Food preferences of the European Rabbit (*Oryctolagus cuniculus*) at bait stations in the Fitz-Stirling macro-corridor, Western Australia

A report for the Foundation for Rabbit-Free Australia

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## Summary

Bush Heritage Australia's Fauna Recovery Project undertakes introduced predator management including the control of rabbits as part of an integrated management approach. A trial was established to investigate the food preferences of rabbits to gain a better understanding of the most effective bait medium for optimal control of this species.

Three different bait types were selected and presented at each bait station. These bait types were carrots, rolled oats and whole oats. All stations were closely monitored using remote cameras to measure bait uptake and assess which bait type, if any, was preferred.

Overall, in year-1 (2022) rolled oats were found to be the most preferred based on the results of both a visual assessment and remote camera analysis. However, the year was impacted severely by an eruption of house mice (*Mus musculus*) with significant evidence of mouse activity in and around the bait stations almost certainly confounding results.

In year-2 (2023) rabbit activity was significantly higher and house mouse activity significantly lower resulting in a much larger, cleaner data set to analyse. Based on time spent feeding in the tunnels whole oats were found to be the most preferred food type, with rabbits spending a cumulative time of 44.2 hours in the tunnels containing this food source compared to rolled oats (33.59 hours) and carrots (20.4 hours).

### Background

Bush Heritage Australia is delivering an integrated feral animal control program as part of its Fauna Recovery Project (The Project) in southwest Western Australia, a global biodiversity hotspot. The Project is generously supported by a 5-year grant from Lotterywest and benefits from a collaborative approach involving partners from both the private and public sectors.

The Project is the product of 15 years of planning and is in its third year of operation, involving 14 local landholders encompassing 26 properties and covering an area of 55,000 hectares in the region between the Fitzgerald River and Stiring Range National Parks, known as the Fitz-Strirling. The reach includes several land tenures including farmland, public conservation estate, privately owned reserves and roadside vegetation.

Since 2021, fox and feral cat control activities (baiting, trapping, shooting and grooming traps) have been undertaken together with targeted rabbit control (toxic and biological). However, rabbit control efforts had been restricted due to limited capacity, resources and knowledge to undertake the work effectively.

In 2022, with support from the Foundation for Rabbit-Free Australia, additional staff and contractor time was used to expand the Project's rabbit control work and incorporate it into an experimental design framework. This experimental component (the trial) was set up to explore the food preferences of rabbits, whilst continuing to provide operational scale control intended to promote wider conservation outcomes.

#### Aims

The trial's original aims were to cover a range of treatments, not just related to food preferences. However, it became apparent that this multi-experimental approach was too broad in scope for the trial after all the parameters were considered. Other treatments originally suggested included examining the impact of different densities of bait station arrays (i.e., the effect of clustering bait stations), expanding the timing of the control effort to include spring baiting (toxicants only) and testing different ground preparations (laying single and multiple furrows of bait).

After due consideration the aims were refined to focus on one specific aim which was to investigate the use of different bait types and determine which was most preferred by rabbits.

## Method

The trial was conducted across the Fitz-Stirling landscape on Bush Heritage reserves, neighbouring private farms, and other private conservation estate. In total 12 properties were included (see figures 1 and 2) and 28 study sites selected using pre-existing bait stations. These bait stations were established in 2021 in areas where significant rabbit activity had previously been identified.



Figure 1: Map showing location of the Fitz-Stirling corridor in south-west Western Australia



Figure 2: Map showing BHA rabbit bait station locations across the Fitz-Stirling Fauna Recovery Project area

The trial consisted of a pre-feed of non-treated bait followed by a feed treated with Rabbit Haemorrhagic Disease Virus (RHDV K5 08Q712 strain). In 2022 the exercise of a pre-feed and RHDV release was repeated twice resulting in four deployments of fresh bait. In 2023 there were two bait deployments based on one pre-feed and one RHDV release.

