Report on non-toxic bait trials
Lord Howe Island – August 2007

Executive Summary

In August 2007 a non-toxic bait trial was conducted at Lord Howe Island to support preparations for a planned eradication of ship rats (*Rattus rattus*) and mice (*Mus musculus*) that are widespread on the island and have significant averse impacts. The study examined palatability of bait to rodents, risks posed to non-target species, bait longevity in the environment, and trialed the use of aerial bating methodology which will be critical for an eradication attempt.

Palatability of baits to rodents was tested by baiting large (23 and 34 ha) areas with baits of two sizes (5.5 mm and 10 mm diameter pellets) at a rate of 13 and 9 kg/ha and then trapping animals over a 7 days period commencing 2 days after the bait drops. Baits were non-toxic and contained a biomarker which fluoresces under ultra violet light. Bait ingestion was confirmed by the presence of fluorescence in trapped rats and mice. Prior to baiting, each area was trapped for between 3 and 7 days and live captured rodents were ear marked and released. Residency of rodents on the trapping grids and thus access to bait prior to capture was assumed if trapped animals were ear marked. 83.9% of mice, and 87.5% of marked rats in the 5.5 mm bait area had eaten bait, and 100% of animals in the 10 mm bait area consumed bait. Robust comparison of the two rates of uptake was prevented by low capture rates with only 1 mouse and 9 rats were captured on the 10 mm grid areas. While results on bait uptake are equivocal, circumstances relating to those animals not consuming bait in the 5.5 mm suggest that bait palatability may not necessarily have been the reason for no observed uptake.

Non-target species were assessed for uptake by baiting a 30 ha area adjacent to the islands golf course with 5.5 mm bait at a rate of 10.1 kg/ha and capturing animals over the following 9 days.

Four bird species were shown to be at risk from the baiting, and would therefore be at risk during a poison drop. Of these, woodhens were the only threatened island endemic to test positive for bait uptake, and confirmed the view that they would be vulnerable during a bait drop. The threat posed to woodhens from a poison bait drop will necessitate the capture and holding of a significant proportion of the population in captivity for the duration of any eradication operation. The period of captivity will be determined by the time it takes for baits remaining in the environment after rodent deaths to breakdown to a stage where they are no longer a risk to non-target species.

Other threatened island endemics; currawongs, golden whistlers and silvereyes did not appear to ingest bait, notwithstanding the findings, currawongs are at high risk of secondary poisoning during any operation as they would prey on dead and moribund rats ands mice. Consequently they would also be captive managed along with woodhens.

Several invertebrate species were observed either fluorescing under UV light indicating bait ingestion, or feeding on baits.

Condition of baits placed in cages in three habitat types was monitored over 55 days and indicated that the smaller 5.5 mm baits disintegrated at a faster rate than the 10 mm which would reduce the period any at risk non-target species were held in captivity during an eradication, and livestock in confined holding facilities.

Aerial baiting was shown to be an effective technique that could be utilised in an operation on Lord Howe Island. The trial provided an opportunity to establish the correct flight configuration: air speed and aperture ring size to produce the required flow rate of bait during operations. Methodologies for loading procedures, and determination of bait usage on flight runs were developed for use in future baiting operations.

Introduction

In common with many oceanic islands Lord Howe Island has unique faunal and floral assemblages, with high degrees of endemism. The introduction of house mice (*Mus musculus*) in 1860, and ship rats (*Rattus rattus*) in 1918 has had extensive adverse impacts on the natural flora, fauna and ecological processes on the island. Rats have been implicated in the decline and extinction of a number of bird, reptile and invertebrate species. They also have significant impacts on the vegetative parts of a number of plant species on the island. While the impacts of mice have not been intensively studied at Lord Howe Island evidence from other locations would suggest that they are likely to be significant predators of invertebrates, the eggs of smaller birds, and of plant seeds.

