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

B.K. Clapperton, L. Robbins, R.E.R. Porter and K. Tallentire

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CONTENTS

Abstract 5

1. Introduction 6
   - 1.1 Background 6
   - 1.2 Objectives 7

2. Methods 7
   - 2.1 Animal husbandry 7
   - 2.2 Experimental procedures 7
   - 2.3 Attractiveness trials 8
   - 2.4 Palatability/'chewability' trials 10
   - 2.5 Longevity trials 12
   - 2.6 Statistical methods 12

3. Results 13
   - 3.1 Attractiveness trials 13
     - 3.1.1 Prey items 13
     - 3.1.2 Commercial products 14
     - 3.1.3 Chemical extracts and additives 14
     - 3.1.4 Rabbit formulations 14
     - 3.1.5 Best lures v. hen eggs 15
   - 3.2 Palatability/'chewability' trials 15
     - 3.2.1 Egg 15
     - 3.2.2 Rabbit formulations 16
     - 3.2.3 Mouse formulations 17
     - 3.2.4 Best baits v. hen eggs 18
   - 3.3 Longevity trials 19
     - 3.3.1 Preservative trial 19
     - 3.3.2 Preserved bait trial 20
     - 3.3.3 Aged baits 20
     - 3.3.4 Aged bait assessment 21

4. Discussion 22
   - 4.1 Lure attractiveness 22
   - 4.2 Bait palatability 24
   - 4.3 Bait 'chewability' 25
   - 4.4 Lure and bait longevity 26

5. Conclusions and recommendations 26

6. Acknowledgements 28

7. References 28

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

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ABSTRACT

Improved, cost-effective stoat control methods are needed to reduce predation rates on New Zealand wildlife. The aim of this project was to identify effective trap lures and baits for use in delivering poisons and biocontrol agents to stoats (*Mustela erminea*). We tested the attractiveness and palatability of a range of lures and baits on captive stoats in two series of multi-choice experiments. We assessed bait longevity by testing the attractiveness and palatability of the most promising bait formulations that had been aged for 1 week, compared with currently-used egg baits. Prey-based lures were the most attractive. We failed to find any additional odours that would substantially enhance lure success. Highly palatable and acceptable bait formulations included gelatine-injected freeze-dried mice and a wax/tallow/rabbit meat mix. The addition of sodium meta-bisulphate to these baits produced attractive, palatable baits with a field life of at least 1 week. We recommend the use of gelatine-injected freeze-dried mice and wax/tallow/rabbit baits as attractive, palatable and long-lasting alternatives to currently-used egg baits, and salted rabbit as a trap lure. Rabbit or beef meat in a soft jerky is also worth further development. While these options are probably more expensive than hen eggs, their cost-effectiveness needs to be assessed on a per stoat capture basis, and they can be viewed as 'boutique' baits when effectiveness is paramount, or where variety is required to counter the effects of bait-shyness.

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

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1. Introduction

1.1 BACKGROUND

This study was part of a 5-year Department of Conservation (DOC) stoat (*Mustela erminea*) research programme. It fits into three of the stated aims of that programme:

- To make stoat control more cost-effective where it is already successful.
- To develop new techniques so that control can realistically be undertaken in more and larger areas.
- To expand the arsenal of methods to ensure that stoat control, and the consequent benefits to biodiversity, are sustainable.

While trapping can be an effective means to reduce stoat predation, it is labour-intensive, and bait- or trap-shy individuals remain a problem (Brown 2003). The Stoat Technical Advisory Group (STAG) identified that more-effective baits and lures may be the best short-term means of achieving gains in control efficiency.

Lures are defined here as materials containing sensory cues that attract animals to control devices. By contrast, baits are edible materials that, while likely also to act as attractants, are consumed by the target animals for the delivery of poisons or bio-control agents. Attractants are used to either draw stoats in from a distance and/or direct their attention and movements to the control device. They will be most cost-effective if they have adequate shelf life and remain attractive for extended periods of time in the field. They also need to be easy and safe to use (Parkes & Murphy 2004). For trap lures, these are the most important characteristics. For poison baits, there is the additional requirement of palatability, and an ability to contain adequate toxin. For use in viral transmission (e.g. Canine Distemper Virus), the requirement is for long chewing, allowing time for the release of the virus into the buccal cavity. The need for lures and baits that fit these requirements is urgent (Brown 2003).

Rodent, rabbit and egg lures can be effective attractants for stoats (Dilks et al. 1996; DOC 2002; Montague 2002; Brown 2003; Christie et al. 2003), but fresh materials rapidly putrefy (Miller 2003). While a range of attractants has been tested on stoats, (Spurr 1999; L. Robbins, unpubl. data), many potential attractant materials remain untested.

Rabbit and other prey items have been used in various long-life formulations as lures for mustelids in New Zealand but have not been rigorously tested against each other. The prey material includes freeze-dried rabbit and rodents (Burns 2000; Miller 2003), salted rabbit (Brown 2003), and solvent extracts of rabbit (Cook et al. 2000).

One long-life matrix—a casein-based material—has already been shown to be effective for stoat anal scent lures and for fish-based crustacean lures (Clapperton et al. 1999; A.D. Woolhouse, Industrial Research Limited (IRL), pers. comm. March 2000). Other matrices (e.g. polyurethane foam, polymer) have been used for the delivery of toxins and vaccines to a range of mammalian species (Linhart et al. 1991, 1993, 1997b; Creekmore et al. 1994).

Commercially-available pet and human food items provide another potential source of already formulated lures and baits.

1.2 OBJECTIVES

- To test the attractiveness to stoats of a range of odorous materials.
- To determine the palatability and 'chewability' of bait formulations.
- To determine the longevity of effective lure/bait formulations and compare them with currently-used lures and baits.

2. Methods

2.1 ANIMAL HUSBANDRY

Twenty-three stoats were captured from the wild in the Tararua region, New Zealand. Eleven stoats were caught at the beginning of the study, then another eight part way through, and four near the end (Tables 1–3). This provided a turn-over of new stoats into the trials, to minimise the effects of multiple testing of the same individuals. The stoats were handled as little as possible to minimise stress. Age class and sex were not determined for most of the stoats. All stoats were housed individually in cages with minimum dimensions 90 × 240 × 200 cm. 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 three-dimensional networks 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. The stoats were fed daily, primarily with an excess quantity of fresh chicken mince, supplemented with fresh hen eggs, dried cat food, and high-quality dog feed sausage. Hen eggs were not offered as a dietary supplement until after the initial trials using hen eggs were complete. Water was provided at all times.

Animals were weighed on arrival, and then weekly until body weights (which usually increased) stabilised, usually at 3–5 weeks. They were then considered acclimatised and ready for use in the trials.

2.2 EXPERIMENTAL PROCEDURES

We tested the stoats individually in one of two indoor pens (200 × 240 × 200 cm) that were constructed similarly to the housing shed described above. Stoats were introduced to the pen on either the day before or on the day of a trial. Water in a dish and a small quantity of fresh hay (as a den) were available to the stoats for the duration of every trial.

Food was usually unavailable during the trials. At the conclusion of each trial the stoat was removed to its regular cage and provided with *ad libitum* fresh food and water. In some trials the baits being tested provided a source of food. In these cases, food was removed from the stoats 12 h prior to the onset of the trials. No stoat was deprived of food for longer than 24 h.

Our general experimental procedure was to place the lure or bait materials in 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. We recorded on video the responses of the stoat to the lure or bait materials over a 12-h period. The stoat was returned to its home cage immediately after the trial or remained for a second night when attractiveness and palatability trials were run back-to-back (see later for details of experimental design). The pen was searched for stray pieces of bait and then cleaned. The baseboards and containers for the bait materials were thoroughly cleaned in soapy water and rinsed in fresh water between trials. The smaller containers were not re-used.

2.3 ATTRACTIVENESS TRIALS

The attractiveness trials consisted of a series of 17 choice experiments, each comparing the responses of 5–11 stoats to 4–6 lures (Table 1). We tested both proven and novel attractants, in both proven and novel formulations (Fig. 1). During the course of the trial, new materials became available for testing, while others became unavailable. We tested lure materials as they became available to us, trying to group together similar types of materials, and often using the most promising lure from one trial against new materials in the next test. The lures were inaccessible to the stoat. In preliminary trials (1–3), the test materials were placed in plastic boxes attached onto the outside wall. The stoat could smell the material, but it could not see the lures. As we achieved only limited levels of response in these trials, and because we became concerned that the stoats were viewing the holes in the wall more as potential escape routes than as odour sources, in Trials 4–14 the lures were placed in containers on the floor of the pen. In Trials 8–11 we used outer containers made of perforated polystyrene over the lures. The stoats could break these open to reveal the lure materials, but could still not access them. In Trials 15–17, we assessed the responses of the stoats to the visual as well as the olfactory aspects of the baits, by placing the lures on the floor under wire mesh covers.

The response measured was the time a stoat spent investigating the lures. The stoat made contact with its nose or mouth on the perforations of the container, made scratching actions on the container with its paws, or pushed the whole container with head or paws. A response was recorded if the stoat sniffed or scratched at the container for > 1 s. This avoided very brief visits while passing by that might have been biased by the resting position of the stoat in the pen.

The various lure materials tested in the attractiveness trials are listed in Table 1. Solid test materials were tested in equal weights (unless otherwise stated) directly placed in the lure containers. Liquid materials were presented in equal volumes on cotton wool. The exception was in Trial 15, where the extracts were added to c. 20-g low-salt, flour/gelatine dough baits at the rates recommended by the supplier. The dacron was added into Trial 13 as an additional negative control, to test whether or not the stoats had developed a general interest in the cotton wool itself, because of association with the attractive lure of previous trials.

TABLE 1. LURE MATERIALS ASSESSED IN ATTRACTIVENESS TRIALS.

n = number of stoats tested. Stoats included those from the original cohort captured (O), those caught in the middle of the project (M), and the last caught (L).

