Using colour to increase stoat (*Mustela erminea*) trap catch

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CONTENTS

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ABSTRACT

This study compared the effects of four different-coloured trap covers on stoat (*Mustela erminea*) trap catch at Okia Reserve and Allens Beach on the Otago Peninsula, South Island, New Zealand. These sites bordered yellow-eyed penguin (*Megadyptes antipodes*) colonies. Kill traps were each placed within a moulded plastic cover coloured yellow, red, green, or black. All four colours were equally allocated among the 200 traps, giving 50 covers of each colour. Traps were baited with rabbit. They were then re-baited and checked every two days for stoats caught, bycatch of other animals, and disturbed traps. Traps were left at each site for 20 nights. During the study, 18 stoats (12 female and six male), two ferrets (*M. furo*) (one of each sex), eight hedgehogs (*Erinaceus europaeus*), and one rabbit (*Oryctolagus cuniculus*) were caught. Data were analysed using MatLab™ simulations. There was no statistically significant difference in trap catch between sites. Stoats had a higher probability of being caught in traps with yellow covers than those of other colours, and in traps with bright covers (yellow and red) than in those with duller covers (green and black).

Keywords: Colour, sex bias, stoats, *Mustela erminea*, attractants, traps, Otago Peninsula, New Zealand.

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1. Introduction

New Zealand's ecological communities have evolved in the absence of mammalian predators for over 80 million years. Its flora and fauna are especially vulnerable to introduced mammalian pests (Holdaway 1989), such as stoats (*Mustela erminea*), ferrets (*M. furo*), weasels (*M. nivalis*), cats (*Felis catus*), mice (*Mus musculus*), rats (*Rattus* spp.), and hedgehogs (*Erinaceus europaeus*) have become major predators of New Zealand's native birds, lizards, and/or invertebrates (Gibb & Flux 1973; King 1990; McLennan et al. 1996). Of these introduced pests, stoats are now considered one of the most important predators of native avifauna in New Zealand (King 1984; O'Donnell et al. 1996).

To combat the effects of stoats and other introduced vertebrate pests and to preserve and/or enhance indigenous biodiversity, control measures have become important aspects of conservation within New Zealand. With respect to stoats, labour-intensive trapping and poisoning have been the main methods of control. These control operations can be expensive, and any methods that can be developed to maximise cost-effectiveness are not only common sense but also a requirement for any responsible conservation management team.

Stoats are relatively solitary animals and tend to occur at relatively low abundances within New Zealand (Murphy 1996). These characteristics, together with their capabilities for wide dispersal and delayed implantation, combined with problems in trapping this species in late winter and spring (King & Moody 1982), mean that stoat control operations are both difficult and expensive. Therefore trapping and poison operations should be focused and take into consideration any behavioural characteristics that make the target animal more vulnerable to the control methodology.

In the past, control station placement (Doyle 1990; Murphy & Dowding 1995; Dilks et al. 1996), spacing and layout of traps (Lawrence & O' Donnell 1999), and the use of specific baits and lures, have all been trialed to increase the efficacy of stoat control. Baits and pheromone-based lures in part 'reward' the animal for entering a control station. They can also increase the station's 'area of influence', as can non-olfactory attractants, thereby increasing both the trap catch in the 'area of influence' and the ability to trap without increasing the number of traps in an area. Efficacy may then be improved while costs remain constant.

Baits are often based on the food source that is available to the target animal. This can be the prey item of highest abundance within an area and can vary from season to season, e.g. rabbit (*Oryctolagus cuniculus*), possum (*Trichosurus vulpecula*), or mouse (M. Bygate, trapper, pers. comm.; also see King 1973a, 1973b; Murphy et al. 1992). Other food items such as eggs (Dilks et al. 1996; Dilks & Lawrence 2000), commercially mixed baits, fish paste, and pet food have been used in New Zealand (see Griffiths 1999 for review). In many cases the choice of type of bait is made more for ease of operation and the long-life properties of the bait than for its attractant capabilities.

