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# Integrating Ecology and Technology to Create Innovative Pest Control Devices

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**ABSTRACT:** To achieve long-term suppression of pest populations, devices capable of continued control over extended timeframes are needed. Creating new pest management tools to achieve this goal requires the integration of animal ecology, toxicology, and design engineering. This research outlines the development and testing of a long-life, resetting, toxin delivery system for vertebrate pest control, coupled with advances in novel species recognition systems. Such devices have the potential to offer advantages over current labor-intensive control techniques. Resetting systems have been developed to target several of the most destructive vertebrate pest species in New Zealand, including stoats and weasels. Results of enclosure trials for these two species showed similar responses after a paste containing 40% *para*-aminopropiophenone was delivered onto the chest and stomach, following triggering by a treadle operated system. Both species groomed the paste off shortly after application and death occurred after an average of 42 minutes for stoats and 57 minutes for weasels. The applications of these resetting devices are now being extended for the control of brushtail possums, another major vertebrate pest in New Zealand. Coupled with this, developments in species identification systems are ensuring that risks to non-targets are substantially minimized. Resetting, long-life toxin delivery systems could be deployed to control a variety of pest species, and further enhancement of these tools are ensuring their use for widespread field applications in a cost-effective, safe and reliable manner.

**KEY WORDS:** *Mustela erminea*, *Mustela nivalis*, *para*-aminopropiophenone, resetting toxin delivery, species recognition, *Trichosurus vulpecula*

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## INTRODUCTION

The arrival of introduced mammalian species in New Zealand resulted in profound and widespread consequences, including significant ecological changes and loss of biodiversity (Allen and Lee 2006). New Zealand has already lost 40% of its terrestrial bird species and over 40% of those remaining are classified as threatened, the highest proportion of any country in the world (Clout 2001). Species such as stoats (*Mustela erminea*), weasels (*Mustela nivalis*) and brushtail possums (*Trichosurus vulpecula*) continue to inflict major ecological harm to native biota (McLennan et al. 1996, Clout 2006). To ensure the survival of many native species on the mainland, continued predator control is vital (Innes et al. 1999, Whitehead et al. 2008).

However, current control strategies rely largely on labor intensive techniques such as trapping, toxin delivery in bait stations, or the widespread distribution of aerial toxin such as sodium monofluoroacetate (1080), the use of which causes ongoing debate within many communities. For species such as stoats, which are held responsible for the decline of many native bird species (McLennan et al. 1996, Wilson et al. 1998, Dowding and Murphy 2001),

labor-intensive kill trapping is still the main control technique used (King and Murphy 2005). Trapping of stoats can be very effective but is costly in terms of dollars per kill due to the need to frequently check and, where necessary, reset them (Brown 2003).

In 2011, the first new, registered vertebrate pest toxin in 30 years became available in New Zealand. *Para*-aminopropiophenone (PAPP) represents a new generation of vertebrate toxic agents, designed with humanness and safety as primary considerations (Eason et al. 2010). The efficacy and efficiency of PAPP when dispensed in meat baits (with an active concentration of approximately 40%) has now been successfully demonstrated in both pen and field conditions (Murphy et al. 2007, Eason et al. 2010, Shapiro et al. 2010, Dilks et al. 2011). During 2012 and beyond we anticipate increased use of PAPP for stoat control in fresh meat baits, and its use should augment current trapping programs targeting stoats and protecting native species. In parallel, we are seeking to develop new delivery systems which further extend the applications and cost-effectiveness of this new toxin.

With this in mind, research was focused on the development of a novel, resetting toxin delivery system which

could be applied to a range of species. Engineers, designers, and ecologists came together to develop a device capable of several hundred kills per unit, which could be left in the field for extending periods of time, with increased species specificity and no need for ongoing maintenance. To take advantage of the natural grooming behavior of vertebrate pests, this system was constructed to deliver a dose of a toxin (such as PAPP) onto an animal's stomach and chest. The target animal then grooms off the paste and ingests the toxin, leading to a rapid death. In this research, we describe the results of enclosure trials using these systems to target stoats and weasels. Coupled with ongoing research and advances in species recognition systems, a new generation of safe, cost-effective control tools are emerging that could offer widespread applications in vertebrate pest control.

