Manaaki Whenua
Landcare Research

Development of ferret lure for invasive predator management

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Development of ferret lure for wildlife management

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Summary

PROJECT AND CLIENT

Predator Free 2050 (PF2050) has given greater urgency to the search for new tools and techniques that will help deliver on this ambitious goal. The discovery that invasive predators, particularly stoats (*Mustela erminea*) and weasels (*Mustela nivalis*), are attracted to the odour of a dominant predator (Garvey, Glen & Pech 2015), ferrets (*Mustela putorius furo*), could provide a new tool for invasive species control. However, for effective deployment, additional information is required on the effectiveness of the lure in kill traps and its longevity in the field. To deploy the lure at landscape scales, a synthetic version of the natural material is required. This report, contracted by HBRC, highlights research that addresses these issues.

OBJECTIVES

- To quantify the effectiveness of the natural lure in control operations.
- To conduct a longevity trial to determine the decay rate of natural ferret odour.
- To develop a synthetic copy of the natural odour.

CONCLUSIONS

- The natural ferret lure is highly effective when added to conventional baits in kill traps designed to catch weasels and stoats. At four established trapping programmes, capture rates were on average 150% higher when the lure was added to kill traps with conventional baits. In a direct comparison between the lure only and dried rabbit meat (i.e. Erayze®), capture rates were identical for stoats (1 vs 1) and slightly higher for weasels (1.3 vs 1).
- The odour longevity trial found there was limited degradation of the natural lure over 1 month, based on chemical analyses of samples maintained in a variety of conditions. The duration of attractiveness remains unquantified, however, because the speed of degradation varies across compounds and the most important compounds for mustelid attraction are currently unknown. A follow-up field trial will assess how capture rates vary across samples of different ages.
- Synthesis of the natural lure is progressing well: a group of eight attractive compounds have been identified using a combination of behaviour trials and chemical analyses. We are testing dilution media and assessing compound concentrations so that the volatile release rates of the synthetic compound will match those of the natural ferret odour. We will subsequently run experiments with stoats to identify the most attractive compound combinations.

RECOMMENDATIONS

- Ferret lure should be added to conventional baits when targeting stoats and weasels to increase capture rates. The lure can also be used alone, which will be particularly advantageous in areas that are difficult to access, or to reduce rebaiting effort/costs. However, results suggest there may be a synergistic effect when the lure is combined with a bait that will achieve the greatest catch rates.
- Additional work should be carried out to assess odour longevity. Field experiments that utilise the Department of Conservation (DOC) trapping networks are planned for early 2019. Lures will be aged for fixed periods of time (1 month, 2 months, 3 months and 6 months) before being deployed in kill traps. Differences in mustelid capture rates will

reflect the duration of attractiveness. This information will help to streamline trap rebaiting, reducing labour costs while still maintaining capture rates.

- Further work is required to synthesise the natural lure. Attractive compounds identified during pen trials, and analysis of their chemical constituents, will now be tested in combination to determine the most efficacious mixture. Formulation chemistry will identify a medium for the compounds that allows for an appropriate compound release rate and ensures lure longevity. Once pen trials have been completed, we will assess the effectiveness of the lure in control operations.

EFFICACY OF THE NATURAL LURE FOR MUSTELID CONTROL

INTRODUCTION

Olfaction is the primary sense of many invasive mammalian predators, yet its potential role in wildlife management has not been fully realised. Stoats are highly successful introduced predators, and they are one of the primary agents of decline for over half of all forest birds currently threatened in New Zealand (King & Powell 2007; Innes et al. 2010). Much of the current stoat control toolbox is based on technologies from last century, and these approaches alone will not be sufficient to meet the goal of Predator Free 2050 (Russell et al. 2015).
The discovery that stoats are attracted to a lure derived from the sebaceous glands of ferrets could be an important development in predator management (Garvey, Glen & Pech 2016). Subsequent field trials in Hawke's Bay have confirmed the lure's attractive properties for stoats (Garvey et al. 2017), but its utility in control operations has yet to be demonstrated. The purpose of this research is to determine whether the lure increases trap captures of mustelids in established control operations.

OBJECTIVES

To quantify the effectiveness of the natural ferret lure in kill-trap operations.

METHODS

Five study sites were selected in the North Island of New Zealand:

- Hunua Kōkako Recovery Project, Hūnua Ranges
- Whangawehi Catchment Management Group, Māhia Peninsula
- DOC Boundary stream, Hawke's Bay
- Ōroua Blue Duck Protection Trust , Manawatū-Wanganui
- Whareroa farm, Kāpiti Coast.

