Para-aminopropiophenone (PAPP) Research, Development, Registration, and Application for Humane Predator Control in New Zealand

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ABSTRACT: Feral cat and stoat control is conducted in New Zealand to protect a number of threatened native species, including kiwi, from predation. *Para*-aminopropiophenone (PAPP) is being developed for predator control. Previously reported cage trials have shown PAPP presented in a meat bait was palatable and effective, while symptoms observed demonstrated PAPP to be humane. Subsequent field trials on stoats were undertaken in two blocks of native forest and achieved 83% and 87% reductions in the stoat abundance index, and a field trial on a population of radio-collared feral cats had an 84% kill. PAPP represents one compound from a new class of active ingredients, which we are calling red blood cell toxins. These vertebrate pesticides have humaneness, and low secondary and non-target poisoning risks, as their primary consideration. The dose is optimised to be effective in the field and reduces oxygen supply to the brain such that animals become lethargic, sleepy and unconscious prior to death within 1-2 hours. Results from these field trials on stoats and feral cats indicate that PAPP will be a useful additional tool for predator control.

KEY WORDS: *Felis catus*, feral cats, *Mustela erminea,* PAPP, *para*-aminopropiophenone, red blood cell toxins, stoats, vertebrate pesticide

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INTRODUCTION

Stoats (*Mustela erminea*) and feral cats (*Felis catus*) are pests in New Zealand and require control. New Zealand bird species, such as kiwi (*Apteryx* spp.), evolved in the absence of mammal predators and are therefore extremely vulnerable to predation by introduced mammal species (Bell 1991, McLennan et al. 1996).

The most commonly used method for control of stoats and feral cats is trapping which, although effective, is also labour intensive (Parkes and Murphy 2004). The toxin sodium fluoroacetate (1080) is registered for use on cats. Although there is no toxin registered for use on stoats, 1080 operations often result in secondary poisoning of stoats as well as cats (Murphy et al. 1999, Wickstrom et al. 1999). However, the use of 1080 has become increasingly controversial because of secondary poisoning risks to non-target animals, as well as the general public's concern over its use (Eason 2002, Sherley 2007).

On-going control of these pest species is necessary, and efforts in this area are topical and current in both New Zealand and Australia (Johnston et al. 2011, Murphy et al. 2011). The development of a more humane and effective toxin would be a highly valuable control tool in this endeavour, and the development of *para*-aminopropiophenone (PAPP) hopes to fill this gap.

Early research regarding PAPP was conducted by Savarie et al. (1983) for the control of coyotes (*Canis latrans*) for the United States Fish and Wildlife Service. However, trials on coyotes revealed problems involving formulation and regurgitation by dosed animals that were not resolved, and research on PAPP was not pursued as a priority after 1080 was registered for use in the Livestock Protection Collar (Connolly 1980). *Para*-aminopropiophenone (PAPP) actively forms elevated methemoglobin (MetHB), reducing the oxygen carrying capacity of blood, which at levels of 70% oxygenation can result in a lethal deficit of oxygen to the brain (Coleman and Coleman 1996, Marrs and Bright 1987, Vandenbelt et al. 1994). Lethal doses of PAPP result in a humane death, with animals becoming lethargic, sleepy and unconscious within a few hours (Eason et al. 2010b, Fisher et al. 2005, Marks et al. 2004, Murphy et al. 2007).

Cage experiments on feral cats and stoats were undertaken to confirm that PAPP was both humane and effective. In the cage trial on stoats, 15 individuals were presented with bait consisting of 5-10 g of meat with the addition of a 40% PAPP paste formulation (12.8 mg PAPP). This bait was palatable and all 15 stoats died

after eating it. Onset of symptoms occurred after an average of 17 minutes and lasted an average of 20-27 minutes, prior to unconsciousness. Symptoms included lethargy and unconsciousness and there were no signs of discomfort, stress, or vomiting. Death occurred in an average of 44 minutes (Eason et al. 2010b, Murphy et al. 2007).

