Efficacy of micro-encapsulated zinc phosphide as a poison for ferrets

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ABSTRACT

The efficacy of micro-encapsulated zinc phosphide (MEZP) as a poison for ferrets (*Mustela furo*) was tested. Ten captive ferrets were presented with a micro capsule containing 40 mg of zinc phosphide and 30 mg of inert carriers and binders. The capsule was coated with a material to provide short-term stability of the capsule in the non-toxic feed comprising their normal dog food diet. All ten ferrets died within 5 h of eating the poison capsule. Five of the ten initially rejected the capsule when it was presented in food weighing 6–19 g, but ate it when it was presented in a smaller piece of food (0.5–1.1 g). Symptoms and timing of poisoning were consistent with those reported in the literature for various species of mammal. They included nausea and vomiting, vocalisation, head shaking and body spasms. Intensity and duration of suffering varied amongst the ferrets but not according to body weight or bait size. This trial has demonstrated that MEZP is an effective means of killing ferrets but there should be discussion on whether or not it is acceptably humane.

Keywords: Pest control, ferret, *Mustela furo*, poison, bait, micro-encapsulation, efficacy, New Zealand.

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1. Introduction

The status of the ferret (*Mustela furo*) as a conservation pest and as a carrier of tuberculosis means that effective control systems are required over large tracts of land in New Zealand. Zinc phosphide has been identified as a potentially cost-effective alternative to sodium monofluoroacetate (1080) or brodifacoum for possums and rodents (Eason & Morgan 2000). It has been commonly used as a pesticide on a range of mammalian species worldwide (Worthing & Hance 1991). The LD_{50}[1] for ferrets is unknown, but as predator control often uses a multi-species approach, levels of poison that will also kill other mammalian predators must be tested on ferrets. The LD_{50} for both cats and rats is 40 mg/kg (Eason & Morgan 2000). Eason & Morgan (2000) identified possible problems with bait rejection and secondary poisoning and recommended micro-encapsulation if this poison is to be used in New Zealand. Micro-encapsulated zinc phosphide (MEZP), if effective, might provide a poison for mustelids and cats, with reduced risks of both secondary poisoning of non-target species and sub-lethal dosing of target animals. Such an approach has been recommended for registration for use on possums (Morgan et al. 2000). It is also important to assess how humane a poisoning system would be. While there are no definitive rulings on the acceptable levels of suffering caused by vertebrate pesticides in New Zealand, it may be possible to rank the relative humaneness of different poisons if the duration, type and severity of suffering are assessed (Littin & O'Connor2002; O'Connor et al. 2003).

We present the results of the test of efficacy of MEZP on ten captive ferrets, as approved by the DOC Animal Ethics Committee (Application AEC87).

2. Methods

2.1 HOUSING AND ANIMAL HUSBANDRY

Fifteen ferrets (wild-caught, 9 male, 6 female) were housed individually in cages (0.62 × 0.81 × 0.77 m) in a 4 m^2 outside shed. The shed had one wall constructed of half netting for adequate airflow and was situated in the shade of tall trees. The metal cages had a wooden nest box attached to one side. A Perspex lid was placed on the nest box during experimental days to allow observation without physical disturbance. Hay and newspaper were provided as nesting material (removed on the experimental day). The shed and cages were cleaned weekly.

Water was provided ad libitum. The ferrets were fed a ration of 70–100 g of commercial brands of dog roll, canned dog food or minced chicken once every 24 h. Consumption levels were monitored daily and the exact amount of food

[1] The dosage level that is lethal to 50% of tested animals.

adjusted appropriately for each individual ferret. Animals were presented with c. 1-g pieces of firm beef/lamb tallow mixed in with their normal food on 3 days in the week prior to the trial, to simulate a white micro capsule inside the food.

During an initial acclimatisation period of at least 5 weeks, and throughout the trial, body weights were recorded on a weekly basis. Health checks, nail clipping and flea treatment were undertaken at these times if necessary. The ferrets were considered to be acclimatised when their body weight was stable or increasing, and they had a regular pattern of food consumption.

2.2 EXPERIMENTAL PROCEDURE

Body weight was determined and a general health check performed one or two days prior to poison bait presentation (to prevent elevated stress levels from handling on the test day). The ferrets were fed their previous meal, as normal, 24 h before the trial began (so were hungry, but had not been deprived of food, at the time of the trial).