TRIAL	STOATS USED	LURE MATERIALS		CONTROLS	
				NEGATIVE	POSITIVE
PREY ITEMS					
1	*n* = 5 (all O)	One cracked hen egg		Empty container	
2	*n* = 11 (all O)	One whole rabbit One whole mouse	One whole sparrow	Empty container	
3	*n* = 11 (all O)	Rabbit flesh Rabbit skin	Rabbit gut	Empty container	
4	*n* = 10 (all O)	Piece of rabbit One rat (opened)	Four sparrows (opened)	Empty container	
5	*n* = 9 (all O)	Rabbit Fish-head oil, one drop	4 canned quail eggs in brine	Empty container	
COMMERCIAL PRODUCTS					
6	*n* = 6 (all O)	Beef jerky[1] Chicken jerky[1]	Chicken 'snausage'[1]	Empty container	
7	*n* = 6 (all O)	Dried sardine Chocolate drops	Colostrum in Albert®[2]	Empty container	
CHEMICAL EXTRACTS AND ADDITIVES					
8	*n* = 10 (9 O + 1 M)	Polar rat extract[3] Non-polar rat extract[3]	Non-polar rabbit extract[3] Freeze-dried ship rat	Cotton wool	Minced chicken
9	*n* = 10 (9 O + 1 M)	Polar sparrow extract[3] Non-polar sparrow extract[3]	Powdered whole cream colostrum Freeze-dried ship rat	Cotton wool	Minced chicken
10	*n* = 9 (8 O + 1 M)	Polar rat extract[3] Polar rabbit extract[3]	Z-dodecenylacetate (c. 10%) Phenyl acetic acid (c. 10%)	Cotton wool	Minced chicken
11	*n* = 9 (all O)	Polar rat extract[3] Female stoat anal sac secretion	Male stoat anal sac secretion Carbon disulphide, 0.01%	Cotton wool	Minced chicken
12	*n* = 11 (8 O + 3 M)	Polar/non-polar sparrow[3] Polar/non-polar rabbit[3]	Non-polar sparrow[3] Non-polar rabbit[3]	Cotton wool	Minced chicken
13	*n* = 9 (3 O + 6 M)	Z-dodecenylacetate (1%) Phenyl acetic acid (1%)	Spirulina (20%)	Cotton wool-dacron	Minced chicken
RABBIT FORMULATIONS					
14	*n* = 11 (5 O + 6 M)	Freeze-dried Salted	Pureed Non-polar extract[1]	Cardboard	
15	*n* = 5 (2 O + 3 M)	Rabbit meat flavour[4] Rabbit 'aroma'[4]	Rabbit musk[4]	Plain dough	Minced chicken
16	*n* = 9 (4 O + 5 M)	Freeze-dried Wax/tallow	Salted Polymer[5]	Cardboard	Minced chicken
BEST LURES					
17	*n* = 10 (3 O + 3 M + 4 L)	GIFD mouse[6] Rabbit in wax/tallow (WT) Salted rabbit	Whole hen egg Cracked hen egg	Cardboard	

[1] Commercially available chewable dog treats.

[2] Provided by Fonterra Ltd, made at University of Otago. Albert® is a bioerodable, solid casein-based matrix.

[3] Extracted from natural products at IRL, Lower Hutt. Non-polar extracts include the oils, fats and lipids, while the polar extracts include the remaining components (Cook et al. 2000).

[4] Provided by Feral R&D, Auckland.

[5] Provided by PestTech Ltd, Christchurch.

[6] GIFD = gelatine-injected freeze-dried.

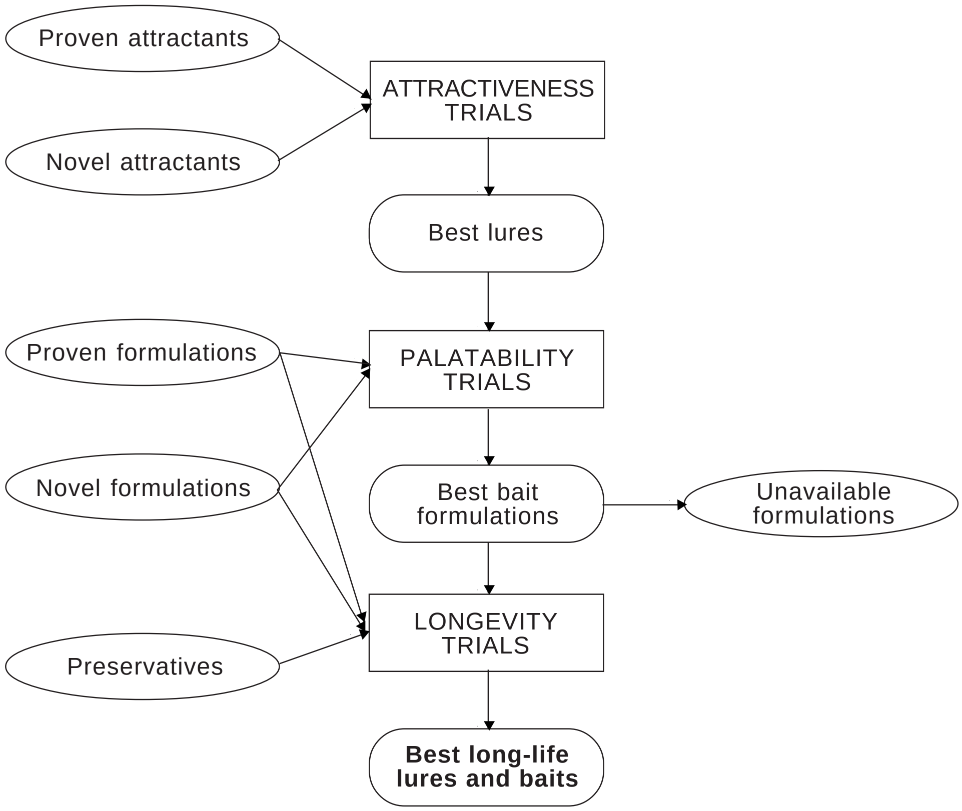


Figure 1. Flow diagram showing progression of the experiments. Ellipses indicate materials used; rectangles indicate trials conducted; rectangles with rounded corners indicate outcomes.

2.4 PALATABILITY/'CHEWABILITY' TRIALS

Bait palatability and acceptance were measured in a series of 'cafeteria' experiments (Table 2). Bait consumption was assessed by rating the baits at the end of the trial on an arbitrary scale of consumption (0–4), except in Trial 1, when it was simply recorded as eaten or not. The consumption scores were:

0 = none eaten.
1 = ≤ 25% eaten.
2 = ≤ 50% eaten.
3 = > 50% eaten.
4 = > 90% eaten.

The time stoats spent chewing baits was recorded from the video footage. In Trial 5, sniff time and chew time could not be distinguished, so total times investigating the baits are reported. In Trials 7 and 8 that used foam baits, we recorded separately the time spent chewing at the foam and the bait coating. In all trials, bait acceptance was calculated as the proportion of stoats scoring ≤ 4 in bait consumption. We also scored the order in which the baits were first chewed.

In Trial 1, the stoats were provided with one whole hen egg and one cracked-open hen egg in their home cages. We recorded whether or not the eggs were moved and/or eaten. This trial was not taped. All subsequent palatability trials were run in the observation pens. The bait materials were attached to wooden baseboards and the stoats had free access to them. Trials 4, 7 and 12 were run back-to-back with the corresponding attractiveness trial (15, 16 and 17, respectively), so the stoats had already had experience of the smell and sight of the baits the night before the trial.

TABLE 2. BAIT MATERIALS ASSESSED IN PALATABILITY TRIALS.

n = number of stoats tested. Stoats included those from the original cohort captured (O), those caught in the middle of the project (M), and the last caught (L).

TRIAL	STOATS USED	BAIT MATERIALS		CONTROLS
EGG				
1	n = 11 (all 0)	One cracked hen egg	One whole hen egg	
RABBIT FORMULATIONS				
2	n = 4 (all 0)	Polar extract[1] on Freeze-dried rabbit/gelatine Non-polar extract[1] on Freeze-dried rabbit/gelatine	Polar/non polar extract[1] on Freeze-dried rabbit/gelatine	FDR/gelatine
3	n = 7 (2 O + 5 M)	Meat extract[2] on chicken mince Aroma[2] on chicken mince	Musk[2] on chicken mince	chicken mince
4	n = 8 (4 O + 4 M)	Meat extract[2] on flour dough Aroma[2] on flour dough	Musk[2] on flour dough	Flour dough
5	n = 7 (all O)	Raw rabbit[3] in lard Raw rabbit[3] in wax/tallow Raw rabbit[3] in bran/gelatine/wax	Cooked rabbit[3] in lard Cooked rabbit[3] in wax/tallow	Foam
6	n = 9 (4 O + 5 M)	Raw rabbit[3] in wax/tallow Plain wax/tallow (no rabbit) Hard rabbit jerky[4]	Raw rabbit[3] in bran/gelatine/wax Soft rabbit jerky[4]	Foam
7	n = 10 (4 O + 6 M)	Freeze-dried rabbit Salted rabbit	Wax/tallow/rabbit[3] Polymer rabbit[5]	Foam
FOAM BAITS[6] WITH RABBIT FORMULATIONS				
8	n = 9 (4 O + 5 M)	Freeze-dried rabbit Pureed rabbit/bran Plain wax/tallow	Pureed rabbit/wax/tallow Plain bran	Foam
9	n = 9 (4 O + 5 M)	Freeze-dried rabbit/egg, FD coating Pureed rabbit/egg, fur	Pureed rabbit/soy butter, fur Plain	Foam
FREEZE-DRIED MOUSE FORMULATIONS				
10	n = 9 (4 O + 5 M)	Soya oil-soaked Tallow-soaked	Tallow/soya oil-soaked Sugar-soaked	Plain FD mouse
11	n = 9 (4 O + 5 M)	Gelatine-injected (GIFD)	Soya oil-injected	Plain FD mouse
BEST BAITS				
12	n = 10 (3 O + 3 M + 4 L)	GIFD mouse Rabbit in wax/tallow (WT) Salted rabbit	Whole hen egg Cracked hen egg	Cardboard

1 Extracted from natural products at IRL, Lower Hutt.

2 Provided by Feral R&D, Auckland, formulation not disclosed.

3 Contained 50% rabbit meat wt/wt. Cooking involved heating just until the rabbit meat was no longer pink.

4 Provided by Fonterra Ltd, made at University of Otago, Dunedin; containing 50% rabbit meat.

5 Provided by PestTech Ltd, Christchurch, formulation not disclosed.

6 Baits in Trial 8 were pieces of polyurethane foam soaked in a 50:50 fresh egg/soya oil mixture with the attractant coating the outside. In Trial 9, the rabbit was more thoroughly mixed with the egg and oil or soy margarine, and soaked into the foam before coating with either finely chopped freeze-dried rabbit or rabbit fur.

