June 2025

Rat Eradication Technical Workshop

A Predator Free 2050 Limited "Deep Dive"

Collins Consulting Limited

Contents

Executive Summary

On April 3, 2025, Predator Free 2050 Limited hosted a “deep dive” workshop that brought together researchers, operational managers and field practitioners to address the significant challenges in eradicating three rat species: the Norway rat (*Rattus norvegicus*), the ship rat (*Rattus rattus*) and kiore (*Rattus exulans*). The primary focus was on the difficulty of detecting and removing the last individuals, a critical hurdle for landscape-scale elimination projects. This report summarises the discussions and synthesises the operational hurdles and prioritised solutions identified during the workshop.

A central theme was that rats surviving initial control efforts exhibit different behaviours, making them significantly harder to capture. Kiore, in particular, were noted as being more likely to survive and are initially difficult to detect when other rat species are present. Neophobia, or the fear of new objects, was identified as a major barrier to success. For example, studies revealed that while over 90% of ship rats might take loose bait, interaction rates with trapping devices were far lower—20% for some enclosed traps and only 10% for bait stations. Research suggests that overcoming this fear may be possible using lures like male rat scent and that device material also plays a role, with wood being preferred over plastic and metal. A trap-only trial on Waiheke Island reinforced these challenges, failing to reach zero rats despite high effort, demonstrating that trapping alone is insufficient for eradication at a landscape scale.

Discussions on tools and technology highlighted several key developments:

- **Toxins**: A species-specific toxin, norbormide, has been in development for 15 years and is now with regulators. A paste formulation proved effective in trials for both Norway and ship rats, though further work is needed on a solid bait for ship rats.
- **Detection Technology**: ZIP is training AI cameras to identify different rodent species at automatic lure dispensers. The use of ultrasonic sounds paired with rat bedding has also shown promise in attracting juvenile rats.
- **Genetic Tools**: Modelling for gene drive technology suggests eradication is theoretically possible on a large island, though this remains a long-term option.

Effective detection relies on a multi-layered "Swiss Cheese" approach, combining various tools like cameras, lures and tracking tunnels, as no single method is foolproof. Detection dogs were noted as valuable, though their accuracy can be limited (e.g., 75-85% on Lord Howe Island), especially when detecting ship rats in trees. Crucially, community engagement was identified as a vital component for success. Maintaining public confidence through rapid responses (within 12-24 hours) to rat sightings and fostering a strong sense of community ownership are critical, particularly in urban areas.

Practitioners shared innovative elimination techniques for hard-to-reach areas, including "boomerang bait stations" on pulleys for cliffs and floating bait stations for mangroves. In urban settings, success requires navigating social diversity and access issues, requiring staff training in conflict resolution.

The workshop concluded by identifying and prioritising solutions to address these operational hurdles. Some key areas for future investment included:

- Ecological and social research: Priorities include mapping the distribution and interaction of all three rat species; studying the long-term environmental impacts of

toxins like brodifacoum; and conducting social research to better engage diverse communities and guide decision-making.

- Embedded R&D: A focus on developing strategies for engaging landowners, using existing projects to test biosecurity measures against reinvasion and running controlled trials in low-density sites to refine tools for finding the last rat.
- Tool development: There is a pressing need for more cost-effective, landscape-scale monitoring tools; a larger and more versatile toolbox of toxins, including urban applications for norbormide; and the development of best-practice guidelines to ensure all tools are used effectively.

Appendix 1 lists the workshop participants and the presenters. In many cases, speakers did not have formal presentations, however those we had copies of are included in Appendix 2.

Context and Background

The Predator Free 2050 strategy includes 3 rat species – Norway (*Rattus norvegicus*), ship (*Rattus rattus*) and kiore (*Rattus exulans*).

Predator Free supported landscape elimination projects have found it challenging to detect and remove the last individual rats, particularly in urban and rural environments where not all operational approaches are available. Projects have responded with innovative developments and have learnt much in their determination to achieve elimination success. As a result, the collective learnings from landscape projects and researchers are a valuable body of information that will be drawn on for the predator free movement.

However, landscape projects and researchers alike are also aware that challenges remain; the more we learn, the more we find technical knowledge gaps that may need solving.

The Predator Free 2050 Limited workshop brought together researchers, practitioners and operational managers to share their knowledge and expertise, particularly in situations where multiple rat species are present. This "deep dive" workshop looked closely at:

- Latest research findings and active research projects
- Current operational knowledge and effective detection approaches and devices
- Current operational knowledge and effective elimination methods and techniques particularly in hard-to-reach places, e.g. cliffs

Discussions within those sessions included:

- Interactions with other rat species and other Predator Free target species
- Navigating social and cultural licence
- Critical knowledge gaps.

This proceedings report summarises the discussions and will help share the large amount of information covered at the workshop. However, we also know that readers may wish to follow up on topics of particular interest with presenters from the workshop. The statements made by presenters and participants at the workshop do not necessarily reflect the views of PF2050 Limited.

Workshop Results

The workshop started with four panels of speakers on selected topics, with questions and discussion immediately afterward. The panels were followed by small group breakout sessions focused on operational challenges and the research priorities that may address those challenges.

Panel 1 - Latest ecological research findings and active research projects

Themes and Key Ideas

Survivor Behaviour
A significant challenge lies in dealing with surviving rats after initial control efforts. Research indicates that survivors may exhibit different behaviours, making them harder to detect and eliminate:

> "Kiore are more likely to survive following a rat control operation. They are initially very hard to detect when other rat species are present - still chasing down single survivors."[1]

These types of behaviour changes may require multi-stage eradication approaches, which mirrors successful eradications elsewhere.

[1] Illustrative quotes are unattributed paraphrasing taken from remarks made at the workshop.

Species-Specific Interactions
The presence and interaction of multiple rodent species (ship rats, Norway rats, kiore and mice) complicates eradication efforts. In some situations mice also can limit biodiversity gains:

> "Need to do things differently when all species coexist."

Neophobia and bait and device Interaction
Studies on ship rat device interactions revealed that while a high percentage initially took bait overnight, interaction with other devices, particularly those with enclosed designs (head-in device or more complex bait station), was significantly lower. Over 90% took loose bait overnight, but some rats would not even take loose bait. Neophobia (fear of new things) appears to be a key factor. Studies found that the top lure to overcome neophobia was the scent of a male rat followed by mouse scent.

In ship rat/device interactions, DOC 200s had 75% interaction. Head-in devices were down to 20% and 10% for bait stations. Material also plays a role, with wooden devices showing higher interaction rates compared to plastic and metal. The research is now looking at how to make bait stations more attractive.

Personality Traits
Measuring personality traits like neophobia and neophilia, which have a potential chemical (serotonin and dopamine) and possibly genetic basis, could inform more targeted control strategies. A solution might be to overcome these fears with more attractive baits, smell, sound.

Limitations of Trapping Alone
A trap-only trial on Waiheke Island was implemented to address concerns about toxins and demonstrate the trap intensity required. The trial did not achieve zero rat numbers despite high effort. This highlighted the challenges of relying solely on trapping for complete eradication, especially in larger areas with higher-than-expected densities:

> "Waiheke trap-only trial… did not get to zero with traps only. The community saw the results and understood. We found both Norway and ship rats and all-year breeding. There was a higher density than expected; about 20 rats per hectare trapped. Trapping alone can get to zero rats in smaller areas but not at landscape scale."

Reinvasion
Forest fragments surrounded by pasture in the Waikato experienced high reinvasion rates, emphasizing the importance of landscape-level management and understanding connectivity:

> "It would be good to do more experiments in eradication areas where we learn from releasing radio-collared rats."

Environmental DNA (eDNA)
Research is exploring the use of eDNA for detecting surviving rodents.[2] A forthcoming paper on using eDNA to find survivors found eDNA probably performs as well as other tools, but it is expensive and the numbers of tests or devices may influence detection rates.

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[2] For additional information see: https://www.researchgate.net/publication/390794744_Environmental_DNA_for_invasive_rat_surveillance_and_biosecurity_on_islands

Scent as a Dominant Sense
There's a growing understanding of the importance of scent, particularly when rodent numbers are low. This opens avenues for exploitation in control efforts:

> "I think scent is the dominant sense when rats are at low numbers. Lay down scent trails, it's universal and exploitable – e.g., use a Judas rat. Dogs can exploit it as well."

The use of rat bedding to attract survivors into traps has shown promise in some UK Norway rat eradications. However, rat bedding was used in 50% of the stations on Waiheke and there were no increased interactions.

Norbormide Development
A species-specific toxin, norbormide, has been under development for 15 years and is currently with regulators for registration. Paste bait containing 1% norbormide is currently being assessed for registration after successful pen and field trials on ship and Norway rats.