Attempts at control of rats have been attempted since shortly after their arrival in 1918. Since 1986 the Lord Howe Island Board has undertaken control at 33 sites on the island primarily to protect the palm industry which is heavily impacted by rats. While control may temporarily reduce number, it can not prevent the ongoing biodiversity impacts by both rats and mice (which are not controlled due to their resistance to the Warfarin used in the programme).

With developments in eradication techniques during the past 20 years, and in particular the use of aerial baiting methods, the eradication of both rodent species on Lord Howe Island in a single operation is considered feasible (Saunders and Brown 2001). To achieve this, while minimising impacts on native species, will require detailed technical and logistical planning. A single eradication operation would have a the major advantages of minimising disturbance to native wildlife, cost efficacy, and limiting the possibility of a dramatic mouse population increase which may occur in the absence of rats on the island.

A prerequisite of all eradications is that all target individuals must be put at risk by the methods used, and impacts on non-target species should be minimised. To this end, this study aims to: determine the palatability of proposed bait types to both rats and mice and assess the risk posed to non-target species. It will also determine the longevity of baits in the environment, and trial and refine aerial bait delivery for use on Lord Howe Island.

Methods

Study Site

Lord Howe Island (31°33'S, 159°05'E) is a crescent shaped, volcanic remnant on the Lord Howe Rise, approximately 600 km east of Port Macquarie, New South Wales. It is 1455 ha in area with very rugged relief, rising to 875 m in the south on the summit of Mount Gower. The central lowland areas have been cleared for agriculture or settlement and are dissected by a network of 11 km of

narrow roads. Patches of uncleared evergreen closed forest (Pickard 1983) adjoin grazing leases and urban settlement. Lord Howe Island was included in the World Heritage List in 1982.

Three baiting areas were chosen on the island, two of approximately 30 ha on Transit hill for the rodent trapping study and a third area (~30 ha) to the east of Intermediate hill used for non-target species capture (Fig. 1). Four trapping grids (numbered 1 to 4) of 49 Elliot traps and 49 cage traps spaced at approximately 10 m intervals (60 x 60 m) were established in the area to the east of Transit Hill (the 5.5 mm bait area) and three grids (numbered 5 to 7) on the western slopes of Transit Hill, the 10 mm bait area. Each of the trapping grids was at least 100m from the nearest adjacent grid and from the edge of the baiting area.

Fig. 2 shows the planned extent of the proposed 5.5 mm baiting area to the east of Transit hill which contained trapping grids 1-4. Prior to aerial baiting, but after commencement of live trapping, it became clear that the paddocks on the western side of the area were being used for grazing cattle, and a decision was made to avoid a bait drop over the paddocks as it was unclear as to how the green dye on the bait would impact milk production, quality, or colour. The baiting area was redrawn to exclude the paddocks (Fig. 3), and in the process resulted in a reduction in area, and the exclusion of part of trapping grid 1 from the baited area.

