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Predator-Free New Zealand 2050: Techniques for Improving Ground-based Control and Monitoring of the Brushtail Possum

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ABSTRACT: The brushtail possum, a marsupial native to Australia, was widely introduced in New Zealand (NZ) to develop a fur industry. Before the settlement of humans in NZ, there were no terrestrial mammals; therefore, the local species evolved without mammalian predators. This resulted in native species populations declining at alarming rates and many possibly facing extinction on the NZ mainland, especially large-bodied endemic birds. In response to this problem, private investors (supported by the NZ government) developed an initiative to eradicate key mammal predators (possums, rats, and stoats) on the NZ mainland by 2050 (PFNZ2050). As a result, control efforts have significantly expanded over the past decade, and there are now 17 PFNZ2050 landscape projects covering 757,000 ha. Research has looked at combining audio, visual and social lures to improve control efforts for possums. Early results indicate that a combination of lures increases both encounter and interaction rates around control devices. In particular, the combination of audio and visual lures was consistently the top performer in both captive and small-scale field trials. Large-scale field trials are currently underway to confirm these initial results, investigating the effectiveness of combination lures paired with multi-kill AT220 possum traps. Additionally, the lures are being assessed at different times of the year and with varying possum densities. With the drive to PFNZ2050, pest mammal monitoring has markedly increased as researchers attempt to evaluate competing management control strategies. Traditionally, this has relied on single-use plastic monitoring devices such as chewcards and tracking tunnels. An investigation of pest-animal interaction with chewcards indicates that approximately 12% of plastic deployed ends up as microplastic pollution. Another NZ government initiative seeks to ban all single-use plastics, and research is currently investigating the efficacy of non-plastic (biodegradable) alternatives. This research also includes a cost-effectiveness analysis and the reliability of identifying animal bite marks on both plastic and non-plastic chewcards.

KEY WORDS: brushtail possum, chewcards, lures, microplastic, New Zealand, PFNZ2050, *Trichosurus vulpecula*

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INTRODUCTION

Mammal species are some of the most damaging and widespread invaders worldwide. They threaten biodiversity significantly, causing environmental degradation, modification, and species extinctions worldwide (Mack et al. 2000, Courchamp et al. 2003). When humans first settled New Zealand (NZ) in approximately 1280 AD (Wilmshurst et al. 2008), the only terrestrial mammals present were three species of bats (King 2005). Since then, 31 species of land mammals have become established, 25 of which are now considered pests (Cowan and Tyndale-Biscoe 1997). The arrival of these mammalian species has been the main driver for the loss of over 40% of terrestrial bird species (Duncan and Blackburn 2004). Currently, there are 168 species of native birds in New Zealand. Of these, 93 are not found elsewhere, and over 30% are considered threatened (PCE 2017), which is the highest proportion of any country in the world (Clout 2001). To address these threats, NZ often uses vertebrate pesticides to mitigate problems caused by introduced mammal species (Clout 1999, Innes and Barker 1999). For example, compounds such as brodifacoum have been successfully used to conserve endangered species (Innes and Barker 1999) by eradicating rodents and other introduced mammals from offshore islands. NZ has successfully eradicated invasive mammals from 105 islands, 10% of our offshore island land area (Russell and Broome 2016). Because of this, 16 species of invertebrates and 76 species of vertebrates now have improved prospects (Bellingham et al. 2010, Russell et al. 2015). Unfortunately, we have run out of defendable, non-human occupied islands, and the current focus is the NZ mainland, with a new government goal of ridding NZ of rats (*Rattus* spp.), brushtail possums (*Trichosurus vulpecula*), and stoats (*Mustela ermine*) by 2050 called "Predator- Free NZ 2050" (herein PFNZ2050).

The achievement of PFNZ2050 requires new mammal pest control tools (Russell et al. 2015), with an increased focus on ground-control techniques that can be employed in privately owned rural and urban habitats. Traditionally, ground-based control relied on single-kill traps using food-based lures; however, PFNZ2050 has developed into a thriving industry full of expertise to boost the efficiency of ground-based trapping and toxins, including species-specific sensory lures. In particular, audio, visual and social lures have shown potential to increase animal interaction rates around control and monitoring devices. Whilst these lures have been tested individually, there are questions regarding the effectiveness of different audio lures and the combination of multiple lure types.

