What's happening with stoat research?

Third report on the five-year stoat research programme

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Cover: Dog stoat in tussock, Otago Peninsula. *Photo: Department of Conservation collection.*

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Stoat research programme

A stoat control research programme was initiated in July 1999 with an injection of funds from the New Zealand Government of $6.6 million over five years.

The programme aims to find more cost-effective and sustainable approaches to controlling stoats, which are a critical threat to many of our native wildlife.

The stoat research programme is guided by the vision:

'*That stoats will no longer be a threat to indigenous biodiversity'*

The four key objectives of the programme are:

- To make stoat control more cost-effective where it is already successful
- To develop new techniques so that control can realistically be undertaken in more and larger areas
- To expand the arsenal of methods to ensure that stoat control, and the consequent benefits to biodiversity, are sustainable
- To seed new, longer-term projects that have the potential to dramatically increase the effectiveness of control

A stoat technical advisory group has been established to develop and oversee this research programme. The group is composed of representatives from the Department of Conservation—Elaine Murphy (Programme Manager), Leonie Fechney, Craig Gillies, Ian McFadden/Darren Peters, Elaine Wright, Harry Keyes, and Fiona McKay; from Lincoln University—Graham Hickling; and from Auckland University—Mick Clout. Funding for the first year was $338,000, increasing to $1.406 million in the second year (2000/2001). Funding for the third year and subsequent two years is $1.631 million annually.

This is the third in the series of progress reports on the programme. The first was published in January 2000 and the second in November 2000.

Overview

New Zealand wildlife evolved in the absence of mammalian predators and has proven particularly vulnerable to some of the mammals introduced since human settlement. Birds have been particularly affected with over 40% of the pre-human land bird species now extinct, and the proportion of the surviving birds classed as threatened higher than in any other country.

Stoats, along with ferrets and weasels, were introduced from Britain to New Zealand in the 1880s in an attempt to control rabbits. Although stoats were quickly implicated in the decline of native birds, the extent to which they still contribute to the decline of native species is only now becoming clear.

The New Zealand Government announced in July 1999 that an extra $6.6 million over five years would be given to the Department of Conservation (DOC) to fund an integrated stoat control research programme. Only in New Zealand are stoats a conservation pest. They are widely regarded as the most significant predator of a number of New Zealand's most threatened and endangered native bird species. Stoat control in New Zealand will have to be ongoing if some endemic species, such as kiwi and kaka, are to survive on the mainland. Currently, stoat control relies largely on labour-intensive trapping—new, more cost effective and sustainable approaches to controlling stoats are urgently needed. The extra funding allocated means that there is now a real opportunity for finding cost-effective solutions for managing stoats.

The stoat programme in the first year (1999/2000) concentrated on reviewing what was already known about stoats and assessing potential directions for research. The second and third years have concentrated on finding more effective baits, lures and traps, as improvement in these areas will bring quick gains in the short-term. A number of these projects look promising and we are hoping to trial these in the near future.

The programme has also concentrated on understanding more about stoats and how they interact with other pest species. Previous ecological research has focussed largely on stoats living in beech forest, where their main prey are birds and mice. It is important to increase our understanding of stoats living in other habitats where different prey are important. For North Island brown kiwi in particular, a better understanding of stoats living in podocarp/broadleaf forests—where rats are a major prey—is needed urgently. Research into the ecology of stoats in a braided riverbed valley—where rabbits and birds are the major prey—has led to the surprising result that stoats and ferrets share den sites (but not at the same time). Common wisdom had been that they avoid each other.

Two major beech seeding years in a row have lead to high numbers of stoats in beech forest because of the dramatic increase in their prey—mice and birds. Although this has been good for collecting stoats for captive studies, it has unfortunately also led to the decimation of a number of bird species in beech forest. The unusually widespread appearance of rats in large numbers at the same time, and the devastation they have caused along with the stoats, highlights the need to be aware of how pest species interact. Although stoat numbers have been high in beech forests, they have been particularly low in the central North Island, hampering efforts to tease out the stoat/rat relationship there, to gain a better understanding of it.

The establishment of a captive-breeding colony of stoats is a high priority, as it will benefit many areas of stoat control research. Landcare Research is being funded to investigate a number of key areas in stoat reproductive biology, including artificial reproductive technologies. The stoat reproductive studies are providing a solid foundation to our understanding of stoats which we will then be able to apply to a number of projects.

Although the programme is focussing on improving traditional methods of control, some longer-term, higher-risk projects have also been funded, because a variety of methods are likely to be needed if stoat control is to become sustainable. Linkages have been made with both the Marsupial Cooperative Research Centre and the Pest Animal Control Cooperative Research Centre in Australia to take advantage of the experience they have gained in investigating biotech options for pest species, to expand our research expertise and to ensure co-operation and collaboration.

Photo: Department of Conservation

1. Year three of the stoat research programme

Welcome to the third year of the stoat control research programme. Since July 1999, when the five-year programme was initiated, a total of 48 projects have been funded.

In the last financial year (2000/2001) 30 research projects were funded. Of these nine have been completed and the remainder will be completed over the next 2–3 years. A total of eight new proposals are so far in the process of being funded for Year 3 (2001/2002). Appendix 1 (Tables 1–3) lists all the research projects from years2 and 3 of the programme.

This annual report will provide:
- A brief insight into the findings from research completed in 2000/2001
- A progress report on ongoing research
- A summary of research to be initiated this year (2001/2002)
- The process for the next funding round

1.1 EXPRESSIONS OF INTEREST

In February 2001, the advisory group sought expressions of interest to undertake research for year three of the stoat control research programme.

When seeking expressions of interest the following three priority areas were identified:

1. Research into management and control of stoats
- Logistically feasible and scientifically meaningful monitoring methods
- New baits and lures
- Improvements to aid current best practise

2. Research into understanding the behaviour and ecology of stoats
- Stoat behaviour
- Breeding of stoats in captivity
- Interactions with other pest animals

3. Innovative research that has the potential to increase dramatically the effectiveness of stoat control

The advisory group received a total of 42 expressions of interest, covering a wide range of research topics. The variety and calibre of the research proposed was impressive and, regrettably, a large number were unable to be funded.

The advisory group assesses each expression of interest in terms of:
- The objectives of the stoat control research programme
- The relevant experience of the research provider
- The proposed methodology

1.2 STOAT BIOTECHNOLOGY WORKSHOP

The stoat technical advisory group hosted a stoat biotechnology workshop in Christchurch on the 30 April and 1 May 2001. The workshop brought together specialists with experience in biotech pest control from New Zealand, Australia and Britain. The aim of this workshop was to get input on possible biotech approaches to stoat control. The key product specifications for any such control were that it be:

- Effective: reduce stoat numbers to levels that ensure viable populations of the species to be protected (e.g. kiwi, mohua, kaka).
- Efficient: no more costly than alternative products (actual costs/ha to aim for will depend on whether any future constraints are put on existing techniques—current costs for stoat control range from about $10 to $100/ha).
- Publicly acceptable:
  —Species or mustelid specific
  —Humane
  —Unable to contaminate the food chain
  —Consistent with the Government response to the Royal Commission
  —Consistent with the Treaty of Waitangi
  —Meets the legal requirements in New Zealand and International agreements

The workshop looked at what technologies are currently being developed for other species and assessed their potential for stoat control. The scientific and technical issues that must be addressed for the most likely approaches to work were also discussed along with what could be achieved by June 2004 (the end of this research programme).

Four approaches were recommended as likely to be successful in the long term if the scientific and technical challenges could be overcome:

- Use of canine distemper virus
  —Host specificity will have to be shown
  —It will need to kill humanely
  —Must be highly transmissible
  —Strain will have to have high mortality
  —Need to develop delivery system (bait/capsule)
- Pregnancy disruption
  —Find orally active form of compounds that disrupt pregnancy (wait for 'Achilles heel' review for suggestions, see Section 2.4)
  —Review risks to non-target species
  —Need to be able to breed stoats in captivity
  —Need to develop non-invasive test for pregnancy
  —Need underpinning research on diapause[1]
  —Develop delivery mechanism

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[1] In a number of species there is a delay between the fertilisation of the eggs by sperm and implantation of the blastocysts in the uterus. In stoats, the blastocysts float free in the uterus for 9–10 months before implanting the following spring—the embryos then develop to full term in about four weeks.

- Mustelid-specific toxin
  - —Select likely candidates from 'Achilles heel' review (see Section 2.4)
  - —Will need to be able to do rapid screening of candidates (could be done on mink farms overseas)
  - —Test target specificity of parent and synergist
  - —Develop aerial bait system
- Blocking reproduction with a disseminating agent
  - —Piggy-back on existing immunocontraception research
  - —Identification of potential antigens
  - —Identification of a transmissible mustelid-specific virus for delivery system
  - —Need to be able to captive-breed stoats

The information and recommendations from the workshop were subsequently used to guide the stoat technical advisory group in their deliberations on what directions should be taken in this innovative area of research. Research into a vaccine strain of canine distemper virus and a potential mustelid-specific toxin are already being funded. An 'Achilles heel' review is also underway and this review will recommend potential compounds to trial that could disrupt pregnancy in stoats, as well as candidates and potential synergists for a stoat- or mustelid-specific toxin. Although the technical advisory group thought it was worthwhile to fund some research into immunocontraception as a stoat control technique (piggy-backing on the considerable amount of research being done on possums and mice), it was thought too preliminary to decide on a delivery method, such as a genetically-modified virus. Before such a decision could be taken, the findings from the study on the social acceptability of new stoat control techniques, and the government response to the Royal Commission on genetic modification, would be taken into account. Risk assessments are also being planned for the various possible control methods.

1.3 LINKAGES WITH OTHER RESEARCH AGENCIES

The stoat programme has given DOC the opportunity to broaden its relationships with other key agencies, both within New Zealand and internationally. Landcare Research and DOC have jointly funded two projects, which has really added value to the work being done and resulted in true collaboration. A Memorandum of Understanding has been signed with the Pest Animal Control Cooperative Research Centre (PAC CRC) in Australia. This has resulted in invaluable advice being provided to the programme, particularly concerning the potential offered by research into biocontrol techniques. We will be funding a PhD through the PAC CRC, linking in with the Landcare Research stoat reproductive studies, for a student to undertake some preliminary research into fertility control for stoats. We are also in the process of signing another Memorandum of Understanding with the Department of Natural Resources & Environment in Victoria, Australia, to share expertise in the development of a humane, predator-specific toxin. These linkages are vital to ensure best use is made of the knowledge and expertise available and are likely to have flow-on effects to our other research programmes.