Initial research on the efficacy of a solid bait for Norway and ship rats achieved successful pen and field trials for Norway rats, however, the efficacy for ship rats was not sufficient to progress to field trials. Further research is being carried out with a focus on the solid bait matrix for ship rats.

Bait Enhancements
ZIP is focusing on improving bait characteristics such as shelf life (refrigeration/encapsulation), palatability (orange/cinnamon flavours) and testing deer repellents across bait types.

Rat Distribution
There is a lack of knowledge regarding the distribution of different rat species across New Zealand, particularly Norway rats and the recent emergence of kiore on the mainland.

Cultural Knowledge
The importance of incorporating traditional ecological knowledge was highlighted. For example, oral records are fairly contemporary and relevant.

Brodifacoum Misuse
Concerns exist regarding the prevalence of poor practices in brodifacoum use, emphasizing the need for better education and adherence to guidelines:

> "I see lots of bad practice in brodifacoum use around the country."

Cost-Benefit Analysis
A cost-benefit perspective is needed to determine whether to implement intensive mop-up operations for survivors versus repeating an entire eradication effort. "If rats are still present, is a $5 million operation a 'failure' if you need another $1 million for mop-up?"

Understanding Norway Rat Dynamics
Evidence suggests Norway rat populations do not necessarily boom after ship rat reductions. This requires further investigation.

Panel 2 - Latest tool and technology developments

Themes and Key Ideas

Cholecalciferol limitations
The current formulation of cholecalciferol is not strong enough for some devices.

Aerial Pindone application is being considered by the Department of Conservation.

Stock-proof bait stations
Regulatory considerations are being addressed regarding the use of stock-proof bait stations, to improve safety and prevent non-target species exposure.

Flow sensors
The Department of Conservation is linking flow sensors to aerial buckets to improve the precision and monitoring of baiting operations.

Species identification
ZIP R&D is actively involved in "AI camera training on all rodents," aiming to enhance the ability of AI systems to identify various rodent species interacting with automatic lure dispensers.

Gene drive eradication modelling
After simulating the release of transgenic rats on a 200km island and running 20,000 simulations, results suggest that eradication is possible in a manageable time frame. Even though germline gene conversion rates used in the model are based on recent empirical results in publicly available research, proof of concept for the proposed strategy that is predicted to effectively eradicate large populations of rats on islands is yet to be developed in laboratory rats. Much work is still to be done and gene drive is not a tool that will be available in the short or even mid-term.

Soundscape technology
ZIP has done ultrasonic work with juvenile rats. There was a good response but volume is important and pairing ultrasonic sounds with bedding further enhanced the response.

Rat Bedding
While the use of rat bedding in bait stations to attract other rats showed some promise, initial trials did not yield statistically significant increases in rat interactions. Further research is needed to understand how these behavioural factors can be effectively leveraged in rat control strategies, particularly in different population densities and environmental contexts.

Panel 3 - Detection approaches and devices

Themes and Key Issues

Multi-layered detection

Several presenters emphasized the need for a combination of detection methods rather than relying on a single approach (the "Swiss Cheese" approach). For example, a multi-layered approach using traps, camera detection paired with MotoLure devices. The use of multiple tools and methods concurrently increases the likelihood of detecting rats.

Crucial role of community engagement

- Community involvement was consistently identified as a vital component of successful rat detection and elimination programs – "keep them keyed in through multiple communications channels." There is a need to maintain public confidence through rapid response (12-24 hours) to any rat reports. Quick response in urban communities builds community confidence in the team, even if only a few of the reports are actually rats. The key is a strong sense of community ownership; it's a critical part of maintaining eliminated areas.
- Successful public engagement usually involves simple language on why incursions occur: i.e., sex, food and shelter.

Context-dependent effectiveness of detection devices

- The suitability and success of different detection devices vary significantly depending on the specific environment, rat behaviour and project goals.
- Camera detection paired with MotoLure is effective but there is potential for overkill.
- Camera density needs to be optimized (e.g. in Wellington it is currently 1 per hectare).
- ZIPInn are cheaper than cameras and provide a carcass for examination.
- One project uses long tracking tunnels to prevent weka interference and relies on dogs as the "last tool" for incursion response.

Value and limitations of detection dogs

- On Lord Howe Island dogs were only 75-85% accurate in detecting rats. Ship rats in trees were particularly hard to detect with dogs.
- Dog effectiveness varies, being more successful in open farmland but less reliable in bush. Rats are hard to detect in the high alpine areas but can be detected in the valleys that cut through those areas. Detection dogs are also good for training trappers how to fine tune trap placement.
- Dogs are individually diverse; "they are only human 😊."
- Well-managed trials using dogs to find released rats would usefully test their effectiveness.

Detection issues

- Constant reinvasion on project boundaries.
- Difficult to detect rats, for example those living in roof spaces or high in trees.

Resource optimization

Projects are considering cost models and how to reduce the labour burden associated with dense camera networks.

Mātauranga needs better integration into detection operations.

Reliable detection of kiore is a gap to address.

False negatives

Experience on Lord Howe with rats avoiding bait highlights the risk of false negatives with certain detection methods.

Panel 4 - Effective elimination methods and techniques

Themes and Key Ideas

- Te Korowai o Waiheke reported success using "boomerang bait stations" and biomarkers to monitor rat presence on cliffs. Another approach was to use a pulley system to attach bait stations on cliffs.

- Predator Free Russell found that in forest, everything is up in trees so they used elevated trapping solutions.

- Floating bait stations have been developed for mangroves.

- In urban environments, social diversity creates challenging access issues, requiring training around conflict resolution.

- Habitat plays a significant role, such as cape ivy, which is challenging to work in and almost always harbours rats. Ship rats and Norway rats prefer different habitats.

- Changing and using a diversity of bait and lures is important for elimination:

  "Don't just leave it in the bait stations."

  There has been a success with coastal rats using a "fishy" lure, as those rats were specialists in intertidal areas. Seasonal considerations are obviously important too.

- Understanding community dynamics in urban areas is very important when dealing with different cultures, mental health issues, etc. Safety and cultural training for team is very important. Projects will encounter these issues, which are complex and across the whole country. They also raise equity issues so that everyone can enjoy the benefits of allowing PF teams access to their properties. Social science is the key on how to connect with people.

- Biomarkers and dyes can be useful for monitoring rats in difficult areas.

- A possible strategy would be to start with controlling or eradicating mice. This might reduce bait competition for rat control. The Rotoroa example illustrated how the removal of one species (rats) can lead to a boom in another (mice). Biodiversity impacts need to be considered and risk management implemented.

- Subdominant animals get caught later than dominant ones, which could inform trapping strategies.

Operational challenges and hurdles

In the first set of breakout sessions, participants listed the operational challenges and hurdles that their projects have faced. These included:

- Scaling – having the capacity and intensity to deliver at much larger scale.
- How do we better integrate and implement automation for elimination and ongoing biosecurity?
- In a rolling front, how do you validate success? What is the new "2-year timeframe" to prove absence?
- Costs of detection / validation - when is it too expensive? How do we make it cheaper and more efficient?
- How long are we comfortable with the last individual being present?
- Starting the conversation about an acceptable target cost to maintain/defend elimination.
- Capacity and capability shortage.
- How do we show benefits from predator elimination that go beyond birds and biodiversity?
- Recognising that people have different motivations (e.g., not always biodiversity) and thus they will look for different benefits.
- How can we better understand and incorporate maramataka and mātauranga?
- We need to know if re-invaders behave differently from survivors.
- How do we utilise rat scents more effectively - especially for Norway rats. We need to be able to understand scent that is in different time classes - less than 24-hour scent is more valuable than 72-hour scent for example.
- There are regulatory systems that create operational barriers.
- When is it OK to stop chasing the last survivors because it is so costly and they are so unlikely to breed?

- What is the best approach for delivering proof of absence? Current models are based on naive population estimates.
- Understand the risk associated with leaving individuals behind, low numbers = lower breeding event risk.
- How to deal with a one-off breeding event.
- How much percentage of a population do you need to remove to get to zero?
- There is a data gap on survivors moving through landscape and effect of other species.
- What is the best approach for a rollout?
- Kiore distribution and importance to mana whenua and understanding.
- Issues with non-targets, high cultural value around some game species. How these values interact with conservation values and where the line sits.
- Other community groups feeling threatened.
- Need to put mouse suppression in there alongside elimination. This will be the reality for a long time for much of NZ.
- Defence of ever-increasing front will be unaffordable. Rakiura will be a good test case for ZIP model.
- Need to keep ahead of species adaptation.
- Kauri dieback is an issue with some devices and operational techniques, with potential constraints on the types of traps or bait stations that can be used in certain areas. Anti-coagulant genetic precursors to resistance in mice from around Auckland is an emerging topic, in six different mouse populations studied. There are species now in Australia that are resistant.

