TOXIC BAIT AVOIDANCE BY MICE

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ABSTRACT: House mice (Mus musculus) are a widespread pest throughout New Zealand habitats, including forests and subalpine tussock areas. Some standard rodent-baiting operations are unsuccessful in controlling field populations of mice, and the possible reasons for this need to be determined. This research investigated avoidance responses of mice to toxic baits, and aimed to identify the particular bait characteristics that mediate any avoidance. In a factorial design trial, 96 wild-caught mice were housed individually and presented with one of 32 possible bait types, for 10 nights. Bait types were all combinations of five factors: (1) toxin type (1080 or brodifacoum); (2) bait (No. 7 or RS5); (3) presence or absence of green dye; (4) presence or absence of mask/lure (0.3% cinnamon); and (5) bait size (2 g or 12 g). Other than toxin, there was no effect of bait characteristics (i.e. bait, size, dye, or lure) on bait avoidance or acceptance. All brodifacoum baits were eaten, resulting in 100% mortality. However, 1080 baits were avoided, resulting in only 8% mortality. This marked avoidance of 1080 baits by mice is likely to have been the cause of control operation failures, and until new methods are developed to improve 1080 bait acceptance in mice, this toxin should not be used for mouse control operations.

INTRODUCTION

House mice (Mus musculus) were carried to New Zealand as stowaways on ships in the 19th century and are now widespread throughout New Zealand, including in forests and subalpine tussock areas (Murphy and Pickard 1990). They are likely to have a significant impacts on invertebrate and herpeto-fauna and contribute indirectly to predation on other species by sustaining populations of introduced predators, such as stoats, when other food is scarce (Ruscoe 2001).

In New Zealand the large-scale eradication of introduced rodents from islands has been achieved through the use of brodifacoum, but there have been more failures with attempted mouse than rat eradications. Standard 1080 (sodium monofluorooacetate) baiting operations are used for wide-scale possum and rat control on the mainland, but have often been unsuccessful in controlling mice (Gillies et al. 2003a). Most animals have behavioural defences against dietary poisoning, including neophobia, the ability to detect and recognise poison, primary or unlearned food avoidance, and learned food aversions (e.g. O’Connor & Matthews 1999). There is a vast literature on the development of bait shyness and poison aversion in rodents, though less on mice (but see Humphries et al. 2000). Further, mice are generally regarded as neophilic (i.e. they have a tendency to approach unfamiliar places or objects), although there are also reports of neophobia in mice (e.g. Kronenberger and Médioni 1985).

This research investigated whether there was any avoidance response of mice to 1080 and brodifacoum baits, and aimed to identify the particular bait characteristics that mediate any avoidance.
METHODS

Wild-caught house mice were housed at the Landcare Research animal facility in individual polycarbonate cages with a wire lid, containing shredded paper for play and nesting, and fed *ad libitum* on rat and mouse pellets (Weston Animal Nutrition, Rangiora). Supplementary food (crushed grains and cereals, Lincoln Grain and Produce, Lincoln) was provided and water was available at all times. Mice were acclimatised for 1 month and weighed weekly to monitor health and well-being. All mice were weighed the day testing began and only those of stable or increasing weight were used for the trial.

In a factorial design, 96 wild-caught mice were presented with one of 32 bait types (manufactured and supplied by Animal Control Products, Wanganui and Wainate), for 10 nights. Bait types were all combinations of five factors: (1) toxin type (1080 (nominally 0.15%) or brodifacoum (nominally 0.002%)); (2) bait (No. 7 or RS5); (3) presence or absence of green dye; (4) presence or absence of mask/lure (i.e. 0.3% cinnamon); and (5) bait size ((10–12 mm (2 g) or 20 mm (12 g)). In a choice-test procedure, mice were presented with 30 g of the toxic test bait and 30 g of the standard pellet diet, for 10 consecutive nights. Three controls for nine of the bait types (including the standard diet) were randomly located in the room to measure any weight changes due to moisture, and the resulting bait intake corrected for these differences. Time to death was recorded, and at 21 days any surviving animals were euthanased humanely.

The toxin concentration in eight of the bait types was analysed at the Landcare Research Toxicology Laboratory, Lincoln. Brodifacoum baits were analysed by HPLC (Method TLM017), and 1080 baits by gas chromatography (Method TLM023). Mortality data were analysed in S-Plus using the ‘GLM’ procedure.

RESULTS

The baits were found to contain a mean of 0.0019% brodifacoum and 0.17% 1080. The only significant effect was toxin type ($X^2_1 = 104.9, P < 0.0001$). All brodifacoum baits were eaten, with a mean consumption of 13.2 ± 0.5 g over the 10 days. However, 1080 baits were avoided, with a mean of only 0.52 ± 0.04 g eaten over the 10 days. In comparison mice, over all bait types, ate a mean of 16 ± 0.15 g standard pellets over the 10 days.

This resulted in 100% mortality from brodifacoum baits but only 8 ± 0.03% mortality for 1080 baits (Fig. 1).
DISCUSSION

In conclusion, mice avoid 1080 toxin. There was no effect of any other bait characteristic (i.e. bait, size, dye, or lure) on bait avoidance or acceptance. Mice, because of their small bodyweight, are generally considered relatively susceptible to 1080, although it is less toxic to mice than to most other rodents (oral LD$_{50}$ 8.33 mg/kg: McIlroy 1982). Gillies et al. (2003b) found a low non-toxic-bait acceptance by mice (compared with ship rats). The inclusion of 1080, especially at 0.15% rather than 0.08%, may have increased the avoidance of baits. However, the higher concentration is the one most likely to be used in 1080 baits for possum control operations and for future rodent control. Furthermore, the addition of cinnamon at 0.3%, does not mask 1080 for mice the way it does for possums (Henderson and Frampton 1999).

There was no avoidance of these same bait types, however, when brodifacoum was included. Although mice are generally considered to be less susceptible than rats to anticoagulants, the oral LD$_{50}$ estimates for brodifacoum are from 0.4 to 0.52 mg/kg and are similar to Rattus species (O’Connor and Booth 2001). As is often found with anticoagulants, mice in this trial ate up to 20 times more bait than was required for a lethal dose (i.e. 0.43–0.65 g; Fisher 2005). Therefore, because of brodifacoum’s environmental persistence (Eason et al. 2001) carcasses of poisoned mice are likely to contain brodifacoum residues. Despite the efficacy of the brodifacoum baits, this over-eating behaviour reinforces concerns over their field use because of the increased secondary poisoning risks to non-target species.

The marked avoidance of 1080 baits by mice found in this trial is likely to have been the cause of control operation failures, and until new methods are developed to improve 1080 bait acceptance in mice, this toxin should not be used for mouse control operations.

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