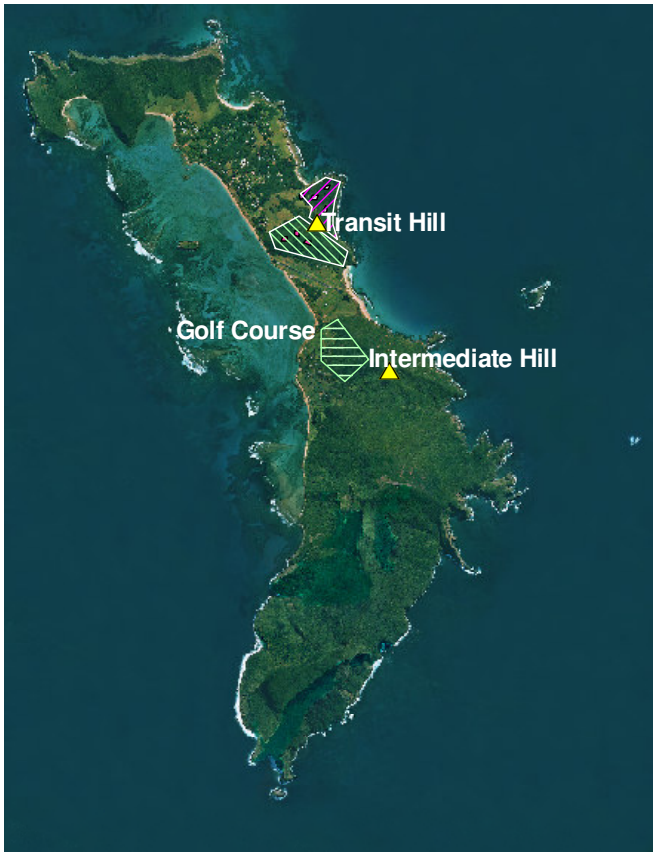

Fig. 1. An aerial photograph of Lord Howe Island showing the location of aerial baiting areas.

Fig. 2. Proposed 5.5 mm (30 ha) baiting area to the east of Transit hill containing rodent trapping grids 1 – 4. Grid 1 is shown darker than the remaining three grids.

Fig. 3. Revised 5.5 mm baiting zone (23 ha) excluding paddocks on the western edge of the area. Note how trapping grid 1 has been partially excluded from the baiting zone.

The location of the 10 mm bait area to the west of Transit hill is shown in Fig. 4, and the golf course bait area and its proximity to the other two areas is seen in Fig. 5.

Fig. 4. 5.5 mm baiting zone containing four trapping grids to the east of Transit hill, and the 10 mm area (34 ha) containing the three trapping grids to the west of Transit hill.

Fig. 5. Location of Golf course baiting area (30 ha) and its proximity to the other two bait areas.

Live capture of rodents

Rodents were live trapped over a period of 8 nights (3-11 August) prior to aerial baiting. Elliot and cage traps (containing leaf litter to prevent trap mortalities) were set in grids, baited with peanut butter and rolled oats. All rats and mice captured were transferred from traps to catch bags to facilitate handling (Fig. 6), and then ear punched (Fig. 7) to allow identification to the grid on which they were captured, and subsequently released. Traps were opened at 16h00 and

then checked at 06h00 before closing traps during the day. Any previously marked animals were recorded.

Fig. 6. Transfer of rat from cage trap to facilitate handling

Fig. 7. Ear punching a rat to enable catch bag to identification to grid on which captured

Aerial Baiting operation

All three areas (Fig. 1) were aerially baited on August 14th using a squirrel helicopter and a custom made bait spreader bucket (Fig. 8) slung under the helicopter (Fig. 9) Flight lines over each area were determined using a differential GPS system fitted in the aircraft, to ensure accurate bait coverage, at a targeted rate of ~10 kg per hectare. Baits dropped were non-toxic PESTOFF 20R produced by Animal Control Products, Wanganui, New Zealand. The baits are cereal based, dyed green, and contain the non-toxic biotracer, Pyranine 120 which when exposed to ultra violet light fluoresces green. Both 5.5 mm (~0.5 g) and 10 mm (~2 g) baits were dropped to allow a comparison to be made as to which would be the most appropriate for a two species eradication. Baits were in all ways, other than presence of a toxin, identical to those that would be used in an eradication operation. The 10 mm baits were spread on the western side of Transit hill and the 5.5 mm baits on the eastern side. 5.5 mm baits were spread over an area to the west of Intermediate hill overlapping the island's golf course which had been identified as an appropriate area to trap non-target species (Fig. 10). A baiting rate of 10 kg/ha results in approximately 1 10 mm bait every two square metres on the ground, while 5.5 mm baits will fall at a density 4 times that giving a ground coverage of 2 per square metre.

While exact baiting areas were calculated prior to flight operations, problems with uploading these areas to the onboard GPS system necessitated the manual establishment of areas during flight. Flight lines were set at the effective

swath width provided by the bucket manufacturer, using a flow rate aperture (Figs 11 and 12) to give a rate of approximately 5kg per hectare. A second flight was then conducted along lines midway between those of the first flight. This flight plan allowed a 100% overlap in baiting producing the desired baiting rate of 10kg/ha. All flight lines were run in parallel to minimise bait gaps which might occur on right angle flight paths as a result of errors in calculating the effective swath width of the bait spreader.

