Evaluating the attractiveness of pest-control baits and lures to captive short-tailed bats, *Mystacina tuberculata*

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ABSTRACT

Bait and scented lure acceptance trials were undertaken to assess the relative attractiveness of non-toxic baits and lures to wild-caught New Zealand endemic short-tailed bats, *Mystacina tuberculata*. Twelve baits, ten scented lures and three pastes commonly used in poison operations and as lures in rodent traps were tested. During each trial, bats were presented with three baits / lures and one control, or the three pastes. Trials were recorded using video surveillance with infrared light. The time bats spent feeding at each bait / lure / paste, and the number of visits they made to each, were analysed to assess preference. Of the twelve baits, bats spent most time feeding on apple, followed by RS5 cereal pellets (cinnamon-lured). Bats spent the least amount of time feeding on aniseed baits. Apple baits also had the most visits, followed by RS5 cereal pellets (cinnamon-lured). The least-visited bait was aniseed. Of the ten scented lures, the greatest number of visits and the most time spent feeding were recorded for peanut, followed by lemon, orange and cloves. Bats spent the least amount of time feeding on spearmint lure. Preferences did not vary according to month or sampling period for the bait and lure trials. However, paste preferences varied between the two sampling periods, probably because the bats in the second period had been used in a prior trial and fed on one of the pastes tested. The results show that short-tailed bats will sample baits in captivity. However, the risk of poisoning may be relatively low in the wild, as previous field trials have shown no evidence that short-tailed bats will approach baits under wild conditions. Nevertheless, it would seem sensible that in areas where short-tailed bats are known to exist, the baits and lures shown to be least favoured in trials should be used for poisoning operations.

Keywords: short-tailed bat, *Mystacina tuberculata*, baits, lures, non-target species, vertebrate pest control, New Zealand.

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1. Introduction

The short-tailed bat, *Mystacina tuberculata*, is the sole surviving species of the ancient New Zealand endemic family Mystacinidae (Molloy 1995). This species, along with the long-tailed bat, *Chalinolobus tuberculata*, constitute New Zealand's only terrestrial native mammals (Daniel & Williams 1984). Once widespread throughout New Zealand, recent surveys have shown that short-tailed bats are now restricted to several isolated areas of the North and South Islands (Lloyd 2001).

One of the perceived threats to the survival of short-tailed bats is accidental poisoning from pest control operations. Poisoning and trapping operations are carried out throughout New Zealand to control a variety of introduced mammals (Eason & Wickstrom 2001). Baits used in pest control are often lured with approved essential oils and essences (e.g. cinnamon, peanut, aniseed) to mask the presence of toxins (Eason & Wickstrom 2001) and to attract the target animals to bait and traps (Morgan et al. 1995). Baits and lures have important roles in pest operations; however, their use may also increase the risk of non-target mortalities in native species. Raspberry lure was implicated in bird deaths in the mid 1970s (Harrison 1978). In captive trials, many species of native birds have been recorded feeding on lured non-toxic baits in quantities which would have caused mortality had the baits been toxic (Day & Matthews 1999).

Short-tailed bats have a number of characteristics which may make them susceptible to poison operations, especially those using scented lures or baits. Short-tailed bats are unique amongst bats in that they spend a significant proportion of foraging time feeding on the ground and in trees rather than aerially (Lloyd 2001). They are thus more likely to encounter toxins used in pest control (Spurr 1993; Molloy 1995), particularly those in ground-laid baits. Short-tailed bats are also remarkable amongst bats for their omnivorous diet, which includes insects, nectar, pollen and fruit (Daniel 1976, 1990). Their wide diet range means that they might be attracted to baits and scented lures (especially sweet or fruit-based ones). Additionally, the consumption of only a minute amount of poison is likely to be fatal to short-tailed bats (Lloyd 1994). Although there has been only one report of a short-tailed bat found dead, on a cyanide bait line laid for possums (Daniel & Williams 1984), the possibility of non-target kills remains a concern where pest control is carried out in short-tailed bat habitat.