We selected locations based on the presence of threatened native biodiversity, habitat heterogeneity, and variability in ecosystem structure. Trapping programmes were managed by different organisations, including DOC, Hawke's Bay Regional Council (HBRC), Auckland Council and community groups. Trap lines were maintained by volunteers under the direction of wildlife managers.
Odour was collected on absorbent towels from ferrets at the Manaaki Whenua – Landcare Research (MWLR) animal facility. Donor ferrets were selected based on phenotypic characteristics that provided the most attractive samples. Towels were stored at –80^{O}C until trials commenced. Each lure was housed in a stainless-steel container (a tea-strainer), which was suspended from a nail within a trap.
The study was designed to minimise the disturbance to trapping programmes while allowing for clear inferences to be made on the benefit of the lure. The main trial occurred at four study sites, where a ferret lure (treatment) was added to every second trap along a trap line, in addition to the regular baiting protocol (see below). The remaining traps along the line were undisturbed, although an empty tea-strainer was added to non-treatment traps at one site as an operational control. The effectiveness of the lure was assessed by comparing mustelid captures at traps with regular baits versus those with regular baits plus ferret lure.

At the fifth study site, on the Kapiti Coast, a direct comparison was made between trap catches with baits (dried rabbit meat plus peanut butter) versus captures with ferret lure only. This allowed us to assess lure capture rates when no regular bait was present.
Baits deployed at other study sites varied both within and between operations: fresh rabbit meat, dried rabbit meat (i.e. Erayze®), and/or eggs were the most common bait types, although fish, possum, and hare were occasionally deployed by some operations. Baits were replaced every fortnight, while the ferret lure was replaced once a month. Trials ran for 4 months at each site, and all trials were completed between December 2016 and April 2017. Distances between consecutive traps varied across sites, ranging from 200 m to 1,000 m.
Using a paired sample *t*-tests, we compared the bait only versus bait plus ferret lure captures of stoats and weasels at all sites combined. Captures were corrected for trapping effort and p-values are displayed to three decimal places.

RESULTS

The trial ran for 73,850 trap nights: 58,478 nights for the main trial and 15,372 nights for the direct comparison trial. A total of 86 mustelids were caught: 53 stoats and 33 weasels. Other invasive mammals frequently captured were ship rats (*Rattus rattus*) and hedgehogs (*Erinaceus europaeus*).

Captures with ferret lure added to regular bait versus regular bait only

There was a significant increase in mustelid captures (paired *t*-test: $P = 0.019$) with the addition of the ferret lure (Figure 1). There were 31 stoats captured with the treatment (bait plus lure) compared with 14 stoats with bait alone, which translates to an increase in capture rate of 150% per trap night. The lure increased mustelid captures across all four study sites, with differences ranging from 55% to 280%. There were 10 weasels caught at these four sites, which was a difference of 260% based on captures per trap night (Figure 2).