Fig. 8. Custom built bait spreader bucket being prepared for use on LHI.

Fig. 9. Squirrel helicopter with bait bucket during baiting operations.

While the size of the bucket would have enabled a single loading to conduct both bait runs on each area, the aircraft landed after the first baiting run to allow confirmation of baiting rates. This was facilitated by determining the amount of bait used during the flight. The inside of the bucket was calibrated prior to use

by filling with the contents of 25 kg bait bags, raking each 25 kg flat and marking the inside of the bucket to show the amount of bait. At the start of the baiting operation, approximately two thirds of the estimated bait required for the whole area was loaded into the bucket, and the remaining bait quantity determined when the aircraft returned by raking the bait in the bucket flat and recording the amount. Changes to the aperture size at the base of the bucket were made, if required, to achieve required flow rates.

Fig. 10. 5.5 mm bait on the golf course after the aerial baiting operation.

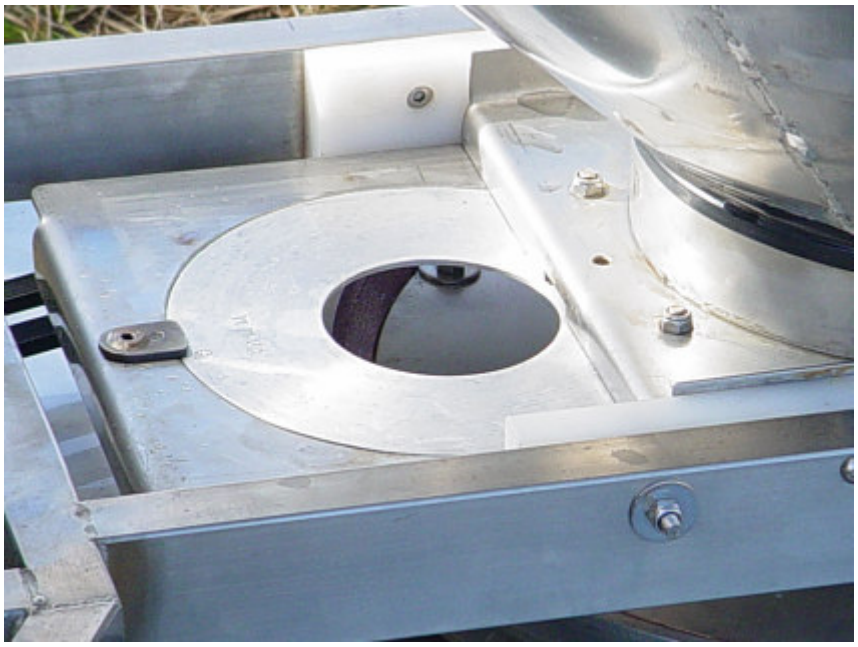

Fig. 11. Adjustable bait flow rate aperture.

Fig. 12. Base of bucket shown with spreader mechanism (spinner) which is powered by lawn mower motor mounted on the side of the bucket. The slide holding the aperture ring shown in Fig. 10 is operated hydraulically by the pilot to allow bait to flow at the required time. This photograph shows the slide in the closed position and no bait would flow from the bucket to the spreader.

Post baiting trapping of rodents

The previously established grids on Transit hill were trapped for 7 days, commencing on the second day after the bait drop (evening of 16 August). Both rat and mouse snap traps were used at each site, placed under cover to prevent non-target bycatch. Subsequent to the first night's trapping, during which there were few captures, Elliot and cage traps were redeployed to provide additional potential forcaptures. All animals captured in live traps were euthanased using blunt trauma techniques in accordance with DECC animal ethics guidelines. Captured animals were weighed to the nearest 2 g and checked for ear marking to determine if they had been captured during the live trapping phase prior to aerial baiting.