2. Research summaries

2.1 TRAPS

The National Animal Welfare Advisory Committee (NAWAC) has draft guidelines for evaluation of kill-traps and a number of traps are being trialled for their humaneness. Currently the most common kill-trap used for stoats is the Fenn trap, which comes in two sizes—Mk 4 and Mk 6. Recent trials undertaken by Landcare Research have shown that Fenn traps may not meet all the draft guidelines, so it is important to have or develop alternatives that do.

2.1.1 Research completed during 2000/2001 (Year 2)

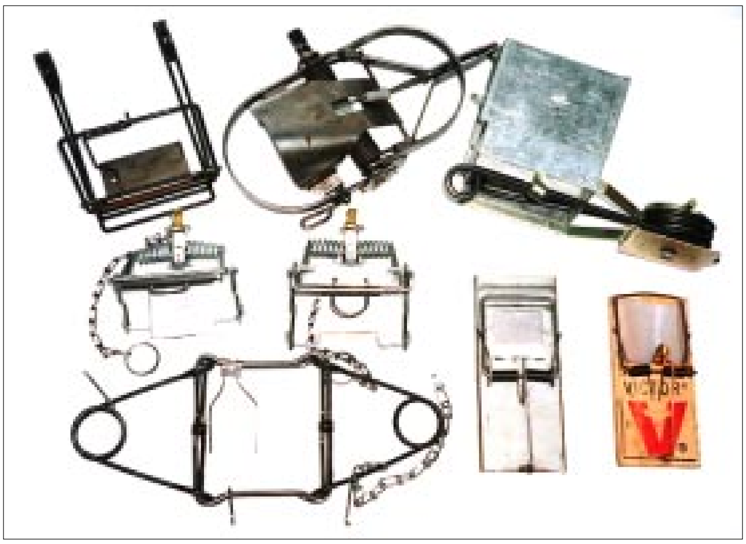
Development of a prototype kill-trap for stoat control

Malcolm Thomas (Pest Control Research Limited) investigated internationally commercially available kill-trap designs that are suitable for stoat control and compared their likelihood of achieving cost-effective and humane stoat kills. A prototype kill-trap was also developed with the view to providing an alternative, cost-effective and humane trap for stoat control operations.

Traps were evaluated in terms of their ability to achieve cost-effective kills (aspects considered were the portability, durability, cost, ease of setting and weight of the kill-trap) as well as their ability to deliver humane kills (aspects considered were striking force, clamping force and likelihood of achieving a neck strike). The study found that all of the commercially available kill-traps for small mammal control were capable of delivering humane kills to stoats provided the neck strike was achieved. The small, less expensive kill-traps were considered more likely to provide cost-effective control provided that humane kills could be achieved.

The prototype kill-trap developed is based on a modified Victor Professional rat trap that is considered to meet the standards for the humane killing of stoats (called short-tailed weasel in North America). The prototype was designed using literature and information gathered from contacts in Canada and from DOC staff. Problems identified with the Victor Professional rat trap was the wooden base that was prone to rot and the plastic trigger plate that was often removed or chewed by rats. The prototype has a steel base to increase robustness and field life, heavier springs to increase the likelihood of a humane kill and a cubby to guide the head into the trap to increase the likelihood of a neck strike. Performance tests have shown that the prototype has four times the striking force and two times the clamping force of the modified Victor Professional rat trap. This prototype also has a similar striking force, but only one-fifth of the clamping force of the Fenn trap.

Various traps used to kill stoats. *Photo: Malcolm Thomas*



A new project has been approved for 2001/2002 to undertake pen and field trials to test this prototype further in terms of humaneness and efficacy.

Gotcha electronic trap

Warren Agnew and co-workers Mark Chittenden, Eric McCall and Geoff Moon have developed a prototype electronic trap for stoats. The trap is operated using a sensor unit that is activated once the animal enters the trap. Two models of the trap have been developed. The first is a live capture trap that will be activated by animals larger than 105 mm and will produce a radio signal when activated. The second model could be used as a kill-trap by delivering a fatal dose of a toxin to the back of the animal passing through, although further trials would be needed to determine its feasibility.

2.1.2 Ongoing research

Development of an automatic multiple kill-trap for stoats

Ian Domigan (Lincoln University) and co-worker Bruce Warburton (Landcare Research) are developing a cost-effective automatic kill-trap. This new trapping system has the potential to provide a robust, multiple-capture trap that will significantly reduce the field time in servicing traps (particularly in remote areas such as offshore islands). Such a trap will also avoid the potential problem of localised trap saturation in years of high stoat numbers.

Four trap systems have been developed to incorporate the prototype kill system and tested. One trap model has shown great promise—it has a ten-kill capacity and has sufficient power to kill a stoat or ferret with a direct blow to the head if targeted correctly. A pressure or light sensor can activate the trap. Trials with a light sensor have identified the need for shielding to prevent the movement of the stoat on the outside of the trap activating the trigger. A treadle and switch pressure pad arrangement has shown good results in terms of detecting stoats, although research on the willingness of stoats to stand on treadles, and the amount of movement they will tolerate, has been hampered by the lack of stoats available for testing. Both mechanisms (light and pressure) require more fine-tuning to provide confidence that the trap will work effectively.

The date for completion of this project has been extended to November 2001.

2.1.3 New research funded for 2001/2002 (Year 3)

Effectiveness of a low-cost kill-trap system for stoats

Bruce Warburton and co-worker Nick Poutu from Landcare Research will test the effectiveness of a low-cost kill-trap system for stoats that could replace the currently used Fenn traps. This trap is the Victor rat snap-back trap that has been approved in Canada as a humane method of trapping stoats (which are called short-tailed weasels there). Stoats in Canada are considerably smaller than in New Zealand, so the trap's effectiveness here needs to be confirmed. The trap will be set with a specific bait cover to ensure a consistent strike location, and it will be tested to ensure that it is safe to use in areas where kiwi are present. This study will aim to demonstrate the humaneness and the effectiveness of the trap in pen trials.

This project will be completed by June 2002

Trials to test a prototype kill-trap for stoat control

Malcolm Thomas of Pest Control Research Limited has developed a cost-effective, compact and efficient kill-trap (see Section 2.1.1 above). This prototype trap is based on the principles of the Victor rat trap system, but has a steel base to increase robustness and heavier springs to increase the likelihood of a humane kill. Testing will now be undertaken with co-worker Fraser Maddigan, to ensure that the trap kills humanely (i.e. according to the draft specifications set by the NAWAC). Pen trials will then be carried out in a simulated natural environment using the standard stoat trapping tunnels used by DOC and the trap will be further refined and tested to determine the most effective setting methods. The final stage will involve field efficacy trials to ensure that the trap is as effective as the Fenn traps and that it is suitable for use in the field.

This project will be completed by June 2003.

Self-resetting mustelid eradicator

Frank Greenall and co-worker Keven Johnston have been funded to develop a cost-effective, humane, self-setting mustelid kill-trap. Preliminary testing has indicated that the device will be able to deliver approximately 20–25 humane kills before resetting is required. The trap will be elevated to avoid trapping ground-dwelling native birds. This trap would result in cost efficiencies by reducing the labour cost involved in resetting traps.

This project will be completed by November 2001.

2.2 BAITS, LURES, AND TOXINS

2.2.1 Research completed during 2000/2001 (Year 2)

Development of a long-life bait for the control of stoats

Ray Henderson (Pest Tech Ltd), Chris Frampton, and James Ross (Lincoln University) aimed to develop a long-life bait for the control of stoats. Fifteen stoats were caught from the wild and housed at the Pest-Tech animal facility. To formulate the bait base, a total of 27 potential bait ingredients were evaluated in 95 palatability trials. The best ingredients were then combined to formulate a bait base for protein baits, gels, and pastes. Flavour additives were evaluated in different bait types during 83 palatability trials. Salt, propylene glycol, sodium lactate and carbon disulfide were the only synthetic flavours evaluated that increased bait consumption. However, the use of natural prey odours in bait substantially enhanced the amounts eaten by stoats. ‘Emulsions’ prepared from the pelage and vital organs of rabbits and chickens were more attractive to stoats than the meat or heads of these carcasses.

Preservatives that contained high concentrations of organic acids (e.g. propionic acid) were unpalatable, as were high concentrations of antioxidants. It was noted that different types of preservative were required in protein baits as opposed to paste and gel baits. The inclusion of waterproofing agents changed the texture of baits. Baits that became hard or very viscous after being waterproofed were eaten in smaller amounts than baits that could be readily chewed and swallowed. For example, baits containing high-density, rigid polymers were harder and less palatable than baits with low-density, flexible polymers.

Baits containing odours from chicken and rabbit were significantly more palatable to stoats than baits constituted solely of processed meals and synthetic flavours. Animal extracts that were prepared as an 'emulsion' were preferred to 'digests', possibly because the application of heat to 'digests' had denatured some of the aromatic compounds in chicken and rabbit that are attractive to stoats. The effectiveness of prey odours for enhancing bait consumption was ranked: chicken = rabbit > hare = rat > freeze-dried rat. Although freeze-dried rat is widely used as a lure for stoat traps, it is not an effective compound in baits. This may suggest that stoats are responding to the visual cue of the freeze-dried rat as opposed to the odour.

While stoats only ate moderate amounts (12–16 g) of bait, they ate most of the 60 g of fresh meat that was provided as a maintenance diet. Therefore, fresh meat was more palatable to stoats than any of the baits formulated. Stoats did not readily eat hen eggs during this study. Few stoats ate eggs on the first day they were offered and one of ten stoats did not eat any eggs, whole or pricked, throughout an 8-day trial. Even though piercing the shell of eggs resulted in a higher percentage of eggs being eaten, most stoats still preferred meat.

Bait texture was important in determining the amounts of bait eaten by stoats. A 'soft' pelleted bait containing chicken emulsion was readily eaten (37 g/stoat) by all stoats. However, the addition of a polymer to waterproof the bait resulted in an increase in hardness and this reduced the amounts of bait eaten. Similarly, gels and pastes were eaten in smaller amounts as the viscosity of each bait matrix increased. Further development of long-life baits should ensure that final bait formulations have a soft texture.

