DEVELOPING A NEW TOXIN FOR POTENTIAL CONTROL OF FERAL CATS, STOATS, AND WILD DOGS IN NEW ZEALAND

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Abstract: The endemic fauna of New Zealand evolved in the absence of mammalian predators and their introduction has been responsible for many extinctions and declines. Predator control will have to be on-going if some native species are to survive on the mainland. Currently, predator control relies largely on labour-intensive trapping, so the development of humane predator-specific toxins would provide valuable additional control methods. Para-aminopropiophenone (PAPP) is being investigated as a toxin for feral cats (*Felis catus)*, stoats (*Mustela erminea)*, and wild dogs (*Canis familiaris*). Carnivores appear to be much more susceptible to PAPP than birds, so it potentially has a high target specificity, at least in the New Zealand context. Pen trials with 20 feral cats, 15 stoats, and 14 dogs have been undertaken using meat baits containing a proprietary formulation of PAPP. A PAPP dose of 20-34 mg/kg was lethal for feral cats, 37-95 mg/kg was lethal for stoats, and 26-43 mg/kg was lethal for dogs. Our results suggest that PAPP is a humane and effective toxin for control of feral cats and stoats, and possibly for wild dogs. We are now continuing studies towards product registration, which will include the assessment of non-target effects, particularly on birds.

Key Words: *Canis familiaris*, control, *Felis catus*, feral cat, invasive species, *Mustela erminea*, PAPP, para-aminopropiophenone, stoat, toxin, wild dog.

Managing Vertebrate Invasive Species: Proceedings of an International Symposium (G. W. Witmer, W. C. Pitt, K. A. Fagerstone, Eds). USDA/APHIS/WS, National Wildlife Research Center, Fort Collins, CO. 2007.

INTRODUCTION

New Zealand wildlife evolved in the absence of mammalian predators, and their introduction has been responsible for many extinctions and declines (Clout and Saunders 1995, Parkes and Murphy 2003). Birds have been particularly affected, with over 40% of the pre-human land bird species now extinct, and the proportion of extant birds classed as threatened is one of the highest in the world (Clout 1997). Predator control in New Zealand currently relies largely on labour-intensive trapping (Gillies et al. 2003, Christie et al. 2004), so the development of a humane predator-specific toxin would be a valuable additional control method.

The United States Fish and Wildlife Service investigated para-aminopropiophenone (PAPP) as a toxin for coyote (*Canis latrans*) control in the 1980s as it was highly toxic to canids (Savarie et al. 1983). Vomiting was a complicating factor, but before solutions could be fully explored, the continued use of 1080 and other toxins was approved in the United States (P. Savarie, personal communication). PAPP is currently being investigated in both New Zealand and Australia for the humane control of introduced predators (Marks et al. 2004, Fisher et al. 2005, Murphy et al. 2005, Fleming et al. 2006, Fisher and O'Connor 2007)

The toxic effects of PAPP appear to be related to the rapid formation of methemoglobin in some species (Vandenbelt et al. 1944). High methemoglobin levels reduce the oxygen-carrying capacity of the blood and can result in death by hypoxia. Carnivore species appear to be much more susceptible than birds (Savarie et al. 1983, Schafer et al. 1983), so PAPP potentially has some degree of target specificity in the New Zealand situation at least.

A proprietary formulation of PAPP has been developed by Connovation Ltd., New Zealand. It delivers PAPP rapidly into the blood stream of an animal via the stomach and can be used in a meat bait. The aim of this study was to evaluate the effectiveness of this formulation on dogs, cats, and stoats.

METHODS

PAPP was milled to produce a consistent particle size, mixed with carriers, and made into pellets or microgranules to be mixed or placed with food. Each dose contained a propriety formulation of PAPP which included an anti-emetic.

Ten dogs were fed chicken (*Gallus domesticus*) mince containing 310-1,200 mg PAPP and 4 dogs were fed dog roll containing a 600 mg capsule of PAPP. The dogs were not fasted beforehand and all ate the bait.