The use of baits or scented lures may pose a threat to short-tailed bats if the baits or lures used are attractive food items. This study set out to quantify that threat by conducting bait and lure acceptance trials on wild-caught bats. Baits used in rodent traps and scented lures used in possum control were presented to bats to determine their relative attractiveness to them.

2. Methods

2.1 STUDY SUBJECTS

This research used 50 short-tailed bats—4 females and 46 males. As pregnant or lactating females were not used, most of the study bats were males. Bats were captured using mist nets over two summer periods (2000/01 and 2001/02) in Rangataua Forest, a 10 000-ha tract of mature *Nothofagus* forest on the southern slopes of Mt Ruapehu, central North Island (39°26'S 175°32'E, 700–750 m a.s.l). Bats were caught in mist net sessions throughout both summers, at roughly two-week intervals. Bats were kept in a captive facility for a maximum of two weeks, before being released back into the wild at the same site where they were caught. Captured bats were marked with black hair-dye on their backs so that individuals could be identified, and so that the same bats were not caught in subsequent mist netting nights. The bats were kept in a purpose-built facility in the town of Ohakune, North Island. They were fed each night with mealworms, honey-water and water. Approval for this study was obtained from the Massey University Animal Ethics Committee, the Department of Conservation (DOC), and Ngati Rangi iwi. No bats died during the course of the study and all appeared healthy upon release.

2.2 STUDY LOCATION

All bats were housed in an enclosure near the Ohakune Department of Conservation Field Centre. The bat facility consisted of two buildings—one for housing the bats (dormitory) and the other for running the trials. The enclosure in which the trials were conducted comprised four identical chambers. Each chamber had a small roost box lined with polar fleece curtains, which held a single bat, and a large adjoining flight area with a feeding tray at the far end. VCRs were placed in the roof of each cage and infrared cameras were positioned above the feeding trays to record feeding behaviour. The dormitory cage housed bats while they were not participating in trials and consisted of a communal roost area, flying area and feeding tray.

2.3 EQUIPMENT

2.3.1 Bait trials

Twelve non-toxic baits frequently used in poison operations and rodent traps and one control were tested. These were:

- Trapperjacks® macadamia nut rodent lure
- Kiwi Care® gel block (orange lure)
- Feral Control® gel (unlured)
- RS5® cereal pellets (cinnamon lure)
- White chocolate

- Tasty cheese
- Pork dripping
- Beef dripping
- Golden Sun® fish sauce—one tablespoon of fish sauce was mixed with 10 g of Pestoff® paste
- Aniseed oil (Animal Control Products, Wanganui)—one tablespoon of aniseed oil was mixed with 10 g of Pestoff® plain paste
- Apple
- Racumin® paste
- Control—one tablespoon of clover honey was mixed with 10 g of Pestoff® plain paste.

Approximately 5 g of each bait was presented to bats in small plastic dishes. The Pestoff® plain paste that was used as a control and also mixed with the aniseed and fish lures was obtained from Animal Control Products, Wanganui. It was specifically made up for this study and was unlured.

2.3.2 Scented lure trials

Ten non-toxic scented lures used in possum control operations were tested:

- Cinnamon
- Peanut
- Orange
- Cloves
- Allspice
- Lemon
- Chocolate
- Eucalyptus
- Raspberry
- Spearmint
- Control—honey-water

Lures were added to honey-water at a concentration of 0.15% (0.03 mL of lure with 20 ml of honey-water) and were presented to the bats in plastic budgie feeders.

2.3.3 Paste trials

Additionally, three pastes used in poisoning operations were also tested on the bats. These were:

- Pestoff® (a non-toxic, peanut-flavoured, green-dyed paste)
- Plain paste with no scent or flavour (as a neutral control)
- Apple-flavoured paste

The pastes were presented to the bats in plastic dishes.

