Field testing the repellency of Prodeer® bait with free-ranging white-tailed deer on Rakiura/Stewart Island

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Summary

Project and client

Manaaki Whenua – Landcare Research, a group of the Bioeconomy Science Institute, was commissioned by Zero Invasive Predators Ltd to assess the repellency of Prodeer® Possum + Rat cereal bait to white-tailed deer (*Odocoileus virginianus*) on Rakiura / Stewart Island. The work was undertaken between January and July 2025.

Objective

To determine if non-toxic Prodeer® Possum + Rat deer-repellent cereal bait is eaten less by free-ranging white-tailed deer compared to the same bait without repellent.

Methods

- Baiting sites were established in areas close to Oban, on Rakiura / Stewart Island. Either two Prodeer® non-toxic baits or two standard non-toxic baits were placed on the ground at each site. A movement-activated camera recorded animal interactions with each pair of baits.
- Possum and rat interference was anticipated, so 143 baiting sites were established to increase the chance that deer would be the first species to encounter bait at some sites.
- Images from the cameras were viewed manually to identify species interacting with the baits and interpret their behaviour.

Results

- More than 206,000 images were collected, with many of the animal images being of possums and rats. These two species together ate 90% of the bait in the first three nights that it was available.
- A total of 1,187 white-tailed deer visits to 103 baiting sites were recorded, with group size varying from one to three deer (1,258 visitors). Most deer visits (89%) were recorded after the baits had been eaten or removed by other species, with only 126 deer visits occurring while bait was still present.
- Seventy-four deer sniffed within 50 cm of the bait (37 Prodeer® bait, 37 standard bait). One fawn pushed a fresh standard bait around with its muzzle then moved on, and one spiker most likely ate a one-week-weathered Prodeer® bait that had been visibly expanded by rainfall.
- The white-tailed deer daily visitation rate did not change significantly over the first 7 days that baiting sites were deployed, indicating that deer were not avoiding the sites because of human disturbance/scent. Only 24 of 1,258 deer visitors to the baiting sites (1.9%) appeared to spook: 11 of these were spooked by the camera and three appeared to be spooked after sniffing the Prodeer® bait.
- Some of the deer photographed were in visibly poor condition with obviously prominent ribs, reflecting the degraded deer habitat on Rakiura / Stewart Island.

- Possums were photographed at bait sites when bait was present 283 times, with bait consumption recorded during 190 of these visits (67.1%). This represented 72.0% of the bait consumed during the trial. Possums were significantly more likely to consume standard bait (76.1%) compared to Prodeer® bait (58.6%; $P = 0.002$).
- Individual rats were photographed 111 times when bait was present. The majority appeared to be ship rats (*Rattus rattus*), but some may have been kiore (*Rattus exulans*). Rats always carried the baits away in their mouths and are assumed to have eaten them later out of the camera's field of view. This represented 26.9% of total bait removed, with significantly more consumption of Prodeer® bait (73.6%) compared to standard bait (55.2%; $P = 0.044$).
- One blackbird was photographed eating two Prodeer® baits at a baiting site.

