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A review of potential techniques for identifying individual stoats (*Mustela erminea*) visiting control or monitoring stations

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Abstract We review ways of individually identifying stoats (*Mustela erminea*) and similar small mammals from visits to bait stations or to monitoring devices in the field. Tracking devices are the cheapest and most practical method currently available of measuring the presence of a particular species, but there has been little research on the recognition of individuals. Elongation of tracking tunnels, or using sooty plates rather than ink to record prints, may improve detectability of individual markings. Recording visits to bait stations or tracking tunnels from DNA sequencing of hair or skin samples is likely to be prohibitively expensive for many monitoring programmes. Identification of stoats visiting bait stations or tracking tunnels using electronic devices has great potential, but these techniques are impracticably expensive because stoats move over such large areas that individual receivers and data loggers would be needed for each bait station. Chemical bait markers such as rhodamine B may be the most suitable method for identifying which animals have used a particular bait station.

Keywords marking; tracking; footprints; genetic markers; PITs; radio tracking; stoats; *Mustela erminea*

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INTRODUCTION

In New Zealand conservation areas stoats (*Mustela erminea*) represent the major threat to some endemic bird species (McLennan et al. 1996; O'Donnell et al. 1996; Ratz et al. 1999; Lyver 2000). This review arose from a study aimed at identifying the optimum spacing of bait stations and traps for efficient stoat monitoring and control. Control will often need to be prolonged and expensive. The area that can be protected with available funds can be maximised if the number of control stations is just dense enough to put all stoats in the population at risk of being killed by traps, or of eating baits containing toxins or biocontrol agents. Too high a station density will be wasteful, but too low a density could jeopardise the success of the overall control operation. Similarly, the most robust monitoring of relative stoat abundance using tracking tunnels is most likely to be achieved when just enough tunnels are placed in each stoat's home range for detection of all the animals present. If too many tunnels are present in each home range the results from neighbouring tracking tunnels are less likely to be independent of one another and some tracking papers may become "saturated" by repeated visits.

There have been few attempts to quantify the relationship between station density and capture/detection probability. King (1994) describes the qualitative effects of varying trap spacing on capture rates and gives rough guidelines to optimise control. The number of tracking tunnels required to detect a stoat with varying levels of certainty was modelled by Choquenot et al. (2001) who assumed constant detection probabilities of 0.7 and 1.0 at individual tunnels. The required numbers of tunnels increased (i) as probability of tunnel use decreased, and (ii) as required confidence level increased. Whilst the general relationships described by Choquenot et al. may hold true, there is no published evidence from field studies that these detection probabilities are realistic. Nevertheless, it is important to be able to predict as accurately as possible the effects of station

spacing on the efficiency of a control or monitoring programme.

Estimates of individual capture/detection probabilities will be best achieved if individual animals can be identified and detected. Some group marking techniques, such as food dyes, could be used for experimental determination of the proportion of stoats that took at least one bait delivered at a given density of stations per home range, but a technique that monitored rates of visiting bait stations by individual stoats would give valuable added information.

Stoats are generally not identifiable by individual variations in pelage pattern and therefore artificial markers need to be applied. Any marking method used must be appropriate to the species in question and to the requirements of the study. Generally, it must:

(i) effectively identify an individual from others in the population;
(ii) have no adverse effect on an animal's behaviour or fitness;
(iii) involve minimal pain and stress;
(iv) be durable for the length of the study and under all likely environmental conditions;
(v) be easy to apply (often under field conditions);
(vi) be affordable;
(vii) be easily recognisable using available techniques (criteria adapted from Nietfeld et al. 1996).

Whilst the primary aim of this review is to identify the most appropriate techniques for identifying individual stoats, the methods described are also applicable to the study of other mustelids and small carnivores. The emphasis throughout is on those techniques that may be suitable for "remote sensing" rather than direct observation methods such as ear tags.