2.4 EXPERIMENTAL DESIGN

2.4.1 Bait trials

After bats were caught, they were kept for three nights in the dormitory cage in order to accustom them to feeding from the budgie feeders. In the day preceding trials, four bats were transferred from the dormitory cage to the trial cage—one bat to each roost of the test enclosure. In 2000/01, each bat was only tested in one trial before being released. However, in 2001/02, each bat was tested in four trials so that they were exposed to each of the 12 baits at least once. All baits were tested approximately fourteen times. Three randomly assigned baits plus the control paste were positioned on each feed tray using small plastic dishes. Video recorders in each chamber were started at approximately 2130 h, and ran for three hours. For every trial, the number of visits bats made to each bait was recorded as well as the time (seconds) each bat spent feeding at each bait. Initially, we had hoped to be able to record the weight of bait eaten by a bat. However, we found that accurate weighing was not possible because the bats tended to walk through the baits, thereby spreading it on themselves and the feed tray. This made accurate ingestive measurements difficult to obtain. We assume here that the time spent feeding approximated the intake or at least the exposure time to potential toxins.

At the conclusion of each trial, bats were provided with the normal diet of honey-water, fresh water and 5 g of mealworms, and the following day each bat was returned to the dormitory. Bats were not used consecutively, but were rested for several days between trials.

2.4.2 Scented lure trials

Method as for bait trials, except four budgie feeders were placed on the feeding tray in each chamber. One budgie feeder contained just honey-water (as a control), and the other three contained honey-water plus a lure. Each feeder contained a different lure. For every trial, the number of visits to each lure was recorded as well as the time (seconds) spent feeding at each lure. Each lure was tested approximately 20 times.

From each trial, the total time spent feeding on each lure was recorded, as well as number of visits made to each lure.

2.4.3 Paste trials

Method as per bait trials, except all of the pastes were presented to a bat in each trial and ten trials were run on each of the pastes.

2.4.4 Analyses

Bait or lure preference was measured by time (seconds) spent feeding at each bait or lure and the number of visits to each bait or lure. Statistical analysis was performed using SAS (Version 8.2, SAS Institute, Cary, North Carolina, 1999–2001). The number of visits to each bait or lure was analysed using a Bradley-Terry model fitted using SAS Proc Genmod (Agresti, 1990). Total time spent at each bait / lure was log-transformed (y = log (time +1)) and then analysed using a similar model, but fitted using an ANOVA procedure (Proc GLM). For each analysis, a bat effect (to examine whether there was individual variation in bait / lure preference between bats), a bait or lure effect (to examine whether some baits or lures were fed on significantly more than others) and a date (bat) effect were fitted. A date (bat) effect was added to the overall model because the baits / lures were presented in combination with other baits / lures, and trials were conducted at different times of the year (from November to April). Thus, there may be a significant date effect if bats feed differently according to which bait / lure is presented with which other baits / lures, and to the time of the year. *A posteriori* tests were performed on the data to compare the different means. For log (visits) and log (time), the LS means (least squares means) are presented. LS Means are the best estimate of average visits made to baits / lures, adjusted for the bat used in the trial, and the date that the trial occurred.

Pastes were analysed using the same methods as the lures, except that unadjusted average visits and time spent feeding are presented. For these tests, the data was balanced and complete as every bat experienced the same combination of three pastes every time, so there was no need to calculate LS Means.

3. Results

3.1 BAIT RESULTS

3.1.1 Visits to baits

Overall, the plain paste was visited more often than any of the baits tested, while the other baits varied in attractiveness (Fig. 1a). Approximately one third of the percentage variation in visits to baits was explained by bait type (Table 1). Of the remaining baits, apple was visited the most, followed by RS5 cereal pellets, racumin paste, macadamia, white chocolate, Feral control, fish, Kiwicare gel, cheese, bacon fat, beef fat and then the least visited bait, aniseed (Fig. 1a).

Bats did not show significant individual variation in their bait preference (Table 1); nor was the number of visits to baits significantly dependent on the combination of baits presented in each trial or the particular night a trial took place.

