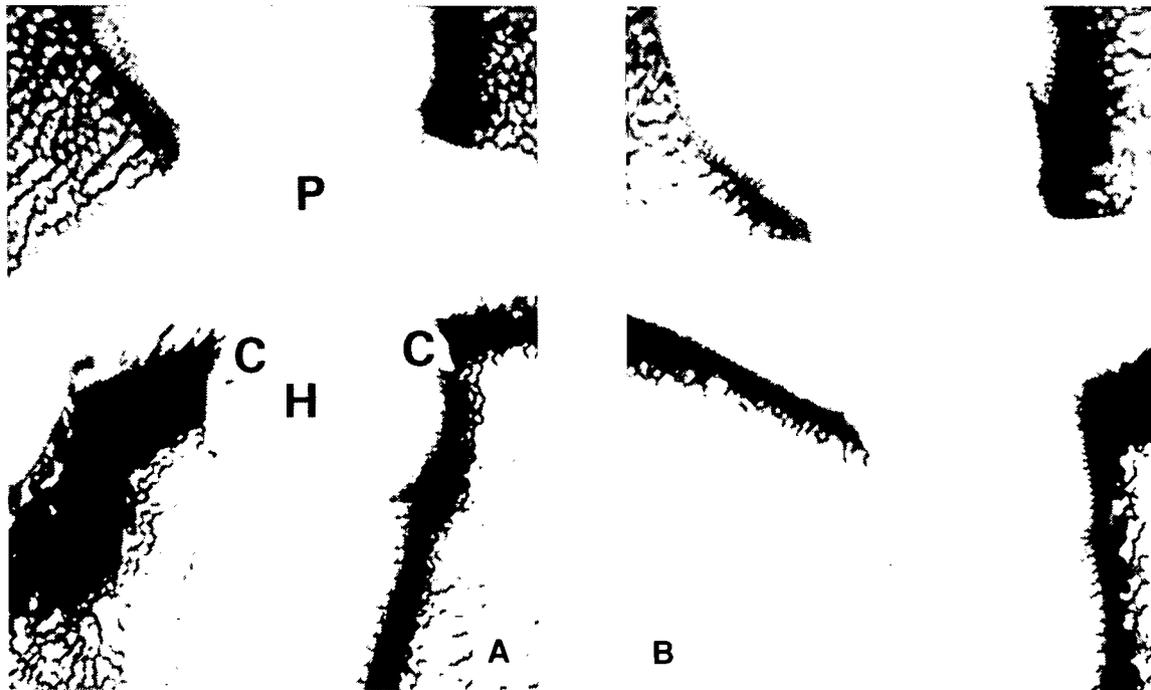


Figure 2 -- Adult male geckos (A) can be easily distinguished from adult females (B) by the presence of femoral and preanal pores (P), enlarged pouches containing the hemipenes (H), and cloacal spurs (C). *Photos: T. Whitaker.*

sources (e.g. flowering plants). Listen for sound of movement, especially in dry litter. Look for visual anomalies; for example, at night green geckos are very pale against normal foliage colours.

Spotlight for eye reflections: nocturnal geckos' eyes show pink through to almost white; diurnal geckos' eyes are white and not so large, nocturnal skinks' eyes are white and very small (cf. red/green/blue, small bright and twinkling for spiders; red, small and bright for moths); gecko eyes noticeably dim when a bright light is shone on them (the pupil contracts).

Try to select a combination of brightness and distance that gives the best results. To get maximum reflection, the light must be as close to the line of sight as possible.

The ideal is to use a binocular-mounted torch with the light directly between the lenses. With such equipment, it is

possible to locate geckos up to 100 m away.

For spotlighting to be most effective (and nearly always when you're using binocular equipment), you will need a cooperative partner to follow up on sightings.

INACTIVE ANIMALS: Use small torch for checking crevices or retreats.

PREDATORS: An excellent additional source of information on lizards is to check the local predators. The gut contents of cats and mustelids (shot or scraped off the road) should be checked, as the prey are nearly always reasonably intact (they will catch things we can never find!); examine predator droppings or casts from birds; watch predators hunting or carrying prey; check predator feeding sites for lizard remains.

CAPTURE TECHNIQUES

Hand capture

Simply grasp any animals you see! Anticipate direction of movement; pounce very quickly as lizard's reaction is almost instantaneous.

A slow approach is OK to a point, but the last movement should be as fast as you can. Terrestrial lizards will almost invariably head towards a retreat; arboreal species usually drop.

Be firm, as lizards are relatively robust. Keep pressure on vegetation or debris as animals can "worm" away if you relax. Don't be tempted to open your hand to see what you have got.

Noosing

Use a fine thread, nylon or hair noose on the end of a pole to capture lizards (most successful on skinks) in habitats where they can easily escape or can not easily be approached.

Most species are not afraid of a noose, and it can easily be placed over their head. Quickly lift animal clear of the ground or flick it out into the open where it can be grabbed. Use noose also for getting animals out of tight crevices.

Trapping

PIT TRAPS: Most commonly used and widely successful method of trapping.

Equipment: Paint tins (advantage is lip; for durability select lacquered tins), plastic containers, waxed cardboard (milkshake) pots.

Containers **MUST** have drain holes to avoid drowning captives and **MUST** have lid to protect them from heat exhaustion. Wire mesh can be put in the bottom to protect captives from mammalian predators.

Select trap size to target particular species: lizards won't drop into traps that are too deep and they escape from those that are too small. Optimum for New Zealand is a 2-litre paint tin.

Site selection: This can vary, depending on the aim of trapping, but it's preferable to choose a site where lizards travel, bask or feed.

Installation: Dig in flush or slightly below surrounding surface and pack substrate close around rim of container. Cover with lid supported 1-2 cm above lip. You can provide "guides" in form of sticks or drift fences.

Baiting: Depends on target species. Use soft fruit (canned pears probably best), sardines or fish-based cat food (meat based kinds are not so attractive).

Checking: Depends a bit on goal of trapping, the weather, the season, the risk from predators, etc., but traps should not be left longer than 3-4 days.

To unset a pit trap, put a stout stick in that is just longer than the diagonal height – too long and it will get knocked out; too flimsy, and it will break. **DON'T RELY ON A LID, AS IT COULD GET DISLODGED.**

TUNNEL TRAPS: A variety of tunnel traps have been used with only marginal success. Depending on circumstances and target species, there may be a case for their use.

PLASTIC SHEET: In places where it is difficult to install pit traps, it is possible to catch skinks by using a sheet of polythene formed into a shallow cone. Bury or hold edge down and place rocks or other cover in the centre. Skinks slide in and cannot climb out.

Artificial retreats

In some situations it is possible to set artificial retreats (slabs of rock or tiles

on outcrops; bits of plywood, planks, logs, or rocks in grassland) which lizards will use after a while. (This can be as soon as a day later.)

Boxes have been used for geckos (both arboreal and terrestrial). These should be wood, small and preferably thin (≈ 1 cm). These will take longer to be occupied.

HANDLING TECHNIQUES

Field containers

Cloth bags (with or without ventilation gauze), small well-ventilated boxes or plastic containers.

Keep containers as cool as possible. Remember **IT IS VERY IMPORTANT TO KEEP CONTAINER OUT OF SUN AND AVOID HIGH HEAT**. This means don't leave them inside closed vehicles!

Some vegetation inside the container will provide space if more than 2-3 animals are housed together, but this may make it difficult to get animals out.

Don't put aggressive or predatory species (large skinks) in with vulnerable ones. If you are holding animals for any length of time, regularly moisten the containers to prevent dehydration. (This is critical for *Cyclodina* species.)

Feeding is not necessary, especially during winter, unless animals are being held for a week or more.

Handling

Handle firmly but not don't be too rough. The animal will settle more quickly if its body is supported.

Avoid heat-stress from your hands. If signs of distress appear, put the animal in its container and cool it as much as possible.

Try to avoid tail loss during capture and handling – tails do regrow, but they are important for fat storage, especially in winter. (Cold lizards lose tails more readily, so be careful.)

Lizards carry some diseases transferable to humans (e.g., salmonella), so take reasonable care in your personal hygiene.

Data collection

MEASUREMENTS: Standard measurements are snout-vent length (SVL), tail length (TL), length of tail regeneration, and weight.

Take measurements of length with a ruler. Suspend animal between index finger and thumb and draw out until relaxed, or lay it in the bottom of a plastic bag. Weigh it in a noose or plastic bag, using a Pesola balance.

Less common measurements are head width, snout-eye, eye-ear, snout-fore limb, axilla-groin, length of longest toe (fore and/or hind limb), whether limbs meet/overlap when pressed towards each other.

SCALE COUNTS: Standard counts for identification are lamellae beneath 4th (=longest) toe of hind foot, supralabials, infralabials. For skinks, also count the scale rows around the middle of the body and the number of scales on the underside from the snout to the vent.

Additional scale counts (or shapes or proportions) for identification can be obtained from the relevant texts, but these mostly relate to head scales.

COLOUR: Colour and colour pattern can be extremely variable in most species. Despite this, some species have remarkably constant characteristics in their pattern.

Features to note are the presence, style and length of longitudinal markings

(mid-dorsal, dorso-lateral, lateral, latero-ventral and ventral), transverse markings, eye stripes, marks down legs; belly colour and markings.

Colouration of inside of mouth and throat is important for geckos.

SEXING: Adult geckos can easily be sexed – males have distinct femoral and preanal pores, enlarged pouches containing the hemipenes, and cloacal spurs each side of the vent (Fig. 2); females lack all these features but can sometimes be confused with immature males; females that are heavily gravid are usually obvious from their shape; immature geckos are difficult to sex.

Adult skinks can also be accurately sexed relatively easily, but it does take practice. Fold the animal over and gently pull the cloaca open while applying slight pressure to each side of the base of the tail. Mature males may evert one or both hemipenes, but even if they don't the gender can be determined from the raised and 'angled' shape of the hemipenal area, the opening to the hemipenal pouches and the prominent veins leading to them.

Female skinks lack all of these features. In particular, the opening to the cloaca appears as a smooth oval. Even relatively young skinks can be sexed.

Marking

PERMANENT: The only satisfactory method is toe-clipping. Remove toe quickly and cleanly with a sharp pair of scissors. The advantages of this method are that it is permanent and permits numerous combinations (150 from two toes, 625 from three toes); further, it is not often affected by natural damage.

The standard method is to list feet in order LF (left front), RF, LR, RR and count toes from inside out.

Ethics Committee approval is required, and standard protocols and databases exist. If the toes are frozen immediately, they can be used for genetic analysis.

TEMPORARY: Felt pens – must be waterproof (spirit-based – xylol or xylene – appear to have no toxic effect); quick and convenient to use; can write numbers; translucent colours are a disadvantage on dark animals, but opaque silver and gold are available.

Nail varnish – easily visible; opaque colours good on all animals; slow and messy to apply; can not write numbers.

Typists' correction fluid – dries a bit faster than nail varnish but otherwise has similar advantages and disadvantages.

Acrylic paint – similar to typists' correction fluid; wider range of colours; can be applied with a stick, thus avoiding the need for capture.

REMOTE: Transponders are now available for larger species – Ethics Committee approval (and big bank balance!) required. The range is generally very small, although units capable of 10-12 m range are reputedly now available.

IDENTIFICATION

If in doubt catch the animal (if possible) or at least take a photograph for specialist identification. New species are still being discovered, and we still know remarkably little about the distribution and habitats of many species. This is especially relevant if you are working in a remote place, where lizards are rare, or if you see something extraordinary.

There are no 'standard' photo angles, but be sure you cover the dorsal, lateral and ventral views.

Texts

There is no single comprehensive and reliable text for identification of all species, so check all avenues of identification.

Geckos – Bauer 1990

Skinks – Hardy 1977, Patterson and Daugherty 1994

General texts with pictures – Robb 1986, Barnett 1985, Gill 1986

Keys to species – Bauer 1990, Gill 1986, Towns 1988

Distribution – Pickard and Towns 1988

Literature – Whitaker and Thomas 1989

People (not an exhaustive list)

All species – Brian Gill, Auckland Museum, Auckland; Dave Towns, DoC, Auckland; Don Newman, DoC, Wellington; Bruce Thomas, Manaaki Whenua, Nelson; Tony Whitaker, Motueka; Alison Cree, Otago University, Dunedin.

Geckos – Rod Hitchmough, Victoria University, Wellington.

Skinks – Geoff Patterson, DoC, Wellington; Charlie Daugherty, Victoria University, Wellington.

Regional – Richard Parrish, DoC, Whangarei; Graeme Loh, DoC, Dunedin.

Societies

Society for Research on Amphibians & Reptiles in New Zealand: %Treasurer, Ms Krista Krey; School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington.

Current annual subscriptions: \$20; publication of *SRARNZ Notes* 2-3 times a year.

MATERIAL

Distribution data

Send records of all lizards (and frogs) to the Department of Conservation, Science & Research Amphibian and Reptile Distribution Scheme (ARDS):

%Geoff Patterson, Science & Research Division, Department of Conservation, PO Box 10-420, Wellington.