Twenty individually-housed cats were fasted for 24 hours and then presented with 10-20 g of feed containing 80-180 mg PAPP. The cats were tested in two groups. In the first group, 12 cats weighing 0.9-2.6 kg received doses of 35-112 mg/kg. In the second group, 8 cats weighing 2.4-3.9 kg received doses of 20-34 mg/kg.

Fifteen individually-housed stoats weighing 135-345 g were fasted for 24 hours and then presented with 10 g of minced rabbit (*Oryctolagus cuniculus*) containing 12.8 mg of PAPP in a paste.

All animals had free access to water and were observed for signs of toxicosis after dosing. To determine if there was a significant relationship between the dose (in the range used) and time to death, a regression analysis was done by log-transforming both dose and time to death.

RESULTS

Ten of 14 dogs (weight range 14-30 kg) fed 21.4-42.9 mg/kg of PAPP in meat baits died within 3.5 hours of bait ingestion (Table 1). There was no significant relationship between the dose (mg/kg) and time to death ($F[1,8] = 0.59$, P [one-tailed] = 0.23). The four dogs that survived received 11.1-25.8 mg/kg of PAPP and all vomited.

Eighteen of the 20 cats (weight range 0.9-3.9 kg) died after eating a PAPP bait and two survived (Table 2). In the higher dose group, the twelve cats showed a wide range of responses with onset of symptoms occurring between 16-204 min and death between 37-246 min. One animal that only ate a fraction of the dose of PAPP recovered (see Table 2, first cat). In the lower dose group, onset of symptoms occurred between 22-55 min with death between 54-125 min. Cats exposed to lethal doses of PAPP tended to lose consciousness without spasms or convulsions. There was no significant relationship between the dose (mg/kg) and time to death ($F[1,16] = 0.19$, P [one-tailed] = 0.34).

All 15 stoats died quickly after eating PAPP baits (Table 3). For stoats (weight range 135-345 g, dose 37.1-94.8 mg/kg), 12.8 mg of PAPP was lethal in all cases, with first symptoms 6-40 min after ingestion and death between 15-85 min. There were no signs of discomfort, stress, or vomiting associated with poisoning. The stoats became quiet, lethargic, and then unconscious for a short period before death. There was a significant relationship between the dose (mg/kg) and time to death ($F[1,13] = 3.8096$, P [one-tailed] = 0.036).

DISCUSSION

The lethal response of dogs, cats and stoats to PAPP was rapid and appeared relatively free of the suffering that accompanies the use of some other toxins (Goh et al. 2005, Potter at al. 2006). PAPP was effective when delivered in a range of different

Table 1. Time to first symptoms, vomit, and death of 14 dogs presented with 310 to 1,200 mg PAPP placed into a meat bait. NA = did not vomit. S = survived.

Weight (kg)	Dose (mg/kg)	First symptoms (min)	Time to vomit (min)	Time to death (min)	Bait
28	11.1	140	158	S	Chicken
20	15.8	70	83	S	Chicken
18	17.5	110	120	S	Chicken
28	21.4	70	70	114	Dog roll
24	25.0	97	140	191	Dog roll
12	25.8	128	135	S	Chicken
21	28.6	62	NA	104	Dog roll
20	30.0	34	38	71	Chicken
21	30.7	46	55	111	Chicken
19	31.6	112	NA	178	Chicken
16	37.5	94	NA	152	Chicken
30	40.7	80	91	151	Chicken
15	41.4	114	NA	210	Dog roll
14	42.9	45	NA	118	Chicken

Table 2. Time to first symptoms and death of 20 cats presented with 10-20 g of bait containing 80 to 180 mg PAPP. S = survived. Rabbit = minced rabbit.