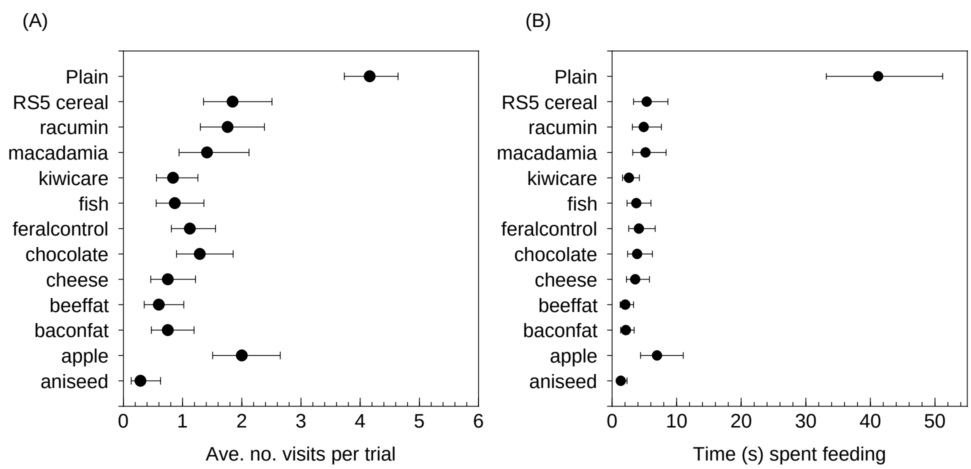

Figure 1. Visitation rates by captive short-tailed bats to baits (least squares mean visits ± standard errors). (A) Average number of visits per trial to baits. (B) Average time spent feeding on baits per trial.

TABLE 1. POISSON ANALYSIS OF VARIANCE OF THE NUMBER OF VISITS TO BAITS BY SHORT-TAILED BATS.

SOURCE	DF	χ^2	P	R^2 (%)
Bat	13	27.64	0.102	8.4
Bait	12	108.99	< 0.0001	33.2
Date (bat)	41	39.13	0.5540	11.9

3.1.2 Time spent feeding on baits

There was significant variation in the amount of time baits were fed on (Fig. 1b, Table 2). Over a third of the percentage variation in time bats spent feeding on baits was explained by bait type (Table 2). The adjusted means show that more time was spent feeding on the plain paste than any of the baits. Out of all baits, the most time was spent feeding on apple, followed by RS5 cereal pellets, macadamia, racumin paste, Feral control, white chocolate, fish, cheese, Kiwicare gel, bacon fat, beef fat (Fig. 1b). The least amount of time was spent feeding on aniseed (Fig. 1b).

The time spent feeding on baits was not significantly dependent on the combination of baits presented or the particular night a trial took place (Table 2). And again, bats did not show significant individual variation in time spent feeding on each bait (Table 2).

TABLE 2. ANALYSIS OF VARIANCE OF LOG (TIME + 1) SPENT FEEDING ON BAITS BY SHORT-TAILED BATS.

FACTOR	DF	F-VALUE	P	R^2 (%)
Bat	13	1.73	0.0596	7.2
Bait	12	9.09	< 0.0001	35.0
Date (bat)	42	0.58	0.9787	7.8

3.2 SCENTED LURE RESULTS

3.2.1 Visits to scented lures

There were also significant differences in the number of visits bats made to the different lures (Fig. 2a, Table 3). This time, bats did show individual variation in their lure preference (Table 3). Number of visits to lures was, again, not significantly dependent on what lures were presented at the same time, or the time of year the trial took place (Table 3).

The adjusted means show that honey-water was visited a great deal more than any of the scented lures (Fig. 2a). Of the lures, peanut was visited the most, followed by cloves, then orange, lemon, cinnamon, raspberry, chocolate, eucalyptus, allspice, and least visited was spearmint.

3.2.2 Time spent feeding on scented lures

Bats again showed small individual differences in their lure preferences (Table 4). However, once again lures differed significantly in visitation times.

Figure 2. Visitation rates by captive short-tailed bats to scented lures (least squares mean visits ± standard errors). (A) Average number of visits per trial to baits. (B) Average time spent feeding on baits per trial.