Specimens

If dead lizards are found (or if they die while being held), send them with full collection data (date, collector, locality, grid reference, habitat, elevation, etc.) to the national herpetological collection at the Museum of New Zealand:

%Andrew Stewart, Museum of New Zealand, PO Box 467, Wellington.

Material can be frozen for temporary storage and then preserved in alcohol or formalin (preferred is 70% ethanol, open body cavity for best penetration and preservation, but not along centre line). Note that even decomposed specimens are of value if they are of rare species or if they can be converted to skeletal specimens.

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THIS ARTICLE IS BASED ON NOTES FROM TRAINING SEMINARS GIVEN AT TE ANAU (MARCH, 1993) AND STRATFORD (NOVEMBER, 1993).

TRANSFER OF MOHUA TO CENTRE ISLAND, LAKE TE ANAU

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ABSTRACT: The first relocation of mohua was carried out by transferring three pairs of birds from the Eglinton Valley, Fiordland National Park to Centre Island in Lake Te Anau. This transfer was made largely to develop techniques for later operations that will involve greater numbers of birds. Three pairs were moved just before the breeding season. One pair appeared to vanish almost immediately but the other two pairs bred successfully shortly afterwards. At the end of summer there were at least three adults and three fledged young on Centre Island. Other island transfers are planned for the near future.

Introduction

The mohua or yellowhead (*Mohoua ochrocephala*) is a small insectivorous forest passerine endemic to the South Island of New Zealand. It has disappeared from large relatively unmodified forests and it is continuing to decline in both numbers and range. Mohua have vanished from 75% of their former range since the introduction of mammalian predators (Gaze 1985). Periodic irruptions of stoat (*Mustela erminea*) numbers in beech forests result in large-scale predation of breeding female mohua (Elliott & O'Donnell 1988).

Justification for transfer

The species recovery plan (O'Donnell 1993) outlines a range of measures aimed at helping mohua both in their current habitats and at introducing them to new, predator-free environments. These are:

- 1 – Increase productivity by improving our ability to control stoat irruptions at key mohua sites.
- 2 – Protect mainland populations by undertaking predator control in areas occupied by key mohua populations.
- 3 – Investigate island transfers and captive breeding techniques.

4 – Promote public awareness of mohua and of the values and ecology of mainland forests.

Although the first management priority is to retain birds within their present range, as long as there are sufficient numbers of wild birds there should be a commitment to developing holding and translocation techniques (Task 3 in the recovery plan). This will insure against possible extinction of mainland South Island populations.

Choosing sites

Islands suitable for introduction of mohua would need to meet two main criteria:

- They should have extensive areas of mature forest – preferably beech (*Nothofagus* spp.). Mohua are found only in beech forests now, but in the past they were found throughout the South Island in all forest types. Without predators, mohua may be able to live in any forest type.
- They have to be free of mammalian predators (*Rattus* spp. and mustelids) and have a low risk of reinvasion. The island should be beyond the swimming range of stoats (about one kilometre).

Centre Island

Centre Island in Lake Te Anau met the above criteria. It is within the existing range of mohua. It extends over 13.5 ha and is covered with mature forest dominated by mountain beech (*Nothofagus solandri*). This island provided sufficient habitat for at least five pairs of mohua.

The island has no known predatory mammals. Norway rats were once found but are no longer present. An initial inspection was carried out in 1992 when poison tunnels, set out to exterminate rats, were removed. Centre Island is relatively close to the Eglinton Valley (the source population), so a small-scale inexpensive translocation could be carried out. Access from the Eglinton Valley was relatively straightforward via road and boat.

Capture

We had a permit to relocate three pairs of mohua from the Eglinton Valley to Centre Island. Birds were caught on 24 and 25 October 1992 and were released on the 26th.

Mohua were captured using mist net techniques developed during studies of forest birds in the Eglinton Valley. A mist net rig was erected 20 m into the forest canopy by using a slingshot to position ropes high in the trees. Up to five mist-nets were then erected one above the other, and we attracted birds into the nets by whistling and playing tape recordings of mohua song and alarm calls. First, we surveyed areas of the valley floor and located six groups suitable for capture. Where possible we targeted pairs of birds (mohua may breed communally in groups of up to six birds), so that we could be certain of catching a male and female. The sex

of the birds was confirmed by measurement and listening to song.

At this time of the year, just before breeding starts, mohua were easily caught. At two sites we caught all the birds present, a pair at one site and a pair and a male helper at the second. At three other sites the male birds were easily caught but we were unable to catch the females, which were much less responsive to tapes. The males caught without their mates were released straight away. At the last site two pairs were present, a young non-territorial pair and an adult pair. Here we caught both of the young birds and the adult male.

Holding

All birds captured were weighed, measured, colour banded and placed in small transfer boxes (approximately 30 x 30 x 20 cm). The birds were transported 5-10 km by car to Knobs Flat where they were held for either 36 hours in a tent aviary (the first five birds in Table 1) or 12 hours in larger holding and transport boxes.

Tent aviary

A tent aviary approximately (4 x 3 x 2 m) was erected under the forest at Knobs Flat. It consisted of a large canvas tent with soft "fly screen" windows that could be screened with canvas flaps. The aviary was erected over moss and ferns, and rotten logs and live branches were placed in it. Shallow dishes of water and live food (mealworms and wax moth larvae) were provided. Later, caddis flies, moths caught around the house lights, grated cheese, carrots and millet were also provided.

Two pairs of mohua and one male helper were held in the aviary for around 36 hours and were watched



Figure 1 -- Gretchen Rasch and Graeme Elliott with mohua nest and transfer boxes, Centre Island, October 1992. *Photo: P. J. Dilks.*



Figure 2 -- Mohua in tent aviary, Centre Island transfer, October 1992. *Photo: P.J. Dilks.*

regularly. When released into the aviary, they flew around and repeatedly banged into the soft mesh windows but after a few minutes they perched and started pecking at their bands – typical behaviour of newly banded mohua. Within half an hour they were foraging on the ground and within an hour were eating the live food provided. No birds were seen to eat any food other than live insects.

Holding/transport boxes

Three birds (the last three birds in Table 1) were held overnight in a box 100 x 30 x 50 cm that had wire netting at one end and two perches in it. They were provided with water, mealworms and waxmoth larvae. We could not observe these birds but they did not flutter around and they ate all live food provided.

Transfer

On 26 October the birds were put into the small transfer boxes. Two extra birds were returned to be released at their site of capture and three pairs transported 30 km by car (20 min) and boat (20 min) to Centre Island. Here birds were released in pairs at one-minute intervals. The birds immediately flew off in pairs and were later observed foraging at various points on the island.

The weather on the day of transfer was fine and mild with a moderate southerly wind blowing.

Follow-up visits

On 3 December 1992, we searched the island for mohua. Only three birds were definitely identified: a nesting pair (R-R and R-Y) and a lone male (Y-W). Another male may have been present but we were unable to confirm this by reading colour bands on a bird seen briefly. The female (R-Y) was

incubating eggs – it was seen feeding at roughly 40-min intervals and was followed, but the nest was not found. All birds proved to be very difficult to follow compared with birds in the Eglinton Valley forests; they stayed high in the forest canopy and covered long distances rapidly.

On 18 February 1993, late in the breeding season, another visit was made. On this occasion two pairs were found. The first pair (R-R and R-Y) were feeding two fledglings and a new brood of chicks in a nest. The second pair was made up of a male (Y-W) and female (B-R) from two original pairs. They were feeding one fledgling and the female was incubating one newly laid egg in a nest just 1.5 m off the ground. Fledglings were seen taking mistletoe (*Peraxilla*) and *Pseudopanax* fruit, an unusual sight in mainland beech forests where fruit is rare.

The other two birds transferred (Y-Y and B-Y) were not found, despite four hours of searching.

Another visit was made on 3 May 1993. This time only three adults, the pair of R-R and R-Y, and the other male Y-W, and three young birds were found. The other female B-R was not seen during three hours on the island and hds probably died. All of the six mohua were foraging together in a mixed flock with fantails (*Rhipidura fuliginosa*), silvereyes (*Zosterops lateralis*) and grey warblers (*Gerygone igata*). The island was visited again briefly on 22 May 1993 to check if the female (B-R) nesting on February had died on her nest. The nest was checked and a dead chick found in it. A flock of mohua was present at the landing, but birds were not followed or individually identified. A visit to Centre

Table 1. Birds held at Knobs Flat and follow-up sightings on Centre Island.

Bands	Sex	Capture weight (g)	Release weight (g)	3/12/92	18/2/93	3/5/93
R-M/R	M	33.0	31.5	Breeding; with R/M-Y	Breeding; 2 fledglings + nest	Present in flock with 5 other mohua
R/M-Y	F	26.0	26.5	Breeding; with R-M/R	" "	" "
Y/M-W	M	34.0	32.0	Present no mate seen	1 fledgling + nest	" "
Y/M-R	M	32.0	31.5	Released at capture site 26/11/93		
Y/M-Y	F	33.0	30.5	Not seen – Died?	Not seen	Not seen
B/M-W	M	26.5	26.0	Released at capture site 26/11/93		
B/M-R	F	26.5	26.5	Not seen	1 fledgling + nest	Not seen – died?
B/M-Y	M	31.5	31.0	Not seen	Not seen – Died?	Not seen

Island in October 1993 found that only three mohua were present, one of the original males (R-R) and two one-year-old birds. The most recent visit, in April 1994, recorded the same three birds plus one juvenile being fed by one of the one-year-old birds.

Success of transfer

This island transfer was undertaken as an experiment in developing capture, holding and transfer techniques, as mohua had previously only been caught and held for brief periods whilst banding and measuring birds as part of other research projects.

Although only a small number of mohua were placed on Centre Island, the exercise has proved to be successful and we have gained valuable information for later transfers. Two birds probably died soon after being trans-

ferred, but two pairs nested within a month of the transfer and successfully fledged chicks. The birds appeared to be robust and amenable to handling. They readily fed on live food, although most birds lost weight during the holding period (see Table 1).

For future transfers, the use of a moth trap would be desirable, as the small number of moths fed to these birds were rapidly caught and eaten. Subsequent experience when catching mohua has shown that birds need a constant and liberal supply of live food if they are not to lose weight when being held for any period of time. Birds ate any live food: mealworms, wax moth larvae, moths or blowflies were all readily consumed. This provision of more "natural" food may

mean that future birds should not lose weight.

The birds were moved from the Eglinton Valley about two weeks before they would have started breeding. It was reassuring to see that the two surviving pairs on Centre Island both bred soon after their introduction. It appears that both of the attempts at second nesting were unsuccessful – though these were both very late in the season.

When compared with the survival of birds in the Eglinton Valley study areas, there has been a high mortality rate amongst the adult birds that were transferred to Centre Island. Only one of the six birds moved in October 1992 still survives, although three other mohua are present – two 18 months old and one six months old. At least one of these young birds is a female and bred last summer.

Centre Island provides only a small area of habitat considered suitable for mohua, and judging from the high turnover of breeding birds, it may not be optimum habitat.

The future

Mohua numbers in the Eglinton Valley are relatively high at the moment as it has been three breeding seasons since there was a stoat irruption. DoC's Southland Conservancy is putting together a proposal to transfer about 15 pairs of mohua to a larger predator-free island, probably Breaksea Island. A captive breeding programme for mohua has also begun, with three pairs

transferred to Orana Park in Christchurch in October 1993 (Dilks 1993). These two new aspects of mohua management should help safeguard the declining populations as research continues on the most effective methods of predator control for the mainland populations.

Acknowledgements

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TRANSLOCATING WILD FOREST BIRDS

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ABSTRACT: In this paper we describe methods used during recent successful translocations of forest birds in New Zealand. We emphasise the importance of habitat repair and describe how some birds can be conditioned to accept changed habitats. Details are given on numbers of birds in translocations, the design of aviaries, foods for captive birds, the design of translocation boxes and methods of release. Frequent reference is made to the successful saddleback translocations to offshore islands as examples of this conservation technique for threatened species, and we stress the importance of monitoring the results of translocations.

The translocation of an endangered species to a new habitat must be regarded, along with captive rearing, as a last resort. In New Zealand, however, it is a conservation technique which has proved highly successful, particularly after habitat has been restored on islands which were part of a bird's former natural range (Merton 1975).

This paper describes methods used on more than 70 occasions (C.R. Veitch, unpub.) to translocate forest birds in New Zealand. Eleven species have been shifted from their natural habitats to more than 50 new or repaired island and mainland habitats (Atkinson 1990; C.R. Veitch, unpub.). Initially few early transfers (e.g., the 1925 transfers of saddleback to Little Barrier and Kapiti Islands - Wilkinson and Wilkinson 1952, Turbott 1961, Nillson 1978) were successful because of inadequate repair of the new habitat or lack of knowledge of the behaviour and ecology of the species involved. Follow-up monitoring to assess survival, dispersal, breeding success and possible threats to the newly released birds is essential if future

mistakes are to be prevented (Fyfe 1978).