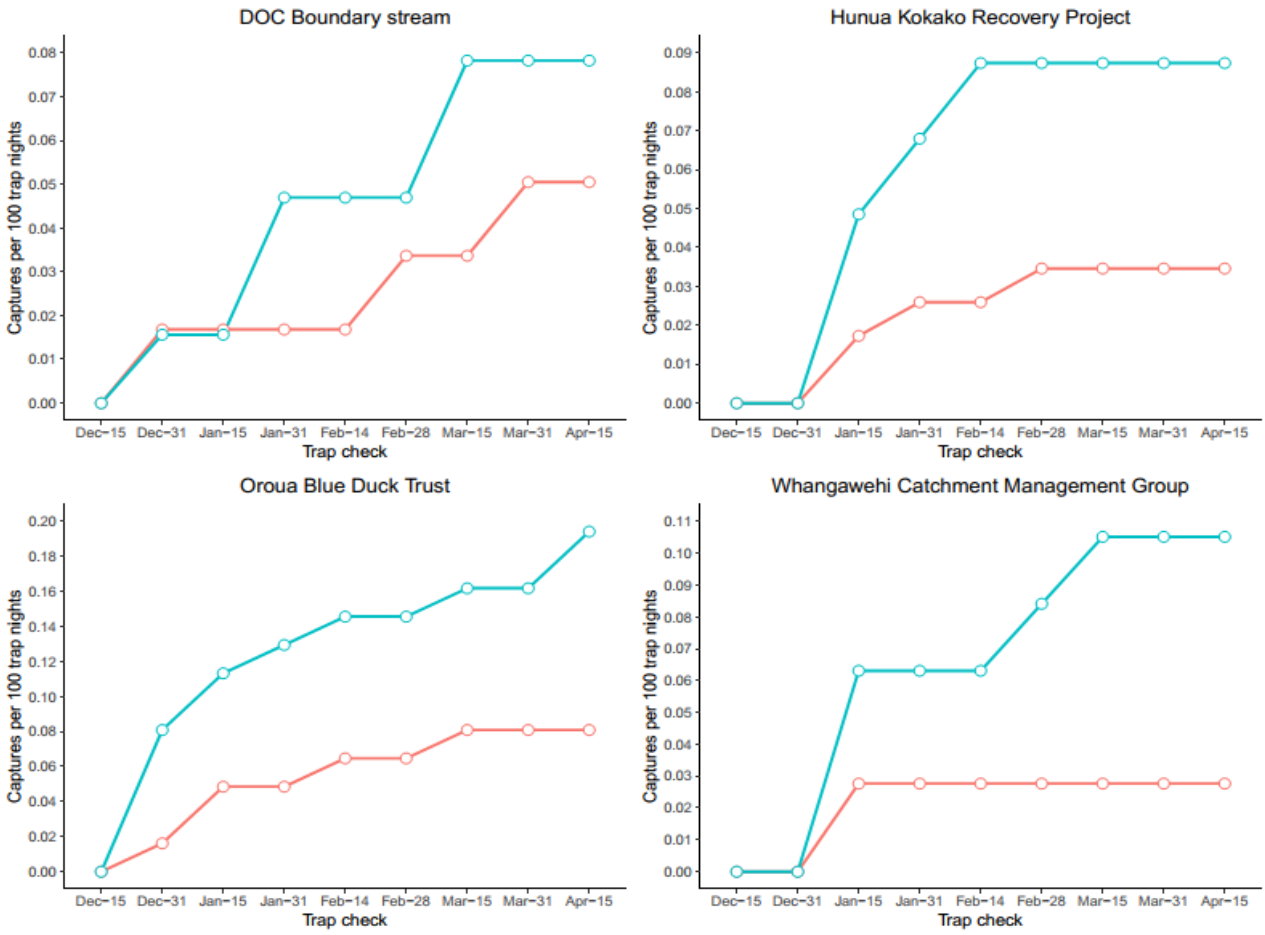

Figure 1. Stoat captures per 100 trap nights at the four study sites. The red line represents stoat captures with regular baiting, and the blue line represents captures with regular baiting plus ferret lure.

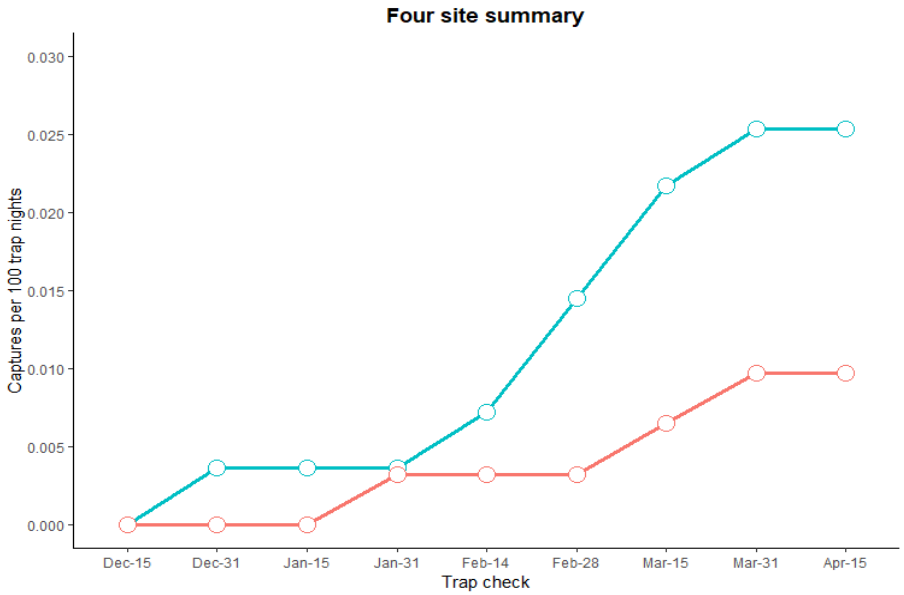

Figure 2. Weasel captures per 100 trap nights averaged across the four study sites (Hūnua, Whangawehi, Boundary Stream, Ōroua). The red line represents weasel captures with regular baiting and the blue line represents captures with regular baiting plus ferret lure.

Captures with ferret lure only versus regular bait

At the Kapiti Coast site eight stoats were trapped: four with the lure and four with bait (Erayze plus peanut butter). Unusually for New Zealand, weasel catches (n = 23) were much higher than stoat captures at this site. Weasel captures per trap night with the ferret lure alone were 30% higher than with bait.

CONCLUSIONS

Stoat and weasel capture rates with the natural ferret lure were higher across all sites, despite differences in the ecological communities, habitat types, bait types and trapping approaches. When added to the regular baiting protocol, stoat captures were on average 150% higher with the ferret lure: for every 10 stoats caught with the normal baiting approach, 25 stoats were caught in traps that had the additional lure. Similarly, for every 10 weasels caught with the normal approach, 26 weasels were caught with the addition of the lure. These differences suggest the lure has a dramatic effect on capture rates and is an important tool for wildlife managers where mustelids are targeted for control.