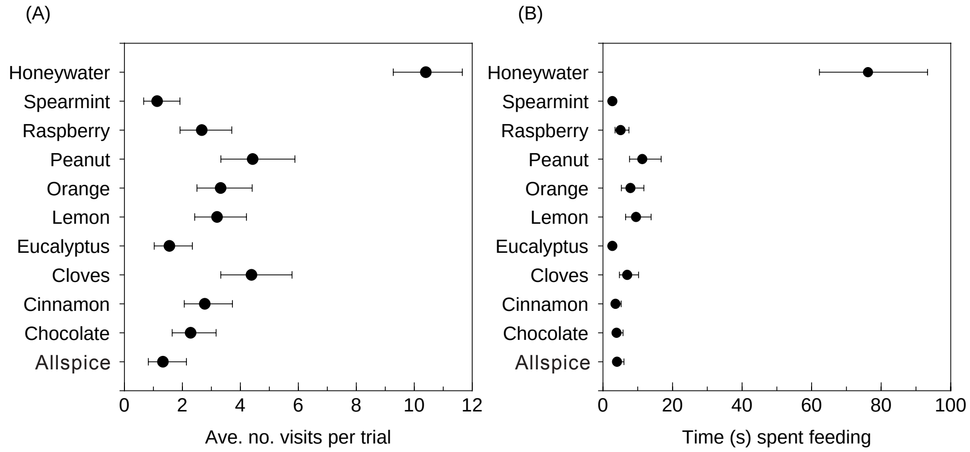

TABLE 3. POISSON ANALYSIS OF VARIANCE OF THE NUMBER OF VISITS TO SCENTED LURES BY SHORT-TAILED BATS.

SOURCE	DF	χ^2	P	R^2 (%)
Bat	30	69.84	< 0.0001	15.8
Lure	10	135.85	< 0.0001	30.8
Date (bat)	40	32.88	0.7801	7.4

TABLE 4. ANALYSIS OF VARIANCE OF LOG (TIME + 1) SPENT FEEDING ON SCENTED LURES BY SHORT-TAILED BATS.

FACTOR	DF	F-VALUE	P	R^2 (%)
Bat	30	2.11	0.0013	13.8
Lure	10	16.21	< 0.0001	35.4
Date (bat)	40	0.73	0.8851	6.4

The adjusted means show that bats spent more time was feeding from the honey-water than on any of the scented lures. Of the lures, the most time was spent feeding on peanut, followed by lemon, orange, cloves, raspberry, allspice, chocolate, cinnamon, and eucalyptus, and least time was spent feeding on spearmint (Fig. 2b).

3.3 PASTE RESULTS

3.3.1 Visits to pastes

Paste trials took place over the two summer seasons, and there was a significant difference in visits to pastes between the seasons, and a significant bat effect, i.e. bats showed individual variation in their visits to pastes (Table 5). Although there was no significant difference in visits to pastes, there was a (season × pastes) interaction, i.e. which pastes were favoured depended on the season. In 2000/01, peanut was visited more than the other pastes, followed by apple, and then plain (Fig. 3a). In 2001/02, however, plain had more visits than the other pastes, followed by apple and then peanut.

TABLE 5. POISSON ANALYSIS OF VARIANCE OF THE NUMBER OF VISITS TO PASTES BY SHORT-TAILED BATS.

SOURCE	DF	χ^2	P	R^2 (%)
Season	1	15.91	< 0.0001	25.4
Bat (season)	6	17.05	0.0091	27.2
Paste	2	5.17	< 0.0755	8.2
Season*Paste	2	6.58	0.0373	10.5