Prioritised Solutions

In the second breakout session, participants prioritised research needed to address key operational challenges. The suggestions were grouped into three themes, although there is inevitably some crossover. Suggestions (in no priority order) included:

Priorities for ecological and social research

Species dynamics and interactions:

- **Rodent response after cat elimination**
  Investigate the misconception that rat populations increase post-cat removal.
- **Pest species reintroduction trials**
  Test reintroducing pest species into pest-free areas, as well as farmland to study detection, behaviour and monitoring methods.
- **Distribution and habitat preferences**
  Map habitat use for key species at both national and local levels.
- **Interactions between pest species**
  Study the dynamics between rats, mice, stoats, cats, wasps and other species—e.g., trophic effects like stoats disappearing after mice removal, or wasps disappearing after rat removal (as seen on Hauturu).
- **Distribution and interaction of all three rat species**
  Understand overlapping and separate ranges and how the species interact ecologically.

Environmental impact and toxicology:

- **Long-term impacts of brodifacoum**
  Study persistence in the environment and impacts of sub-lethal doses on non-target species.
- **Chronic need for species-specific toxins**
  Continue development of more targeted, safer eradication tools.
- **Genetic research on rats**
  Includes gene drive, population genetics and identifying traits useful for control or eradication.
- **Proof of absence and risk posed by survivors**
  Develop better data and detection systems to confirm eradications and assess risks of lone survivors.

Community engagement and behaviour:

- **Research on human communication and collective decision-making**
  How to guide communities toward optimal ecological outcomes.
- **Community-based maintenance at national scale**
  Test feasibility and sustainability across different regions.
- **Social research in populated areas**
  Learn from urban projects (e.g., Wellington, Dunedin, Lord Howe Island, Waiheke) to inform future approaches.
- **Education, outreach and social licence**
  Shift public willingness to support eradication tools by emphasizing outcomes, not just methods.
- **Cultural significance and motivation**
  Understand the values and drivers for different communities, including Māori perspectives.
- **Urgency and awareness**
  Making the ecological crisis visible and tangible to more people.

Infrastructure and support

- **Centralized communication resource**
  A single hub for tools, data and messaging.
- **Economies of scale for procurement**
  Optimize purchasing and deployment efficiency.

Priorities for embedded R&D

Focus on working with people, landowners and increasing public understanding

- **Case studies on how to deal with landowners**
  Especially large landowners, who are key stakeholders.
- **Pilot PF2050 Limited taking responsibility for all the permissions required**
- **Public education around threats posed by mice and rats**
  Broaden understanding and support for eradication efforts.

- **Have people experience the uplift**
  Showcase biodiversity recovery in accessible areas to build support and momentum.

Understanding tools and systems to confirm success and prevent reinvasion.

- **Use landscape projects to test biosecurity measures**
  Study how to detect and respond post-eradication.
- **Dog versus species interaction data**
  Improve use of detection dogs, especially for ship rats.
- **Trials and research in sanctuaries where rats are at very low density**
  Controlled experiments to refine tools and understand behaviour at low densities.

Improving the technical approach to eradication.

- **Improved approaches for scalability**
  e.g., switching lures at large scale.
- **Optimisation of tools to get last animal**
  Instructions and strategies for that final push.
- **Effective and affordable methods**
- **Adaptive management**
  Build nimbleness and flexibility into operations.

How rat eradication affects or is affected by other species and ecosystems.

- **Work on eradicating kiore**
  Including consideration of cultural and ecological significance.
- **Address potential predator release issues**
  (e.g., stoats increasing after rats removed).
- **Understand the altitudinal range impacts**
  Use landscape projects to get ecological insights tied to where rats persist or reinvade.
- **Develop stock-proof options**
  Ensuring eradication tools are farm-compatible.

Priorities for tool development

Tools and techniques for finding and tracking rats more efficiently, especially at scale.

- **Soundscape utilisation**
  Analyse environmental audio to detect or attract rats.
- **Passive detection methods**
  Such as listening devices that pick up rat vocalizations; requires understanding of rat communication frequencies.
- **Cost-effective landscape-scale monitoring tools**
  Broader, scalable systems to monitor success or reinvasion.

Expanding and refining options for lethal control.

- **Tools to use norbormide for urban work**
- **A larger toolbox of toxins**
  More targeted, species-specific, or context-appropriate options.

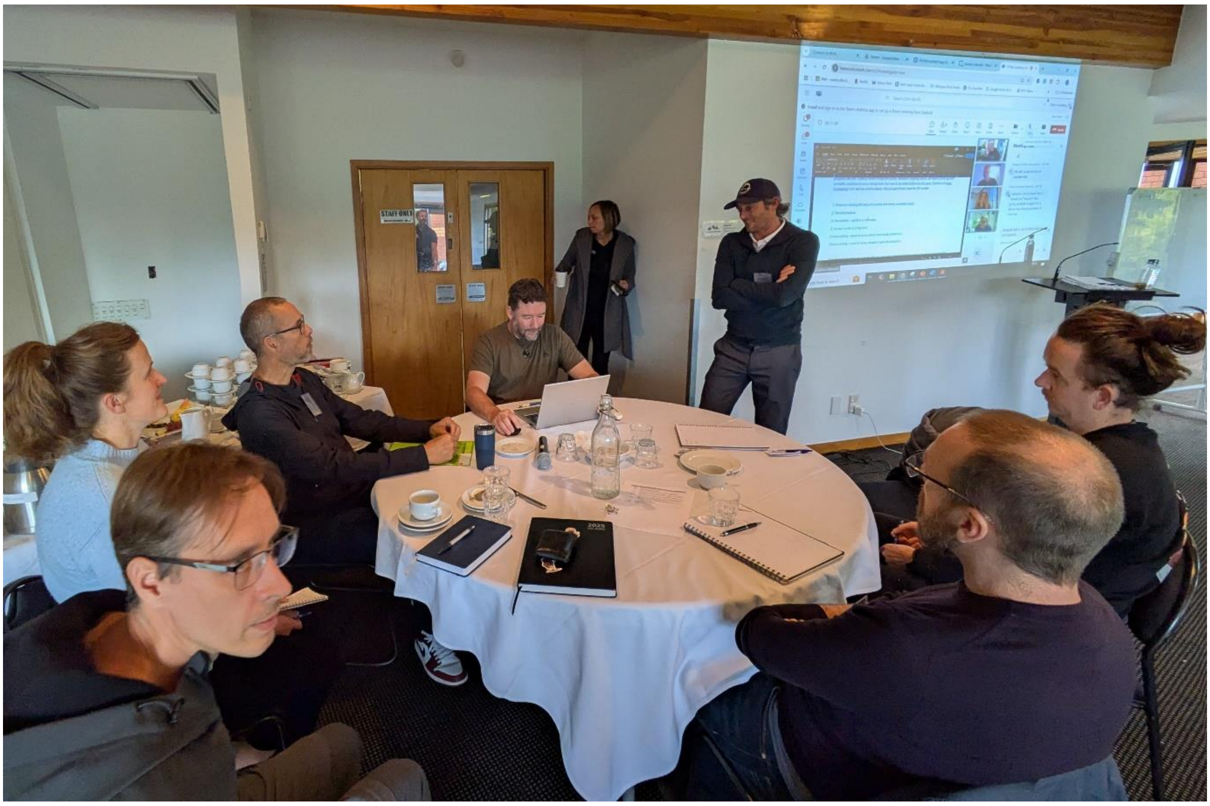
- **Traditional biocontrol, e.g., pathogens, or other biological methods.**
- **What is the "perfect" device? E.g., wooden bait stations?**

Supporting effective, ethical and widely accepted use of tools.

- **Bait use best practice**
  Training and education to prevent misuse and increase efficacy.
- **Virtual reality immersive experience**
  Public engagement tool to raise awareness about biodiversity loss and motivate support.

Improving logistics, access and policy support.

- **Economies of scale**
  Reducing costs and improving coordination by using scale of procurement.
- **Legislation to create biodiversity arks**
  Policy support to protect key safe zones and anchor future recovery efforts.



Conclusions

The Rat Eradication Technical Workshop brought together researchers, operational teams and Predator Free 2050 project leads for a focused, in-depth look at rat control and eradication efforts across Aotearoa New Zealand. The aim was to consolidate the most recent findings and operational experiences to better understand what's working, what still needs attention and where investment in new research or tool development could make the biggest difference.

