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ECOLOGICAL MANAGEMENT is produced by the Threatened Species Unit of the Department of Conservation, P.O. Box 10-420, Wellington, New Zealand. Please send comments and contributions to this address.

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 (editor), Kaye Green, and Don Newman. Mike Aviss provided valuable comment on several of the articles, and Sean Hutton redrew the figures for the mist net article.

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, and we will format material at this end. Please include a hard copy as well.

ERRATUM: Ecological Management Number 2, 'Stoat Control on Maud Island':

p. 41, top paragraph, right column: Last sentence should end, '...but as at April 1994, no stoat sign has been seen.'

p. 45, add 'Acknowledgement: Many thanks to Gideon Climo for the major role he has played in this operation.'

Cover adapted from original by Cathy Jones.

FOREWORD

ECOLOGICAL MANAGEMENT was initiated to provide a medium through which conservation management practioners could share information relating to the development and refinement of management techniques. That we already have enough articles to produce another issue this year suggests that project operators have been waiting for such a publication.

In this, the third issue, we have yet again an interesting selection of articles written by people who are at the cutting edge of conservation management. Advances are reported here in such disparate activities as bat captive management, plant and bird monitoring, and predator management.

Given the significant technical advances which have been made, coupled with the prospect of further progress as new programmes are initiated, I can predict that ECOLOGICAL MANAGEMENT will provide an important vehicle for project operators to share topical information.

Threatened Species Unit staff and the editorial board welcome not only further articles, but also any suggestions you may have to improve this publication.

For those of you who are wondering why this issue of ECOLOGICAL MANAGEMENT is a black-and-white photocopied version, with no photographs, the answer is that in the face of budgetary constraints it was a matter of a 'cheap' version or nothing at all! Our view is that it is preferable to disseminate this sort of information as widely as possible, and we trust that the reduced quality of the publication does not affect its value as a resource. Hopefully we will be able to secure more consistent funding for ECOLOGICAL MANAGEMENT in the future.

Alan Saunders
Manager, Threatened Species Unit

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Dactylanthus taylorii, SURVEY, MONITORING AND MANAGEMENT

Cathy Jones

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ABSTRACT: *Dactylanthus taylorii* is a parasitic plant, severely threatened by possums and a range of other introduced animals. To prevent its extinction it is necessary to find as many plants as possible, to monitor and protect them, using browser control, protective cages, and advocacy.

BACKGROUND INFORMATION

The wood rose, *Dactylanthus taylorii*, is a cryptic (i.e. hard to see and recognise) species of parasitic plant which is attached to tree roots; its flowers grow just above the leaf litter. The plant is brown and lumpy, looking rather like a half-buried rock or tree root. The flowerheads are also brown, generally, although there are occasional more brightly coloured variants. They contain large quantities of nectar which is designed to attract pollinators such as New Zealand's threatened short-tailed bat (*Mystacina tuberculata*).

Unfortunately the nectar also attracts introduced possums (*Trichosurus vulpecula*), which destroy the flowers, often when they are still in bud, and prevent regeneration of the species. Rats, in many instances, probably act as pollinators if bats are absent. They do, however, damage plants, and kiore (*Rattus exulans*) have been found to destroy flowers completely.

At the point where the *Dactylanthus* plant is attached to a tree the host root is distorted forming attractive wooden "roses". To obtain these, whole *Dactylanthus* plants are dug up and destroyed by people and the roses are sold as ornaments/curios.

This is illegal on reserve land, but New Zealand laws do not yet effectively protect threatened plants on private land. So far efforts to have *Dactylanthus* put on to the CITES list, so that exporting of woodroses becomes illegal, have proved unsuccessful.

The range and distribution of *Dactylanthus* has been greatly reduced. Pollen records and sightings before 1970 came from Northland to the central North Island and Wellington to Nelson, but current records are confined to a few thousand plants in a band across the middle of the North Island, including Taranaki, Waikato, the central Volcanic Plateau, East Cape and Hawke's Bay.

MANAGEMENT

Conservation managers, then, have three main problems to deal with:

- Survey: How to find the plant.
- Monitoring: What to record, how and when.
- Protection: How to protect the plant from threats.

Survey Technique

Season

In the past it was said to be very easy to find *Dactylanthus* when it was flowering because of its strong scent. Now, however, possums are so efficient at eating the buds long before they get to open that there is generally no advantage in waiting until the flowering season (March-April) for survey. In fact any plants found earlier in the year can be caged and have a chance of flowering provided that they are protected

prior to the emergence of buds in January-February. Some plants below ground may only become visible when they attempt to flower.

Place

Dactylanthus is not an easy plant to find. Because it is possible to waste large amounts of time searching for it, it is generally more sensible to confine survey to areas where there are old records, or where someone has reported a plant or plants. It is worth contacting loggers, hunters, possum trappers and amateur botanists for information. In some instances it is worthwhile to search for suitable habitat – well-advanced second-growth broadleaved species forest. Common hosts are *Griselinia littoralis* (broadleaf), *Pittosporum eugenioides* (tarata or lemonwood), *Melicytus ramiflorus* (mahoe or whiteywood), and *Pseudopanax crassifolius* (horoeka or lancewood), but there are many others (see list of known hosts in Appendix 1). Now that a connection has been established between short-tailed bats and *Dactylanthus* it may also be productive to search in areas where these bats have been recorded.

Method

Mark off the area to be surveyed on a topo map. Familiarise people doing the survey with live *Dactylanthus* plants, or at least photographs, before starting the job. The aim is to cover as much ground as possible but to eyeball ALL of it, so if you can muster a team of, say, four people it is better than doing it alone.

People should work in a grid pattern, walking about two metres apart, or more if there is very little ground cover. You may wish to use features such as streams, tracks, ridges as reference points and work in sweeps parallel to these, or just work along a bearing and then back on a parallel path at 180 degrees to the original bearing. If there is only a small area of suitable habitat the search pattern can be more random. It is sometimes possible with experience to assess what is likely to be good habitat in a particular area, but an open mind is necessary at all times.

Recording

Plants found should be tagged, counted and recorded on a map and on the forms described in the section on monitoring below. A photographic record may be useful.

Monitoring

***Dactylanthus* Monitoring Form**

John Barkla (DoC, Wanganui Conservancy) has designed a monitoring method and forms which can be used for initial recording as well as for later monitoring of both *Dactylanthus* health and effect of possum control operations. They document sex, state of flowering, seed production and degree of browse. (Contact John for copies of method and form.)

The best time to monitor plants is during flowering (March-April) and when seeds may be present (July). Monitoring should be carried out at least annually.

Threatened Plant Form

For each population a Threatened Plant Site Report Form should be filled out and a copy sent to Peter de Lange, Science and Research Division, at DoC's Auckland Conservancy for inclusion in the national database. (Peter can supply more forms.)

Protection

General

Where possible possum control should be instituted or increased in the area. Experience has shown that *Dactylanthus* flowers are extremely palatable and near-eradication of possums is necessary to prevent browse and allow flowering and seedset. This control may also benefit the host species. Further information is being gathered on the necessary levels of control. Even a single possum may be enough to

destroy all the flower buds in an area in one night.

Caging

At sites where public attention is not going to be drawn to plants, a proportion of each population should be caged. Except on islands where kiore are present, cages should be made of wire with a 50 mm x 50 mm mesh to allow entry by bats or rats and mice for pollination (see Appendix 2).

If a finer mesh is used, pollination may need to be done by hand with a paintbrush. Spraypainting the roll of wire with black or brown paint before use helps camouflage the cages so they are less visible to the public. After initial monitoring it may be discovered that all caged plants in an area are of only one sex and it will be necessary to cage more until some of each gender are secure and pollination can occur.

ADVOCACY

Education of the public about the problems facing *Dactylanthus* and what we are doing about it will be helpful. A few sites in each conservancy could be used for interpretation. This will help to raise the profile of the plant and enlist members of the public for monitoring and watchdog work. A *Dactylanthus* Recovery Plan (Ecroyd 1995) has just been published.

ACKNOWLEDGEMENTS

John Barkla, Wanganui Conservancy; Peter de Lange, DOC Science and Research; Chris Ecroyd, New Zealand Forest Research Institute, Rotorua; John Mason, Waikato Conservancy; and the *Dactylanthus* Recovery Group.

REFERENCES

Cheeseman, T.F. 1914. Illustrations of the New Zealand Flora. John Mackay, Government Printer, Wellington, Volume 2.

Ecroyd, C.E. 1995. Recovery Plan for *Dactylanthus taylorii*. Threatened Species Unit, Department of Conservation, Wellington.

APPENDIX 1.

List of Hosts (from Ecroyd 1994)

Aristotelia serrata		wineberry
Brachyglottis repanda		rangiora
Carpodetus serratus		putaputaweta
Coprosma arborea		mamangi
Coprosma grandifolia		kanono, raurekau
Coprosma sp. aff. *parviflora*		small-leaved coprosma
Coprosma tenuifolia		
Coriaria arborea	(1)	tutu
Geniostoma rupestre var. *ligustrifolium*		hangehange
Griselinia littoralis		broadleaf
Hebe arborea		
Hebe stricta	(2)	koromiko
Hedycarya arborea		pigeonwood
Melicytus ramiflorus		mahoe
Myrsine australis		mapou
Myrsine salicina		toro
Nothofagus sp.	(3)	beech

Pittosporum ellipticum		
Pittosporum eugenioides		lemonwood
Pittosporum ralphii		
Pittosporum tenuifolium		kohuhu
Pseudopanax anomalus		
Pseudopanax arboreus		fivefinger
Pseudopanax colensoi		mountain fivefinger
Pseudopanax crassifolius		lancewood
Pseudopnax edgerleyii		raukawa
Pseudopanax simplex		haumakaroa
Pseudowintera sp	(4)	horopito
Quintinia serrata	(5)	tawheowheo
Schefflera digitata		pate
Streblus heterophyllus		turepo
Weinmannia racemosa		kamahi

New or unverified host record sources:
1. Arthur Little pers. comm.
2. Arthur Little pers. comm.
3. Cheeseman, 1914.
4. Nan Garland pers. comm.
5. Auckland Institute and Museum Herbarium specimen, AK 165701.

APPENDIX 2.

Exclosures for *Dactylanthus*

N.B. Do not use where people are likely to find them.

Materials and Tools:

- Roll of 50 mm x 50 mm x 1.6 mm galvanised mesh - excludes possums only (occasionally Hurricane has 50 x 50 x 2 mm available, for a stronger cage)

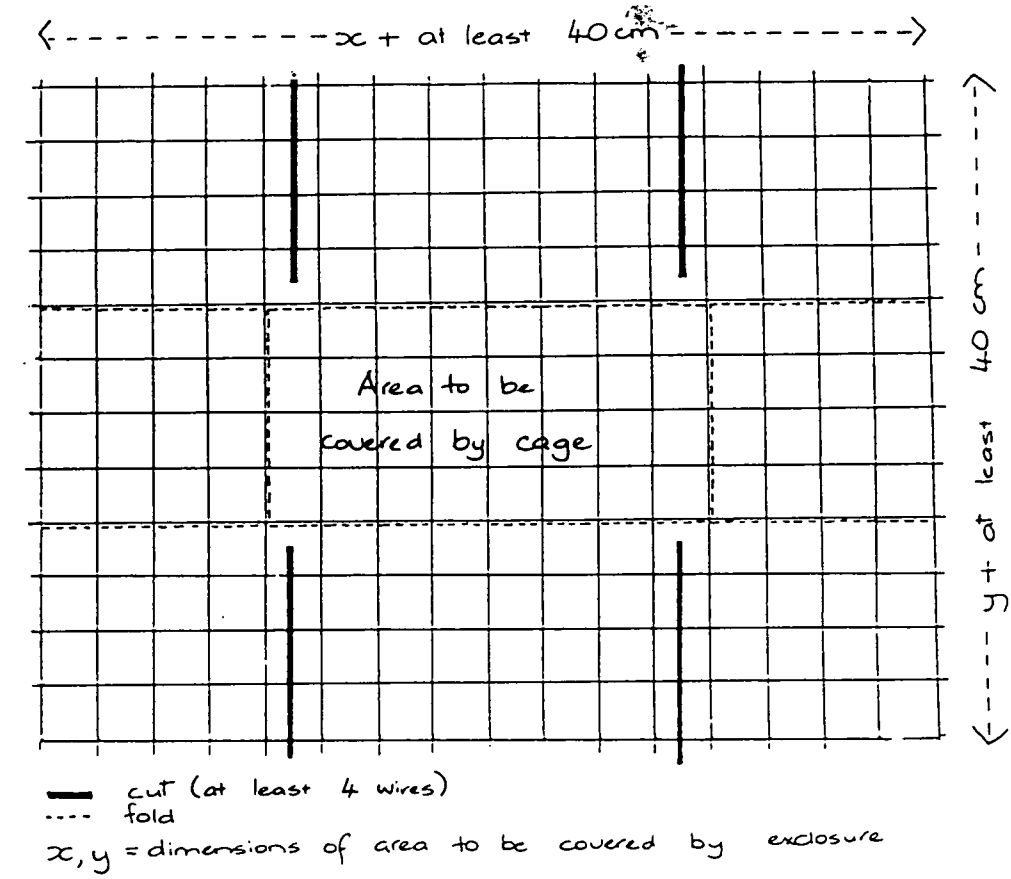
  OR 20 x 20 x 1.6m m galvanised mesh (excludes bats, rats as well as possums)
- 3 mm wire
- Tags
- Wirecutters
- Spray paint (black or brown) for camouflage

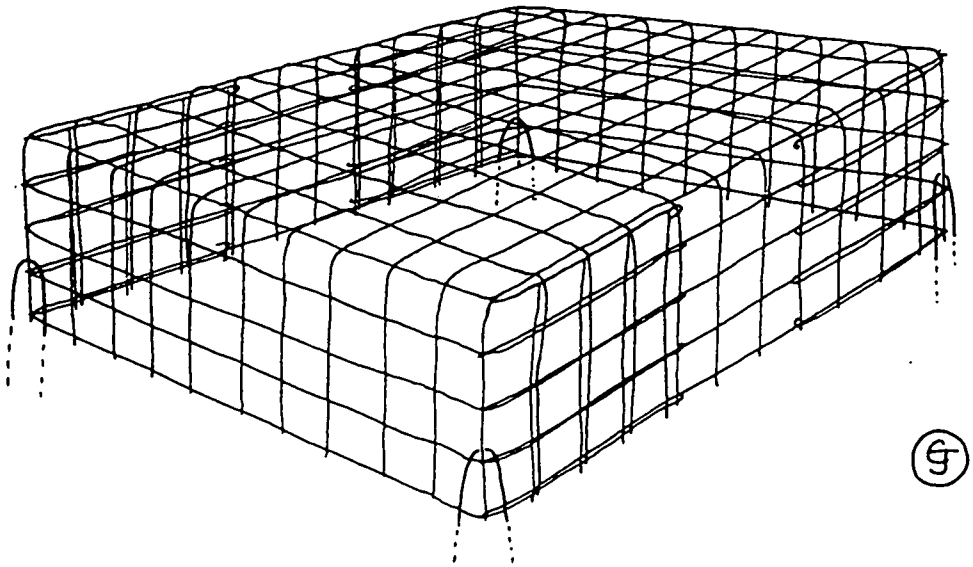
Method:

Spray paint entire roll of wire. Allow to dry. Cut and fold wire as shown in diagram. Fold along dotted lines, overlapping at corners. Bend cut ends to hold cage together. Cut four 60 cm lengths of 3 mm wire, fold in half and use to pin cage into forest floor. Avoid gaps around edges of cage or block them with litter or branches.