FOOTPRINT TRACKING

Tracks have been used for many years to monitor and survey carnivore populations. Movements of animals are most easily studied from observation of natural tracks in snow or fine-grained soil or sand, although these substrates are unlikely to provide sufficient fine detail to permit identification of individual small carnivores (Zalewski 1999). Monitoring devices have been designed to record presence or activity of a study species at a particular location where conditions prevent reading of tracks. Early devices were based on carbon-sooted aluminium tracking surfaces (Mayer 1957) and this type of device has persisted in North American studies, which generally focus on species' distribution (Barrett 1983; Fowler & Golightly 1993; Zielinski & Kucera 1995; Zielinski & Truex 1995; Foresman & Pearson 1998). A similar device, based on a board sprayed with a chalk/alcohol suspension has detected feral cats (*Felis catus*), mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and brushtail possums (*Trichosurus vulpecula*) in New Zealand (Clapperton et al. 1994). The ink-print tracking tunnel developed by Lord et al. (1970) and by King & Edgar (1977) is the method of choice in New Zealand (Ratz 1997; Murphy et al. 1999; Ragg & Moller 2000) and has also been used in studies of British mustelids (Messenger & Birks 2000; Graham 2002). Both methods are essentially the same: animals walk across an area to obtain bait and in doing so either leave prints (on simple sooted plates/chalk boards) or pick up some sort of deposit (soot or ink) with which they leave tracks on a recording medium upon exiting the device. In tracking tunnels, the pad-marking solution is either blue food dye (Murphy et al. 1999) or a ferric nitrate solution that requires a tannic acid solution to be applied to the tracking papers for the prints to be recorded (King & Edgar 1977). Various inks that simplify application procedures have recently been commercially developed for use in tracking tunnels (R. Heyward pers. comm.).

There have been no published comparisons of print quality obtained using different tracking tunnel inking systems or sooted plates. Uncovered sooted plates are, unsurprisingly, of little use when it rains (Foresman & Pearson 1998). Moisture spoiling of covered plates was overcome by Mowat et al. (2000) when the cover over the plates was extended by 20 cm. Prints obtained using tracking tunnels are also prone to smudging in wet conditions, although the two-stage dye used in the chemical system may be slightly better than the food dye system in this respect (C. Jones pers. obs.) and newer inks may lessen this problem further. Prints from tracking tunnels are solid, with no fine details within the body of each pad, primarily because coarse brown paper is normally used as a recording medium. Use of glossy white paper would improve print quality, but may deter some animals from using the tunnels (C. M. King pers. comm.). Ratz (1997) developed a key based on a series of measurements of print dimensions with which New Zealand small mammals can be identified. An algorithm based on similar measurements has been developed to distinguish between American marten (*Martes americana*) and

fisher (*M. pennanti*) prints (Zielinski & Truex 1995). Herzog (2003) identified individual fishers by analysing digital images of tracking paper prints.

Identification of individual animals using tracking devices would depend on there being naturally varying pad characteristics or some reliable method of marking or manipulating pads that would leave clearly identifiable tracks. There has been some success in this regard with sooted plate tracks: the quality of some tracks has allowed individual fishers to be identified from pad scar patterns (Foresman & Pearson 1998), which led these authors to suggest the use of forensic fingerprinting techniques in identification. Individual black-footed ferrets (*Mustela nigripes*) have also been identified from print characteristics (K. Foresman pers. comm.).

Whilst these few instances of identification of individuals infer much about the potential quality of resolution that can be achieved under optimal conditions, incidental chance identification is not enough. A good study design would require a deliberate, systematic method of marking individual animals' pads such that each animal leaves its own individual sign. This type of marking has often been achieved in studies of rodents (Twigg 1976; Fitzgerald et al. 1980; Innes & Skipworth 1983) by removing one or two digits at the first joint. Removing one toe from each of two feet allows 98 animals to be marked and if one toe from each of all four feet is removed, 899 animals can be identified (Nietfeld et al. 1996).