All rodents captured were assessed for bait uptake by visual inspection under UV light for pyranine dye (green fluorescence) in their mouth, rectum and in faeces. Any animals which showed no external signs of dye were dissected and examined internally. The proportion of previously marked (an indication of residency), and unmarked (assumed to have originated outside the baited area) rodents was determined. Separate analyses were conducted for the 5.5 mm and 10 mm bait areas.

Assessment of non-rodent impacts

Birds were captured on the golf course area adjacent to Intermediate hill commencing 2 days (16 August) after the bait drop using mist nets and butterfly cage traps, and trapping continued for 9 days. Additional captures using butterfly cage traps were made in the 5.5 mm baiting zone to the east of Transit

hill. Once captured, birds were placed in a drawstring bag to minimise handling stress. Mouth linings, and cloaca of all birds were checked under UV light for fluorescence indicating consumption of bait. They were colour banded for identification if recaptured, and then transferred into lined aerated boxes in a quiet, dark place to minimise disturbance until a faecal sample had been produced. Each bird was held for the minimum period necessary for them to produce faeces, which did not exceed 1 hour. All faecal samples were checked for fluorescence under UV light, and then frozen for further analysis if required.

In addition to trapping, opportunistic observations were made of foraging animals, faecal material collected when species producing it were observed, and on several occasions baits were directly presented to birds to determine palatability.

A harp trap was set for five nights on the golf course, and for three in the bait zone to the east of Transit hill, to catch Large Forest Bats (*Vespadelus darlingtoni*).

Bait longevity

Rodent cage traps were covered with 6 mm aperture wire mesh to prevent access by rodents or non-target species to trial baits. Cages containing 5.5 mm and 10 mm baits were placed at three locations: an open site (Fig. 13) with zero canopy cover, a medium cover site with a broken canopy and a full canopy cover site to monitor bait longevity. 100 baits were placed in each cage and samples removed at approximately weekly intervals and photographed to assess the status of the baits, 10mm and 5.5 mm baits are shown in cages in Fig 14. Bait condition was assessed according to a 6 point scale developed by the New Zealand Department of Conservation (Fig. 15).

Fig. 13. Bait cages in 'open' area.

Fig. 14. 10 mm baits shown in bait cage (left), and 5.5 mm baits swollen after rain in bait cage (right).

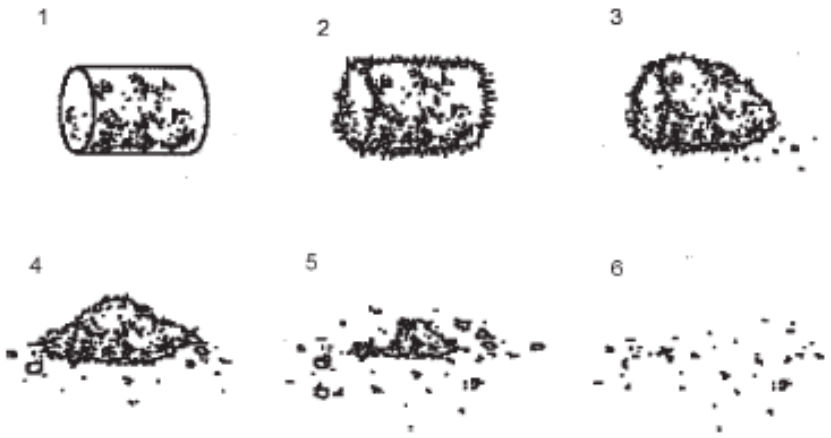

Fig. 15. Scale used to measure bait decomposition (see Green & Dilks 2004).1 = fresh, 2 =soft (may have some mould), 3 = mushy pellet (> 50% may have some mould), 4 = pile of mush (> 50% with mould), 5 = disintegrating pile of mush, 6 = gone or identifiable by grain flakes.