1.1 SENSORY ATTRACTANTS IN BAITS

Lures use the animal's sensory perception to attract it into a control station. Anal gland secretions (Clapperton et al. 1999), the smell of the cut wood used to build trap covers, and auditory cues such as mice and chick noises have been trialed (Griffiths 1999). In contrast to auditory and olfactory responses, the impact of visual cues on the effectiveness of lures and attractants has not been widely researched. In many cases control stations have been designed to be camouflaged or less obtrusive within the stoat's habitat (King & Edgar 1977; King et al. 1994; Dilks et al. 1996; Blair 2002). Where this is not the case, control stations have been left by default in their colour of manufacture, with plastic covers tending to be black, or occasionally green. Part of the reason behind these colour choices is the cost, with black control stations being at least 15% cheaper than other colours (B. Keith, Philproof™, pers. comm.). There is no animal behavioural reason for the selection of these colours.

The lack of research into visual cues is surprising, as stoats are in part visual predators and are likely to respond to such signs. There have been anecdotal reports of increased capture rate and bait take when yellow trap surrounds or bait stations are used in control operations involving other small mammalian predators (Ratz et al. 1992; K. Mitchell, trapper, pers. comm.). In North America, colours have been tested for their attractant characteristics to coyotes (Windberg 1996) and for the presentation of poison to these animals (Mason et al. 1999). Both vertebrates and invertebrates show preference for different colours (Ryan 1990; Hsieh et al. 2001; Meagher 2001). These colour preferences in many cases are reflected by the animal's sexual selection behaviour. There is also evidence that colours not normally involved with sexual selection can trigger animal sensory systems (Ryan 1990). Whatever the mechanisms, if animals are attracted to certain colours, it is possible that control methodology can use this to provide efficient and cost-effective control measures. If this colour preference is sex-biased, there are possibilities for differentially controlling a particular sex.

1.2 OBJECTIVES

This study was designed to investigate:

- Use of colour in bait stations as a stoat attractant to improve catch probability.
- Potential differences in trap catch probability from using traps with covers in four different colours (yellow, red, green and black).
- Potential gender differences in stoat colour preference.

2. Methods

2.1 TRAPPING

Trapping commenced during February to April 2002 in pastureland, scrub, and sand dune areas around Allens Beach (45°54´S, 169°38´E). Trapping also occurred between June and July 2002 around Okia Reserve (45°49´S, 169°43´E). Both of these areas are situated on the Otago Peninsula, South Island, New Zealand, and border important breeding grounds for yellow-eyed penguin (*Megadyptes antipodes*).

At each site, 200 No. 6 Fenn™ kill-traps were laid. These traps were placed within single Philproof™ coloured moulded plastic trap covers (red, green, yellow, and black). The coloured covers were allocated equally among the traps, giving 50 of each colour.

Traps were set out in groups of four, with each different colours present. These 50 groups were spaced at 100 m intervals along tracks within the forest and scrub habitat. Traps were baited with fresh rabbit meat. They were checked and then re-baited with rabbit every two days. Traps were left at each site for 20 nights, giving a maximum of 1000 trap nights per colour and 10 separate recording events per site.

Stoats caught, bycatch of other animals, disturbed traps, and traps with bait removed were recorded during each check. The sex of mustelids caught was determined by autopsy.

2.2 STATISTICAL ANALYSIS

To establish if the different coloured trap covers had different capture probabilities, the data were analysed using simulations run in Matlab™ (Release 12). Several models were used to predict capture probabilities, and simulations were then run to see how likely it was to obtain the observed data. Expected capture probabilities for each model were calculated by averaging the observed capture rates over the appropriate combinations. To measure the difference between the observed data and the expected results if the null hypothesis were true, a 'difference' value was calculated. This difference value was the sum of the squared differences between the observed captures for each combination of colour and site and the expected number of captures if the null hypothesis was true.