Meat- and rodent-scented lures as attractants for stoats

Tom Montague (Roe Koh and Associates Ltd) compared lures designed to attract stoats to tracking tunnels in beech forest. The study was undertaken in Craigieburn Valley and Arthur's Pass National Park using a total of 160 tunnels lured with minced rabbit meat and 160 tunnels lured with a proprietary formulation based on mouse urinary proteins.

Attendance rates of stoats at tracking tunnels lured with rabbit meat were around 22%, nine times higher than at tunnels lured with mouse urinary proteins. This suggests that stoats are more attracted to rabbit meat than to a mouse urine lure, although it is possible the response may be different in a year when beech is not masting and when mouse numbers are low. Tunnel attendance by mice for both lures was 63%.

Tracking tunnels of standard DOC design were used initially; however, there were problems with mice eating the foam ink-pad. As a result, an alternative design was developed. The main innovation was the use of an ink, made of mineral oil and carbon (MOC ink), which was applied as a film (without a foam pad) to the middle section of the tunnel. This ink mixture did not dry out as quickly as the foam pad of food dye and water and produced waterproof ink tracks.

Evaluation of new toxins for stoats

Currently, no toxic baits are registered for stoat control and although 1080 in hen eggs has been used previously, the use of 1080 is controversial due to its lack of specificity. Landcare Research prepared a report for DOC in 1998 identifying possible mustelid-specific toxicants and this project has involved testing them to determine if any had potential.

Cheryl O'Connor (Landcare Research) and co-workers evaluated:

- Sensitivity of captive stoats and ferrets to new, potentially mustelid-specific toxicants in single-dose acute toxicity studies
- Sensitivity of captive possums, wallabies, and ducks to the most promising of the toxicants

This study found that in ferrets, acetaminophen (a methaemoglobin-inducing agent) induced 50% mortality at 200 mg/kg, the highest dosage tested. However, stoats given the same dose showed no signs of illness and no mortalities were recorded.

Non-steroidal anti-inflammatory agents were also tested on ferrets, with no signs of illness or death from acetylsalicylic acid, while ibuprofen induced loss of consciousness for several hours in one ferret and vomiting in another.

A compound designated 'Mustelid New Toxin' (MNT) was also trialled. MNT is based on the Australian predator toxin being developed and has similar toxicological effects to acetaminophen. MNT caused no deaths in ferrets at the lowest dose tested (12.5 mg/kg), while 55% mortality was caused at 25 mg/kg and 91% mortality at 50 mg/kg. For stoats, dosages of both 25 mg/kg and 50 mg/kg caused the death of all animals tested within 50 minutes.

Tests on brushtail possum, wallaby, and Peking ducks were also undertaken. All animals exhibited susceptibility to MNT—ducks died at dosages similar to those that caused mortality in ferrets, possums and wallabies died at higher dosages.

Summary

- Ferrets, but not stoats, were susceptible to acetaminophen at the low doses tested.
- Human non-steroidal anti-inflammatory agents (acetylsalicylic acid and ibuprofen) were not toxic to ferrets at the doses tested.
- Ferrets were susceptible to MNT with an approximate LD_{50} of 29 mg/kg (95% CI: 22–37 mg/kg).
- Stoats were highly susceptible to MNT, with 100% mortality at 25 mg/kg.
- Preliminary observations indicate that death from MNT is relatively humane in mustelids, with no obvious signs of distress or pain observed.
- The non-target species tested (possum, wallaby, and duck) were all susceptible to MNT. The lethal dose for ducks was similar to that for stoats and ferrets; the dose for possums and wallabies was higher.

2.2.2 Ongoing research

Feracol for stoat control

Jeremy Kerr (Feral R&D Limited) and Dr Andy Lavrent (Immuno Laboratories) are looking at the effectiveness of a long-life bait which they have developed. Trials indicate that the bait may be highly palatable as captive stoats readily consumed it. Work this year concentrated on refining the formulation to ensure that it is stable in the field. To date 16 formulations have been trialled at the Landcare Research facility at Lincoln. A final pen trail was undertaken in August with the most palatable formulation containing a lethal dose of the poison Cholecalciferol, to test whether captive stoats would still eat the baits.

This project will be completed in September 2001.

Paired trial of long-life stoat baits in a northern coastal environment

Nigel Miller and Pete Graham from DOC, Northland are comparing the use of fresh rabbit with dehydrated rabbit as baits in Fenn traps. Previous experience had indicated that baiting traps with fresh rabbit meat was more effective in warmer climates than baiting with hen eggs. However, the baiting of traps with fresh meat is labour-intensive, as the meat rapidly deteriorates and has to be replaced. The aim of this study is to determine whether fresh meat can be preserved (through a freeze-drying process) and yet still retain its attractiveness. For warmer climates this would present a more cost-effective means of controlling stoat numbers.

Difficulties have been encountered in obtaining a sufficient quantity of freeze-dried bait from the suppliers and, as a result, this project was not initiated until after the summer peak in stoat numbers. Thus, to date, catch rates have been insufficient to build up a robust picture of stoat preference, and the trial will therefore need to run for a further summer to collect enough data to draw any conclusions.

This project will be completed by June 2002.

Testing attractiveness, palatability, and longevity of stoat lure and bait formulations

The aim of this research is to search for new, highly attractive, long-life lure and bait formulations. Kay Clapperton and co-workers Lloyd Robbins, Tony Woolhouse, and Dick Porter are comparing different food lures (e.g. rabbit, rat and sparrow) and novel odours in a range of possible bait matrices for their attractiveness, palatability, chewability, and longevity in terms of attracting stoats. These could be used as long-life attractants to lure stoats to traps, or to entice stoats to eat poisoned baits or baits containing a vector for biological control.

To date, tests have been carried out to determine the test procedures and criteria for the stoat responses to odour sources. Tentative results have indicated that cracked eggs show a low-level response, which is consistent with the experience from some field trials where rabbit and hare bait are more effective than eggs. Rabbit, rat, mouse, and sparrow have all shown promising results in terms of their attractiveness to stoats. Whole animals have been offered so that all sources of possible odour are present. Further trials have indicated that flesh and gut were more attractive than skin. Tests using dried pet food indicated that this material held no attraction for stoats.

Craig Gillies holding a stoat with radio-transmitter attached. *Photo: Nic Gorman*

The promising odour materials are currently being tested in various edible bait and long-life lure formulations. It is intended that the most attractive lures will be field-tested in an intensively managed stoat population at Lake Waikaremoana.

This project will be completed in June 2003.

Prey odours as lures for stoats

Andrea Byrom and co-workers Eric Spurr and Cheryl O'Connor from Landcare Research are developing a prey odour lure encapsulated into a long-life, slow-release matrix.

To date, four matrices for incorporating rodent odours for testing on captive stoats have been developed. The four matrices, into which powered freeze-dried laboratory rats have been incorporated, are:

- A PVC matrix developed in the USA and created at Landcare Research
- A casein-based matrix, Albert®, developed by KiwiTech Ltd
- A gel matrix created by KiwiCare Corporation
- A pelletised meat-and-bone-meal developed by AgResearch, Ruakura

Liquid odour compounds will also be extracted from around the headspace of live lab rats (and possibly feral ship rats) and this compound will then also be incorporated into the above matrices for testing. It is anticipated that between 4 and 8 different lures will be available for testing on captive stoats in 2001/2002.

This project will be completed by June 2003.

2.2.3 New research funded for 2001/2002 (Year 3)

Comparison of hen eggs, freeze-dried laboratory mice, and freeze-dried feral rats as lures for trapping stoats

Rhys Burns and Pete Shaw from DOC, Opotiki will undertake a study to compare freeze-dried feral rats, freeze-dried laboratory mice and hen eggs as lures for a trap-based stoat control programme in the northern Te Urewera National Park. Promising results were obtained from a study undertaken by the Opotiki Area Office last year which compared the effectiveness of freeze-dried feral ship rats as a lure compared with hen eggs (one of the common lures currently used by DOC for trap- or poison-based stoat control). Freeze-dried rats remained viable for approximately 6 weeks and out-performed hen eggs in terms of their effectiveness at luring stoats into a trapping tunnel. However, the practical difficulty and cost associated with obtaining and drying enough feral rats to maintain the trapping programme was identified as an issue. Freeze-dried laboratory mice would provide more readily available and cost-effective lures, but they need to be tested against freeze-dried feral rats.

The project will be completed in June 2002.

A pregnant female stoat which turned white in winter, and is just starting to moult back to brown—Sep 2001.
Photo: John Dowding

Development of a new toxin for stoat control

Currently no toxic baits are registered for stoat control. Although 1080 in hen eggs has been used previously to control stoats, its use is controversial due to its lack of target specificity. Previous research by Landcare (see Section 2.2.1) identified a promising toxic compound to which certain target predator species have a high susceptibility. In conjunction with the Victorian Department of Natural Resources and Environment (Australia), this compound (designated 'Mustelid New Toxin' MNT for confidentiality) is being developed for use in baiting methods for pest predator control. Initial results indicate a lethal dose of MNT to be less than 25 mg/kg in stoats and suggest that toxicosis is relatively humane and rapid. Penny Fisher and Cheryl O'Connor from Landcare Research will build on these encouraging results and conduct dose-range-finding trials in stoats to derive a working lethal dose value for this species. The project will also review the likely susceptibility of non-target species (especially dogs and birds) to MNT in baits prior to its further development as a new tool for stoat control. This project addresses the first stage in development of a new toxin for stoat control and aims to build baseline information about the efficacy and humaneness of MNT in stoats.

The project will be completed in June 2002.

Control of stoat dens with magnesium phosphide (Magtoxin) after locating with trained dogs

Scott Theobald and Natasha Coad of DOC, Northland will investigate the effectiveness of 'Magtoxin' as a method of killing stoats in natal dens at Trounson Kauri Park. A study undertaken in Northland last year demonstrated that natal dens could be located by trained predator dogs. The pellets of Magtoxin (Magnesium phosphide) produce a poisonous gas that has been shown to be effective against burrowing pests. Trounson Kauri Park experiences an influx of young stoats (many of which appear to be reared locally) during the summer. A mustelid control programme has been undertaken in the Park for the last five years to protect the young kiwi chicks that are particularly vulnerable to stoat predation. While this project of poisoning dens would not negate the need for mustelid control during the summer, it has the potential to significantly reduce the numbers of young stoats entering the area.

This project will be completed by March 2002.

2.3 ECOLOGY

2.3.1 Ongoing research

The movement and diet of stoats in an alpine-beech forest habitat

Des Smith (MSc student) and Ian Jamieson (University of Otago) have completed the fieldwork associated with their study of the effectiveness of low-intensity trapping techniques in the Takahe Special Management Area during a stoat outbreak (the topic of Des's thesis).