Conclusions

- The repellency of Prodeer® Possum + Rat cereal bait to white-tailed deer could not be confirmed because there was minimal consumption of either Prodeer® or standard non-repellent bait by deer.
- We speculate that the deer photographed did not recognise the pairs of baits as food on initial encounter. In contrast, during an aerial baiting operation deer could repeatedly encounter numerous baits, and on second, third or fourth encounter may begin to sample bait and discover it is palatable.
- White-tailed deer did not appear to avoid baiting sites because of human scent/disturbance. Three deer appeared to be spooked by the Prodeer® bait which suggests some aversion.
- Some of the white-tailed deer photographed were in very lean condition and were fossicking around in the litterfall for palatable species to eat. This indicates that the deer on Rakiura / Stewart Island will find bait quickly during an aerial 1080 baiting operation and may be killed if they choose to eat the bait. The small size of the white-tailed deer on Rakiura / Stewart Island makes them particularly vulnerable to poisoning.
- The lower proportion of possums eating Prodeer® bait compared to standard bait in this trial may indicate that Prodeer® bait was less preferred. Nevertheless, after several encounters this initial avoidance behaviour may be overcome, which highlights the benefits of using prefeed during aerial baiting operations.
- There was some evidence that rats preferred Prodeer®, but the sample size was small and consumption of the bait was not recorded on-camera. Operational data from elsewhere in New Zealand show high possum and ship rat kill efficacy with Prodeer® 1080 bait (its effectiveness on kiore and Norway rats is unknown). The 2025 aerial baiting operation conducted by the Department of Conservation and Zero Invasive Predators to protect pukunui (southern New Zealand dotterel) will provide an opportunity to compare possum and rat kill rates with Prodeer® 1080 bait and standard 1080 bait on Rakiura / Stewart Island.
- The single example of a blackbird eating bait is not surprising as blackbirds are the most likely bird species to be found dead following aerial 1080 baiting operations. The species is widespread in New Zealand and there is no indication of any significant suppression of their population when aerial 1080 baiting is used.

Recommendations

- This trial was unable to confirm repellency to white-tailed deer. Nevertheless, based on past trials with other deer species, we strongly recommend the use of Prodeer® Possum + Rat bait in future aerial 1080 baiting operations on Rakiura / Stewart Island, as is happening with the current operation to protect pukunui.
- To reduce the uncertainty related to the impact of aerial 1080 baiting on white-tailed deer monitoring of future replicate operations should be considered.

1 Introduction

Manaaki Whenua – Landcare Research, a group of the Bioeconomy Science Institute, was commissioned by Zero Invasive Predators (ZIP) to assess the repellency of Prodeer® Possum + Rat cereal bait to white-tailed deer (*Odocoileus virginianus*) on Rakiura/Stewart Island. The work was undertaken between January and July 2025.

2 Background

White-tailed deer (*Odocoileus virginianus*) were introduced to Rakiura / Stewart Island as a hunting resource in 1905 (Nugent 2005). They were initially protected to help them establish, but licensed hunting then began in 1919. Despite this their numbers increased rapidly, and in 1926 all protection was removed and official culling was carried out in the following decades (Nugent 2005). In 1981 foliage baiting was trialled for white-tailed deer control using 1080 gel (10% w/w) smeared on broadleaf leaves (*Griselinea littoralis*); this proved highly effective, with up to 96% reductions in treated areas (Nugent 1990).

Since then there has been little official deer control, with most white-tailed deer harvested by recreational hunters. A 1988 survey estimated that 1,500 deer were taken by about 2,000 recreational hunters that year (Nugent 1992). Around the perimeter of the island there are 44 designated hunting blocks administered by the Department of Conservation (DOC) and the Rakiura Māori Lands Trust. Between 2018 and 2022 approximately 2,500 hunters harvested just over 1,000 white-tailed deer each year from Public Conservation Land (i.e. excluding harvest on Rakiura Māori Land Trust blocks) (Game Animal Council 2023).

Predator Free Rakiura aims to permanently remove rats, possums, feral cats, and hedgehogs from the island.[1] Although white-tailed deer have an impact on the native biodiversity of Rakiura / Stewart Island, they are not being targeted for control or eradication because they are valued as a recreational, and economic resource by some members of the community. Aerial 1080 baiting, which DOC and ZIP aim to use on Rakiura / Stewart Island, can result in variable unintended deer by-kill (Morriss et al. 2020). Although data are sparse, white-tailed deer by-kill was noted during aerial 1080 carrot baiting for possums on Rakiura / Stewart Island in the 1970s (Nugent 1990), and more recently when cereal 1080 bait was used in the Dart Valley, Lake Wakatipu in 2014 (Morriss et al. 2020; Pinney et al. 2021).