Island translocations were pioneered in New Zealand by Richard Henry, who translocated hundreds of kakapo (*Strigops habroptilus*) and kiwi (*Apteryx* spp.) to Resolution Island in Fiordland, sadly to no avail because stoats (*Mustela erminea*) reached Resolution Island soon after (Williams 1956, Atkinson 1990).

Since 1900, little spotted kiwi (*Apteryx owenii*), buff weka (*Gallirallus australis hectori*), black robin (*Petroica traversi*) and South Island saddleback (*Philesturnus c. carunculatus*) have, using translocations, been saved from extinction (Wilkinson and Wilkinson 1952, Merton 1975, Turbott 1990, Butler and Merton 1992). Two other birds, Stewart Island snipe (*Coenocorypha aucklandica iredalei*) and Stead's bush wren (*Xenicus longipes variabilis*) became extinct because we did not act in time or knew too little about them (Merton 1973).

Repair of habitats

Removing factors which caused a bird's decline in the first place - i.e., habitat repair - is essential. In New

Zealand there is little point in translocating the saddleback, for example, to the mainland because rats (*Rattus rattus* and *R. norvegicus*), cats (*Felis catus*) and stoats, which wiped out the saddleback from the mainland in the 19th century, are still widespread.

In New Zealand, habitat repair has included:

- Planting new forest, such as on Tiritiri Matangi Island (Mitchell 1985) and Mana Island (Timmins *et al.* 1987);
- Eliminating or excluding browsing mammals such as feral goats (*Capra hircus*), brush-tailed possums (*Trichosurus vulpecula*), feral sheep (*Ovis aries*) and rabbits (*Oryctolagus cuniculus*) (Veitch and Bell 1990);
- Removing predators such as feral cats, kiore (*Rattus exulans*), Norway rats, mice (*Mus musculus*), and weka (*Gallirallus australis*) (Veitch and Bell 1990).

Habitat repair has also included habitat enhancements such as providing food for kakapo on Little Barrier Island (Powlesland and Lloyd 1990), water supplies for little spotted kiwi on Long Island, and shelter, for example, burrows for newly released little spotted kiwi on Red Mercury and Hen Islands (C.R. Veitch, unpub.) and roost and nest boxes for North Island saddleback (*Philesturnus carunculatus rufusater*) on Tiritiri Matangi and Kapiti Islands (Lovegrove, in press).

If a habitat has been spoilt by an undesirable introduced species, that species should (if possible) be eradicated rather than controlled, as the latter requires constant effort.

Adaptations to changed habitats

An alternative to repairing the habitat is to get the bird to adjust in some way to the changed environment (Reed and Merton 1991). Unfortunately all too often the species is at risk in the first place because it has failed to adapt to the rapid, human-induced modification of a habitat, and one is faced with a declining population, sometimes a mere handful of survivors. This is often true of specialised island birds, which are much more prone to extinction than continental species (Diamond 1985). Low numbers of survivors means reduced genetic variability and fewer individuals that are able to cope with changed conditions.

A recent series of North Island saddleback translocations has illustrated that introducing birds to unsuitable habitat can be risky but that some individuals can cope with changed conditions. In a renewed effort to establish saddlebacks on Kapiti Island between 1981 and 1983, 244 birds were introduced (Lovegrove 1991). This was the first time that saddlebacks had been introduced intentionally to an island with Norway rats. It was thought that, among the 244 birds, there might be a few with more arboreal habits, which would avoid predation by the predominantly terrestrial Norway rats (Atkinson 1978) and would produce offspring with similar habits.

By 1990, only three of the original 244 birds remained. These birds habitually roosted in cavities in tall trees, where they avoided predation. Unfortunately too few birds survived from these translocations to form the nucleus of a new population.

Behavioural conditioning

Between 1986 and 1990 an experiment was conducted to test whether North Island saddlebacks could be conditioned to use artificial roost sites in preference to natural roosts. After a conditioning period of one to two years on Stanley (Kawhiti) Island, two lots of saddleback - those that used roost boxes and a control group that did not - were translocated simultaneously to Kapiti and released into habitat provided with roost boxes like those on Stanley Island. The box-using birds maintained their box-using habit and had a significant higher survival than did the control birds (Lovegrove, in press).

How to translocate birds

Much is still to be learned about how to translocate birds successfully. The needs of each species are different, and each capture and release site has its own particular set of problems.

In New Zealand three basic methods have been used so far:

- Quick capture, translocate and direct release.
- Capture, hold in aviary, translocate and direct release.
- Capture, hold in an aviary, translocate, hold in a pre-release aviary, and release.

The first two methods are examples of hard release techniques, while the latter is a soft-release technique (Scott and Carpenter 1987).

Some species, such as small insectivores that are difficult to feed, are perhaps better suited to the quick, hard method than to the soft, slower pre-release aviary method (Jansen 1993). However, other ways, such as the right choice of invertebrate cultures, may yet be found to keep "difficult" species in captivity. Early translocations tended

to be by the hard method, but recently we have used the soft method, made possible by better avicultural techniques. (See below.)

Ideal number for a translocation

Successful saddleback populations have been established following releases of between 15 and 200 birds; most releases involved 25-40 birds, introduced to islands smaller than 200 ha (Lovegrove 1992).

Flack's (1974) successful translocations of South Island robins (*Petroica a. australis*) in 1973 comprised releases of just two pairs and an extra bird to each release site. The high quality of the habitat at the release sites was important in the success of Flack's releases.

Handling birds

After capture, small birds should be held in black bags made from light-weight porous cotton. For passerines up to about 100 g we use bags measuring 300 x 200 mm. Larger species obviously need larger bags. A black bag helps minimise stress. It is very important to keep black bags with birds in them out of the sun, because the bags overheat very quickly. We have found that mist-netting parties should consist of two or three people so that someone is always available to take birds to the aviary. Birds often have to be measured to establish their sex and possibly their age, so that a translocation contains an even sex ratio and a mix of ages. To facilitate post-release monitoring, every bird must be individually colour-banded. When a species is being translocated for the first time it is useful to re-weigh a sample of the birds after their spell in the holding aviary as a way of measuring the success of their stay. With saddlebacks, after five days we

found an average weight gain of 2.5%, but some gained as much as 10%.

Holding aviary

As it usually takes several days to catch enough birds for a translocation, an aviary is necessary. An aviary is also necessary to get the birds used to artificial foods such as nectar mixes, invertebrate cultures, diced cheese and cake - foods new to them but necessary to keep them well fed during a translocation.

The size of an aviary depends on the size and number of birds being captured. Our usual aviaries measure about 5 x 3 x 2 m high and are constructed with timber and ½" bird netting. All have an entrance-way measuring 1 x 1 x 2 m with double doors. Part of the aviary is very sheltered with roofing and side walls of plywood, galvanised iron, or heavy-grade plastic sheet. When first released into the aviary, birds often fly straight into the netting and may injure their heads and bills. We have found that white shade cloth inside the netting almost eliminates this problem. It still lets plenty of light in and allows the captive birds to see outside. Black plastic windbreak cloth can be used as temporary internal partitions when necessary.

For translocations of small forest passerines on Cuvier, Little Barrier, Stanley and Kapiti Islands we found this type of aviary satisfactory. It is big enough for translocations of 40-50 birds.

The pre-release aviaries on Kapiti Island were rat-proofed by burying netting under the floor. This precaution is not usually necessary on islands where kiore is the only rat. Before releasing the birds into the aviary we added fresh leaf litter and rotted wood, branches for perches, and greenery to

make the interior as natural as possible. A shallow tray of water big enough for the birds to bathe in is also provided.

Although we have translocated most saddlebacks in batches of up to 50 birds held together, we have held pairs separately to test the benefits of releasing the birds as pairs rather than as groups from a single large aviary (see later). So far we have found that most territorial species live communally with a minimum of conflict for the short time that they are in the aviary.

The males and females of some species have to be kept separately because of male dominance at food sources. We suggest that trials be conducted with such species before translocations to see whether separation is necessary. As a precaution, during translocations of bellbirds (*Anthornis melanura*), a species with male dominance and at food sources (Craig et al. 1981), we kept the sexes separate, although we have not done any trials to see whether both sexes can be held in one aviary. With stitchbirds (*Notiomystis cincta*), another honeyeater with dominance hierarchies at natural food sources, we found that we did not need to separate the sexes.

North Island kokako (*Callaeas cinerea wilsoni*) were handled and held pair by pair, partly because of the very slow capture rate. Kokako adapted well to captivity.

With North Island robins (*Petroica australis longipes*), we had to keep each bird separate. If placed together in a small aviary the birds fought, suffered considerable stress, and sometimes died 12-15 hours after capture. Jansen (1993) also reported problems with keeping robins in captivity, although one bird was held for 21 days.

This is a species where the quick capture and hard release method seems to be preferable.

Some species prefer to roost at night alone and in cavities. In the early saddleback translocations, we provided a darkened corner of the aviary with open perches. For the recent translocations of roost-box-using saddlebacks we added roost boxes to the holding aviaries, mainly to ensure the birds kept using them. Both box-using and non-box-using (control) birds were included in the translocations, and the two groups of birds were kept separately. The box-users were provided with roost boxes, while the non-box-users were given open perches in a darkened corner. In the evening the box-using birds roosted up to an hour earlier than the non-box-users, which fought over roosting sites. Handfuls of dried bracken stuffed around the perches to create secluded places solved this problem. This emphasises how knowledge of a species' requirements can be used to reduce stress.

Feeding in captivity

Most small New Zealand forest birds are omnivorous, even the honeyeaters, and some components of the diet that we have perfected for saddlebacks have been used with species such as bellbird, stitchbird, kokako, whitehead (*Mohoua albicilla*) and robin. The total diet must, however, be modified to suit the species.

The food is given to the birds in straight-edged containers which measure 100 mm across and 30 mm deep. These are suitable for both aviary and translocation boxes. They are heavy enough to stay upright even with birds weighing up to 100 g perched on the rim. We use a "cafeteria" system in the aviaries with

about five removable feeding tins (nails round the outer edges stop them sliding) spaced out along lengths of 150 x 25 mm timber. Several of these lengths of timber are placed in the aviary so that each food type is available at several locations. With this arrangement food can be placed in or removed from the aviary quickly, minimising disturbance at feeding time.

We have found that the birds accept artificial foods more readily when many birds are in the aviary together because they can learn from each other. Thus, it helps to catch as many birds as possible on the first day, to facilitate the copying and learning process.

Foods for captive forest passerines

(1) NECTAR MIX:

1 litre cold water
6 tablespoons Complian
4 tablespoons Farex
1 tablespoon honey
Stir together well. Keeps longer if refrigerated.

(2) JAM MIX:

2 tablespoons fruit jam stirred well into
1 litre of cold water.
Keeps longer if refrigerated.

(3) SUGAR BUNS:

Cream 200 g butter and 1 cup sugar.
Add 3 eggs and beat.
Add 2½ cups flour.
Add 2½ teaspoons baking powder.
Add 1 cup pre-soaked sultanas.
Stir well, spread into a greased baking dish or patty pans.
Bake 30 minutes in moderate oven. Cut when cool. Makes enough for about 20 buns.

(4) DICED MILD CHEESE

(5) CRUMBLED HARD-BOILED EGG YOLKS

- (6) PRE-SOAKED SULTANAS OR RAISINS
- (7) ORANGE QUARTERS, CUT ACROSS THE GRAIN
- (8) INVERTEBRATE CULTURES OF: mealworms (*Tenebrio molitor*) waxmoth larvae (*Galleria mellonella*) blowfly larvae (*Calliphora vicina*) migratory locusts (*Locusta migratoria*)
- (9) NATURAL FRUITS IF AVAILABLE, ROTTED LOGS, LEAF LITTER AND FRESH GREENERY
- (10) PLENTY OF CLEAN FRESH WATER.

Some birds feed in the aviary within half an hour of capture. Saddlebacks always take the invertebrates and locally available forest fruits first, then the orange halves. After a day or so most birds are taking the nectar mixes, buns and other foods. During longer spells in the aviary it is noticeable that the saddlebacks "go off" some foods. It is important to keep the birds in the aviary for a few days after the last capture so that as many as possible are taking the artificial foods before the actual translocation.

For insectivorous species that actively hunt for their prey, it is important to provide a good supply of live invertebrates. For saddlebacks we provide a large sack of fresh leaf litter daily as well as rotted logs and branches. This natural diet is supplemented with cultures of mealworms and waxmoth larvae. Forty saddlebacks (average weight c.75 g) will easily consume 1000 larvae per day. It is better if the invertebrates are fed out as several small feeds per day rather than one big one. Collecting invertebrates from natural sources is not recommended because it is time-consuming and damages the habitat.

We have also added local natural fruits when these are in season. For saddleback and bellbird translocations we have used fruiting branches of kawakawa (*Macropiper excelsum*), karamu (*Coprosma macrocarpa*), mapou (*Myrsine australis*) and five-finger (*Pseudopanax arboreus*). We provided natural fruits at intervals throughout the day to spread the availability of fresh foods. It is usually necessary to refresh the artificial foods two or three times a day.

When birds are in transit a maintenance diet consisting of the two nectar mixes, invertebrate cultures, oranges, sugar buns and water has been very successful.

