Testing the attractiveness and palatability of stoat lures and baits with various sensory cues

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ABSTRACT

More attractive lures and acceptable baits are required to improve the efficacy of stoat (*Mustela erminea*) control in New Zealand. We conducted a series of preference trials on captive stoats to determine the potential of various visual, textural, and movement cues in lures and baits. Bait colour did not affect the time spent investigating or chewing baits, or bait consumption. One mouse-shaped bait with realistic eyes was eaten more than a disk-shaped bait. The addition of possum (*Trichosurus vulpecula*) fur significantly increased palatability of wax baits, but did not affect consumption of an already palatable bait. Stoats were more likely to cache both of the fur-coated baits than the control baits. Stoats spent more time investigating a concave mirror on the wall than a similarly shaped piece of plastic, and more frequently entered and spent more time in a trap box containing a large mirror than in one without a mirror. However, similar amounts of time were spent in trap boxes with either a small mirror or a hole covered in wire mesh, and in tunnels with and without a mirror, when both contained egg baits. Adding a red light-emitting diode into a trap box did not increase investigatory responses. Stoats ate more egg baits if they could roll (and thus break) the egg than if eggs remained stationary and unbroken. Stoats spent longer investigating moving baits (dead day-old chicks *Gallus gallus domesticus,* or mice *Mus musculus*) that were attached to a pendulum, but such baits did not elicit increased biting or chewing responses. This study demonstrates that visual and textural bait features could improve bait consumption, that mirrors could attract stoats to enter traps, and that movement devices could direct the attention of stoats towards baits or control devices. All these concepts need to be refined and field tested before being used.

Keywords: stoat, *Mustela erminea*, bait, lure, attractant, trapping, pest control, New Zealand

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1. Introduction

1.1 BACKGROUND

This research is an extension of previous work for the Department of Conservation (DOC) five-year stoat (*Mustela erminea*) research programme, testing the attractiveness, palatability and longevity of baits and lures (see Clapperton et al. 2006). The Stoat Technical Advisory Group identified that more effective baits and lures may bring quick gains in control efficiency in the short-term.

Like most stoat bait development projects, our previous trials focused on the role that olfactory and gustatory cues of lures play in attracting stoats, and on making the baits more palatable. However, since stoats are visual hunters that respond to the movement of prey (King 1989, 1990), we contend that visual cues are likely to be important features of baits and lures, directing the animal's attention and activities, and possibly playing a role in initiating chewing and biting responses to edible baits. Adding extra sensory stimuli to baits or control devices may, therefore, either attract or distract stoats sufficiently to allow them to be captured or poisoned.

Anecdotal evidence from field operators suggests that while stoats may visit trap sites, they are reluctant to walk over the treadle mechanism of a trap. Even the presence of attractive and palatable baits may not be adequate to ensure the capture of these 'trap-shy' individuals. This evidence has been confirmed by time-lapse video recordings of wild stoat behaviour at poison-egg tunnels, which showed that in at least 20% of visits stoats did not enter the tunnel (Dilks & Lawrence 2000). This figure is likely to be an underestimate because the camera was placed inside the tunnel, restricting the field of view outside the tunnel; thus, some stoats that visited the tunnel may not have been detected.

While whole eggs are less palatable to stoats than either whole animals (mice *Mus musculus* or day-old chicks *Gallus gallus domesticus*) or fresh flesh (Dilks et al. 1996; Spurr 1999; Clapperton et al. 2006), they are the recommended bait for poison-based stoat control programmes (Spurr 1999). The primary advantage of eggs over other baits is that they are readily available (Dilks et al. 1996) and remain palatable (in their unbroken state) for much longer than other protein-based baits such as beefsteak or whole mouse (Spurr 1999). However, despite the advantages of poison eggs, problems with inadequate bait take are apparent: some stoats enter the tunnel, but do not attempt to break into the egg, while others attempt to break into the egg but fail (Dilks & Lawrence 2000).

Aversion problems are not restricted to poison-egg tunnels; they have also been reported with live traps (Dilks & Lawrence 2000; C. Gillies, DOC, pers. comm.), kill traps (Crouchley 1994; Peters 1997; Rudolf 2000; J. McLennan, Landcare Research, pers. comm.), and tracking tunnels (Lawrence & Loh 1997). The aversion of stoats to control devices is a serious problem that needs to be overcome if traditional methods of mustelid control (trapping and poisoning) are to become more effective. The reluctance of stoats to eat hen eggs poses another significant barrier to the success of poison-egg-based stoat control.

1.2 ROLE OF VISION AND MOVEMENT IN STOAT HUNTING AND FEEDING

It is believed that stoats have some colour vision, but that they may not need it to identify food (King 1989). We could not find any information on the significance of bait colour, shape, or texture to stoats. Stoats' eyes are adapted for activity in bright light (King 1989), and they are more likely to be caught in traps that are placed under brightly coloured covers than under duller colours (Hamilton 2004). The fact that members of the weasel family orientate their killing bite to the back of the neck of prey indicates that they have some ability to distinguish prey shape, even though they do not recognise prey from their shape (King 1989). However, prey shape did not affect the investigatory or biting responses of ferrets (*Mustela furo)* (Apfelbach & Wester 1977); instead, the outside texture of the bait was important (Apfelbach & Wester 1977).