Ecological and Operational Learnings

A major theme was the difficulty of eliminating the last few rats after initial control. Survivor behaviour is a significant challenge, especially in mixed-species contexts. Ship rats, Norway rats and kiore each present unique issues and their interactions can complicate detection and control. Survivors often behave differently—avoiding devices or bait—and that has implications for tool design and baiting strategy. Neophobia appears to be a key trait and there's growing interest in how scent, bait composition and even personality traits could be used to overcome that.

There also is increasing recognition of the limitations of trap-only approaches, especially at larger scales. A trial on Waiheke showed that despite significant effort, trapping alone was not sufficient to get to zero. Reinvasion remains a major concern, particularly in fragmented landscapes or where boundaries are not secure.

Some promising developments include the use of eDNA for low-density detection, although cost and sampling effort are limiting factors. Species-specific toxins like norbormide are nearing registration and research into scent-based attractants continues. The role of traditional knowledge—especially in understanding kiore populations—was also acknowledged as important.

Tools and Detection

From a tools and technology standpoint, there's active work on everything from AI camera systems to ultrasonic lures and automated detection devices. However, no single method is enough. Most presenters emphasized the importance of multi-layered detection—combining tools like cameras, lures and dogs in a complementary way. This "Swiss Cheese" approach increases the chances of detection and helps reduce false negatives.

Community response is also critical, particularly in urban areas. Projects that respond quickly to public reports—even if they turn out to be false alarms—maintain better support and trust. There's a clear need to keep refining detection systems, both to reduce cost and improve performance across varied habitats.

Elimination Techniques and Site Challenges

The workshop highlighted the ingenuity being applied to difficult environments—cliffs, forests, mangroves and urban spaces all present different challenges. Projects are using pulley systems, floating stations and elevated traps, depending on the terrain. Bait and lure diversity was stressed, as was the need for seasonal and habitat-specific approaches. Social factors—like land access, cultural diversity and equity—are increasingly part of operational planning, especially in urban settings.

Emerging Priorities

The breakout sessions generated a clear set of research and development priorities across three areas:

1. **Ecological and Social Research**: There's a need to better understand rat species interactions, reinvasion behaviour, long-term toxin impacts and the social dynamics around community support for eradication.
2. **Embedded R&D**: Landscape projects should be used as testbeds for biosecurity systems, low-density tool development and improved public engagement. There's also interest in refining tools for the "last animal" problem and understanding how rats behave when populations are near-zero.
3. **Tool Development**: Continued investment is needed in scalable detection tools (e.g., acoustic monitoring), new lethal control options (like norbormide and biocontrol) and public engagement tools. Reducing costs and integrating better logistics are also key goals.

The workshop reinforced that rat eradication at scale remains quite complex. The technical, behavioural and social challenges are significant—but so too is the progress being made. Continued collaboration between research and operations, along with targeted investment in innovation and engagement, will be essential for the Predator Free 2050 initiative to reach its goals. This report captures the learnings from the workshop and offers a reference point for future investment.

Appendix 1 – Workshop participants

Name	Organisation
James Russell	University of Auckland
Richard Griffiths	Island Conservation
Markus Gronwald	Manaaki Whenua – Landcare Research
Elaine Murphy	Department of Conservation
Jo Ritchie	Nelson Marlborough Institute of Technology
Biz Bell	Wildlife Management International
Joel Chisholm	Auckland Council
Lee Shapiro	Boffa Miskell
James Wilcox	Predator Free Wellington
Isaac Nash	Predator Free Wellington
Owain Tanner	Te Korowai o Waiheke
Phil Salisbury	Te Korowai o Waiheke
Makere Jenner	Tū Mai Taonga
Andy Warneford	Tū Mai Taonga
Nik Minchin	Predator Free Russell
Grant Harper	Biodiversity restoration
Jessi Morgan	Predator Free New Zealand Trust
John Innes	Researcher
Emmanuel Oyston	Department of Conservation
Aysegul Birand	Adelaide University
Shaun Ogilvie	University of Canterbury
Izzy Busby	University of Canterbury
Kevin Collins (Facilitator)	Collins Consulting
Melissa Brignall-Theyer	Predator Free 2050 Ltd
Brett Butland	Predator Free 2050 Ltd
Nathan McNally	Predator Free 2050 Ltd
Dan Tompkins	Predator Free 2050 Ltd
Judy Gilbert	Windy Hill Sanctuary
Andrew Veale	Manaaki Whenua – Landcare Research
Patrick Garvey	Manaaki Whenua – Landcare Research
Tom Agnew	Zero Invasive Predators
Jenny Dent	Zero Invasive Predators
Marissa Le lec	Zero Invasive Predators

Appendix 2 – Presentations (only those that were available)

1. **Elaine Murphy**

Latest tool and technology developments, and active projects

Q.1 What are your recent tool and technology developments relevant to rats?

Precision aerial deployment – Aerospread (biodegradable bait pods & drones) – T2M

Heavy-lift drones for bait deployment – 50kg, then 200kg (Envico) – T2M

NAWAC trap testing – T2M

Rat Spitfire lab trials – brodifacoum, 1080, chole (Lincoln Uni/DOC)

Q.2 What developments are you currently doing or will be doing soon?

Cereal bait uptake – isotopes – Claire Kilner, DOC

Validating camera indices (Craig Gilles, Tristan Rawlence)

Distinguishing rats from mice camera AI – Alita (Joris Tinnemans, DOC & Olly Powell, weka research)

Increasing effectiveness of aerial 1080 - Bait spread improvements (physics model) – (Graeme Elliott, James Griffiths, DOC)

Field testing aerial pindone ?

Q.3 Are there ongoing developments by others that projects should be aware of?

Rat Spitfire? (Envico)

SNP panel (Landcare)

Brian Hopkins – specific toxins

GoodNature – optimised rat trap

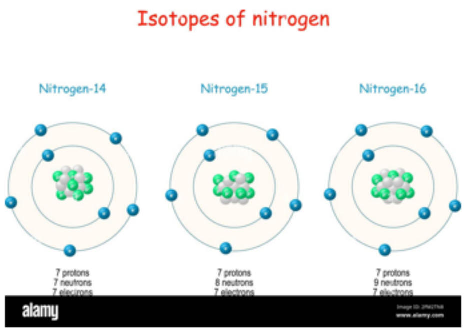
Gene Drives in Australia

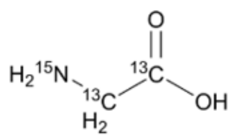
Precision aerial deployment – Aerospread (biodegradable bait pods & drones

- Broadcast bait across a 46-meter swath
- Bait pods with accurate GPS positioning
- Approved to conduct close-proximity beyond visual line of sight (BVLOS) operations
- Successfully completed eight 1080 operations, 6-70 hectares
- In discussions to undertake a project on a 264-hectare island