Alpine study site in Ettrick Burn, Murchison Mountains. *Photo: Kristen Charleton*

Almost all of the ecological research on stoats in New Zealand has been confined to lowland forest habitat, with little or no study of alpine regions. DOC is investigating the feasibility of a stoat control programme in Fiordland to protect breeding takahe and other avian species that live above the treeline in the alpine/tussock zone. The objective of this study was to determine whether trapping in adjacent, more accessible valley floors would impact on the alpine stoat population.

The second and final field season for this study has now been completed. Three kilometres of valley floor in beech forest and three kilometres of adjacent alpine ridge with tussock habitat in the Murchison Mountains were live-trapped from December 2000 to March 2001, and stoats fitted with radio collars. Tracking tunnels were also used as an additional measure of stoat abundance in the study area, as well as in two nearby sites. In all three study sites, tracking tunnel indices were higher for the valley floor than the alpine habitat. In the main study area, 13 stoats were caught in the valley floor and five in the alpine zone. Fifteen radio-collared stoats were tracked over the study period and no stoats moved between the two habitat types. Although relatively few stoats were caught in the alpine habitat, those that were tracked there appear to be resident, at least during the summer. Analysis of the diet from stoats kill-trapped in other areas of the Murchison Mountains, found that mammals (mostly mice) were the main prey item in beech forest, but birds had a slightly higher frequency of occurrence in stoats killed in the alpine zone. Interestingly, weta were a predominant food item in both habitats. Overall, the research indicates that trapping a network of valley floors is unlikely to directly protect nesting takahe and other native species inhabiting the alpine zone, especially during a stoat outbreak.

A report/thesis on this work will be completed by December 2001.

Ecology of stoats in a South Island braided river valley

John Dowding of DM Consultants and co-worker Mike Elliott are studying the ecology of stoats in the Tasman River valley, Mackenzie Basin. South Island braided rivers, such as this, provide an important breeding habitat for a number of threatened endemic ground-nesting birds such as black stilt, wrybill and black-fronted tern.

A tracking tunnel line on the gravel bed of the Tasman River. *Photo: John Dowding*

Live-capture and radio-tracking of stoats in and around the Tasman River is being undertaken to gain information on stoat home range size, activity patterns and habitat preferences. Radio-tracking is being done during a 3-month period in spring-early summer (when the shorebirds are breeding) and again in autumn-early winter (when the shorebirds are absent). Some problems have been experienced with transmitter life in the bouldery environment of the riverbed; however, good data has been collected as animals were easily re-trapped, where necessary.

Tracking tunnel in the Tasman River.
Photo: John Dowding

Results to date show that stoats are generally evenly spread throughout the area with no obvious 'hot spots' and no large areas where they are absent. Range sizes appear to be consistent with the limits found in other studies in different habitat types in New Zealand. Rabbit numbers are not high in the study area and rodents appear to be scarce for much of the year (RHD was introduced to the study area 3 years earlier). Thus, it appears that relatively high densities of stoats can persist in spite of the lowered rabbit densities. Stoats appear to survive in this environment by eating birds and the few rabbits available. Remains of eggs, chicks, or adults of pied oystercatcher, banded dotterel, spur-winged plover, wrybill, and black-fronted tern have all been found in dens, indicating that stoats in this area are having a major impact on breeding shorebirds.

To date, the study has also found that interactions between stoats may be much more common than previously thought, with the level of consecutive den use relatively high. While males and females are known to interact during the breeding season, this study has also found examples of males using a common den site consecutively in spring, and males and females using them consecutively in autumn (i.e. outside the breeding season). These findings have implications for the transfer of potential biocontrol agents. Consecutive den use by stoats and ferrets also suggests potential for the spread of biocontrol agents between mustelid populations. However, few ferrets were radio-collared and thus the extent of common den sites between species is not yet clear. Collaring of a greater number of ferrets in year two will provide more information with respect to this.

This project will be completed in September 2002.

Quantifying stoat and rodent population parameters in podocarp/broadleaf forests for predictive modelling

Wendy Ruscoe and Andrea Byrom from Landcare Research are conducting a three-year study of the ecology of stoats in a podocarp/broadleaf forest. The aim of this study is to:

- Gain information on the recovery of stoat and rat populations after a 1080 control operation
- Determine the nature of the relationship between rat and stoat abundance
- Determine dispersal and survival characteristics of adolescent stoats in response to food availability (rodents) and the density of resident stoats

This information is needed because the mechanisms regulating the density of stoats in a podocarp/broadleaf system and their propensity to prey on key native bird species is not well understood. While dietary studies have indicted that rats are an important food for stoats, it is not clear whether changes in rat availability lead to changes in stoat numbers.

The first part of the study is looking at the interaction between rats and stoats. Sites have been selected in the north-west half of Tongariro Forest and two trapping sessions were undertaken prior to a 1080 poison operation in

September 2001. A further set of trapping sessions will be undertaken after the poison operation to look at the recovery trajectories of rat and stoat populations.

The second part of the study is looking at the dispersal of juvenile stoats. A total of 150 traps were laid out and baited with mice, lab rats, rabbit, hare or possum meat for a 4-month period between November 2000 and March 2001. However, despite the intense trapping effort, only low numbers of stoats were caught. Seven juvenile stoats were radio-collared and the logistics of catching, collaring and tracking the juveniles were fine-tuned. Of the seven stoats, three died soon after collaring as a result of inclement weather; of the four remaining, one female survived 5 months, while the others survived for between one and four weeks. While the sample size was too small to draw conclusions, the stoats that were radio-collared and tracked remained close to the area where they were originally caught, which may suggest density-dependent dispersal. However, further work and larger sample sizes will be required to test this hypothesis. One adult female stoat was collared in July and it hoped to be able to find and follow her young when they disperse.

This project will be completed by June 2003.

Effect of reducing possum densities on ship rat and stoat abundance

Peter Sweetapple and Graham Nugent of Landcare Research have begun a study looking at the effects of possum control on ship rat and stoat abundance. Periodic aerial control of possums on five to seven year cycles (either for Tb control or conservation management) is the most common management regime on land administered by DOC. Aerial use of 1080 typically kills greater than 80% of both the possum and ship rat population and an unknown proportion of stoats. Possums in large control areas typically recover from a 90% reduction within a decade, while rats and, presumably stoats can recover from any direct effects of poisoning within a year. However, there is increasing evidence that decreased possum numbers allow rats and presumably, stoats to reach much higher densities than before the 1080 control. For example, at Pureora the density of rats after 1080 control was three times higher than pre-control densities. This increase may be due to a reduction in competition from possums for fruit and seeds.

The key questions to be answered from this work are:

- How much do rats and stoats increase as a consequence of reduced possum density?
- How long does the effect last?
- What are the causes of changes in rodent and stoat numbers?
- What are the benefits and losses of fewer possums but more rats and stoats?

Work to date has focused on identifying where new possum control operations, in North Island podocarp/hardwood forests, will be undertaken in 2001/2002. Two sites (treatment and non-treatment blocks) near Minginui, where possum control is planned for July 2001, were selected as the first of two possum control operations to be monitored for this project. Pre-possum control indices of possum, rat and stoat abundance were found to be similar in both the treatment (Okahu) and non-treatment (Whirinaki) blocks, with possum densities high and rat and stoat densities low. The first post-possum control assessment of rat and stoat abundance at the Minginui sites will be undertaken in December 2001. Moki forest, Taranaki has been selected as the second site for investigation.

This project will be completed in June 2004.

Evaluating the use of tracking tunnels to monitor mustelids as well rodents

Craig Gillies and Peter Dilks (DOC Science & Research Unit) have been investigating whether a small change in the current protocol for using tracking tunnels to monitor rodents is all that is required to allow the same tunnels to be used to track mustelids. Ink footprint tracking tunnels are now commonly used at many mainland conservation sites to monitor the effects of pest control operations on rodent abundance. The abundance indices obtained can be directly related to rodent impacts on several native bird species. Since the technique does not impact the pest population it can be used for direct comparisons between managed and unmanaged sites.

Craig Gillies checking a tracking tunnel. *Photo: Ian Marshall*

The same tunnels used to track rats (with peanut butter as bait) can also be used to track stoats (using meat bait) without any residual effects on rat tracking rates. However, because there are huge differences in the ranging patterns of stoats and rodents the currently accepted tunnel layout for rodents does not provide much in the way of statistically reliable information on stoat abundance beyond simple presence or absence. At sites where managers wish to monitor both rodents and mustelids it would be logistically much simpler if the same tunnels could be used to track both pests. A small change in the current design protocol for using tracking tunnels to monitor rodents may be all that is required to allow the same tunnels to be used to track mustelids.

Several DOC managers from different sites around New Zealand agreed to participate in trials to assess the effectiveness of a revised tracking tunnel layout for providing indices of both rodents and mustelids. Mustelid and rodent tracking rates under the trial tracking tunnel layout were recorded from

Tracking papers showing stoat and ferret prints (*left*), and mouse and hedgehog prints (*right*). *Photos: John Dowding*

Boundary Stream (and non-treatment sites), the Dart, Caples, and Eglinton valleys and at Whirinaki (two sites) four times throughout the previous two years. At all sites, where some form of mustelid control was taking place, tracking data could be compared against non-treatment sites. It was found that the proportions of lines tracked were generally lower than at the associated non-treatment sites. The work at these management sites also highlighted the considerable logistical difficulties associated with attempting to survey mustelids on a spatial scale relevant to their typical ranging patterns (i.e. many hundreds of hectares). Nevertheless, this technique provided a useful stoat management indicator and a coarse index of mustelid abundance. While the trials have now been completed for these sites, many DOC managers have decided to continue to use this technique as an independent indicator of the impact of their mustelid control operations on local mustelid populations.

In conjunction with the trials run at management sites, tracking rates have been compared with live trapping estimates of stoat abundance at three sites—North branch of the Hurunui and Craigieburn (in Canterbury) and Pureora (central North Island). High tracking rates were recorded at the same time as large numbers of stoats were caught in the live traps. Conversely, at Pureora, lower tracking rates were recorded at the same time as few mustelids were caught in the live traps.