Using the expected capture probabilities, the trapping sessions were simulated 5000 times and difference values were calculated for each simulation. If the null hypothesis were true, the difference values calculated for the observed data would be similar to those calculated for the simulated data. If not true, the difference values calculated for the simulated data would only rarely be greater than those calculated for the observed data.

2.2.1 Site or colour difference in trap catch

The analyses tested whether there was a significant difference between the two sites. The null hypothesis for this analysis was that the capture probabilities for each tunnel colour did not differ between sites. Expected capture probabilities were calculated by pooling captures and total trap nights for each colour and dividing captures by trap nights, giving four probabilities.

The next set of simulations looked at differences between colours or sites. The null hypothesis for this analysis was that there was no effect of colour on capture probability. All captures and trap nights were pooled for this analysis.

The next set of simulations looked at the difference between bright (yellow and red) versus dull colours (green and black). The null hypothesis for this was that bright traps had a different capture probability from dull traps.

2.2.2 Effect of sex on capture probability

The two models described below were used to assess if there was a difference between capture probabilities for males and females.

Model one: No difference between male and female capture rates

The probability of capture was calculated by averaging the capture for each colour at each site between males and females. This model fitted eight different capture probabilities. If there was a significant difference between male and female capture rates, the calculated difference for the observed data would be greater than the calculated difference values for the simulated data for 95% of the time (using a 5% level of significance).

Model two: Different capture probabilities for the bright and dull covers

This model used two capture probabilities, the first for bright covers and the second for dull covers. These capture probabilities were the same at both sites and for both sexes.

3. Results

3.1 TRAPPING

Over 5654 trap nights (2764 at Allens Beach and 2890 at Okia Reserve), 12 female and six male stoats, one male and one female ferret, eight hedgehogs, and one rabbit were caught and killed in traps. Equal numbers of stoats were trapped and killed at Allens Beach and Okia Reserve. Both the ferrets were trapped at Okia Reserve, while equal numbers of hedgehogs were caught at each site, and the rabbit was caught at Allens Beach. Of the stoats, seven were caught in red traps, one in a black trap, and 10 in yellow traps; no stoats were captured in traps with green covers. Ferrets were caught in red and yellow traps, and hedgehogs were equally dispersed among all four colours.

3.2 TRAP CATCH AND SITE DIFFERENCES

There was no difference in the trapping probabilities between the Allens Beach and Okia Reserve sites. The difference value for the observed data was 14.2 (Table 1). Over 5000 simulations this value was surpassed 2601 times (P = 0.52), indicating that there was not enough evidence to reject the null hypothesis that there was no difference in the trapping probabilities between sites.

TABLE 1. OBSERVED AND EXPECTED CAPTURES FOR THE NULL HYPOTHESIS OF NO DIFFERENCE IN CAPTURE PROBABILITIES BETWEEN TRAP SITES.

TRAP	TOTAL TRAP NIGHTS		OBSERVED CAPTURES		EXPECTED CAPTURES		CAPTURE PROBABILITY	D^2	
	Okia	Allens	Okia	Allens	Okia	Allens		Okia	Allens
Yellow	738	698	3	7	5.14	4.86	0.0070	4.6	4.6
Red	696	708	5	2	3.47	3.53	0.0050	2.3	2.3
Green	732	712	0	0	0.00	0.00	0.0000	0.0	0.0
Black	724	646	1	0	0.53	0.47	0.0007	0.2	0.2

Capture probability is calculated from the pooled captures and total trap nights for each colour at both sites.

D^2 = squared difference between observed and expected values, which were then summed to obtain the total difference value.

3.3 TRAP CATCH AND TRAP COLOURS

There were significant differences between the capture probabilities for the trap cover colours, with yellow trap covers being the most successful. In this analysis all captures and trap nights were pooled, giving a capture probability of 0.0032, which was used to calculate the expected captures (Table 2). The total difference calculated for the observed data was 47.6. Over 5000 simulations this value was exceeded 82 times (P = 0.01), indicating that there were significant differences between the capture probabilities for the trap cover colours. Looking at the differences for the cell values, most of the lack of fit can be seen to come from the yellow traps used at Allens Beach.