N.B. The cage must be high enough above the *Dactylanthus* to prevent possums being able to reach the flowers with their paws.

Fig. 1– Construction of exclosure for protecting Dactylanthus plants from possums.





***ECOLOGICAL MANAGEMENT*, Number 3 (June 1995). Threatened Species Unit, Department of Conservation, PO Box 10-420, Wellington.**

CONTROL OF *Tradescantia* ON STEPHENS ISLAND

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ABSTRACT: *Tradescantia flumenensis* (wandering jew) has become established on the only two sizeable forest remnants left on Stephens Island (Takapourewa) in Cook Strait. The island is a wildlife sanctuary renowned for its population of tuatara and vast numbers of burrowing seabirds. Hand control proved impossible; trials with various herbicides suggest that Grazon used with a penetrant, if handled carefully, could control and eventually eradicate *Tradescantia* with little effect on canopy vegetation.

INTRODUCTION

Stephens Island (Takapourewa) is a 150 hectare Wildlife Sanctuary, situated in Cook Strait. It is renowned for its population of tuatara *Sphenodon punctatus* as well as for a range of other species, including vast numbers of burrowing seabirds (fairy prion *Pachyptila turtur,* sooty and fluttering shearwaters *Puffinus griseus* and *P. gavia*, diving petrel *Pelecanoides urinatrix* and little blue penguin *Eudyptula minor.*

Seven species of gecko and skink are present, including the rare *Hoplodactylus stephensi* as well as an endemic frog species *Leiopelma hamiltoni,* and an endemic weevil *Anagotus stephensi.*

Originally almost totally forested, Stephens Island vegetation has suffered drastic modification in the 100 or so years of human habitation. Currently only c.10 ha of forest remains, much of which is secondary or heavily modified. The remnants are dominated by a low canopy of kohekohe *Dysoxylum spectabile,* taupata *Coprosma repens,* ngaio *Myoporum laetum,* mahoe *Melicytus ramiflorus,* kohuhu *Pittosporum tenuifolium* and nikau *Rhopalostylus sapida.*

Forest regeneration has been identified as a key component in securing the status of many species on Stephens including the striped gecko which is thought to be arboreal (Whitaker, 1991), the ngaio weevil which as far as can be ascertained is totally reliant on ngaio trees, the Hamilton's frog which is currently severely restricted in habitat, and tuatara which occurs in highest densities in forested areas (Butler, 1989).

During the islands occupation by lighthouse keepers, many exotic plant species (c.80) were introduced to Stephens Island for the purposes of human or plant food or as ornamentals, or by accident – for example, in potting mix.

Some of these plants have become, or threaten to become, serious weed problems. By 1989 when the Department of Conservation inherited responsibility for the island and established a permanent caretaker on the island it was faced with a number of ecologically noxious species including wandering Jew *Tradescantia flumenensis*, mignonette or Madeira vine *Anrederia cordifolia*, periwinkle *Vinca major*, and ivy *Hedera helix.*

By far the most serious of these was the presence of *Tradescantia* in the only two sizable forest remnants left on Stephens. Though no records exist of its introduction to the island, *Tradescantia* was probably first introduced as a garden ornamental. It subsequently spread and was well established in the bush remnants by 1974/75. Between 1975 and 1988 the area it covered had trebled in area (G Walls, 1988). By 1988 it occupied large areas (c.1 ha) of Keepers Bush including most of the eastern half, and had spread over the nearby cliff edge. It was

also well established in Ruston Bush, where it covered c.1500 m^2 of ground.

It grew to a height of 1.8 m over branches, buildings or other structures and formed very dense layers over the forest floor. The *Tradescantia* flourished in the relatively open light conditions and high fertility soils, and its ability to vegetatively propagate was probably a great advantage given the level of soil disturbance from tuatara and seabirds on the forest floor.

Growth of the *Tradescantia* was so dense that it became obvious that it was causing serious ecological problems by

- preventing or greatly reducing establishment of seedling tree and other understorey species, and
- greatly impairing access to burrows of tuatara and fairy prion.

As it spread, an increasing number of burrows became blocked from use by tuatara and fairy prion, both very important species in the Stephens Island ecosystem.

The rate of spread of *Tradescantia* and its impact on forest regeneration and faunal communities meant that it threatened the very survival of the best forest remnants on Stephens Island, and many of the fauna species inhabiting them.

METHODS

Because of the importance and possible sensitivity of the native flora and fauna, we examined the possibility of non-chemical control of the weed. In 1990 we attempted to remove *Tradescantia* from fixed areas by physically pulling up the dense mats and stockpiling the material under large black polythene sheets or filling wool bales and then transporting it to an unused concrete shed for composting.

It was hoped this would remove the immediate problem of burrow overgrowth and allow germination of tree seedlings. However, this method proved extremely labour-intensive. The rolling up and composting process left many small pieces of *Tradescantia* behind which could easily re-establish. This was of particular concern on cliff areas where we feared that we could in fact accelerate its spread by such means.

Using this technique we were barely keeping pace with re-establishment and spread of the weed. Because of the urgency of control we decided that use of herbicides needed to be trialled. Four herbicides were chosen for the initial trial, on the basis that they MIGHT prove effective. The Field Centre had quantities of these in stock.

Each was tried in a small area, usually of 10-20 m^2 in a variety of concentrations and with or without an added penetrant. Application was with a 15-l 'Solo' knapsack pressure sprayer. Notes were made of the various concentrations etc. and the area covered. Great care was taken to ensure applications were made with minimal risk to surrounding vegetation: applications were made only during calm periods, and excess 'run-off' of herbicide was avoided when possible.

The trials were made from June to August 1990. They were generally confined to more open former garden areas, rather than in more heavily forested areas to minimize any possible effects on non-target species. General field observations rather than specific measurements of effectiveness were made in each trial area.

RESULTS

Table 1 summarises the results of the 17 trials carried out. Although all showed some effect on *Tradescantia*, only one ('Grazon' by DowElanco) showed a high degree of effectiveness. At lower (recommended) concentrations the addition of a penetrant ('Pulse' by Monsanto) was made. At higher concentrations the effect with or without 'Pulse' was the same, with considerable die-off.

With 'Grazon', some wilting of plants was noticed within two days of application, and within a month the *Tradescantia* appeared dead. Not unexpectedly, some small tree seedlings in the same area were killed, but there was no obvious damage to any of the surrounding vegetation.

FOLLOW-UP WORK

The results of the trials had given us an effective herbicide that with careful use could control and eventually assist to eradicate *Tradescantia,* with apparently little if any threat to canopy vegetation.

We chose for the main control operation a concentration of 5 ml of 'Grazon' and 1.33 ml of 'Pulse' per litre of water (75 ml 'Grazon' and 20 ml 'Pulse' per 15-l knapsack). The bulk of spraying was done during the period August 1990 to July 1991. This spraying effectively removed what we estimated to be c.95% of the *Tradescantia.* We believe 'Grazon' properly applied is close to being 100% effective but the density and depth of the *Tradescantia* patches on Stephens meant the lower layers could not be adequately sprayed without excessive use of herbicides. Once the top layers had died away, the rest was open to respray.

With the bulk of the *Tradescantia* gone by July 1991, we could concentrate more thoroughly on complete coverage, sector by sector. Major resprays occurred in March and April 1992 and since then periodic small-scale spraying has taken place as necessary.

We found that application of 'Grazon' was very effective at killing *Tradescantia* **but only where satisfactory spray coverage was achieved**. If *Tradescantia* was growing amongst very dense ground vegetation, e.g. rank grasses, the effectiveness of the spray was greatly impaired, presumably because total coverage of the plant could not be achieved. ('Grazon' is not effective against grass species.) In such cases we found control of the weed could be greatly improved by first 'removing' the grass cover with a standard solution of 'Roundup', which would then over several weeks expose the *Tradescantia* to full coverage of 'Grazon'.

DISCUSSION

To date, we have not been able to detect any damage to canopy vegetation or to wildlife. However, it has come to our attention that some individual species of tree not found in the sprayed areas of Stephens Island are vulnerable to 'Grazon'. Shannel Courtney of Department of Conservation in Nelson has reported the death of large kaikomako *Pennantia corymbosa* in a area sprayed to control *Tradescantia* in Golden Bay.

While 'Grazon' appears particularly effective against *Tradescantia,* vulnerable non-target species may also be affected and caution should be used in its application. In different vegetation types small scale trials are recommended before wholesale application. It is also recommended that wherever possible, 'Grazon' is not directly sprayed onto trunks or large exposed roots of trees. Accuracy and quantity of spray in any given area may be important factors.

Some fauna species obviously favoured areas of dense *Tradescantia* as it provided a suitable habitat that was effectively safe from predatory tuataras. In particular, the snail *Rhytida stephensensis*, the striped gecko *Hoplodactylus stephensi* and native earthworms (Megascolacidae) were encountered at relatively high densities (cf. other forest areas) when hand-clearing areas of *Tradescantia.* These species may have suffered some habitat loss and displacement of individuals but the overall effect on their total island population appears insignificant.

There appeared to be no obvious seasonal variation in results of spraying *Tradescantia* with 'Grazon'. It seemed to be equally effective throughout the year but this could possibly be explained by the fact that Stephens Island has a mild climate which is conducive to year-round plant growth. We were more restricted as to when spraying could occur by seabird breeding activity. We intentionally avoided spraying in the prion nesting season between October and February to avoid undue damage to burrows or nest contents.

To date, approximately 15 l of 'Grazon' herbicide has been used, and this has virtually eliminated an estimated area of 1.2 ha of vigorously growing *Tradescantia.* Control on Stephens Island has now reached a stage where the remaining patches of *Tradescantia* (generally isolated patches of 1 m^2 or more often less than 0.1 m^2) can be

sprayed using a small (1-l) mist-sprayer or carefully dug up by hand and incinerated.

It is expected that thorough searches will have to be made for several more years to detect any further patches, but total eradication is now a very realistic target. Use of maps, and painted stakes to mark known patches is becoming increasingly important to ensure search coverage is adequate and for relocation of sprayed patches to ensure they are completely killed. This is particularly important on the very steep cliff areas where vegetation is low and dense, and where access is difficult.

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Walls G 1988. Vegetation and Flora of Stephens Island (Takapourewa), with Management suggestions. Unpublished report to the Department of Conservation, Nelson.

Whitaker A H 1991. Research on the striped gecko *Hoplodactylus stephensi* on Maud Island, Pelorus Sound, Marlborough: 6 - 12 March 1991. Unpublished report, Department of Conservation, Nelson. 37p.

TABLE 1. HERBICIDE TRIALS ON Tradescantia, STEPHENS ISLAND, 1990.

CHEMICAL	APPLICATION RATE	PENETRANT	EFFECT
Pennazol SDA	25 g/l	1 ml/l	Outer leaves turned yellow
Roundup	10 ml/l	-	Very little effect. Some wilting of leaves noted.
	20 ml/l	-	
	30 ml/l	-	
	10 ml/l	Variable between 20-50 ml for 15 l	Considerable die-off with blackening of leaves and stems
	20 ml/l		
	30 ml/l		
Escort	8g/15 l	-	Little effect. Some leaf die-off
	16g/15 l	-	
	8g/15 l	20ml/15 l	Some leaf die-off but no plants actually died.
	16g/15 l		
Grazon	3.3ml/l	20ml/15 l	Wilting within 2 days. Plants completely dead within one month.
	5ml/l	20ml/15 l	
	6.7ml/l	-	Wilting within 2 days. Plants completely dead within one month. No differences noted between mixes with or without Pulse
	13.3ml/l		
	6.7ml/l	-	
	13.3ml/l	20ml/15 l	
		20ml/15 l	

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SHORT TERM CAPTIVE MAINTENANCE OF A LONG-TAILED BAT

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ABSTRACT: A male long-tailed bat (*Chalinolobus tuberculatus*) was kept in captivity and then successfully re-introduced to the wild. Handling and feeding methods are described. Captivity appeared to have no adverse effects. The bat was radio-tagged and released; its activity patterns and behaviours were similar to those of other bats which had not been held in captivity.

Many bat species have been kept in captivity overseas: in zoos, as laboratory animals, sick and injured bats, and even as pets. While much has been written on the maintenance of bats in captivity, little seems to be known about rehabilitation of bats into the wild. Each year in the United Kingdom and Australia many bats, orphaned babies and the sick or injured, are cared for, nursed to health and then released. Usually, their fate is unknown.

There is little known about keeping New Zealand long-tailed bats (*Chalinolobus tuberculatus*) in captivity, and nothing known about the rehabilitation or reintroduction to the wild of either of the New Zealand bat species.

Over the last two years there has been a sudden increase in interest in New Zealand bats, with new research projects and much more publicity. Further knowledge of captive maintenance, rehabilitation and reintroduction techniques is required to help conservation programmes.

In December 1993, an adult male long-tailed bat was captured in a mist net in the Eglinton Valley, Fiordland National Park. It was kept in captivity for seven days and then released and radio-tracked for seven days. This was done as part of a study of the short-term effect of banding long-tailed bats (O'Donnell 1994). We were also able to observe how the bat responded to captivity and how it behaved on release.