Based upon the results to date, it appears that tracking using the same tunnels could be used to monitor both rodents and mustelids. For stoats (and possibly other mustelids) the index should be considered as a very basic management indicator and a coarse index of mustelid abundance. This project has been extended for another year to enable at least another seven live capture versus tracking rate data points to be obtained. As yet, few data for 'medium' densities of stoats (or other mustelids) have been obtained and it is anticipated that this 'gap' may be filled over the 2001/2002 year. The fieldwork component of this project will be completed by June 2002 and data analysis and write up completed by June 2003.

Modelling the immigration rate of an island stoat population

Graeme Elliot and Murray Willans of DOC have initiated a four-year study looking at the re-invasion rate of stoats at islands in Fiordland. All the islands included in this study are within stoat swimming distance, but are too small to support resident stoat populations.

Predator-free islands are important in the conservation of some of our most endangered species and while many of the islands in this study are too small for this purpose, the information obtained in this study will allow us to estimate likely re-invasion rates of larger islands. While it is impossible to permanently eradicate stoats from these islands, if re-invasion rates are low and stoat control efficient, such islands (although within swimming distance for stoats) may be safe enough to support key endangered species.

The information obtained from this study will be used to construct a predictive model to show the relationship between invasion rates and topographical and population parameters. This predictive model would then be used to implement control regimes based on an estimate of the invasion rates and persistence times for specific islands being considered for the conservation of endangered species.

Twenty-eight islands in Doubtful, Breaksea, and Dusky Sound, and Lakes Te Anau and Manapouri were selected for this study. The islands range in size from 2 ha to 200 ha and also range in distance from the shore, but all are within the known swimming range of stoats. A trapping regime has now been set up on all the islands. The traps are serviced twice a year (May and December). The first servicing took place in December 2000 and stoats were caught on six of the islands and the egg baits had been removed from the traps on a further three of the islands. It is believed that the eggs were removed by stoats (there has been a problem with the traps not being activated, but this has now been resolved). It was observed that all stoats or stoat sign was found on the islands which were within 500 m of the mainland.

This study will be completed by June 2004.

Modelling the dynamics and control of stoats

This two-year project is being undertaken by Nigel Barlow from AgResearch, and implements one of the recommendations from the review of modelling carried out in 1999/2000. The results of this study will provide more soundly based assessments of the feasibility of biological control options and of the likely levels of control necessary to achieve the given reductions in stoat density. This work could be extended to apply to the evaluation of all controls (traditional and novel).

Work this year has involved refining the existing crude model for stoats (based on the relationship between exponential growth rate and density) by including age structure, birth and death rates and separate coefficients for the three key systems/scenarios (i.e. beech forests during mast years, beech forests in non-mast years, non-beech forests). In addition, a preliminary analysis has been carried out to predict and compare the likely impacts of some general control strategies. With respect to the impact of stoats on kiwi populations, a re-analysis has been carried out using a different approach than that previously adopted. Work has also been initiated to determine whether it is possible to deduce actual densities from trapping data based on rates at which catches decline over time during consecutive nights and then recover during intervals between series of trap catches.

Results to date have indicated that in the short term culling is more effective than fertility control, but the difference is less for stoats than for other key pests. This is partly because of their high rate of increase, particularly in beech forests. In the long term, culling and fertility control have been shown to be equally effective, with fertility control being more effective in beech than in non-beech forests. This makes stoats a potentially good target for vectored immunocontraception, other things being equal, since it offers a way of achieving the necessary proportion of sterile animals.

Work on the modelling process to date has identified a number of critical data and analysis/modelling needs. These include:

- In non-beech habitats—adult survival rate, survival of juveniles in relation to density, and productivity.
- In beech forests—adult survival in mast years.

- Sequences of trapping off-take per night from sequential trapping and non-trapping periods.
- Population increases estimated from live-trapping.
- More data relating stoat density indices to kiwi mortality and on stoat density changes from year to year in kiwi habitats, including immigration and density-dependence.
- Analysis of kiwi data collected post-1996, using the life-table approach and with reduced uncertainty about the contribution of predation to unknown mortality.

The project will be completed in June 2002.

2.4 BIOLOGY

2.4.1 Ongoing research

Stoat reproductive biology

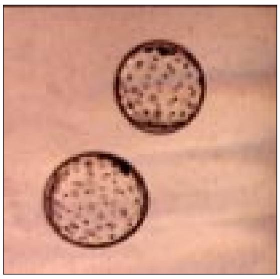
Development of an effective fertility control for stoats requires a thorough understanding of stoat reproduction, about which little is presently known. Cheryl O'Connor and Janine Duckworth, with co-workers Frank Molinia and Andy Glazier from Landcare Research have embarked on a three-year study of stoat reproductive biology. The aims of this study are:

- To monitor reproductive biology, stress physiology, immunology and behaviour of wild-caught stoats during and following acclimatisation to captivity.
- To alter photoperiod (light-dark cycle) to examine control of oestrus, seasonal breeding and the prolonged 10-month period of embryonic diapause.
- To develop techniques to assess and manipulate the reproductive state of stoats during oestrus and pregnancy.
- To optimise husbandry and welfare of stoats leading to the establishment of a captive-breeding colony of stoats that will benefit research in many areas of stoat control.

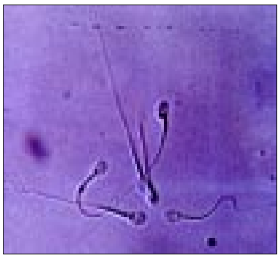
A captive stoat breeding facility has been established at the Landcare Research Animal Facility. Six female stoats were paired with males in breeding pens during the period October–December 2000. All six females will remain in the facility until the expected birth of offspring in October 2001. Non-invasive monitoring of pregnancy is being undertaken during this time by collection of faecal samples for future reproductive hormone analysis.

A total of 17 female stoats have been sampled as part of the acclimatisation study. To date there has not been an obvious effect of time since capture on blastocyst survival. The number of blastocysts recovered from females at 0, 4, or 12 weeks after capture varied little (mostly 6–9), and there was no difference in ovarian tissue and reproductive tract weights.

In addition, 31 animals (including the 17 stoats in the acclimatisation study) have been subjected to both 'feeding' and 'behaviour response' tests since capture. Initial observations indicated changes in feeding behaviour after 6 weeks and in response to humans after 8 weeks in captivity. Immunological responses improved after 4–12 weeks of captivity. As a preliminary



Stoat blastocysts (c. 1 mm in diameter). *Photo: Janine Duckworth*



Picture of stoat sperm. *Photo: Andy Glazier*

recommendation it is suggested that an 8-week period of acclimatisation to captivity is required for stoats.

This project will be completed by June 2003.

Stoat artificial reproductive technology

Andy Glazier and Frank Molinia of Landcare Research are developing 'assisted reproductive technologies' (ART) for the stoat so that aspects of their reproduction may be controlled and manipulated in captivity to generate gametes, embryos/blastocysts and, ultimately, live young on demand. This information will significantly broaden our knowledge of the key features of stoat reproduction, and thereby assist in captive breeding and the future identification, development and testing of unique reproduction-based targets for biocontrol.

The development of stoat ART will be undertaken in three broad parts. It will:

- Maximise the use of materials opportunistically available from wild-trapped stoats, to establish methods for collection and handling of sperm, eggs, embryos/blastocysts and reproductive tracts.
- Develop *in vivo* models of key reproductive events. A model for egg maturation will be established by developing oestrus synchronisation and/or ovulation induction of females. Primed females could then be used to generate embryos /blastocysts following either natural mating or artificial insemination. In this way, models of sperm maturation, gamete interaction, fertilisation and embryogenesis, occurring within the female stoat can be developed.
- Develop *in vitro* models of these processes. Given that stoats carry blastocysts for up to 10 months, thus presenting a logical target for biocontrol, development of *in vitro* methods for culturing embryos/blastocysts will be undertaken.

To date, the emphasis has been on establishing collection and handling skills. Stoats (male and female) have been accessed either fresh from ongoing trials at Landcare Research or from frozen storage, and familiarisation of the reproductive tract physiology and methods of recovery of gametes and blastocysts undertaken. Flushing uterine horns with tissue culture media yielded recovery of fully expanded, diapausing blastocysts, whereas earlier attempts to flush using phosphate-buffered saline (PBS) had resulted in the collapse of the blastocysts. Maintenance of blastocyst viability is a vital step in understanding the relationship between diapause, implantation and (hormonal) regulation of these events.

Viable sperm can be recovered by flushing the epididymides of recently euthanased males. However, this method is only reliable from sexually mature males during the breeding season, when sperm production is at its highest. Routine methods for collection and fixation of reproductive tracts have also been established.

An application to the Landcare Animal Ethics Committee (AEC) for permission to perform experimental manipulation of stoat reproduction, towards development of *in vivo* and *in vitro* models of key reproductive events, has been submitted.

This project will be completed in June 2002.

Review of potential 'Achilles heel' characteristics of the stoat

Clive Marks, sub-contracted by the Pest Animal Control Cooperative Research Centre (Australia), is undertaking a review to find possible 'Achilles heel' characteristics of the stoat. This type of review attempts to identify anomalies in the pest that could lead to the development of highly targeted methods of control.

The stoat is phylogenetically divergent from New Zealand's endemic animal groups and this has seen the evolution of different behavioural, physiological, and biochemical characteristics compared with indigenous and endemic species. Identification and exploitation of such anomalies represents a unique opportunity to produce species–specific control techniques for exotic pest species. This approach has not been widely exploited in the development of mammalian pest control techniques in New Zealand and Australia, although both countries are well placed to do so by virtue of their unique assemblage of indigenous fauna that contrast with the recent introductions of exotic fauna. As literature pertaining to stoats is limited, other closely related mustelids (e.g. ferrets, mink, weasels) were included in the review. The general overview to date has identified a range of characteristics as possible 'Achilles heels' in the stoat, which include:

- The small body size and high metabolic rate compared with other carnivores is likely to increase its susceptibility to bait-delivered lethal and anti-fertility agents.
- Stoats may be particularly susceptible to a range of novel agents that may selectively produce a state of hypothermia and rapid death.
- Existing studies of ferrets suggest that the stoat red blood cells (RBC) may also be susceptible to methaemoglobin (MetHb)-forming compounds which birds are highly tolerant of.
- It is likely that stoats maintain unusual monovalent ion (Na^+ and K^+) concentrations in their RBC's and lack Na^+ membrane pumps. It is possible that an unusual ion transport system can be manipulated to further predispose the stoat RBC to oxidative stress and increase the target-specificity of MetHb-forming compounds.
- Selective inhibition of key metabolic enzymes in the RBC may also predispose the stoat to the lethal effects of MetHb-forming agents.
- Oestrogens can cause an unusual form of anaemia in mustelids and a better understanding of this mechanism may reveal another selective method of enhancing the lethality of MetHb-forming compounds.
- The ability to selectively predispose some carnivores to 1080 toxicosis is also proposed.
- The use of analgesic and anxiolytic compounds in combination with lethal agents is a promising technique that may address concerns about the humaneness of lethal agents.
- The seasonally monoestrous breeding pattern and unusually long period of embryonic diapause is a highly anomalous feature of stoat reproduction. Partial dependence upon prolactin to maintain pregnancy suggests that dopamine agonists may produce abortions in the stoat. Alternatively,

dopamine antagonists may terminate embryonic diapause. Both approaches are potentially viable methods of fertility control.