In the cage trial on feral cats, 20 animals were presented with feed containing PAPP (80-180 mg). Eighteen out of 20 cats ate the bait and died. The average time to death was approximately 90 minutes. The cats which received lethal doses tended to lose consciousness without convulsions or spasms. Symptoms prior to unconsciousness were lack of co-ordination, lethargy, and sleep. A short period of retching (one minute duration) was observed in some animals that were presented with a high-fat bait. The symptoms observed in these cage trials on stoats and cats, as well as the high mortality and average time to death, support the conclusion that PAPP is humane and effective for use on these species (Eason et al. 2010b, Murphy et al. 2007).

PAPP is also readily metabolized and is unlikely to be present in carcasses at levels that will cause secondary poisoning (Savarie et al. 1983). PAPP has some selective toxicity for felids, mustelids, and canids. The lethal doses are: cats, 20-34 mg/kg; stoats, 37.1-94.8 mg/kg; ferrets (*Mustela furo*), 13-25 mg/kg; and dogs (*Canis familiaris*), 21.4-42.9 (Fisher and O'Connor 2007, Murphy et al. 2007). Birds and rodents appear to be somewhat less susceptible to PAPP (Eason et al. 2010a, Fisher et al. 2005, Marrs et al. 1991, Savarie et al. 1983), though there is some variability in the response of different bird species (Eason et al. 2010a). The unlikelihood of secondary poisoning, and the reduced toxicity to birds and rodents, means that PAPP will result in less unintended by-kill, whether of domestic animals (through secondary poisoning), native animals (birds), or non-target pest species. In any case of accidental poisoning, there is a simple and effective antidote to PAPP, methylene blue (Coleman and Coleman 1996).

PAPP is not yet registered as a vertebrate toxin in New Zealand, as further research was required by the NZ Food Safety Authority and by the Environmental Risk Management Authority to register PAPP for this purpose. Field trials have now been completed that tested the effectiveness of PAPP in reducing feral cat and stoat numbers, and these results are reported here.

METHODS

Field Evaluation of PAPP for Stoats

The stoat trials were carried out at two different sites in Waitutu Forest, Fiordland National Park, New Zealand. The area is hardwood forest with an understorey dominated by crown fern (*Blechnum discolor*), and is known to have a large and stable stoat population. The PAPP used in these trials was manufactured by Connovation Ltd. PAPP was milled to produce a consistent particle size, mixed with carriers, and then mixed with a proprietary paste to create a unique product. Baits used in these trials were c. 10 g of rabbit mince with 32-35 mg of PAPP paste in the centre (c. 13 mg PAPP). Tracking tunnels, with fresh rabbit meat and pre-inked tracking cards, were run immediately before and after both trials to determine changes in stoat abundance.

Trial 1: Waitutu South

Eighty-eight bait stations, black-tracker tracking tunnels (Connovation Ltd., Auckland, NZ) with pre-inked tracking cards, were positioned in a grid at 300-m intervals and baited with the PAPP meat bait. Bait take was attributed to a species when their prints were recorded. Uneaten baits were replaced daily to maintain freshness, and the trial lasted 5 days.

Trial 2: Waitutu North

Ninety-nine bait stations were deployed and were a mixture of existing wooden tunnels (stoat kill trap tunnels with traps removed), and black-tracker tunnels. The wooden tunnels had mesh across the ends with a hole for stoats to enter, and most had an internal mesh "baffle". Stations were placed 200 m apart, and all were pre-baited with rabbit mince 3 weeks before the PAPP baiting. Toxic baiting occurred for 5 nights.

Field Evaluation of PAPP for Feral Cats

The trial site was a 1,500-hectare block of land consisting of windbreak hedging, pasture, and seral vegetation in the central plateau in the North Island of New Zealand. Feral cats were pre-fed fresh rabbit at 22 different locations using submarine-shaped bait stations (entrance through top) and Havahart® live capture traps (wired open). Following pre-feeding, the Havahart® live capture traps were unwired for 5 consecutive days to catch cats. Captured cats were restrained using a crush, sedated, and fitted with radio collars. Cats were tracked and infra-red motion detector cameras were used to monitor any un-collared cats also visiting the bait stations.