Simms (1979) monitored individual stoat movements by toe-clipping followed by snow-tracking and mark-recapture. The author "minimised effects" on study animals by "preferentially removing the least functional toes". How the relative importance of each digit was ascertained was not explained. Feral ferrets (*Mustela furo*) were toe-clipped, and an attempt made to describe their activity using ink-print tracking tunnels, by Ragg & Moller (2000). These authors concluded that the technique was neither reliable nor worthwhile because of the effort required (ferrets were treated with antibiotics, sutured and given convalescence time to reduce risks), the stress to the animals affected, and the inability of the prints obtained to be reliably identified. A large number of unclipped ferrets were also present in the study area, and it was impossible to differentiate between partial prints that were from clipped animals and those prints that were simply of poor quality. Toe-clipping may also adversely affect the behaviour or survival of treated animals. This can lead to biased data and effectively invalidate the results of the study (CCAC 1984).

An alternative to toe-clipping that may achieve the desired result may be to attach small markers, possibly in the form of combinations of dots or of small characteristic shapes, to the pads of study animals that provide clear enough prints to enable individuals to be identified. Our pilot study of this technique was unsuccessful because the markers were lost during the first night after application.

A common problem with standard tracking devices is that there are often insufficient good quality prints to permit identification (Ragg & Moller 2000; H. Ratz pers. comm.). It would be advisable therefore to extend the length of the recording area of the tracking device to obtain more prints. Research designed to compare the resolution of fine details of prints obtained using sooted plates with those from ink systems, possibly using a variety of recording media, would be a logical next step.

Use of tracking devices by other species may cause problems due to (i) other species' prints obscuring stoat prints; (ii) removal of bait before a stoat encounters the device; or (iii) other dominant species' scent acting as a possible deterrent to use of a device by stoats. For some research questions, it may therefore also be advisable to construct/modify tracking devices so that no animals larger than stoats, e.g., hedgehogs (*Erinaceus europaeus*) and ferrets could enter them. On the other hand, work towards a multi-species monitoring system should view these other influences as a natural part of the situation being monitored, and therefore as factors that should merely be taken into account when interpreting data from larger open tunnels.

GENETIC MARKERS

Recent developments in molecular techniques have led to the development of a completely non-invasive method of remotely identifying individual mammals at monitoring stations. Genetic analysis of tissue samples has been used in this way to identify individuals in a number of bear species (*Ursus* spp.), American marten, coyote (*Canis latrans*), and humpback whales (*Megaptera novaeangliae*) (Foran et al. 1997a,b; Palsboll et al. 1997; Kohn et al. 1998; Woods et al. 1999; Mowat & Strobeck 2000). These techniques also have the potential to provide information on relatedness between individuals in a population and can be accomplished without capture and handling of animals.

Although a number of analytical techniques by which individuals may be identified are available

(Parker et al. 1998), the use of microsatellite markers has become the method of choice (Sunnucks 2000; Byrom & Gleeson 2003). This technique utilises the fact that there is a high degree of individual variation in the length of sequences of non-coding, repetitive genomic DNA. These sequences are known as variable number tandem repeats (VNTR) or "satellites" ("microsatellites" are repeating units of only 2–6 base pairs) found at scattered sites within the genome. Variation between individuals takes the form of differences in the number of repeat units at a particular locus (Parker et al. 1998). Only very small samples (nanogrammes) of DNA are required. The microsatellite regions can be amplified by replication using polymerase chain reactions (PCR) to provide large enough quantities for laboratory analysis. Variation in length between alleles of a particular microsatellite can be compared by electrophoresis. Typically, an individual will possess two alleles for a microsatellite: one from each parent. By measuring the exact length of these alleles with the high resolution now possible, an individual can be defined (Mowat et al. 1999).