Capture rates with the lure can be interpreted in different ways. The additional captures could be mustelids that would not have entered traps with regular food baits and required the greater impetus provided by a 'social lure' to enter traps. Alternatively, it could be that since the average distances between traps was less than the average size of a stoat's home range, entering a trap was effectively a choice test, where each individual was displaying a preference for one of the treatments. However, given the overall increase in capture rates, it is more likely that additional individuals were removed from the population. This is important in the context of conservation, as native species can achieve positive growth rates where invasive predators are maintained at low population densities (Norbury et al. 2015).

Traps with ferret lure had more than double the capture rates of stoats and weasels than traps with the normal baiting approach. The lure alone was as good at catching stoats as the best bait combination on the market (Erayze plus peanut butter) and slightly better at catching weasels. Moreover, ferret odour was changed monthly, whereas baits were changed fortnightly, so labour and rebaiting costs were halved for the same capture rates.

Although the capture rates for the lure alone were slightly higher than captures for the bait, there seems to be a synergistic effect when the lure is combined with a bait. Pen trial experiments have demonstrated similar results (Garvey et al. 2016), suggesting that the greatest capture rates will be achieved by combining these attractants.

Recommendations

Ferret lure should be deployed when targeting stoats and weasels to increase capture rates. The lure can be used alone, particularly in areas where it is difficult to rebait frequently, but the results suggest that the greatest catches are achieved when the lure is combined with a bait.

DECAY RATE OF NATURAL FERRET ODOUR

INTRODUCTION

Ferret odour has recognised potential as a lure for predator control (Garvey et al. 2017). Research is underway to synthesise this odour, but before this happens natural ferret odour will continue to be required for mustelid control and monitoring. HBRC field staff need to know how long natural odour maintains attraction so that lures are replenished only when required, reducing labour and operating costs. A chemical assay trial was undertaken at MWLR to

determine lure decay rates by testing cloth impregnated with ferret odour, stored under different environmental conditions at various time intervals. Here we present the results from these trials.

OBJECTIVES

To determine the decay function for ferret body odour over a 12-month period.

METHODS

We placed 5 × 5 cm pieces of ferret-odour-impregnated towel into small plastic pottles, which were then placed inside Holden traps, simulating deployment in DOC 200/250 traps. Holes were drilled in each pottle to allow air movement and to replicate the approach of trapping operations. Beginning in January 2017 at the Lincoln site, we deployed pottles inside traps in two vegetation types: 60 pottles in open grass and 40 pottles in traps among trees. We assayed odour from five replicates (three randomly chosen from grass and two from trees) at the following time intervals: after 1 day (five samples), weekly for 6 weeks (30 samples), fortnightly for 2 months (20 samples), and monthly for 8 months (45 samples). We also maintained 40 samples in a controlled lab environment (20°C, constant temperature and humidity) and assayed two replicates during each of the above sampling times to control for any seasonal effects. We present here a subset of these samples.

In addition to this sampling regime, we assayed odour from old towel that had been deployed at Lake Opouahi Kiwi Crèche. This involved assaying 10 random towels for ferret odour from the 90 samples sent to us by HBRC staff. Towels had been deployed at the crèche from January to December 2016, representing samples that had been in traps for nearly 12 months.

The odour extraction process involved taking 2 g pieces of towel (i.e. the approximate weight of towels used by HBRC) in duplicate, prewashing them in a 50 mL glass centrifuge tube, and adding 25 mL of 1:1 hexane:acetone. Samples were left in the fridge overnight, followed by 1 hour of sonication at 30 degrees, and 1 hour of horizontal shaking. Samples were then refrigerated to equilibrate for 48 hours.

Samples were removed from the fridge, and 5 mL filtered through a 0.45 µm PTFE filter. These were split into two fractions: one for analysis and one for archiving in the –20°C freezer. An aliquot was filtered and injected directly into a mass spectrometer, a machine that measures the masses of compounds within a sample. Each sample was scanned for 50–300 atomic mass units (AMU).

There was some variability in sample quality based on both extrinsic (e.g. localised environmental conditions) and intrinsic (e.g. variations across donor ferrets) factors. Therefore, we selected chromatograms (graphs showing the amount of each odour component) with the largest peaks to ensure that compromised samples did not skew the results.

RESULTS

Odour decay over 7 days

Chromatograms for two samples from day 1 and three samples from day 7 from the controlled lab environment are shown in Figure 3. The larger the peak, the greater the amount of that particular component in the sample. As the value on the x axis increases, odour components increase in molecular weight and decline in volatility. Odour does not appear to have diminished over the course of a week and signal intensity remained relatively constant.