HOLDING CAGE

On the night of capture the bat was banded and after being held for three hours in a small cloth bag was placed in a small box, 23 x 15 cm, and 17 cm high. The box had a sliding perspex lid. The sides of the box did not fit together very well, so there were several narrow gaps which provided ventilation. The cloth bag was placed in the box to give the bat a hiding place with a familiar smell (it contained several droppings). The box was made of untreated wood and had roughened walls to provide a surface the bat could grip when hanging up. The wooden box mimicked the size of a natural tree-hole roost to some degree, while being small enough to allow easy capture of the animal, with minimal stress. The small space also gave the bat easy access to its water and food. (See Hopkins 1990.)

The bat spent most of the time roosting on the floor of the box either under or inside the bag. He moved easily around on all surfaces except for the lid, but was only occasionally observed hanging from the sides. This behaviour is similar to that observed in captive *Chalinolobus gouldii*, a close Australian relative (L. Lumsden pers. comm.).

TRAINING THE BAT TO EAT

The bat was fed mealworms, the larvae of the beetle *Tenebrio molitor*. They are the most commonly used food for insectivorous bats in

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captivity (Wilson 1988) and are readily available in New Zealand from Biosuppliers (Auckland). Ordinary mealworms are deficient in certain proteins, vitamins and minerals and are not suitable as a long-term food for bats (L. Lumsden pers. comm.). However, the sustenance of mealworms can easily be improved by feeding them on an enriched medium such as protein chicken feed (Wilson 1988), small carnivore mix (available in Australia), fruit (L. Lumsden pers. comm.) or by dusting them with a vitamin mix (Richardson 1985). Enriched mealworms are completely adequate to maintain the health of insectivorous bats (Wilson 1988).

Mealworms are an unfamiliar food to bats. Captive wild caught bats frequently have to be "encouraged" or trained to eat mealworms (Richardson 1985, Wilson 1988). The bat was usually fed in the early evening, a time when wild bats would begin feeding.

It is important that no attempt is made to hand-feed a bat while in torpor, and that it does not enter torpor immediately after feeding (Hopkins 1990). Torpor is a state similar to deep sleep, which enables bats to conserve energy between feeds. It can take at least 15 minutes for a bat to arouse completely from torpor. Only then will it become interested in food. Flying around after feeding provides exercise and helps ensure the bat doesn't become overweight (Richardson 1985).

Our bat was taken out of the box and held loosely in two hands until he had warmed up from a torpid state and started to move around. He was then held firmly (but gently!) in one hand with just his head protruding.

The bat was taught to eat mealworms in the following four stages:

- A decapitated mealworm held in a pair of forceps (or fingers) was presented to the bat. The worm's body fluid was smeared on the bat's lips, and fluid was squeezed into the bat's open mouth.
- Decapitated mealworms were held and allowed to wriggle in front of the bat's face so he snapped and chewed them.
- Whole mealworms were offered by forceps.
- The bat was hand fed close to a bowl of wriggling mealworms and encouraged to feed directly from the bowl. At first he snapped at them but couldn't grip them properly, often sneezing.

On the first two nights water was first offered by holding a soaked cotton bud to the bat's lips, which he licked. Then a bowl was held very close under his mouth, and water was taken directly. The bat drank water every night with his meal.

We aimed to feed the bat ten mealworms per day. Richardson (1985) recommended eight mealworms per day for the 8 g European bat *Pipistrellus pipistrellus* and proportionately more for larger bats. Our bat weighed 10 g on capture. A shallow dish (spice jar lid) of water was placed on the floor of the box to provide the bat with liquid and improve the humidity (Richardson 1985).

The bat took whole mealworms from the hand on the second night. He ate more than we expected, an average of 11-20 mealworms per night. These are usually spread over two or three feeding bouts, with exercise between. The bat weighed 9-10 g before feeding and 11-12 g after feeding. His droppings looked normal and he maintained his weight.

EXERCISE

Each evening the bat was flown for about an hour in a small 4x5x3 m high room, usually after the first feeding bout. The room was lighted. Bats will launch themselves from an open hand and should not be thrown into the air. Food was offered between flights, and the session finished with a flight.

On the first night the bat was flown around the room he avoided large objects without difficulty. However, his wings kept hitting the ceiling as he flew too close. After the first night his manoeuvrability steadily increased, he avoided the ceiling and executed far more complex turns, often flying low in and out of chair legs. The bat appeared to rely on vision rather than echolocation.

REINTRODUCTION TO THE WILD

One day before release a 0.7 g transmitter (Holohil, Canada) was glued with F2 contact adhesive to the bat's back between the shoulder blades. During the exercise sessions before release we noted that the transmitter and its aerial in no observable way impaired the bat's activity and manoeuvrability. The bat was released at the site of his capture and tracked for seven days.

For the first three hours after release he stayed within 1 km of the release site. He was active for the first 2.5 hr and then visited a night roost in the forest for 30 min. We did not check such night roosts. He then took about 1 hr to fly 10.6 km north and back again. During the remaining 3 hr of the night, he was active within 2 km of the release point. He finally settled into a day roost about 2.5 km away with 56 other bats. Twenty-two of these were caught, mainly adult females.

On the second night the bat stayed within 1 km of the day roost, and spent longer periods being inactive in two new night roosts. He settled into a new day roost 0.5 km away from the previous day roost and 2.5 km away from the release point. There were no other bats in this roost. It rained all night, but the bat was active for most of the night.

On the third night it rained again all night and the bat did not leave its roost. On nights four and five it was active again, usually staying within 1.5 km of the second day roost. Periods of activity and rest were similar to previous nights. Because of heavy rain on the sixth night, the bat was only followed for an hour after he emerged. He was active, but close to the roost, and he returned to the solitary roost the next day.

On night seven the bat left the roost on dusk, but was not followed, and was not found again when we returned two weeks later (when the transmitter battery was probably flat). Twelve other bats in the Eglinton Valley were followed via transmitter during summer 1993-94. After release, the captive bat moved similar distances and had similar periods of activity and rest to the other bats.

DISCUSSION

The male long-tailed bat responded well to captivity. He got used to being handled and adapted very quickly to an artificial diet. At the end of the captivity period he was in good health and had maintained weight. On release he did not behave in a significantly different way to other radio-tracked bats.

Some improvements

Although the box was adequate for holding the bat in the short term – and Hopkins (1990) suggests that insectivorous bats can be held indefinitely in calico bags, providing they are removed for feeding and exercise – a more comfortable box would be preferable for prolonged holding. We used bags of a soft material, 12-15 cm wide and 18-20 cm high. They had drawstring or tied tops. (Bats can wriggle through surprisingly small holes.)

There are several overseas designs for holding boxes that have separate roosting and feeding compartments, are lined with mesh for the bats to grip, and have pockets for the bat to crawl into (Richardson 1985, Hopkins 1990).

Although the bat maintained a fairly constant weight, he did eat a surprisingly high number of mealworms per night. *Chalinolobus gouldii* (11-14 g) take 10 mealworms a night (L. Lumsden, pers. comm.). Our bat (9-12 g) consumed up to 20 in one night.

Captive bats can eat until they become too obese to fly (Wilson 1988). Therefore, feeding rate and weight would need to be monitored closely if long-tailed bats were to be kept for longer periods.

If a bat is to be kept for longer than a few days, some people prefer to provide a more varied diet. D. Eason (pers. comm.) kept a female long-tailed bat for three months. He fed her on moths, insects, mealworms, jelly-meat pet food, mince, water, milk, and a Farex, Complan and water mix. She preferred moths and mealworms, but learnt to eat mince from a tray and drink from a bird water feeder.

M. Meads (pers. comm.) kept seven long-tailed bats for over six months. He fed them on moths and 1.5 teaspoons of chopped liver every two nights. Roach and Turbott (1953)

kept a long-tailed bat for three days and fed it on mealworms, milk, minced liver and a praying mantis. Another bat we kept for two nights took a moth from the hand and consumed it rapidly, biting off and discarding the wings.

Significance to conservation management

This study has shown that wild caught long-tailed bats can be successfully held in captivity with relative ease, at least for a short time, and then reintroduced to the wild with no apparent ill effect. This has implications for captive breeding, translocation, reintroduction and rehabilitation to the wild, and bodes well for future conservation management.

ACKNOWLEDGEMENTS

Thank you to Lindy Lumsden for providing copious information on keeping Australian bats, Daryl Eason for his notes, Greg Burrows and Richard Griffiths for invaluable field assistance and to Colin O'Donnell for commenting on this paper and providing the opportunity for me to work on the project.

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MONITORING BREEDING OF OKARITO BROWN KIWI IN WESTLAND NATIONAL PARK 1990 - 1993

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ABSTRACT: Okarito brown kiwi (*Apteryx a. australis*) in Westland National Park were monitored by means of remote video recording. This has increased knowledge of breeding behaviour at the burrow as well as giving some insight into incubation problems. Monitored pairs were near public areas, and it would be valuable to determine if more remote birds behave differently.

INTRODUCTION

Okarito has a long history of human occupation; it was the site of one of the most intensive gold mining operations on the West Coast and timber mills operated until the late 196's. Charles Douglas, an early explorer of South Westland, found Okarito brown kiwi (*Apteryx australis australis*) only between the Okarito and Waiho Rivers. This still represents the geographical limits of the population.

There was speculation during the late 1970s early 1980s that the population of brown kiwi confined to Okarito State Forest 39 were genetically different to other South Island brown kiwi (Roderick 1983). At the time this created quite a controversy as the information was used as part of the rationale to halt the proposed logging of the forest. Logging did not proceed and the forest eventually became part of Westland National Park.

Limited surveys were carried out during the early 1980s, but unfortunately the results are not well documented. Recent renewed interest in kiwi conservation and the need to clarify the taxonomy of kiwi species led to another survey of this population.

Surveys from 1990 to 1992 estimated the population at 60-100 birds. During this period blood samples were collected for mitochondrial DNA and allosome analysis. Results from these surveys showed that some territories occupied during the early 1980s had been vacated, but birds were found in some sites where some had not been recorded previously.

It seems that the population had declined and may still be declining due to a combination of: habitat modification, gin trapping, predation by possums (*Trichosurus vulpecula*), stoats (*Mustela erminea*), rats (*Rattus* sp.) and dogs (*Canis familiaris*). Disease may be another possibility. It was decided to monitor breeding pairs of kiwi to establish breeding routines and, if possible, to determine what factors affect breeding success.

STUDY AREA

The study area is almost entirely within Westland National Park, on the west coast of the South Island, New Zealand. The area (9800 ha) in which the kiwi are found is bounded by the Waiho and Okarito Rivers, the Tasman Sea and State Highway 6. The pairs monitored are all located close to the Okarito Road.

The dominant vegetation communities in the study area as classified by the Native Forests Action Council (1976) are:

Forest: dense rimu (*Dacrydium cupressinum*) terraces; rimu/kamahi (*Weinmannia racemosa*) /quintinia (*Quintinia acutifolia*) on hill country; rimu/kahikatea (*Podocarpus dacrydioides*) on post glacial terraces; dense kahikatea on recent soils and swamps; rimu/silver pine (*Lagarostrobos colensoi*) on wetter terraces; kahikatea/rimu/silver pine on wet peaty soil; hardwoods on coastal cliffs.

Non-forest: scrub on coastal cliffs; grassland with flax (*Phormium tenax*) and gorse (*Ulex europaeus*) on coastal flats; manuka (*Leptospermum scoparium*) with gorse on terraces (induced); pakihi on terraces; *Leptocarpus* sp./flax swamp on lagoon margins; yellow-silver pine (*Lepidothamnus intermedius*) shrubland on terraces; silver pine/'pink pine'(*Halocarpus biforme*)/manuka on terraces.

Aquatic: associated with lakes, streams and lagoons.

INTRODUCED MAMMALS

Red deer (*Cervus elaphus*) have probably been in the study area since the 1950s (King 1990) and are now in moderate numbers (J Reid pers. obs.). Chamois (*Rupicapra rupicapra*) are present in very low numbers (M Thomas pers. comm.). Possums were released at Lake Mapourika between 1925 and 1930 (Pracy 1974) and are widespread and common through the study area. Ship rat (*R. rattus*), rabbit (*Oryctolagus cuniculus*), hare (*Lepus europaeus*), cat (*Felis catus*) and stoat are all known from the study area. Other animals likely to be present are mouse (*Mus musculus*) and Norway rat (*R. norvegicus*). Pigs (*Sus scrofa*) are occasionally present and were first recorded in the late 1980s and dogs enter the study area.

The exact impacts these species are having individually or collectively on kiwi in Okarito is not known, although nationally most kiwi populations are declining.

METHODS

Birds were caught by calling them in at night and hand netting them. Radio transmitters were fitted to the thigh of at least one bird of each pair and the birds were released. Birds were then able to be tracked back to their burrow. Specially trained kiwi tracking dogs were also used to locate unmarked birds in burrows.

During 1990 and 1991 the main focus of kiwi management in the study area was survey and gathering blood samples. Limited visual monitoring was undertaken on one pair (pair A) by checking their main burrow. Surveys and blood sampling continued in 1991 and a slightly more intensive monitoring programme was undertaken on pair A, combined with localised stoat control.

It became obvious that the techniques being used for the monitoring were not going to provide adequate information on the causes of breeding failures. In 1992, we monitored three pairs and stationed a low light intensity camera outside the burrow entrance of one of the pairs. The frequency of burrow visits was increased for the two pairs monitored manually.

EQUIPMENT

The following is a list of equipment used in the monitoring programme.

- Transmitters: DOC standard kiwi transmitters with external aerials, Sirtrak standard kiwi transmitters with internal aerials for adults. For chicks, a Sirtrak transmitter with whip aerial was used.
- TR4 Telonics receiver.
- Sirtrack aerial.
- Low light intensity outdoor camera.
- Infrared light.
- Infrared movement detector.
- Transformer (230V/12V).
- Inverter (12V/230V).
- Video recorder.
- Monitor.
- Logger (date/time/recording time).
- Heavy duty truck batteries.

RESULTS

Pair A

Pair A has had their breeding activity monitored visually since 1990. Their first nest (A1) found at Cemetery Creek in 1990 contained one egg. Manual monitoring of this

pair during 1990 found no conclusive evidence of hatching, the egg had gone, no juvenile was seen in the nest and both adults had deserted the nest at the next visit approximately a fortnight later. It seemed most likely the egg was preyed upon. Discoveries of another burrow in the territory with egg shell fragments in it raised the possibility of this pair double clutching in a season.

In 1991 we found that again one egg disappeared with no conclusive evidence of hatching. The pair was not seen again until much later after the disappearance of the egg.

During the 1992 breeding season both birds were monitored with 16 visits from 30 June to 23 October 1992. No breeding activity was observed during this period.