- A range of delivery systems for toxicants and anti-fertility agents that target short gastro-intestinal passage time, differential bite forces and particle size ingestion compared with non-target species are proposed.

The preliminary review indicates that the potential for developing highly targeted lethal and non-lethal control techniques for stoat is high. Now that the general overview has been undertaken, a more focused assessment will be carried out on target-specific toxicants and dopamine antagonists and agonists as fertility control agents.

'Proof of concept' for a number of the suggested approaches could be rapidly obtained in discrete trials using captive populations of mink or ferrets as an experimental model in 2002.

This review will be completed by December 2001.

2.4.2 New research funded for 2001/2002 (Year 3)

Monitoring hormones of stoat reproduction

Andy Glazier and co-worker Frank Molinia of Landcare Research will provide information on the major hormones associated with reproduction in stoats (testosterone in male stoats and oestradiol, progesterone and follicle-stimulating hormone (FSH) in female stoats). Little is currently known about these hormones in stoats and the development of assays to monitor the hormones throughout the natural reproductive cycle will provide much-needed information for the work currently underway in stoat reproductive biology and artificial reproductive technology. Once the benchmark values for the natural reproductive cycle are established, any artificial manipulations of the breeding cycle can be validated. Knowledge of the reproductive hormones is essential if biocontrol through interruption or manipulation of the breeding cycle is to be contemplated in the future.

This project will be completed by June 2004.

2.5 BIOTECH/BIOCONTROL

2.5.1 Ongoing research

Biological control of stoats using a vaccine strain of canine distemper virus

Tao Zheng (AgResearch) with co-workers Bryce Buddle, Guangjin Lu, Anna Dickie, and Lindsay Matthews have initiated a three-year investigation of the vaccine strain of canine distemper virus as a lethal agent for the biocontrol of stoats. Overseas studies have shown that stoats and other mustelids are susceptible to the canine distemper virus and the vaccine strains of this virus can cause mortality in ferrets. Using the vaccine strain of the virus has several advantages:

- The vaccine strains are currently approved in New Zealand as a vaccine for dogs.

Portacom ferret holding facility (canine distemper studies). *Photo: Tao Zheng*

- The vaccine would not represent a biological hazard to domestic animals.
- The use of the vaccine strain would not require genetic manipulation of an agent and is unlikely to attract the same level of public concern as a genetically modified organism would.

The key aims of this study are to determine the:

- Lethality and transmissibility of vaccine strains of canine distemper virus in stoats.
- Infection status of New Zealand stoats to the canine distemper virus by examining the sera from trapped animals.

The first year of this investigation has focused on the establishment of a $50,000 three-module stoat and ferret housing facility (Portacom) which has been installed on the Wallaceville campus. Forty-seven ferrets are currently being acclimatised in this new facility.

In terms of the virus:

- A Vero cell adapted canine distemper virus has been obtained from Massey University, chicken fibroblast cell cultures have been established, and a canine kidney cell line (MDCK) has been obtained from the National Centre for Disease Investigation. These cell cultures will all be used for the culture of canine distemper virus in the laboratory.
- Various vaccine strains of canine distemper virus have been obtained from commercial suppliers.
- An import permit from MAF for importing different stains of canine distemper virus from overseas has been obtained. Various strains of canine distemper virus are in the process of being imported from Cornell University, U.S.A.
- Approval has been obtained from the Wallaceville Animal Ethics Committee for the experiment proposal.

Research to be initiated in 2001/2002 will include:

Ferrets in free-range pen at facility. *Photo: Tao Zheng*

- Experimentally infecting ferrets with different strains and dose of canine distemper vaccine to determine the virulence of each vaccine to ferrets.
- Testing the sera from feral stoats for antibodies against canine distemper virus.
- Establishing a captive stoat colony and carrying out challenge trials with vaccine strains of canine distemper virus.

The project will be completed by June 2003.

Incidence and diversity of Bartonella *in stoats and other wildlife*

Robbie McDonald with co-workers Richard Birtles and Michael Day from the University of Bristol are looking at the carriage rates and species diversity of *Bartonella* in stoats and alternative hosts in Britain and New Zealand. *Bartonella* is known to infect 73% of stoats living in Great Britain and is therefore a benign organism (bacteria) worth investigating as a vector for biocontrol. This study will look at:

- Stoats from Britain to assess the biodiversity of *Bartonella* and examine whether stoats are host to a specific form of the bacterium.
- Stoats collected from New Zealand to identify the species range of *Bartonella* present.
- The host specificity of *Bartonella* spp. in New Zealand, by examining alternative wildlife hosts.

To date, sequencing of British *Bartonella* samples has been carried out and preliminary analysis would suggest that the stoats are a host to *Bartonella henselae*, a species of *Bartonella* that is known to be present in New Zealand and is best known as a pathogen of domestic and feral cats.

Fresh blood and fixed tissue samples have been collected from 88 stoats, 3 weasels, 25 ferrets, 6 house mouse, 1 ship rat, 2 kiore, 15 feral cats, 3 hare, 1 rabbit, 3 possum, and 2 hedgehogs. These samples will be sent to Bristol for *Bartonella* sequencing. The results from the analysis will indicate the biodiversity of *Bartonella* in the New Zealand stoat population and whether or not there is host specificity.

This project will be completed by January 2002. (An extension was required, resulting from difficulties experienced in importing the blood and tissue samples into England following the recent Foot and Mouth epidemic, and increased biosecurity control measures.)

2.5.2 New research funded for 2001/2002 (Year 3)

Identification of zona pellucida antigens of the stoat and assessment of their potential for immunocontraception

A PhD student under the supervision of Chris Hardy and Lyn Hinds (Pest Animal Control Cooperative Research Centre, Australia) and Janine Duckworth and Frank Molinia (Landcare Research) will investigate the potential of a fertility control method as a long-term solution for the control of stoats. The process of developing a fertility control agent is complex and will take many years—the first stage will involve the identification of potential antigens. Previous studies with mice and rabbits have indicated that zona pellucida antigens can be effective as immunocontraceptives when delivered by recombinant species-specific viruses. Direct immunisation of these antigens can also be undertaken to assess their potential at affecting fertility.

This project aims, initially, to assess the immune responses of stoats to a heterologous reproductive antigen—porcine zona pellucida C and to examine the function of the zona pellucida proteins in ovarian follicular development as well as during diapause and implantation. In parallel studies, a stoat ovarian cDNA library will be prepared and the stoat zona pellucida genes cloned. Once full-length cDNAs have been identified and sequenced, recombinant proteins will be expressed for use in immunisation trials in captive stoats (at the Landcare facility in New Zealand). Eventually (beyond the scope of this project), the effective proteins will be inserted into delivery systems for use in he field.

This study will be completed in 2004 and will form the basis of a PhD thesis.

2.6 MISCELLANEOUS

2.6.1 Research completed during 2000/2001 (Year 2)

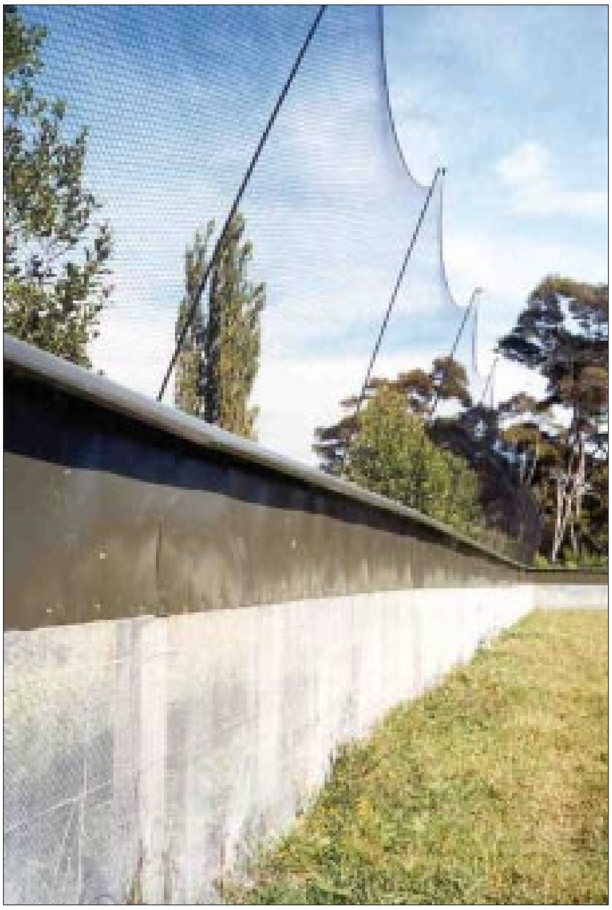
Cost-effectiveness of exclusion fencing for stoat control

Kay Clapperton (private consultant) and Tim D. Day (AgResearch Ltd) examined the use of exclusion fencing for mustelid control. The costs of exclusion fencing using the Xcluder™ design of multi-species pest-proof fence and conventional pest control were compared for a variety of scenarios. It also compared the cost of a non-electric barrier fence to an electric fence.

Cost-effective pest control can be achieved by exclusion fencing in reserves of 5000 ha or more, and especially on peninsulas. In these situations the cumulative cost of conventional control would exceed the initial cost of a fence plus maintenance costs in as little as four years.

Fencing may also be a cost-effective option for pest control in reserves of 100–1000 ha. The cost factors that would need to be considered include:

Xcluder standard pest-proof fence.
Photo: Tim Day



- The fence line length to reserve area ratio
- The numbers of gates and water crossings
- The site work required to install the fence
- Access to the fence for maintenance
- The number of abutting fences
- The presence of stock outside the reserve
- The current costs of materials and freight

It is also dependent on the actual costs of conventional control and the desired conservation outcomes. The control of stoats using the currently available trapping and poisoning techniques is not always effective. The extra cost of fencing may be acceptable as it is likely to result in more effective control, and fewer adverse environmental impacts.