The poison bait consisted of a portion of dog roll (or in two cases, softer dog food) weighing between 6 and 19 g (Table 1). It contained 40 mg zinc phosphide and 30 mg of inert carriers and binders in a coated (water-resistant) micro capsule. On the day of poison bait presentation, all scraps of old food were removed from the cage(s). The ferrets were fed the poison bait on the morning of the test day. Uneaten capsules were retrieved and re-presented to the ferrets in smaller food portions (0.5–1.1 g) if necessary (Table 1). When this portion of food had been eaten, the ferret was provided with the rest of its normal food ration. The ferrets in the control group were provided with the dog roll portion containing white tallow instead of a poison capsule. All but two of the ferrets were observed eating the baits. Two of the females refused to approach the food while there was an observer present so we had to move further away while they were eating.

The ferrets were observed continuously until death (or for up to 5 h). Our experimental protocol allowed for further regular scan sampling of the ferrets over 24 h, and then daily checks for up to 14 days on any ferrets that survived. Five hours was the critical period within which the ferrets were expected to die (J. Kerr, Connovation Ltd, pers. com. March 2003.). We recorded changes in behaviour including: posture and alertness, vocalisations, feeding and drinking, gait and co-ordination, reaction to touch, palpebral and pedal reflexes. We also recorded the occurrence and timing (duration) of acute symptoms of poisoning including: retching and vomiting, extreme head and body shaking, tonic seizures, unconsciousness, agonal spasms and death. A veterinary surgeon was present for one day of the trial and on stand-by throughout the trial to euthanase any suffering, moribund or in extremis animals if acute poisoning lasted more than 5 h, but this was not necessary. Dead animals were labelled and kept in the freezer for later gross pathological examination, if required.

2.3 EXPERIMENTAL DESIGN

The initial DOC Animal Ethics Committee approval (see Section 1) was to test the poison on 5 ferrets. Only one ferret was tested on the first day, to ensure that our test procedures were suitable. We then dosed the other four, two per day, to allow close observations. Eleven weeks later, after receiving approval from the Animal Ethics Committee, we tested a second group of five ferrets, again running no more than two tests on any one day. Each test ferret was paired with a control group animal of the same sex and similar weight. The five ferrets used in the second poison trial were the five animals from the control group in the first trial.

3. Results

All ten ferrets consumed the poison capsules and all ten died. However, five of the ferrets left the poison capsule on first presentation (Table 1). Four of these ferrets accepted the original poison capsules when they were placed in smaller baits. These baits appeared to be swallowed whole. The fifth ferret rejected the capsule a second time, from a 0.6-g bait but finally ate the capsule in a yet smaller bait (0.5 g). The control group ferrets all ate the non-toxic baits.

For between 20 min and > 2.5 h after consuming the poison, the ferrets showed their normal patterns of behaviour, curling up in the nest box, resting, consuming more (but not all) of their daily food ration, drinking, and moving around the cage. The first symptoms of poisoning were signs of nausea and abdominal discomfort, including licking lips, retching, lying prone on the stomach, multiple swallowing and salivation. In all but two cases nausea was followed by vomiting (Table 2). Then came periods of violent head shaking and arching of the tail, release of anal sac odours and high pitched squealing sounds. While this period lasted for over 1 h in female F, it consisted of just one head shake in male K. These severe symptoms were interspersed with calmer periods of lying prone with the back legs splayed out, uttering quieter chattering sounds. The ferrets were breathing rapidly, and had limited co-ordination. The next stage involved lying on their side (lateral recumbency) with occasional tonic spasms, while the front legs pawed the air. This accompanied, or was followed by, dilation of the pupils and lack of palpebral and pedal responses when touched. A ferret was declared moribund when the pupils were completely dilated, the gums were a grey colour and the gums and legs were cool to the touch. This was followed by an agonic spasm and heart failure within 25 min. There was a wide range of latencies to death, but all fell within the predicted 5-h period (Table 2).

There were no clear determinants of speed of action of the poison. Neither first signs of nausea nor latency to death were correlated with body weight (r = –0.39, $P > 0.2$; r = –0.13, $P > 0.7$, respectively). Neither sex appeared more susceptible to poisoning than the other (Table 2). Most of the ferrets appeared to swallow the capsules whole. One of the males (K) may have broken open the capsule while chewing on the bait as indicated by a crunching sound. This ferret

TABLE 1. SUMMARY OF DATA ON TRIAL DATE, FERRET SEX AND WEIGHT (g), BAIT WEIGHT (g) AND SPEED (MIN) OF MEZP CAPSULE CONSUMPTION FROM TIME OF BAIT PRESENTATION.