Genetic identification of individuals is dependent on the identification of sufficient microsatellite markers for the species under study. Fewer markers are required to identify an individual from a highly variable population compared with one from a small, island population that may show reduced variation due to a founder effect. Markers from closely related species can be used (Mowat et al. 1999). Much of the cost and effort in a study of this type is in the identification of suitable markers and the development of appropriate "primers" (short DNA sequences that flank the markers and act to initiate polymerisation during PCR). North American work on mustelids has helped to identify sufficient loci in the stoat genome to allow identification of individual animals (Fleming et al. 1999; D. Gleeson pers. comm.).

Sufficient DNA for analysis has been obtained from skin samples, hair, and faeces (Foran et al. 1997a; Palsboll et al. 1997; Kohn et al. 1998; Woods et al. 1999; Mowat et al. 2000). The most feasible method of tissue collection without biopsy or blood sampling is from hair samples. Collecting faeces from stoats would require live trapping the animals to ensure collection of the scats, so the identity of the stoat would be known immediately from tags anyway. Carnivore faeces may be an unreliable source of DNA because of possible contamination by DNA from prey remains. Isolation of target DNA from faeces is possible, but it requires much more laboratory effort in developing PCR primers that will amplify target species DNA whilst being a mismatch for any of the potential prey items (Hansen & Jacobsen 1999).

Hair itself does not contain any DNA. Samples must therefore be removed with the root, or follicle, intact. At least 3–5 hairs per sample are required to provide sufficient DNA for analysis. Hair samples can be obtained using metal or wire brushes or catchers (Pasitschniak-Arts & Messier 1995; Woods et al. 1999) or sticky traps (Foran et al. 1997b; Lindenmayer et al. 1999; Mowat et al. 2000). Messenger & Birks (2000) describe a system based on a metal spring, stretched across the mouth of a tunnel, that was used to obtain hair samples from pine martens (*Martes martes*) in Britain. Sticky traps are often modified rodent glue traps that have been aligned to catch hair and may be unreliable in damp conditions (Mowat et al. 2000; B. Lawrence pers. comm.). An adhesive-covered rubber band was successfully used by Byrom & Gleeson (2003) to obtain hair samples from stoats in New Zealand beech forest. Care must be taken when choosing the solvent to be used to remove the hairs from the glue so that any DNA is not degraded. Foran et al. (1997b) found chloroform to be the best method of reliably freeing marten hair from glue.

Mechanical devices, although less complicated, may remove variable and inconsistent amounts of hair and root tissue (Foran et al. 1997b). Identification to species level is possible using hair scale patterns under normal microscopy (see Teerink (1991) for details on European mammals). Samples containing hair from more than one individual can be identified during laboratory analysis as those with more than two alleles at any one locus, and excluded from later analyses (Mowat & Strobeck 2000).

Whilst molecular genetic techniques have great potential they also suffer a number of disadvantages, primarily cost, although the cost/unit can decrease if a number of samples can be analysed together. The development of microsatellite markers and primers is also very expensive. Contamination and degradation of samples can also cause problems. Samples should never be directly handled and should be preserved in silica gel as soon as possible (Foran et al. 1997b; Taberlet et al. 1999). There are also a number of potential pitfalls that should be avoided during laboratory analysis: these are described by Taberlet et al. (1999) and are outside the scope of this review.

ELECTRONIC METHODS

Advances in the field of microelectronics have led to the development of a reliable, permanent method for marking individual animals. Passive integrated transponder (PIT) tags consist of a tiny electromagnetic coil and a microchip programmed with a unique 10-digit code. The circuitry is encased within an inert (generally glass) casing. The transponder has no internal power source and lies dormant until activated by a signal from a reading device, when it transmits its code to the reader (Fagerstone & Johns 1987; Nietfeld et al. 1996). The small size of PIT tags (around 2 mm diameter × 10–11 mm length) means that they can easily be inserted under the skin with a syringe-like implanter. PIT tags have been extensively used in studies of fish population dynamics as well as in many other taxa, including mustelids. They have been successfully used in sea otters (*Enhydra lutris*), badgers (*Meles meles*), Townsend's ground squirrels (*Spermophilus townsendii*), and feral, domestic, and black-footed ferrets (Fagerstone & Johns 1987; Thomas et al. 1987; Schooley et al. 1993; Morley 2002; Rogers et al. 2002).

