
Toxicity of cholecalciferol to rats in a multi-species bait.

Charles Eason; Dan Baigent , Lindsay Wilson, Steve Hix, Duncan MacMorran, James Ross, Aroha Miller and Shaun Ogilvie

Department of Conservation, Opotiki
Connovation Research, Auckland
Lincoln University, Lincoln

Summary

The effectiveness of Feracol® a paste bait containing 0.8% cholecalciferol as a rodenticide has been assessed in cage and field trials. Caged rats were provided with toxic bait in choice and no choice tests. Feracol® was readily eaten when presented as the sole food source or with other food and was effective at killing rats in both situations. A total of 35 wild caught and laboratory rats including both Ship and Norway rats were presented with between 30 to 60 gms of Feracol® alone or with an equivalent toxic bait over 48 hours. Thirty-four rats died in an average 4.0 days. Having established the paste originally designed for possum control is also an effective rodenticide for the control of rats, field trials were initiated with the paste delivered in the field Philproof® and Striker® bait stations. Monitoring of rat numbers before and after application of toxic bait was undertaken at three trial sites in the Urewera national park, namely the Lions Hut, Mangaone and Pakoakoa in the North Island of New Zealand. The sites were 34, 180 and 220 hectares respectively. Rat population density was assessed using tracking tunnels. Philproof® bait stations containing 200 gm Feracol® were placed 50 metres apart on grids at Lions Hut and monitoring was undertaken at one location per hectare using tracking tunnels. At Mangaone and Pakoakoa two Striker® bait stations containing 18 gm Feracol® were sited at 25m intervals on lines 150m apart, and monitoring was undertaken with 5 lines of 10 tunnels at 50 metre intervals. At all three locations Feracol® was extremely effective in reducing the % rat tracking rate. At Lions Hut rat tracking was reduced from 78% to 3%, at Mangaone the reduction in rat tracking was from 51% to 0% and at Pakoakoa from 36% to 0%. These trials demonstrate that Feracol® is effective at reducing both moderate and high concentrations of ship rats in the Philproof® and Striker® bait station delivery systems.

Introduction

The paper covers efficacy studies on Feracol® in wild-caught and laboratory rats in cages and field trials. We have been heavily reliant on anticoagulants and 1080 for broadscale pest control however 1080 use is under pressure with a re-assessment in New Zealand by ERMA 2007. Public support for 1080 poisoning has declined and current alternatives used for field control of pests (e.g. second-generation anticoagulants) have resulted in wildlife contamination (Eason et al 2002). There has been increasing demand for alternatives to anticoagulant toxicants for the field control of rodents, and this study is an important step towards demonstrating that Feracol® possum bait is effective in rats as well as possums. Anticoagulant poisons, particularly second-generation anticoagulants, are very persistent and have been detected in a range of non-target species including game (i.e. pigs and deer) and native birds (e.g. kiwi). In the face of increasing incidence of brodifacoum contamination of wildlife and secondary poisoning in New Zealand and overseas (Eason et al. 1999; Stone et al. 1999; Ticknell 1999; Dowding et

al 2006), the present study was conducted to provide further information on Feracol®, a potential alternative tool for control of rodents as well as possums.

Cholecalciferol (vitamin D₃) was developed in the 1980s as a rodenticide (Marshall 1984; Tobin et al. 1993). It is registered under the trade name of Quintox® (0.075% cholecalciferol) in the USA, and in Europe it has been added to baits (Racumin® plus) to overcome anticoagulant resistance in rats and mice (Pospischil & Schnorbach 1994). In 1999 it was registered in New Zealand in a paste bait containing 0.8% cholecalciferol (Feracol®). This was based on work in the early 1990's which demonstrated the susceptibility of possums to cholecalciferol (Eason 1991, Eason et al. 1996).

Cholecalciferol is synthesized in animal skin by the action of sunlight on its precursor, 7-dehydrocholesterol. Natural dietary sources of vitamin D₃ include liver, fish oils, egg yolk, and milk fat. Cholecalciferol in toxic doses raises blood calcium levels (hypercalcaemia), and causes metastatic calcification of the blood vessels (Marshall 1984; Marsh & Tunberg 1986). Death usually results from heart failure. These effects are comparatively rapid when compared to anticoagulant rodenticides; animals normally take 3–7 days to die (Marshall 1984; Marsh & Tunberg 1986; Jolly et al. 1995). The acute LD₅₀ is 43.6 mg/kg for Norway rats (Marshall 1984) and 16.8 mg/kg for possums (Jolly et al. 1995). Whilst a higher dose on a mg/kg basis is required to kill rats versus possums, possums regularly weigh between 2- 4 kg versus rats weighing less than 500 gm. Hence, Feracol® which contains 0.8% (or 8 mg/gm) cholecalciferol should kill most rats in a weight-range, e.g. 100-500, between 0.5gm and 3.0gm. This amount of bait should be equivalent to or exceed the LD₅₀.