Previous trials have indicated that visual cues are probably of equal importance to olfactory cues in the responsiveness of captive stoats to egg baits (LR, unpubl. data), and it has been demonstrated that colour affects the responses of other predators to lures and poison baits (Mason & Burns 1997; Mason et al. 1999). Another novel visual stimulus that has not been tested as an attractant for stoats is a mirror. Many different animal species are responsive to mirror images, including domestic chicks, ungulates, rodents, and primates (Montevecchi & Noel 1978; Gallup & Suarez 1991; Brent & Stone 1996; Piller et al. 1999; McAfee et al. 2002; Sherwin 2004). Should a mirror image be effective in encouraging a stoat to enter a tunnel, it would serve as a cheap, practical, and long-life attractant. Alternatively, it is possible that a low-powered light, which comes on as a stoat put its nose into the entrance to a tunnel, would be another simple system of drawing trap-shy stoats into a trap set.

Stoats hunt moving prey; they may not even see a potential quarry if it freezes (King 1989). This suggests that baits that incorporate a moving component may be much more attractive to stoats and may release biting responses. Prey-catching reactions (investigation and biting) of ferrets were elicited more by moving dummies than by stationary ones (Apfelbach & Wester 1977). Simple mechanical systems that make eggs and dead-prey baits move could prove to be a cost-effective way of improving bait attractiveness and acceptance.

1.3 AIM

The aim of this study was to assess various visual, textural, and movement stimuli for their ability to direct the activity of stoats onto or into control devices, or to enhance bait consumption.

2. Methods

2.1 ANIMAL HUSBANDRY

All 22 stoats were live-trapped from the wild in the Tararua region, New Zealand, using egg, rabbit, or mouse baits. Thirteen of these stoats had been in captivity for months prior to the start of the study and had been used in previous trials (Clapperton et al. 2006), while the others were trapped at various times during the study. They were treated for fleas upon capture and then as required. All stoats were housed individually in cages with minimum dimensions of 90 cm × 240 cm × 200 cm high. The cages were contained in a plywood-lined corrugated iron shed, with the upper half of the front wall constructed of netting to allow the entry of fresh air and sunshine. Half of each cage was thickly stuffed with hay, in which the stoats created a three-dimensional network of tunnels. The other half was kept clear and 'toys' such as branches, plastic tunnels and cardboard boxes were placed there and periodically re-positioned and/or replaced to provide behavioural enrichment. Animals were weighed on arrival and then weekly until body weights (which generally increased) stabilised; this was usually at 3–5 weeks post-capture.

Water was provided in dripper bottles at all times. The stoats were fed daily, primarily with an excess quantity of fresh chicken mince. Supplements such as fresh hen eggs, dried cat food and high-quality dog feed sausage were also offered.

This research was conducted with animal ethics approvals from the DOC Animal Ethics Committee (Approval number 074) and the Estendart's Animal Health Services Centre Ethics Committee (Approval number 008/04).

2.2 EXPERIMENTAL PROCEDURES

The baits, devices tested, and numbers of stoats used in the trials are shown in Table 1.

In all trials except V4 and V5, stoats were tested individually in one of two indoor pens (200 cm × 240 cm × 200 cm high) that were of similar construction to the housing shed described in section 2.1. Trials V4 and V5 were run in the stoats' home cages. Stoats were introduced to the pen either on the day before or on the day of a trial. Fresh water in dripper bottles and a small quantity of fresh hay (as a den) were available to the stoats for the duration of every trial.

At the beginning of each trial, *ad libitum* food was usually removed. At the conclusion of each trial, the stoat was returned to its regular cage and provided with fresh food and water. In some trials, the baits being tested provided a source of food. In these cases, food was removed 12 hours prior to the onset of the trial.

The general experimental procedure was to place the bait materials or devices in a random order in specified positions in the pen in the late afternoon or evening. If not already in the pen, the stoat would then be placed in the pen inside its nest box. If the stoat was already in the pen at the beginning of the trial, it would often be somewhere in the hay rather than the nest box. We used a black-and-white video camera to record the responses of the stoat to the bait materials or devices over a 12-hour period. The stoat was returned to its home cage immediately after the trial or, when trials were run back-to-back (Trials V8 and V9), remained for a second night. The pen was searched for stray pieces of bait and then cleaned. The baseboards, containers or devices for the bait materials were thoroughly cleaned in soapy water and rinsed in fresh water between trials. Up to 11 of the total 22 stoats were used in any one trial (Table 1).

2.3 VISUAL CUES

Trials V1–V11 (Table 1) tested the response of stoats to visual cues.

2.3.1 Bait colour, shape and texture trials

Trials V1–V5 tested the response of stoats to baits of different colour, shape, and texture. As in previous trials that have tested the responses of stoats to baits (see Clapperton et al. 2006), we used the time spent investigating a bait (with nose, mouth, or paws touching the bait) and bait consumption as measures of bait attractiveness and palatability, respectively. We also noted which bait was eaten first. Because a mouse was present in one pen and interfered with the bait, we could not collect bait consumption data in Trial V1. Mouse interference was not an ongoing problem—mice were not seen on the video footage from three years of trials conducted prior to this trial, or in any subsequent trial.

A deliberate response was recorded if the stoat sniffed, bit, or scratched at the bait container or bait for more than 1 s. This avoided the recording of very brief visits while passing by, which could have been biased by the position in the pen chosen by the stoat as a resting area. Consumption was scored on an arbitrary scale: 0 = none eaten, 1 = ≤25% eaten, 2 = 25%–50% eaten, 3 = 50%–90% eaten, and 4 = >90% eaten.

Trials V1 and V2 were both run over two consecutive nights. On the first night, the baits were under mesh covers so that the stoat could see but not access them. On the following night, the same stoat was presented with the same baits with the mesh covers removed. Trial V3 was run over one night, during which the baits were accessible. The responses in Trials V4 and V5 (single-night trials) were not videoed. For each trial, we recorded bait consumption and whether baits had been moved or cached by the stoats.