Weight (kg)	Dose (mg/kg)	First symptoms (min)	Time to death (min)	Bait
0.9	?	26	S	Did not eat
2.6	34.6	45	119	Dog roll
2.4	37.8	54	73	Dog roll
2.4	37.8	60	101	Dog roll
2.5	40.2	45	77	Dog roll
1.7	53.3	204	246	Beef fat
1.6	54.9	16	37	Dog roll
1.3	67.2	26	74	Did not eat
1.2	76.3	136	224	Beef fat
1.1	80.4	66	86	Peanut butter
0.9	96.8	78	108	Peanut butter
1.6	111.8	25	55	Dog roll
3.9	20.4	35	92	Rabbit
3.5	22.7	31	67	Rabbit
3.4	23.7	55	125	Rabbit
3.3	24.3	35	74	Rabbit
3.1	25.6	22	54	Rabbit
2.5	32.0	30	83	Rabbit
2.8	32.4	50	S	Rabbit
2.4	33.9	30	79	Rabbit

Table 3. Time to first symptoms and death of 15 stoats presented with 10 g minced rabbit containing 12.8 mg PAPP in a paste.

Weight (g)	Dose (mg/kg)	First symptoms (min)	Time to death (min)
345	37.1	15	45
321	39.9	10	85
298	43.0	17	43
295	43.4	15	35
292	43.8	15	62
281	45.6	7	35
249	51.4	20	55
232	55.2	10	20
210	61.0	20	59
199	64.3	15	35
198	64.6	35	45
192	66.7	20	51
185	69.2	15	30
163	78.5	40	51
135	94.8	6	15

vehicles or baits, such as minced rabbit, beef fat, and dog roll. The two cats fed the PAPP in beef fat had the longest time till first symptoms and longest time to death, suggesting that fat may slow the absorption of PAPP.

In stoats, the symptoms of poisoning and time to death after ingestion of baits were similar to those previously reported by Fisher et al. (2005) following administration of PAPP in the hydrochloride form by oral gavage.

A previous complication of using PAPP was that some animals vomited after ingesting a bait, thereby reducing its effectiveness (Savarie et al. 1983, Murphy et al. 2005, Fisher and O'Connor 2007). This was not a problem with cats and stoats in this study. However, vomiting did occur in 9 of 14 dogs and all four that survived had vomited. The unusually large weight range observed in dogs (Vila 1999) may also be a complicating factor in the field use of PAPP (and other toxins).

Our results suggest that PAPP is a humane and effective toxin for control of feral cats and stoats (and possibly wild dogs) and we are now continuing studies towards product registration. The registration requirements will have to be met of both the Environmental Risk Management Authority (ERMA) - who administers the Hazardous Substances and New Organisms (HSNO) Act 1996 - and the NZ Food Safety Authority under the Agricultural Chemicals and Veterinary Medicines (ACVM) Act 1997. These studies will include the assessment of non-target effects, particularly on birds. Although birds are not as susceptible to PAPP as carnivores on a weight to weight basis, because they generally have lower mass, they could still be vulnerable. For example, the red-winged blackbird (*Agelaius phoeniceus*) has an LD_{50} of 133 mg/kg (Savarie et al. 1983) which equates to only 9 mg of PAPP. This is slightly less than a lethal dose for stoats, but considerably less than a lethal dose for cats. A list of New Zealand birds that potentially could be vulnerable (depending on their LD_{50}) to PAPP stoat or cat baits was presented by Murphy et al. (2005). It may be possible to improve specificity by developing more targeted delivery systems if required (e.g., Marks et al. 2004, Marks et al. 2006).

A PAPP bait could be particularly useful for stoats, because currently there are no toxins registered for use against them. Stoats continue to have an impact on a wide range of threatened birds, lizards and invertebrates in New Zealand, and there are few effective techniques available to control them (Parkes and Murphy 2004). Registration of a toxin that appears to show some relative specificity for mammals and is lethal to stoats at low dose would be a significant advance.

ACKNOWLEDGMENTS

We would like to thank Lloyd Robbins and Ray Henderson who helped with some of the pen trials, Andy Lavrent who provided formulation advice, and John Dowding for comments on the draft. Dr Lynn Booth is thanked for undertaking analyses of PAPP in the baits used in the study and Graeme Elliott provided statistical advice.

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