Additionally, with the drive to PFNZ2050, the scale of pest mammal monitoring has increased as researchers attempt to evaluate competing management control strategies. Traditionally, this has relied on single-use plastic monitoring devices such as chewcards and tracking tunnels. Many groups use such devices, and there are standardised protocols for assessing the relative densities of pest species. Another concurrent NZ government initiative seeks to ban all single-use plastics, mainly targeting items that commonly end up in landfills and pollute soil, waterways, and the ocean. Advancements in alternatives to plastic-based products have seen the development of bio-based materials that can be used for items such as tree guards and are fully biodegradable. While this new material sounds promising, there are questions regarding the extent of plastic pollution following pest monitoring operations and whether biodegradable monitoring tools should be a research priority.

This article presents preliminary research results from two projects attempting to answer the above questions. The first project investigated the attractiveness of different possum vocalisations and combinations of different sensory lures. The second study quantified the level of microplastic plastic pollution following pest monitoring.

METHODS

Pen Trial – Possum Audio Lure

In June/July 2022, ten wild possums were caught by a private contractor in wire live capture cage traps (see: Live Capture Cage Trap) and individually housed in outdoor pens at Lincoln University. The possums had at least a two-week acclimatisation period before the trial started and were cared for following the SOP 25-14 with Lincoln University Animal Ethics Committee approval (AEC2022-21).

During the trial, each possum was individually transported (via their nest box) into a two-hectare predator-fenced observation arena. The nest box was placed in an apple crate (Length 42 cm × Depth 51 cm × Height 30 cm) and turned on its side to provide shelter in the middle of the arena. The apple crate had a green sunshade cloth over three-quarters of the opening to shade the nest box during the day. All animals were also provided with food and fresh water.

Four different audio lure treatment stations were set up in the corners of the pen. Three different sounds and a control (no sound) were played via Project Cacophony Thermal Cameras with speakers at 85 decibels (see: Thermal camera for predators – 2040).

The audio sounds were as follows:

1. Generic beep (300 Hz)
2. Conspecific sound - aggressive possum sound
3. Conspecific sound - distressed possum sound
4. Control - no audio

Each sound was one minute long and played every fifteen minutes between 6 pm and 6 am to ensure the possum had the opportunity to encounter each lure station. Each possum's sound station was randomised to ensure no biased behaviour was shown.

The corner stations consisted of a live-capture possum cage trap baited with an apple cut into quarters, a sack placed over the trap for protection against the weather, and a Cacophony Project thermal camera and speaker attached to a camera tripod. Each possum was in the trial pen for a maximum of two nights. If the possum was caught on the first night, it was moved back to its pen via a hessian sack. If the possum was not caught on the first night, it stayed in the trial pen and had another night to be trapped. If the possum was not trapped after the second night, it was removed from the arena and returned to its pen.

Field Trial – Possum Combination Lures

The field trial was on a private farm in Windwhistle, Canterbury (Lat -43.528, Long 171.828). The farm is a low-lying sheep and beef farm with a river running along the lefthand side of the boundary fence. The property consists of mixed exotic plants and pasture for stock grazing.

Twenty treatment sites were located 100 m apart and consisted of a live-capture possum cage trap (that was zip-tied open and therefore could not be triggered to close) and a Reconyx Hyperfire 2- HF2X trail camera (see: HyperFire 2 Covert IR Camera | Reconyx) to record 30-second long videos (no time delay between videos). The trap was zip-tied open because our intention wasn't to control population numbers on the site but to monitor behaviour around the lures.

Following the captive possum trial above, we chose the aggressive possum audio lure for the audio. Other complementary research investigating visual lures indicated that a constant LED was most attractive (Graham et al. 2023), and we also included a social lure based on other promising research on captive and free-ranging stoats (Murphy et al. 2018). All combination lure treatments were randomly assigned to the trap sites.