From 2 to 16 July 1992 the birds were observed together in burrow A3. This burrow had not been used extensively in the past and was not thought to be a breeding burrow although it was located near burrows A1 and A2 that had been used for nesting in previous breeding seasons.

For the remaining observation period 17 August to 23 October 1992 the birds were tracked to several burrows. The male was often found alone using shelters beneath bushes of *Gahnia* spp. and 15 dens (including burrows and surface shelters) were located. The spread of these dens (combined with topographical features) indicates a territory size of approximately 70 - 100 hectares.

Both of the DOC type transmitters fell off within four weeks of being fitted and during part of this period 23 July to 1 August 1992 the female could not be located. Sirtrack standard kiwi transmitters were fitted on 16 August 1992 and these stayed on the birds until removed (female 52 days, male 67 days). The legs of both birds were in good condition when the transmitters were removed.

Pair B

Pair B has a territory in the Deep Creek area (see Figure 3). They were monitored visually by visiting their burrow 13 times from 1 July to 5 October 1992.

The female was removed from burrow B1 on 7 July 1992 and found to be very gravid. B1 is a dug burrow and had many kiwi feathers outside a well worn entrance indicating that it had been used often. On the 8 July 1992 the burrow was found to be abandoned and the birds were not recorded in it again.

During the remaining observation period (8 July to 5 October 1992) both birds remained together in nearby burrow B2. B2 is another dug burrow and also appeared to be well used.

No sign of an egg was seen in either B1 or B2. This could have been due to being handled close to laying. Any birds caught during the breeding season need to be handled with extreme care to reduce the chance of causing the bird to abandoned its nest or lose its egg.

DOC type transmitters fitted to this pair also fell off; the females' within three weeks and the males' within seven weeks. These transmitters were never located. Replacement transmitters were not fitted as both birds remained in B2 and no evidence of breeding was observed.

Pair C

The monitored burrow used by pair C is located in the Jenkins Creek area. Pair C was monitored intensively with video recording equipment. The equipment uses a low light intensity outdoor camera mounted outside the burrow. Movement in front of the burrow is detected by an infrared motion detector and a signal is sent from the detector back to a video recorder to start recording. The period of recording is one minute. An infrared light provides light for night time viewing and is activated by a solar switch at the onset of darkness. The video recorder, logger and power supply are stored 500 metres from the burrow in a waterproof shed. The power supply is from three to four truck batteries run in parallel and rotated at three to four day intervals.

A total of 1759 one-minute observations were recorded from 7 July to 5 November 1992. Monitoring over the entire period was not possible due to failure of the infrared light for one week and the batteries going flat on numerous occasions.

From 6 November 1992 to 5 February 1993 the video recording equipment was operated irregularly for sessions of up to three nights. A further 172 one-minute obser-vations were recorded.

During these periods two successful breeding incubation attempts were observed.

Breeding Attempt 1

The female was caught on 30 June 1992 and a DOC transmitter fitted. On 2 July 1992 the female was tracked to a burrow C1 where the male was incubating one egg. The female is easily recognised by the prominent patch of white feathers on her head.

The burrow is dug under an old stump and is approximately 1.5 metres deep and slopes slightly downwards from the entrance. The nest is in the rear of the burrow and consists of a mound of dry leaf litter and kiwi feathers.

On 6 July 1992 the video equipment was set up outside the burrow and the burrow inspected. Recording began on 7 July 1992. The burrow was inspected three other times: 16 July 1992, 22 July 1992 (when the infrared light was replaced) and 12 August 1992. When the burrow was inspected the male was always incubating and the female was sitting very close to the entrance. Both birds always sat very still and sometimes made occasional grunting sounds to each other.

Incubation was shared by both birds with the male incubating from after midnight through to darkness the following evening. The female would then take over until the return of the male. The female would return at daylight and spend the day in the burrow with the male. The female was seen to leave the burrow three times and not return until the following evening.

Possums were recorded coming to the burrow six times: twice a possum looked into the burrow then moved off; twice a kiwi came out of the burrow and the possum moved off and the other two times the kiwi chased the possum away. Visits by a possum were made only on dry nights without any rain and each time one of the kiwi pair was in the burrow.

The adult birds started leaving the burrow unattended for extended periods of up to 5 hours from 1 September 1992. On the 6 September 1992 a chick was recorded coming out of the burrow and based on the change in the activities of the adults at the burrow we estimated the chick to be less than a week old when first seen and probably hatched on 1 September 1992, 61 days after we first found the nest. The chicks first few excursions outside the burrow were helped by the male nudging it with his beak. Both the male and female were seen with the chick outside the burrow entrance. The chick stayed very close to the burrow until 9 September 1992 when it left the burrow for 29 minutes. After this initial period of staying near to the burrow the chick started staying away for periods of up to seven hours. On 9 September 1992 the pair copulated outside the burrow entrance. On 16 September 1992 unsuccessful attempts were made to catch the chick to attach a transmitter. Two people waited outside the burrow with handnets and a zenoscope but when disturbed the chick would run quickly back into the burrow. From the 19 September 1992 to 5 February 1993 the chick didn't normally return to the burrow before daylight and when it did visits were usually short. The chick was often seen arriving and leaving the burrow during the day.

At 1645 hours on 28 September 1992 the chick was caught and measured (bill length 43.50 mm, weight 220 g). It had dark legs and claws and a pale bill.

Feathers on the back just forward of the wings were cut to clear an area to attach a Sirtrack single stage chick transmitter. The transmitter was glued to the feather bases with Locktite 401 and the chick was returned to the burrow. The transmitter was tracked on 2 October 1992 and was found to have fallen off 300 metres from the burrow. We had experienced difficulty removing the feathers and in the end a generous layer of feathers remained and it is likely this, along with not enough glue being applied, contributed to the transmitter falling off prematurely. We decided not to refit the transmitter as the chick was still regularly

being seen on the video tape, and we didn't want to remove the chick from the burrow as we wanted to minimise disturbance at the burrow.

On 8 October 1992 dog tracks were seen on the muddy path to the weather proof shed and also following the cables from the shed to the kiwi burrow. The dog didn't approach the kiwi burrow (i.e. not recorded on video) and it returned from the direction it came from. The burrow was entered once by a possum on 14 October 1992 when both kiwi were absent; it is not known whether an egg was present at the time. The only other animals seen on the video tape were South Island robins, grey warblers, tomtits, a chaffinch and redpolls. Robins and grey warblers gathered kiwi feathers outside the burrow on several occasions, possibly for nest building. Grey warblers would also enter the burrow to collect feathers.

A distinct change in the activity patterns of the pair was recorded on 16 October 1992 similar to patterns observed in the first breeding attempt.

Second Breeding Attempt

During this breeding attempt the video monitor was operated less regularly because we had not expected the birds to renest, we had other commitments, and the truck batteries had deteriorated to a state where they were not good enough to run the monitoring equipment continuously.

The video monitor was operated for 29 days from 16 October to 5 November 1992, then from 7 December to 9 December 1992, 21 December to 23 December 1992, 12 January to 15 January 1993 and 2 February to 5 February 1993.

The lens cap of the camera had to be put on when the power was off for long periods to prevent the iris in the camera from burning out. Nest inspections usually coincided with turning on or off the video gear and in total 10 visual inspections were made.

Three inspections of the burrow were made between 6 November to 16 November 1992. The male was always sitting on the nest with the female sitting very close to the entrance. The first chick was seen on all of these visits, twice it was sitting with the male and once with the female. The presence of an egg could not be confirmed until 1 December 1992 when the male stood up off the nest. The first chick was returning on an irregular basis and was not always seen during the later inspections.

Possums were recorded coming to the burrow eight times during the second incubation. Four times a possum looked into the burrow and moved away, once a kiwi came out of the burrow and a possum moved off, and the other three times the kiwi physically chased the possum away. Visits by a possum were again made on dry nights and on all visits one of the pair of kiwi were present in the burrow.

Another chick was seen during an inspection on 12 January 1993, the first chick was also present with both adults. The second chick was later recorded on the video and was quite active and may have been up to two weeks old when first seen. If it hatched on 30 December 1992 the incubation period was approximately 75 days. Both chicks made irregular visits to the burrow from 12 January to 15 January 1993 and the male spent a day in another burrow during this period. On 15 January 1993 when the lens cap was put back on the camera the younger chick was in the burrow with both adults.

The burrow was checked again on 2 February 1993 and only the adults were present. The burrow was monitored from 2 February to 5 February 1993 and the chicks were not recorded and the female was cleaning out the burrow. On 4 February 1993 both adults left the burrow and didn't return. The burrow was inspected on the 5 February 1993 and it was found to be empty with the nesting material cleaned out.

DISCUSSION AND RECOMMENDATIONS

The use of remote video-recording equipment has greatly increased our knowledge of breeding behaviour at the burrow; it has also given a small insight into the problems kiwi face in trying to incubate eggs. Possums regularly visit and will enter a kiwi burrow during incubation but it appears that adult

kiwi are capable of defending their burrows. The possums may have been interested in the burrow, the egg or the adult, we don't know what the result would have been if the possum had entered the burrow and found an unattended egg.

This information raises as many, if not more, questions than the ones it has answered. Crucial gaps in our knowledge are in the area of chick survival: two chicks were hatched from one nest; one survived for at least four months and the other for several weeks, but beyond this period we have no knowledge of their fate. Unfortunately neither was marked and so we will have difficulty determining if they survived long enough to be recruited into the breeding population.

Of the three pairs monitored, the two pairs checked visually received fewer visits than desired but we are confident that neither of these pairs hatched any chicks. All three pairs were near public roads and it would be valuable to know if more remote birds behave differently.

If kiwi are to be managed long-term in Westland National Park then some, if not all, of these questions need addressing. With this in mind it is recommended that the video monitoring continue for at least two further years and up to ten radio - tagged pairs are monitored by visual inspection of burrows in the following breeding seasons. Some of the ten pairs should have more remote territories than those monitored to date.

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APPENDIX

Pair A - Cemetery Creek

30/06/92

Male and female captured: male R - 28242 (banded 1979) weight 2.10 kg, good plumage, medium condition and a leg-attached transmitter attached with baby identification bands; female R - 34151 (banded 1990) weight 2.71 kilograms, good plumage, good condition, possibly just gravid and a leg-attached transmitter fitted.

Pair B - Deep Creek

01.07.92

Male caught, R - 34156 (banded 1991), good condition (weight 2.00 kg) and a DOC type transmitter fitted. Its toenails were black in contrast to other birds which are pale.

07.07.92

Female caught, R - 34155 (banded 1991), good condition (weight 2.95 kg), very gravid (possibly 4 - 5 days from laying) and a DOC type transmitter fitted.

ECOLOGICAL MANAGEMENT, Number 3 (June 1995). Threatened Species Unit, Department of Conservation, PO Box 10-420, Wellington.

MIST NETTING TECHNIQUES

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ABSTRACT: This report outlines methods we have used to erect mist-net rigs in forests and in more open areas. Using this rig, mist nets can readily be erected in the forest canopy up to 30 m high, forming a curtain of mist nets from the forest floor to the canopy. In beech forest, nets can easily be erected by two experienced people within one hour without tree climbing equipment. Using the same attachment method and telescopic aluminium poles (5 or 6 m high), nets can quickly be erected.

FOREST RIG

This rig was developed from the methods outlined by Whitaker (1972) and Humphrey *et al.* (1968), who set up permanent structures at fixed sites to sample birds of the forest community at regular intervals. Tree climbing equipment was required. Other methods for erecting mist net rigs have been published. Two aerial rigs (Greenlaw & Swinebroad 1967, DeJonghe & Comuet 1983) used modified mist nets which were restrung to form a tall narrow rig; the pocket strings were removed and replaced at right angles.

None of these were suitable for our requirements. We needed a method whereby rigs could be moved about the forest and quickly erected to catch territorial pairs of yellowheads (*Mohoua ochrocephala*). We targeted specific birds and often erected nets, caught the birds and removed the rig within two or three hours. These net rigs have also been used extensively in studies of yellow-crowned kakariki (*Cyanoramphus auriceps*) and long-tailed bat (*Chalinolobus tuberculatus*).

Equipment

(see Appendix I)

A sporting catapult.

A fishing reel with braided fly fishing dacron backing line.

Round 2 ounce lead fishing weights.

A roll of light braided nylon cord to be pulled over the tree with the fishing nylon. This is used to pull over the top rope and can be used for the cradle once the rig is erected.

A roll of braided or twisted rope for the top rope of the net rig.

Two lengths of braided nylon cord. These are for endless loops at either end of the rig – the nets are attached to these. Each length needs to be at least twice the height of the proposed rig.

Four karabinas to be used as "pulleys" for the end loops.

Various spare lengths of cord.

Curtain rings for attaching mist nets.

Mist nets.