Cereal bait uptake – isotopes – Claire Kilner, DOC

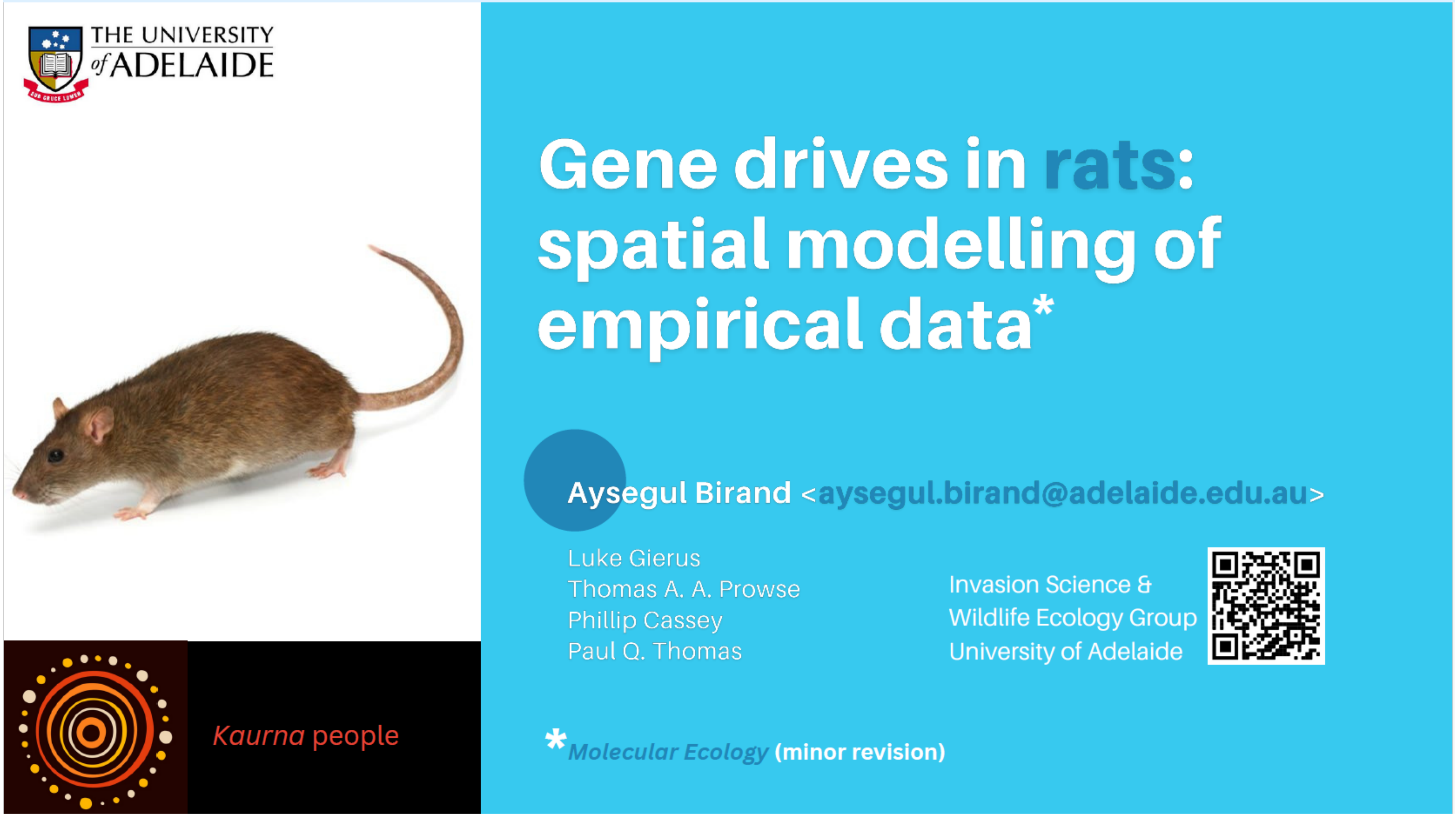
- Using enriched isotopes as tracers to quantify consumption of non-toxic RS5 or Wanganui No. 7 cereal baits by rodents (focusing initially on enriched isotopes of N)
- Quantitatively measure toxic bait consumption
- Improve understanding of how food availability affects bait take and consequences for control operations
- Evaluating methods to incorporate the enriched isotope into the cereal bait matrix & tissue concentration
- What tissue type(s) are suitable for sampling incorporation of the tracer in the target species?
- What is the relationship between amount of bait consumed and isotopic signal in tissue(s) over time?

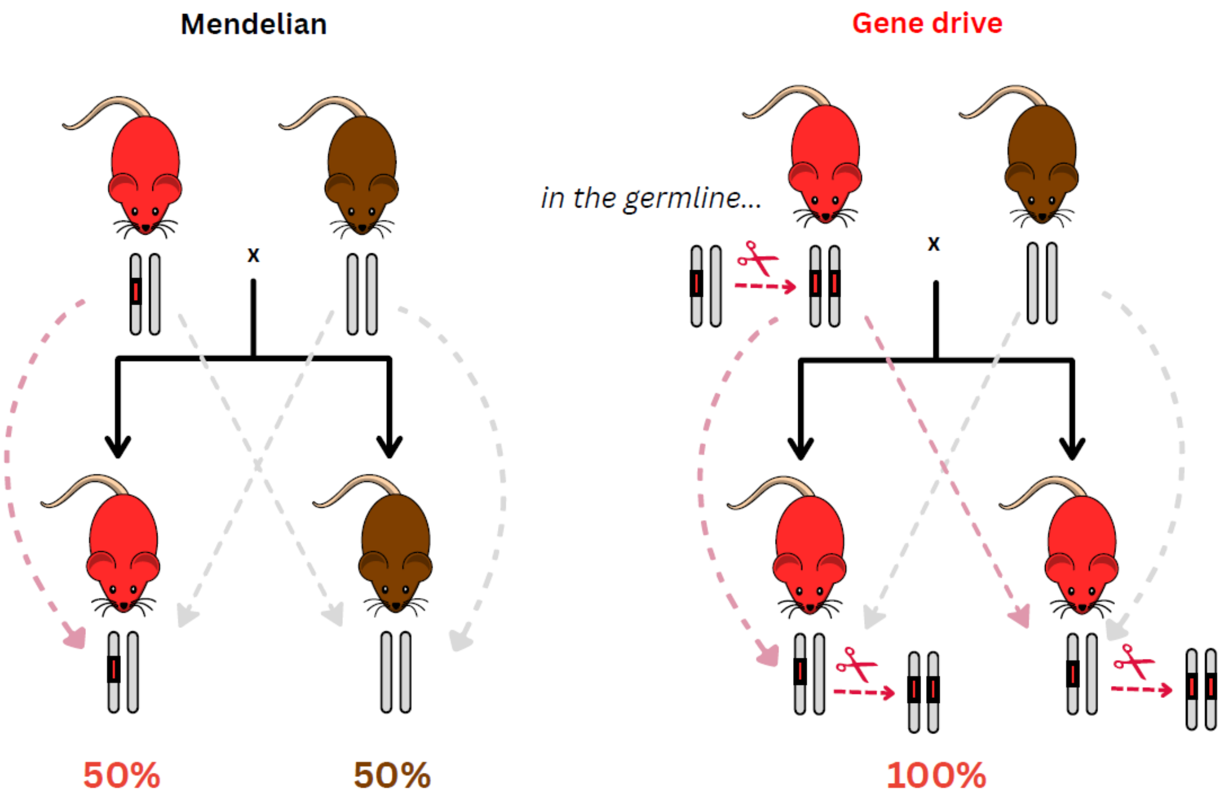




Glycine-$^{13}C_2$, ^{15}N Chemical Structure

2. Aysegul Birand



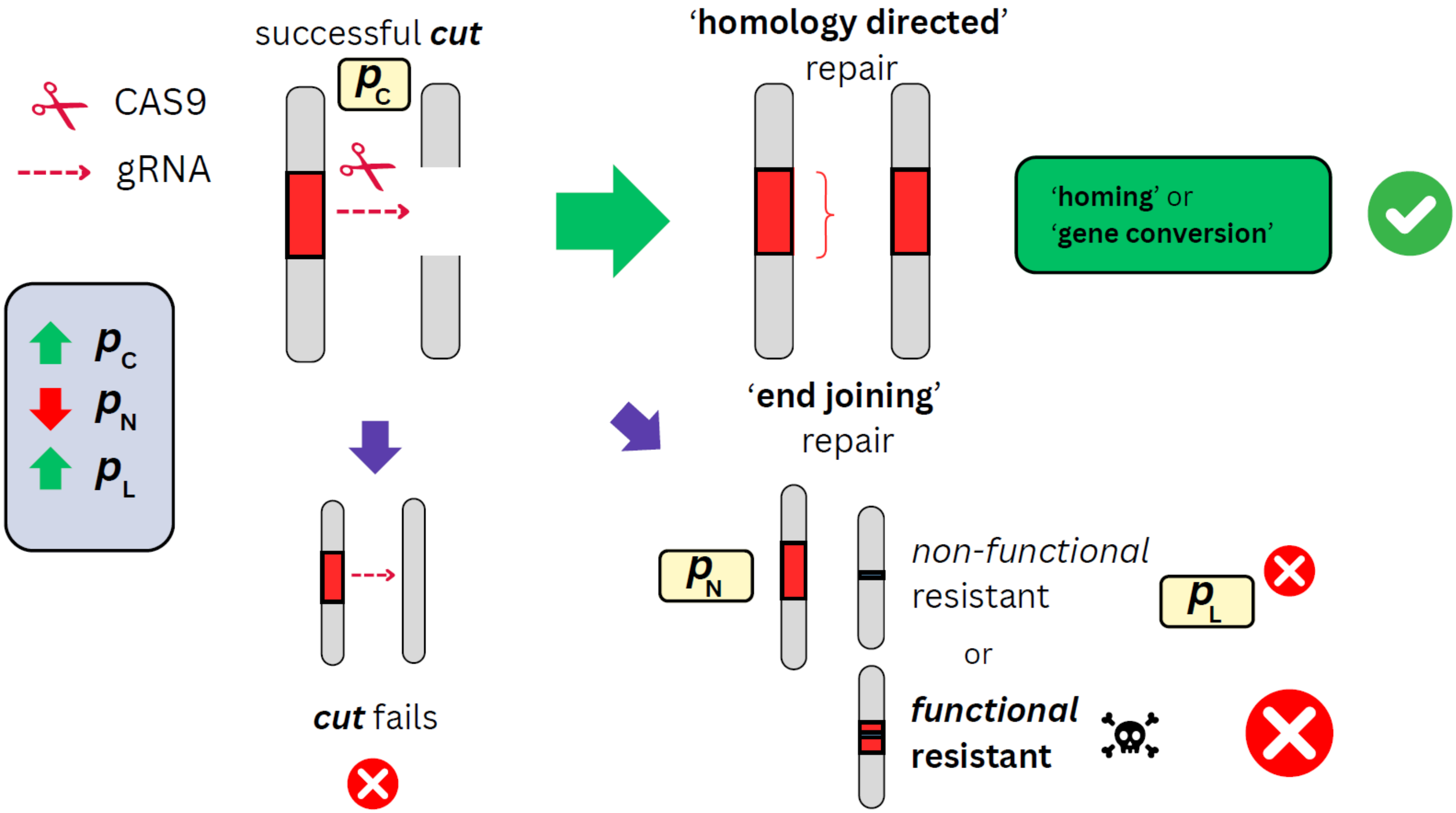


The **aim:**

bias the inheritance of desired (**costly**) traits,

increase their frequency in the population, and

ultimately **suppress** or **eradicate** the population.


