

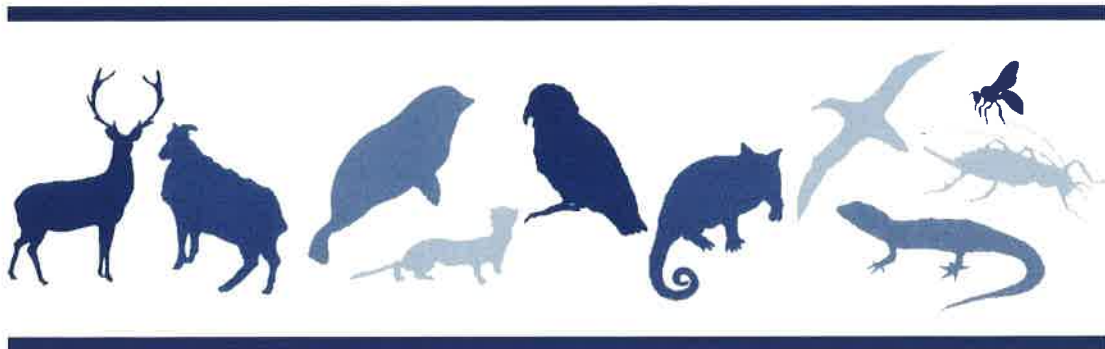


Consumption of acute and chronic toxins by 1080 bait shy possums in captivity

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**Lincoln University
Wildlife Management Report
No. 17**

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BY 1080 BAIT SHY POSSUMS IN CAPTIVITY**

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INTRODUCTION

Aversions caused by sub-lethal doses of sodium monofluoroacetate (1080) apparently persist in captive possums for at least 3 months, during which time such possums remain averse (or 'shy') to bait containing either a chronic or acute toxin (Morgan, Meikle & Hickling 1995). This suggests that when shyness has been induced with cereal 1080, such possums cannot be successfully controlled by reapplying cereal bait, regardless of the toxin used.

However, when a chronic toxin is used in the field it seems that possums eat progressively more bait at each night's exposure, until eventually the cumulative dose becomes lethal (R. Henderson, unpublished data).

These pen and field trials suggest different approaches for how best to combat 1080 shyness. Further trials were therefore required to clarify this issue, by ascertaining how the type of toxin influences the amount of bait that shy possums eat when they next re-encounter cereal bait, and whether nightly *per capita* consumption increases or decreases during prolonged re-exposure to such baits.

BACKGROUND

A preliminary FRST-funded alternative toxin trial was started at the Landcare Research (NZ) LTD. Rangiora pen facility in the 1995/96 financial year.

The overall goal of this trial was to expose 60 possums, sub-lethally dosed with 1080, to three alternative toxins (cholecalciferol, gliftor and brodifacoum). Unfortunately there was high possum mortality during acclimatisation and only 30 1080 shy possums were available to be trialed.

The results of this preliminary research (Table 1) suggest 1080 shy possums could be killed using a chronic toxin in a new bait matrix. However, the results highlighted two areas of uncertainty (summarised in Table 2). The main cause of which was confounding of differences in toxin and bait matrix in the 1995/96 trial. For example, the brodifacoum and cholecalciferol were presented in commercially produced cereal baits that differed from the RS5 bait used in the 1080 sub-lethal dose.

Table 1: Numbers of 1080 shy possums killed by alternative toxins in cereal baits (J. Ross, unpublished data).

Toxin	Toxic loading (%)	No. of possums	Mean group weight (kg)	Mortality (%)
Non-toxic	-	8	2.40 ± 0.15	0
1080	0.08	6	2.44 ± 5.3	67
Gliftor	0.4	6	2.75 ± 0.17	50
Cholecalciferol	0.8	6	2.42 ± 0.15	83
Talon	0.002	5	2.43 ± 0.17	60

Table 2: Current gaps in knowledge regarding the use of acute and chronic toxins on 1080 shy possums.

Acute toxin in RS5	Unsuccessful
Chronic toxin in RS5	Unknown
Chronic toxin in new matrix	Successful

Subsequent discussions within the research team concluded that a study design was required that controlled for the familiarity/novelty of both the toxin and the bait matrix. Accordingly, a new trial was undertaken that incorporated the new treatment groups stemming from the uncertainties highlighted in Table 2.