Results

Live capture of rodents

A total of 95 mice and 147 rats were captured and marked during the 8 night period of trapping prior to the aerial baiting operation. Numbers of rats and mice in each trapping grid are shown in Table 1. An estimate of minimum numbers of rodents per hectare was calculated by dividing the total number of marked animals by the area of the grid on which they were captured (Table 1).

Table 1. Numbers of trapping days, trap nights, trapping grid areas, rats and mice caught and marked on LHI, and estimates of minimum numbers of mice and rats per hectare.

Grid	Days grid trapped	Trap nights (nights * # of traps)	Area of grid (ha)	Mice marked	Minimum Mice/ha	Rats marked	Minimum Rats/ha
1	6	492	0.37	37	100.0	13	35.1
2	4	336	0.38	28	73.7	15	39.5
3	5	420	0.31	29	93.5	23	74.2
4	3	252	0.30	0	0.0	22	73.3
5	7	686	0.40	0	0.0	25	62.5
6	7	686	0.37	1	2.7	23	62.2
7	7	588	0.40	0	0.0	26	65.0
Totals		3460		95		147	

Unmarked rats and mice were still being captured on most grids at the cessation of the live trapping period (Figs 16 & 17), indicating numbers marked represented minimum numbers of animals on each grid. Only one mouse was captured during the live trapping period on the western group of grids, which is not shown on Fig. 16.

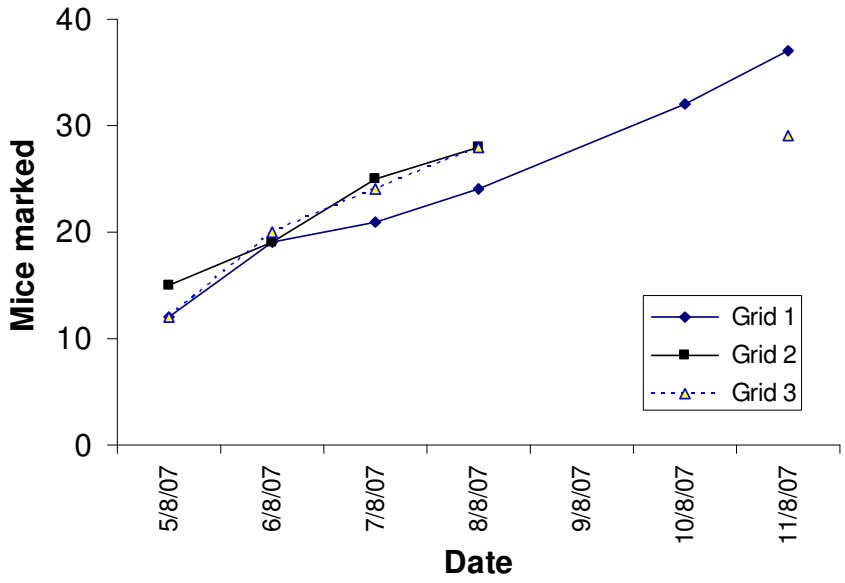

Fig. 16. Cumulative numbers of mice marked on trapping grids prior to aerial baiting.