CAS9
gRNA
p_C
p_N
p_L
successful *cut*
p_C
'homology directed' repair
'homing' or 'gene conversion'
'end joining' repair
p_N
non-functional resistant
p_L
or
functional resistant
cut fails

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ROBUST AND EFFICIENT ACTIVE GENETICS GENE CONVERSION IN THE RAT AND MOUSE

Chenyen Lai, Oscar Alvarez, Kristen Read, Don van Fossan, Christopher M. Conner, Shannon (Xaing-Ru) Xu, Dale O. Cowley, Valentino Gantz, David R. Webb, Kurt Jarnagin

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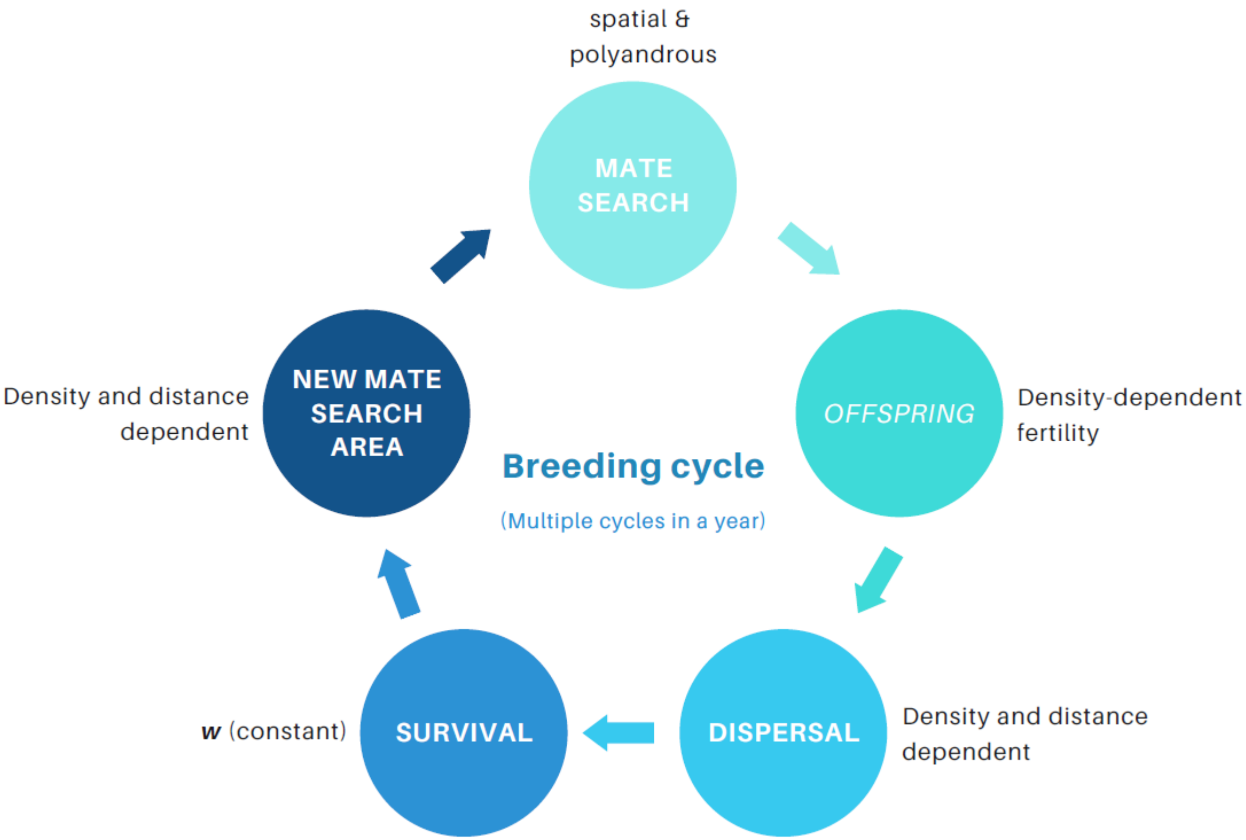
Abstract

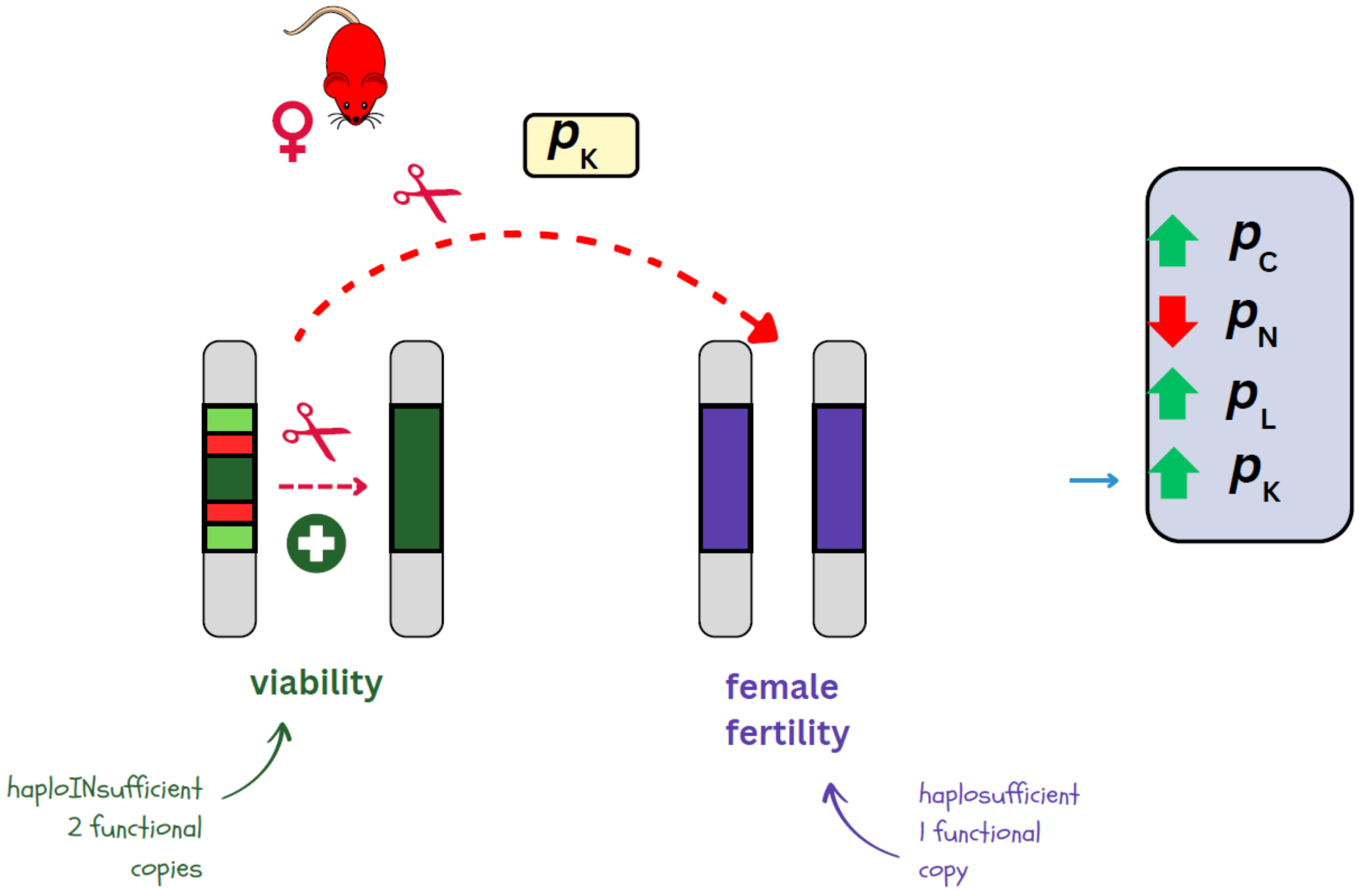
The utility of Active Genetic (AG) gene conversion systems in rats and mice holds great promise for facilitating the production of complex strains harboring multiple humanizing genes. The practical application of such systems requires the identification of a robust, reusable, and highly efficient system. By characterizing twenty-eight different promoter and target site pairs we aimed to define the parameters needed to establish an efficient conversion system in male and female rats and mice. Using three specific meiosis prophase I active promoters to drive Cas9 expression. We studied several variables, including the number of Cas9 target sites, the distance between target sites, the cis versus trans configuration in linked pairs, and the effect of Cas9 copy number.