In the early 2000s research in New Zealand identified a repellent that, when added as a surface coating to carrot or cereal 1080 bait (for rodents and possums), changed the appearance and smell of the bait in a way that successfully repelled deer while still being palatable to the target species (Morriss et al. 2021). The surface coating of bait with repellent was an extra step in bait production, so two other bait manufacturers developed cereal baits with deer repellent incorporated. One of these is Prodeer® Possum + Rat Bait (manufactured by Orillion), which is planned to be used for the upcoming aerial 1080 operation to protect pukunui/Southern New Zealand dotterel on Rakiura / Stewart Island. Although there is good operational evidence of repellency with this bait

[1] https:// www.predatorfreerakiura.org.nz/ (accessed 9 July 2025).

type with red and sika deer (Morriss & Gormley 2022, 2023; Morriss et al. 2021), there are limited efficacy data for white-tailed deer.

In 2022 Prodeer® Possum + Rat Bait was used in an aerial 1080 baiting operation for rat and stoat control in the Dart Valley, Lake Wakatipu, where white-tailed deer are present. The New Zealand Game Animal Council carried out observational monitoring to assess whether there was a detectible difference in white-tailed deer counts before and after poisoning. There was no change detected, which suggested that use of Prodeer® bait may have reduced the risk of by-kill of the white-tailed deer in the area. In conjunction with this monitoring, non-toxic Prodeer® and standard cereal bait were presented to captive white-tailed deer. Only 3 of 14 deer consumed Prodeer® bait, whereas all 14 consumed standard bait (Kaylyn Pinney, New Zealand Game Animal Council, pers. comm., 30 July 2025).

In April 2025 Orillion registered a second bait type containing the same deer repellent: Prodeer® WF Possum + Rat Bait for use in wetter areas (John Quigley, Orillion, pers. comm., 29 July 2025). This newer product was not assessed in the trial reported here.

The trial aimed to robustly assess whether Prodeer® Possum + Rat Bait is repellent to white-tailed deer on Rakiura / Stewart Island by comparing the consumption of standard (repellent-free) and Prodeer® non-toxic bait by free-ranging white-tailed deer.

3 Objective

To determine if non-toxic Prodeer® Possum + Rat deer-repellent cereal bait is eaten less by free-ranging white-tailed deer compared to the same bait without repellent.

4 Methods

The trial involved placing pairs of cereal baits in the bush on Rakiura / Stewart Island, together with a movement-activated camera photographing animals as they interact with the baits. It was expected that in areas with high possum and rat densities these other species were likely to eat or remove bait before white-tailed deer encountered the bait. Consequently, many sites were established to increase the chance that, at least for some sites, the deer would encounter bait first. This method was intended as a proxy for aerial baiting, with the limitations that only two baits were placed at each site (whereas many baits are presented during control operations), and the addition of cameras plus human scent might have elicited avoidance behaviour by some deer around the baiting sites, at least in the short term.

Local DOC staff suggested suitable areas where white-tailed deer were present at moderate to high density, and permission was gained from DOC and landowners to establish baiting sites near Oban, including Port William, Māori Beach, and Lee Bay (Figure 1).

ZIP field staff subjectively selected sites where deer were likely to pass, after being trained by Manaaki Whenua staff on tell-tale deer sign. These included game trails, and areas where faecal pellets and browse sign were prevalent. Areas with litterfall from preferred food species (broadleaf *Griselinia littoralis*) were also selected.

Once a site was selected, two baits of the same type were placed on the ground in an area cleared of leaf litter. Staff minimised the risk of human scent directly on the bait by deploying bait straight from a plastic bag without touching it. A motion-sensitive camera (Browning Dark Ops DCL Nano, Alabama, USA) was attached to a tree within 2–3 metres of the bait at a height of c. 0.5 metres and set to record an eight-photo burst when an animal was detected, with a 1 second delay between bursts.