The combination lure treatments were as follows:

1. Aggressive possum sound (A)
2. Aggressive possum sound and visual lure (constant LED light) (AV)
3. Aggressive possum sound, visual and olfactory "social" lure (conspecific combination of
4. male and female possum bedding (AVS)
5. No lure (C)

The audio sound was played for 1 minute and repeated every 15 minutes between 6 pm and 6 am. The visual lure was programmed to turn on with the audio lure. Sites with just an audio lure were transmitted by the Cacophony Project thermal camera and speaker used in the pen trial above. The sites with audio and visual lures were transmitted using a new device developed by a local engineer (Rob Wareing of Altissimo Consulting). The olfactory social lure was multiple pieces of towel that were a mix of female and male possum bedding material that captive possums had used for one month. The towels were stored in a freezer, defrosted, cut into small pieces, and put into a small pottle with holes. The pottle was zip-tied to the back of the trap, right near the AVL also zip-tied to the cage. The trial ran for seven nights with clear weather and no notable rain. This field trial was conducted with Lincoln University Animal Ethics Committee approval (AEC2023-53).

Plastic Consumption

To determine the percentage of microplastic left in the environment from chewcards, a damage grid was developed consisting of one hundred 10 mm × 10 mm squares. All the chewcards were 10 cm × 10 cm in size, and once collected from the field, they were placed onto the damage grid to determine the amount of plastic removed. The number of squares missing estimates the percentage of microplastic left in the environment. Additionally, any partial square with any plastic missing was counted as an entire square.

Once the percentage of plastic left in the environment was calculated, the damage score was converted into grams. Each square on the grid weighs 0.05 grams. If two squares of plastic are missing, 2% or 0.1 grams of the plastic has been left in the environment; if twenty squares are missing, 20% or 1 gram of the card has been left in the environment.

Field trials were completed at three sites and run for one night. The Taranaki trial was conducted in dense native podocarp with regular pest control targeting possums and rats. The Tai Tapu site was an exotic pine plantation, and the Windwhistle site was mixed farmland. Both had no known recent pest management.

For each field trial, twenty chew cards (Chew Cards - monitoring) were mounted on a tree approximately 30 cm from the ground. Each chew card was at least 20 m apart, adhering to current standards (NPCA 2015).

Data Analysis

All possum video footage was categorised into encounters and interactions. An encounter was defined as the time (secs) spent near a trap or the number of times a possum touched the inside of the trap but did not activate it. An interaction was defined as the possum getting caught by the live-capture cage trap. In the field trial, an interaction was determined when the possum was entirely in the cage and would have activated the trap had it been set.

Once the video footage had been categorised, all analyses were performed using R Statistical Software (v4.2.2; R Core Team 2022) and RStudio (v2023.03.0; Posit Team 2023). A General Linear Model (GLM) was used to analyse the encounter data with a negative binomial error distribution. For the interaction data, a GLM was used with binomial error distribution. The plastic consumption data was analysed using a GLM with a gaussian error distribution. Where any model indicated statistical significance, pairwise comparisons of means were undertaken using package emmeans (v4.2.3). Checks for model fit and inspection of the residual plots were assessed using package DHARMa (v0.4.6). All graphs were created using the package ggplot2 (v3.5.0).

RESULTS

Pen Trial – Audio Lures

For the encounter data, the audio lure with the highest average number of touches inside the trap (without setting it off) was the aggressive possum sound, with an average of 1.25 (± 0.81 SE) touches per night. This average was higher than the control (1.00 ± 0.67 SE) and the beep and distressed possum sounds (both 0.38 ± 0.30 SE). There was variation between treatments, but these differences were not significantly different (x^2=2.31, p=0.51).

In this trial, eight of the ten possums were successfully trapped. The other two animals were removed after the second night. The aggressive sound treatment trapped four out of the eight trapped possums compared to a low of one possum for the control and distressed possum sound treatments. Again, there was no significant difference between the audio sound treatments (x^2=3.85, p=0.28; Figure 1)

Field Trial – Audio Lures

For the encounter data, the highest average time possums spent near the traps was the AVS treatment at 260.4 sec (± 104.6 SE) compared to a low of 75.4 sec (± 30.5 SE) for the A treatment. Whilst the AVS treatment had a notably higher average, these results were variable and overall not significantly different (x^2=6.81, p=0.08; Figure 2).