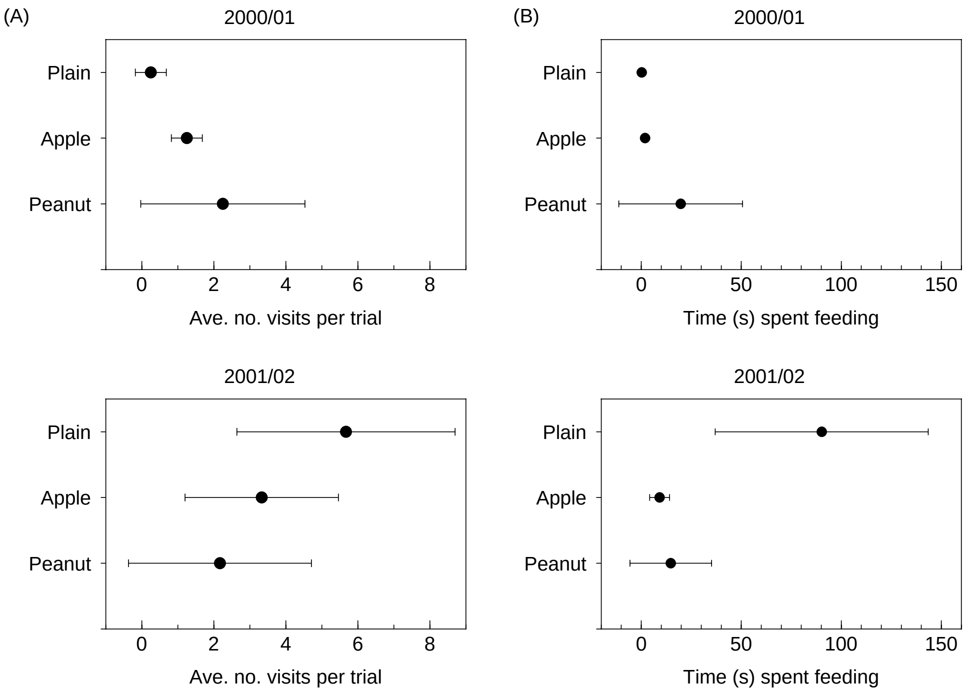

Figure 3. Visitation rates by captive short-tailed bats to scented pastes over two seasons (least squares mean visits ± standard errors). (A) Average number of visits per trial to baits. (B) Average time spent feeding on baits per trial.

3.3.2 Time spent feeding on pastes

Time bats spent feeding on pastes varied significantly, but there was no significant difference in the time they spent feeding related to paste type (Table 6). There was, again, a significant season effect, and a significant (paste × season) interaction. In 2000/01, more time was spent feeding on peanut than the other pastes, followed by apple, and then plain (Fig. 3b). In 2001/02, more time was spent feeding on the plain paste, followed by peanut and then apple.

TABLE 6. ANALYSIS OF VARIANCE OF LOG (TIME + 1) SPENT FEEDING ON PASTES BY SHORT-TAILED BATS.

FACTOR	DF	F-VALUE	P	R^2 (%)
Season	1	17.07	0.0006	21.7
Bat (season)	6	2.76	0.0441	21.1
Paste	2	1.53	0.2441	3.9
Paste*Season	2	11.98	0.0005	30.5

4. Discussion

This study shows that captive short-tailed bats will feed on a range of baits and lures used in poisoning operations. Moreover, some baits and lures were preferred over others; this is demonstrated by the significant difference in number of visits and time spent feeding at each bait or lure. However, no bait or lure was preferred more than the control (paste with honey in the bait trials, plain paste in the paste trials, and water with honey in the lure trials); probably because the control was lured with clover honey, and the bats had become accustomed to feeding on this diet, which was used as the staple diet whenever the bats were held in captivity.

4.1 BAIT PREFERENCE

Of all the baits, the three most favoured by bats in our trial were, in descending order, apple, RS5 cereal pellets and Racumin paste. Morgan (1999) found a similar attraction to apple paste when it was offered to six captive short-tailed bats. Apple is used as bait in rodent traps, and thus may increase the risk of these traps to short-tailed bats. The acceptance of the cinnamon-lured pellets in our trial was an unexpected result, as previous studies (Ecroyd 1993), and the scented lure trials indicated that cinnamon lures are not attractive to short-tailed bats. It is possible that the cinnamon smell and / or taste of the pellets were weaker than in previous studies, as the same batch of pellets was used throughout the trial.

The least preferred bait was aniseed, followed by beef fat, bacon fat and cheese. These baits are all used to attract pests into rodent trapping tunnels. Where pest control is carried out in short-tailed bat habitat, the use of these less palatable baits may decrease the risk of traps baited with them to bats. Aniseed is also currently an approved essential oil for use as a mask on 1080 carrot baits (Eason & Wickstrom 2001) and has been found to attract possums (Morgan et al. 1995). Some reports of short-tailed bats being attracted to meat have been documented (Stead 1936); however, our study and others (Lloyd 1994; McCartney 1994) have found no evidence for this.

Although the study bats showed a statistically significant preference for certain baits, it is worth noting that no bait was fed on avidly. The mean time spent feeding on baits was consistently less than 10 s during the 3-h trials and, from video observations, bats showed a general lack of interest in baits.