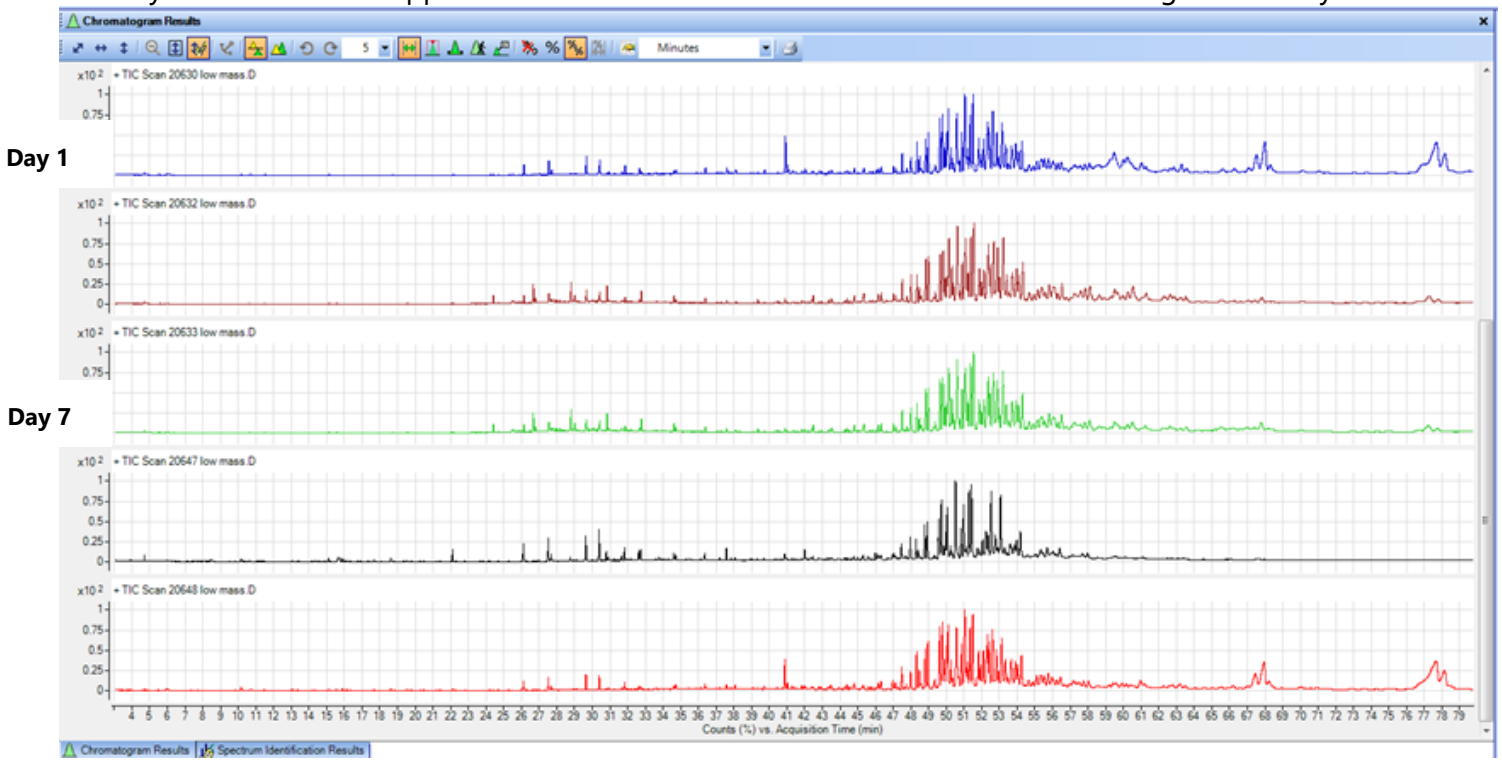

Figure 3. Chromatograms showing two samples from day 1 versus three samples from day 7.

Decay over 1 week versus 12 months

Figure 4 compares the chromatograms of Day 7 samples from the controlled lab environment versus 12-month samples from the Lake Opouahi Kiwi Crèche. Significantly less odour material was present in the crèche samples, although there were still detectible compounds, especially those of higher molecular weight.