OBJECTIVE

- To determine the role of chronic and acute toxins in combating 1080 shy behaviours in possums, with a view to recommending alternative bait formulations that 1080 shy possums will accept.

METHODS

Animal husbandry

The trial was undertaken from Aug-Nov 1996 using 96 wild-caught possums housed in indoor cages at Landcare Research's captive animal facility at Lincoln. All possums were acclimatised to captivity for 6 weeks before the start of the trial.

The trial aimed to mimic non-prefed aerial application of possum control baits (i.e., the first bait that each possum encountered was a toxic 1080 cereal pellet; Morgan 1986). Therefore, possums were prefed on a range of fruit and vegetables, provided *ad libidum*. No cereal-based food was provided during the acclimatisation period.

Health of individual possums was monitored by checking body weight during the acclimatisation period. All possums were weighed three times at seven day intervals immediately prior to the sub-lethal dose. Significant weight loss over this period ($> 0.5\text{kg}$) was considered indicative of a stressed possum that should be withdrawn from the trial. Typically weight loss was negligible (mean weight loss 0.23 kg) and only 3 of 96 possums were withdrawn for this reason.

During the acclimatisation phase the captive possums were inadvertently exposed to an unidentified viral disease that killed 23 (24%) of the possums. All surviving possums were monitored as above to ensure that only healthy possums were used in the bait consumption trial. As a further safeguard all possums dying during the bait consumption phase were postmortemed to confirm cause of death. An additional six possums were withdrawn from the trial because no signs of poisoning were evident at postmortem.

Induction of bait shyness

After acclimatisation each possum was weighed and fed 1g of 0.08% 1080 bait per kg liveweight (RS5 pellet containing 0.1% cinnamon and green Lavanyl dye). RS5 is a proprietary mix of cereals and sugar sweeteners supplied by Animal Control Products (ACP) Waimate. Normal diet was available on the day of dosing.

Bait consumption trial

After one week, shyness was confirmed by presenting each possum with 1g of 0.08% 1080 bait. If the possum consumed the entire bait it was presented with a further two baits over the next two days. If the possum continued to eat the toxic bait on the third exposure it was removed from the trial. Possums taking more than one exposure to develop shyness were allocated equally amongst the subsequent treatment groups.

Once the possums were confirmed as shy they remained on the vegetable diet for a further week. They were then re-weighed and divided into six equal-weight treatment groups (Table 3).

Table 3: Treatment groups for 1996/97 trial conducted at Landcare Captive Animal Facility.

Group	Toxin	Conc. ¹	Bait Familiarity	Base Material	Lure	Dye	No. of possums
1	1080	0.08%	Familiar	RS5	Cinnamon	Yes	10
2	1080	0.08%	Unfamiliar	Apple-Paste	Jaffa	No	10
3	Cholecalciferol	0.6%	Familiar	Cereal ³	Cinnamon	Yes	11 ²
4	Cholecalciferol	0.6%	Unfamiliar	Apple-Paste	Jaffa	No	9
5	Brodifacoum	0.002%	Familiar	RS5	Cinnamon	Yes	11
6	Brodifacoum	0.002%	Unfamiliar	Apple-Paste	Jaffa	No	9

¹ Confirmed by laboratory assay.

² Including five possums that received this treatment in the 1995/96 trial.

³ A commercial bait similar to RS5, manufactured by ICI New Zealand Ltd, Lower Hutt.

To check for any difference in bait palatability between the three bait matrixes, standard Landcare palatability trials (D. Morgan, pers. comm.) were run comparing non-toxic RS5 pellets (0.1% cinnamon) with non-toxic apple paste lured with five different concentrations of jaffa. Palatability scores were similar (0.51%) when the jaffa concentration was 0.4% (a concentration considered sufficient to mask all three toxins).

Possoms in treatment groups 1-4 were presented with 50g of fresh bait per day. Treatment groups 5-6 were presented with 100g of fresh bait daily. All baits were presented in standard Landcare metal feed trays. Six control trays were put out each day in adjacent unoccupied cages to assess bait weight loss due to desiccation.

Possum survival and bait consumption for treatment groups 1-4 were monitored daily during the two week treatment period. Brodifacoum is a slow-acting toxin, so treatment groups 5-6 were monitored for bait consumption over four weeks and for survival over eight weeks.