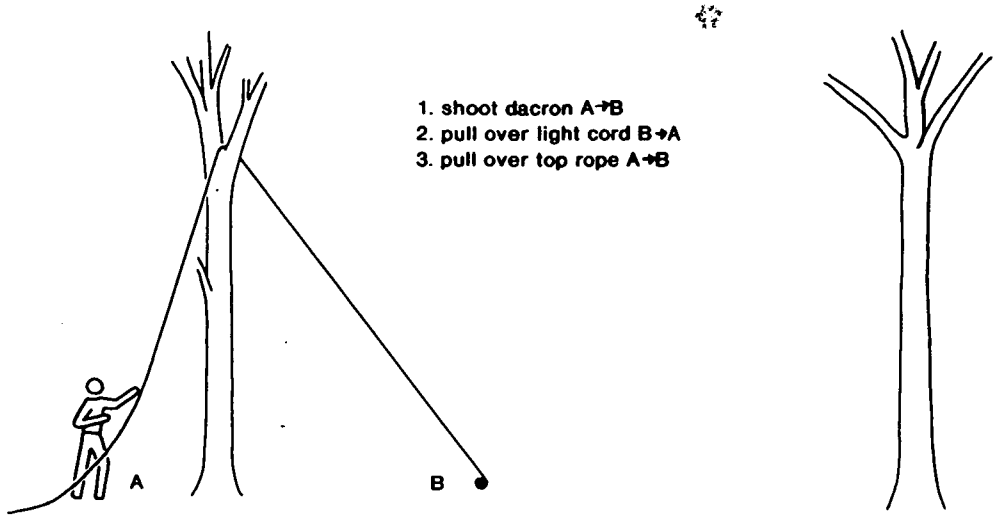
Erecting the Rig

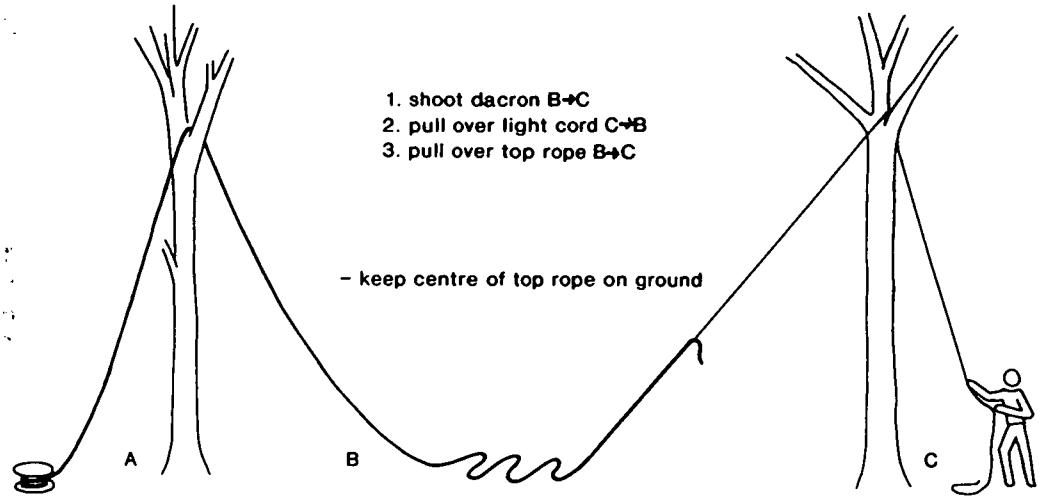
The prerequisites for a good mist net site are a suitable gap in the forest, longer than the nets that are to be used. A large canopy, or preferably emergent tree is required at each end of the site.

The steps to erect a rig are as follows:

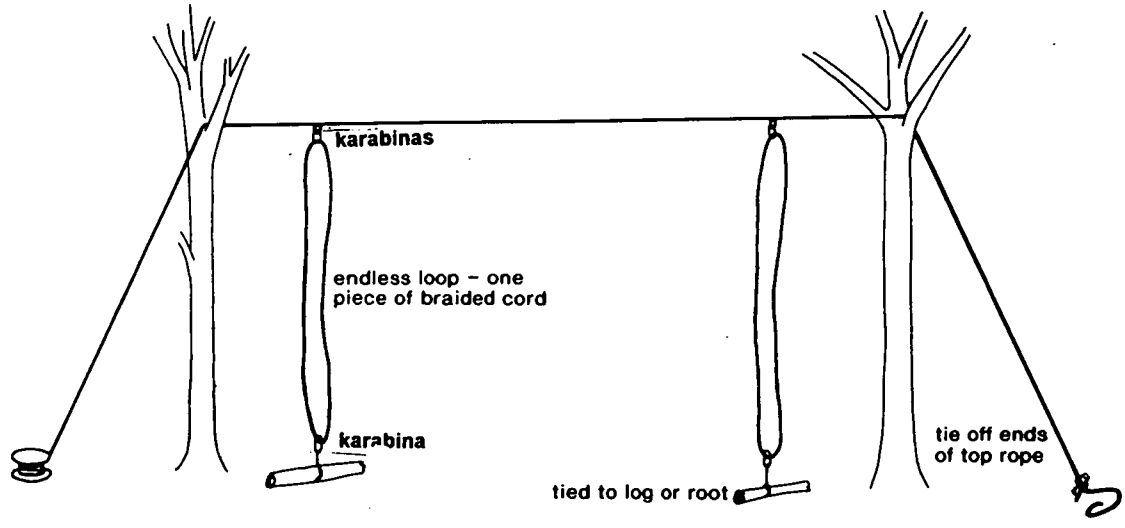
(1) For each tree, at either end of the clearing fire a light nylon line over a strong branch of the tree using a catapult to propel a lead weight with the fishing line attached. A helper is needed to stand behind the shooter holding the fishing reel angled in the direction aimed. When the line is positioned correctly the weight is removed and a light nylon cord is attached and pulled up and over the tree. This is then used to pull over

Fig. 1 – Stages in erecting a mist net rig. Top to bottom: 1a, 1b, 1c.





Tie loops in top rope at just over mist net length, attach a **karabina** to each loop and braided cordend loop. Pull top rope into position.



the heavier rope that is used for the top rope of the net rig.

This procedure is repeated, shooting from the centre of the site, out over the second tree. When the top rope is pulled over this second tree ensure that the centre of the top rope is kept down at ground level; run it through a karabina attached to a log or root (Figure 1).

This procedure can be carried out by one person, the fishing reel needs to be attached to a pole or jammed in a nearby tree and angled in the appropriate direction.

Positioning the top rope is the most time consuming part of the procedure. It may take many shots to position the ends of the net but with practice this can be accomplished in one or two attempts. When poor shooting or tangles put the weight and braided dacron line in the wrong place in a tree, it is best to let the weight fall to the ground, cut it off and wind the dacron line back without the weight.

Attempting to pull the weight back through a tree almost invariably results in it becoming tangled in branches. When rewinding the dacron onto the fishing reel keep the line under light tension, run it through your helper's fingers, as this makes it unreel smoothly when the lead weight is fired. This is very important when shooting over high trees. Initially aim to have the top rope over a solid limb but we have found that if fired over the top of a tree and many twiggy branches it was just as secure as over a large limb.

WARNING – If the dacron is rewound loosely on the reel; when the weight is fired the dacron sometimes snags and the weight can shoot straight back at the same speed as it left the catapult!.

Likewise, if the weight and dacron are tangled in a tree you need to pull hard to free or break it. Stand behind a tree when doing this – the weight returns at speed and usually embeds itself deep in the ground.

(2) While the top rope is on the ground tie two loops in it, separated by a distance slightly more (60 cm) than the length of the mist nets. We leave these loops tied permanently in our top ropes as all nets we use are of the same length (Figure 1c).

(3) Clip a karabina into each of the loops and thread a length of braided cord through each karabina; these are the "end loops". Make sure both ends of this cord remain on the ground (tie to a handy tree).

With a person at each end of the top rope hoist it up into position. When the rope is tight the position of the end loops can be adjusted by pulling one end of the top rope and loosening the other. When the rig is in a satisfactory position pull the top rope as tight as possible and tie off both ends.

Initially we used pulleys at the top and bottom end of the endless loops but found that they often caused problems. Karabinas have several advantages: they have no moving parts and are strong and not worn by the rope running through them. They can be easily clipped on and off rope loops at top and bottom without having to undo knots. This can prove extremely useful if you need to move the bottom ends of the net (to get it away from branches higher up because the wind has changed) as you can just unclip the attachment point and clip it onto another.

(4) Directly below the two karabinas on the top rope, attach the other two karabinas to the ground. We do this either by tying them to a conveniently placed tree root or by carrying a heavy log into position (this is preferable as the ends of the net can more easily be moved).

Now thread the end loops through the lower karabina and tie it off as tight as possible to form an endless loop. One piece of cord is preferable for end loops: do not cut off the excess but bundle up any excess cord and attach this to the knot so it is out of the way. If at all possible do not have a join in the endless loop, but if two pieces are joined make sure the joining knot will pass easily through the karabinas.

(5) Tidy up. Any vegetation close to or overhanging the nets needs to be removed. For dead branches we shoot a line over them using the catapult and pull up a heavy cord – the branch is then broken off by pulling on

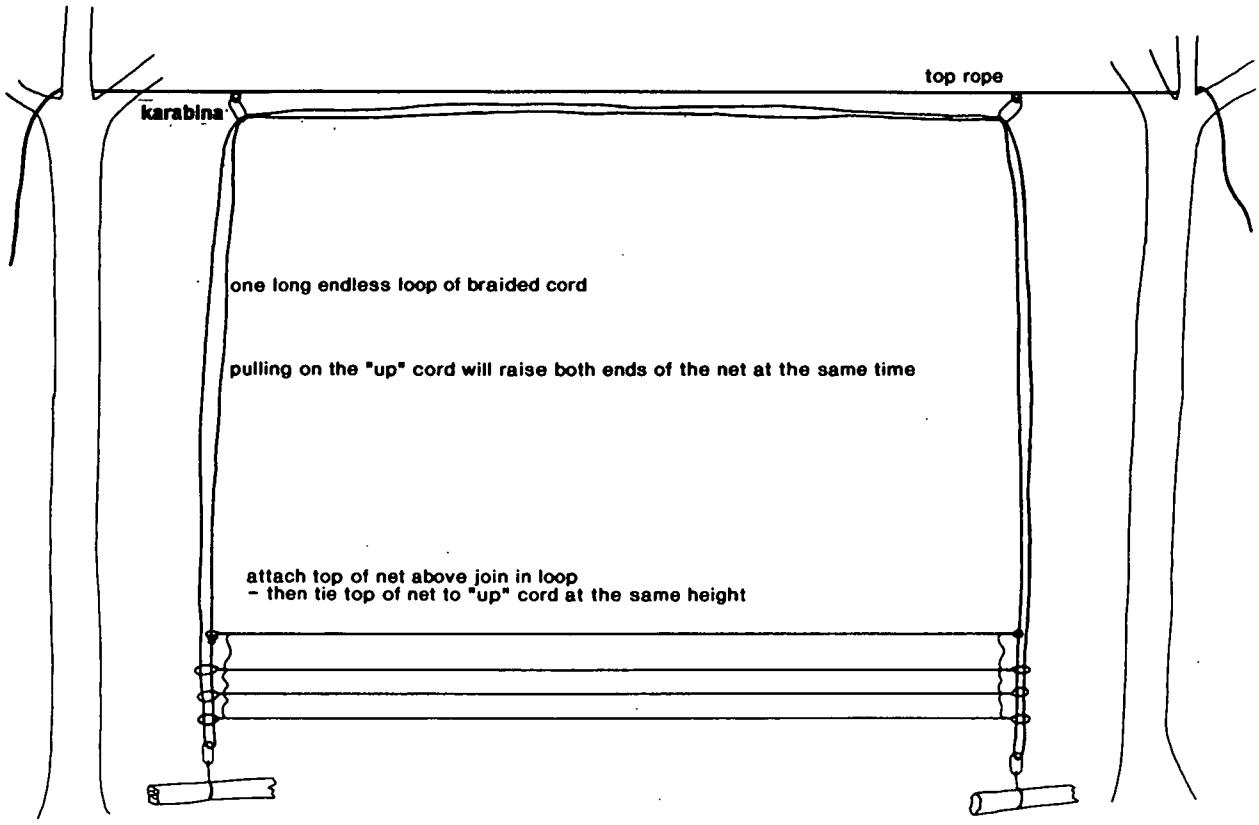


Fig. 2 – An alternative net rig when using only one operator. Raising and lowering can be done from either end, but there is more force required than when using two separate end loops.

the cord. Long leafy branches can be pulled down and tied out of the way using the same method. When the rig is removed they are released back into their former position.

Those branches that defy either of the above methods can be sawn off by shooting a line up and attaching a flexible saw which is pulled back and forth by two pieces of cord. Flexible saws designed for such purposes are commercially available, but the most effective is a wire used for dehorning cattle and obtainable from veterinary suppliers.

(6) When the site is finally prepared erect a cradle for the nets by crisscrossing a fine cord back and forth beneath the nets about 1.5 m above the ground. The cord is tied around any convenient trees or shrubs and prevents the nets dropping onto the ground and becoming tangled when the rig is lowered. If mist netting is to be carried out by only one person an alternative method can be used to attach the end loops as at (4) above. Instead of using two separate loops, one long piece of braided cord is threaded through the bottom karabina. Both ends are then threaded through the top karabina along the rig then through the second top karabina and lastly down to the bottom karabina at the other end (Figure 2).

This results in one long endless loop of cord encompassing both ends and the top of the rig. Nets are attached using the same method as above and can be raised and lowered by pulling on one rope at either end of the rig. This method means that the nets can be raised and lowered from one end – a lone operator does not have to move from end to end of the rig to get both ends of the nets up or down. However, the rig is harder to raise or lower as there is more resistance with this design.

Attaching the Nets

Before hanging nets it is important that the end strings of all net pockets are shortened by tying a knot midway up each (Figure 3). This allows deep pockets to form when the net is erected. If this is not done the nets will hang with shallow pockets which can result in many birds escaping.

Mist nets are attached using plastic curtain rings which clip together to form a locked circle. They are attached as follows – the top loop of the first net is securely attached to the knot on the endless loop (Figure 3). All subsequent rings are closed around both strings of the endless loop below the knot. As the ends of the nets are attached the rig is slowly raised by pulling on one cord of the endless loop.

When two nets are joined the bottom of one net and the top of the next are attached to the same curtain ring. Gaps that form between nets can be closed by tying the top and bottom strings of the adjacent nets together. We use short pieces of flexible green twig for this as these are easily pulled off afterwards and are readily available. When all nets are attached the nets are raised by pulling on the "up rope" of the endless loop until the nets are in the required position. Nets are lowered by pulling on the other cord, and as they descend the nets fold onto the cradle.

Another method of preventing gaps between nets is to overlap the nets by one pocket. This, however, provides a double layer of mesh in which birds can become horribly tangled. For species such as yellow-crowned kakariki which need to be removed quickly, this can prove fatal.