For the interaction data, the highest average number of times possums entered the traps was 1.2 (± 0.4) for the AV treatment compared to a low of 0.4 (± 0.4) for the AVS treatment. Overall, there were relatively few interactions, and these differences were insignificant (x^2=1.74, p=0.63).

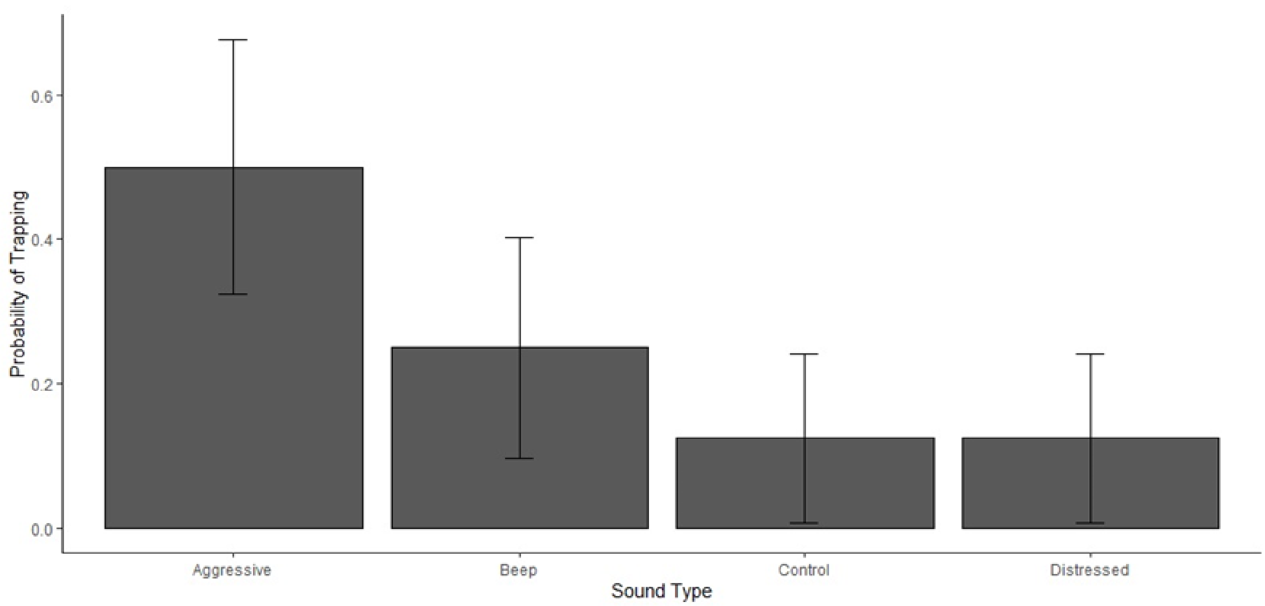

Figure 1. Probability of a captive possum being trapped near different possum audio lures (± SE).