FERRET	SEX	DATE	WEIGHT	FIRST PRESENTATION		SECOND PRESENTATION		THIRD PRESENTATION	
				BAIT WEIGHT	CAPSULE EATEN	BAIT WEIGHT	CAPSULE EATEN	BAIT WEIGHT	CAPSULE EATEN
F	Female	7 Apr. 03	1075	17	12				
C	Male	8 Apr. 03	1292	9	Not eaten	1.1	13		
K	Male	8 Apr. 03	1699	7	2				
N	Female	9 Apr. 03	886	6	Not eaten	0.8	3		
J	Male	9 Apr. 03	1269	7	Not eaten	0.7	1		
T	Male	26 Jun. 03	1500	11	45				
'Tunnel'	Female	26 Jun. 03	1204	13	Not eaten	0.6	< 1		
L	Male	27 Jun. 03	1474	19	Not eaten	0.6	Not eaten	0.5	1
P	Male	27 Jun. 03	1435	18	5				
S	Female	30 Jun. 03	1246	11	2				

TABLE 2. BEHAVIOURAL RESPONSES TO MEZP POISONING (EXPRESSED AS MIN AFTER BAIT CONSUMPTION); 'NO'-NOT OBSERVED.

FERRET	NAUSEA	VOMIT	PRONE/ SPLAYED	HEAD SHAKE	SQUEAL	ANAL SCENT	TONIC SEIZURE	LATERAL RECUMBENCY	COMATOSE	MORIBUND	DEATH
Females:											
F	164	176	202	208	208	232	218	293	283	293	297
N	65	93	112	NO	107	NO	107	104	117	118	127
'Tunnel'	92	92	101	108	108	108	108	139	139	197	200
S	22	NO	35	43	77	50	52	61	72	87	92
Males:											
C	56	104	107	117	113	NO	116	NO	132	134	136
K	30	33	30	37	NO	37	51	52	63	70	72
J	20	NO	36	36	29	44	30	44	73	88	112
T	65	65	86	84	84	85	90	115	115	219	220
L	75	84	91	NO	139	193	119	147	NO	269	271
P	62	63	80	82	91	91	85	94	111	138	152

showed early signs of illness and was the quickest to die (Table 2). Male J, however, also showed very early signs of illness, with no signs of having broken open the capsule.

4. Discussion

The 100% kill rate achieved in this study has demonstrated the potential of MEZP to kill ferrets at a dose that will be effective as a multi-species poison. The fact that half of the ferrets initially rejected the poison capsule indicates a need to develop more palatable capsule coatings or baits that are easily swallowed whole without the capsules being detected. A new capsule coating is now available for testing While it is possible that the capsule coating failed to contain or mask the characteristic garlic odour of zinc phosphide, we doubt that this was the reason for capsule rejection. The dog food bait was garlic-flavoured, and the capsules were almost always eaten in the small baits, where the odour of the zinc phosphide might be expected to be even more noticeable if present. It is more likely that the white colour, hard texture and flavour of the coating itself were the aversive cues. The fact that the ferrets appeared to swallow the capsules whole when presented in small bait pieces indicates that the size of these capsules is suitable for encapsulating poisons for ferrets. If the capsule texture or flavour could be made more acceptable and/or the capsules were disguised in suitably sized and flavoured baits, they should prove successful.

The symptoms of illness observed in this trial were those expected from zinc phosphide poisoning (Eason & Morgan 2000). Exposure to phosphine gas (PH_3) is known to produce abdominal pain, nausea and vomiting. It can affect the lungs (Eason 1996) and cause death by asphyxia (Hood 1972). The rapid breathing seen in all the ferrets was indicative of respiratory problems. Zinc phosphide is thought to cause death by cardiac as well as respiratory failure, but the severe tonic seizures often observed suggest disruption of the central nervous system (H. Boaler, VetFirst Ltd, pers. comm. June 2003). Some researchers have reported cerebral oedema following zinc phosphide poisoning (Mannaioni 1960; Puccini 1961).

Latencies to death of the ferrets in this study were well within the periods reported for zinc phosphide poisoning in other species (Hone & Mulligan 1982; Eason 1996; Eason & Morgan 2000). However, the long latencies to death in some cases (up to 297 min) combined with the length of acute symptoms of poisoning indicate a level of suffering that may make this means of poisoning unacceptable. While zinc phosphide has been used as a rodenticide for decades, there are no data available identifying differences in the toxicosis to zinc phosphide poisoning amongst animal species. Anecdotal evidence of possums poisoned with sub-lethal amounts of zinc phosphide suggests the animals can suffer from the toxicosis for several days. The lack of a relationship between body weight or sex and speed of action of the poison suggest that slight increases in dose would not alleviate suffering.

The authors consider that while the micro-encapsulating technique holds real promise for the delivery of poison to mustelids, with 40 mg zinc phosphide effective in these trials, alternative, more humane poisons should be incorporated in the capsules for ferrets. More palatable capsule coatings and easy-to-swallow baits should also be tested.

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