Smaller reserves are unlikely to be cost-effective to fence, even though conventional control is likely to cost more per hectare at these sites than in larger reserves. However, fencing may still be a viable option for these sites because it allows for a pest-free status not achievable by conventional methods.

The Xcluder™ fences were found to be as cost-effective as electric fences, excluding a wider range of pest species. Both electric and non-electric fences require a commitment to maintenance. Stoats, in particular, are likely rapidly to breach a fence if vegetation encroaches onto it, if there are gaps in the mesh or, in the case of electric fences, if there is a power failure.

Conventional control will continue to be the best pest control option in situations where pest eradication is not necessary, or where only a few pest species are to be targeted.

Microsite factors affecting stoat trap success

Barry Lawrence and Bruce McKinlay (DOC) looked at how differences in the immediate vicinity of trap tunnels may effect trapping success. A range of factors were assessed including:

- Dense ground cover, with vegetation hard against the tunnel
- Dense ground cover present within 3 m of the tunnel
- Tunnel invisible at ground level (stoat eye level), at all positions at 3 m
- Tunnel within 100 m of the bush edge
- Tunnel beside or on logs
- Tunnel within 3 m of trees
- Tunnel within 20 m of water
- Tunnel within 3 m of animal tracks
- Humpy or even topography
- Slope steep, moderate or flat
- Presence of cover within 10 m of tunnel

A total of 572 tunnel sites in the Eglinton and Dart valleys were assessed using success or non-success. Multiple kills were not considered due to the influence of confounding factors such as scent. None of the factors were found to be significant in terms of trap success. Sites were also assessed at Rotoiti, and although an analysis has yet to be completed, a cursory consideration suggests that there is no pattern in terms of placement of traps.

Rhodamine B as a systemic hair marker for assessment of bait acceptance by stoats

Rhodamine B is a dye that becomes incorporated into the structure of growing hair of animals that have ingested it and appears as an orange-red fluorescent band detectable in hairs under a fluorescent light microscope. Eric Spurr (Landcare Research) evaluated this marker as a means of assessing bait acceptance by stoats.

Eleven wild-caught captive stoats were each fed a broken hen egg injected with 25 mg of Rhodamine. At least three facial whiskers were collected from each dosed stoat on two occasions (giving a total of six whiskers per stoat). At least one fluorescent band was detected in at least one of the whiskers collected from the eleven stoats dosed with Rhodamine B. No fluorescent bands were detected in the sample of stoats not fed Rhodamine B.

The fluorescent marking persisted for at least 6 weeks in all dosed stoats and in one dosed stoat the marking was still present 19 weeks after dosing. However, only 56% of the 91 whiskers inspected from dosed stoats had fluorescent bands and only 9% had two bands which represented the two doses of Rhodamine B. The distance between bands indicated a mean growth rate of 0.6 mm a day and the distance from the base of the whiskers to the base of the fluorescent bands was broadly related to the time after ingestion of the bait containing the marker dye. However, the variation was too great for the distance along the whisker to be used reliably as a quantitative measure of time after bait ingestion.

This technique can now be reliably used to assess bait acceptance in the field provided all stoats are sampled within about 6 weeks of baiting and at least 6–9 whiskers are sampled from each stoat.

'Find Out' project

Warren Agnew piloted a programme that involved schools in a campaign to raise their awareness of the conservation issues facing New Zealand's unique bird life and, in particular, the threat that stoats pose to their survival.

The objectives of the project were:

- To introduce students to applied conservation science
- To increase the student and teacher awareness of small animals about the school environment
- To assess preferred sites of visitation by small animals
- To assist teachers and students to identify different small animal prints
- To assess the relative tracking rates of small mammals at different sites and clusters of habitat
- To combine the results of the habitat clusters and disseminate that information to interested parties
- To provide data on the relative index rates of small mammals in selected urban areas

The 'Find Out' programme uses tracking tunnels to discover more about the small animals (rodents, mustelids, and hedgehogs) that are present in the school environment and surrounding area.

Instructions on how to use tracking tunnels in terms of assembly, placement, inking, and lures were provided, along with ideas for experimentation to allow for student extension, i.e. to compare different lures or tracking tunnel location on tracking rate and/or success. The students also learn to identify small animal prints.

To support the programme a spreadsheet has been developed and is currently being installed in schools. A website is also being developed to facilitate information sharing and transfer.

The 'Find Out' programme has been presented to 35 schools in the Auckland area and Coromandel. Of the schools visited 33 (94%) have, or are in the process of, implementing the 'Find Out' programme. There has also been keen interest and support for the programme from the Auckland Regional Council, which has assigned staff to work directly with schools to assist with the dissemination of this programme. The Auckland Regional Council has also included the programme in their publication material. The response to the programme has been enthusiastic and students have enjoyed finding out what animals are living in the local area, and are leaving tracks in the tunnels.

Mustelid bibliography on-line database

Kim King of Waikato University has compiled an on-line mustelid bibliography. This project was initiated several years ago and funding was provided through the stoat programme to add the mustelid listing to an existing one on possums, and to set up a new, integrated site for invasive species bibliographies on the web. For mustelids there are three linked databases, supplying references on stoats, common weasels (both present in New Zealand), and long-tailed weasels (an American species similar to stoats). Some references include abstracts. The bibliographic listings are updated every six months. The layout is still to some extent experimental and feedback is welcomed to help design future improvements.

This site can be accessed through: http://www.invasive-mammals.org.nz/

2.6.2 Ongoing research

Evaluating a low intensity stoat control regime on large inshore islands

Graeme Elliot and Murray Willans of DOC have initiated a four-year study to assess the likelihood of success of stoat eradication programmes on Resolution and Secretary Islands through pilot study trials on smaller, but similar islands.

In some areas on the mainland, it is possible to reduce stoat densities to levels low enough to support some relatively endangered species. Therefore it follows that the same techniques will reduce stoats to even lower densities on large inshore islands where the stoat re-invasion rate is low. Resolution Island and Secretary Island are the two largest inshore islands that are entirely managed by DOC, but both currently have stoats present. If they could be managed in near stoat-free states, they could support viable populations of some of our most endangered species.

Modelling is one way of estimating the rate at which stoats can be killed against the rate of invasion of these islands. However, a pilot trial 'eradication' of stoats from medium-sized islands at similar distances from the mainland provides an empirical test of this approach, without the considerable expense of attempting eradication on either of the large islands. Monitoring would have to continue through at least one beech mast cycle.

Three islands within Dusky Sound (Anchor, Long, and Cooper) which currently have stoats on them, have been investigated for their suitability for this study. Cooper Island was found to have a population of ship rats and, therefore, will not be used. Long Island has mice present which makes it suitable as a pilot for Resolution Island (which also has mice present). Anchor has neither mice nor rats.

The first stage of this project will be to attempt to eradicate stoats from Anchor Island using a low-intensity trapping regime. Stoats are unlikely to re-colonise, as the islands which they would have used for stepping stones are now all trapped. If the eradication succeeds on Anchor then this will indicate that the intensity of trapping is appropriate. This same level of trapping will then be carried out on Long Island, which has a very high likelihood of being reinvaded. A successful trial at Long Island will mean not only that the trapping regime is sufficient to eradicate stoats, but that it is also sufficient to control re-invasion. If eradication and control on Long Island is successful, eradication on a third island will be undertaken.

An eradication plan for Anchor Island has been prepared and during May and June 2001 a network of tracks was cut and pre-baiting of the traps undertaken. Initial trapping was initiated in July 2001 and this is now complete with encouraging results.

This project will be completed by June 2004.

Social acceptability of control options for stoats

Gerard Fitzgerald (Fitzgerald Applied Sociology) with co-worker Roger Wilkinson (previously Landcare Research) are looking at the social acceptability of new stoat control techniques as well as the acceptability of the existing trapping and poisoning techniques.

Potential biological control techniques for stoats that involve the use of exotic diseases, viral vectors and genetic modification are likely to be contentious. Any new methods are only likely to be used if they are socially acceptable. The findings from this research will enable DOC to assess the level of public knowledge of stoats and their impact on New Zealand's environment and their knowledge of current stoat control strategies. This information will assist the department and other researchers in their decisions on, and marketing of, stoat control strategies.

To date, seven focus groups with members of the public, iwi and special interest groups have been held. The groups were selected to represent a range of views about stoats, their impacts and the acceptability of current and potential future control methods. The participants comprised urban men, urban women, rural public, East Coast Maori, animal welfare interests, environmental interests and people with scientific and technical interests. Informal interviews were also held with Northland Maori and field pest controllers. Analysis of the data has been completed and a report is in preparation. Preliminary results indicate that many of the participants had little experience or knowledge of stoats and their impacts. Once the impact of stoats was explained, most of the participants were keen to eradicate them, and to increase efforts to protect kiwi. However, during discussion of the possible new control technologies and their associated issues, they tended to retreat from such a view. Many participants expressed unease about the use of genetic engineering for stoat control and, particularly, about the prospect of unforeseen effects.

The results of this qualitative phase of the research will be used to design the quantitative national survey that will be conducted in 2001/2002.

This project will be completed by June 2003.

Potential techniques for marking stoats to determine optimum spacing of tracking tunnels, bait stations, and traps

Chris Jones, Henrik Moller, and Billy Hamilton undertook a review of marking and monitoring techniques, as a method of counting the number of visits by individual stoats to control stations needs to be found to help determine the optimum spacing of bait stations, traps or tracking tunnels.

DNA sequencing of hair, skin and faeces would allow the identification of individual stoats. However, there was considerable expense ($30 per sample) and time delays in terms of perfecting and proving such systems.

Ear-tagged stoat coming out of a live trap. *Photo: Nic Gorman*

Electronic methods using either short-range detection (via radio transmitters) or Passive Integrated Transponder (PIT) tags would be the best tools for determining the optimum spacing of stations. However, while PIT tags are inexpensive, the capital investment needed for antennae to detect the tags and associated data-loggers would be high. A PIT reader ($500 each) would be needed at each tracking tunnel or bait station being monitored in the study. Data-loggers for the PITs or radio-tracking would cost over $2500 each. The wide spacing between control stations would mean that few stations could be monitored from the same data-logger. Thus the scale of stoat movements makes the use of electronic tools impractical for the proposed spacing study.