Translocation

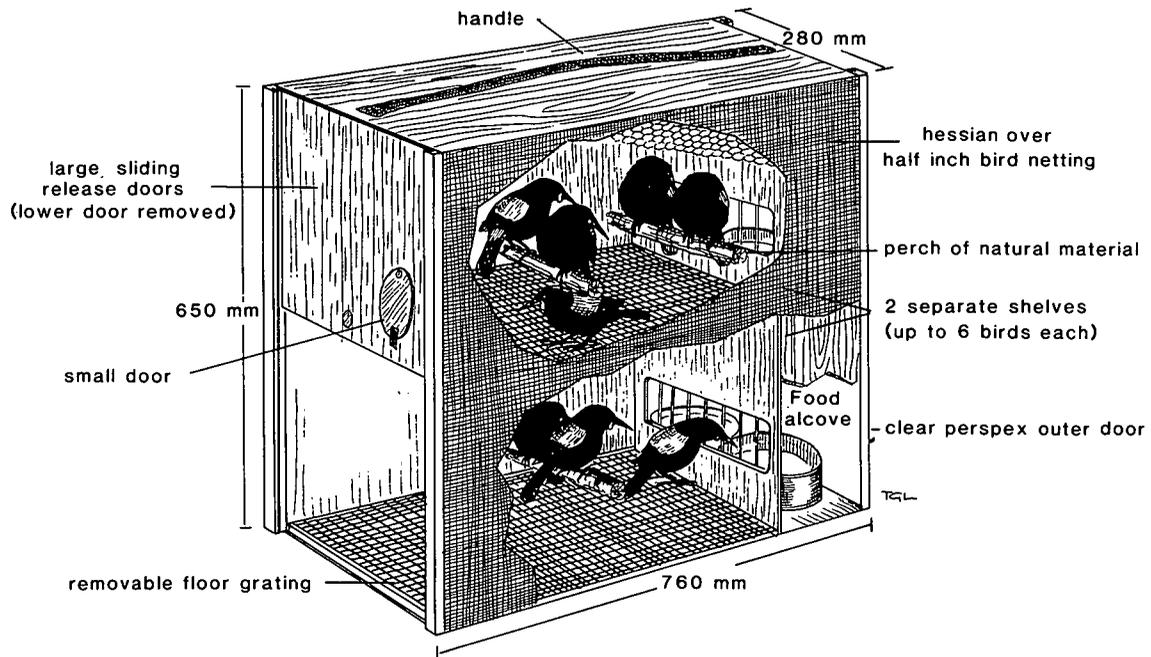
The birds are captured against the walls of the holding aviary with hand nets. After checking their bands off the list, we weigh the birds if necessary and put them in the translocation boxes. As the journey from the aviary to the release point may take 24 hours or more and may involve various forms of transport, the design of the translocation box or carrying crate is very important.

Boxes are constructed of 9 mm plywood, with bird netting covered with hessian on one side to let in plenty of air and light.

It is a difficult compromise to construct a box which protects the birds from excessive noise and vibration and yet allows ventilation and enough light for the birds to feed.

Some features should be common to all translocation boxes. The entry door should be small and placed low on the box, preferably with its lower edge flush with the floor so food can be easily placed inside. A tube of mutton

Figure 1 - Saddleback transfer box



cloth can be added outside the door for extra security. The exit door should be large and take up most of one side of the box, or at least be closer to the top. Perches should be either natural branches or rectangular in cross section with rounded-off corners. They should allow birds adequate headroom and space to walk underneath. The birds should have enough space to hop or flap up to the perch. Floors should be a mesh which will not damage the birds' feet but will allow debris to drop to a cleanable tray below. For a handle, we suggest using a lengthwise strip of synthetic material, which must be long enough to allow the boxes to be passed from person to person but have no protrusions so that the boxes can be stacked.

The saddleback translocation box shown in Figure 1 is, with minor modi-

fications, suitable for many small passerines. It includes a feeding alcove that the birds can reach into to feed and drink. A smaller swinging or sliding door placed low on one side of the release door can be useful for putting the birds into the box, and also for adding food en route.

To translocate kokako (average weight 223 g), we used larger boxes of 0.6 x 0.6 x 0.6 m (see Figure 2). Each is designed to hold just one pair and to fit easily into a helicopter. It has a single perch and the release door is designed so that the birds can be fed en route.

For quick translocations, which do not need a holding period in an aviary and feeding en route, smaller boxes have been used (Flack 1978, Morris 1977).

The robin transfer box shown in Figure 3 is the type used for South Island robins and black robins (Flack 1978,

Figure 2 - Kokako transfer box

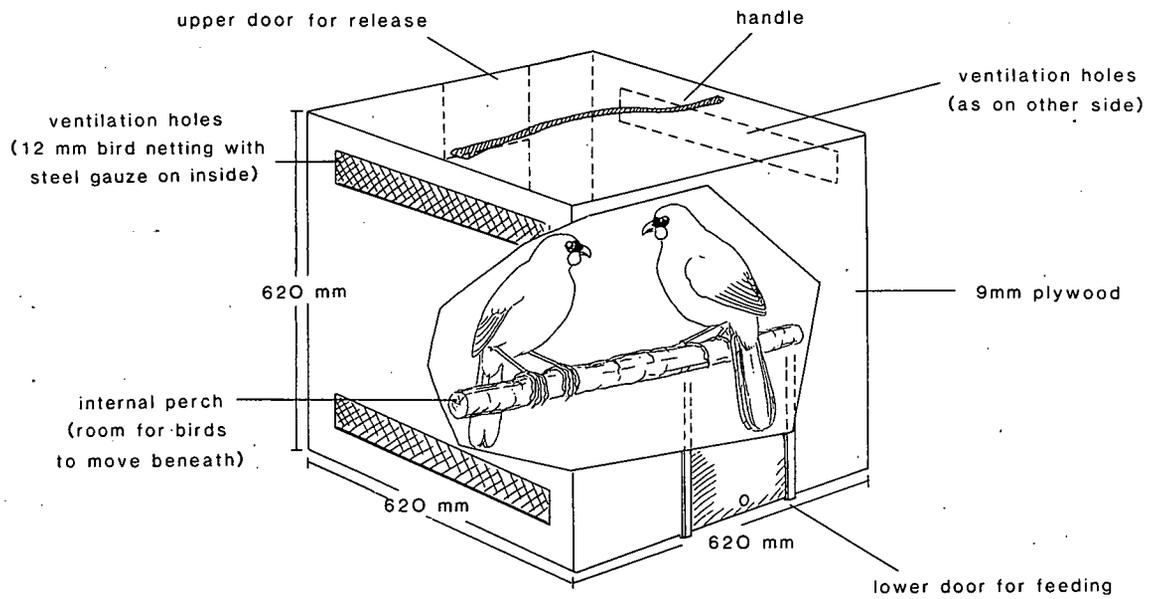
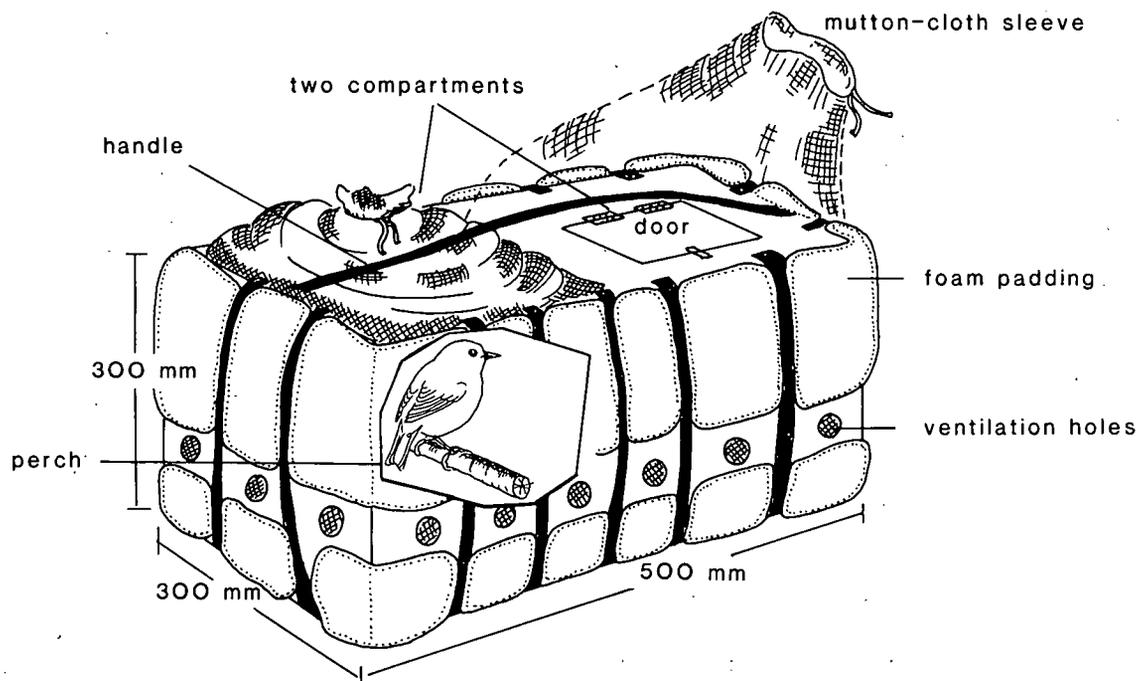


Figure 3 - Robin transfer box



Morris 1977, Butler and Merton 1992), and features sound-proofing and mutton cloth sleeves over the doors. We consider the saddleback transfer box to be a considerable improvement on this design because the doors are placed near the floor and there is provision to feed the birds more easily.

Release

Most releases of forest birds in New Zealand have been by the hard method. Although this has clearly worked successfully in that many new populations have become established, there is scope for carrying out more soft releases. With this method, birds are acclimatised for a period at the release site and provided with some aftercare (e.g. supplementary food) following release. High mortality has been a feature of many saddleback releases during the first few months after release (Lovegrove 1992). On some islands fewer than half of the released birds survived the first year. This experience prompted an experiment to test the benefits of a soft release and also emphasised the importance of having sufficient numbers in the release to maintain some genetic variability and a balanced sex ratio.

The test of hard and soft releases was conducted on Kapiti Island in 1988 (Lovegrove 1992) using North Island saddlebacks. In this experiment a group of 20 birds was released directly (hard release) while 19 others were held in an aviary at the release point for 12 days before release (soft release). There was no significant difference in post-release survival in the two groups.

In a further refinement of the soft release technique, the saddleback release on Kapiti in 1989 consisted of paired and unpaired birds which were

released from aviaries simultaneously (Lovegrove 1992). This approach was tried with the saddleback because this species is strongly site-attached and permanently pair-bonded (Jenkins 1978). This experiment was conducted to test whether paired birds had enhanced survival by being released with their partners.

The 40 birds from Stanley Island included ten pairs (seven known pairs) and three forced pairs created for the experiment), and 20 unpaired birds. The pairs were held in ten separate aviaries spaced about 500 m apart, while the unpaired birds were held together in a centrally-sited large aviary.

After release the paired birds dispersed more quickly than the unpaired birds, which formed a loose flock for several weeks near their release site. Only two of the ten pairs (one known and one forced) remained intact after release, and there was no significant difference in survival of paired and unpaired birds (Lovegrove 1992.).

Discussion

In New Zealand translocations have averted the extinction of several taxa and have greatly reduced the risk of several others becoming extinct (Merton 1975, Moorhouse and Powlesland 1991, Butler and Merton 1992). Since endangered birds usually occur in low numbers and may be difficult to capture, special measures are needed to maximise the survival of birds during the capture, translocation and release phases. With North Island saddlebacks we have made a number of refinements to aviary and transfer box design and diet over the years, and survival of transferees between capture and release is now very high. Aviaries and transfer boxes need to be designed

to meet the requirements of the species being translocated, and a thorough knowledge of the behaviour and ecology of the species is essential if losses are to be kept to a minimum during a translocation.

Post-release monitoring is essential if problems are to be detected. This was emphasised on Kapiti Island where monitoring showed high levels of predation by Norway rats at roosts. As a result of this, measures were taken to improve the quality of the habitat. The provision of roost boxes, and behavioural conditioning of birds to use them, resulted in greatly enhanced survival in subsequent translocations (Lovegrove in press).

For most New Zealand forest birds it is probably not necessary to release large numbers. Flack's (1978) experimental transfers of South Island Robins succeeded with as few as five birds, and most of the successful saddleback transfers have been of 15-40 birds (Lovegrove 1992). The prime factor is that the habitat on the release island is of high quality (i.e. all potential limiting factors identified and either controlled, or preferably removed).

The needs of all species are different, and we suggest that pilot studies should be undertaken to identify potential problems before translocations proceed. Such a study was made before the successful release of Little Barrier-sourced whiteheads on Tiritiri Matangi Island (Allen 1990).

The hard and soft release experiment on Kapiti Island suggests that little was gained by a soft release (Lovegrove 1992). This result is consistent with a review of translocations by Griffith et al. (1989) who show that high quality habitat at the release site is probably the most important prerequisite

regardless of whether the release is hard or soft. Soft releases are labour-intensive, and thus costly, captivity may be stressful for caged wild birds, foods for a maintenance diet may be unsuitable, time consuming or difficult to obtain, and there is increased risk of injury or disease.