2.5 LONGEVITY TRIALS

In Trial 1 we compared the palatability of three chemical preservatives in minced chicken baits (Table 3). We then added the most palatable of these to the two most promising bait formulations identified in the palatability trials (GIFD mouse and WT rabbit). In Trial 2, both attractiveness and palatability of these preserved baits were compared with those of salted rabbit and egg, in 'back-to-back' trials on consecutive nights. Samples of all these baits were then aged for 1 week outdoors (protected from direct sunshine and rain) and their attractiveness and palatability re-assessed in Trial 3.

Rabbit jerky baits from Fonterra were aged for 5 weeks (hard formulation) or 6 weeks (soft formulation) in simulated field conditions. They were protected by mesh from rodents and birds, and were under a wooden roof to avoid direct sunlight and rainfall. They were weighed at approximately weekly intervals, and visually assessed for the growth of mould.

2.6 STATISTICAL METHODS

Time data (response time in attractiveness trials and chew time in palatability trials) were log transformed before analysis. We used a randomised block two-way ANOVA, testing for variation in responses by treatment (lure/bait type) blocked by individual stoat (Zar 1984). Attractiveness Trials 8 and 9 were replicated and night (1 or 2) was included as a factor in the ANOVA, along with the relevant interaction factors. For trials that included minced chicken as a positive control, we present the results of analyses that exclude these responses. The positive control was included in the experimental design to confirm that the stoat was responsive. We were not interested in the attractiveness of the minced-

TABLE 3. BAIT MATERIALS TESTED IN LONGEVITY TRIALS.
n = number of stoats tested. They included those from the original cohort captured (O), those caught in the middle of the project (M), and the last caught (L).

TRIAL	STOATS USED	BAIT MATERIALS	CONTROLS
1	*n* = 8 (4 O + 4 M)	Monosodium glutamate 0.5%	Plain chicken mince
		Sodium metabisulphate 0.02% (SM)	
		Potassium sorbate 0.075%	
2	*n* = 9 (3 O + 2 M + 4 L)	GIFD mouse + 0.07% SM	Cardboard
		WT rabbit + 0.07% SM	
		Salted rabbit	
		Dried beef jerky[1]	
		Cracked hen egg	
3	*n* = 6 (3 O + 1 M + 2 L)	GIFD mouse + 0.07% SM	Cardboard
		WT rabbit + 0.07% SM	
		Salted rabbit	
		Dried beef jerky[1]	
		Cracked hen egg	
4	Not applicable	Soft rabbit jerky[2] (*n* = 14 baits)	
		Hard rabbit jerky[2] (*n* = 13 baits)	

[1] Manufactured by 'Country Meats'.

[2] Provided by Fonterra Ltd, made at University of Otago, Dunedin.

chicken which the stoats had been trained to eat. Negative controls were included in the analyses. Kruskal-Wallis and Friedman non-parametric tests were used for one-way (chew order) and two-way (bait consumption score) rank data respectively. The significance level was set at $P \leq 0.05$ but we also draw notice to all analyses that produced probability levels of $P \leq 0.1$.

3. Results

3.1 ATTRACTIVENESS TRIALS

3.1.1 Prey items

In Trial 1, there was only limited responsiveness. While all the stoats investigated both boxes, the maximum time spent responding at any box was only 18 s within the total 12-h period. Only two of the stoats spent more time at the egg lure than the empty container and, overall, there were no significant differences in response times between the boxes ($F = 0.714$, df = 1, 4, $P = 0.45$).

The responses of the stoats tested in Trial 2 lasted up to 64 s. Mean responses were similar for rabbit, sparrow and mouse. The empty container was always the least- or second-least-preferred box, but overall response times did not vary significantly amongst the treatments ($F = 2.262$, df = 3, 30, $P = 0.10$).

In Trial 3, with the lure materials lower on the wall, the time spent responding reached a maximum of 1164 s. There were significant differences amongst the treatments ($F = 3.403$, df = 3, 30, $P = 0.03$). Rabbit gut and flesh elicited the longest mean responses (Fig. 2A).

In Trial 4, the differences in response times bordered on significance ($F = 2.725$, df = 3, 27, $P = 0.06$). One stoat spent more than 7000 s interacting with the bucket containing the rat. Not only did the stoats sniff at the containers, but they also worried at the lid and attempted to push the whole containers over. Mean responses were high to all three prey types (overall mean response time = 300 s) (Fig 2B).

There were no significant differences in response times in Trial 5 ($F = 0.389$, df = 3, 24, $P = 0.76$). Only one stoat responded for more than 100 s in this trial.

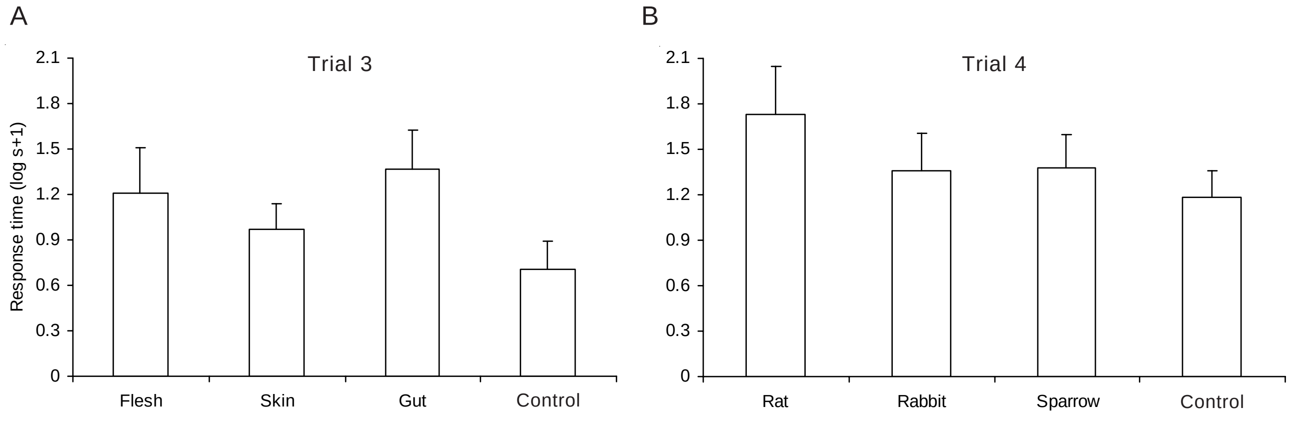


Figure 2. Mean time (+ 1 SEM) stoats spent sniffing at or touching the buckets containing prey odours, plus control. **A**. Rabbit parts from Attractiveness Trial 3 (responses ≥ 1 s). **B**. Rabbit, rat and sparrow odours from Trial 4 (responses ≥ 5 s). The controls are empty buckets.

3.1.2 Commercial products

Trials 6 and 7 of commercially available pet jerkies and treats were characterised by short response times (Max. = 45 s). The chicken 'snausage' recorded the highest average response time (13.7 s) in Trial 6, but there were no significant differences amongst the treatments (F = 1.229, df = 3, 15, P = 0.33). In Trial 7, neither the dried sardine nor the chocolate drops scored as highly as the empty container, while the colostrum in Albert® only just scored higher than the empty container (F = 2.769, df = 3, 15, P = 0.08).

3.1.3 Chemical extracts and additives

The freeze-dried (FD) rat produced the longest average response time in Trial 8 (46.7 s). The differences between the treatments were not significant (F = 2.555, df = 4, 36, P = 0.082). The non-polar rabbit extract (34.9 s) was the only other treatment to score more highly than the empty container (28.4 s). Mean responses on the first night (31.7 s) were not significantly different from the second night (36.8 s) (F = 2.164, df = 1, 36, P = 0.150).

In Trial 9, the FD rat again had the highest average response time (63.7 s), followed by the non-polar sparrow extract (48.7 s) while the colostrum had a lower average score (27.0) than the cotton wool negative control (38.0) and the polar sparrow extract (37.4 s). Differences amongst the treatments were significant (F = 2.313, df = 4, 67, P = 0.014). Average responses on the first night (25.4 s) were significantly lower than those on the second night (60.6 s) (F = 8.632, df = 1, 67, P = 0.006).

Neither of the prey extracts (polar rat = 180.7 s; polar rabbit = 304.7 s) nor either of the synthetic chemicals (phenyl acetic acid = 120.1 s; Z-dodecenylacetate = 105.8 s) were significantly more attractive to the stoats than the cotton wool control (117.2 s) in Trial 10 (F = 1.42, df = 4, 32, P = 0.25). Stoats in this trial were, however, highly responsive to all the treatments compared with other trials (overall average response = 162 s, maximum = 1689 s).

In Trial 11, only the polar rat extract (108.4 s) and the male anal sac secretion (87.7 s) had mean response times greater than the cotton wool negative control (85.3 s). The female anal sac secretion averaged 73.3 s, and the carbon disulphide 69.7 s. These scores did not differ significantly (F = 0.225, df = 4, 32, P = 0.92).

Neither the non-polar rabbit (13.0 s), non-polar sparrow (23.0 s), nor the combined non-polar rabbit (11.8 s) or sparrow (19.0 s) extracts tested in Trial 12 were significantly more attractive than the cotton wool negative control (F = 0.388, df = 4, 40, P = 0.81).

In Trial 13, the spirulina-impregnated cotton wool had the highest mean response time (8.4 s), followed by the phenyl acetic acid (5.7 s) and Z-dodecenylacetate (5.0 s), but these responses were not significantly greater than those to the plain cotton (5.0 s) or dacron (4.4 s) (F = 2.341, df = 4, 32, P = 0.08).

3.1.4 Rabbit formulations

In Trial 14, the stoats spent more time at the pureed rabbit meat than the other formulations (Fig. 3a). It was significantly more attractive than the cardboard control and the non-polar rabbit extract (F = 9.131, df = 4, 40, P < 0.0001), but only marginally more attractive than the salted rabbit and FD rabbit.