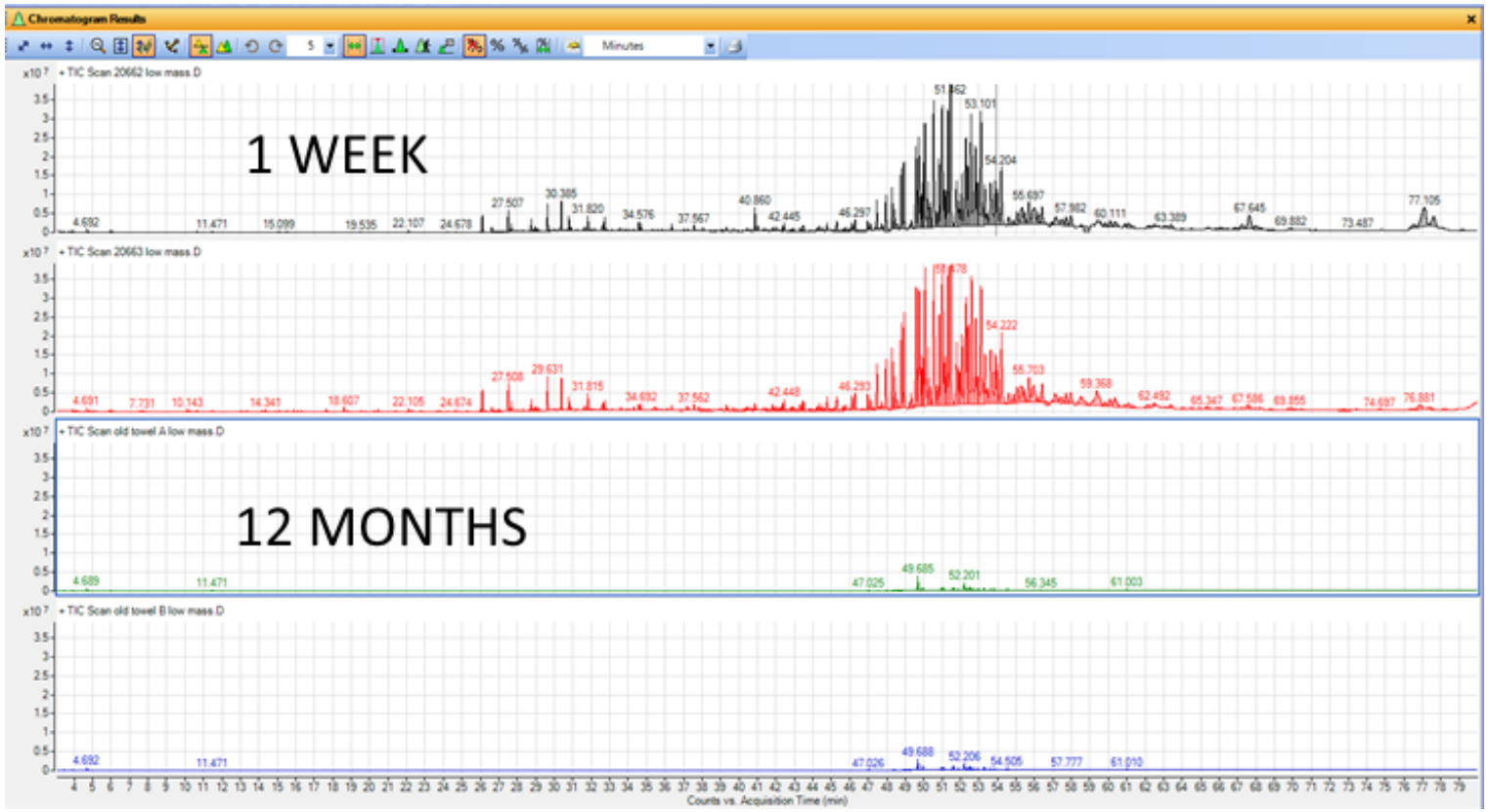

Figure 4. Chromatograms showing two 1-week samples versus two 12-month samples.

Decay for 6, 8 and 10 weeks

Figure 5 shows chromatograms for two samples each from 6, 8 and 10 weeks that were maintained in the controlled lab environment. These graphs reveal considerable variations between samples, both within and between weeks.