Provided that sterility of equipment is maintained, few adverse reactions to PIT tags have been recorded other than localised encapsulation in fibrous connective tissue (Fagerstone & Johns 1987; Schooley et al. 1993; Morley 2002). Rates of tag loss are low: under 5% in Townsend's ground squirrels, the majority soon after implantation (Schooley et al. 1993). None of 69 recaptured feral ferrets in New Zealand lost a tag, but 17 tags failed or were lost from 174 recaptured badgers in England (Morley 2002; Rogers et al. 2002). Tag loss in black-footed ferrets has declined since surgical glue has been used to close the implant hole, and any remaining tag loss is compensated for by double-tagging (Seebeck & Booth 1996; D. Biggins pers. comm.).

PIT tagging has two disadvantages for use at multiple monitoring stations. Firstly, readers must be within 10 cm or less of the tag to record the identification code. The other drawback is cost, which is prohibitive for any large-scale monitoring programme. The reader proximity requirement can be overcome by using a loop antenna that encircles a burrow entrance or a tunnel. The antenna and a reader may be left *in situ* for extended periods to automatically record tunnel use, or visits to feeder stations, by tagged individuals (Fagerstone & Johns 1987; Nietfeld et al. 1996; Dell'Omo et al. 1998; D. Biggins pers. comm.). Sutherland & Singleton (2003) used an automated system to monitor burrow use by PIT-tagged wild house mice (*Mus domesticus*). Simultaneous monitoring of 16 burrows was made possible by connecting four readers to each of four data loggers. Although a similar design could be expanded to cover many more monitoring stations, limits imposed by signal deterioration with increasing cable length and the costs associated with monitoring over large areas may be prohibitive when studying wide-ranging mustelids.

If animals are to be fitted with radio-collars, the signal emitted by the radio transmitter can be monitored and recorded by static receivers. Dilks & Lawrence (2000) used data loggers to record the presence of radio-tagged stoats within a radius of 30 m of the recording device in New Zealand beech forest. The data loggers were made up of radio receivers tuned to the frequencies of tagged animals, and electronic recorders from which data could be downloaded at a later date. As with PIT tags, data loggers are likely to be prohibitively expensive, although costs are likely to come down as better technology becomes more widely available.

CHEMICAL AND DYE MARKERS

If the objective of a study is to obtain information on which individuals in a population have visited a monitoring/bait station, a location-specific marking technique may be used. Individuals are trapped or observed at a later date to look for evidence of use of that location. Options for suitable markers include systemic chemical and radioisotope markers and internal and external dyes.

Of the many systemic, or "blood", markers that have been tested (Savarie et al. 1992), iophenoxic acid has potential for regular use. It is an iodine-containing organic compound originally used as a contrast agent in X-rays (Baer et al. 1985). If treated bait is ingested the marker raises the level of protein-bound iodine in the blood for several weeks (Larsen et al. 1981; Baer et al. 1985; Savarie et al. 1992). Plasma/serum iodine concentration is measured by laboratory analysis of blood samples and, until recently, it was necessary to compare this with baseline levels in order to determine uptake. A new technique using high performance liquid chromatography to detect the marker itself has eliminated the need for this preliminary step, and also requires much smaller blood samples: 10 μl as opposed to 5–10 ml (Purdey et al. 2003).