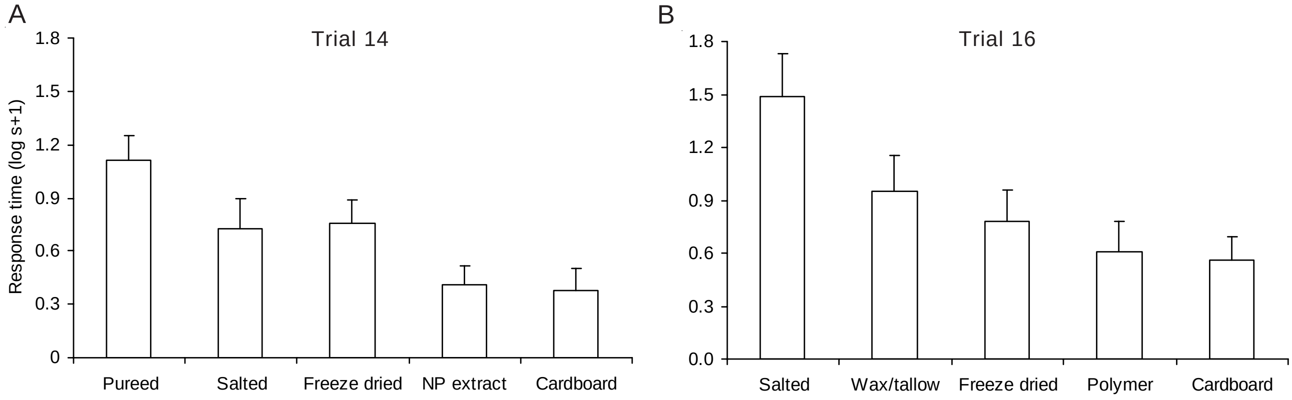


Figure 3. Mean time (+ 1 SEM) spent sniffing at or touching the odour containers for ≥ 1 s, comparing forms of rabbit odour. **A**. Baits in opaque containers in Attractiveness Trial 14. **B**. Baits visible under mesh in Trial 16. NP = non-polar extract.

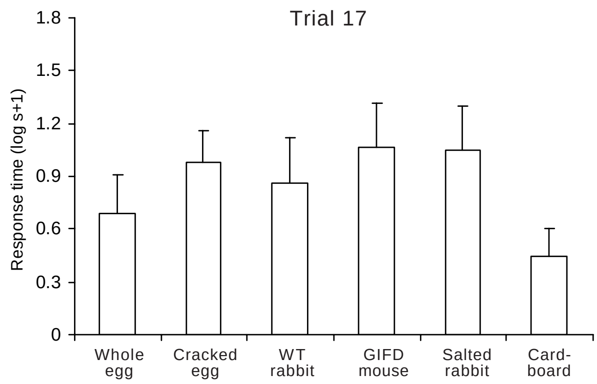
The three rabbit essences tested in Trial 15 elicited only minimal responsiveness ($F = 0.435$, df = 3, 21, $P = 0.73$). The maximum response time was only 14 s.

There were significant differences in response times amongst the treatments in Trial 16 ($F = 10.324$, df = 4, 32, $P < 0.0001$). The stoats spent more time investigating the salted rabbit formulation than any other treatment (Fig. 3B).

3.1.5 Best lures v. hen eggs

Response times indicated that gelatine-injected freeze-dried mice (GIFD mice), salted rabbit and cracked egg were all highly attractive in Trial 17, significantly more than the cardboard negative control ($F = 7.73$, df = 5, 40, $P = 0.04$). The stoats also spent time investigating the wax/tallow (WT rabbit) formulation and, to a lesser extent, the whole egg (Fig. 4).

Figure 4. Mean time (+ 1 SEM) stoats spent sniffing or touching the odour containers for ≥ 1 s in Attractiveness Trial 17, comparing best lure options from this study against hen eggs. WT = wax/tallow, GIFD = gelatine-injected freeze-dried.



3.2 PALATABILITY/'CHEWABILITY' TRIALS

3.2.1 Egg

Seven of the 11 stoats presented with cracked and whole eggs in Trial 1 interacted with them. Only one of the whole eggs was eaten, but five were moved. Of these, four were moved by male stoats and only one by a female stoat. Six of the 11 cracked eggs were eaten. This included two out of five presented to stoats that had been captured on egg bait, two out of five by stoats captured on rabbit bait, and the one stoat caught on mouse bait. The eggs were not eaten by any of the four female stoats tested.

3.2.2 Rabbit formulations

The four stoats tested in Trial 2 showed varied responses. One stoat spent a long response time (139 s) at the plain FD rabbit bait, two preferred the bait with both polar and non-polar extracts (169 s, 112 s, respectively) while the fourth showed little responsiveness to any of the baits. The trial was terminated, as there was no likelihood of demonstrating significant differences between the treatments.

In Trial 3, there were no significant differences amongst the treatments including the negative control in either time spent chewing the baits ($F = 1.665$, df = 3, 18, $P = 0.21$) or in the amount of bait eaten ($S = 1.17$, df = 3, $P = 0.76$). No one bait was consistently eaten first ($H = 6.44$, df = 3, $P = 0.22$). In Trial 4, none of the stoats consumed any of the baits.

The stoats showed preferences for wax-coated bran/gelatine (BGW) rabbit and the raw wax/tallow (WT) rabbit baits in Trial 5 (Fig. 5A, B). While the differences between the bait consumption scores were not statistically significant ($S = 9.34$, df = 5, $P = 0.097$), they mirrored the pattern shown in time spent sniffing at and eating the baits ($F = 2.592$, df = 5, 30, $P = 0.046$). The stoats appeared to prefer the rabbit meat raw to slightly cooked. Bait acceptance was 42.9% for the BGW rabbit and raw WT rabbit, 28.6% for the raw lard baits, and 0% for both the cooked baits and the foam negative control. The order in which the baits were first chewed did not significantly favour any one bait ($H = 8.09$, df = 5, $P = 0.152$), although the BGW rabbit was attacked first by four stoats (Fig. 5C).

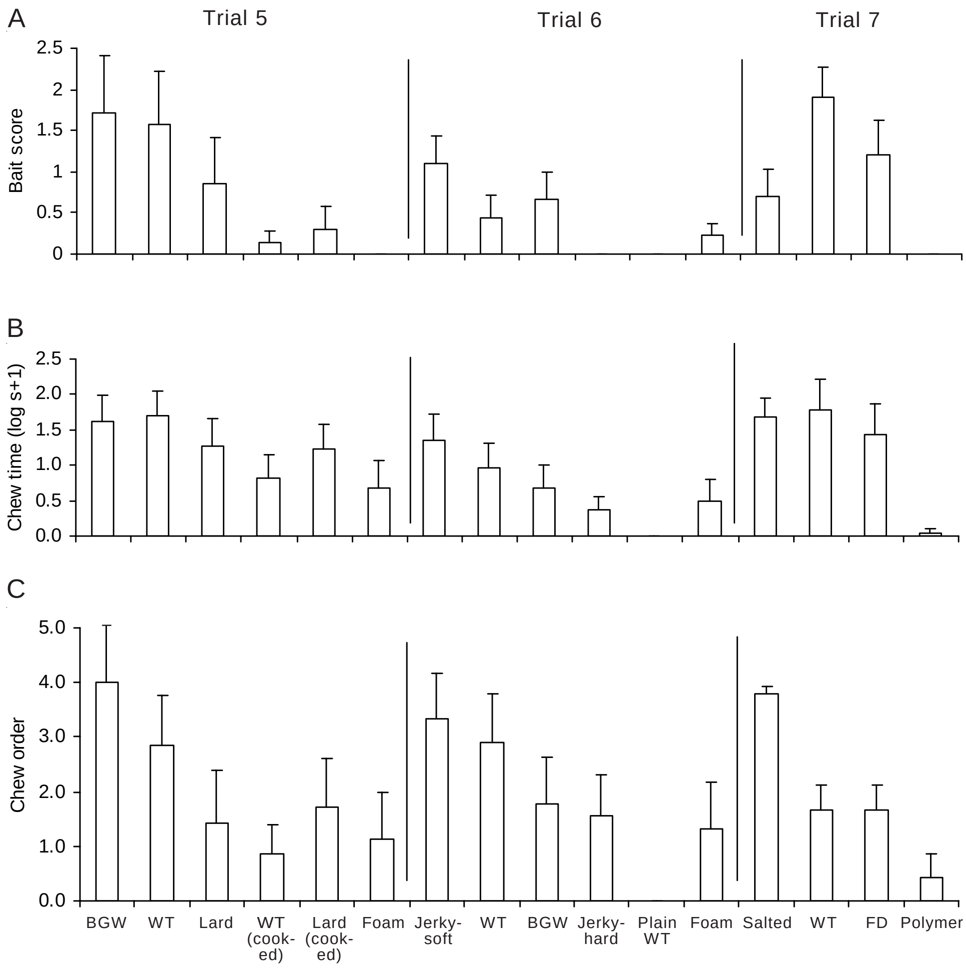


Figure 5. Results (mean + 1 SEM) from Palatability Trial 5, comparing various rabbit bait formulations. **A**. Bait consumption score. **B**. Time spent sniffing or chewing the baits. **C**. Scores for order in which baits were chewed. All baits contained rabbit except the foam negative controls. BGW = bran/gelatine/wax, WT = wax/tallow, FD = freeze-dried.

There were significant differences in bait scores in Trial 6 ($S = 16.98$, df = 5, $P = 0.005$). The soft, chewy jerky from Fonterra was the most palatable bait (Fig. 5A). More of it was eaten than either the harder Fonterra jerky or the wax/tallow with no rabbit meat, both of whose mean scores were lower than the foam negative control. While little of the WT rabbit bait was eaten, the stoats spent plenty of time chewing it, as they did also with the soft jerky bait (Fig. 5B). Time spent chewing varied significantly amongst the bait types ($F = 3.43$, df = 5, 40, $P = 0.011$). Only one stoat ate more than 50% of the soft jerky. None of the other baits ever scored this high in bait palatability. Chew order favoured the soft jerky, then WT rabbit, then BGW rabbit (Fig. 5C), but the overall difference amongst bait types was non-significant ($H = 9.70$, df = 5, $P = 0.08$).