4.2 SCENTED LURE PREFERENCE

Of the scented lures, bats spent the most time feeding on peanut, followed by lemon, orange and cloves. Less time was spent feeding on (in descending order) raspberry, allspice, chocolate, cinnamon, eucalyptus, and the least time was spent feeding on spearmint.

In terms of the number of visits to lures, bats visited peanut, cloves and orange and lemon the most. Less visited were (in descending order) cinnamon, raspberry, chocolate, eucalyptus and allspice, and the least-visited lure was spearmint. However, despite the fact that the bats fed from all the lures, they preferred none of the lures more than the honey-water control. Bats spent considerably more time feeding on honey-water than any of the lures, and honey-water was visited a great deal more often in each trial than any lure that was offered.

4.3 PASTE PREFERENCE

Bats fed from all of the pastes presented to them and did not consistently prefer one paste, as the preference pattern (time spent feeding) in 2000/01 was reversed in 2001/02. A possible explanation for this may be found in the fact that the same bats were used in rat bait trials in 2001/02. In the rat bait trials, the plain paste flavoured with honey was used as the control. Thus, the bats may have fed more from the plain paste in the second summer because they associated it with being flavoured with honey, even though it wasn't, with the result that their paste preference switched between the two sampling periods. This result highlights that bats can learn to associate certain attributes with food. They may have learned that the plain paste was flavoured with honey, and continued feeding from it as if this was still the case. Or they could be more inclined to feed from something that is familiar to them, as the plain paste had been presented to them in every rat-trap bait trial prior to the paste trials. It is thus difficult to conclude which pastes the bats preferred. Future trials should take into consideration bats' ability to rapidly learn associations.

4.4 AMOUNT OF BAIT EATEN

The bait trials did not provide conclusive evidence that bats ate large enough quantities of bait to be at risk from poisoning. The proportion of bait consumed was not weighed; however, in most instances, bats appeared to sample only small amounts of any bait. Whether these amounts would have been sufficient to poison the bats would depend on the type of poison used. The second-most preferred bait, RS5 cereal pellets, is used in the aerial and ground distribution of 1080. The toxicity of 1080 to mammals varies between species (Eason & Wickstrom 2001). The only available estimation of a lethal dose (LD_{50}) (a statistical estimate of the poison dose in terms of milligrams/kg of body mass required to kill 50% of a population) of 1080 for any species of bat in the world is 0.15 mg/kg (for the American big brown bat, *Eptesicus fuscus*: Timm 1983). Based on this estimate, Lloyd (1994) asserts that a toxic dose of 1080 for a 14-g short-tailed bat is likely to require ingestion of between 0.88 mg and 17.5 mg of bait. The lower end of this range is cause for concern, as a lethal dose of 1080 may be ingested from small amounts of bait sampled or licked by a bat. During the scented lure trials, bats often fed for long periods on particular lures. Such lengthy feeding periods would greatly increase bats' potential to receive toxic doses of poisons if they are present in lures. The loss of just a few bats in a population can be significant, as the short-tailed bat's low fecundity (< 1 young/ female adult per year) (Lloyd 1994) means that populations will have little resilience against such relatively small mortality events.

The risk of 1080-driven secondary poisoning is perhaps greater for short-tailed bats than primary poisoning from baits. Lloyd & McQueen (2000) found that a short-tailed bat can consume an LD_{50} from a single *Nuncia* harvestman of mass 0.05 g, or a single *Dimerogonus* millipede of mass 0.59 g. Also, as bait consumption by arthropods occurs mostly at night, nocturnal foragers such as bats are at greater risk (Lloyd & McQueen 2000).