Fortunately, the toxicity to birds is low, e.g. the LD₅₀ for mallard ducks is 2000 mg/kg (Marshall 1984). The risk of secondary poisoning to non-target species is also low (Marshall 1984; Eason et al. 1996; Booth et al 2004). We report data on the effectiveness of a possum bait product containing cholecalciferol at 0.8% (Feracol®) as a rodenticide.

Methods

The effectiveness of Feracol®, a possum control paste bait containing 0.8% cholecalciferol has been assessed as a rodenticide firstly in cage trials and then in field trials.

Cage Trials

Norway rats and Ship rats were housed in individual cages, which contained a smaller nesting tube and shredded paper as nesting material. Daily feeding comprised grain pellets and clean drinking water was continuously available. A total of 35 rats were exposed to toxic bait, this included 15 laboratory sources Norway rats weighing between 230 and 405 gms and 20 wild caught Ship rats weighing between 108 and 184 gms were presented with between 30 to 60 gms of Feracol®.

All 15 of the Norway rats and 4 ship rats were allocated to a choice test and were offered both Feracol® and a non-toxic equivalent paste over 48 hours. The remaining rats were presented with Feracol® alone. Consumption of this bait was recorded, as were time until death, and body weights

Field Trials

Monitoring of rat numbers before and after application of Feracol® baits was undertaken at three trial sites in the Urewera national park. The sites were chosen as they were known to have moderate to high populations of ship rats. The sites, namely the Lions Hut, Mangaone and Pakoakoa ranged from 34 to 220 hectares. Monitoring was undertaken using tracking tunnels (Black Trakka) for presence or absence of rats and the result expressed as a % of tunnels tracked. The % tracking rate prior to application of Feracol® baits ranged from 36 to 78%. The target was to achieve a <5% mean rat tracking rate per line.

Lions Hut: Field sites included paired treated areas and untreated areas. The treated area was 34 hectares and the untreated block was 40 hectares. Baseline monitoring was undertaken in both blocks on 15th September 2006. Follow-up monitoring occurred between the 9th and 11th January 2007 following prefeeding on the 24th November 2006 and placement of toxic baits on the 8th December 2006. Bait stations were placed 50 metres apart on a 50 metre grid with 200gm of bait placed in each bait station. Monitoring was undertaken using one location per hectare using tracking tunnels (Black Trakka). Appendix 2 shows the study site where Feracol® was dispensed including the bait stations sites and the location of the tracking tunnels for monitoring rat numbers. Monitoring sites were located with the same distribution in the untreated site.

Mangaone: The core area was 180 hectares in size. Baseline monitoring was undertaken on 8th August 2007. Follow-up monitoring occurred on the 11th September 2007 following prefeeding on the 10th August 2007 and placement of toxic baits on the 18th August 2007. Striker bait stations were placed 25 metres apart on a 150 x 25 metre grid. This provided control lines at 150m spacing. Monitoring was undertaken following the Department of Conservation (DoC) standard operating system with 5 lines of 10 tunnels at 50 metre intervals.

Pakoakoa: The core area was approximately 220 hectares in size. Baseline monitoring was undertaken on the 23rd August 2007. Follow-up monitoring occurred on the 18th October 2007 following prefeeding on the 7th September and placement of toxic baits on the 27th September 2007. Striker bait stations were placed 25 meters apart on a 150 x 25 meter grid. This provided control lines at 150m spacing. Monitoring was undertaken following the DoC standard operating system with 5 lines of 10 tunnels at 50 metre intervals.

Results

Cage trials

Thirty-four rats died in an average 4.0 days. (see Table 1).

Table 1. Study type, bait eaten and mortality in cage trials.

Rat	Study type	Bait eaten (gm)	Mortality
Norway	Choice	0-20.4	14/15
Ship	Choice	1.6-6.3	4/4
Ship	No-choice	0.7-16.1	16/16

Deaths first occurred after one day and most deaths occurred with 2 and 4 days (see Tables 2-3). The Feracol® paste formulation whilst originally designed for possum control is also an effective rodenticide. Only one rat out of 35 survived and this rat did not eat any toxic bait. Feracol® was effective when given alone or in the choice test when presented alongside non-toxic feed pellets and appeared to be equally effective at killing both Ship rats and Norway rats.

Table 2. Sex, weight, days until death*, bait eaten and amount of toxin ingested by Norway rats.