In Trial 7, the WT rabbit was eaten the most and the polymer bait the least (Fig. 5A, $S = 11.86$, df = 3, $P = 0.008$). WT rabbit and FD rabbit baits scored higher than either the polymer or salted formulations. There were also significant differences in the time spent chewing the various baits ($F = 6.16$, df = 3, 24, $P = 0.003$). This time wax/tallow, salted and FD formulations were all preferred over the polymer bait (Fig. 5B). The order in which baits were first chewed also varied significantly ($H = 18.75$, df = 3, $P = 0.001$); but this time, salted rabbit was the highest-ranked bait (Fig. 4C). Bait acceptance favoured WT (40%) over FD (20%), salted (10%) and polymer (0%).

In Trial 8, consumption of bait coating and time spent chewing both varied significantly amongst the treatments ($S = 24.39$, df = 5, $P = 0.001$; $F = 5.27$, df = 5, 40, $P = 0.0008$, respectively). The FD rabbit coating was the most preferred (Figs. 6A, B). The stoats left the plain foam almost untouched, but one stoat chewed more than half of an FD bait. This contributed to a significant difference in foam bait consumption scores amongst the treatments ($S = 14.35$, df = 5, $P = 0.014$). Percentage bait acceptance was only 22% for the FD-coated baits, the same as for the plain foam. No other formulations scored any bait acceptance. Chew order also favoured the FD-coated bait (Fig. 6C), but the differences amongst the baits were not significant ($H = 9.09$, df = 5, $P = 0.11$).

In the second foam bait trial (Trial 9), the baits varied significantly in the amount of the coating that was removed ($S = 17.25$, df = 3, $P = 0.001$), amount of the foam bait eaten ($S = 9.47$, df = 3, $P = 0.024$) and in time spent chewing ($F = 4.58$, df = 3, 24, $P = 0.011$). The addition of pureed rabbit to the egg/oil bait with FD rabbit coating improved both bait score and chew time scores (Fig. 6A, B). Replacing the egg/oil mixture with soy butter reduced palatability. The foam baits containing the rabbit/egg/oil formulation were the only baits where more than 50% of the bait was consumed (bait acceptance = 22% for rabbit/egg/oil, v. zero for the other treatments). One stoat consumed all the rabbit/egg/oil/fur bait. Chew order did not reveal any significant preferences amongst the baits ($H = 4.14$, df = 3, $P = 0.25$; Fig. 6C).

3.2.3 Mouse formulations

In Trial 10, FD mice soaked in various fat, oil and sugar combinations were less palatable than the plain FD mice (bait score: $S = 21.43$, df = 5, $P = 0.001$, chew time: $F = 5.33$, df = 5, 40, $P < 0.0001$) (Fig. 7A, B). The plain FD mice were always the first to be chewed ($H = 19.61$, df = 5, $P = 0.002$, Fig. 7C). Bait acceptance for plain FD mice was 22% and 11% for sugar-coated FD mice, the only baits to score above zero.

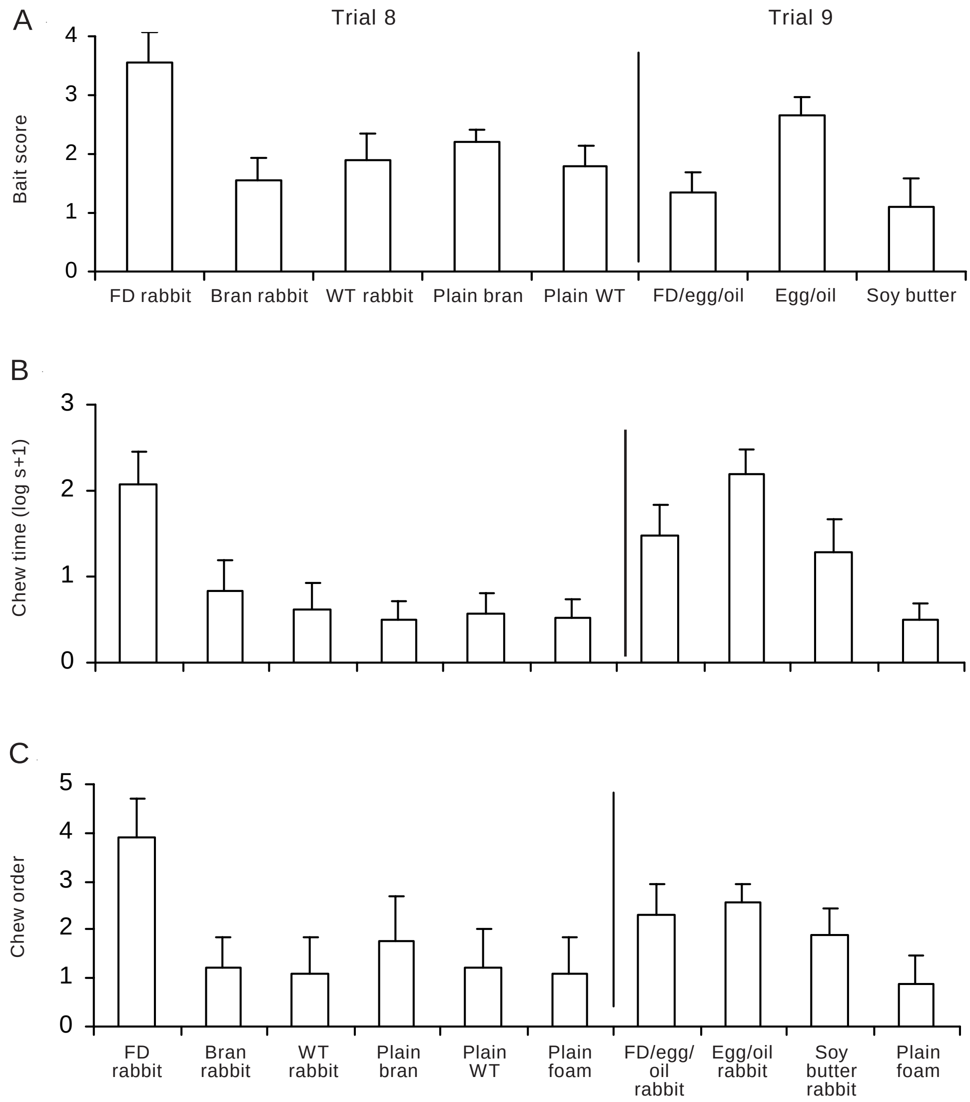
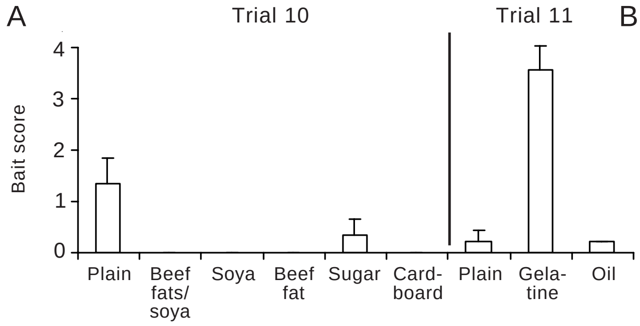


Figure 6. Results (mean + 1 SEM) from Palatability Trials 8 and 9, comparing rabbit-flavoured polyurethane foam baits. **A**. Bait consumption score; plain baits had no coating. **B**. Time spent chewing the baits. **C**. Scores for order in which baits were chewed. FD = freeze-dried, WT = wax/tallow. The bait coatings contained pureed rabbit meat unless described as 'plain'.

The FD mice in Trial 11 injected with gelatine (GIFD mice) were the most palatable treatment (bait score: S = 14.30, df = 2, P = 0.001, chew time: F = 25.05, df = 2, 16, P < 0.0001) (Fig. 7A, B). They were usually the first to be chewed (H = 13.45, df = 2, P = 0.001, Fig. 7C). Bait acceptance was 78% for the gelatine treatment compared with 0% for the oil treatment and plain FD mouse control.

3.2.4 Best baits v. hen eggs

In Trial 12, there were significant differences amongst the treatments in bait score (S = 30.68, df = 5, P < 0.001), time spent chewing (F = 9.48, df = 5, 40, P < 0.0001), and in chew order (H = 24.60, df = 5, P < 0.0001). The GIFD mouse was always the most favoured bait in all scores (Fig. 8A–C). Cracked egg scored almost as highly in chew time and chew order, but it had a lower bait consumption score. While WT rabbit was not chewed for as long as the mouse or cracked egg, it did achieve the second-highest average bait score. The whole egg was never eaten. Bait acceptance levels were 30% for GIFD mouse, 20% for WT rabbit, 10% for cracked egg, and 0% for whole egg, salted rabbit and the negative cardboard control.



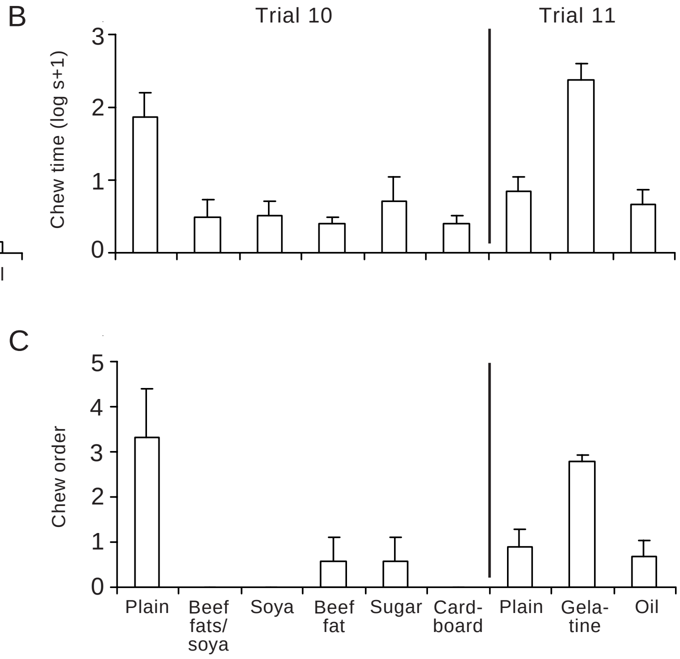
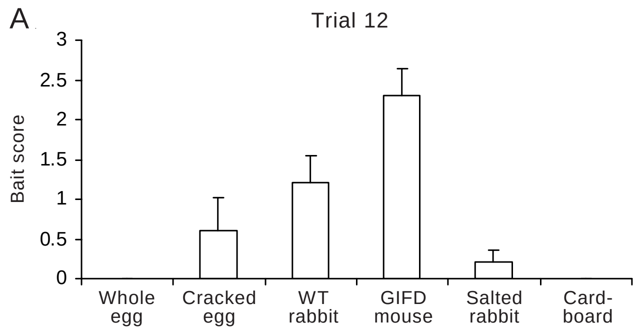


Figure 7. Results (mean + 1 SEM) from Palatability Trials 10 and 11, comparing freeze-dried mouse formulations with cardboard negative control. Plain = plain FD mouse.
A. Bait consumption score.
B. Time spent chewing the baits.
C. Scores for order in which baits were chewed.