Hard releases should be used with most wild-caught forest birds, and the period in captivity should be kept to a minimum to reduce stress. In some cases, e.g. where capture and release points are close together, and where catching is efficient and fast transport is available, birds may be caught and released within a few hours.

This is possibly the best technique for small insectivores which may be difficult to feed. Usually however, translocations are to distant sites, and it may take several days to catch sufficient numbers, so a holding aviary is needed near the capture site. The period in captivity should be used to accustom birds to artificial foods that will sustain them during transport, especially if the distance is great or delays are expected.

Studies elsewhere suggest that soft releases should be used where birds are captive-bred or where they have had a long stay in captivity. These birds usually need some form of training to adjust to life in the wild (Temple 1978, Cade and Jones 1992, Jones et al. 1992). Soft releases may also be appropriate for migratory species or those likely to disperse far from the release point, e.g. weka (MacMillan 1990), although recent work has indicated that the needs of some of these may be complex (Franzreb 1990).

Recommendations

- For a translocation to succeed, the habitat at the release site must be of

high quality and all potential limiting factors controlled or removed.

- Assuming good quality habitat at the release site, it is probably not necessary to release large numbers of individuals. However, possible post-release mortality needs to be taken into account and sufficient numbers need to be released to compensate for this.
- Experimental work with each species should be undertaken to identify possible problems during translocation and release. Behavioural conditioning and habitat manipulation may be necessary to enhance the chances of success. A thorough knowledge of the behaviour and ecology of the species is essential if losses are to be kept to a minimum.
- Aviaries, transfer boxes and captive diets need to be designed to meet the requirements of the species being translocated.
- Wild-caught forest birds should be held for a minimum period and then hard released on arrival at the release site. Soft releases are probably more suitable for captive-reared birds which need time and/or training to adjust to the wild.
- Translocated birds should be monitored after release (especially during the first breeding season) to check success or (if the translocation is unsuccessful) to determine the reasons for failure.

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HANDREARING OF "FREEFALL", A KOKAKO CHICK AT THE OTOROHANGA KIWI HOUSE

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ABSTRACT: 'Freefall', a Mapara kokako chick hatched in December 1992, suffered a broken wing after falling 30 m from its nest. This provided an unexpected chance to hand-rear a kokako chick, the first time that has occurred. The chick's diet and living conditions are described, and a history of its progress for the next three months is outlined.

Introduction

The kokako (*Callaeas cinerea*) is the only species of New Zealand wattlebird still surviving on mainland New Zealand. The North Island subspecies (*C. c. wilsoni*) is classified as endangered, with probably fewer than 2,000 birds remaining throughout its known range, while the South Island subspecies may be extinct.

The North Island subspecies is now being managed under a Department of Conservation Recovery Plan which aims to maintain two large populations of 400 birds, along with several moderately sized populations in well protected forests (Rasch 1991). A number of island populations are also being established, along with a self-sustaining captive population for public display.

Management

"Freefall" was one of three chicks produced by the Mapara pair "Nice" and "Sleazy" during December 1992. When the chicks were about 16 days old, the chicks were banded in the nest. "Freefall" fell from the nest, which was some 30 m above ground, and suffered a broken wing.

The chick arrived at the Otorohanga Kiwi House on the evening of 29 December, where it was taken to the

park's veterinary clinic. Here, a clinical examination revealed a spiral fracture to the right humerus. It was thought that the chick may have also suffered internal injuries during the fall and would probably not survive the night, so it was decided not to immobilize the wing but wait until the morning and review the situation then.

The next morning, the chick was found to be alive and in full voice; after a morning feed of mixed fruits, it was returned to the vet's clinic where the wing was immobilized by applying two bandages around the body. The wings were first folded into their natural position against the bird's body, and we made sure that pressure on the chick's chest did not interfere with its breathing.

Next we faced the problem of the long-term feeding of this chick. Although there was plenty of information on the feeding requirements of naturally reared chicks, this was the first known opportunity to handrear a kokako chick. Macerating foliage and collecting ever-increasing amounts of supplejack, pigeonwood (*Hedycarya racemosa*) and *Coprosma* berries was not practical.

After consulting with several Department of Conservation officers, we adopted the following diet:



Figure 1 - Kokako chick: Day 32.
Photo: Eric Fox.

Diced fruits (as available), bananas, blueberries, apples, pears, oranges, strawberries, sultanas, whole kernel corn, peas, and tofu. When available native fruits were also provided - fuchsia (*Fuchsia excorticata*), wineberry (*Aristotelia racemosa*), pigeonwood, and various types of *Coprosma* berries. Nectar was also provided, one jam based and one Complan based, used on alternative days (see note on diet).

Feeding was done with a pair of plastic coated tweezers; nectar was administered through a plastic syringe. Each day half hourly feeds were given between 0600 and 2100 hours. I took the chick home to feed it outside work hours. The chick was weighed every two hours, before and after feeding. This information was then graphed, as it allowed us to better monitor the chick's progress. No other measurements were taken because of the initial injuries suffered by the chick.

Food consumption varied throughout the handraising stage from as little as

0.4 g to as much as 23.7 g per feed, the average being around 8 g.

For the first week of the handrearing the above diet appeared to meet all the chick's nutritional requirements. But by 7 January (when the chick was about 25 days old), the chick started to show a marked decline in body weight. After further consultation with a zoo vet, Farrell's Extruded Kibble Meal was added to the diet (see note); this was fed dry to the chick. The meal added more fibre and bulk to the diet.

On 8 January our order of invertebrates arrived from Biosupplies in Auckland; it included locusts (*Locusta migratoria*), waxmoth (*Galleria mellonella*) (both moth and larvae), and mealworms (*Tenebrio molitor*). Of the insects fed, waxmoth and larvae were the most readily accepted. Locust nymphs were accepted to a lesser degree, but before the larger adult locust were acceptable, they had first to be dewinged and have their hind legs removed.

Of all the insects, mealworms were the least accepted. Once the insects had been included in the diet, the chick's body weight and general condition showed a marked improvement. By the time the wing bandage was removed (12 January) its weight had reached 168.2 g an increase of 22.1 g since its arrival.

On 13 January, the chick was transferred to a larger brooder - 130 x 80 x 40 cm, and the feeding was reduced to hourly. Also, feeding times were cut back to between 0800 to 1900 hours (so I no longer took the bird home at night). The larger brooder was lined with the branches of fruiting native shrubs, which the chick was soon seen to be testing. The larger brooder also allowed the chick to use its wings and legs more freely.

By 28 January, the chick's body weight stayed between 180-190 g. The chick also fed itself, although it continued to solicit food whenever a staff member was nearby. On 1 February (when about 50 days old), we stopped frequent weighing. Two days later the chick was transferred to a 6 x 2 x 2 m outside aviary; its weight then was 189.5 g.

The insects were also deleted from the diet, and the chick was now eating vegetables and fruit only. Branches of pigeonwood and *Coprosma*, both laden with ripe berries, were added regularly to the aviary, although whole kernel corn still remained the most accepted food item.

On 21 February, the chick (at about 71 days old) was transferred to the blue duck aviary along with another injured juvenile kokako from Rotorua. This aviary measured some 22 x 11 x 3 m and was heavily planted out with a variety of native shrubs and trees.

The diet described above continued to be given daily, although both birds regularly fed on natural vegetation. They were observed eating dandelion flowers, clover and tagasaste (tree lucerne, *Chamaecytisus palmensis*) leaves.

By 11 April 1994, Freefall weighed 207.4 g, with a tarsus length 63 mm.

Freefall's remaining two siblings were killed by a possum on 5 January, and by 22 February, its parents were busily feeding chicks from their second clutch.

Note on diet

NECTAR MIXES:

(1) 3 tablespoons jam (apple/strawberry based), blended with one litre warm water.

(2) 3 tablespoons Complan, 3 tablespoons Nutripet, 1 tablespoon honey, 1 tablespoon sweetened condensed milk, 1 raw egg, all blended with one litre warm water.

FARRELL'S EXTRUDED KIBBLE MEAL:

Crude protein 10%, crude fat 3.0%, crude fibre 5.0%, salt 1.0%.

Ingredients - Whole ground wheat, maize, meal and bone meal and animal fat.

Acknowledgements

My thanks to Warwick Reed for his comments and corrections to a draft copy of this report.

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STOAT CONTROL ON MAUD ISLAND 1982-1993

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ABSTRACT: A stoat was seen on Maud Island in May 1982. This was the first evidence of stoats, and a trapping programme has been in place since. Between May 1982 and August 1983 seven were trapped, all probably from one litter. Between December 1990 and July 1993 a further eight were trapped, shot or found dead; several could have been from a single litter born on the island. The trapping programme was upgraded in 1991/92 to include the mainland, 900 m away and within stoat swimming distance. The rodent-free environment of Maud Island offers an abundant lizard and insect food supply for stoats. This probably contributes to the difficulty of trapping but also reduces the risk of stoats preying on larger bird species such as takahe and kakapo.

Introduction

Maud Island (309 ha) in the Marlborough Sounds had most of its forest cover cleared in the early 1900s for sheep farming. The main forest remnant (15 ha) was fenced off in 1965. Further parts of the island were gifted to the Crown as reserve in 1972, and the remainder was bought and reserved in 1975. Maud Island has high conservation values as it is relatively large and rodent-free. Some rare endemic species have survived on the island - for example, Hamilton's frog (*Leiopelma hamiltoni*) and Stephens Island gecko (*Hoplodactylus stephensi*); others, such as kakapo (*Strigops habroptilus*), takahe (*Porphyrio mantelli*) and Mana giant weta (*Deinacrida rugosa*), have been introduced.

To the west, two mainland peninsulas are the closest points to Maud, 900 and 950 m away (Fig. 1). This is within the known swimming range of stoats.

Trapping programme

In April 1982, saddleback numbers had dropped markedly. (They had only recently been introduced.) In May, played saddleback calls were imitated

in the main bush, and one stoat was attracted.

We began Fenn trapping immediately. A wide variety of baits was used over the following months but no stoat was caught. It wasn't until late December 1982 that the first stoats were caught. Two young (less than 1 year old) males were caught. It seemed likely that the first stoat seen in May 1982 was a female and had since dropped a litter of young.

In July 1983, four young females were trapped; in August, after some changes were introduced to the programme, a young male was caught.

The changes included the use of gloves to set cleaned traps, to reduce human scent. The scent glands of the first animals caught were used as lures in some trap tunnels, and scrub barriers were formed to funnel stoats along tracks and into trap tunnels. These stoats were caught in late winter when food would have been more scarce and this probably also contributed to the improved capture rate. Autopsy of the females confirmed that they were all likely to have been from one litter and

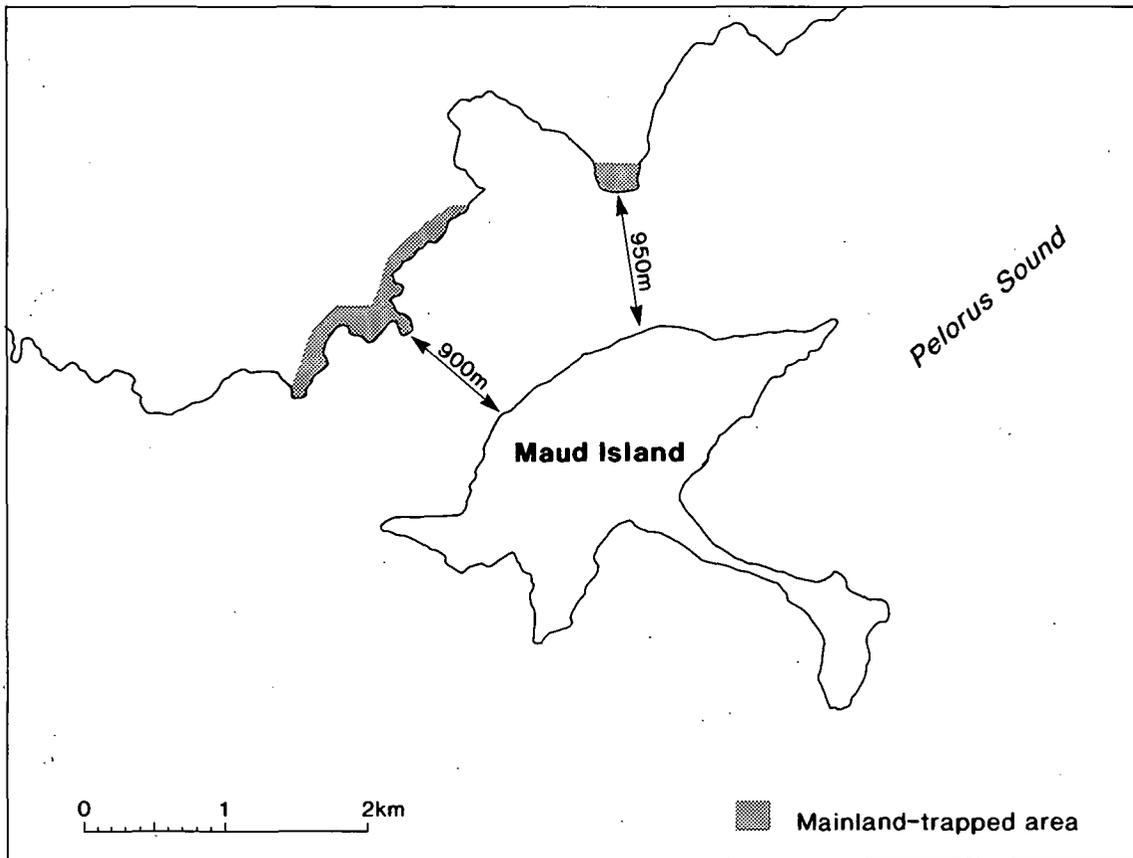


Fig. 1--Maud Island in relation to the mainland.

that a male had not been present on the island when they had been born. None were pregnant and all were less than one year old. The parent female was not caught, and no further stoat sign was seen after the capture of a young male in August 1983. She probably died of old age.