RESULTS

Mortality

All ten 1080 shy possums failed to consume a lethal dose when re-exposed to 1080 in a familiar cereal bait matrix. In contrast, the cholecalciferol and brodifacoum toxins in a familiar matrix were equally successful, both killing eight out of eleven (73%) of shy possums (Table 4). The difference in kill between these toxins and 1080 was statistically significant (Fisher Exact test; $p = 0.001$).

Table 4: Numbers of 1080 shy possums killed by alternative toxins in a familiar and unfamiliar bait bases.

Group	Toxin	Base Material	No. of possums	Mean group weight (kg)	Numbers dying	Mortality (%)
1	1080	RS5	10	2.72	0	0%
2	1080	Apple-paste	10	2.20	4	40%
3	Cholecalciferol	Commercial	11	2.71	8	73%
4	Cholecalciferol	Apple-paste	9	2.12	9	100%
5	Brodifacoum	RS5	11	2.71	8	73%
6	Brodifacoum	Apple-paste	9	2.35	9	100%

1080 toxin in the unfamiliar apple-paste bait killed four out of 10 (40%) possums previously made shy with 1080 in a cereal bait (Table 4). Brodifacoum and cholecalciferol had a similar, higher, success rate killing nine out of nine (100%) of the 1080 shy possums.

Bait consumption

Shy possums exhibited a high level of shyness when re-exposed to 1080 cereal bait. The mean amount of bait eaten on the first night was negligible (0.63g) with the subsequent nightly consumption reducing further (Table 5 and Appendix 1). 1080 shy possums also exhibited a high level of shyness to the cholecalciferol cereal bait. Mean nightly consumption then declined, although to a level higher than for the 1080 group. The mean consumption of brodifacoum in cereal on the first night (6.62g) was considerably higher than for 1080 and cholecalciferol and mean nightly consumption then increased over the next 27 nights.

Mean total consumption of the 1080 cereal bait was only 2.8g over 14 nights (Table 5 and Appendix 1). Consumption of cholecalciferol in cereal bait was low at first however, the possums continued to eat small amounts with a mean total consumption of 17.8g over the 14 nights. Possums eating cholecalciferol took 7-15 days to consume a lethal dose and die. Consumption of brodifacoum cereal bait increased after the first night, with a mean total consumption of 281g over the 28 nights. Five out of eight possums eating brodifacoum took 18-25 days to consume a lethal dose and die. The other three took more than 28 days. As with 1080 cereal bait, the bulk of the 1080 paste consumption occurred on the first night. However, the mean of 1080 paste consumed on the first night (10.48g) was higher than for any of the cereal baits. Mean nightly consumption then reduced for the next 13 nights (Table 5 and Appendix 2). The 1080 shy possums exhibited a low level of shyness to the

cholecalciferol paste, consuming a mean of 26.22g on the first night. Mean nightly consumption then reduced markedly over the next 13 nights. The 1080 shy possums also showed little aversion to the brodifacoum paste, with consumption remaining fairly high throughout the trial.

The total mean consumption of 1080 paste was higher than expected at 43g. Possums consuming a lethal dose of 1080 died within 24 hours. The total mean cholecalciferol paste consumption was 42g with the bulk of this consumed on the first night. Possums eating cholecalciferol paste took 4-15 days to consume a lethal dose and die. The total mean brodifacoum paste consumption was 320g over 28 nights. Five out of eight possum eating the brodifacoum paste took 15-25 nights to die. The remaining three took longer than 28 nights to die.

Table 5: Mean consumption of various toxic cereal baits by captive possums over a four week period. All possums had previously survived a sub-lethal dose of 1080 (0.8 mg.kg⁻¹ body weight). Means are presented \pm SE.