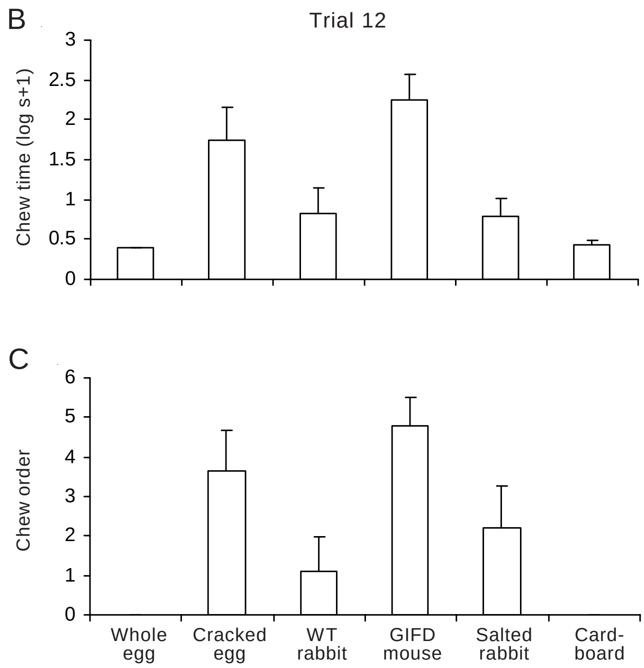
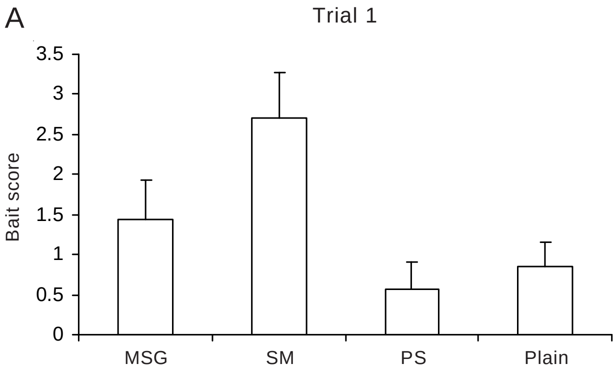


Figure 8. Results (mean + 1 SEM) from Palatability Trial 12, comparing the best bait options from this study against hen eggs and cardboard negative control.
A. Bait consumption score.
B. Time spent chewing the baits.
C. Scores for order in which baits were chewed.

3.3 LONGEVITY TRIALS

3.3.1 Preservative trial

There were no significant differences amongst the consumption scores in Trial 1 ($S = 5.74$, df = 3, $P = 0.126$). Sodium metabisulphate (SM) was the only preservative that achieved a higher mean bait consumption score than the plain baits (Fig. 9A). Because of video failures, chewing time data and chew order scores were retrieved from only six stoats. These response criteria did not reveal significant differences amongst the baits but, again, SM was the highest scoring bait in each category (Fig. 9B, C). Bait acceptance was 55% for SM, and 25% for MSG. No stoats achieved a bait score above 3 for either PS or plain baits.



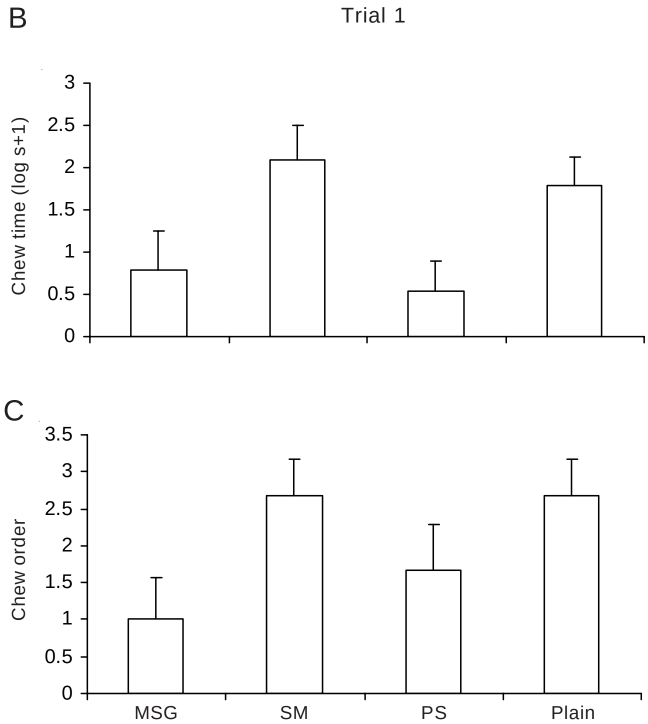


Figure 9. Results (mean + 1 SEM) from Longevity Trial 1, comparing three preservatives added to minced chicken baits. MSG = monosodium glutamate, SM = sodium metabisulphate, PS = potassium sorbate, plain = minced chicken only.
A. Bait consumption score.
B. Time spent chewing the baits.
C. Scores for order in which baits were chewed.

3.3.2 Preserved bait trial

The preserved GIFD mice were the most attractive and palatable bait in Trial 2 (Figs. 10, 11A–C). Sniff times in the attractiveness trial varied significantly amongst the treatments ($F = 5.67$, df = 5, 40, $P = 0.0005$). Second-ranked behind the mice was the cracked egg. The salted rabbit scored similarly to the wax/tallow rabbit and the dried beef baits. In the palatability trial, however, the cracked egg and, particularly, the salted rabbit scored relatively poorly in all three response criteria. Differences amongst the treatments were all significant (Bait score: $S = 24.37$, df = 5 $P < 0.001$; chew time: $F = 8.19$, df = 5, 40, $P < 0.0001$; chew order: $H = 29.16$, df = 5, $P < 0.001$). Bait acceptance for preserved GIFD mice was 80%, compared with 30% for dried beef, 20% for preserved WT rabbit, 10% for salted rabbit and 0% for both the cracked egg and cardboard control.

3.3.3 Aged baits

The preserved GIFD mice continued to be the most attractive bait after being aged for 1 week in Trial 3 (Fig. 12). There were significant differences amongst the baits in sniff times ($F = 4.51$, df = 5, 25, $P = 0.0045$). There were also signifi-

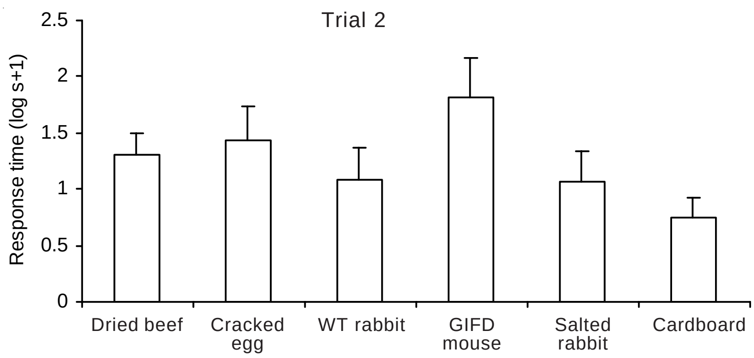
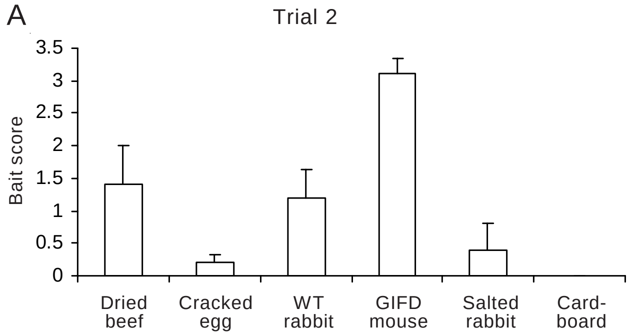


Figure 10. Mean time (+ 1 SEM) stoats spent sniffing at or touching the odour containers for ≤ 1 s in Longevity Trial 2, comparing fresh best lure/bait types with preservative and cardboard negative control.



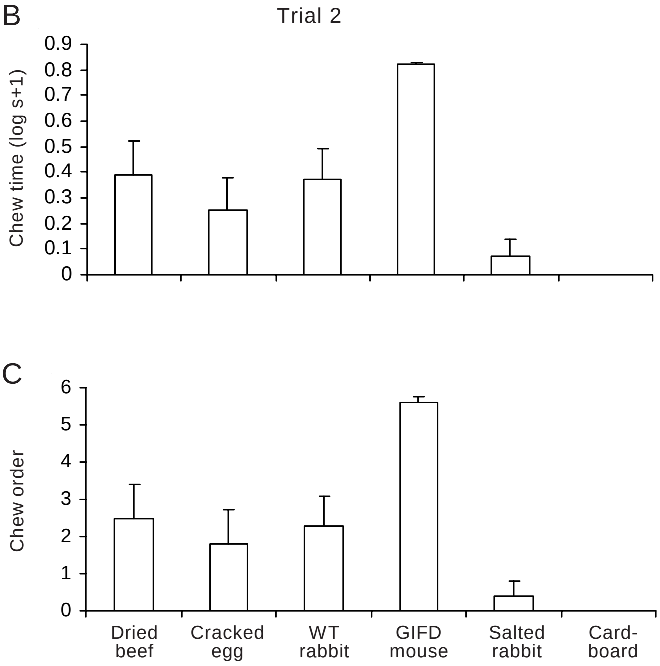
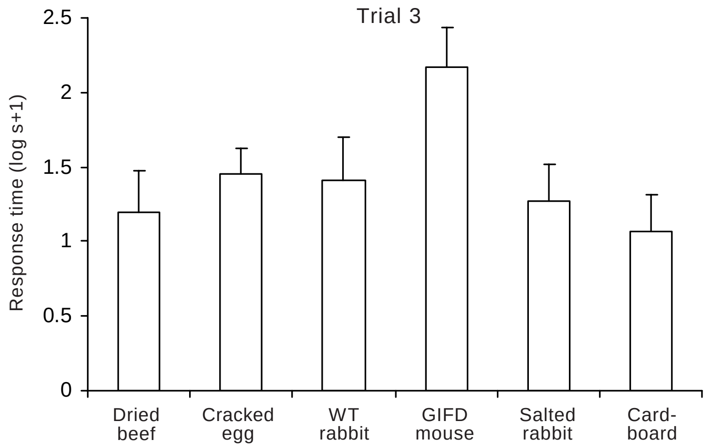


Figure 11. Palatability results (mean + 1 SEM) from Longevity Trial 2, comparing best lure/bait types with preservative.
A. Bait consumption score.
B. Time spent chewing the baits.
C. Scores for order in which baits were chewed.