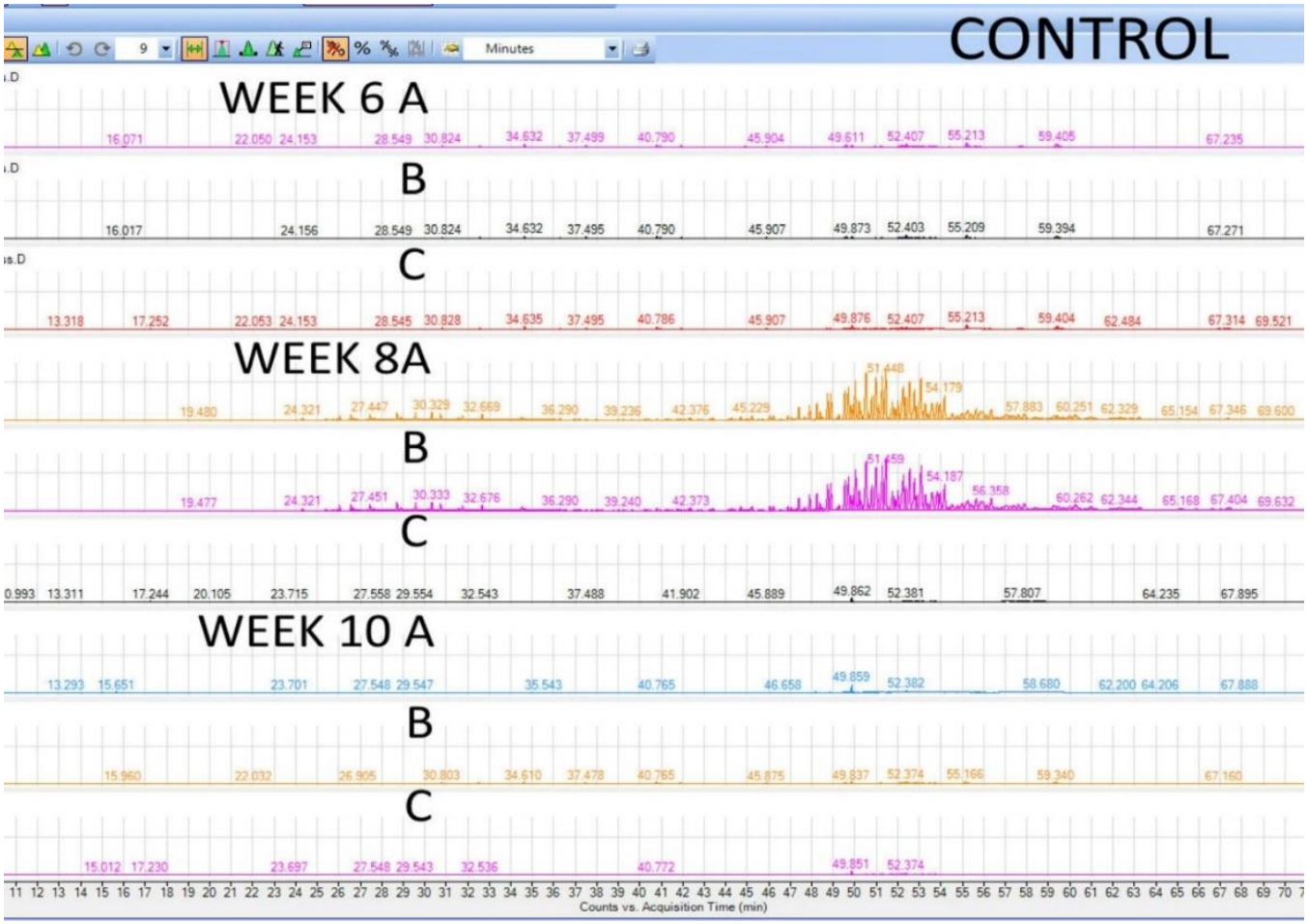

Figure 5. Chromatograms showing samples from 6, 8 and 10 weeks maintained in the controlled lab environment.

CONCLUSIONS

As expected, there was no discernible loss of odour over 1 week and very low amounts of odour remained after 12 months. The fact that some heavier components could still be detected in the old samples is encouraging. Indeed, HBRC staff could still smell ferret on these samples, suggesting they may still attract predators. However, heavier compounds that remain after a year are usually only detectable if the nose is in contact with or almost touching the towel. Compounds with higher volatility, and therefore more likely to be detected at a distance by predators, were not emitted from the 1-year-old samples. Therefore, even though some compounds were present, these have very low volatility, drastically reducing their utility as a lure.

Chromatograms revealed considerable variation in the amounts of odour present on towel samples, even for samples collected on the same day or maintained with the same environmental conditions. This suggests that ferret odour samples will vary in attractiveness when deployed for control operations, and that current odour collection protocols could be improved to standardise odour collection and minimise variability. Based on this study, in due course we will develop a visual scale for cloth to reduce variations between samples and maximise attractiveness for field deployment by removing compromised samples (e.g. cloths with urine stains).

Our results demonstrate the decay of compounds in odour samples. Decay rates will vary by compound type, based on the volatility and vapour pressure of compounds within a sample. Results for the mass spectrometer analyses are indicative of decay rates, but this information alone is insufficient to determine longevity of attractiveness. Mustelids may be responding to a single compound within the odour profile, and because decay rates vary across compounds, additional trials are necessary.

Further work is required to assess odour longevity and how this relates to mustelid capture rates. Using DOC trapping networks, field experiments will be undertaken to assess how the age of a lure influences capture rates. Lures will be aged for fixed periods of time (1 month, 2 months, 3 months, 6 months) before deployment, and mustelid capture rates will be compared to determine the attractive life of the natural odour.

RECOMMENDATIONS

- The trial revealed that ferret odour degrades with time. An additional trial is required to assess how odour decay influences mustelid capture rates. In collaboration with DOC, aged lures will be deployed in traps using the same methods as outlined in the efficacy trial and the same ageing process as outlined above. This will inform HBRC about how frequently odour will need to be replenished.