2.3.2 Mirror trials

Trials V6–V10 tested the response of stoats to mirrors (Table 1).

In Trial V6, the mirror and the control were placed on opposite sides of a corner in the observation pen, each c. 50 cm from the corner. The mirror was a 10-cm-diameter, concave, circular mirror and the control was semi-transparent plastic of the same dimensions.

Trial V7 was a paired trial in which two simple tunnels were set side-by-side, one with a mirror, one without. Both tunnels were baited with an egg in all replicates except the final two. The tunnels were 12 cm × 60 cm × 17 cm high, had one entrance (the other being blocked) and a mesh top to allow light into the tunnels for the mirrors to provide reflections and to allow video monitoring of stoat behaviour. A flat mirror (12 cm × 17 cm) that filled the entire tunnel was positioned at the end.

Trials V8 and V9 each used two trapping tunnels (Fig. 1), one with a mirror and one without. Trial V8 used the flat rectangular mirror (12 cm × 17 cm) while trial V9 used a 5-cm, convex, circular mirror. The boxes were 39 cm × 22 cm × 21 cm high with a mesh top to allow video monitoring. There was a single entry from the side, around two baffles that were designed to prevent the entry of non-target species. Each box contained a DOC-200 trap that was wired open to prevent it being tripped. The mirror was placed behind the trap, so that a stoat would have to move over the trap's treadle to investigate the mirror closely.

Trial V10 again used paired boxes, configured as described above. A 5-cm, round, convex mirror was placed in one trap box, while the other trap box had a 5-cm hole drilled through the back wall. The hole was covered with wire mesh to prevent entry/exit of the stoats.

TABLE 1. BAITS, DEVICES, AND NUMBER OF STOATS (*Mustela erminea*) TESTED IN EACH TRIAL.

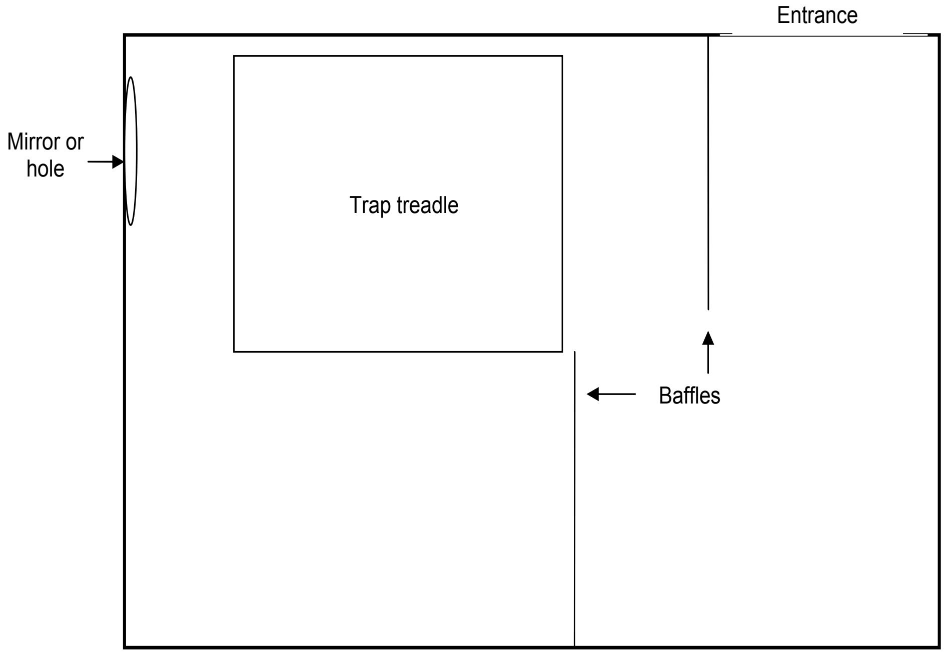
TRIAL	NO. STOATS	BAITS OR DEVICES USED	SENSORY CUES COMPARED
Visual or textural			
V1	5	Flour, salt, water and food colouring	Black v. blue v. red v. yellow v. green v. plain
V2	9	Gelatine/playdo/minced rabbit meat	Mouse-shaped* v. roundish blob
V3	4	Gelatine/minced freeze-dried mouse	Flat round v. egg-shaped† v. mouse shaped‡
V4	11	Preserving wax (9 g)	With v. without 1 g of possum fur bound to the bait
V5	11	Proprietary stoat bait (9 g)	With v. without 1 g of possum fur bound to the bait
V6	6	Corner wall of pen	Convex circular mirror v. equivalent semi-reflective plastic
V7	7	Adjacent wooden tunnels with clear tops plus one hen egg each	With v. without a mirror at end
V8	9	DOC 'Get Real' box traps	With v. without a mirror at end
V9	11	DOC 'Get Real' box traps	With v. without a concave, circular mirror beyond treadle
V10	4	DOC 'Get Real' box traps	With mirror v. hole covered in wire mesh beyond treadle
V11	7	DOC 'Get Real' box traps	With v. without a red LED beyond the treadle
Movement			
M1	7	Hen eggs	On a platform v. on the ground
M2	5	Hen eggs	On a ramp v. in a box
M3	4	Dead 1-day-old chicks	On a pendulum v. tied onto a stand
M4	7	Dead white mice	On a pendulum v. on the floor

* Eyes, ears, and tail made of shaped pieces of twist ties.

† Cast in and remaining in an open egg shell.

‡ Eyes made of 'silver cachous' cake decorations (St James brand).

Figure 1. Trap box as used in Trials V8–V11.