Each bait station consisted of three 1.5-metre-long aluminium exclusion tunnels positioned side by side. The tunnels were used to reduce non-target uptake of the bait particularly by birds and macropods and, in a few cases, livestock. The area around and underneath the tunnels was cleared of vegetation and a remote camera was positioned 3 metres away so that the camera's field of view captured all three tunnel entrances. To secure the tunnels a sandbag, rock or log was placed on top of each (see figure 3).

As viewed from the camera, bait types were allocated exclusively to each tunnel such that the left tunnel contained diced carrot, the middle tunnel rolled oats and the left tunnel whole oats. A quantity of one cup per bait was apportioned to the middle of each tunnel in a dug-out scrape. A trail of bait consistent with the bait type in the tunnel was then spread from inside the tunnel to approximately 1 metre beyond the entrance at the end where the camera was installed (see figure 4)



Figure 3: Images showing tunnel and camera configuration



Figure 4: Showing placement of bait types (left - carrots / middle - rolled oats / right - whole oats

#### Visual assessment

After a fixed number of days each bait station was revisited and a visual assessment of uptake of each bait type in the scrape inside the tunnels was undertaken. This was carried out after the pre-feed event only and, for logistics, at the time of re-visiting the stations to add the RHDV. Therefore, two assessments were made in 2022 and one in 2023.

In 2022 the assessment was based on a judgement of how much bait was perceived to have gone using the following descriptors – 'gone', 'most', 'some', 'no', 'N/A'. In 2023 the value judgements were changed to represent a percentage quartile of bait eaten i.e., 0%, 25%, 50%, 75%, 100% in an attempt to make the estimates less arbitrary.

## Results

#### Year-1 - visual assessment

bait uptake	carrot tunnel	rolled oat tunnel	whole oat tunnel
gone	6	19	6
most	4	1	6
some	7	1	9
no	9	5	5
N/A	2	2	2
total	28	28	28

Table 1: visual assessment of bait taken of each food type in terms of number of tunnels (pre-feed March 2022)



Figure 5: graph showing visual assessment of bait uptake of each food type in terms of number of tunnels (pre-feed March 2022)

bait uptake	carrot tunnel	rolled oat tunnel	whole oat tunnel
gone	10	25	17
most	0	0	0
some	2	0	6
no	13	0	2
N/A	3	3	3
total	28	28	28

Table 2: visual assessment of bait taken of each food type in terms of number of tunnels (pre-feed April 2022)

Figure 6: Graph showing visual assessment of bait uptake in terms of number of tunnels (pre-feed April 2022)



Based on the visual assessment for 2022, rolled oats were the preferred bait type with 19 and 25 tunnels out of the 28 bait stations assessed as 'gone' for March and April respectively. Carrots had the lowest uptake for both periods with 9 and 13 tunnels (March and April) recording no uptake.

#### Year-2-visual assessment

Table 3: visual assessment of bait taken of each food type by number of tunnels (pre-feed February 2023)

bait uptake (%)	carrot	rolled oat	whole oat
100	6	3	2
75	2	3	1
50	6	4	2
25	4	6	7
0	4	6	10





Based on the visual assessment for 2023 (table 3 and figure 7), the most preferred bait type was carrot with 6 instances of the entire bait (100%) having been consumed. Overall, carrot had the best uptake record across all the sites with 14 bait stations revealing a 50% or greater uptake compared to rolled oats (10 stations) and whole oats (5 stations). However, based on the limitations of this monitoring method regarding the level of subjectivity of the assessment and unknown non-target uptake this metric was given less weighting than the camera data result in the final analysis and therefore carrots were not considered a preferred food type for rabbits (see next section).

#### Camera analysis

#### Year-1- (2022)

At the end of the baiting period the cameras were removed so that the images could be analysed to define the number of independent uptake events. In year-1 (2022) the images were analysed to identify all the images of rabbits which were then separated into two categories, one labelled 'rabbits outside tunnel', the other 'rabbits inside tunnel'.

The 'rabbits inside tunnel' category was further sub-divided depending on which of the three tunnels rabbits were present in - left, centre or right. The times of each visit into a tunnel were recorded and independent events tallied based on a quiet period or interval time of 30 minutes between visits.