About 80 Fenn traps in wooden tunnels, on most of the tracks and around the coastline, have been maintained as a "precautionary" trapping programme since May 1982.

In late December 1990 a stoat was caught in one of these traps on the peninsula. Another animal was seen in January 1991 but renewed effort failed to gain a quick capture. In mid February 1991 the remains of a stoat were found and it was thought that this was likely to have been the animal seen

previously. Then a few months later further stoat sign (footprints on a beach) was seen and again the number of traps and trapping effort was increased. New baits were tried (including dead mice and deer udders), as well as some Elliott and Edgar live capture traps (King and Edgar 1977). In late August 1991, two weeks after the introduction of the first Edgar traps, one of these traps caught a male. Another stoat (female) was caught in an Edgar trap about a month later.

Further sign (droppings) found in November 1991 confirmed the continued presence of stoats and trapping efforts were again increased. A variety of baits and lures were used, and several different types of Fenn trap tunnels were tried.

Gun vigils, often combined with taped bird calls, squeakers or attractant baits were also carried out. The presence of ground birds like takahe and kakapo restricted opportunities for open trap sets. Because the takahe were nesting, however, and were thus less mobile and because the kakapo were not known to use the peninsula (on the southeastern side of the island), some open Fenn sets were used there. A further stoat was caught in a concealed, boiled Fenn trap, set using gloves, late in December 1991.

The kakapo became more mobile in early January 1992 so no further open sets were used. On 18 January, a stoat was attracted by using a squeaker and shot. A stoat was again called in using a squeaker in early February but it detected human scent and was gone before it could be shot.

Autopsies showed that the four stoats caught between August 1991 and January 1992 were of the same age class. They may have been in a litter born on the island in October 1989, in which case at least seven stoats were present during most of 1990. (See Figure 2 for the family tree of these Maud Island stoats.)

Stoat sign was still being seen but despite the ongoing intensive trapping effort it wasn't until June 1992 that the next stoat was caught. A young female was caught in a double-ended treadle tunnel trap set in a sandpit. No bait had been used. Occasional stoat sign was still being seen through until September 1992 when another young female stoat was caught in an Edgar trap. This trap had been in operation for just over one year and had been baited with hens eggs for most of this time. Stoat sign was still present after this but became very infrequent at

times. On 5 July 1993, a 20-month-old male was caught in a Fenn trap. As before, this trap had been in place and operated in a similar manner for over one year. Fifteen days later a recent stoat dropping was found but no further sign has been seen since April 1994.

Detecting sign

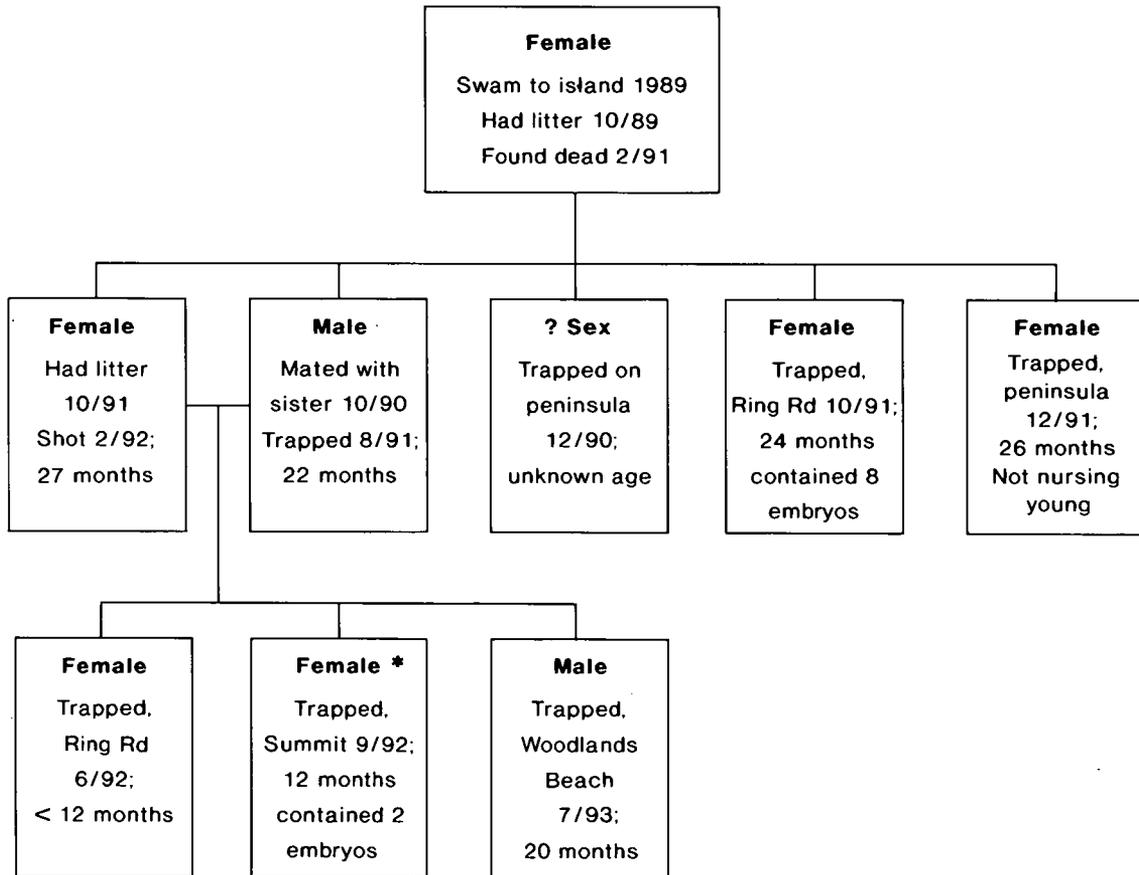
Sign found has mostly been droppings (scats) on or beside tracks. Finding it has relied on the observation skills and experience of those working on the island. Certain sites were used repeatedly and were checked whenever possible. Careful detection of sign not only helps confirm the presence of stoats but can also help with trap site selection.

Sandy beaches have also been useful in revealing stoat footprints. With this in mind, sandpits were placed on all main tracks during early 1992. They are checked whenever possible and have provided interesting information on kakapo and takahe movements as well as stoat movements. Stoats have apparently been attracted to play in these sandpits at times. Because of this, "run-through" double-ended treadle traps were placed in some of the sandpits.

Baits and lures

Many different baits and lures have been used, including mutton, fish, jellimeat, small live birds, rabbit, mice, aniseed, milk powder, deer udder, live guinea pigs, canaries, bantams, weka, skinks, stoat scent glands and droppings, and even mirrors. Currently, whole fresh hen eggs or mussels are most commonly used.

Many of the baits used have not resulted in captures but because of the



* -Mated with unaccounted-for male of previous generation

Fig. 2--Possible family tree of Maud Island stoats, 1989-1993. * = mated with unaccounted-for male of previous generation or swam to Maud Island.

situation (low stoat numbers in a rodent-free environment) this can not be considered a good test of their effectiveness. No one method or bait has been predominantly successful but baits appear to have been most effective during the late winter and spring, and also in December and January when young stoats first leave the den.

The most successful bait used has been fresh hen eggs (see Table 1). It has also been one of the more convenient baits to use. Captures in baited traps tended to occur several days or more after the bait had been placed in the trap. This may have been due to

human scent being left about the trap site at the time of rebaiting. Gloves are worn while setting traps. Many of the captures were made in unbaited traps that were placed in carefully chosen sites.

The diet of stoats on Maud Island, as determined from droppings and some stomach contents, appears to be predominantly skinks or geckos and insects. They also appear to eat some passerines, mostly in the nesting season.

Types of traps

Many different types of trap covers have been used but, as with baits, the

low density of stoats on Maud Island does not offer a fair test of their comparative effectiveness.

Over the period 1982 to 1991 single Fenn traps in 600 mm long wooden tunnels were the only type of trap used. The tunnels had no floors and had either a circular or inverted "V" notched entrance at both ends. From mid 1991, some Elliott and Edgar traps were used in the programme.

Over the summer of 1991/92 all Fenn traps on the island were brought in. The traps were boiled and waxed and new tunnels constructed. Single (600 mm long) and double (900 mm long) wooden trap tunnels were made. Most had circular (60 mm diameter) entrances at both ends and some had a circular entrance at one end and clear or opaque perspex/plastic at the other end.

We removed the chains from the Fenn traps. With floors and lids on the tunnels the traps can not be removed by a partially caught animal. The floors simplify the setting of the traps and help keep them in good operating condition. Recent trials in the Eglinton Valley have shown no difference in the capture rate of Fenn traps in tunnels with floors and in those tunnels without floors (Dilks *et al.* 1992). We also removed the safety catches to prevent them from being left engaged inadvertently.

The double-ended treadle traps that were introduced into the programme in May 1992 were a modification of the traditional weasel trap to allow entry from either end. They were constructed with plywood and were approximately 600 mm long.

Current programme

The current servicing and rebaiting programme was established in early 1993. Eighty traps are maintained in the trapping programme on the island:

47 Fenn traps sets

30 Edgar traps

3 Double-ended treadle traps

The traps have been laid out in five lines. Four are along the main tracks so all traps can be readily checked and rebaited by one person over one day.

The fifth line is along the western shoreline, complementing the mainland trapping (see Fig. 1.) Some additional unbaited traps have been placed around the kakapo pens.

It is planned that the re-waxing of Fenn traps be carried out at least twice a year for all shoreline traps and annually for all other traps.

Invasion prevention

Fortunately for Maud Island, its closest mainland points are two peninsulas. This clearly identifies likely stoat launching sites and makes a preventative trapping programme more likely to be effective. A trapping programme was set up at the mainland sites in November 1991. Stoats are far more easily caught at these mainland sites where they are obviously competing for food with other stoats, and where there is a healthy rat population. Thirty-one trap sets are operated on the mainland. These are all Fenn trap sets, some have double trap tunnels others are single entrance, single trap tunnels. Kill type traps are used here, and captures are frequent. Thirty-four stoats were caught in the first year of operation of the mainland trapping programme and twenty-six over the second year.

TABLE 1: Stoats caught on Maud Island

DATE	AGE	SEX	METHOD	BAIT
Dec '82	< 1 year	M	Fenn in Tunnel	Fish
Dec '82	< 1 year	M	Fenn in Tunnel	Fish
July '83*	< 1 year	F	Fenn in Tunnel	By guinea pig pen
July '83	< 1 year	F	Fenn in Tunnel	No bait/ Barrier
July '83	< 1 year	F	Fenn in Tunnel	Scent gland
July '83	< 1 year	F	Fenn in Tunnel	No bait/ Barrier
Aug '83	< 1 year	M	Fenn in Tunnel	No bait/ Barrier
Dec '90	?	?	Fenn in Tunnel	None
Feb '91	Adult	F	Found dead	Head only
Aug '91	22 months	M	Edgar trap	Egg
Oct '91	24 months	F**	Edgar trap	Egg
Dec '91	26 months	F+	Fenn trap	None - camouflage
Jan '92	27 months	F+	Shot	Squeaker
June '92	<1 year	F	Treadle trap	None
Sept '92	1 year	F++	Edgar trap	Egg
July '93	20 months	M	Double Fenn trap	Egg

* Female first seen May 1982, not caught. No sign after August 1983.

** Contained 8 embryos. Possibly re-absorbing some.

+ No sign of having nursed young.

++ Contained 2 embryos. Possibly re-absorbing.

Conclusions

- Regular stoat trapping of a high quality will be required on Maud Island and close mainland points to maintain the island's high conservation values.
- Good means of detecting the presence of stoats and careful observation on Maud Island are needed to monitor and help manage the stoat problem.
- A variety of capture methods, the reduction of human scent around traps and persistence by trappers all appear to have aided in the capture of stoats on Maud Island.
- The ongoing trapping programme needs to be designed so that it can be easily maintained on a regular basis and have all traps in good working order at all times.
- The number of stoats that have swum to Maud Island between 1982 and 1993 can not be determined as it appears one or more litters may have been born on the island. Certainly each kill does not correlate with a new invasion from the mainland.
- It is now known that kakapo have been on Maud Island for several years while stoats have been present. Predation has not occurred, probably due to the abundant lizard/invertebrate food supply for stoats.