We recorded the number of times the stoat entered each device or touched the objects on the wall, and the amount of active time spent in or at the control devices.

2.3.3 Light trials

Trial V11 tested the response of stoats to a red LED (light-emitting diode) using paired trap boxes identical to those described above. A mercury switch attached to a treadle in the trap-box entrance triggered the light. When a stoat entered the box the light was triggered on and when the stoat left the box the light was triggered off.

2.4 MOVEMENT CUES

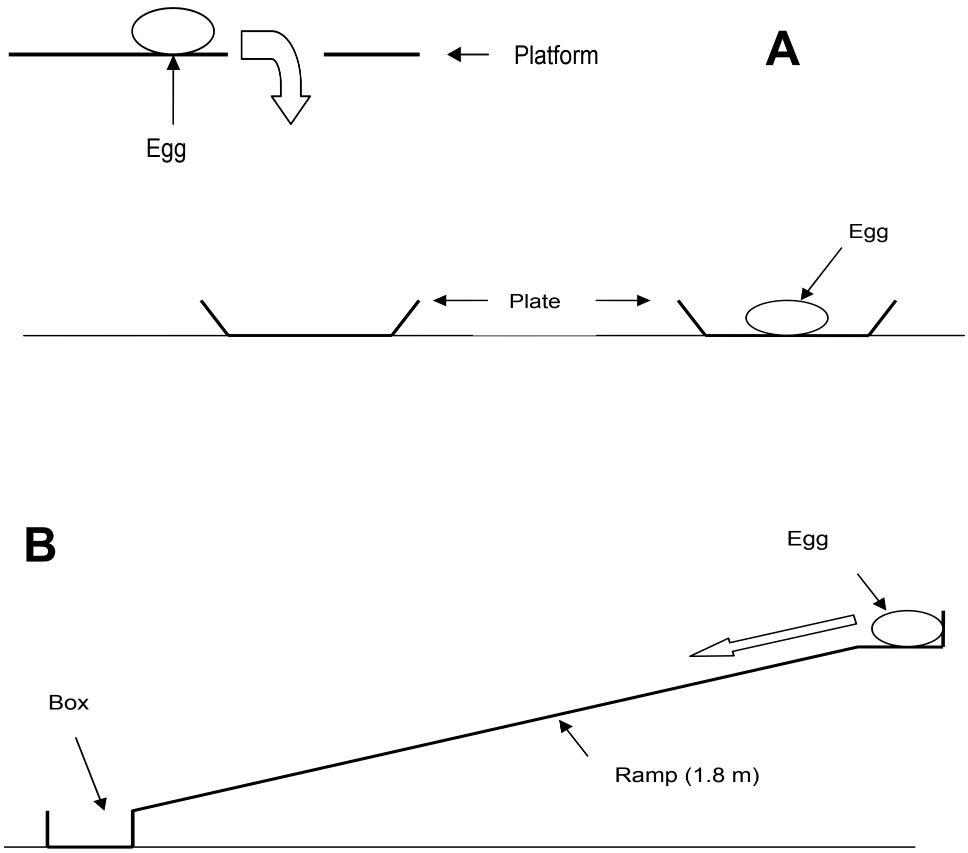
Trials M1–M4 (Table 1) tested the response of stoats to movement cues.

2.4.1 Automatic egg feeders

In Trial M1, an egg was placed on a 25-cm-high platform with a hole in it, beneath which was a plate (Fig. 2A). This enabled the stoat to roll the egg so that it would fall through the hole and break on the plate below. The control was a whole egg placed on an identical plate with no platform.

In Trial M2, the stoat was presented with two 1.8-m-long wooden ramps, each sloping (15–20°) down to a 25-cm-square wooden box (Fig. 2B). A hen egg was placed at the top of one ramp and, as a control, a second egg was placed in the terminal box of the second ramp. A successful trial involved the stoat pushing the 'mobile' egg down the ramp so that it smashed in the box.

Figure 2. Egg movement devices used in (**A**) Trial M1 and (**B**) Trial M2.