Havahart® cage traps were removed, leaving only the submarine bait stations. Further pre-feeding was carried out in the submarine bait stations, with the wire mesh on either end of the bait station removed so cats could enter from the sides or top. When cameras confirmed that cats had returned to feed after live capture, the wire mesh was re-attached to either end of the submarine bait station and toxic baiting began. Baits consisted of 200 mg of 40% PAPP paste (80 mg PAPP) applied to rabbit mince balls measuring 15mm in diameter. Baiting was carried out for 5 nights, though the fourth night baiting was delayed until the following night due to a snowstorm.

A non-treatment site was set up in a 300-hectare block of land adjacent to the trial site, and 7 Havahart® cage traps (wired open) were baited with rabbit meat and ink tracking cards and checked daily for any visits before and after the toxic trial in the adjacent trial area.

RESULTS

Field Evaluation of PAPP for Stoats

Trial 1: Waitutu South

Pre-trial tracking tunnels showed a stoat abundance index of 100% at both the trial site and the non-treatment site. Fourteen baits were taken by stoats, as well as 7 baits being taken by mice, and 1 by a possum (*Trichosurus vulpecula*). Bait take declined after the second night. Immediately after the trial, the stoat abundance

Table 1. PAPP for feral cat and stoat control milestones.

Date	Activity	Results
2007	Stoat cage trial	15/15 stoats died, average time to death 44 mins, humane
2007	Feral cat cage trial	18/20 cats died, average time to death 90 mins, humane
June 2008	Feral cat field trial: North Canterbury Trial	1/3 cats at smaller site and 4/5 cats at larger site killed
Aug 2008	Stoat field trial: Waitutu Trial 1	Stoat abundance index reduced 82%
Nov 2008	Stoat field trial: Waitutu Trial 2	Stoat abundance index reduced 90%
June 2009	Feral cat field trial: Ngamatea Trial	84% (16/19) of monitored cats killed
Sep 2009	HS1 registration dossiers for PAPP for stoat control resubmitted	
2010	Forecast registration of PAPP	

index was 17%, a decrease of 83% at the trial site. Only 5 tunnels registered stoat footprints compared to the non-treatment site, which registered stoat activity in 29 of the tracking tunnels (98% stoat abundance index).

Trial 2: Waitutu North

There was a stoat abundance index of 97% before baiting, and this fell to 10% immediately following the trial (a 87% reduction). Bait take declined after the second night, and all 19 baits taken were by stoats.

Field Evaluation of PAPP for Feral Cats

Of the 21 radio-collared cats, 16 were alive inside the trial area during toxic baiting; 13 of these cats entered the bait stations and died. An additional 3 un-collared cats, monitored by camera, entered bait stations and died. A total of 84 % (16 out of 19) of the monitored cats, present in the trial area at the time of the toxic baiting, were poisoned with PAPP. All cats that entered feed stations and ate PAPP died and were found dead on average 123.5 m from the visited bait station. On 4 occasions multiple baits were found 'licked' but not eaten; each time, a monitored cat was found dead near the feed station.

In the non-treatment site, 4 out of 7 tunnels were tracked for cats prior to the trial, and 5 out of 7 tunnels were tracked after the trial.

CONCLUSION

Results from these field trials on stoats and feral cats indicate that PAPP will be a useful tool for predator control. Data and reports from the pen and field trials on stoats and feral cats, together with chemistry and manufacturing, toxicology, and ecotoxicology dossiers have been generated for NZ registration authorities' assessment in 2009 and 2010 (Table 1). In parallel, meetings with community groups to discuss the use of PAPP for predator control have had favourable outcomes.

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