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DISEASE CONSIDERATIONS IN CAPTIVE BREEDING AND TRANSLOCATIONS OF NEW ZEALAND BIRDS

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ABSTRACT: The increased use of captive breeding and translocation as management tools has highlighted the importance of a knowledge of avian disease to species management programmes. Much more work on disease in New Zealand birds needs to be done; research so far indicates that most of the significant avian diseases are closely linked with environmental factors which - if properly identified - can be controlled by careful management. There is also a need for monitoring, surveillance and quarantine in order to reduce the disease risks entailed in shifting birds from one captive institution to another, or from captive management to the wild. More sensitive testing techniques need to be developed, and a national database should be established in order to provide adequate information to all bird management facilities and to link New Zealand's work with international information sources.

Introduction

For the past few decades, translocation has been used with increasing frequency around the world as a management tool to establish, augment or re-establish animal populations. There has already been a long history of this in New Zealand, with conservation of New Zealand birds concentrating on translocation of birds to predator-free islands.

In the last 15 years, there have been more techniques developed to manipulate breeding biology, physiology and behaviour of endangered species. Some of the techniques are egg and nest manipulation, fostering and cross-fostering (Merton 1981, Reed *et al.* 1993), supplementary feeding (James *et al.* 1991, Powlesland and Lloyd 1992), and hand-rearing and captive breeding (Reed 1986). Many of these techniques have saved species from extinction.

The effect of bird transfers on the spread

of disease between mainland and island populations is not often considered. Of 700 translocations in North America, New Zealand and Australia, only an estimated 24% of animals were examined professionally for parasites, disease or injury (Griffith *et al.* 1993).

Many New Zealand and Australian releases were made to areas outside the species' historic range. Not only could birds spread disease to new areas, they could also succumb to new ones following their release. Our increased awareness of avian disease should also make us aware of the greater need for basic health monitoring, improved general hygiene during transfers (including quarantine and health standards in institutions), and for the establishment of a central database for avian disease.

Disease

The concept of 'disease' can refer to various things: characteristic clinical and

pathological findings (e.g., yolk-sac infection) or impaired functions (e.g., nutritional deficiency).

Infection does not always cause disease. The balance between a bird and a potential pathogen (bacteria, protozoa, or a virus) can change for many reasons. These can involve the pathogen itself (e.g. degree of virulence), the host (e.g., age), or habitat (e.g., degree of hydrocarbon pollution); the impact of the infection involves the interaction among all three of these factors (Reece 1989).

Disease agents are often transmitted by insects or higher animals (e.g., malaria, rabies), water (e.g., cholera), or wind (e.g., foot and mouth disease). Milder diseases are passed on by adult animals to younger ones by contact - for example, many gut bacteria or external parasites - or from adults to adults - e.g., venereal organisms. Large parasites such as ticks and other insects, nematodes, and trematodes also cause disease, but the extent depends on how many there are, as well as how and where they hit the host bird.

The susceptibility of a bird to disease is influenced by many factors. These can include its sex, current physiological state (moulting, breeding, etc.), and the general state of its immune system (e.g., stress or nutritional levels, intermittent viral infection). The bird's environment also matters, as this affects the relation between bird and pathogen and the scope for pathogen spread, among other things.

Disease risks in conservation

Disease has its most significant consequences for small populations. Large-scale mortality of local populations has occasionally been reported (Plowright 1988, Cromie *et al.* 1991), but most biologists do not consider disease to be a significant factor in changing population dynamics (Cooper 1989).

It can, however, be a catastrophe for a species that only exists as one population. The best documented example of this was the extinction of the wild population of the black-footed ferret (*Mustela nigripes*) in North America after dogs, coyotes, and raccoons were thought to have infected it with canine distemper (Thorne and Williams 1988).

Disease can also have a large impact on populations not previously exposed to a particular pathogen. Mosquitoes were introduced to Hawaii in 1826 and subsequently acted as an avian malaria vector, playing a major role in the extinction of many native species (Warner 1968). Distribution of many surviving species is now restricted to mosquito-free areas. Malaria and pox both seem to have had a central role in reproductive dysfunction in the Hawaiian crow (*Corvus hawaiiensis*), which now is down to a population of twenty birds (Jenkins *et al.* 1989).

History of avian disease in New Zealand

Is avian disease a problem in New Zealand, as well as overseas? There have been some historical accounts of disease being linked with the death of wild birds. In the 1860s, bellbirds (*Anthornis melanura*) began to decline in the north (Craig and Douglas 1984), and the decline had reached Canterbury by the 1900s. Populations persisted on northern islands and slowly recovered elsewhere; the pattern of decline and the fact of the recovery are strong circumstantial evidence for disease as having been a factor.

It may also have been a factor in declines of weka (*Gallirallus australis*) (Falla *et al.* 1979), brown teal (*Anas aucklandica*) (Hayes and Williams 1982) and stitchbird (*Notiomystis cincta*), but there is no direct evidence of this (Angehr 1984).

Rockhopper penguins (*Eudyptes*

chrysocome) declined on Campbell Island from the 1940s to the 1980s. Dead birds found were uninjured and seemed in good condition. Predation was apparently not a factor. In a 1986/87 disease survey, *Pasteurella multocida* was isolated (de Lisle *et al.* 1990), but it was not possible to determine whether this bacterium had caused disease or contributed to the population decline.

Avian pox was prevalent in the Chatham Island black robins (*Petroica traversi*) on South East Island (Rangatira) during 1982. In 1985/86 pox was still prevalent, food supplies were disrupted by storms, and there was high mortality. Unfortunately, analysis of tissue samples (Tisdall and Merton 1988) showed little evidence of disease, owing to the decomposition of the sample material. (This study highlights the problems of disease surveillance on a remote island.)

Antipodes Island parakeets (*Cyanoramphus unicolor*) were brought into captivity in 1967; some were cross-fostered to New Zealand parakeets or kept in aviaries near them. By 1980, adults were dying of psittacine erythroblastosis, a disease whose etiology is not known but which is present in both wild and captive *Cyanoramphus* species. The disease had been undetected in New Zealand birds until it was found in the relatively susceptible Antipodes Island parakeets (Vickers 1991).

Takahe (*Porphyrio mantelli*), including one bird caught in the Murchison Mountains and other birds at the Te Anau Wildlife Centre, have contracted erysipelas (*Erysipelothrix* spp.). This pathogen is known to occur in pigs and poultry and may have been transferred to Te Anau on the soil of tussocks (Rasch 1993). Haemosiderosis (characterised by excess iron deposits in the tissues, which can cause organs to lose their normal func-

tion) was also identified in a takahe captured in the 1970s.

The Takahe recovery plan (Crouchley 1994) mentions two Mt Bruce takahe dying in 1973 from haemochromatosis associated with *Campylobacter* bacterium, this being the major reason for current restrictions on movement between sites. The association with *Campylobacter* may be coincidental. We now know that haemosiderosis (the term preferred to haemochromatosis) may not have any clinical significance, although it has been linked to infectious disease (Lowenstine and Petrak 1980) and even starvation.

Diseases of New Zealand birds

Most disease occurrences in captive birds result from deficiencies in management, rather than from a sudden 'plague' sweeping through the population. This opinion is borne out by study of 456 autopsies done by MAF and Massey University (Johnstone and Cork 1993), which indicate that most deaths were sporadic and frequently due to infection secondary to other factors (e.g. stress, poor nutrition). Mycotic (fungal) pneumonia, particularly *Aspergillus* sp., is associated with cold, damp conditions and is a common cause of death in most birds, including stitchbirds, blue penguins (*Eudyptula minor*), New Zealand falcons (*Falco novaeseelandiae*), tui (*Prothemadera novaeseelandiae*), harrier hawks (*Circus approximans*), and Chatham Island snipe (*Coenocorypha pusilla*). *Aspergillus* is found everywhere, and infection is generally related to stress levels secondary to a weakened immune system.

Haemosiderosis has been suggested to result from several factors, including bacterial infection (Lowenstine and Petrak 1980). In the past it was considered the cause of death in some species, but this may not necessarily be the case, because the organs may still function normally

with high levels of iron. Iron deposits have been seen in stitchbirds, saddlebacks (*Philesturnus carunculatus*), tui, kokako (*Callaeas cinerea*), New Zealand pigeons (*Hemiphaga novaeseelandiae*), weka, takahe and pukeko (*Porphyrio p. melanotus*).

In black stilts (*Himantopus novaeseelandiae*), heart failure has been seen in juveniles which had been malnourished as chicks. Non-specific cardiac lesions appear to be a common cause of death in black stilts and shore plovers (*Thinornis novaeseelandiae*).

High protein diet is implicated in visceral gout and nephritis, commonly seen in brown kiwi (*Apteryx australis*) and weka. Inguveitis or crop infections have occurred in New Zealand pigeons and New Zealand falcons. Other causes of death included fatty liver (stitchbird, blue duck (*Hymenolaimus malacorhynchus*); toxicosis (kea); yersiniosis (brown kiwi, black stilt, possible Antipodes parakeet; *Clostridium* spp. (New Zealand pigeon), avian pox (New Zealand pigeon, black robin, oystercatcher (*Haematopus* sp.), possibly black stilt); bacterial meningoencephalitis (black stilt); pancreatitis (spur-winged plover (*Vanellus miles novaehollandiae*)); sarcoma (New Zealand pigeon); and parasitic infection (blue duck, red-crowned parakeet).

There have also been reports of large-scale disease-related deaths from renal fluke disease and starvation in blue penguins in Northland (Crockett and Kearns 1975) and from botulism in water fowl (Mertinovich *et al.* 1972, Gardiner 1993).

Factors encouraging avian disease

As said earlier, most disease-related deaths of New Zealand birds seem to be sporadic, and caused by pathogens which have become a clinical problem because of an imbalance between the host, the pathogen and the environment. This

imbalance occurs particularly when birds are under various forms of stress: behavioural, nutritional, physiological, environmental, among others.

The problems are most acute for captive birds maintained in a confined area for breeding or for display. Overcrowding, inadequate diet, and inappropriate social conditions can cause stress; close contact aids transmission of pathogens. Imbalance of these factors can also occur in the wild, but we can rarely observe it. Even in the case of captive birds, more monitoring of stress is needed, not only how to recognise it when it happens but also to understand its role in health and reproduction.

Risks in translocation

There are at least five potential-risk scenarios:

1. An infected animal with no clinical signs of infection is moved into a clean, uninfected local population of that same species. One example in the United States was the release of pen-raised turkeys which could have transferred histomoniasis, avian pox, *Salmonella* spp. and mycoplasmosis to wild turkeys (Schorr *et al.* 1988).
2. An infected animal is moved into an environment containing a clean, uninfected population of a different species. For example, eastern equine encephalitis virus was transmitted to a captive flock of the endangered whooping crane (*Grus americana*). This resulted in a major loss to the breeding programme, as well as a reduction in the options available for release of the cranes in the wild (Dein *et al.* 1986). Carrier birds were probably also responsible for an outbreak of inclusion body disease at another centre.
3. A clean animal is moved into an infected population of the same, or a similar species, where the new animal has

either no or little immunity to the disease. Antipodes Island parakeets died from erythroblastosis transmitted from captive redcrowned parakeets (Vickers 1991).

4. A clean animal is placed with an infected population of a different species. Australian brushtail possums (*Trichosurus vulpecula*) were infected with bovine tuberculosis by domestic cattle (Davidson 1976), and Mauritius pink pigeons (*Columba mayeri*) died from pigeon herpes virus normally resident in the domestic pigeon flock with which they were fostered (Snyder *et al.* 1985).

5. A clean animal is placed into a contaminated environment. Whooping cranes were threatened with infection when placed in wetlands containing fowl cholera (Friend 1987).

Pathogens are most easily passed between animals closely related taxonomically, but certain pathogens may have a very wide range of hosts (e.g., *Chlamydia* spp., rabies, or *Mycobacterium* spp.). Avian influenza can even be spread from humans to ferrets (Bernard *et al.* 1984).

Minimising chances of disease

Where there is the potential for disease to spread, the risk should be assessed. The benefit of moving birds should be balanced against any risk brought about by such moves. Such an assessment would use data on disease incidence, probability of transmission, and its effect on population dynamics. The IUCN (1993b) working group on disease suggests that the 'currency' for the assessment would be 'the probability of extinction and maintenance of genetic diversity' within the species.

Captive birds should be clinically screened before they are moved or released. This would ensure that infected ones are recognised and that only healthy ones are moved further.

At the Wellington Zoo, Dr S Huntress uses a 30-day quarantine period. A cloacal swab and faecal sample are taken on the bird's arrival, and a second faecal sample is taken a week later to allow time for worming before release in the zoo. In some cases a physical examination (weight, clinical signs) can be used to predict the bird's survival chances. Screening for all possible pathogens is prohibitively expensive; it is only practicable to screen for likely ones.