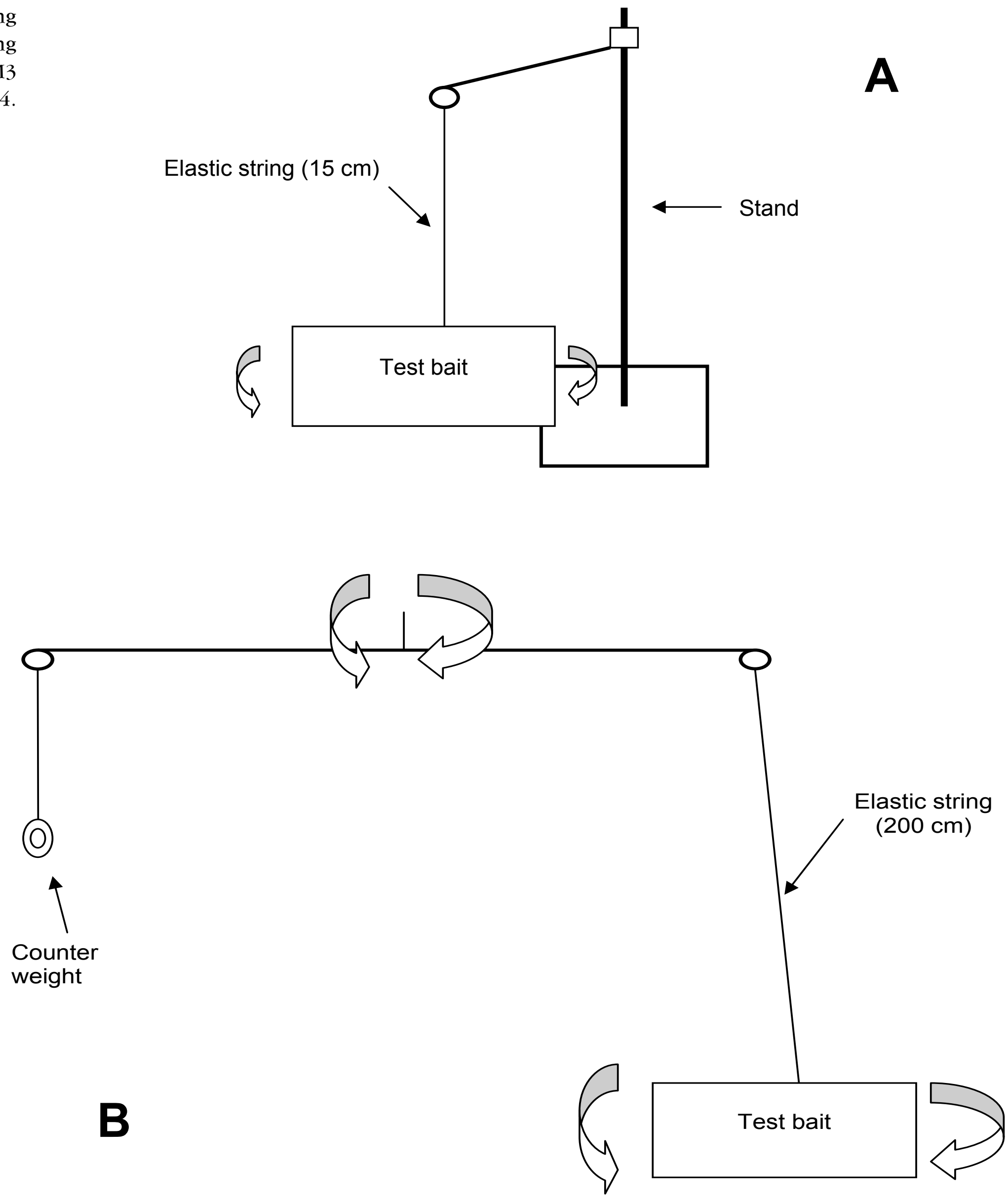
2.4.2 Swinging baits

In trial M3, a dead 1-day-old chick was attached by an elastic string to a 10-cm horizontal bar that was capable of being pulled in a circle around a vertical, 25-cm-high stand (Fig. 3A). As a control, a second chick was securely attached to a second stand (i.e. no elastic and no swinging bar).

Trial M4 also compared a bait on an elastic string with a stationary bait, using dead white mice as the bait. The length of the elastic string was increased to 200 cm. The string was attached to one end of a horizontal bar that was counterweighted at the other end. This bar was in turn supported at its centre of gravity by a string attached to the ceiling (Fig. 3B). The device was 'wound up' 12 rotations and the bait was precariously secured to the floor. On disturbance, the device then unwound in a rocking motion, with the mouse describing an erratic, 50-cm-diameter circle. Any interference with the bait by the test animal would further randomise movement of the bait. As a control, a second stationary bait was attached to the floor of the pen.

We measured the time stoats spent investigating the baits until the first bait was eaten, and the amount of bait eaten or the number of times the baits were bitten. This was determined at the end of the trial and scored on an arbitrary scale: 0 = none eaten, 1 = ≤25% eaten, 2 = 25%–50% eaten, 3 = 50%–90% eaten, and 4 = >90% eaten.

Figure 3. Setup of swinging baits used for testing movement in (**A**) Trial M3 and (**B**) Trial M4.



2.5 STATISTICAL METHODS

Time data were log transformed before analysis. We used one-tailed paired *t*-tests or randomised block 2-way ANOVA (blocked by individual stoat) to test for variation in responses by treatment (lure/bait type) (Zar 1984). This allowed us to control for the typically large differences in responsiveness amongst the individual stoats. The non-parametric Wilcoxon paired-sample test or Friedman's randomised block test were used to compare numbers of entries into devices, bait consumption, and bait attack data.

3. Results

3.1 VISUAL CUES

3.1.1 Bait colour

Bait colour (Trial V1) did not significantly affect the amount of time the stoats spent investigating a bait, although all of the dyed baits were sniffed less than the plain bait. (Table 2). Similarly, colour did not affect the average amount of time stoats spent chewing baits on the second night of the trial. The amount of time spent chewing the baits varied widely amongst the stoats, with the exception of the plain bait, which was never chewed for long. There was also no preference for dark (blue, green, and black) v. bright (red, plain, and yellow) colours (Table 2). Two stoats chewed the green bait first, two the red bait, and one chose the blue bait first.

3.1.2 Bait shape

Stoats did not spend significantly different amounts of time investigating or chewing the mouse-shaped and the blob-shaped baits (Trial V2), although the mean length of time was greater for the blob (Table 2). In this trial, bait shape also did not significantly affect bait consumption (Table 2). Seven of the eight stoats chewed the blob-shaped bait first. The ninth stoat did not chew either bait.

TABLE 2. MEAN ± SEM RESPONSE OF STOATS (*Mustela erminea*) TO BAITS WITH VARIOUS VISUAL AND TACTILE CUES.
Statistical test results are shown. NS = not significant ($P > 0.05$). Dash (–) indicates data not collected.