Figure 12. Mean time (+ 1 SEM) stoats spent sniffing at or touching the odour containers for ≥ 1 s in Longevity Trial 3, comparing best lure/bait types with preservative aged for 1 week.



cant differences in bait score (S = 19.93, df = 5, P < 0.001), in chew time (F = 4.94, df = 5, 25, P = 0.003), and in chew order (H = 17.60, df = 5, P = 0.004) in the palatability trial. GIFD was clearly the most highly preferred bait (Fig. 13A–C). The salted rabbit again scored worse in palatability than in attractiveness. In this trial the dried beef also had lower palatability scores than in Trial 2. Bait acceptance was 67% for GIFD mice. Only one stoat (17%) consumed more than half of either a WT rabbit bait or a beef jerky bait. None of the other treatments achieved any bait acceptance.

3.3.4 Aged bait assessment

The rabbit jerky baits aged for 5 or 6 weeks lost little weight over this time (Fig. 14). The hard jerky did not go mouldy. The soft jerky started to show signs of mould by two weeks and most baits were covered in mould by the third week.

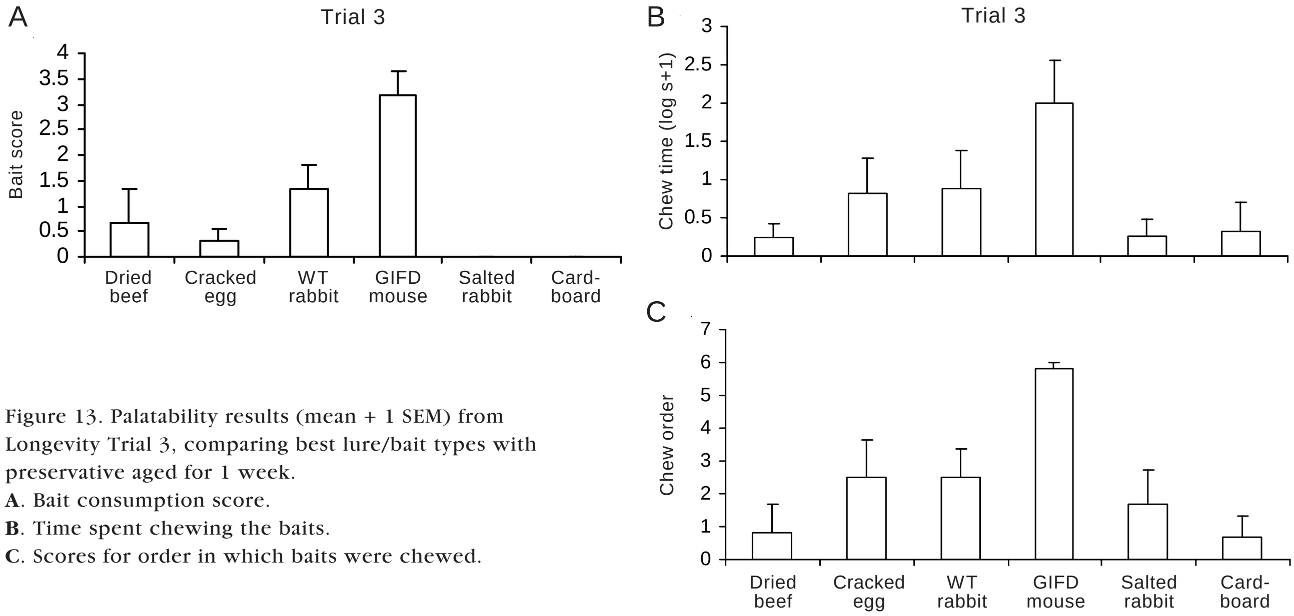


Figure 13. Palatability results (mean + 1 SEM) from Longevity Trial 3, comparing best lure/bait types with preservative aged for 1 week.
A. Bait consumption score.
B. Time spent chewing the baits.
C. Scores for order in which baits were chewed.

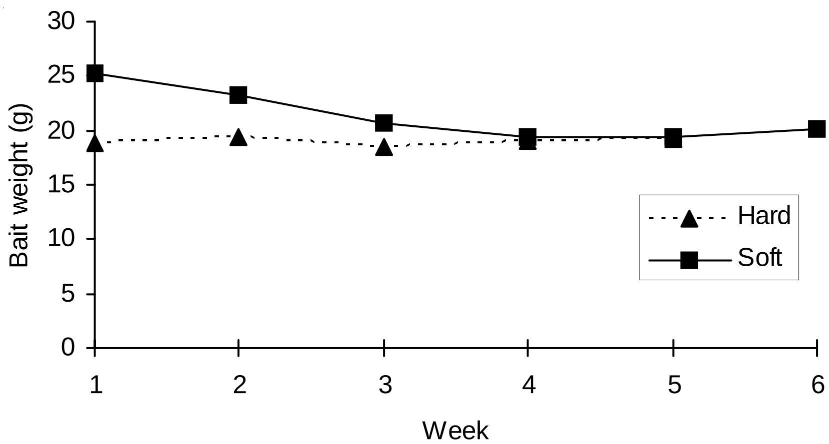


Figure 14. Changes in mean weight of hard and soft rabbit jerky baits (n = 13, 14 respectively) aged under semi-field conditions for up to 6 weeks.

4. Discussion

4.1 LURE ATTRACTIVENESS

Our initial trials aimed to establish whether or not rabbit had potential as a lure or bait. We also had to be sure that the particular stoats we had in captivity (mostly caught on egg and mouse baits) would respond well to rabbit. Our initial trials of rabbit parts and comparing rabbit to other prey items established these points. The pureed rabbit used in Attractiveness Trial 14 was particularly attractive to the stoats. The comparisons of rabbit, rodents and bird odours indicate that any prey odour has potential as a lure.

Of the range of chemical attractants and commercial products tested, the general trend was for more natural, complex products to be more successful. This is consistent with previous lure and bait screening trials on stoats (Spurr 1999; L. Robbins unpubl. data). While anal sac odours have shown promise as attractants for both stoats and ferrets in other studies (Clapperton et al. 1989, 1994, 1999; Spurr et al. 2004), they were not successful in our trial. This may have been an artefact of the captive conditions, with the experimental pens probably containing many traces of stoat anal sac odours from previous nights' occupants. The overall high responsiveness in the first trial of phenyl acetic acid and Z-dodecenylacetate may indicate some responsiveness that could not be focused because of the tightly enclosed environment of the tests. Carbon disulphide was tested at 0.01% concentration in Attractiveness Trial 11. This may have been too strong to produce a positive response. Rats and mice are attracted to CS_2 at 0.001% (Bean et al. 1988; Shumake & Hakim 2001; Shumake et al. 2002) and rats at 0.005% (Veer et al. 2002) concentration but rats are deterred at 0.01% (Veer et al. 2002). Phenyl acetic acid, a common ingredient in commercial animal lures, and spirulina did have some attractiveness to some stoats (in Trial 13). They were tested at arbitrarily assigned concentrations. Tests at different concentrations may produce more positive results. Z-dodecenylacetate was tested because it is a chemical found in the pheromones of both elephants and moths (Rasmussen et al. 1996), suggesting some potential general attractiveness across diverse phyla. Again, different concentrations may be worth testing.

Of the rabbit formulations, the salted rabbit showed consistent performance as a lure equal to or better than the wax/tallow rabbit. It rated well when presented in opaque odour containers as well as under mesh which allowed visual as well as olfactory cues. The order in which baits were chewed in the relevant palatability trials confirms the relative attractiveness of salted rabbit. The salted rabbit was at least equally attractive as freeze-dried mouse and cracked egg in our final lure test.

Both fresh and freeze-dried rodent lures also showed good promise in our trials. The higher attractiveness of the freeze-dried mouse compared with whole egg and, possibly, greater attractiveness than cracked egg, confirms the potential of freeze-dried rodents as trap lures for stoats. This potential has been further confirmed by a field trial on ferrets and cats (Robbins & Clapperton 2003).

Hen eggs were used in this study as the standard against which our lures were compared, because they are commonly used in stoat traps in New Zealand and are considered to be effective (Parkes & Murphy 2004). Even though the stoats could see all the baits in the final attractiveness test, they spent little time sniffing or scratching at the wire mesh trying to access the whole egg. This suggests that the olfactory cues from cracked egg are important for egg lure attractiveness. The lack of responsiveness in our very first trial of cracked egg suggests, however, that some visual cues are also necessary. The perceived advantage of eggs over meat baits may simply be the result of putrefaction of meat baits reducing their attractiveness.

Our attractiveness trials tested the ability of a lure to direct a stoat's attention when it was already close to a control device. They did not test the 'calling' power of a lure to draw a stoat from a distance. This would have required large outdoor pens where it is possible to simulate field conditions (Jolly & Jolly 1992). Highly concentrated lures like the fish-head oil (potent even to human noses) may have diffused across the whole pen and overwhelmed the olfactory sense of the stoats.

4.2 BAIT PALATABILITY

Our early bait palatability trials testing rabbit meat identified wax/tallow as a promising bait matrix. The combination of wax and tallow, at various percentages, has been developed to deliver oral contraceptives to coyote, *Canis latrans* (Linhart et al. 1968; Servheen 1983; Knowlton et al. 1986), and oral rabies vaccination to raccoons *Procyon lotor* (Linhart et al. 1991), striped skunk *Mephitis mephitis* and foxes *Vulpes vulpes* (Rosatte et al. 1990) and *Vulpes fulva* (Linhart 1964). Tallow has also been shown to be a palatable bait coating for rabies vaccine baits for domestic dogs, *Canis familiaris* (Linhart et al. 1997a). The wax raises the melting point of the bait, improving bait longevity in warm conditions. The wax/tallow/rabbit mix proved successful against a variety of alternative baits. Wax/tallow baits are also attractive to rodents (Roy & Dorrance 1992; B.K. Clapperton, pers. obs.). This may be a positive or negative characteristic, depending upon the aims of a particular pest control programme.