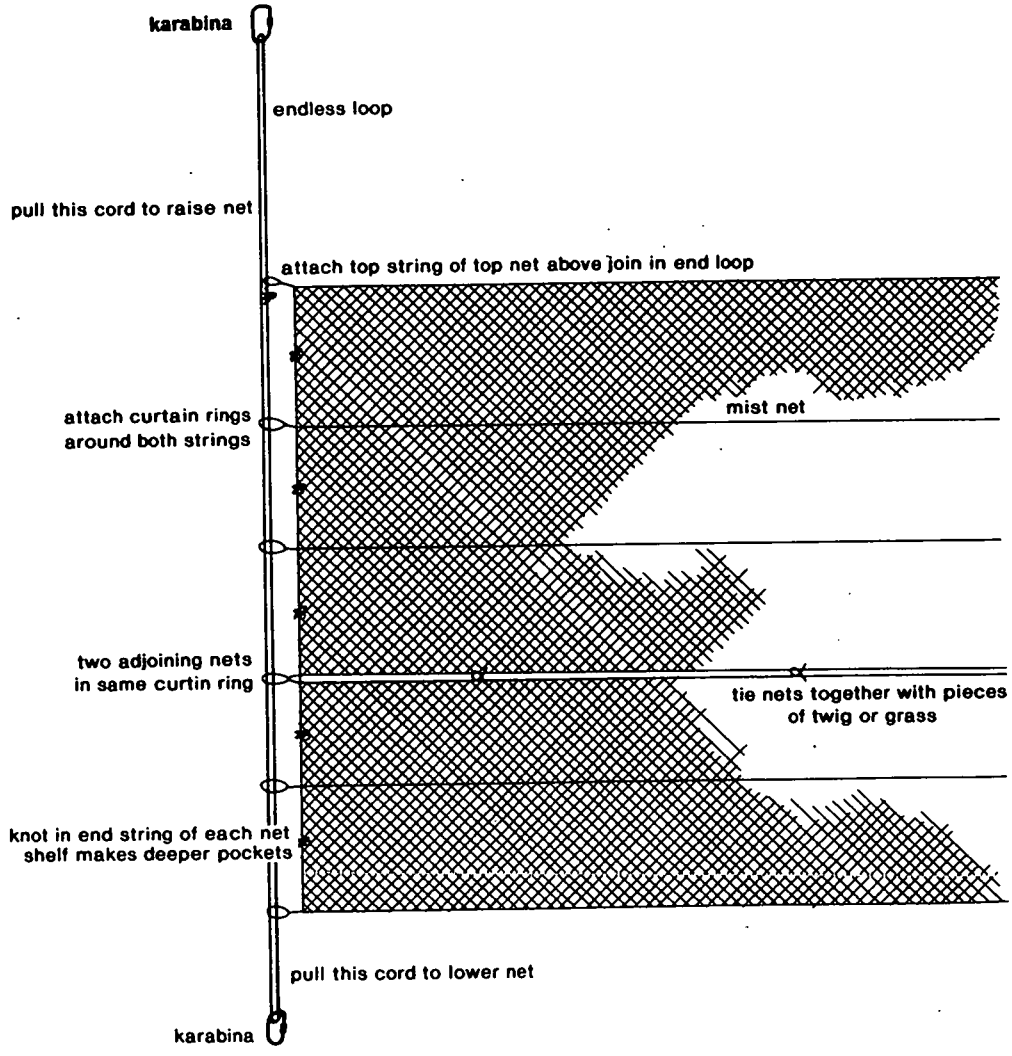


Fig. 3 – Detail of mist net attachment to end loops.

When nets are left on the rig unattended we lower the nets onto the cradle, grasp all the nets at the centre and "spin" them so they form a long tight tube. This is secured by tying lengths of tape at intervals along it. To unfurl them remove the tapes and spin the nets in the opposite direction. Slowly raising each end of the net assists it to unroll.

If the site is to be reused at a later date a thin braided cord should be pulled over the trees as the top rope is removed. This is left in place with both ends tied securely to trees. When the site is to be reused the top rope can be pulled up directly into position – no catapult shooting required.

Decoy/Call Birds

When netting kakariki we found that birds were much more readily caught when we used a decoy bird. Using the catapult we erected a rope high in a tree on one side of the net – mid-way along its length and as close as possible to the net. The bird, in a wire cage, was attached to a rope with a karabina and hoisted up so it was suspended at mid net height.

The usual method of attracting birds to the net is by using tape-recordings of their calls and song. For some species alarm and distress calls work especially well. Shy species, such as kokako (*Callaeas cinerea*), require speakers positioned either side of the net so the calls can be switched from side to side to attract the bird into the net.

For more tolerant species such as yellowheads we use a portable tape recorder and openly move back and forth under the net with the bird following the calls.

We have used this rig for catching birds on countless occasions and have had no problems with malfunction of the rig setup. On one occasion when we were catching yellowheads for an island transfer we surveyed for pairs of birds and erected and removed four rigs during one day. All gear needed for the operation including the tape recording equipment to lure birds and small transport boxes could be carried in two packs.

TELESCOPIC POLES

The same method of net attachment onto endless loops can also be used to erect nets on poles where a lower rig is required. This method is also useful in lower canopy vegetation or where there are no solid trees to attach a rig to. The poles and nets can be erected very quickly (in 15-20 minutes) and are easily moved to another site.

Normally when using poles, mist nets can only be erected to the height that can be reached from the ground. However, using telescopic aluminium poles and a net rig that can be raised and lowered, much higher nets can be erected and readily serviced.

For species (parea: Chatham Island pigeon: *Hemiphaga novaeseelandiae chathamensis*) that are very confiding and can be found in open habitats the nets can be erected and the whole structure lifted and carried by two people. When nets are positioned correctly the bird can then be flushed into the net!

Lower nets also work well for some species that at times react very strongly to tapes. Yellowheads with chicks will often follow someone playing tapes of chick distress calls closely. However, when using lower nets within tall canopy forest you need an area of dense low understorey vegetation to enable the birds to be attracted to your level.

EQUIPMENT (see Appendix I)

Aluminium poles of suitable diameters to slide freely one inside the other.

Short bolts to lock poles at their required height.

Four eye bolts, four flat nuts, four wing nuts.

Two lengths of braided nylon cord – for end loops.

Cord to anchor poles.

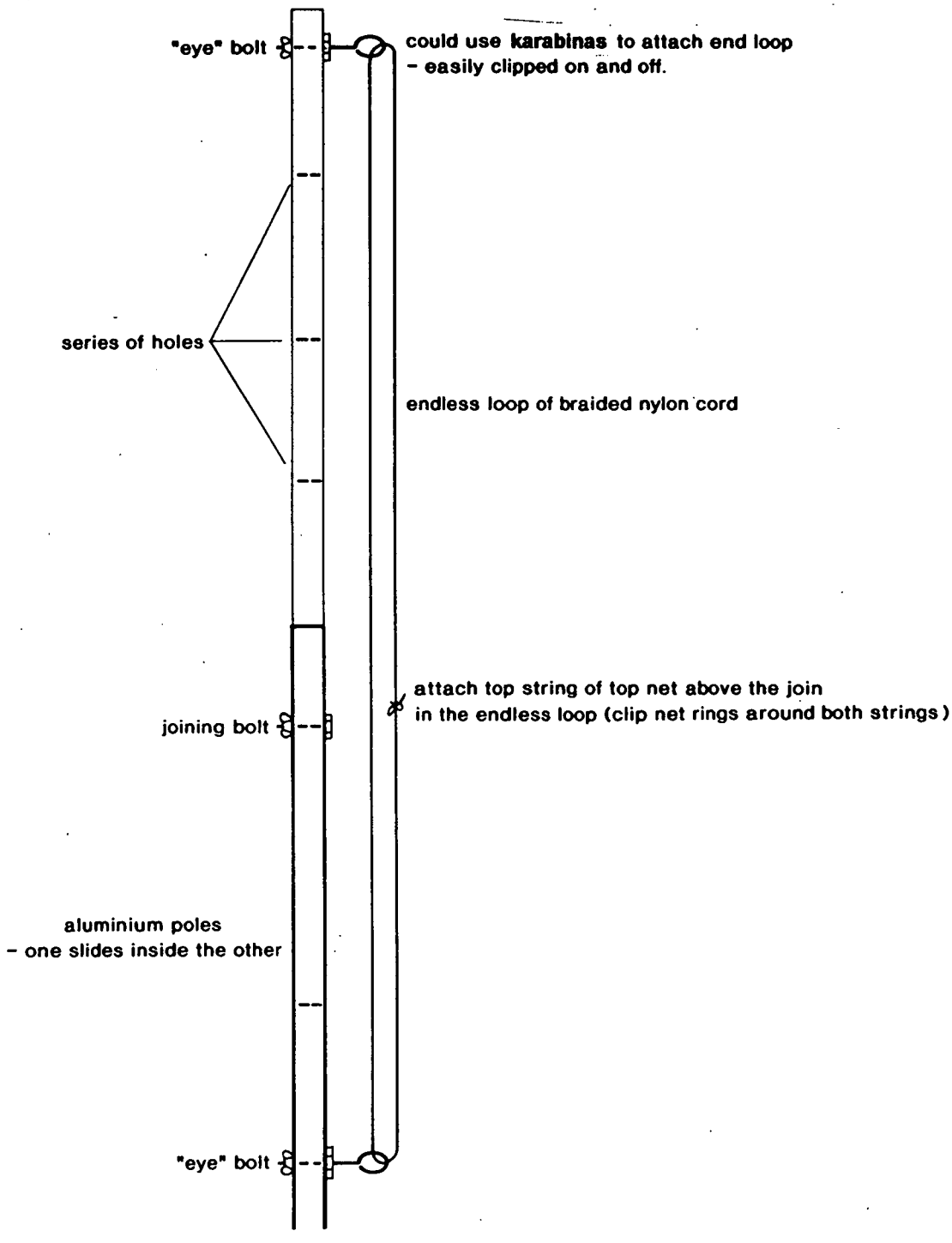
Plastic curtain rings for net attachment.

Mist nets

Aluminium tubing is available in five-metre lengths and comes in a range of diameters that will readily telescope inside one another. The diameter of tubing used for poles depends on how tall the net rig is required to be, and hence how much they will bend when under tension.

Fig. 4 – Telescopic aluminium poles: nets are attached using the same method as the forest rig. We have used a net rig with two aluminium poles. If larger diameter poles are used (that would not bend under the strain), three or more poles would give extra height.

For easy transport and reassembly, just remove the joining bolt, telescope the poles together, and bundle up the cord and guys, leaving them attached.



We cut the tubing lengths in half, into two 2.5 m lengths. These telescope out to give two poles around four metres tall (two at 2.5 m with about 0.5 m overlap on each pole). They can be collapsed to one 2.5 m length.

The poles have a series of holes drilled through both of them and using a bolt and wingnut can be fixed at the required height.

Erecting the Rig

(1) Extend the poles to the required height and bolt together.

(2) Insert an eyebolt at the top of each pole and another around half a metre above ground level (Figure 4).

(3) Thread the endless loop cord through both eye bolts, join ends and bundle up the excess.

(4) Attach anchor ropes two-thirds of the way up the poles and stand the poles up. Initially, this can be done by pushing the poles into the ground in approximately the right position. Adjust the poles to the right spacing when attaching one net and anchor them in place.

(5) Attach the nets using the same method as in the previous rig. The first plastic curtain ring goes above the knot in the end loop – the rest below. All rings are attached around both strings.

A cradle is not usually necessary for nets on poles as the nets can be kept tighter and clear of the ground. However, one or two strings erected at right angles to the nets will keep the net above ground level when they are lowered.

Nets are raised and lowered using the same method as the forest rig – pull on one string for up, the other for down.

ACKNOWLEDGEMENTS

Thanks to Ian Flux, Suzanne Clegg, Andy Grant and Greg Sherley for comments on the manuscript.

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APPENDIX I: EQUIPMENT AND SUPPLIERS

Catapult: Available from sports/gun shops. A variety of models are available but choose one of solid construction with a folding wrist brace. The rubber as supplied is adequate for short trees but is best replaced with speargun rubber of a greater thickness (make sure it has a hollow centre for threading on).

It is best to have the rubber shorter than supplied (about 20 cm long). This needs more strength to pull back but you will be able shoot considerably further. Keep spare rubbers handy as the dacron can become caught and sometimes cuts through them. When replacing the rubber, a little detergent makes the join at the pouch much easier to thread through.

Reel: Any fishing/sports shop. Any casting reel will do but a larger model is better than one that is too small. The dacron unravels more freely off a larger reel – important for tall trees. Having the spool full makes a big difference too. Try and keep the reel dry, once the dacron becomes wet it is much more difficult to shoot over tall trees.

Dacron: Any fishing/sports shop. Braided dacron 20 lb breaking strain. White is easier to see (where it's tangled) than black. Braided dacron is far better than monofilament nylon which after a little use seems to become twisted and leaps off the reel into huge tangles. Braided dacron is also much easier to untangle. Keep a couple of spare rolls handy as tangles can waste a lot.

Weights: Any fishing/sports shop. Round, two ounce lead weights. Have plenty of spares for those difficult trees and novice shooters. A short streamer of coloured tape

threaded through the weight can make the weight easier to find on the ground.

Cord: Braided nylon cord of various thicknesses is used: to pull the top ropes into position, for the end loops of the rig, to tie branches out of the way and for the cradle. It can also be used for the top rope but is more expensive than twisted 3-ply rope. Braided cord is essential for the end loops as plied rope tends to twist and not flow so freely through the karabinas. Braided cord is also much easier to untangle. However, after a lot of use even braided cord can become twisted and will need to be replaced.

Braided cord can be bought on contract (Donaghys or similar), or from hardware stores, but we have found it is considerably cheaper to buy from a fisheries supplier who imports their own from Asia. Try fishing suppliers in the yellow pages. We use:

Quality Equipment Ltd:

- 73 Hillside Road, Glenfield, Auckland (PO Box 40-154)
  Ph (09) 444 7742, Fax (09) 444 5872
- 14 Tanya Street, Bromley, Christchurch (PO Box 24-069)
  Ph (03) 3842 330, Fax (03) 3844610
- 124 Vickerman St, Nelson (PO Box 5097)
  Ph (03) 546 9179, Fax(03) 546 6347

Wellington – agency
Agent = Harley Smithson
268 Mitchell St, Brooklyn

For end loops – 16 x 16 supplied in 1 kg roll (130 m) = $21.00 (+GST)

Other tasks – cradle, tying back branches, pulling over the top rope.

6 x 16 in a 1 kg roll (380 m) = $21.00 (+GST)

There is a wide range of other thicknesses available, all come in 1 kg rolls and are the same price per kg. All the cord we use is white. Black is available in some sizes but it is less flexible and harder to handle. It is however, much less conspicuous if cords are to be left in trees in areas with free public access.

Rope: Plied rope for the top rope is also available from the same suppliers and is supplied in rolls which are the right length for one high rig. Rope we use is green Danline, 4 mm diameter, 240 kg breaking strain which comes on 220 m rolls – $16.00

Karabinas: Any sports shop. Standard size karabinas are better than the small ones because any joins in the end loops can be pulled through these providing the knots are kept small. Four are needed to set up one rig. (Medium: $10.50; large $16.00)

Net rings: Try curtain suppliers. The brand we use are Rufflette and are shower curtain rings. They are 35 mm diameter and clip together to form a closed circle. This type is by far the best as there are no ends to tangle in the net. They do tend to wear with heavy use and they can be difficult, sometimes impossible, to obtain so if you find a supply buy plenty of extras.