Identification of individual stoats from footprints and toe clipping has not yet been tested, but it appears to hold the most promise as a means of identifying individual stoats. This method has been used successfully in rodents but it failed to distinguish individual ferrets in one study. Improving the clarity of prints by elongating tracking tunnels and using sooty substrates rather than ink was outlined as a possible solution. However, there are ethical objections with this method, as well as practical difficulties.

Marking stoat footpads with individual tags is proposed as an idea worth further investigation. Small dots or shapes made of a rubber-like polymer could be attached to stoat footpads with medical or cyanoacrylate adhesives. These would provide an individually coded pattern that would be translated onto the tracking paper. The main challenge was identified as trialing the best adhesive to ensure the identification remained attached to the footpads of free-ranging stoats. A preliminary study to test the utility of a footpad marking technique in a captive trial is underway.

Use of colour to increase trap and tracking success rates of stoats

Billy Hamilton and Henrik Moller (Ecosystems Consultants) are studying the effects of different coloured control stations on stoat trappability and tracking rates. Previously there have been anecdotal reports of increased capture rate and bait take when yellow trap surrounds or yellow bait stations are used in control operations involving small mammalian predators. There is also scientific evidence that many animal sensory systems are triggered or 'biased' in favour of certain colours, such as red.

During February, March, and April of 2001 tracking tunnels of four different colours (i.e. black, green, red, and yellow) were set out in two different mixed forest sites. These tunnels were run for over 700 tracking nights per colour per site. Initial indications suggest that the darker-coloured control stations, such as black and green, are more successful in tracking stoats than the brighter colours of red and yellow. Conversely, the brighter-coloured tracking tunnels tend to be disturbed more regularly by possums than the black- or green-coloured tunnels. Records of the use of different colours by other mammalian species such as hedgehogs, rats, mice, and weasels have also been recorded, but not analysed as yet.

This study will be repeated during October and November using kill-traps encased in covers of the four colours listed above. Again, non-target species colour bias both in kills and disturbance will be recorded.

A report on this work will be completed by January 2002.

3. Process for funding 2002/2003

The Stoat Technical Advisory Group invites any organisation or individual interested in proposing new research within the high priority areas identified below to submit an expression of interest by **1 February 2002**. Authors of expressions of interest will either be asked in early March to submit full proposals, or they will be informed that their expression of interest was unsuccessful. Approximately $700,000 of the $1.631 million allocated for 2002/2003 will be available for new projects.

Not all the expressions of interest will be able to be funded and projects will be prioritised by relating their cost to their likely benefit of increasing the effectiveness of stoat control.

3.1 PRIORITY AREAS FOR STOAT RESEARCH FUNDING

1. Research into management and control of stoats
- Logistically feasible and scientifically meaningful monitoring methods
- New baits and lures
- Improvements to aid current best practise

2. Research into understanding the behaviour and ecology of stoats
- Stoat behaviour
- Interactions with other pest animals

3. Innovative research that has the potential to increase dramatically the effectiveness of stoat control

3.2 EXPRESSIONS OF INTEREST

Expressions of interest for DOC stoat new initiative funding should be sent by mail or email to Elaine Murphy, Department of Conservation, Private Bag 4715, Christchurch (emurphy@doc.govt.nz) no later than: **Friday 1 February 2002.**

Expressions of interest **must** include the following information:
- Research leader and contact details
- Project title

- The research objective(s), which must be specific, time-bound and measurable
- Proposed research (outlined in 1–2 paragraphs)
- Likely time frame to complete the research
- Estimated annual cost to complete the research
- Identification of what other funds will, or may be, aligned with this project or other related work, and outlines of any collaborations or leverage benefits
- Demonstration of how the research can build on work already funded by the stoat programme, or will fill an identified gap
- Explanation of how it relates to current best practise for stoat control within DOC

For more information contact:
Elaine Murphy
Department of Conservation
Private Bag 4715
Christchurch
email: emurphy@doc.govt.nz

4. Bibliography

4.1 PUBLISHED RESEARCH FROM STOAT RESEARCH PROGRAMME

Choquenot, D.; Ruscoe, W.A.; Murphy, E.C. 2001. Colonisation of new areas by stoats: time to establishment and requirements for detection. *New Zealand Journal of Ecology 25*: 83–88.

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Hinds, L.A.; Williams, C.K.; Pech, R.P.; Spratt, D.M.; Robinson, A.J.; Reubel, G.H. 2000. Feasibility of immunocontraception for managing stoats in New Zealand. *Science for Conservation 158.* 109 p.

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O'Keefe, J. 2001. Stoat pathogen survey, submission and testing protocol. *Conservation Advisory Science Notes 339*. 6 p.

Polkanov, A. 2000. Aspects of biology, ecology and captive breeding of stoats. *Conservation Advisory Science Notes No. 307*. 15 p.

Appendix 1

RESEARCH PROJECTS FROM YEARS TWO AND THREE OF THE PROGRAMME

TABLE 1. NEW STOAT RESEARCH PROJECTS INITIATED IN YEAR 3 (2001/2002).

PROJECT TITLE	LEADER/CO-WORKERS	ORGANISATION
Effectiveness of a low-cost kill trap system for stoats	Bruce Warburton and Grant Morriss	Landcare Research
Trials to test a prototype kill trap for stoat control	Malcolm Thomas	Pest Control Research Ltd
Feral-X-it	Frank Greenall	Private
Comparison of hen eggs, freeze-dried laboratory mice with freeze-dried feral rats as lures for trapping stoats	Rhys Burns and Pete Shaw	DOC
Development of a new toxin for stoat control	Penny Fisher and Cheryl O'Connor	Landcare Research
Control of stoat dens with Magnesium phosphide (magtoxin) after locating with trained dogs	Scott Theobold and Natasha Coad	DOC
Monitoring hormones of stoat reproduction	Andy Glazier and Frank Molinia	Landcare Research
Identification of zona pellucida antigens of the stoat and assessment of their potential for immunocontraception Research	Chris Hardy, Lyn Hinds, Janine Duckwork and Frank Molinia	PAC CRC, Australia/ Landcare

TABLE 2. ONGOING STOAT RESEARCH PROJECTS INITIATED IN YEAR 2 (2000/2001).

PROJECT TITLE	LEADER (CO-WORKER/S)	ORGANISATION	CURRENT STATUS
Feracol for stoat control	Jeremy Kerr (Andy Lavrent)	Feral Control R&D Ltd	Extension given until September 2001
Automatic stoat trap pilot study	Ian Domigan (Bruce Warburton)	Lincoln University	Extension given until November 2001
Paired trial of long-life stoat baits in northern coastal environment	Nigel Miller (Pete Graham)	DOC	Completion June 2002
Testing the attractiveness, palatability and longevity of novel stoat lure and bait formulations	Kay Clapperton (Lloyd Robbins, Tony Woolhouse, Dick Porter)	Private	Completion June 2003
Prey odours as lures for stoats	Andrea Byrom (Eric Spurr, Cheryl O'Connor)	Landcare Research	Completion June 2003
Tracking tunnels for monitoring stoats	Craig Gillies	DOC	Completion June 2003
Optimum spacing of bait stations and traps for efficient stoat control—pilot study	Henrik Moller (Billy Hamilton)	Ecosystems Consultants Ltd	Extension given until January 2002
Using colours to increase trap and tracking success rates of stoats	Billy Hamilton (Henrik Moller)	Ecosystems Consultants Ltd	Extension given until January 2002
Quantifying stoat and rodent population parameters in podocarp/broadleaf forests for predictive modelling	Wendy Ruscoe and Andrea Byrom	Landcare Research	Completion June 2003
Ecology of stoats in a South Island braided river valley	John Dowding (Mike Elliott)	DM Consultants	Completion September 2002
The movement and diet of stoats in an alpine-beech forest habitat	Des Smith (Ian Jamieson)	University of Otago	Completion December 2001
Modelling the immigration rate of island stoat populations	Graeme Elliott (Murray Willans)	DOC	Completion June 2004
Modelling the dynamics and control of stoats	Nigel Barlow	AgResearch	Completion June 2002
Stoat reproductive biology	Cheryl O'Connor (Janine Duckworth, Frank Molinia, Andy Glazier)	Landcare Research	Completion June 2003
Review of potential 'Achilles heel' characteristics of the stoat	Clive Marks	PAC CRC, Australia	Completion December 2001
Social acceptability of the various control options for stoats	Gerard Fitzgerald (Roger Wilkinson)	Fitzgerald Applied Sociology/ Landcare Research	Completion June 2003
Biological control of stoats using a vaccine strain of canine distemper virus	Tao Zheng (Bryce Buddle, Annie Dickie, Lindsay Matthews)	AgResearch	Completion June 2003
Evaluating a low-intensity stoat control regime on large inshore islands	Graeme Elliot and Murray Willans	DOC	Completion June 2004
Stoat artificial reproductive technology	Andy Glazier and Frank Molinia	Landcare Research	Completion June 2002
Effect of periodic reduction of possums on rats and stoats	Peter Sweetapple and Graham Nugent	Landcare Research	Completion June 2004
Incidence and diversity of *Bartonella* in stoats and other wildlife	Robbie McDonald	University of Bristol	Completion December 2001

TABLE 3. SUMMARY OF STOAT RESEARCH PROJECTS COMPLETED IN YEAR 2 (2000/2001).

PROJECT TITLE	LEADER (CO-WORKERS)	ORGANISATION
Develop a prototype kill-trap for stoat control	Malcolm Thomas	Pest Control Research Ltd
Gotcha electronic trap	Warren Agnew (Mark Chitterden, Eric McCall, Geoff Moon)	Private
Development of a long-life bait for the control of stoats	Ray Henderson (Chris Frampton, James Ross)	Pest Tech Ltd
Meat- and rodent-scented lures as attractants for stoats	Tom Montague	Roe Koh and Associates Ltd
Bait marker for stoats	Eric Spurr (Cheryl O'Connor)	Landcare Research
Evaluation of new toxins for mustelid control	Cheryl O'Connor (Charlie Eason)	Landcare Research
Microsite factors affecting stoat trap success	Barry Lawrence and Bruce McKinlay	Private/DOC
Cost-effectiveness of exclusion fencing for stoat control	Tim Day (Lindsay Matthews)	AgResearch
'Find Out' project	Warren Agnew (Eric McCall, Geoff Moon)	Private
Mustelid bibliography on-line database	Kim King	Waikato University