Preliminary palatability trials indicated that gelatine was palatable to stoats. To make more-stable, longer-lasting gelatine baits, we developed the bran/gelatine/wax baits. With rabbit meat as the active ingredient, these baits proved palatable in two trials (Palatability Trials 5 and 6). This formulation was still difficult to handle, however, and would have a short shelf and field life. With further refinement it may have potential as edible bait. Ross & Henderson (2003) similarly found that relatively soft gel baits were more palatable to stoats than harder polymer baits, but they had a limited shelf life.

The mixture of lard and rabbit meat has been trialled in the field (N. Miller, DOC, pers. comm. 2000). Lard has also been used as bait for coyotes (Linhart & Knowlton 1975). It was used in Trial 5 only in this study, as it did not perform as well as the tallow or gelatine formulations. Slightly cooking the meat was intended as a means of making a longer-lasting bait. However, cooking reduced palatability in both the lard and the tallow baits, so this system of producing a longer-lasting bait was dismissed.

The soft jerky rabbit formulation proved to be a promising bait. It contained 50% rabbit meat as an active ingredient in a flexible matrix produced by Fonterra. It scored highly compared with both the gelatine and tallow formulations. Unfortunately, this bait became unavailable.

Salted rabbit and freeze-dried rabbit were not highly palatable to the trial stoats, and rabbit-flavoured polymer baits even less. This makes them less versatile baits than the wax/tallow rabbit baits, which combine reasonable attractiveness with moderate palatability. However, all these bait types have the advantage of a very long shelf and field life (see below).

Hen eggs are commonly used as baits for stoat traps, and have been used effectively as poison carriers (Dilks & Lawrence 2000; Spurr 2000). We used hen eggs as the standard to determine the potential of our test bait formulations. Our GIFD mouse and WT rabbit baits were highly palatable compared with both whole and cracked hen eggs. Moreover, only half of the stoats ate the cracked egg in Palatability Trial 1. The fact that only one of the female stoats moved a whole egg and none ate any of the cracked egg in the first trial suggests an additional weakness for egg as a bait for stoats.

Because rodent baits performed well in our early attractiveness tests, and freeze-dried rats and mice have shown some promise in the field (Burns 2000; Robbins & Clapperton 2003), we opted to pursue ways of turning these lures into more versatile baits by increasing their palatability. Freeze-dried mice were acquired commercially (from Feral R&D Ltd, Auckland). They have the advantage over freeze-dried ship rats of being pathogen-free. Coating the freeze-dried mice in attractants proved unsuccessful. In fact, the treatments strongly discouraged the stoats from eating the mice. Of the attractants tested, only the sugar-coated mice were eaten at all. The beef fat and soya oil had scored well in lure attractiveness tests (L. Robbins, unpubl. data). The stoats often licked at the mice, but did not bite them. This trial did confirm that plain freeze-dried mice were not palatable to stoats. Video footage revealed that the stoats would take one bite and then retreat from the bait. We suspect that the brittle texture of the freeze-dried mice was off-putting.

Our second freeze-dried mouse trial therefore aimed at not only adding an attractant to the bait in a way that it could not easily be removed from the outside, but also at softening the texture of the mice. While the soya oil did not either improve or reduce bait palatability, the softening effect of the gelatine vastly improved bait palatability and acceptance. These GIFD mice proved to be, by far, the most palatable bait tested. The possibility of adding extra attractants to the gelatine provides the potential to further enhance bait attractiveness and palatability. Robbins & Clapperton (2003) discuss the other advantages of cost-effectiveness and low pathogen risk of using freeze-dried mice.

4.3 BAIT 'CHEWABILITY'

Various baits we assessed in this study show promise as chewable baits. Such baits could be used for the delivery of canine distemper virus, or other biocontrol agents that require a long time in the buccal cavity for successful transmission)(R. Peebles, pers. comm. 2000). Foam baits were specifically tested for this purpose because they have been used successfully on raccoons (Linhart et al. 1991, 1993) and mongooses *Herpestes javacanicus* (Linhart et al. 1993; Creekmore et al. 1994). While the stoats would readily consume the coatings from the foam baits, there were seldom signs of the foam itself being chewed. Mean chew times for freeze-dried-rabbit coated baits, especially those where the foam contained pureed rabbit, were higher than in any other trials. Trials of baits containing breakable capsules would be needed to determine whether or not this amount of chewing is enough to allow viral transmission. There were also problems with formulating a coating that would remain on the foam. One way around this would be to place the foam baits in plastic sachets, with the attractant in an outer bag. This system has been used for domestic dogs (Perry et al. 1988; Kharmachi et al. 1992), and raccoons (Perry et al. 1989). It may be worth testing on stoats.

While our wax/tallow bait coatings were not as chewable as the freeze-dried rabbit coatings, the solid wax/tallow/rabbit baits did elicit long chewing responses. This suggests that further development of either solid wax/tallow or the foam and wax/tallow concept may be worthwhile. Wax/tallow-covered foam baits have been successfully used in the immunisation of foxes against rabies (Lawson et al. 1987; Bachmann et al. 1990). Linhart et al. (1991) reported that paraffin wax ampoules were readily accepted vaccine containers for raccoons.

A potential formulation that was not tested on stoats was the deep-fried food batter used by Linhart et al. (1991, 1994) for raccoons. We opted against this system because it had to be cooked and we had found that cooking reduced the palatability and chewing time of rabbit meat.

The long chewing response times to GIFD mice, salted rabbit and soft rabbit jerky baits demonstrate their potential as a chewable biocontrol delivery system. These would be cheap and easily-produced products, with good shelf life.

4.4 LURE AND BAIT LONGEVITY

The addition of sodium metabisulphate to minced chicken did not reduce consumption. The GIFD mice and wax/tallow/rabbit baits preserved with SM performed as well as in the previous trial without preservative compared with egg baits. After ageing for 1 week, the GIFD mice and wax/tallow/rabbit baits again showed similar success relative to egg baits in both attractiveness and palatability, with preserved GIFD mice still the preferred bait. The salted rabbit again matched the cracked egg in attractiveness. The only bait to show lower success after a week was the dried beef jerky. While it retained its attractiveness, its palatability was now lower than the other baits.

The promising soft rabbit jerky from Fonterra remained free of mould for 2 weeks. While the baits lost some weight (presumably from water loss) over this time, they remained malleable. The harder jerky formulation from Fonterra lasted for 4 weeks without turning mouldy or losing weight, but even when fresh this jerky was not palatable to the stoats. While it would have been worth testing as a long-life trap lure, the problem with supply prevented further testing.

5. Conclusions and recommendations

We have identified a range of prey-based lure and bait formulations that show promise for use in stoat trapping, poisoning and the delivery of biocontrol agents (Table 4). While we failed to find any additional odours that would substantially enhance stoat lures or baits, some are worthy of further testing. The trialling procedure using captive animals allowed us to test a wide range of materials on stoats cost-effectively. Its limitations in terms of the restricted range of behaviours that can be measured, the number of animals tested and possible autocorrelation effects from re-using the same animals, and the effects of potent chemicals in enclosed spaces all mean that tests in captivity should be viewed as only the first step in identifying effective lures and baits. All our recommended formulations require field testing before they can be recommended for common use.

GIFD mice are attractive, palatable and chewable to stoats. They are also long-lasting, and maintain their attractiveness and palatability when treated with sodium metabisulphate. They could be commercially produced in a pathogen-free form. This makes them highly versatile baits. They were consistently high performers across a series of trials and to most of the captive stoats. We recommend that they are tested in field trials as trap attractants and as poison baits. Further trials are needed on the potential of biocontrol agents in chewable baits, but we recommend GIFD mice as a candidate bait for this as well. The stability of GIFD mice might be improved by modifying the gelatine formulation. It would be worthwhile assessing the effects of additives in the gelatine. Freeze-dried mice are easily produced and long-lasting. Even if their cost-effectiveness proves to be inadequate for broad-scale application, we have demonstrated that they can be a very effective lure and bait. They could, therefore, be considered 'boutique' baits to be used in conjunction with other baits to overcome bait shyness, and in situations where it is imperative for stoats to be caught; for example, in the case of island invasions.

Wax/tallow baits containing rabbit meat would make valuable alternative trap lures or poison baits, but only in situations where rodent interference is not a problem. These baits were at least as attractive and as palatable as currently used egg baits and possibly more so. When they contain sodium metabisulphate

TABLE 4. SUMMARY OF MOST PROMISING LURE AND BAIT FORMULATIONS IDENTIFIED FROM THIS STUDY.

LURE/BAIT	PRODUCT
Lure	Salted rabbit
	Wax/tallow rabbit
	Freeze-dried mouse
	Soft rabbit jerky[1]
	Dried beef jerky
Edible bait	Gelatine-injected freeze-dried mouse
	Wax/tallow rabbit
	Soft rabbit jerky[1]
	Dried beef jerky
Chewable bait	Gelatine-injected freeze-dried mouse
	Wax/tallow rabbit
	Salted rabbit
	Soft rabbit jerky[1]
	Dried beef jerky
Long-life lure	Gelatine-injected freeze-dried mouse + sodium metabisulphate
	Wax/tallow rabbit + sodium metabisulphate
	Salted rabbit
Long-life bait	Gelatine-injected freeze-dried mouse + sodium metabisulphate

[1] Product no longer available from manufacturer.

they are effective for at least one week. Further work should focus on experimenting with the proportions of active ingredient, and the ratio of wax and tallow to provide the best compromises amongst efficacy, cost, and durability, depending upon climatic conditions.

Salted rabbit is an effective trap attractant, with good shelf life, and field life of at least 1 week. We recommend that it be more widely tested in the field. It should not, however, be used as a poison delivery system, as it is relatively unpalatable.

The soft rabbit jerky bait was highly promising as an attractant, poison bait and chewable bait. If the product became available again, it should be field tested. Commercially-produced beef jerky showed promise as a trap attractant and an edible bait, but appeared not to have as good longevity as the other baits. This could be further investigated using modified bait formulations.

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