Saw: Flexible pruning saws are occasionally available at camping, outdoor or army surplus shops. However cattle dehorning wire (available from veterinary suppliers) works well and doesn't jam as the saws can do.

Mist nets are obtainable in various lengths and mesh sizes from the Banding Office, Department of Conservation. Insure all the nets you use are of the same length and are interchangeable on any rig that is set up. Try to use new nets, as old nets can become "brittle" and birds will, on occasions, fly straight through them!

Poles: Aluminium tubing suitable for mistnet poles can be obtained from many sources – check the yellow pages. Choose two sizes where one will slide snugly inside the other.

Bolts etc. are available from any hardware shop. Wingnuts are much easier to use and do not require a spanner.

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A TRIAL OF DUMMY TRANSMITTERS AND HARNESSES ON MALLARDS

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ABSTRACT: Dummy transmitters were fitted to free-flying adult mallards (*Anas platyrhynchos*) in an attempt to observe feather-wear where the transmitter was attached. There seemed to be a correlation between such feather-wear and the birds' weight. This may, in the short term, have a greater effect on weight loss than does cord abrasion. Behavioural changes resulting from transmitter attachment should be taken account of in breeding studies.

INTRODUCTION

Transmitters mounted on captive mallards and blue-winged teals in the USA caused feather-loss where the package was in contact with the bird's body (Greenwood and Sargeant, 1973), Identical feather-wear patterns on wild juvenile blue ducks (*Hymenolaimus malacorhynchos*) fitted with transmitter packages was seen in 1990-91. This prompted concern about potential thermoregulation problems for birds in a waterway draining an alpine-fed catchment. Although survival to 18 months was normal (Williams 1991), survival in harsher winters might not have been as great, feather-wear making a crucial difference.

In addition, the harness-release mechanism (Karl and Clout 1987), designed for use on terrestrial birds has not proven reliable for blue ducks. Five of 14 transmitters applied to blue ducks (including one captive bird) are known to have only partially released (rear of the wings), leaving the birds encumbered with a 'pendant'. One of the four wild birds is known to have worn his transmitter in the semi-released state from October 1991 to January 1994. The same bird was seen with a mate and one juvenile in November 1992.

A need was identified to test an alternative design of harness and the materials the harness was made from to determine whether a more comfortable fit could be achieved. In addition, a simpler degradable release mechanism was needed to ensure that the whole assembly released fully.

OBJECTIVE

Determine effects, as measured by weight-loss and feather-wear, of different under-side surfaces and harness-attachments of dummy transmitter packages on waterfowl.

METHODS

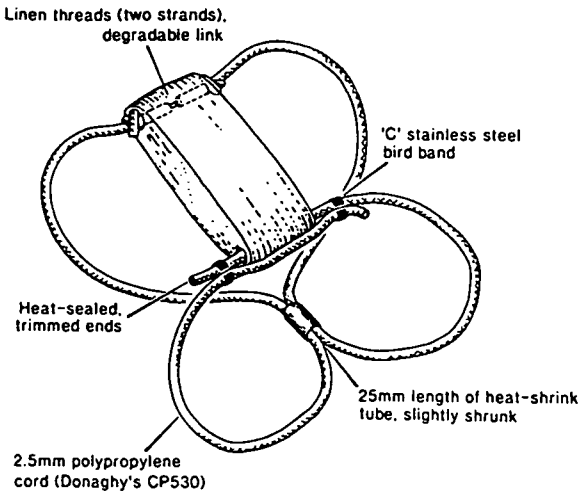
Materials

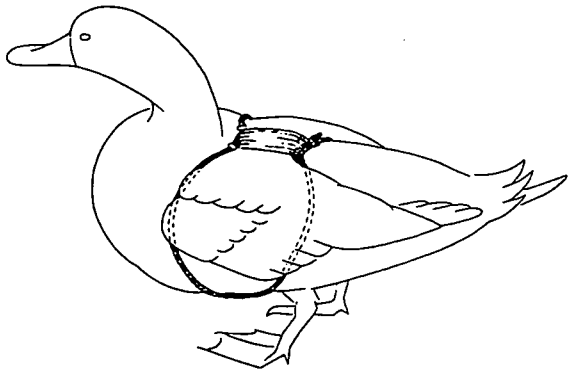
Dummy transmitters were manufactured from 'Fimo' modelling clay to the same size and weight as a transmitter designed to last 9.5 months on an adult or fledged juvenile blue duck. Measurements are: length – 44 mm incl. cord tubes; width 26 mm; depth – 13 mm; weight – 15.5 g including coating (Five-minute Araldite)

All dummy transmitter packages were contoured on the underside by moulding the package over a 70mm diameter plastic container, and back-pack harness-mounted. A rump-mounted system was tested but did not stay on the birds for more than a few seconds.

Mounting harnesses used were the nylon Karl and Clout ('K&C' harness) standard chest harness and a simple Figure-of-8 type (Fig. 1) made from polypropylene, releasing at the front only. Both designs incorporated a double strand of linen thread as the degradable link allowing eventual release of the harness.

Dummy transmitter packages were fitted to free-flying adult mallards at Nga Manu Sanctuary near Waikanae, north of Wellington. All birds were colour-banded according to the type of package and harness





(Table 1), weighed at the start and every 14 days thereafter, where catchable, for six months.

Table 1: Experimental regime:

K&C harness – 6 birds with unpadded package.

(Nylon) – 6 birds with padded (3mm neoprene) package.

Figure-of-8 harness – 6 birds with unpadded package.

(Polypropylene) – 6 birds with padded (3mm neoprene) package.

Control – 9 birds banded, no package, no harness.

TOTAL BIRDS: 33

Each condition applied to equal numbers of sex (three male, three female).

RESULTS

The weights of birds fitted with padded packages appeared to stay generally lower than start weight throughout most or all of the sampling period, whereas those fitted with unpadded packages maintained weight patterns similar to the control birds. Also, the K&C-padded birds lost weight at a time when all others, roughly following the pattern of the controls, gained weight.

Differences in feather-wear and cord abrasion became quite distinct between the different groups of birds with an unexpected result of a noticeably smaller impact of the polypropylene Figure-of-8 harness. This was initially designed to minimise cord-abrasion (a function of the soft material) and to release at the front only but appears to have had the additional benefit of minimising feather-wear under the package.

Those birds fitted with K&C harnesses fared worse than those with the polypropylene figure-of-8 harnesses, and padded packages caused noticeably more feather-wear under the package than unpadded. Although the sample sizes are generally small, the indications are that the K&C harness causes greater feather-wear and cord-abrasion, the under-package feather loss becoming noticeable in the first two weeks, peaking at about six weeks before partial recovery. Cord-abrasion in the axillary area of the wings started to become obvious around the beginning of March, increasing in severity to the end of the investigation period.

The release mechanism of the new harness type was not fully tested as the trial period lasted just over 6 months, not long enough to fully determine its effectiveness. However, a few did release earlier than expected, one remaining partly attached, around the bird's pelvis. In this instance the rear 'loop' was probably tighter than was necessary, preventing the bird from stepping out of the loop after releasing at the front.

DISCUSSION

Although the data are not robust enough to withstand rigorous testing, the indications are that even slight feather-wear on the back may be more likely, at least in the short-term, to

contribute to weight loss than cord-abrasion at the axillas of the wings (although continued abrasion at the base of the wings will ultimately cause injury, rendering the bird immobile, and may eventually lead to death). Curiously, the consistently greatest feather-wear was noticed among both group of birds fitted with the K&C harnesses. I am unable to explain this and can only suggest that the design of the harness somehow causes the package to sit or move in a way that abrades the feathers. Whatever the explanation, harness design and choice of materials can mean the difference between an attachment which is an irritation (with associated behavioural changes), and one which causes injury, in some cases contributing to death.

Recent research in the USA by Pietz *et al.* (1993), Rotella *et al.* (1993), and Houston and Greenwood (1993) has shown that harness-mounted transmitters do negatively affect the breeding success and weight of wild waterfowl. Whether this was attributable to feather-wear, the harness type (Dwyer 1972), package weight, or a general irritation from both is not known. Most studies compared harness-mounted (all Dwyer 1972) packages with sutured and implanted transmitters, but none investigated different designs or materials for the harnesses. Calvo and Furness (1992) conducted an extremely useful review on the effects of marks and devices fitted to birds, demonstrating that assumptions about the 'nil' effects frequently reported (or simply not looked for, or not reported), can be unfounded.

Future investigations must accept that attachments will almost certainly bring about behavioural changes which must, somehow, be accounted for, particularly in breeding studies. There is therefore a very clear need for longer term, detailed studies on methods which will minimize the impacts of transmitter mounting systems. In their discussion Calvo and Furness (1992) remarked "We consider it is desirable that bodies regulating the marking of birds should encourage research specifically to assess the effects of marks and devices" On the basis of the findings of the American workers, it appears that implanted and suture-mounted transmitters may be better for short term studies (if such techniques are acceptable from an animal ethics point of view) but are of limited use in long term studies which necessitate bigger packages. Additionally, such studies must include a captive component followed by trials in the wild before widespread use is acceptable.

ACKNOWLEDGEMENTS

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PREDATOR CONTROL AT TAIAROA HEAD ALBATROSS COLONY

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ABSTRACT: Taiaroa Head, a 9-ha Nature Reserve near Dunedin, contains the world's only mainland colony of royal albatross. In February 1994, four of the ten chicks present were preyed upon by a mustelid. The management response to this incident is detailed.

Taiaroa Head Nature Reserve contains the world's only mainland colony of the northern royal albatross (*Diomedea epomophora sanfordi*), as well as being home to sooty shearwaters (*Puffinus griseus*) and little blue penguins (*Eudyptula minor*). It is about 9 ha in area and is at the tip of the Otago Peninsula, northeast of Dunedin. A detailed description of the site is contained in the Taiaroa Head Reserve Resource Inventory, published by the Department of Conservation. The reserve runs a year-round predator trapping programme, using a variety of traps and methods.

In February 1994, four of the ten albatross chicks present were attacked, probably by a mustelid, a form of predation which occurs periodically at the reserve. The management response to this incident is described in this report

The year-round trapping programme uses 47 Fenn traps and six cage traps. Because of possible risk to the small penguins and shearwaters, only twelve of the Fenns are open set. The remaining 35 are in tunnels, either singly or in pairs. All the traps are baited with fresh rabbit (the most common prey species in the area). Each of the traps is checked daily.

CHRONOLOGY

On 12 February 1994, staff found a chick which had been dead for several hours. It was on a track about three metres from its nest. The dead chick was fly-blown and had puncture holes on the top of the leg, neck, and wing.

On 18 February, another chick was found dead in the nest, with its head and neck stretched over the rim of the nest. The skull was eaten, and small pieces of munched-up bone were present. There was a hole in the neck and on the back and further puncture marks on the top of the right wing, as well as lacerations on the upper and lower mandible.

On 19 February, another dead chick was found in the nest. The body was warm and dry. The back of the skull had a 2-cm diameter hole exposing the brain, but the brain had not been eaten. The flesh on the back of the next was exposed, and the right eye was punctured. There was a significant area of chewing the bill tip, and an area on the back was skinned. One short, pale-coloured hair with a black tip was found inside the chick's bill.

The three dead chicks were given to Henrik Moller and University of Otago students to see if they could identify by tooth marks the predator involved.

On 20 February, another chick was found dead, cold and wet. Its neck was stretched out over the nest rim. The back and top of the head had a 2-cm diameter hole in it. The brain was eaten out, and other eyes were missing. The back was partly stripped

of skin, and another area of skin was stripped off the neck. The head of this chick was removed and given to the university; the rest of the carcass was kept for use as predator bait.

There were distinct, recently-formed 'tunnels' through the grass near where the chicks were killed on 18 and 20 February.

PREDATOR CONTROL RESPONSE

After the first event, more traps were laid out by nests. By 20 February, there were an additional six open Fenn sets and two tunnels laid out.

Rat snap traps were used because of the number of rats being caught in the Fenn traps. Eggs containing 1080 were used from 20 February until 6 March.

Night shooters were used from 20 February to 24 February. Night checks, consisting of hourly walks around each nest, were begun on 20 February and continued until 7 March.

Rabbit meat poisoned with cyanide was laid in three Novaflo pipes on 24 February. The afternoon of the same day, a weimaraner dog was used to check out area around the lighthouse and the fog station. The dog was given an artificial ferret scent and pointed strongly over areas of *Muehlenbeckia* and elderberry.

The control methods (and numbers) used by 24 February were:

Open set Fenn traps: 18

Fenn traps in tunnels: 37

Cage traps: 6

Dog: 1

Rat traps: 20

Hunters: ??

Poison eggs: 12

Cyanide bait: 3

On 25 February, a live ferret was used – without success – as a lure in a cage set among open Fenns.

RESULTS

On the night of 20 February, the hunters saw a large ferret near the lighthouse and fog station. An open Fenn set on an adjacent concrete step was later found sprung with bait removed.

On the night of 22 February a possum was shot in the same part of the reserve.

On 26 February, Otago Peninsula Trust guides reported that a stoat had been seen by people in the Richdale Observatory, inland from the nests; traps were rearranged to give better coverage near the observatory.

On 26 February, a stoat was sighted near one of the open run-through sets. On 27 February a large stoat was caught in the same set.

On 3 March, a ferret was caught in an open set below the bluffs, 200 m away from the nests, at the southwest corner of the reserve.

On 6 March, a stoat was caught at the trap within the fence line on the northeast side of the reserve.

DISCUSSION

After extra measures were taken to control predators, no further albatross chicks were preyed on.

By the morning of 20 February, we thought – going by the type of damage done and the hair retrieved from the 19 February chick – that the animal involved was a ferret. This seemed to be confirmed on the night of 20 February, when the hunters reported seeing a ferret. However, they may have been misled by eye colour. They reported a pink-eyed ferret, but later tests with the ferret used as a lure showed yellow, or bright green/blue eye colour, not pink.

On 23 February, Hiltrun Ratz (University of Otago) reported that the tooth marks on the dead chicks seemed more like those from stoats than from ferrets. Later examination of the other dead chicks showed

that the four chicks may have been killed by a stoat. However, the results are inconclusive as to whether a stoat or a ferret was the primary predator. Tooth marks can also come from secondary predation of the carcase.

In response to the earliest signs, we had assumed that we were looking for a ferret. However, as the traps were placed in a variety of sets and arrangements, only our use of the ferret pheromone scent on 24 February was inappropriate for catching both stoats and ferrets. It is possible the extensive use of ferret smell boxes could have acted as a repellant to stoats. This could warrant further study where both predators are a problem. Using more open sets could make future trapping more effective, but this use is constrained by the presence of the shearwaters and the penguins.