Sites were separated by 50 to 100 metres, with alternate placement of non-toxic Prodeer® Possum + Rat Bait and the same non-toxic bait without deer repellent (hereafter called standard bait). Sites were selected in several separate regions to ensure different individual deer were encountering the baits (Figure 1).

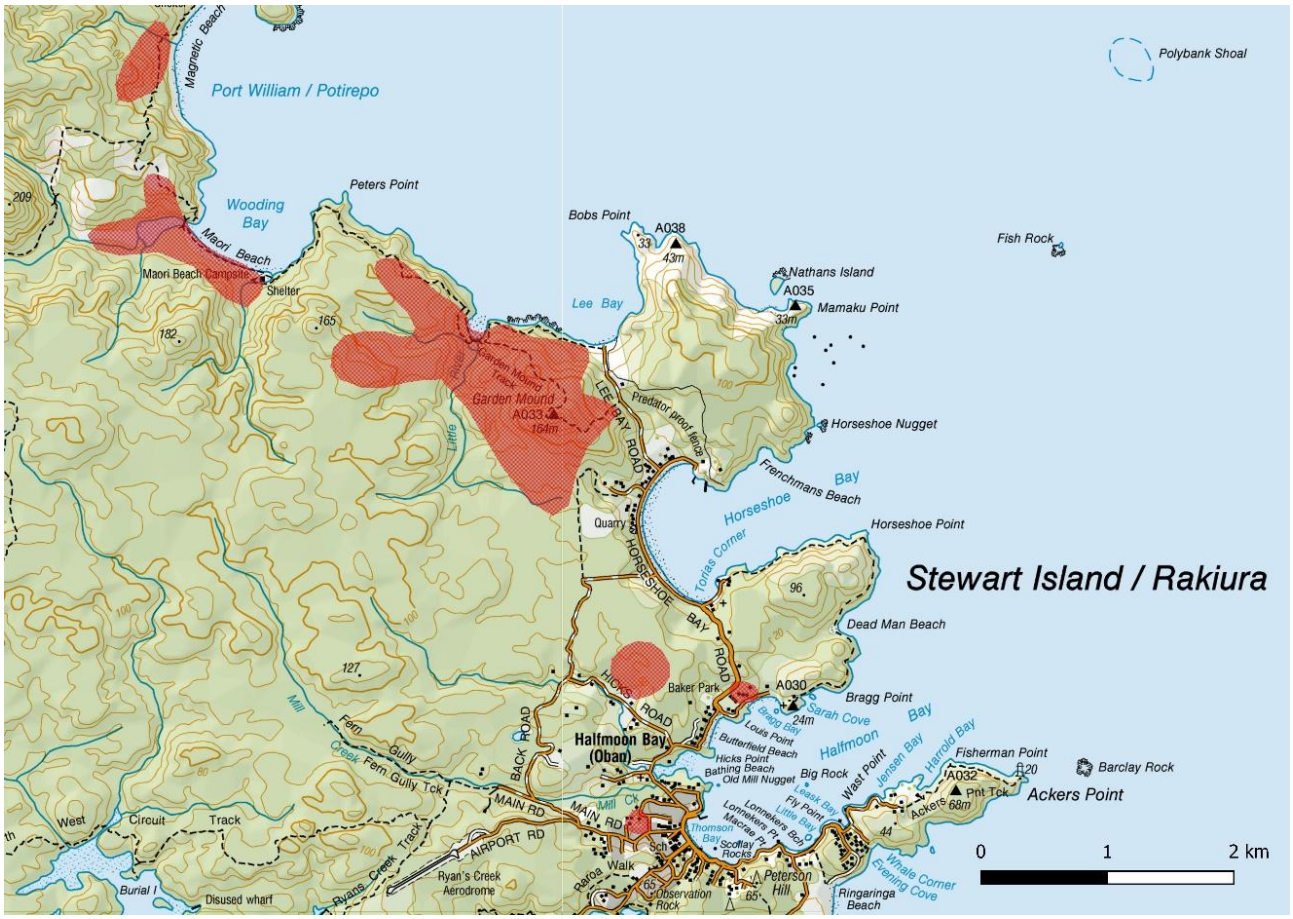

Figure 1. Red-highlighted areas show where baiting sites comprising non-toxic Prodeer® Possum + Rat Bait or standard non-toxic cereal bait were located on Rakiura / Stewart Island from January to July 2025.