4.5 RISK TO BATS FROM BAITS AND LURES ENCOUNTERED IN THE WILD

Given their ground-feeding habits and omnivorous diet (Spurr 1993; Molloy 1995; Lloyd 2001), short-tailed bats have a high potential for encountering poisons or baited traps in the wild. Additionally, short-tailed bats have very sensitive olfactory systems and are capable of locating small amounts of food by smell (Ecroyd et al. 1995). If bats are attracted to particular strong-smelling lures in food trials, then it is possible that they will be attracted to the same lures in bait stations or baited traps. In the case of trapping tunnels, it must be remembered that a bat does not have to actually eat the bait to be killed. All that is needed is for the bat to enter a trapping tunnel to investigate a strong-smelling attractive lure. However, results from previous bait acceptance studies (Ecroyd 1993; Lloyd 1994; Lloyd & McQueen 2002) suggest that bats will not actually feed on baits in the wild. The only evidence presently available that they have been killed during poison operations is a report of one short-tailed bat found dead on a cyanide line laid for possums (Daniel & Williams 1984).

Ecroyd (1993) conducted a field trial to test whether wild short-tailed bats in the Pureora Forest would consume non-toxic carrot bait dyed green and cinnamon lured. They recorded no evidence of a bat landing near the carrot bait during three nights of monitoring, nor any evidence that the bait had been eaten by bats. Lloyd & McQueen (2002) caught 269 bats during eleven days following a poisoning operation in Rangataua Forest—none of the bats displayed any of the signs of 1080 intoxication. A broadificoum drop on Codfish Island had no apparent effect on short-tailed bats (Sedgeley & Anderson 1999), with bats being monitored after the poison drop showing no signs of having been poisoned. Non-toxic bait field trials on Codfish Island have also been carried out (Lloyd 1994). Agchem pellets containing fluorescent tracer dyes were distributed over 200 ha in October 1993. Seventy-six bats were caught after the broadcast operation but no traces of fluorescence were found on the bats or in their droppings (Lloyd 1994). Further trials undertaken at Wellington Zoo showed no evidence of captive bats consuming cereal baits or carrot (Lloyd 1994). From these trials and other relevant information, Lloyd (1994) concluded that 'short-tailed bat populations are unlikely to suffer from direct poisoning by consuming baits'.

Captive bait trials may, perhaps, have limited application to individuals in the wild—in this study bats were enclosed in a comparatively small area and presented with a limited amount of feeding options for three hours. This may not be representative of conditions in the wild where bats frequently fly more than 10 km from their roosts whilst foraging for their natural foods such as arthropods and nectar (Lloyd 2001). In the wild, bats may be more interested in foraging for their natural food than investigating poison baits. Therefore, future research investigating the response of bats to baits and lures in the field is required. Field testing of lures must be used whenever possible, either through tracer dyes or videotaping short-tailed bat foraging areas to determine if they will approach and feed from baits in the wild.

4.6 COMPILING A LIST OF BAITS OR LURES LIKELY TO BE 'SAFE' FOR SHORT-TAILED BATS

As new baits and lures are developed, they should, ideally, be field-tested to determine whether they increase the likelihood of non-target species kills. At a recent Bat Recovery Group meeting (Lyall 2001), it was suggested that a list of lures that are bat-safe be compiled. This would be of great value when pest control operations are planned for areas where short-tailed bats are present. Results from the bait study did not show a significant variation in bait preference between individual bats, suggesting that one list might represent the preferences of the greater population. While this makes compiling a bat-safe list possible, more extensive research is required to test other baits with captive and wild bats.

In the scented lure trials, bats showed a significant difference in lure preference between individuals—suggesting that no one lure would be unattractive to all bats. However, the use of less preferred lures (e.g. spearmint) would be likely to deter a larger proportion of bats than a more preferred lure (e.g. peanut). Thus, a list of lures that were 'safer' than others could be compiled.

5. Conclusions

This study has demonstrated that short-tailed bats will approach and sample a wide range of baits and lures whilst in captivity. However, it remains to be seen whether bats will approach baits in the wild, and current research suggests that they are at a low risk from direct poisoning.

Based on our study, we believe that the use of baits or lures in pest control probably does not pose a meaningful risk to short-tailed bat populations. Nevertheless, given their status as a threatened species, attempts must be made to lesson the risk of short-tailed bat mortalities. Where possible, baits that are known to be unattractive to bats should be used. This and previous studies indicate that baits and lures such as aniseed, beef or bacon fat, cheese or spearmint are likely to be most suitable for use in areas where short-tailed bats are present.

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