Ogilvie & Eason (1998) tested the duration of raised iodine levels in captive and wild ferrets. Significantly higher levels than pre-treatment baseline

levels were recorded in captive ferrets for up to 28 days and in 21 feral ferrets captured 10 days after bait was set. Spurr (2002a) recorded raised iodine levels in captive stoats for up to 14 days after dosing and Purdey et al. (2003) detected the presence of iophenoxic acid in wild stoats up to 27 days after dosed bait was deployed.

Although the developments in analysis described by Purdey et al. (2003) have removed some of the drawbacks associated with the use of iophenoxic acid, the expensive analytical equipment required and the associated sampling and laboratory costs may still put this technique out of the reach of some investigators.

Radioactive markers in the form of metabolisable radionucleotides can be used in a similar manner (Nietfeld et al. 1996). These materials may be detected in tissues, faeces or urine. Zinc[65] has been used as a bait marker in a number of mammal studies and may be detectable in the faeces of marked individuals for over a year (Kruuk et al. 1980). A major disadvantage of radioactive material is the strict restriction on its use. It can also cause tissue damage.

Some compounds are laid down in growing tissues to produce characteristic patterns of fluorescence under ambient or ultra violet (u.v.) illumination. Tetracycline antibiotics have been successfully used in this way in both laboratory and field studies of a number of mammal species including raccoons (*Procyon lotor*), black bears (*Ursus americanus*), and coyotes (Linhart & Kennelly 1967; Nelson & Linder 1972; Garshelis & Visser 1997). The effectiveness of this technique in marking mustelids was demonstrated by Nelson & Linder (1972) who detected evidence of demethylchlortetracycline consumption in skunks (*Mephitis mephitis*) following deployment of the marker in dosed eggs. Fluorescence is characteristically observed in bones and teeth where the tetracycline combines with calcium ions. Persistence is in terms of months and can even be seen in frozen specimens (Savarie et al. 1992). As tetracyclines are therapeutic antibiotics, their use is controlled by legislation in many countries.

Rhodamine B has also been employed as a systemic fluorescent marker. It is most commonly detected in hair where it can be detected for several weeks after dosage, and has also been described in claws and other tissues (Evans & Griffith 1973; Johns & Pan 1981; Lindsey 1983). Mystacial vibrissae (whiskers) are considered the best tissue to test for fluorescence, as they are often unpigmented and have a longer growth period than other hair (Fisher 1998).

Fluorescent marking was detected in the vibrissae of all of 18 feral house cats tested using ultra-violet microscopy 10 days after dosage with rhodamine B-soaked bait (Fisher et al. 1999). Ogilvie & Eason (1998) fed six ferrets on bait soaked in 1% aqueous rhodamine B solution. Fluorescence was detected up to 7 days later on footpads, but not on the other tissues examined (mouth, anus, claws). Spurr (2002b) successfully detected rhodamine B markings in the vibrissae of all 11 captive stoats dosed with the marker (at 60–108 mg/kg body mass). A number of vibrissae showed two bands, corresponding to two doses of rhodamine, given 5 weeks apart. He suggested that rhodamine B markings would persist for at least 6 weeks and that six to nine vibrissae should be sampled from each animal to be confident of detecting consumption of dosed bait. Purdey et al. (2003) detected rhodamine B markings in wild stoat vibrissae at up to 27 days after deployment of baits with dosages assumed to be up to a maximum of 60 mg/kg. Between two and eight bands were found in vibrissae from some stoats, indicating multiple visits to bait stations.

If bait markers are deemed inappropriate because of restrictions on their use, difficulty of administration, ethics or cost, it may be possible to develop a means of applying an external marker at a bait station. A range of paints and dyes have been successfully used as temporary markers: coloured spray lasted for up to 10 days on the pale underfur of polecats (*Mustela putorius*); picric acid dyes stoat fur for over a month, and various dyes, including human hair dye, have been applied to black-footed ferrets and ground squirrels (J. Birks, J-F. Robataille, D. Biggins pers. comms; Schooley et al. 1993; Nietfeld et al. 1996). Whilst this has potential, the development of an application system, such as a hanging applicator under which a stoat must brush when passing through a tunnel, will require further testing and development.