Bait sites were checked after 1 to 89 days (mean of 11 days), with bait replaced up to four times at some of the sites. The number of deployments per site and duration of deployment were dependent on site accessibility and logistical constraints. Seventy-one sites had one bait deployment; 52 sites had two bait deployments; 13 sites had three bait deployments; and 7 sites had four bait deployments.

4.1.1 Sample size

The trial design aimed for a total of 100 white-tailed deer interactions across the two bait types. An interaction was defined as deer sniffing and/or eating bait and not just being photographed in the vicinity. A power analysis was carried out to show that this would give the ability to reliably detect a repellency effect of 70% or higher (for example, if the deer consumed 100% of the non-repellent bait and 30% or less of the deer-repellent bait).

After analysis of initial data up until mid-June 2025, ZIP decided to end the trial early because minimal bait consumption by deer had been observed. The decision was also made because the upcoming aerial 1080 operation to protect pukunui/Southern New Zealand dotterel[2], which includes deer monitoring with trail cameras across three treatments (Prodeer® Possum + Rat 1080 bait, Pronature™ Possum & Rodent 1080 bait, and unbaited), should provide a real-world measurement of the impact of aerial 1080 baiting on white-tailed deer.

4.1.2 Analysis

Captured images were viewed manually, species interacting with the baits were identified, and their behaviour was interpreted. All behaviour interpretation was done solely by the author throughout the trial to ensure consistency in viewing and interpretation. Individual visits by the same species were classified as those separated by at least 5 minutes. Individual deer could usually not be identified (except for some of the male white-tailed deer with unique antlers), so total visits certainly included repeat visits by some individuals. Photos of white-tailed deer, possums, rats, and other species investigating the bait were recorded up until all bait was eaten or removed. Although it was not the main aim of the trial, we also recorded consumption of baits by possums and rats. After the bait was gone, only deer visits were recorded to measure daily deer encounter rates at baiting sites.

The proportion of the two different cereal baits eaten by possums and rats was compared and the difference analysed using a chi-squared test with a significance level of $\alpha = 5\%$. No analysis was done on proportion of the two different cereal baits eaten by deer because there was so little consumption recorded.

5 Results

5.1 White-tailed deer

There were 143 baiting sites established (72 Prodeer® bait, 71 standard bait) and more than 206,000 photos were collected. White-tailed deer were photographed at 103 sites (72.0%).

Two-thirds of all bait was eaten by possums and rats the first night it was available. This increased to 90% after three nights. In total, Prodeer® and standard bait was available for 209 and 180

[2] Protecting pukunui on Rakiura — Zero Invasive Predators (ZIP) (accessed 30 July 2025)

nights, respectively (i.e. excluding nights when cameras were still deployed but bait had been eaten or removed).

There was a total of 1,187 white-tailed deer visits to baiting sites, with group size varying from one to three deer (1,258 visitors). Most deer visits (89%) were recorded after bait had been eaten or removed by other species.

At least one bait was still present at a site for 126 deer visits, at which 74 sniffed within 50 cm of the bait (37 Prodeer® bait, 37 standard bait; Table 1, Figure 2). On the day of bait deployment one fawn pushed a fresh standard bait around with its muzzle then moved on, and a spiker appeared to eat a one-week-weathered Prodeer® bait (visually expanded by rainfall), although this could not be confirmed because its body blocked the camera view for the final image of the visit and the bait was gone in the next burst of photos 3 hours later. No other bait was consumed by deer.