TABLE 2. RESULTS FOR SIMULATION ANALYSES ASSUMING NO DIFFERENCES BETWEEN TRAP COVER COLOURS.

TRAP	TOTAL TRAP NIGHTS		OBSERVED CAPTURES		EXPECTED CAPTURES		D^2	
	Okia	Allens	Okia	Allens	Okia	Allens	Okia	Allens
Yellow	738	698	3	7	2.35	2.22	0.4	22.8
Red	696	708	5	2	2.22	2.25	7.8	0.1
Green	732	712	0	0	2.33	2.27	5.4	5.1
Black	724	646	1	0	2.30	2.06	1.7	4.2

The capture probability used to calculate the expected capture rates was 0.0032.

D^2 = squared difference between observed and expected values, which were then summed to obtain the total difference value.

3.4 TRAP CATCH FOR BRIGHT AND DULL COVERS

Bright covers had a higher expected capture probability (0.006) than the duller covers (0.003). These probabilities were used to calculate the expected capture frequencies (Table 3). The total calculated difference between the observed and the expected captures was 16.7 and this was exceeded 2201 times from 5000 simulations ($P = 0.44$). This shows that there was not enough evidence to reject the null hypothesis that there were different capture probabilities between the dull and bright trap covers.

TABLE 3. OBSERVED AND EXPECTED CAPTURES FOR THE NULL HYPOTHESIS THAT THERE WAS A DIFFERENCE IN CAPTURE PROBABILITIES BETWEEN BRIGHT AND DULL TRAP COVERS.

TRAP	TOTAL TRAP NIGHTS		OBSERVED CAPTURES		EXPECTED CAPTURES		D^2	
	Okia	Allens	Okia	Allens	Okia	Allens	Okia	Allens
Yellow	738	698	3	7	4.42	4.18	2.0	8.0
Red	696	708	5	2	4.17	4.24	0.7	5.0
Green	732	712	0	0	0.00	0.00	0.0	0.0
Black	724	646	1	0	0.00	0.00	1.0	0.0

D^2 = squared difference between observed and expected values, which were then summed to obtain the total difference value.

3.5 TRAP CATCH AND SEX BIAS

There was no difference in capture rate between male and females when the differences between study site and colours are allowed for. From Table 4, the observed total difference of 6 was exceeded 4769 times over 5000 simulations. The results from the simulation show that there was no significant difference between male and female capture rates (P= 0.95). The probability value is quite high, suggesting that males and females do have the same recapture rates.

TABLE 4. DIFFERENCE BETWEEN MALE AND FEMALE CAPTURE RATES ALLOWING FOR DIFFERENCES BETWEEN COLOURS AND SITE.

	EXPECTED CAPTURE PROBABILITIES		EXPECTED CAPTURES		OBSERVED DIFFERENCE FROM EXPECTED	
	Male	Female	Male	Female	Male	Female
Okia						
Yellow	0.0020	0.0020	1.5	1.5	0.25	0.25
Red	0.0036	0.0036	2.5	2.5	0.25	0.25
Green	0.0000	0.0000	0.0	0.0	0.00	0.00
Black	0.0007	0.0007	0.5	0.5	0.25	0.25
Allens Beach						
Yellow	0.0050	0.0050	3.5	3.5	2.25	2.25
Red	0.0014	0.0014	1.0	1.0	0.00	0.00
Green	0.0000	0.0000	0.0	0.0	0.00	0.00
Black	0.0000	0.0000	0.0	0.0	0.00	0.00

Capture probabilities for bright and dull covers were calculated assuming that there was no difference between site or sex (Table 5). The observed total difference of 14.2 was exceeded 2936 times from 5000 simulations, indicating that the observed results were consistent with the brighter traps having a higher capture probability and the dull traps a lower capture probability. Most of the lack of fit is contributed by the yellow covers and female captures at Allens Beach.