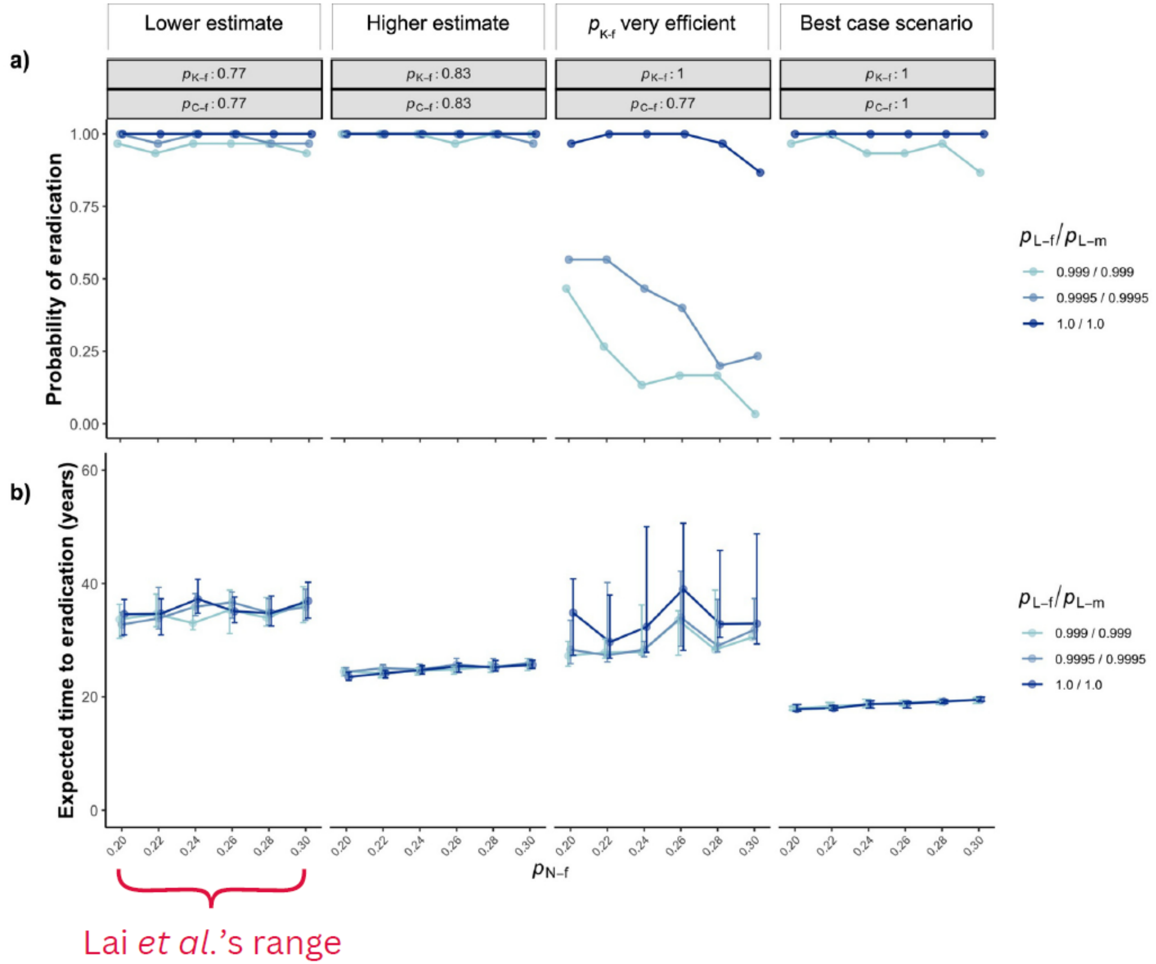
In the rat, three of twelve tested configurations provided efficient AG gene conversion in the 22% - 67% range, and four others catalyzed AG in the 0.7-1% range. The rat *Ddx4* (Vasa)

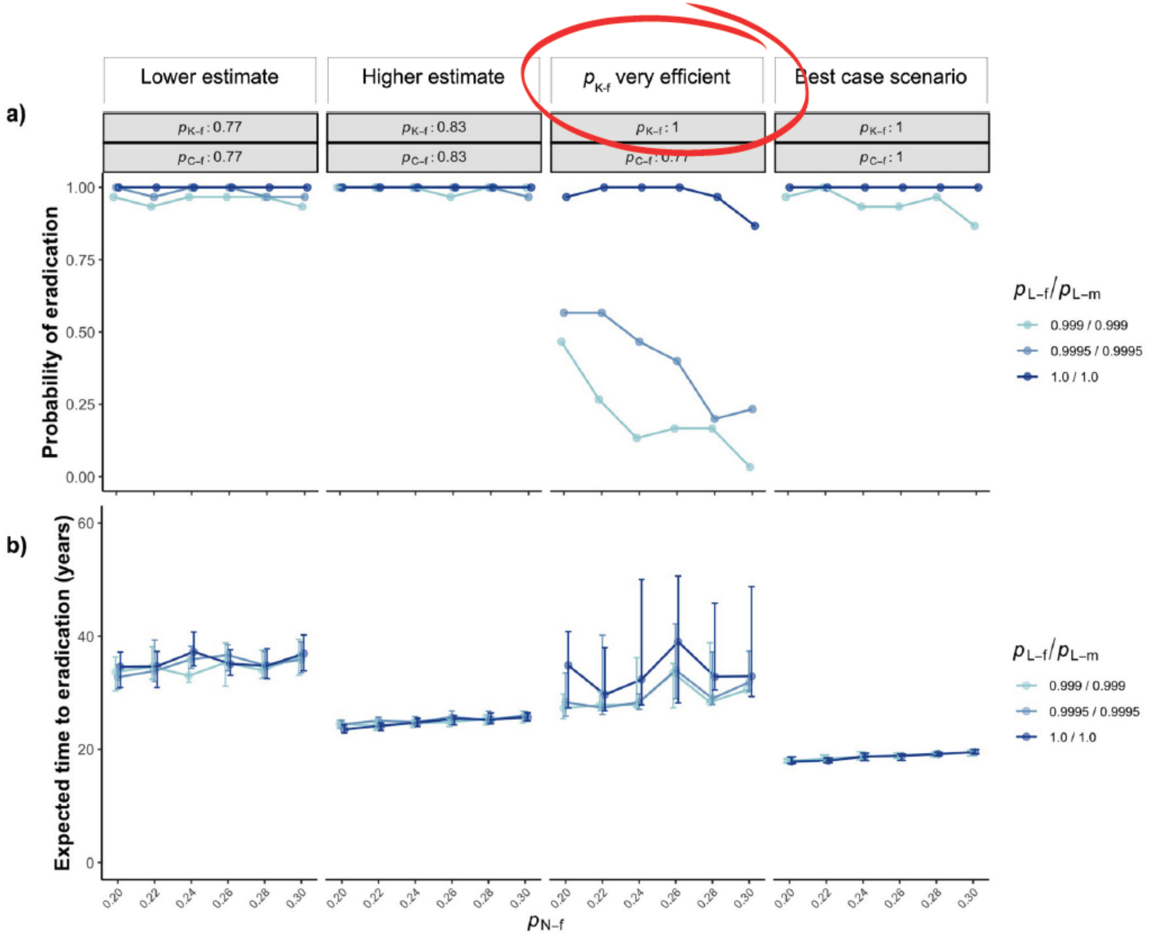
The model:

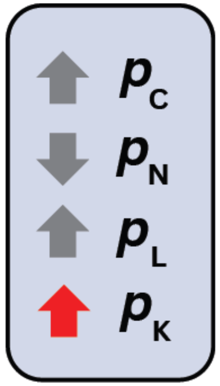

spatial &
polyandrous
MATE
SEARCH
Density and distance
dependent
NEW MATE
SEARCH
AREA
OFFSPRING
Density-dependent
fertility
Breeding cycle
(Multiple cycles in a year)
w (constant)
SURVIVAL
DISPERSAL
Density and distance
dependent