## METHODS

Resettable toxin delivery systems for stoats and weasels were developed by Connovation Ltd (Auckland, New Zealand). These devices were designed to dispense 1 gram of a toxic spray (containing 40% PAPP liquid formulation), using compressed CO<sub>2</sub> gas, to an animal's sternum. The toxic paste was securely contained within an internal chamber and was only activated when a target animal stood on the treadle trigger. Each device was capable of approximately 100 doses and was also fitted with a counter and a 2-minute 'timeout' to allow animals to escape following dosage (therefore clearing the device for the next individual).

Stoats and weasels were caught from the wild and transported to the Lincoln University animal facility where they were housed in purpose-built enclosures, fed a mixed diet of fresh rabbit or chicks, and had access to water ad libitum. All animals were given a minimum period of a week to acclimatize to their new surroundings before trials commenced. Initial trials focused on stoat and weasel interactions with devices and their success in triggering systems to get a non-toxic dose of spray. After proof of concept was achieved, PAPP was included within the system. Two 40% PAPP liquid formulations were tested, one with a water-based carrier solution and one with an oil-based carrier. Resettable tunnels were placed in a large observation enclosure using fresh meat as a lure. Animals were monitored with motion-sensing video cameras for the following information: behavior towards device, time until device triggered, time until grooming, onset of symptoms, ataxia, coma, and death.

## RESULTS

Behavioral results from video surveillance showed that both stoats and weasels readily entered the systems and triggered the silicon treadle when they passed through, receiving a dose of PAPP paste. Both species quickly removed themselves from the system following delivery of the toxin. The lightest animal to trigger the system was a 55-g weasel, while the heaviest was a 386-g stoat (Table 1).

The water-based PAPP formulation was trialed first, with mixed results. Seven stoats were tested and 4 of these died within an average time of 3.4 hours. However, while the other 3 stoats showed signs of induced methe-

moglobinemia (becoming uncoordinated and prone), they made a full recovery within 24 hours. Due to the lower-than-expected success of this formula with stoats, it was not progressed through to testing on weasels.

Following this result, the formulation was altered to have an oil-based carrier solution, and 100% of the stoats and weasels tested with this solution quickly succumbed. The average time to death was 42 minutes for stoats and 57 minutes for weasels (Table 1). Closer analysis of video footage for some of these individuals enabled us to establish that both stoats and weasels started grooming the toxin off their chest and stomachs within a few minutes of delivery (Table 2). Average time until coma was 24 minutes (range 20-33) for stoats and 18 minutes (range 14-58) for weasels. There were no signs of stress or vomiting associated with the poisoning.

## DISCUSSION

Results of laboratory trials showed similar reactions for weasels and stoats to an oil-based PAPP formulation delivered in a resettable toxin delivery system. Both species groomed PAPP off shortly after it was dispensed onto their fur, and the onset of symptoms was rapid. There were no obvious signs of distress nor was there any vomiting, with responses suggesting that PAPP delivered in this manner was effective and humane.

Similar efficacy has been achieved with PAPP in meat baits, with trials showing stoats died quickly after eating the PAPP bait, with first symptoms occurring from 6 to 40 minutes after ingestion and death between 9 and 45 minutes (Eason et al. 2010). Likewise, stoats orally gavaged with PAPP generally died within 1 hour of receiving a lethal dose (Fisher et al. 2005). Therefore, there do not appear to be any significant changes in the efficacy of PAPP when delivered and ingested following a spray onto the animal. The success of these different delivery mechanisms for PAPP indicates that it has the potential to become a widely-used tool for the management of vertebrate pests.

Resetting systems using PAPP have proven extremely effective during enclosure trials at killing both stoats and weasels. These systems could offer a cost-effective control tool in the future, which negates the need for re-bait-

**Table 1. Average time until death for stoats and weasels after triggering of a resetting toxin delivery system dispensing an oil-based PAPP paste (40% active ingredient).**

Species	<i>n</i>	Weight range (g)	Avg. time to death (mins)
Stoats	16	148 - 386	42
Weasels	4	55 - 156	57

**Table 2. Time until onset of symptoms for stoats and weasels following dosage with a PAPP paste (40% a.i.) sprayed onto their chest and stomach.**

Species	Average time to onset (mins)		
	Grooming	Ataxia	Unconscious
Stoats ( <i>n</i> = 6)	3	8	24
Weasels ( <i>n</i> = 4)	4	11	18

ing and continued maintenance. Systems are now being modified to target other mammalian pests such as brush-tail possums and feral cats (*Felis catus*). In order to meet the challenges facing vertebrate pest control in New Zealand and overseas, a strategic approach needs to be taken that incorporates the development of new baits and toxins with resetting, multi-kill, long-life, tunnel toxin delivery systems.

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