Sex	Weight	Days*	Bait Eaten gm	Toxin Consumed mg	mg/kg	Design
Female	230	3	2.4	19.2	83.48	Choice
Female	242	3	1.8	14.4	59.50	Choice
Male	410	3	8.9	71.2	173.66	Choice
Female	271	13	0.7	5.6	20.66	Choice
Male	416	3	18.6	148.8	357.69	Choice
Female	234	4	3.7	29.6	126.50	Choice
Female	242	3	4.2	33.6	138.84	Choice
Male	386	3	20.4	163.2	422.80	Choice
Male	390	3	8.5	68	174.36	Choice
Male	389	3	11.1	88.8	228.28	Choice
Male	393	3	2.8	22.4	57.00	Choice
Female	302		0	0	0.00	Choice
Female	242	5	5.1	40.8	168.60	Choice
Male	387	4	4.1	32.8	84.75	Choice
Male	405	2	9.4	75.2	185.68	Choice

Table 3. Sex, weight, days until death*, bait eaten and amount of toxin ingested by Ship rats.

Sex	Weight	Days*	Bait Eaten gm	Toxin Consumed mg	mg/kg	Design
Male	148	4	3	24	162.16	Choice
Female	117	5	1.6	12.8	109.40	Choice
Male	139	3	6.3	50.4	362.59	Choice

Female	151	5	1.9	15.2	100.66	Choice
Male	184	4	10.55	84.4	458.70	No Choice
Female	151	5	13	104	688.74	No Choice
Male	158	3	16.15	129.2	817.72	No Choice
Female	148	5	8.7	69.6	470.27	No Choice
Male	192	5	10.35	82.8	431.25	No Choice
Male	152	6	12.05	96.4	634.21	No Choice
Male	131	2	12.5	100	763.36	No Choice
Female	110	2	11.8	94.4	858.18	No Choice
Female	108	7	0.7	5.6	51.85	No Choice
Male	130	1	3.3	26.4	203.08	No Choice
Male	148	3	26.5	212	1432.43	No Choice
Female	108	5	2.7	21.6	200.00	No Choice
Male	144	4	4.55	36.4	252.78	No Choice
Male	147	4	12.5	100	680.27	No Choice
Male	141	3	17.5	140	992.91	No Choice
Female	127	6	8.7	69.6	548.03	No Choice

Field trials

At all three sites Feracol® was extremely effective at reducing the mean tracking rate per line from 36-78% to <5%. At Lions Hut the rat tracking rate was reduced from 77.9% (\pm 12.2% SEM) to 2.9% (\pm 2.9% SEM), at Mangaone the reduction in rat tracking was from 51.0% (\pm 8.0% SEM) to 0% and at Pakoakoa from 36.0% (\pm 6.5% SEM) to 0%. Further details are provided below and in Table 4.

Lions Hut: Baseline pre-treatment monitoring undertaken on the 15th September 2006 revealed a rat tracking rate of 92.5% (\pm 3.7% SEM) in the "control" untreated block compared with 77.9% in the 34 hectare block designated for poisoning (see above). Follow-up monitoring on the 9th and 11th January 2007 approximately one month after toxic bait had been dispensed revealed a rat tracking rate of 58.75% (\pm 6.67% SEM) in the "control" untreated block and 3% in the 34 hectare block poisoned with Feracol® which is below the target level of 5%. Tracking at 3% versus 59% represents a percentage tracking decline of approximately 96% in the tracking rate following control with cholecalciferol. The mean tracking rate did decrease by 34% in the untreated block; however, a rat tracking rate of 59% at the end of the study was still 10 fold greater than the acceptable target level of 5% indicating high rat numbers versus very low numbers in the treated area.

Mangaone: Baseline pre-treatment monitoring undertaken on the 8th August 2007 revealed a rat tracking rate of 51%. Follow-up monitoring occurred on the 11th September 2007 approximately one month after toxic bait had been dispensed and revealed a rat tracking rate of 0%. Hence rat tracking declined by 100% to below the target level of < 5% as in the Lion Hut trial.

Pakoakoa: Baseline monitoring undertaken on the 23rd August 2007 revealed a rat tracking rate of 36%. Follow-up monitoring occurred on the 18th October 2007 approximately one month after toxic bait had been

dispensed and revealed a rat tracking rate of 0%. Hence rat tracking declined by 100% to below the target level of < 5% as in the Lion Hut trial and Mangaone trial.

Table 4. Trial area size, treatment regimen, monitoring systems and % rat tracking rate before and after application of toxic bait.