SYNTHESISED FERRET ODOUR

INTRODUCTION

Ferret odour has demonstrated attractive properties that make it a viable tool for wildlife management in New Zealand. Collecting natural odour is not feasible in the long term, however, given the animal husbandry requirements and the volume needed for deployment at landscape scales. The challenge, therefore, is to reduce these biological materials down to their

minimum chemical, non-perishable components while maintaining their attractive properties. We developed a bioassay that generates data on behavioural response to ferret odours, and paired this with chemical analyses of those same samples to identify specific attractive compounds.

OBJECTIVES

- To quantify the attractive chemical compounds of ferret odour.
- To obtain those components and test their suitability for a synthetic lure.

METHODS

We used the behavioural responses of stoats to identify the compounds in ferrets' olfactory profiles responsible for attraction. We conducted bioassays in pen trials where 12 stoats were exposed to odour collected from 12 individual ferrets. Using a repeated measure crossover design, each stoat was exposed to a ferret sample on a nightly basis and responses were recorded with motion detection cameras. We recorded three behaviour measures: 1) number of visits, 2) visit duration, and 3) time until first approach. These measures were compared both at the individual level and across all stoats to assess attraction. Trial nights extended for 16 hours, from 5 pm to 9 am the following morning.

In tandem with the bioassay, ferret odour samples were analysed to identify chemical compounds. Samples from the 12 ferrets were described using gas-chromatography mass spectrometry (GC-MS), an analytical method that can identify different substances within a sample. Chemical analyses were carried out at Victoria University of Wellington.

Results from the bioassay and chemical analysis were combined based on the individual ferret number and information common to both datasets. To find compounds that were significantly positively associated with stoat attraction, we ran partial least-squares regression models to compare behaviour responses to GC-MS outputs.

RESULTS

Behavioural trials revealed that stoat attraction varied across ferret samples (Table 1). Stoats made almost three times as many visits to the most attractive profile sample compared with the least attractive. While all stoats displayed greater attraction to ferret odour than to a control, responses varied between individuals and across trial nights for the same individuals.

Table 1. Stoat behavioural responses towards odour from different ferrets. Ferret odour attractiveness was ranked based on the number of times a stoat entered a tunnel containing that odour

Ferret	Tunnel entries	Avg. duration (s)	Time until first entry (min)
Ferret_9	31	5.2	29.4
Ferret_4	30	6.3	49.8
Ferret_12	25	7.4	56.4
Ferret_11	24	5.9	30.2
Ferret_3	23	6.0	39.5
Ferret_8	23	6.7	45.7
Ferret_1	18	7.6	60.7

Ferret_2	18	7.2	50.8
Ferret_6	18	5.8	75.2
Ferret_10	18	3.5	39.4
Ferret_7	17	7.8	37.9
Ferret_5	11	5.9	45.2

The GC-MS identified 210 different compounds from ferret odour samples. Compounds with only a single observation were removed from the analysis, leaving 140 compounds that may be partly or wholly responsible for attraction. Data analysis identified eight compounds that significantly determined stoat attraction. These compounds have now been sourced and will be the subject of further trials.

CONCLUSIONS

Behavioural trials revealed that stoat responses varied across ferret odour samples. Individual variability between stoats could be attributed to behaviour traits (i.e. personality) and/or habituation to ferret odour over successive trial nights. Chemical analyses tentatively identified 140 compounds in ferret odour that may be responsible for attraction. Using regression analyses, a suite of eight candidate compounds have been identified that warrant further investigation. These compounds have been confirmed by running standards (i.e. purchased compounds of known identity) on the GC-MS and comparing this run to the original GC-MS output.

The compounds identified will now be tested in pen trials, alone and in combination, to determine the most efficacious synthetic lure. Before compounds can be tested on stoats, samples must be diluted and chemically analysed to determine the appropriate concentration (i.e. when the volatile release rate of the diluted compound matches the release rate in the natural odour). Work on identifying compound concentration is due to be completed by the end of January 2018. Pen trials will then be initiated, testing each compound at three dilution rates to determine the most attractive compounds and concentration. After single compounds have been tested, we will then test different combinations to attempt to maximise attractiveness. Once the best combination has been identified, field trials will test the attractiveness of the lure in predator control operations.

FUTURE WORK

- Key attractive compounds will be tested alone and in combination to identify the optimal lure mixture for attracting stoats. Formulation chemistry will determine a medium for the compounds that ensures an appropriate release rate and lure longevity. The final lure, containing the most efficacious combination, will be tested on mustelids, and the results compared to those of the natural lure.
- Once pen trials have been completed, field experiments will be conducted with the synthesised lure at established operations.

ACKNOWLEDGEMENTS

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