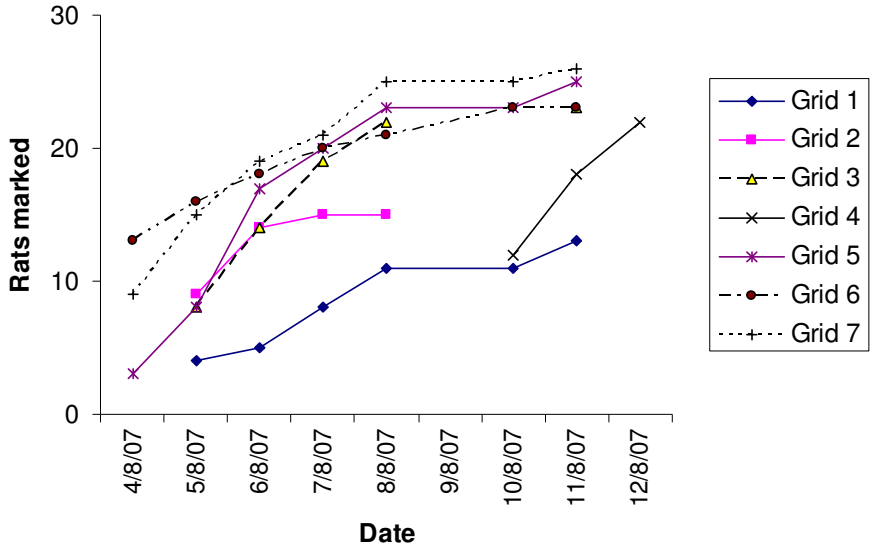

Fig. 17. Cumulative numbers of rats marked on trapping grids prior to aerial baiting

Aerial Baiting

Aerial baiting was conducted during 7 flights on 14 August. A total of 920 kg of non-toxic bait was spread during the flights. Two measured bait drops were undertaken over the first two areas baited. During the 10 mm bait drop to the west of Transit hill 170 kg bait was used on the first run with a 70 mm aperture on the bucket, and a swath width of 70 metres. This resulted in a delivery rate of 4.9 kg/ha over the 34.8 hectares baited. The second run used the remainder of the bait with flight lines offset by 50% of the swath width from the first run.

During the baiting over the golf course the first flight used a 60 mm aperture to spread the 5.5 mm baits resulting in only 75 kg of bait being used over the 29.6 ha. The second run used a 70 mm aperture and 150 kg were used providing a baiting rate of 5.1 kg/ha which was consistent with the figure for the 10 mm runs. A third run dropped a further 75 kg of bait over the area. All baiting with 5.5 mm bait used a swath width of 60 metres.

The details of the baiting, with baiting rates and numbers of baits spread per hectare are shown in Table 2.

Table 2. Details of aerial baiting conducted on LHI on 14 August.

Zone	Bait size (mm)	Area (ha)	Bait (kg)	Baiting rate (kg/ha)	Baits/ha
West	10	34.8	320	9.2	4600
East	5.5	23.1	300	13.0	26000
Intermediate hill	5.5	29.6	300	10.1	20200

The modification to the planned baiting area to the east of Transit hill (Fig. 2) resulted in baits only being distributed over part of trapping grid 1. In flight changes to the baiting area resulted in an area of 23.1 ha (area shown in Fig. 2) being sprayed, rather than the planned 25 ha. All baiting for the east area was conducted in a single flight, with bucket apertures set for a 5 kg/ha baiting rate. At the start of the fight sufficient bait to achieve the 10 kg/ha coverage was loaded (250 kg), along with an extra 50 kg to cover variation on flow rate, and to allow extra baiting along the boundaries of the area which may be missed during the flight lines. The reduction in the actual size of the East bait area, combined with a slight increase in bait loaded resulted in higher baiting rate ~13 kg c.f. ~10 kg/ha for the other two areas.

Within 7 days of the aerial operation (21 August), baits which had been easily visible on the ground in both baiting areas had all but disappeared, presumably as a result of removal by rodents, and invertebrate activity.

Bait uptake by rodents

A total of 132 mice, and 39 rats were caught over 7 nights on the trapping grids. 10 of 24 (41.7%) adult rats, 1 of 15 (6.7%) of juvenile rats, and 56 of 132 (42.4%) mice were ear marked indicating capture prior to aerial baiting. All marked animals were captured in the grid in which they were marked indicating a high degree of fidelity to the area. Fifty six (58.3%) of the 96 mice marked on the grids were captured, compared to only 11 (7.5%) of the 147 rats.

Mass of 122 mice and 37 rats were recorded. Adults rats weighed 207.4 ± 10.2 g (range 92 – 266 g, n = 24), juveniles 43.8 ± 3.0 g (range 28 – 62 g, n = 13), and mice 19.2 ± 0.4 g (range 8 – 28 g, n = 122). mean 43.8 ± 3.0 g), and mice (n=122) ranged from 8-28g with a mean of 19.2g.