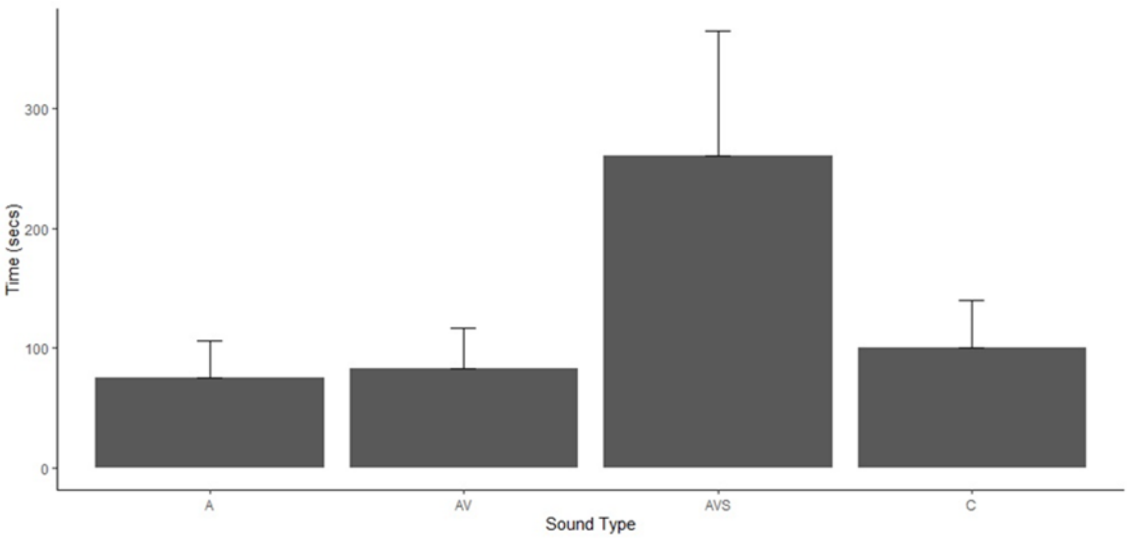

Figure 2. The average amount of time spent near the traps over seven nights (± SE). Treatments were Aggressive possum sound (A), Aggressive possum sound and visual lure (AV), Aggressive possum sound, visual and olfactory "social" lure (AVS), and no lure (C).

Table 1. Plastic chewcard consumption at three sites with different habitats.

Trial Site	Number of Plastic Cards	Total Plastic Deployed (g)	Plastic Missing/Consumed (grams)	% of Plastic Missing	Habitat
Taranaki	20	100g	188 g	9.4%	Dense Native Forest
Tai Tapu	20	100 g	224 g	11.2%	Pine Forest
Windwhistle	20	100 g	306 g	15.3%	Farmland

Plastic Consumption

At all sites, 20 chewcards were deployed for only one night. Plastic consumption varied from 9.41 - 15.30%. This equates to an average of 11.72% (± 1.74% SE) with major differences between the sites (Table 1). For all three trials combined, this equates to 718 g of microplastic left in the environment.

DISCUSSION

Unfortunately, the pen trial was limited to 10 possums, and two of these animals could not be trapped over two nights. Despite this, the key result was that the aggressive possum sound had the highest number of both encounters and interactions. Possums being most attracted to an aggressive conspecific sound does confirm a previous study by Sutherland (2021), where she found possums responded to a different aggressive possum sound over other conspecific and prey sounds. Certainly, communication plays an important role in the social behaviour of possums (Kreigenhofer 2011). As possums are generally solitary animals (Spurr 1999), it is likely that vocal communication is used to enforce territorial boundaries and attract mates in the breeding season.

The combination lure treatments utilising audio and visual (AV and AVS) were the best performers in the field trial. Again, these results were not statistically significant but did suggest that a combination of lures increased activity around the traps. The visual lure result is not unsurprising given that possums have previously been found to locate monitoring WaxTags® quicker with a white 'flour blaze' than without (Kavermann 2004). This suggests that possums will initially use visual cues to investigate novel objects in their environment. These results are also similar to the Carey et al. (1997) study, where they found increased attraction by possums towards trap boxes using white light and audio.

The above research indicates some promising lure options for increasing activity around monitoring devices, but the plastic consumption result is concerning. If 12% of all chew cards deployed end up as microplastic, this will undoubtedly contribute to the accumulation of microplastic in some of our most vulnerable ecosystems. Given that the NZ government plans to phase out all single-use PVC and polystyrene-based food and beverage packing in July 2025 (Ministry for the Environment, 16th May 2024), the conservation sector needs to look more closely at this issue.

In conclusion, the above research highlights the potential for increasing activity around monitoring and control tools using a combination of lures. Large-scale field research is underway to confirm these results and investigate the ongoing effectiveness of lures at different times of the year. For example, possums have two distinct breeding periods, autumn and spring, when most offspring births occur (Jolly et al. 1995). Therefore, animals may respond differently to lure(s) in the mating versus the non-mating season. Additionally, the issue of plastic waste from current monitoring tools is a problem that must be addressed. Non-plastic (biodegradable) chewcards have been developed, and research is currently comparing their efficacy to plastic options. This research includes a cost-effectiveness analysis and the reliability of identifying animal bite marks on plastic and non-plastic alternatives.

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