TABLE 5. CAPTURE PROBABILITIES FOR BRIGHT AND DULL COVERS CALCULATED ASSUMING NO DIFFERENCE BETWEEN SITE OR SEX.

	EXPECTED CAPTURE PROBABILITIES		EXPECTED CAPTURES		OBSERVED DIFFERENCE FROM EXPECTED	
	Male	Female	Male	Female	Male	Female
Okia						
Yellow	0.0030	0.0030	2.21	2.21	1.46	0.04
Red	0.0030	0.0030	2.08	2.08	0.01	0.84
Green	0.0002	0.0002	0.13	0.13	0.02	0.02
Black	0.0002	0.0002	0.13	0.13	0.02	0.76
Allens Beach						
Yellow	0.0030	0.0030	2.09	2.09	0.01	8.47
Red	0.0030	0.0030	2.12	2.12	1.25	1.25
Green	0.0002	0.0002	0.13	0.13	0.02	0.02
Black	0.0002	0.0002	0.11	0.11	0.01	0.01

3.6 BYCATCH

Hedgehogs were only caught on eight occasions and were caught in equal numbers in all coloured traps. The trap catch data available for ferrets and the rabbit were too low to perform any meaningful statistical analyses.

4. Discussion

Animal colour choice or preference is a well-known phenomenon, especially with respect to sexual selection characteristics (Endler 1978, 1980; Andersson 1982: Burley et al. 1991; Bakker & Mundwiler 1994; Hamilton & Poulin 1997). In some cases the choice of colour by an animal bears no resemblance to the animal's natural habitat or characteristics. An example of this type of colour choice can be seen where female zebra finches prefer males with artificial red leg bands over those with other colours even though red is not a colour used 'normally' in their sexual selection processes (Burley 1981). It has been hypothesised that, in these cases, some animals have a predisposition to certain colours or have a 'sensory bias' towards them, and that these biases are not based on sexual selection characteristics (Ryan 1990).

In this study it was found that stoats were more likely to be caught in traps that had the brightest coloured trap covers. Of the four colours tested (yellow, red, green and black), yellow was the most successful for trapping stoats. The data also indicated that there was no difference between sexes in colour choice, nor any sex-based preference for bright or dull trap covers; males were just as likely to pick a yellow and/or brightly coloured trap as females. Although there was no sex-based colour choice found during this study, it is possible that the number of captures were too low to pick up a significant difference between male and female capture rates. Therefore, the effects of colour on sex-targeted control should not be overlooked.

In this study, colour was used 'on its own' to attract stoats. Using colour as an attractant in concert with other control methods has the potential to increase the efficacy of stoat control operations. Control operations targeted towards periods of high pest numbers, or during the prey's high vulnerability period, towards specific habitats or ecotones, and also the use of other appropriate lures and baits may enhance the effects of colour on trap catch probability. Adoption of a combination of these methods could maximise control. From the results obtained in this study, it is suggested that the use of colour as an attractant to increase the efficacy of pest control operations should be an important consideration in the future design of control stations.

5. Recommendations

More research using a variety of colours is recommended to confirm whether the preference for bright colours detected in this short study is generally found. In particular I recommend:

- Monitoring of stoats throughout the year, within areas of known high density, using greater numbers of the coloured tunnels to test the seasonality of the coloured effect.
- Trapping in these areas during different seasons to investigate further any possible sex-based colour bias.
- Trapping of stoats using the brighter coloured traps in conjunction with differently baited lure types to test for any accumulated effect of different combinations of the attractants.
- Comparing the effect of different coloured bait stations and coloured bait on the efficacy of stoat poison control operations.
- Determining the area of influence of yellow control stations compared with standard coloured stations and the the density required to provide effective coverage of designated areas.

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