TRIAL	SENSORY CUE	SNIFFING TIME (s)	CHEWING TIME (s)	NO. OF BAITS CONSUMED
V1	Black*	8.0 ± 3.2	42.8 ± 30.3	–†
	Blue	3.6 ± 1.5	160.4 ± 86.3	–†
	Green	5.7 ± 2.0	20.0 ± 12.0	–†
	Red	7.1± 3.3	88.0 ± 76.6	–†
	Plain	12.3 ± 9.5	3.6 ± 3.6	–†
	Yellow	11.7 ± 5.5	54.0 ± 43.9	–†
		F = 0.627, df = 5, 40, NS	F = 0.983, df = 5, 20, NS	
V2	Mouse	66.1 ± 29.1	144.7 ± 50.9	1.3 ± 0.5
	Blob	68.3 ± 27.8	384.1 ± 42.7	2.7 ± 0.6
		F = 0.05, df = 1, 8, NS	F = 1.009, df = 1, 8, NS	T– = 1.5, NS
V3	Mouse	–	95.3 ± 36.4	2.7 ± 0.7
	Egg	–	85.8 ± 36.7	0.7 ± 0.3
	Flat round	–	13.3 ± 4.0	0 ± 0
			F = 3.00, df = 2, 6, NS	S = 7.00, P = 0.031
V4	With fur	–	–	2.64 ± 0.43
	Without fur	–	–	0.18 ± 0.12
				T– = 0, P ≤ 0.0025
V5	With fur	–	–	2.27 ± 0.36
	Without fur	–	–	2.18 ± 0.55
				T– = 20.5, *NS*

* The coloured baits are listed in order from darkest (Black) to brightest (Yellow).
† Baits interfered with by mice (*Mus musculus*).

Stoats spent significantly more time chewing the mouse-shaped and egg-shaped baits than the flat round baits (Trial V3, Table 2), and they ate significantly more of the mouse-shaped bait than either of the other two baits

3.1.3 Bait texture

The addition of possum (*Trichosurus vulpecula*) fur into preserving wax significantly enhanced the palatability of the wax (Trial V4, Table 2). However, bait consumption of an already palatable bait was not affected by the addition of possum fur (Trial V5, Table 2). In both trials, all of the stoats cached the possum-fur baits, but only 18% and 36%, respectively, cached the control baits.

3.1.4 Mirrors

In Trial V6, stoats investigated the mirror on the wall significantly more often and for longer than the plastic circle (Table 3). However, in Trial V7a, the frequency and duration of investigations was no different between tunnels with and without mirrors (Table 3). Furthermore, in this trial, stoats were equally likely to take the egg from the tunnel with the mirror and the one without. Trial V7 was designed so that the mirror image would make it appear that there were two eggs in the tunnel rather than one; however, this does not appear to have influenced the behaviour of the stoat. Two additional trials (Trial 7b) were run in which there was no egg

TABLE 3. MEAN ± SEM RESPONSE OF STOATS (*Mustela erminea*) TO DEVICES WITH AND WITHOUT MIRRORS OR A RED LIGHT-EMITTING DIODE (LED).
Statistical test results are shown. NS = not significant ($P > 0.05$).

TRIAL	SENSORY CUES	RESPONSE TIME (S)	NO. OF RESPONSES
V6	Mirror	24.0 ± 3.6	13.8 ± 1.8
	Plastic	10.0 ± 2.9	6.5 ± 13
		$t = 3.34$, df = 5, $P = 0.01$	$T- = 0$, $P \leq 0.05$
V7	Mirror + egg	102.8 ± 41.2*	8.6 ± 4.2
	No mirror + egg	83.2 ± 30.8*	8.8 ± 2.7
		$t = 1.48$, df = 4, *NS*	$T- = 7$, *NS*
	Mirror	344.5 ± 174.0	21.5 ± 2.5
	No mirror	51.0 ± 11.0	6.0 ± 1.0
V8	Mirror	68.5 ± 14.5	10.5 ± 1.5
	No mirror	34.1 ± 9.6	6.3 ± 1.0
		$t = 3.35$, df = 7, $P = 0.006$	$T- = 0$, $P \leq 0.05$
V9	Mirror	108.6 ± 31.8	14.2 ± 2.0
	No mirror	66.4 ± 20.9	11.1 ± 2.7
		$t = 3.23$, df = 11, $P = 0.004$	$T- = 10.5$, $P \leq 0.05$.
V10	Mirror	760.5 ± 583.0	22.7 ± 8.8
	Hole	264.5 ± 207.9	14.8 ± 4.0
		$t = 0.84$, df = 3, *NS*	$T- = 1$, *NS*
V11	Red LED	33.9 ± 14.0	3.1 ± 1.0
	No red LED	48.3 ± 11.6	4.3 ± 1.1
		$t = 0.92$, df = 6, *NS*	$T- = 20.5$, *NS*

* Time in tunnel until the first egg was removed from a tunnel.

in the tunnel; in both replicates, stoats visited the tunnel with the mirror more often and for longer. This response was more thoroughly investigated in Trials V8 and V9.

In Trials V8 and V9, stoats more frequently entered and spent more time actively investigating the centre of the trap box containing the mirror than the one without the mirror (Table 3). However, when stoats were given a choice between a mirror and an air hole in the box (Trial V10), there was no significant difference in the number of times stoats entered or the length of time they spent in each box (Table 3).

3.1.5 Light trials

There was no significant difference in the frequency of visits to and the length of time stoats spent in box traps with and without the red LED light (Trial V11, Table 3). There was no significant difference in time spent in the two boxes (Table 3).

3.2 MOVEMENT CUES

3.2.1 Automatic egg feeders

Although stoats spent similar amounts of time on average investigating baits that were stationary or fell through a hole, they consumed significantly more of the eggs that fell through the hole of the platform and broke than the stationary whole eggs (Trial M1, Table 4). If the eggs successfully fell through the hole, they always cracked.