Table 1. Summary of the outcome of white-tailed deer visits to bait sites deployed on Rakiura / Stewart Island, recorded between January and July 2025

Bait type	No. visits with baits present	Sniffs bait*	Consuming bait
Prodeer®	69	37	1
Standard	57	37	0

* White-tailed deer photographed with their nose close to the ground ≤50 cm from the bait.

Figure 2. White-tailed deer sniffing, but not eating, non-toxic cereal bait on Rakiura / Stewart Island. All examples above were deer investigating standard cereal bait.

The daily visitation rate did not change significantly over the first 7 days that baiting sites were deployed (mean of 0.2 deer visits per camera per 12 hours after, see Figure 3), indicating that deer were not avoiding the sites because of human disturbance/scent. Most deer photographed appeared to behave normally, and only 24 of 1,258 deer visitors to the baiting sites (1.9%) appeared to spook. Of these, 11 appeared to be spooked by the camera, although some individuals (21 visits) calmly investigated the camera (Figure 4). Three deer appeared to be spooked after sniffing the Prodeer® bait, whereas this behaviour was not recorded with standard bait, indicating some possible aversion to the bait with those individuals.

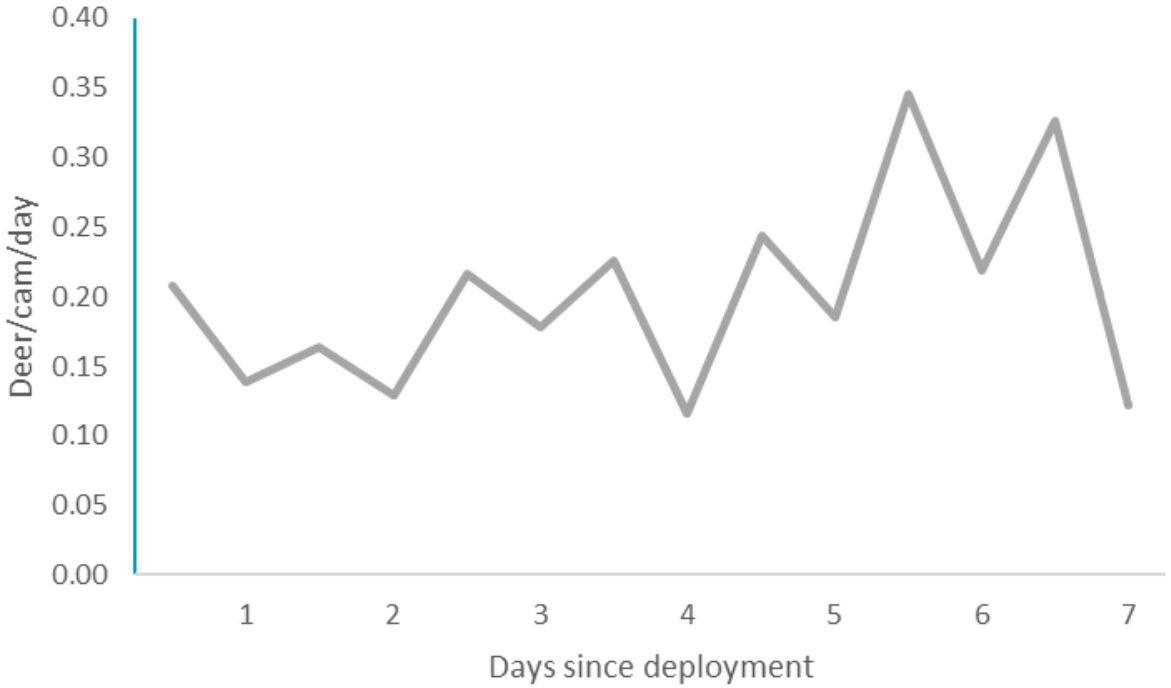

Figure 3. White-tailed deer visits per camera to baiting sites (Prodeer® and standard bait sites combined) over 7 days post deployment.