During egg or bird transfers, there are relatively simple techniques that can be used. Eggs and chicks should be clean. Eggs can be wiped with a mild disinfectant to remove excess dirt, but the egg must be thoroughly dried and care must be taken not to abrade the outer membrane. (Egg washing and fumigation are widely used in the poultry industry, but they are of limited value for small numbers of valuable eggs.) Chicks should have their feet and bills washed with mild disinfectant before transfer.

Eggs should be transported in sterile (or at least clean) containers and placed in sterile incubators. All transport containers should be cleaned after each use. If eggs are to be put into nests, contaminated nest litter should be removed, as long as this does not disturb incubating adults.

Some diseases can be transmitted from the hen to the embryo. These include *Salmonella* spp., *E. coli*, and avian encephalomyelitis virus, and signs should be looked for after the chicks have hatched.

Extra precautions should be taken in areas with high conservation value - e.g., Codfish (Whenua Hou) or Little Barrier Island (Hauturu). These would include disinfecting all equipment (for example, transport boxes, weighing bags) before entering the area, or else storing all equipment on site and restricting access. Access may be

limited to people who do not keep domestic poultry or caged birds. Poultry should not be permitted on high conservation value islands.

Preventive medicine is an extremely important and effective way of dealing with disease risks, before the actual disease becomes a problem.

The most effective way to minimise disease transfer would be to set health standards at all captive breeding institutions. Standards would require an autopsy for all dead birds, regular health screening and maintenance of good records. There might also be restrictions against holding domestic poultry and controls on the number of wild birds being moved in and out of the facility.

Standards might vary in accordance with the ultimate destination of birds being held or transferred. For example, transfer from one captive facility to another (for display) would not require as stringent a health standard as would transfer of birds from a captive facility to the wild. Standards would apply equally to all captive breeding facilities, with the objective that transport and release would be carried out in such a way as to prevent exposure to disease, to reduce stress and to lessen the chance of trauma.

Monitoring programmes

Surveillance is essential to disease management. The source and destination sites for translocations should be carefully studied. Transferred birds should also be free of disease (IUCN 1993a). The IUCN working group on monitoring and surveillance of disease (IUCN 1993b) recommended that physical examinations, blood, faecal and tissue samples, vectors and other matter (e.g., feather ectoparasites) be collected for areas or birds of interest.

Samples of blood can be taken from leg, jugular or wing veins with a small-gauge

needle and a capillary tube. Up to 1% of blood volume (e.g., 2 ml per 200 g bird) can be taken safely. Even a 200-300 μ l sample, taken just by pricking a vein, can give worthwhile information. Various diagnostic tests can be used for these samples.

Valuable tests include packed cell volume (PCV), total plasma protein estimates, haemoglobin estimates, white blood cell (WBC) and red blood cell (RBC) counts. Blood smears can also be used for screening for blood parasites, as well as for evidence on past or present exposure to some diseases. Serology is important in captive breeding and in re-introduction programmes to reduce the chance that released birds will introduce disease into free-living populations. But the results can be difficult to interpret.

Microbiological samples can not be screened for ALL potential pathogens, but cultures of *Salmonella* spp., *Yersinia* spp., *Pasteurella* spp. and *Campylobacter* spp. are recommended (Cork 1992). Ova shed from intestinal worms or protozoa (e.g., ascarids, coccidia) can be detected from faecal flotations. Smears from cloacal/choanal/faecal swabs can be stained to look at trends in populations of bacterial species. Dead birds can be autopsied and samples taken for microbiology (e.g., fresh liver), histology (fixed in 10% buffered formalin), and virology or toxicology (frozen at -70°C). It is important that tissues are fixed for histology as soon after death as possible, to minimise post-mortem breakdown. The types of samples and their treatment will depend on the type of disease being surveyed. For example, viruses can be detected with cloacal swabs and are best transported in special viral media to a lab.

Establishing a database

Medical information is essential to our ability to manage small captive and wild

populations successfully. Most of this information is not yet collated and is, hence, generally not accessible to anyone but zoo and institution veterinarians and species managers. Medical information needs to be gathered at every facility; it should meet minimum standards and be in a format suitable for integration into a single database. MEDARKS (phase 4) is a recently developed, IBM-compatible computer program, used at Taronga, Adelaide, and Wellington zoos. MEDARKS includes clinical parasitology, treatment, vaccinations and examinations, anaesthetic and medical reports, inventory reports, and an interface to ARKS (Animal Record Keeping System). Pathology cannot be incorporated yet, but will be soon.

LYNX and SNOWMED (American Veterinary Association, Illinois, USA) have been developed in the United States. They are also IBM-compatible and hold both qualitative and quantitative haematological and biochemical reference data (Bennett *et al.* 1991).

A central database will help widely dispersed facilities communicate efficiently and will also be of help in national monitoring and surveillance. A nation-wide database could also report to an international one co-ordinated by the IUCN (IUCN 1993b).

Data output is only as good as the input. Major limitations of a New Zealand database will be: the amount of disease monitoring that can be carried out, both in the field and in captive breeding institutions, the quality of the samples, the reliability of test results, and the support given to database maintenance by those dealing with avian disease.

The amount of surveillance depends largely on cost and departmental priorities. The lack of sufficiently sensitive tests can also be a problem. For example, a recent

Chlamydia testing resulted in up to 75% false positives being given from 121 faecal samples of native New Zealand birds, owing to the lack of specificity in the technique. Further research is being conducted to establish a sampling and testing protocol for this disease.

Conclusions

Disease risks have to be addressed as early as possible in the planning stage of any captive breeding, translocation or re-introduction programme. This gives time to develop appropriate health monitoring procedures before and after any releases. This reduces the potential risk to both the released and the already-present populations (IUCN 1993a).

Lowered vitality and opportunistic pathogens are the cause of most New Zealand bird disease problems, judging from autopsies on wild and captive birds. Vitality may be lowered because of nutritional problems, the inability to express normal behaviour, or because of social stress (from the bird's own species or from other species). Good hygiene, adequate nutrition, and stress reduction are effective measures in reducing these types of disease.

Health and quarantine standards need to be established and maintained, and there should be closer monitoring of the health of both wild and captive populations of endemic fauna. Disease threats need not necessarily disrupt or restrict management practices, if the risks of disease are carefully balanced against the advantages of manipulating populations. We need to know more about these risks, and this knowledge can be gained through surveillance of disease. A computerised database for collating and disseminating the information is also essential in improving our understanding of disease issues in New Zealand birds.

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TRAINING SEMINAR

A training seminar for DoC staff dealing with health management of wildlife was held at Massey University in 1992. The veterinary faculty at Massey is continuing work on wildlife disease: autopsies and some surveillance (i.e., for *Yersinia* and *Chlamydia*). Two papers which scope disease management issues in captive and wild populations are being prepared. These will address many of the points raised in this article and will provide DoC with recommended options on how to address the issues.

Those interested in contributing to development of disease protocols should contact the authors or the Threatened Species Unit.



SHORT NOTE: A MODIFIED HARNESS DESIGN FOR ATTACHING TRANSMITTERS TO BIRDS

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The backpack transmitter harness design described below is modified from a design published by Clout and Karl (1987) and is - in my experience with kokako - quicker and simpler to fit. Reduced handling time may reduce stress to the bird. The minor variation to the weak-link threading (described below) should prevent problems with either the neck or body loops remaining intact after breakage of the link.

Synthetic braided cord is used. The gauge selected will depend on the transmitter weight and the bird species concerned. A soft, non-abrasive cord is least likely to cause skin damage to the bird. For kokako I have used nylon and polyester braids of 1.5 mm diameter for 4 g radios and 2.5 mm for 10 g radios; no skin damage has been noted on recaptured birds.

1: Cut two lengths, one long enough to pass around the bird's neck with at least 5 cm to spare, and one long enough to pass around the body behind the wings AND loose enough to pull the wings through. Seal their ends with a hot wire or a match. Mark the mid-point of each cord with a coloured pen.

2: Fit the shorter (neck) cord to the front attachment tube and the longer (body) cord to the rear of the attachment tube of the transmitter. Each cord is passed twice through the attachment tube to form loops at either end of the transmitter (Fig. 1).

Now form eyelets at the end of each cord by turning the end 1.5 cm back on itself and binding firmly.

3: To enclose the weak-link thread, take two short lengths of soft plastic tubing. They should fit neatly inside one another; I use an outer tube with 5 mm external and 3 mm internal diameter, and an inner one of 3 mm and 2.2 mm. The outer tubing selected should neatly accommodate the two cord eyelets (Fig. 2). Cut the outer tube to an appropriate length (this depends on the species concerned). Cut the internal tube 6 mm shorter.

4: Slide the two tubes together. Use Vaseline if required. They should be flush at one end.

5: Using cotton thread(s) of the required breaking strain, form a loop through the inner tube. Pass the thread through all four harness end loops. Ease the two loops from one end of the transmitter into the end of the plastic tube until they rest against the inner tube. Draw the thread tight, bringing the two loops at the other end of the transmitter into the tube. Knot the thread securely at the accessible end of the inner tube. If the thread loop breaks, all four ends should fall free.

6: Push the inner tube gently until it is centred within the outer tube. (This will protect the weak-link thread from abrasion.)

7: Take the mid point of each cord and pull until each harness loop is centred. Push the mid point of each cord through a neatly fitting toggle of plastic or aluminium tubing.



FITTING TO THE BIRD

8: Pass the bird through the harness head first. Pull its wings forward, so that the rear loop lies behind the wings and the front loop lies in front of the wings.

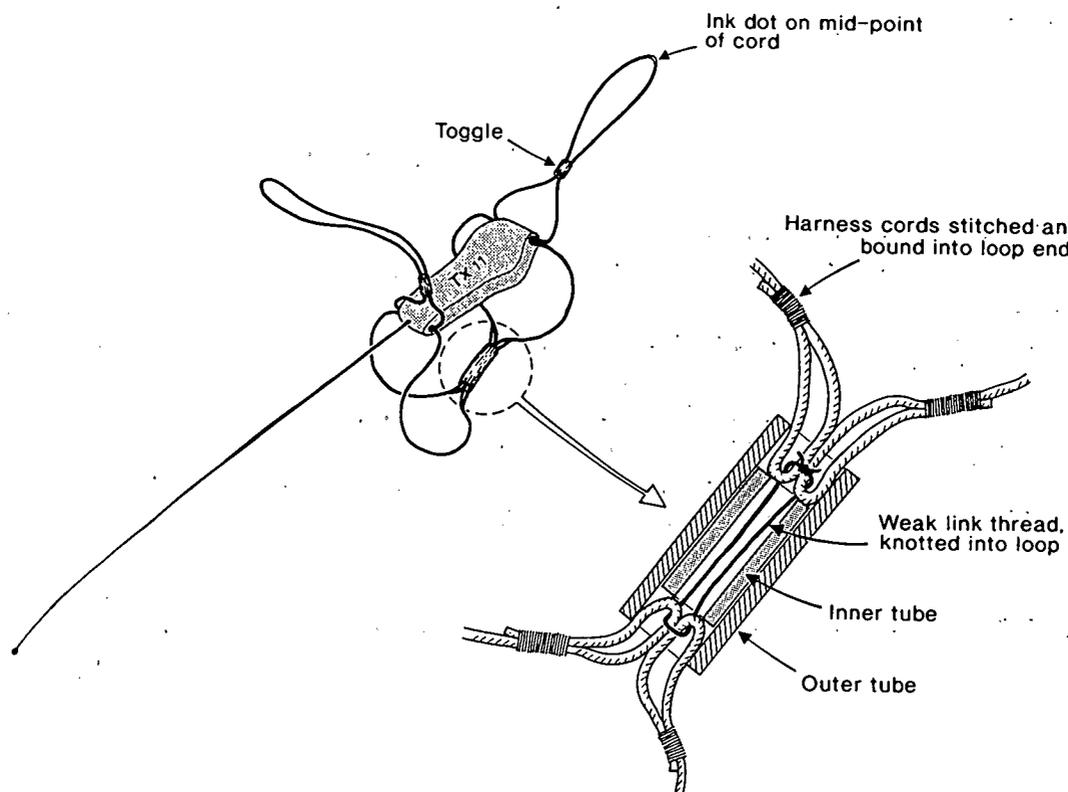
9: Pull the mid point of each cord to draw the loops firmly around the bird. Preen the harness cords under the feathers. Adjust the cords so that the harness will not be tight during activity of the bird. (A pencil should slip below a fitted kokako transmitter, or a large finger below a kereru transmitter.) The weak-link tube should lie along the bird's keel.

10: Crimp and/or glue the toggles against the transmitter body to fix the harness. Melt off excess cord protruding from the toggle. (Nichrome wire heated by a 6V battery is a simple tool for cutting or sealing nylon-cord neatly.)

At this point, the sliding loops should be completely secure. CHECK by pulling the cord ends at the toggle to ensure the loops are immobilised.

Reference

Clout, M.N. and Karl, B.J. 1987. An improved radio transmitter harness and a weak link to prevent snagging. *Journal of Field Ornithology* 58(1): 73-77.



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