Name of site Size of treatment area (hectares)	Treatment Regimen. Number of bait station/amount of bait	Monitoring systems	% rat tracking results before treatment (non-treatment area in brackets)	% rat tracking results after treatment (non-treatment area in brackets)	% reduction in tracking (non-treatment area in brackets)
Lions hut/34	Philproof bait stations 50 x 50 metre grind. 200 gm	Randomly placed at approx one tunnel per hectare.	78 (93)	3 (59)	96 (34)
Mangaone/180	2 Strikers containing 18 gm every 25 meters on lines 150 meters apart	Five lines of 10 tunnels at 50 metre intervals	51	0	100
Pakoako a/220	2 Strikers containing 18 gm each every 25 meters on lines 150 meters apart	Five lines of 10 tunnels at 50 metre intervals	36	0	100

Conclusions

Feracol® shows considerable promise as a rodenticide as well as a product that effectively kills possums and is therefore an alternative to anticoagulants or for integrated use with anticoagulants.. The high mortality in both Norway and Ship rats is not surprising given the published acute LD₅₀ is 43.6 mg/kg for Norway rats (Marshall 1984). The maximum sized Norway rat was a little over 400 gm and Ship rats a little over 180 gm. The LD₅₀ was exceeded in most animals, however this should not be a concern as cholecacliferol unlike 1080 and brodifacoum, does not cause secondary poisoning. In fact the high dose had a positive effect in that most animals died swiftly. Humaneness is an important consideration (NZFSA 2002) and the Feracol® formulation resulted in

death in well under 7 days in most animals which is an advantage. The average time to death in Norway rats was 3.9 days and in Ship rats was 4.1 days. These values are at the low end of the range of 3-7 days published in previous literature.

The field trials confirmed the effectiveness of Feracol® as a product that can kill rats, which is consistent with the use of cholecalciferol in the USA as a rodenticide for 25 years. It is therefore an alternative to anticoagulants or suitable for integrated use with anticoagulants to reduce reliance on these bioaccumulative poisons. Targeting rodents as well as possums will more effectively protect native fauna, and overcome any unexpected consequences of conventional control methods targeting single species (Tompkins & Veltman 2006). Expertise has been gained during these field trials to optimise the use of Feracol® in terms of the amounts required and bait station placement under New Zealand field conditions.

9. References

- Booth, L.H.; Fisher, P.; Hepplewaite, V.; Eason, C.T. 2004. Risk of Feracol baits to non-target invertebrate, native skinks, weta. *Science for Conservation* 239: 18 p.
- Dowding, J.E.; Lovegrove, T.G.; Richie, J.; Kast, S.E.; Puckett, M (2007) Mortality of Northern New Zealand dotterels following an aerial poisoning operation. *Notornis* 53: 233-239
- Eason, C.T. 1991: Cholecalciferol as an alternative to sodium monofluoroacetate (1080) for poisoning possums. *Proceedings of the New Zealand Weed and Pest Control Conference* 44: 35–37.
- Eason, C.T.; Wright, G.R.; Meikle, L.; Elder, P. 1996: The persistence and secondary poisoning risks of sodium monofluoroacetate (1080), brodifacoum, and cholecalciferol in possums. Pp. 54–58 in Timm, R.M.; Crabb, A.C. (Eds): *Proceedings of the 17th Vertebrate Pest Conference*, Davis, California, U.S.A.
- Eason, C.T.; Milne, L.; Potts, M.; Morriss, G.; Wright, G.R.; Sutherland, O. 1999: Secondary and tertiary poisoning risk associated with brodifacoum. *New Zealand Journal of Ecology* 23: 219–224.
- Jolly, S.E.; Henderson, R.J.; Frampton, C.; Eason, C.T. 1995: Cholecalciferol toxicity and its enhancement by calcium carbonate in the common brushtail possum. *Wildlife Research* 22: 579–583.
- Marsh, R.; Tunberg, A. 1986: Characteristics of cholecalciferol. Rodent control: other options. *Pest Control Technology* 14: 43–45.
- Marshall, E.F. 1984: Cholecalciferol: a unique toxicant for rodent control. Pp. 95–98 in Timm, R.M.; Crabb, A.C. (Eds): *Proceedings of the 17th Vertebrate Pest Conference*, Davis, California, U.S.A.

Stone, W.B.; Okoniewski, J.C.; Stedelin, J.R. 1999: Poisoning of wildlife with anticoagulant rodenticides in New York? *Journal of Wildlife Diseases* 35(2): 187–193.

Tompkins, D.M and Veltman,C.J. (2006). Unexpected consequences of vertebrate pest control: predictions from a four-species community model. *Ecological Applications* 16(3), 1050–1061.

Ticknell, O. 1999: It's a rat trap: poison aimed at rodents is killing their predators instead. *New Scientist* 23: 4.