Figure 4. A white-tailed doe investigates a camera.

Some white-tailed deer photographed (c. 20%) were in lean condition, with obviously prominent ribs (e.g. Figure 5). White-tailed deer on Rakiura / Stewart Island were recorded in poor condition as early as 1985 (Nugent 1990), reflecting the degraded deer habitat. In the current study 499 of

1,258 recorded white-tailed deer visitors (40%) included photos of deer with nose to the ground actively fossicking for litterfall, indicating that if bait were present there was a high probability deer would encounter it.

Figure 5. Lean white-tailed buck (L) and doe (R). One in five of the deer photographed were in this condition.

5.2 Possums and rats

Possums were photographed at bait sites when bait was present 283 times, with bait consumption recorded during 190 of these visits (67.1%; Table 2). There was significantly more consumption of standard bait (76.1%) compared to Prodeer® bait (58.6%) (χ^2 [1, N = 283] = 9.7, P = 0.002). Possums ate 72.0% of the total bait consumed. Some of the possums that were photographed but did not eat bait may have passed upwind of the bait and did not detect it, or were otherwise occupied interacting with or avoiding other possums. A female and juvenile possum were photographed together six times, with both eating baits; and three pairs showing agonistic behaviour when competing for a single bait. There was also one instance when an adult possum had just eaten both baits at a site when another adult attacked it and chased it off.

Individual rats were photographed 111 times when bait was present. The majority of these appeared to be ship rats (*Rattus rattus*), but there may have been some kiore (*Rattus exulans*) as well. No Norway rats (*Rattus norvegicus*) were clearly identified in the photographs, although it was not always possible to identify the rat species. The rats always carried baits in their mouths out of the camera field of view and are assumed to have eaten them later. There was significantly more removal of Prodeer® bait (73.6%) compared to standard bait (55.2%) (χ^2 [1, N = 111] = 4.1, P = 0.044). Rats removed 26.9% of the total bait (we assume it was later consumed, although by then the rats were always off-camera).

Table 2. Summary of the outcome of possum and rat visits to bait sites deployed on Rakiura / Stewart Island, recorded between January and July 2025

Species	Bait type	Bait consumption[a]	No bait consumption	Proportion consuming bait (%)
Possum	Prodeer®	85	60	58.6
	Standard	105	33	76.1
Rat[b]	Prodeer®	39	14	73.6
	Standard	32	26	55.2

[a] Rats always removed bait from the field of view of the camera and are assumed to have eaten it later.

[b] Three species of rat (Norway rat [*Rattus norvegicus*], ship rat [*Rattus rattus*], and kiore [*Rattus exulans*]) are present on Rakiura / Stewart Island. The rats photographed could not always be assigned to species, but none were obviously Norway rats. The majority were likely to be ship rats.

5.3 Incidental observations

One cat (*Felis catus*) and one southern brown kiwi / tokoeka (*Apteryx australis*) were photographed sniffing/investigating non-toxic Prodeer® bait before moving on. There were two occasions when blackbirds (*Turdus merula*) were photographed eating or removing bait. At one site a female blackbird eventually ate both repellent baits, whereas at the second site another female blackbird picked up a standard bait, carried it a short distance, and then dropped it. No other species were recorded investigating or interacting with any of the bait during this trial.

6 Conclusions

The white-tailed deer photographed in this trial did not consume the standard bait, as expected, therefore the repellency of Prodeer® Possum + Rat cereal bait to white-tailed deer could not be determined.