The amount of time spent investigating mobile and static eggs on ramps (Trial M2) also did not differ significantly (Table 4). Two stoats completely consumed the egg they had broken, two others ate more than half of the egg, and the fifth stoat did not eat any. None of the stoats ate any of the whole egg in the other box.

TABLE 4. MEAN ± SEM RESPONSE OF STOATS (*Mustela erminea*) TO BAITS WITH OR WITHOUT MOVEMENT. Statistical test results are shown. NS = not significant ($P > 0.05$). Dash (–) indicates data not collected.

TRIAL	SENSORY CUES	RESPONSE TIME (s)	BAIT CONSUMPTION	NO. OF BAIT ATTACKS
M1	Mobile egg	19.2 ± 5.0	2.4 ± 0.6	–
	Static egg	18.8 ± 9.7	0.9 ± 0.1	–
		t = 0.59, df = 5, NS	T– = 1.5, $P \leq 0.025$	
M2	Mobile egg	74.0 ±48.4	2.8 ± 0.7	–
	Static egg	82.8 ± 60.9	0 ± 0	–
		t = 0.33, df = 4, NS	T– = 0, NS (n = 4)	
M3	Mobile chick	9.8 ± 2.6	–	0.8 ± 0.3
	Static chick	2.3 ± 1.7	–	1.3 ± 0.4
		t = 3.25, df = 3, P = 0.025		(three responses only)
M4	Mobile mouse	113.9 ± 8.6	2.5 ± 1.7	13.1 ± 4.8
	Static mouse	33.0 ± 8.6	2.5 ± 1.0	5.7 ± 1.1
		t = 3.76, df = 6, P = 0.005	T– = 5, NS	T– = 8, NS

3.2.2 Swinging baits

Stoats spent longer investigating the swinging chick than the stationary chick (Trial M3) before beginning to bite and chew a bait (Table 4). Two of the stoats chewed the stationary bait first, one the swinging bait, while the fourth did not attack either bait. Stoats did not bite very frequently at either bait.

Stoats also spent significantly longer investigating the mobile mouse than the stationary one (Trial M4, Table 4). Two stoats chose the swinging bait to bite first, two chose the stationary bait, and the remaining three stoats did not attack either bait. The number of biting attacks on the baits did not differ significantly between bait types (Table 4).

4. Discussion

4.1 VISUAL CUES

4.1.1 Bait colour, shape and texture

Colour did not affect bait consumption in the single trial conducted in this study. This indicates that the use of green- or blue-coloured poison baits, as required by law in New Zealand, will not affect bait consumption by stoats.

There was some indication that some visual characteristics of the bait affected bait acceptance. When a mouse-shaped bait was presented beside two other novel shapes (egg- or disk-shaped baits) (Trial V3), stoats preferentially ate the mouse-shaped baits. It is not clear which features made the mouse-shaped bait most acceptable, but it is possible that the hard egg shell around the egg-shaped bait may have been a barrier to bait consumption, as found in Trial M1 and in previous studies (Dilks & Lawrence 2000; LR, unpubl. data). However, stoats showed no preference for mouse-shaped v. blob-shaped baits (Trial V2). This may have been because the stoats had been conditioned to eat a blob of minced chicken as their daily food allowance. Alternatively, it is possible that the crude mouse shape did not have the key features used by stoats to identify it as a mouse. The mouse used in Trial V3 had more realistic eye shapes than the model used in Trial V2, and it has previously been shown that the position of the ears and eyes are important features for orientating the killing bite (King 1989), as most advanced carnivores bite at the anterior end or neck region of the prey (Leyhausen 1965, cited in Apfelbach & Wester 1977). It should also be noted that the baits in the two trials were made of different meat: freeze-dried mouse was used in Trial V3, compared with rabbit in Trial V2. Therefore, the visual and olfactory cues may have reinforced each other in Trial V3, allowing the stoats to more easily identify the mouse baits as prey.

The presence of possum fur significantly enhanced the palatability of a previously unpalatable wax bait. Although possum fur did not enhance the palatability of an already palatable bait to these captive stoats, it may be worth investigating the effect on more naïve stoats in the wild. It is not clear from these trials whether it was the textural cues that increased the palatability. Since possum fur is odorous, its incorporation into bait may have transmitted olfactory and gustatory, as well as visual and textural stimuli. Regardless of the stimuli, possum fur appears to be attractive to stoats. This supports a previous finding for ferrets, which were shown to be more likely to bite fur-coated objects than those with hard surfaces (Apfelbach & Wester 1977). Fur attractants have the potential to be long-life lures for kill trapping.

Since possum is not a preferred food of stoats, it is likely that the fur from other species may be even more attractive. Possum fur was used in this study because it is commercially available. In future studies, it would be worthwhile assessing rodent and rabbit fur as bait additives.

4.1.2 Mirrors and lights

Stoats showed marked interest in the larger mirrors, both on the wall (Trial V6) and in the box traps (Trial V8). The addition of eggs (Trial V7) appeared to complicate the stoat response and made conclusions about the impact of the mirror on stoat behaviour difficult. The smaller concave mirrors also proved effective in attracting the stoat into the control devices. The inclusion of a mirror was at least as attractive as an 'escape' hole in the box.

A mirror was more attractive to stoats than a semi-transparent piece of plastic. We do not know whether the stoat interprets the image in the mirror as another stoat or a random pattern of moving lines, and this may affect how they will respond when close to the mirror. However, in all cases the initial response is likely to be one of investigation, which is important if mirrors are to be used to attract stoats.