Group	Toxin	Base Material	LD ₅₀ mg.kg ⁻¹	LD ₉₅ mg.kg ⁻¹	No. of possums	Bait eaten per night ¹		Mean Total	Days to death
						Night 1	Night 2-28		
1	1080	RS5	1.3 ²	3.3 ²	10	0.63 \pm 0.43	0.17 \pm 0.04	2.9	-
2	Cholecalciferol	Commercial	15 ³	24.1 ⁴	11	0.92 \pm 0.78	0.31 \pm 0.11	18	6-36
3	Brodifacoum	RS5	0.34 ²	0.8 ²	11	6.62 \pm 3.49	12.45 \pm 1.12	281	18-23
4	1080	Apple	1.5 ²	5.8 ²	10	10.48 \pm 4.7	3.64 \pm 0.56	43	1
5	Cholecalciferol	Apple	-	-	9	26.22 \pm 6.6	3.06 \pm 0.68	42	4-15
6	Brodifacoum	Apple	-	-	9	28.25 \pm 8.7	12.30 \pm 1.86	320	15-25 ⁵

¹ Excluding the nights that followed each possum's death

² R. Henderson unpublished data

³ Eason *et al.* 1994

⁴ Henderson *et al.* 1994

⁵ Three possums were euthanised at the end of the four week feeding trial for humane reasons. All had consumed a lethal dose and were showing signs of anticoagulant poisoning. This was confirmed by a postmortem.

DISCUSSION

This trial supported the results of the preliminary 1995/96 trial in showing that is possible to kill 1080 shy possums using a sub-acute or chronic toxin in a familiar cereal bait matrix. Both trials also suggest that there is little difference in the effectiveness of cholecalciferol and brodifacoum as a mean of overcoming 1080 bait shyness.

The effect of changing the bait matrix appears to be twofold. Firstly, this trial showed that it is possible to kill some 1080 shy possum using 1080 in a new bait matrix. This result supports Morgan's (1996) research, in which the greatest success in overcoming 1080 shyness was obtained by switching both the bait matrix and lure.

The second effect is that it reduces the initial level of shyness. All possums ate more paste, on average, on the first night than those feeding on cereal. This enhanced the effectiveness of the cholecalciferol and brodifacoum toxins, with both achieving a 100% kill. In contrast, several possums survived the cholecalciferol and brodifacoum cereal treatments, apparently by avoiding the bait matrix throughout the trial. It seems that the surviving possums were 'averse' to the cereal bait package and this could not be overcome by changing the toxin, whereas in the paste treatment all the possums ate some paste on the first night and eventually consumed a lethal dose.

Previous research has attempted to identify whether possums develop an aversion to the toxin or the bait matrix. The results of this trial suggest that an aversion to the bait matrix can be partially overcome by switching to a sub-acute or chronic toxin. Because of the slow acting nature of these toxins possums are able to consume sub-lethal doses without the onset of poisoning symptoms. With regards to toxin detection this trial and Morgan's (1996) trial both suggest that some possums are unable to detect the 1080 toxin once the bait matrix has been changed. However, re-exposing 1080 shy possums to an acute toxin in a new matrix does not appear to be as effective as using a sub-acute or chronic toxin in the same or in a new bait matrix. What this suggests is that 1080 shy possums appear to develop a cautious feeding strategy (Hickling 1994), particularly in response to a familiar bait matrix. It would be interesting to trial an unfamiliar acute toxin (gliftor) in a new bait matrix to test this hypothesis.

In conclusion, the majority of the results of this trial confirmed predictions based on previous research work. However, I was surprised to observe the high mean total consumption of 1080 paste. One would expect any possums eating a sub-lethal dose of 1080 to develop an aversion to the new bait matrix. This was not the case, with most possums continuing to consume small sub-lethal amounts of bait. Nevertheless, the only possums consuming a lethal dose did

so on the first night. 1080 has a much lower toxicity in the paste matrix than in cereal (R. Henderson, unpubl. data). Therefore, it may be that the small amounts of paste being eaten were not producing severe poisoning symptoms as the sub-lethal 1080 cereal dose. Another consideration is that the paste desiccates by between 8-15% per night. While controls were placed out to estimate the rate of desiccation perhaps some of the paste consumption could have been caused by variations in this rate. This did not seem to be a problem with the other paste treatments but could be worth considering in further bait consumption trials involving a paste matrix.

RECOMMENDATIONS

Switching to a sub-acute/chronic toxin is an effective way of overcoming 1080 shyness however, the best results are achieved when all components of the bait packages are unfamiliar. I believe that further research should: i) investigate the practicability of the new paste bait in the field and ii) investigate the effectiveness of other bait matrixes. While the results of this trial confirm that sub-acute or chronic toxins will be the most effective, I recommend trialing an unfamiliar acute toxin in the apple-paste bait to confirm this hypothesis. Brodifacoum and cholecalciferol were equally effective at killing 1080 shy possums. Given that cholecalciferol has major cost and environmental advantage it seems likely that this toxin is the current best alternative toxin to 1080 for maintenance possum control.