The camera data for year-1 was analysed as follows: -

- 80 camera data sets were analysed in total from 23 cameras / bait stations, covering the following dates:
  - o 15-21 March (Pre-feed 1)
  - 22 March 8 April (RHDV release 1)
  - 9-11 April (Pre-feed 2)
  - 12 April onwards (RHDV release 2)
- Only 23 of the 28 available cameras were analysed and this was due to human errors including those bait stations where only two tunnels were deployed, where bait types were laid in an

incorrect sequence in relation to the tunnels, and where the camera field of view did not capture the entrances of all three tunnels.

- Of these 80 camera datasets, 32 were analysed through to rabbit camera events. The reasons for only 32 datasets being analysed in part or full included:
  - $\circ$   $\;$  No rabbits recorded at the bait station by the camera;
  - $\circ$   $\;$  No rabbits recorded inside bait tunnels; and
  - Tunnels and cameras disturbed by sheep.
- Each independent rabbit event was classified as a rabbit partially or fully inside the bait tunnel, or having its head partly inside the tunnel and seen eating the bait. Each rabbit camera event was deemed to begin more than half an hour after the previous recorded rabbit camera event.
- The total rabbit camera events for each bait type were recorded as follows:
  - Carrots 137 events
  - Rolled oats 171 events
  - Whole oats 104 events
- The above totals were split for each feed session as follows:

**Feed session Rolled Oats** Carrots Whole Oats 3 7 Pre-feed 1 16 RHDV 1 49 26 72 Pre-feed 2 37 29 15 RHDV 2 33 71 54 Totals 137 171 104

Table 4: results for feed events in 2022

 The results of the first year of monitoring in 2022 were confounded heavily by the occurrence of house mice (*Mus musculus*) which occurred in plague proportions. Many of the tunnels contained mouse holes and the cameras revealed high levels of mouse activity at most stations. It is likely that significant bait uptake was attributable to house mouse and not rabbit.

Table 5: extent of mouse activity on camera for selected bait stations

Camera	Feed session	No. of mouse photos	Percentage of total photos
T05	Pre-feed 2	894	40.1
T05	RHDV 1	855	46.5
T23	RHDV 2	3617	50.1
T31	Pre-feed 2	338	67.1
T31	RHDV 1	356	42.2
T43	Pre-feed 2	8222	99.3
T43	RHDV 2	1181	63.4
T44	Pre-feed 2	3069	96.1
T45	Pre-feed 2	7263	86.8
T45	RHDV 2	9130	91.3
T45	RHDV 2	4655	93.2
T50	Pre-feed 2	115	43.4

#### Year-2 (2023)

In year-2 (2023), the number of rabbit detections was significantly higher than for 2022. It was decided to change the analysis approach from independent events to cumulative time spent inside each tunnel. The frequency of rabbit visits to the tunnels was sufficiently high that recording a new event only after a 30-minute interval had elapsed would have resulted in some events extending for several hours and under-representing the amount of activity, particularly inside the tunnels.

Additionally, as recording all visits was too time consuming and confusing with multiple individuals entering, leaving and occupying the tunnels at any given time, it was decided to break up the activity into half hour blocks from the start time of the first visit. Within this block rabbits were recorded entering and feeding in the tunnel and again when leaving each tunnel. As most of the feeding sessions were over within half an hour, with a reasonable gap in between, handling the data in this way was much more manageable and did not mis-represent the level of activity in the way that independent events might.

As the main aim of the trial was to assess food preferences within the context of a RHDV release, in year-2 it was considered less important to extract meaningful independent events but instead to focus on the total combined occupancy within any given tunnel, even if this may potentially have been biased by the majority of visits being made by the same few individuals. Despite this bias, from a land management perspective, even if only a handful of rabbits were consuming the bait containing RHDV they would still be effective vectors in the warren and therefore still provide the benefits of a wider, more effective means of control.