From a practical perspective, the tests of mirrors on the wall in these captive trials were analogous to placing a mirror on the outside of the stoat control device in the field. In a field situation, the expectation would be to improve encounter rates: that is, to attract stoats to a box but not necessarily inside. As previously mentioned, research in the field has shown that at least 20% of visits by wild stoats to a tunnel do not result in the animal actually entering the tunnel, despite it being baited with an egg (Dilks & Lawrence 2000). The present study has shown that the placement of mirrors inside a trapping tunnel behind the treadle mechanism is likely to attract stoats across a control device. In a field situation, this has the potential to increase capture rates, especially of those animals that are averse to entering a tunnel. One limitation on the use of mirrors is their need for a light source so they can provide reflections. This would limit their use to mesh or clear plastic trap tunnels, rather than the best-practice solid wooden stoat trap tunnels.

The use of any control stimulus that involves the deception or otherwise artificial stimulation of an animal faces the problem of repeated encounters causing habituation, resulting in the stimulus becoming ineffective. Using a mirror on the outside of a tunnel would allow a stoat to investigate the novel stimulus closely without an actual kill being achieved. Even if a mirror was also deployed inside a tunnel, it may be that the stoat's curiosity would already be at least partly satiated, so that control efficacy may not be increased. Therefore, based on the evidence available, we recommend that mirrors should initially only be used inside tunnels to address the problem of non-entry rates. Although it may also be useful to use mirrors outside tunnels, we have no evidence that non-encounter rates are a problem, and this strategy may compromise the efficacy of the mirror inside the tunnel. Further research is required in the field on the use of mirrors.

The red LED light did not appear to attract stoats to tunnels. Since the light was activated by the stoats themselves upon entry to the trapping tunnel, habituation to the red light cannot have been a problem. It should be noted that the observation pen was constantly lit by a regular incandescent light bulb, so that the effect of the red LED was somewhat minimised. Nevertheless, this was a novel stimulus to these stoats and was activated at close range, yet we still observed no effect.

4.2 MOVEMENT CUES

4.2.1 Moving eggs

The bait consumption results from the moving egg trials confirm the higher palatability of cracked over whole eggs, as previously demonstrated in other studies (Clapperton et al. 2006; LR, unpubl. data). The success of the apparatus tested showed how easy it is to turn an unpalatable whole egg into a tasty bait. Because whole eggs remain fresh if not damaged for several months, these simple mechanical devices allow for a long field-life and high palatability, both of which are essential characteristics of cost-effective pest baits.

Experimental attempts to control stoats at a landscape scale using poison eggs have been moderately successful, although problems with lower than optimal bait take are apparent (Dilks & Lawrence 2000; Spurr 2000). We have demonstrated a method that significantly improves the bait take of eggs by captive animals, and suggest that poison eggs set in moving egg tunnels may be cost-effective long-life baits with high palatability.

4.2.2 Swinging baits

The swinging baits elicited investigatory behaviours, such as chasing, but not biting or chewing responses. Although these mobile baits did not increase bait palatability, they would be appropriate for attracting stoats into traps. When the baits are moving, the stoat's attention is focused on the bait for longer, so that there is probably an increased likelihood that a trap-shy stoat will make a mistake and stand on a kill-trap treadle. These moving devices require modification before they can be used in the field.

It is possible that in these trials the baits were moving at an inappropriate speed for stoats to be able to attack them effectively. The apparatus used to make the baits move did not control the speed or direction of movement. The mouse sometimes moved very slowly and sometimes moved at up to 200 cm/s. The stoats would lose interest in the moving baits when they slowed down, but could also be scared away from the baits if they swung back at them very quickly. They would follow the bait around the pen when it was travelling at a steady rate. Apfelbach & Wester (1977) found that ferrets respond most to baits moving at 25–45 cm/s, which approximates the escape speed of a mouse.

5. Conclusions and recommendations

5.1 VISUAL CUES

Colour—No one colour of bait was preferred over others.

Bait shape—Influenced bait investigation and consumption, but only in the second trial, when the shapes were more distinctive. It is unclear which features of the mouse-shaped bait were most important to the stoats. However, it would be prudent for a bait manufacturer, given freedom of choice for mould shape, to create baits that are moulded like a commonly eaten prey item, such as mice, or at least with a distinctive anterior end or 'neck' region.

Possum fur—Has the potential to enhance consumption of relatively unpalatable baits. Its effectiveness in enhancing the consumption of palatable baits needs to be tested in the field. Further research using furs of other more preferred prey items may result in further enhanced bait palatability. Because stoats almost invariably cache or otherwise interact with possum-fur baits, these have the potential to be a cost-effective, long-life attractant for trapping.

Mirrors—Have potential to be cheap, practical, long-life attractants for stoats, which would increase both encounter and entry rates. We recommend that mirrors be field trialled as part of an established predator control programme. They should be used inside tunnels behind the control device with adequate light penetration (e.g. mesh-lidded) to increase entry rates.

Light—Red LED light did not influence stoat behaviour.

5.2 MOVEMENT CUES

Moving egg tunnels—Simple mechanical devices that allow stoats to roll whole egg baits so that they fall and break significantly improves the bait take of eggs by captive animals. Therefore, we suggest that eggs set in moving-egg tunnels would be highly palatable, cost-effective, long-life baits.

Swinging baits—Stoats are clearly interested in investigating moving objects. Therefore, moving baits have the potential to attract stoats into kill traps. However, before moving baits can be used for poison baiting, this concept needs further development to produce a device that will consistently attract a stoat towards it and initiate biting responses.

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