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APPENDIX 1

Appendix 1: Amounts of toxic cereal baits eaten by possums over 4 weeks after a sub-lethal dose of 1080 ($0.8\text{mg}\cdot\text{kg}^{-1}$ body weight).

Toxin	Possum	Weight (kg)	Night 1	Total consumption (g)	Night until death¹
1080	21	3.86	0	3.6	Survived
	40	3.19	0	2.8	Survived
	24	3	0.1	0.7	Survived
	38	2.96	1.6	1.6	Survived
	8	2.72	0	1.3	Survived
	5	2.56	0.4	4.6	Survived
	27	2.53	0	1.0	Survived
	25	2.3	0.1	7.1	Survived
	23	2.3	0	1.2	Survived
	31	2.06	4.7	5.8	Survived
			MEAN	2.97	
Cholecalciferol	14	3.37	0	0.4	Survived
	11	3.11	0	0.8	Survived
	41	2.81	0	13.1	15
	44	2.52	0.6	2.2	Survived
	63	2.75	1.8	54	6
	9C	2.05	0	8	36
	8D	2.43	4.7	50	4
	12D	1.92	0	33	5
	12F	2.55	0	2	Survived
	11B	2.81	1.3	16	7
11B	2.81	1.3	16	7	
			MEAN	17.77	
Brodifacoum	3	3.39	9.5	196	20
	13	3.32	0.2	299	Survivor ²
	48	3.13	13.7	578	18
	4	2.91	0	210	23
	45	2.77	0.4	409	Survivor ²
	18	2.69	0.7	759	Survivor ²
	30	2.52	9.4	170	18
	20	2.4	0	63	Survivor
	1	2.34	0.8	44	Survivor
	28	2.37	38.1	304	18
42	1.96	0	60	Survivor	
			MEAN	281.09	

¹ Survival was monitored for 30 days post treatment

² These possums were euthanised at the end of the 4 week feeding trial for humane reasons. All had consumed a lethal dose and were showing signs of anticoagulant poisoning. This was confirmed by an autopsy

APPENDIX 2

Appendix 2: Amounts of toxic paste eaten by possums over 4 weeks after a sub-lethal dose of 1080 (0.8mg.kg⁻¹ body weight).

Toxin	Possum	Weight (kg)	Night 1	Total consumption (g)	Night until death¹
1080 paste	29	3.0	14.4	14.4	1
	45	2.7	0.6	12.89	Survivor
	10	2.38	0.2	105.1	Survivor
	15	2.39	6.6	55.1	Survivor
	23	2.95	0.9	10.1	Survivor
	6	2.47	3.3	59.8	Survivor
	27	2.18	37.6	37.6	1
	11	1.87	37.4	37.4	1
	31	2.1	3.9	56.4	Survivor
	34	2.38	45.3	45.3	1
			MEAN	43.41	
Cholecalciferol	48	2.57	37.9	38.3	5
	37	2.71	1.3	31.98	5
	21	2.39	0.6	26.4	5
	47	2.37	37.7	41.9	5
	36	2.28	43.4	56.6	4
	5	2.4	0	32	5
	32	2.14	49.5	51.5	5
	26	2.05	36.7	47.6	5
	4	2.26	28.8	54.5	15
			MEAN	42.30	
Brodifacoum	1	3.23	7	131.1	Survivor ²
	18	2.23	66.7	653.1	15
	16	2.37	0	361.8	Survivor ²
	12	2.3	38	300.5	18
	39	2.11	6.8	322.8	22
	19	1.94	32.6	208	15
	33	2.01	0	438.6	25
	20	1.52	63.1	237.2	Survivor ²
	35	1.38	40	223.9	21
			MEAN	319.66	

¹ Survival was monitored for 30 days post treatment

² These possums were euthanised at the end of the 4 week feeding trial for humane reasons. All had consumed a lethal dose and were showing signs of anticoagulant poisoning. This was confirmed by an autopsy