Two-target home and rescue drive - female fertility gene

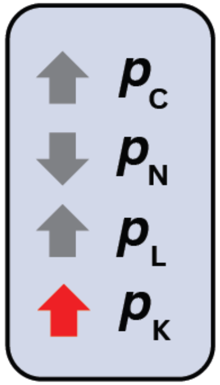


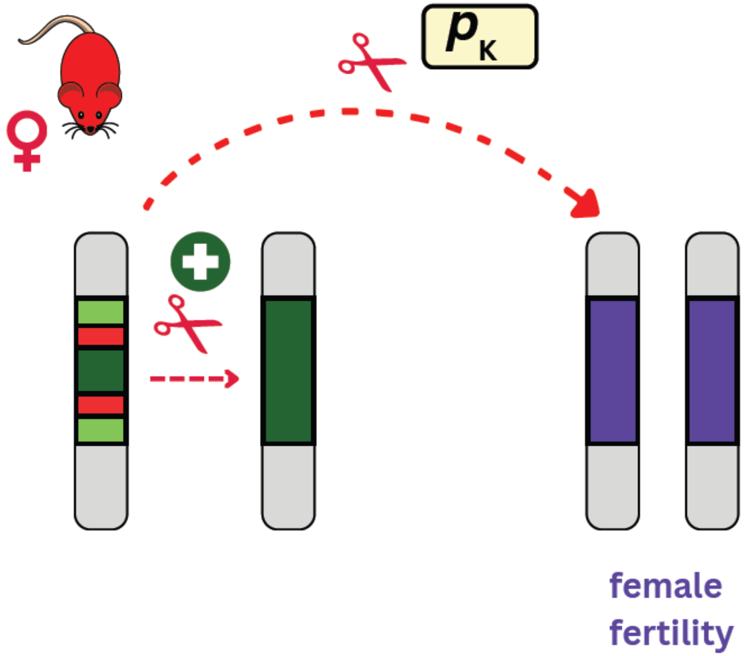

Lower estimate
Higher estimate
p K-f very efficient
Best case scenario
a)
b)
Probability of eradication
Expected time to eradication (years)
pL-f/pL-m
0.999 / 0.999
0.9995 / 0.9995
1.0 / 1.0
pN-f
Lai et al.'s range


a)
b)
Lower estimate
Higher estimate
p_{K-f} very efficient
Best case scenario
p_{K-f} : 0.77
p_{C-f} : 0.77
p_{K-f} : 0.83
p_{C-f} : 0.83
p_{K-f} : 1
p_{C-f} : 0.77
p_{K-f} : 1
p_{C-f} : 1
Probability of eradication
Expected time to eradication (years)
p_{N-f}
p_{L-f}/p_{L-m}
0.999 / 0.999
0.9995 / 0.9995
1.0 / 1.0


p_C
p_N
p_L
p_K

2. two-target home and rescue drive - female fertility gene





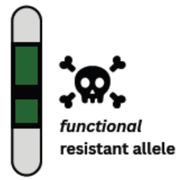
When p_K ↑

-fewer fertile females carry the drive;

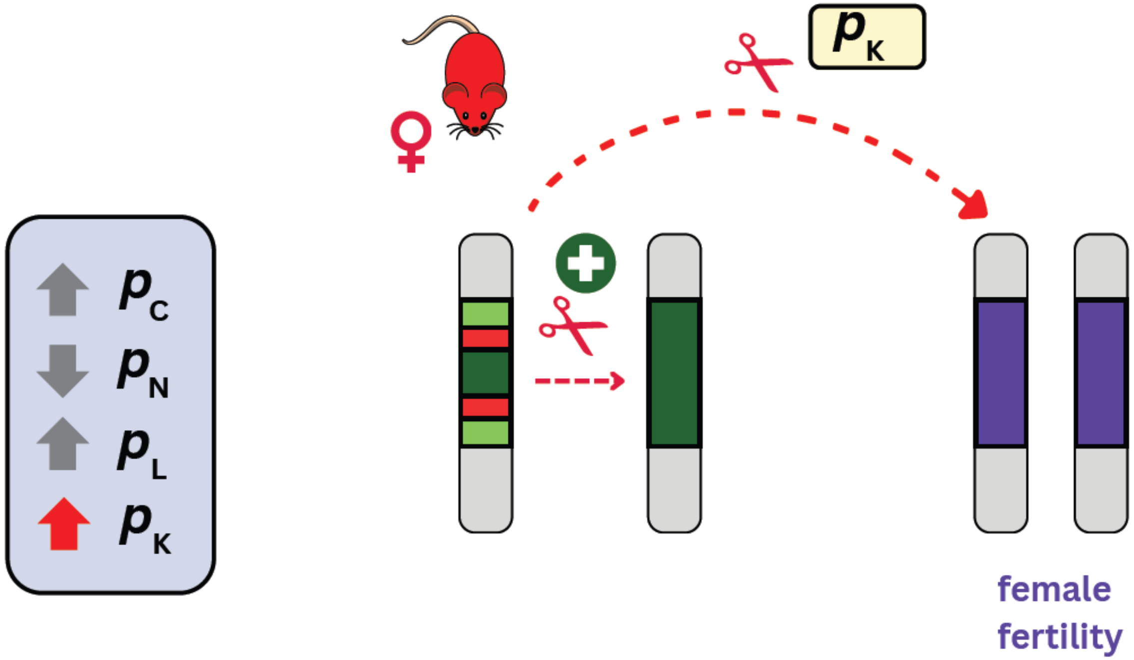
-drive's spread is slower

-population suppression is slower

-more opportunity for resistant alleles to emerge



2. two-target home and rescue drive - female fertility gene



Knockout efficiency of the second target affects the **evolution of resistance** at the first (*unlinked*) target...

Eradication of large populations of rats **is possible** even with ***not-so-efficient*** gene conversion rates (and within comparable time frames to mice)…

Birand, A., Gierus, L., Prowse, T. A. A., Cassey, P., and P. Q. Thomas (*minor revision*) Maximising eradication potential of rat gene drives using a two-target Homing Rescue strategy: spatial modelling of empirical data. ***Molecular Ecology.***

aysegul.birand@adelaide.edu.au

3. Emmanuel Oyston

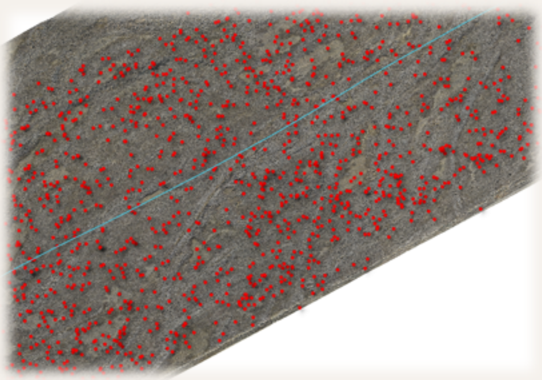
Recent tool & technology developments relevant to rats

(National Eradication Team)

- Development and testing of machine learning classification models and GUIs:
  - AddaxAI and NZ invasives model
  - Alita
  - Building and curating significant LILA imagery library for open-access for developers
- Development and testing of Sentinel devices with CXL: Edge device that connects to trail cameras and runs onboard classification and notifies users remotely of detections of interest
- Understanding limits of detection with common trail camera models – FOV vs FOD and efficacy within FOD
- Data management tools for island incursions to better understand situations, make better management decisions, and identify information gaps
- Integration of Real Time Kinematic equipment into hand broadcast operations
- Learning about impacts of improving the basics, and limits of current tools

Planned work / developments

(National Eradication Team)



- Further improvements on classification models based on increasing curated dataset
- Direct-to-Cell development of Sentinel units, field testing in sub-antarctics and remote island settings
- Investigating ultrasonic soundscapes of ship rats and Norway rats; detection soundscape; and the use of ML models for automating detections
- Improving the efficacy/reducing false triggers of trail cameras in open environments
- Understanding the impact common modifications have on biosecurity device efficacy
- Light-curtain bait flow sensors for aerial baiting buckets
- Understanding distribution patterns of 2g and 0.6g baits
- Understanding 0.6g bait degradation

Awareness of other on going developments
(National Eradication Team)

- Various camera development – Cacophony DOC AI and onboarding AI – linking to traps; ASG camera; critter-pic; eVorta thermal; prototype of FTP solutions RGB camera and cloud system using Yarnmesh
- Automation or lure – ZIP H2 and NZAutotraps bladder
- NZAutotraps ground based resetting trap
- Norbormide DR8 products – both from Orillion and Connovation
- NAMBIT handheld eDNA analysis