Further supporting the justification to change from independent events to a cumulative time metric could be attributed to the fact that many of the visits by rabbits inside the tunnels lasted just a few seconds so it was highly unlikely that any feeding activity would have taken place. Counting these visits as independent events would have resulted in many false positives whereas combining them into an 'overall hours spent' score meant their significance was greatly reduced and therefore more reflective of their (lack of) contribution to feeding activity.

site id	landholder	carrots	rolled oats	whole oats
R01	nelson	0	0	0
R05	hannig	0	0.09	0
R22	chereninup	2.6	1.1	0.6
R26	hyde	0	0	0
R29	cooke	2.3	6.6	9.7
R43	cooke	1.1	3.1	2.4
R44	cooke	0.1	0.3	0.6
R46	pater	0.2	1.3	3.9
R47	beringa	0.9	0.2	0.1
R48	ediegarrup	3.3	4.6	7.9
R49	ediegarrup	8.8	13.4	16.1
R50	ediegarrup	1.1	2.9	2.9
Total		20.4	33.59	44.2

Table 6: combined number of hours rabbits spent inside each tunnel at each site based on camera analysis throughout trial

Table 7: combined number of hours rabbits spent inside each tunnel at each site based on camera analysis during pre-feed (23-26 February 2023)

site id	landholder	carrots	rolled oats	whole oats
R01	nelson	0.0	0.0	0.0
R05	hannig	0.0	0.0	0.0
R22	chereninup	0.0	0.0	0.0
R26	hyde	0.0	0.0	0.0
R29	cooke	0.7	2.2	2.3
R43	cooke	0.8	2.0	2.1
R44	cooke	0.0	0.0	0.0
R46	pater	0.0	0.4	1.3
R47	beringa	0.0	0.0	0.0
R48	ediegarrup	2.9	3.4	2.9
R49	ediegarrup	6.4	7.6	8.8
R50	ediegarrup	0.0	0.2	0.8
Total		10.8	15.8	18.2

Table 8: combined number of hours rabbits spent inside each tunnel at each site based on camera analysis during RHDV release (27 February – 23 March 2023)

site id	landholder	carrots	rolled oats	whole oats
R01	nelson	0	0	0.0
R05	hannig	0	0.1	0.0
R22	chereninup	2.6	1.1	0.6
R26	hyde	0	0	0.0
R29	cooke	1.5	4.4	7.3
R43	cooke	0.2	1.1	0.3
R44	cooke	0.1	0.3	0.6
R46	pater	0.2	0.9	2.6
R47	beringa	0.9	0.2	0.1
R48	ediegarrup	0.4	1.2	5.0
R49	ediegarrup	2.4	5.8	7.3
R50	ediegarrup	1.1	2.7	2.1
Total		9.4	17.8	25.9

Tables 6, 7 and 8 above show the total hours spent by rabbits in each tunnel at those bait stations where there was: a) presence of rabbits captured on camera; and b) activity of rabbits entering at least one of the three tunnels. In table 6, the data shows that during both the pre-feed session and the RHDV release the tunnel containing whole oats (44.2 hours) was occupied more often than for rolled oats (33.59 hours) and carrots (20.4 hours). This is not consistent with year-1 findings where rolled oats were the preferred food type. However, year-2 results are arguably more significant for two reasons: the much larger data set of rabbit activity in year-2 and the confounding house mouse activity in year-1.

Although carrots scored highest in the visual assessment, tables 6, 7 and 8 show that it was least preferred in the camera analysis. As previously mentioned, it was concluded that the camera analysis was deemed to be a more accurate and instructive means of measurement for rabbits and so provided the over-riding verdict in terms of bait preference. One suggestion as to why carrot was least preferred might be the readily available supply of green pick resulting from two above average wet years. However, the carrot was also found to be desiccated after 24 hours so perhaps in this degraded state it was less palatable.