White-tailed deer not consuming either bait type in this trial was somewhat unexpected, because there have been reports of captive white-tailed deer consuming bait, the ground-fossicking feeding behaviour anecdotally observed and recorded of wild-ranging deer indicated they would encounter bait on the ground, and operational data have confirmed by-kill when standard 1080 baits are used (see section 2). We speculate that the deer photographed in this trial did not immediately recognise the bait as food at initial encounter. In an aerial 1080 baiting operation deer will have the opportunity to progressively encounter many more baits, and at second, third or fourth encounter could sample bait and discover it is palatable (with the standard baits at least) and then consume more later.

If the white-tailed deer do not eat bait, as indicated by this trial, then during a future aerial 1080 operation on Rakiura / Stewart Island the risk of deer removing sufficient bait to prevent some individuals of the target species accessing bait (i.e. creating gaps in bait coverage) would be reduced. Also, the risk of white-tailed deer poisoning would be lower than expected. This latter outcome is being assessed in an aerial 1080 operation being undertaken to protect pukunui.

When designing the trial, we were concerned that human scent at the baiting sites might induce avoidance behaviour by some of the white-tailed deer. We do not know what proportion of the deer in the vicinity of baiting sites were photographed, but visitation rates and behaviour indicated they were not avoiding the baiting sites. Although a small sample size, the three deer that appeared to be spooked after sniffing Prodeer® bait suggests there could be some repellent effect.

Some of the white-tailed deer photographed were fossicking, looking for litterfall of palatable species to eat. This was in part an artefact of baiting site selection, as areas with high deer use around broadleaf trees were preferentially chosen. Nevertheless, it is an indication that the deer on Rakiura / Stewart Island are likely to find bait quickly in an aerial 1080 baiting operation and may be killed if they choose to eat the bait.

The small size of the white-tailed deer on Rakiura / Stewart Island is another factor to consider. Most does and fawns would be less than 50 kg live weight (Nugent 1990). The estimated number of 6 g 0.15% 1080 cereal baits that a deer of 50 kg live weight would need to eat to have a 50% chance of dying is 3.3 baits (Morriss et al. 2018). The planned sowing rate of 2 kg/ha for the aerial 1080 operation to protect pukunui on Rakiura / Stewart Island will mean there is abundant bait available, even after the targeted pests have eaten some.

The lower proportion of possums eating Prodeer® bait compared to standard bait in this trial may indicate the Prodeer® bait was less preferred; however, evidence from other operations suggests that it is still highly effective at controlling possums. The best operational example of Prodeer® 1080 bait being used was at Molesworth Station, Marlborough, in 2021, where the kill rate of radio-collared possums was used to assess possum control efficacy. A 100% kill of the 161 radio-collared possums was achieved (Morriss et al. 2021).

The evidence that rats preferred Prodeer® bait can be viewed as a positive, but the sample size was small, and the underlying assumption was that bait removed was eaten. Data from DOC shows 100% tracking reduction in three broad-scale aerial operations in 2022 when Prodeer® bait was used (Morriss & Samaniego 2024), although it is recognised that tracking tunnels surveys like these are not sensitive enough for detection of survivors during eradication operations. Prodeer® effectiveness on kiore and Norway rats is unknown. The aerial 1080 operation to protect pukunui will provide an opportunity to compare possum and rat kill rates with Prodeer® 1080 bait and standard 1080 bait on Rakiura / Stewart Island. Camera monitoring has been initiated to undertake this work.

The single example of a blackbird eating bait was not surprising, as blackbirds are the most common bird species found dead following aerial 1080 baiting operations (Morriss et al 2016). This introduced species is widespread in New Zealand, and there has been no indication of any significant suppression of their population when aerial 1080 baiting is used.

7 Recommendations

- This trial was unable to confirm repellency to white-tailed deer. Nevertheless, based on past trials with other deer species, we strongly recommend the use of Prodeer® Possum + Rat bait

in future aerial 1080 baiting operations on Rakiura / Stewart Island, as is happening with the current operation to protect pukunui.

- To reduce the uncertainty related to the impact of aerial 1080 baiting on white-tailed deer monitoring of future replicate operations should be considered.

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