Until this incident, rabbits have been the most common prey species at Taiaroa Head. In September 1993, there was a major rabbit poisoning operation, undertake in the reserve area by the Regional Council. The predator/prey imbalance that followed this operation might have been responsible for the switch from rabbits to albatross chicks.

If this did in fact cause the February 1994 incident, future rabbit control operations will need to be scheduled for much earlier in the year. Alternatively, rabbit numbers may need to be kept at a permanently low level in order to discourage mustelids from using the reserve.

From the evening of 20 February onwards, hourly checks were made throughout the reserve. The disturbance caused by the hunters' activities might have been an important factor in scaring away potential predators, as after this date there was no more predation. It may be that in the future, when predation occurs, night-time disturbance of the nature reserve is the most effective way of preventing further predation.

ACKNOWLEDGEMENTS

Thanks are due to Sandra McGrouther, Isobel Burns, Shirley Webb, Dean Nelson, Arnie Albers, Shane and John Pearce, Pete Ravenscroft, Rod Morris, Chris Roberston, Andy Cox and Dave Murray.

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IMPROVING RID RAT (RENTOKIL) BAITS FOR KIORE

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ABSTRACT: Flavouring was added to the wax and the grain of Rentokil Rid Rat wax block baits in 16 different combinations of flavours. These were tested on captive kiore (*Rattus exulans*) on Little Barrier Island (Hauturu). These rats preferred Rentokil Rid Rat baits with sucaryl added to the grain in the form of 7.5 ml/l added to the dye/toxin mix. Their second preference was bait with 10 ml/kg of sucaryl in the wax with or without vegetable oil being added. These baits were preferred to Talon 50WB.

INTRODUCTION

For some time I have held the opinion that commercially available rat baits, while perceived as being "readily eaten" by rats, could be improved. Ian McFadden (pers. comm.) observed that in tests he had carried out, kiore (*Rattus exulans*) preferred Talon 50WB to Rentokil wax block baits. As far as I am aware there have been no other field or captive trials on wild or wild-caught kiore comparing these bait types, with or without added flavours.

The tests described were part of a programme to improve the acceptability of rat baits generally, but particularly of the Rid Rat (Rentokil) baits which fit into the purpose-built plastic bait stations. Such results should enhance implementing kiore control programmes on, for example, Little Barrier Island (Hauturu) where there is a further important requirement for better baits to kill kiore at kakapo feeding stations and nests.

Two tests were carried out during each of two visits to Little Barrier island: one on captive animals and the other by placing baits in field locations. This paper records the results of the captive trials only, as almost no bait in the field bait stations (which contained all the bait flavours listed in Appendix 1) was eaten by rats. These tests took place on Little Barrier between 23 November and 3 December 1993, and 25 January to 6 February 1994.

Rentokil are participating in this work by making all baits available free of charge. A number of volunteer helpers assisted throughout the project. This project was approved by the Department of Conservation Animal Ethics Committee.

METHODS

Bait Preparation

All baits used were the standard Rid Rat toxic wax block bait with flavour added as detailed in Appendix 1 or the standard Talon 50WB.

As the outside surface of the wax block bait is wax and flavours can be readily added to the wax it was decided initially that the flavours should be added only to the wax. Baits prepared in this manner were used in both trials. This group of baits is referred to in this paper as the 'flavoured wax' group.

The grain within the bait is the medium to which toxin and green dye are added. It is possible that the toxin or dye could contain a flavour which is not attractive, although not offensive, to rats. It is also possible that sucaryl added to the grain would have a differing acceptability to sucaryl added to the wax. Sucaryl was therefore added at a rate of 7.5 ml/l in the dye/toxin mix before the grain was steeped in the liquid. This group of baits is referred to in this paper as the 'flavour in the grain' group.

Captive Rats

During both visits up to 82 cage traps of various types were set at approximately 50 m

intervals on the Thumb/Waipawa Track circuit. All traps were checked daily starting between 6:30 am and 7:00 am. Captured rats were kept in individual cages which were screened so that no rat could see any other rat. Each cage contained a water dish and shelter for the rat.

Pairs of baits of differing flavours were placed on small boards (Figure 1) in each cage for one night. Each bait was fitted onto a nail on the board so that the rat could not drag it away. Each morning the remaining bait was weighed. Crumbs which fell to the floor of the cages became mixed with crumbs from the neighbouring bait and rat faeces so were not weighed. It is assumed that similar percentages of each bait type were dropped as crumbs.

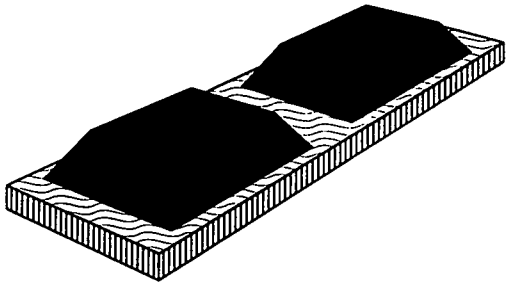

Fig. 1--Two baits on a board, as used in the trials.

Each pair of baits was tested on five rats, with each rat being offered different pairs each night. Each rat was offered bait for only three nights, after which it was humanely destroyed.

Grouping of Baits

The 'flavoured wax' baits were all made before the first trial in November/ December 1993 and were then tested against one another. The 'flavour in the grain' baits were introduced for the January/February 1994 trial and were then tested against one another. The grain contained in these baits differed slightly from that used in the 'flavoured wax' baits in that some of the grain had been crushed. The best of the 'flavoured wax' baits were then compared to the best of the 'flavour in the grain' baits and Talon WB50. This group of baits is referred to in this paper as the 'top order' bait.

RESULTS

As not all bait types were tested against all other bait types and differing total quantities of each bait type were used a simple overall ranking from the quantities eaten or preferences shown is not possible for the entire array of baits. If, however, it is accepted that bait type A being preferred to bait type B and bait type B being preferred to bait type C is sufficient evidence that bait type A is preferred to bait type C, then some ranking is possible.

The standard Rid Rat bait, vanilla and carbon disulphide flavourings were clearly low in the preference order. The carbon disulphide rapidly evaporates leaving no flavour in the bait. These baits are not included in the comparisons that follow.

In the comparisons that follow, the average quantity of bait consumed and the percentage of occasions that a bait type was preferred by each rat in each comparison has been used rather than absolute consumption or number of occasions. This allows baits which were offered to differing numbers of rats to be fairly compared.

'Flavoured Wax' Baits

The quantities of 'flavoured wax' baits consumed when tested against one another are shown in Figure 2. Baits with 10 ml/kg of sucaryl are clearly preferred to baits with lesser quantities of sucaryl while bait with only vegetable oil and coconut flavouring are also high in the order of preference.

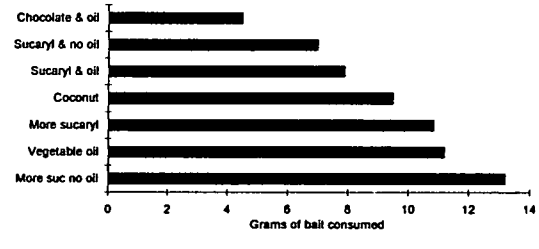

Fig. 2--Average weight (g) of bait consumed when each bait was compared with others in the 'flavoured wax' group.

The percentage of occasions when each rat preferred one bait to another in the 'flavoured wax' group is shown in Figure 3.

Again, baits with higher levels of sucaryl are preferred to those with lower levels while coconut flavouring was eaten on more occasions than bait with only vegetable oil or only sucaryl.

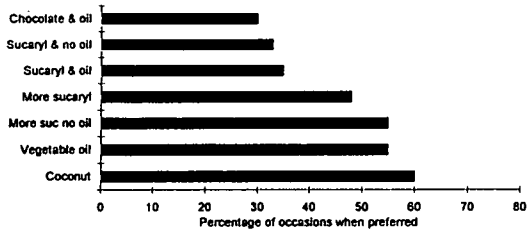

Fig. 3– The percentage of occasions on which each bait was preferred when compared to others in the `flavoured wax' group.

'Flavour in the Grain' Baits

The quantities of 'flavour in the grain' baits consumed when tested against one another are shown in Figure 4. The addition of sucaryl only to the grain made a bait which was clearly preferred to most others, yet when chocolate was also added then that flavour was slightly preferred to sucaryl only. This top preference is contrary to the preferences shown in the 'flavoured wax' group, where coconut was preferred to chocolate.

The percentage of occasions when each rat preferred one bait to another in the 'flavour in the grain' group is shown in Figure 5. Again, the bait with sucaryl only added and the bait with sucaryl and chocolate were clearly preferred to other flavours. It is notable that when sucaryl was added to both the wax and grain and then chocolate was added, the bait was eaten on fewer occasions; this suggests that combining some flavours may make the resulting bait less palatable than bait with any of the flavours used alone.

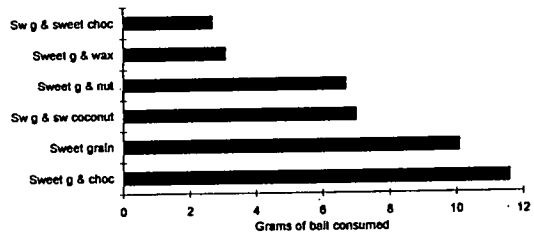

Fig. 4–The average weight, in grams, of bait consumed when each bait was compared against others in the 'flavour in the grain' group.

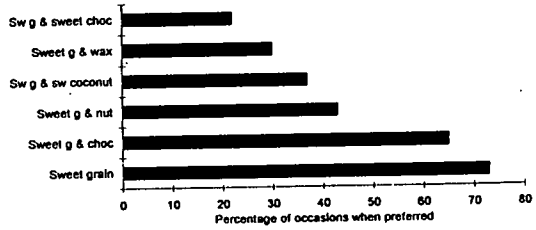

Fig. 5–The percentage of occasions on which each bait was preferred when compared to others in the 'flavour in the grain' group.

The variable reaction of rats to chocolate and coconut flavours compared to the consistent reaction to sucaryl flavouring suggested that sucaryl flavouring should be the first tested against the previously 'best' Talon 50WB bait as shown in the following tests of 'top order' baits.

'Top Order' Baits

The quantities of 'top order' baits consumed when tested against one another are shown in Figure 6. Bait with 7.5 ml/l of sucaryl added to the dye/toxin mix applied to the grain is clearly preferred to baits with higher levels of sucaryl in the wax. Talon 50WB is below these baits in the preference order.

The percentage of occasions when each rat preferred one bait to another in the `top order' group is shown in Figure 7. Again, baits with 7.5 ml/l of sucaryl added to the dye/toxin mix applied to the grain were clearly preferred to

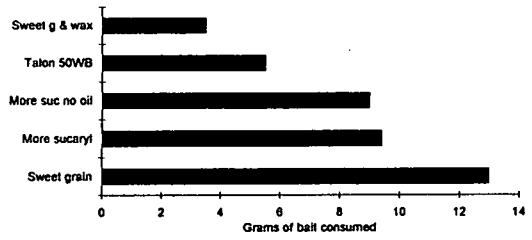

Fig. 6– The average weight, in grams, of bait consumed when each bait was compared with others in the 'top order' group.

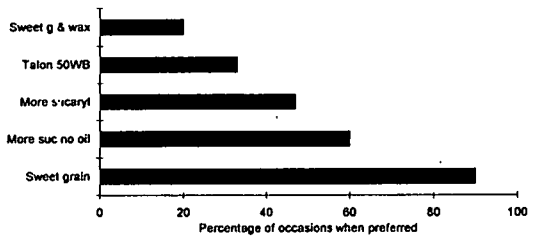

Fig. 7–The percentage of occasions on which each bait was preferred when compared to others in the 'top order' group.

baits with higher levels of sucaryl in the wax. Talon 50WB was below these baits in the preference order. The 'sweet grain and wax' bait had sucaryl in the grain at the same rate as 'sweet grain' and in the wax at half the rate of 'more sucaryl' and 'more sucaryl no oil'; it was notably the least preferred of the 'top order' baits.

DISCUSSION

These tests of baits on captive kiore showed that these rats preferred Rentokil Rid Rat baits with sucaryl added to the grain in the form of 7.5 ml/l added to the dye/toxin mix. Their second preference was bait with 10 ml/kg of sucaryl in the wax with or without vegetable oil being added. These baits were preferred to Talon 50WB.

These tests now need to be replicated on captive kiore from another location and field tested in at least two locations. Additional flavours may be considered in such tests.

The effect of the new flavours on bait take by potential non-target species has not been tested, nor has the possibility of using these flavours in baits with differing composition such as the tallow and grain Talon 50WB, or any pollard baits.

APPENDIX 1:

Descriptions and abbreviated names of baits used in the trials.

FULL DESCRIPTION OF BAIT	NAME
Standard Rid Rat	**standard**
'Flavour in the wax' group	
standard + 10% vegetable oil	vegetable oil
standard + 7.5 ml/kg sucaryl	sucaryl & no oil
standard + 15 ml/kg sucaryl	more suc no oil
standard + 7.5 ml/kg sucaryl + 10% vegetable oil	sucaryl & oil
standard + 15 ml/kg sucaryl + 10% vegetable oil	more sucaryl
standard + 5 ppm CS_2 + 7.5 ml/kg sucaryl + 10% vegetable oil	CS_2
standard + 10 ml/kg coconut flavouring + 7.5 ml/kg sucaryl + 10% vegetable oil	coconut
standard + 10 ppm CS2 + 7.5 ml/kg sucaryl + 10% vegetable oil	more CS_2
standard + 100 g/kg dark cooking chocolate + 10% vegetable oil	chocolate & oil
standard + 10 ml/kg vanilla essence + 10% vegetable oil	vanilla & oil

'Flavour in the grain' group	
standard + sucaryl in the grain (see text)	sweet grain
standard + sucaryl in the grain + 7.5 ml/kg sucaryl in the wax	sweet g & wax
standard with sucaryl in the grain + 100 g/kg dark cooking chocolate in the wax	sweet g & chocolate
standard with sucaryl in the grain + 10 ml/kg coconut flavouring in the wax	sweet g & nut
standard with sucaryl in the grain + 7.5 ml/kg sucaryl + 100 g/kg dark cooking chocolate in the wax	sw g & sweet choc
standard with sucaryl in the grain + 7.5 ml/kg coconut flavouring in the wax	sw g & coconut
Talon 50WB	

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