# Limitations of the study

# Limitations of the visual assessment method

- The method of visual assessment was subjective and undertaken by multiple people, leading to potential inconsistencies in the assessments from site-to-site and person-to-person.
- Grain was de-husked by some birds and rodent species creating a false impression of there being more bait on the ground and hence a potential for over-estimating the amount of bait remaining.
- Carrots naturally became desiccated and would shrink in mass potentially creating overestimates of bait consumed.
- Weighing the bait would have resulted in a more accurate assessment of quantity before and after laying and hence assessment of bait uptake. Collecting the remaining bait to reweigh was problematic however as the bait was disturbed by feeding animals and mixed with sand and litter.

# Limitations of the remote camera survey method

- Each independent event took no account of duration of time in tunnel could have been a few seconds or several minutes. It was also unclear as to how much time rabbits were actually feeding inside the tunnel.
- Rabbit behaviour rabbits generally have small home ranges (0.2-2 hectares) and tend not to wander too far from their home warren. On several occasions, repeat visits to a camera could be seen to be one or two of the same rabbits only – especially obvious on camera T50 which looked like an escaped black/dark pet rabbit repeatedly visiting the bait station with another rabbit. These same few individuals could bias the impact of which food type was most preferred.
- Some cameras, particularly in 2022, recorded very little valid rabbit activity, e.g. only one event recorded throughout the entire feeding session where the rabbit went into the tunnel at one site.
- Accidental removal of one of the tunnels at bait stations T39, T41, T43, T44, and T45 in 2022 reduced the sample size as these sites could not be used.
- The 2022 methodology defined an event as a rabbit entering / occupying a tunnel this could at times be a single photo recorded of the rabbit which looked to be running through the tunnel therefore creating false positives.
- Cameras may miss or only capture part of rabbit activity at certain times. In one or two instances the camera placement made it difficult to see all three tunnels at one time or the rabbit was moving off by the time the camera began recording.
- House mouse issues in 2022 had a significant impact on data quality in year-1.

# Conclusion and recommendations

The results from year-1 of the rabbit bait preference trial (March-April 2022) indicated that rolled oats were the most preferred. This was based on the preliminary visual assessments of each tunnel and the highest number of independent events of rabbits visiting tunnels containing rolled oats (171 events). Whole oats were the next preferred in terms of the visual assessment whereas carrots were next preferred regarding independent events. However, significant evidence (from observations and camera footage) of high levels of house mouse activity means all the results from year-1 are likely to be highly confounded.

The results from year-2 (February-March 2023) revealed that whole oats were the preferred food type based on the amount of time spent in each tunnel. The study may have benefitted from a control set of bait sites where all three tunnels were baited with the same food type.

Current monitoring and observation (spring 2023) suggests that rabbits are increasing despite control efforts. The reduction of foxes through control measures and the recovery of vegetation after two years of above average rainfall suggests conditions are improving for local rabbit populations to grow.

However, thanks to this trial, distribution and extent of local rabbit populations across the Fitz-Stirling landscape are more clearly identified and understood. As a result, in 2024 Bush Heritage will establish additional rabbit stations, therefore expanding the level of control. There are now 66 stations set up at key sites (compared to 28 in 2022/2023) within Bush Heritage's Fitz-Stirling management zone.

The trial also improved confidence levels that whole oats appear to be the preferred food type of rabbits in the area. This means whole oats should be selected as the bait type for pre-feeding activities and for mixing with Rabbit Haemorrhagic Disease Virus (RHDV) to optimise uptake and potential spread of the virus.

More generally, the trial supported an expanded rabbit program as a key component of the Fauna Recovery Project with a more sustained and frequent effort of control at the most critical time of year (late summer and early autumn). It enabled additional techniques to be adopted, including the use of live trapping and intra-muscular injection of RHDV. The use of dummy traps will be expanded in an attempt to improve trap success.

The trial has contributed to our wider understanding of the most effective rabbit control techniques in this landscape, especially recognising the importance of regular and sustained pre-feeding as a significant factor to increase bait efficacy. The work also highlighted the challenges of controlling this species using current best practices and commercial products and the amount of effort required to deliver a successful programme.

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