SUMMARY

Most of the recent emphasis in published research on stoat ecology has been on describing activity patterns using radio-telemetry or the use of tracking tunnels or trap returns as indices of population change, and there has been little development of novel monitoring methods since King & Edgar (1977). This means

Table 1 Summary of properties of potential techniques for marking and identifying stoats and other small carnivores. Costs are approximate and are given in New Zealand dollars. For detailed descriptions of each technique see text.

Technique	Footprint tracking	Molecular techniques	Electronic (I): PIT tags	Electronic (II): Data loggers	Chemical markers (I): iophenoxic acid	Chemical markers (II): rhodamine B
Individual identification	May be possible with modifications	Yes	Yes	Yes	No	No
Detects bait uptake	No	No	No	No	Yes	Yes
Effect on behaviour/ fitness	Minimal	Minimal	Minimal; short-term	Possible: relies on attachment of radio transmitter	None on application; requires blood sampling	None on application; requires tissue sampling
Pain/stress	Nil	Minimal	Moderate: on implantation	Moderate, due to handling and transmitter attachment	Sampling involves either restraint, anaesthesia or death	
Duration	Dependent on recording medium	Life-long	Life-long	Dependent on transmitter battery life (months)	Up to 1 month	
Ease of application/ sampling	Simple	Simple: hair/ faeces collection	Requires trapping, handling and anaesthesia		Application in dosed bait. Sampling requires trapping, handling and possibly anaesthesia/death	
Ease of identification	Simple	Complex, requires highly specialised skills and equipment	Reliable, but reader has very limited detection range (<1m)	Limited detection range (tens of metres)	Complex, requires highly specialised skills and equipment	Simple, but requires fluorescence microscopy
Relative cost	Low ($100s)	High ($1,000s)	Medium ($100s to low $1,000s)	High ($1,000s)	Medium (high $100s) assuming equipment available	Low (low $100s) assuming equipment available

that few of the techniques described in this review are ready to use without further testing. The general characteristics of major techniques are summarised in Table 1.

Although tagging with PIT tags is likely to be the most reliable method of identifying individuals it is also by far the most expensive, with high initial set-up costs for equipment alone. If sufficient funding were available, the development of coil readers suitable for placing around/within tunnels and remote automatic recording devices should be given high priority for research.

DNA markers are also likely to be prohibitively expensive for many large-scale monitoring programmes. Recent developments in simple hair-capture devices could be routinely deployed in tunnels so that samples could be collected concurrently with other data and stored until required for analysis, or until costs become less prohibitive.

If funds are limited, priority should be given to further investigation into the quality (definition, fine detail discrimination) of natural footprints obtainable from sooted plates and ink-print recording devices. Tracking tunnels should be lengthened to increase the number of prints obtained, and entrances made to exclude larger animals so that any stoat prints recorded are not obscured, and so that bait is less likely to be removed before the tunnel is detected by a stoat.

Bait markers may be the most suitable method for identifying which animals have used a particular bait station. With the advent of the simplified detection procedures of Purdey et al. (2003) the suitability of iophenoxic acid for large-scale field trials has increased, although cost and access to the appropriate analytical equipment may still prove prohibitive in some cases. Rhodamine B has been shown to be a reliable marker in stoats and other small mammal species, and its non-invasive tissue sampling procedures and lower cost probably make it the preferred option.

The widespread distribution of stoats, their keen sense of smell and hearing, and their ability to climb and swim make them a formidable foe of many New Zealand endemic animals. Control is made more difficult by low trappability in some seasons and places, their rapid and long-range dispersal, delayed implantation and ability to increase in numbers rapidly when food is abundant. Development of a practical and humane individual recognition system would provide a valuable tool to guide managers towards more effective and reliable monitoring and control of stoats.

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