Uptake of 5.5 mm bait for 131 marked and unmarked mice inferred from the presence of pyranine fluorescence (Fig. 18) is estimated at 78.6%, with corresponding figures of 88.9% for 18 adult rats and 91.7% for 12 juvenile rats (Table 3). Both rats and a single mouse showed 100% uptake of 10 mm bait

Table 3. Estimates of rates of uptake of 5.5 mm and 10 mm non-toxic baits indicated by pyranine fluorescence.

Species	Consume 5.5 mm bait		% Positive	Consume 10 mm bait		% Positive
	No	Yes		No	Yes	
Mouse	28	103	78.6	0	1	100.0
Rat - Adult	2	16	88.9	0	6	100.0
Rat - Juvenile	1	11	91.7	0	3	100.0

The corresponding values for marked animals, those assumed to be resident in the area, are shown in Table 4.

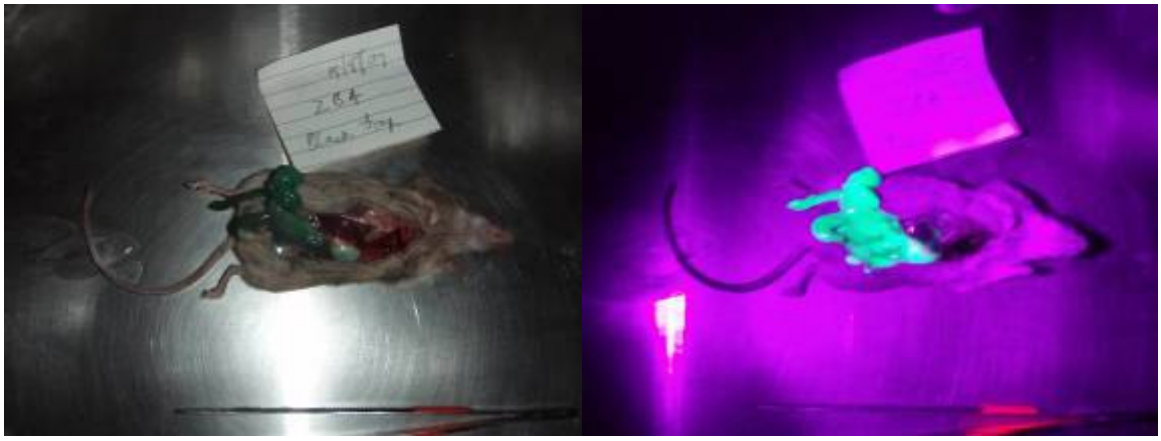

Fig. 18. Mouse captured on 5.5 mm trapping grid 2 showing green colouring in gastro intestinal tract under natural light (left), and pyranine fluorescence confirming ingestion of bait under UV light (right).

Table 4. Estimates of rates of uptake by previously marked rodents of 5.5 mm and 10 mm non-toxic baits indicated by pyranine fluorescence.

Species	Consume 5.5 mm bait		% Positive	Consume 10 mm bait		% Positive
	No	Yes		No	Yes	
Mouse	9	47	83.9	0	0	-
Rat - Adult	1	7	87.5	0	2	100.0
Rat - Juvenile	1	0	0	0	0	-

The marked adult rat which showed no signs of bait consumption was captured in grid 3 on 16 August, the second night after the aerial baiting. The juvenile rat was captured on 21 August on grid 1 in an area that was missed during the baiting (see Fig. 3)

Nine marked mice showed no sign of bait uptake during the trial. Seven of these animals were captured on the partly baited grid 1, the two remaining animals were trapped in grid 3, 7 and 9 days after the aerial baiting. Data for mice in grids other than the partially baited grid 1, show 100% positive results until day 6 after baiting (20 August), and a significant drop by 9 days post baiting. (Fig. 19).

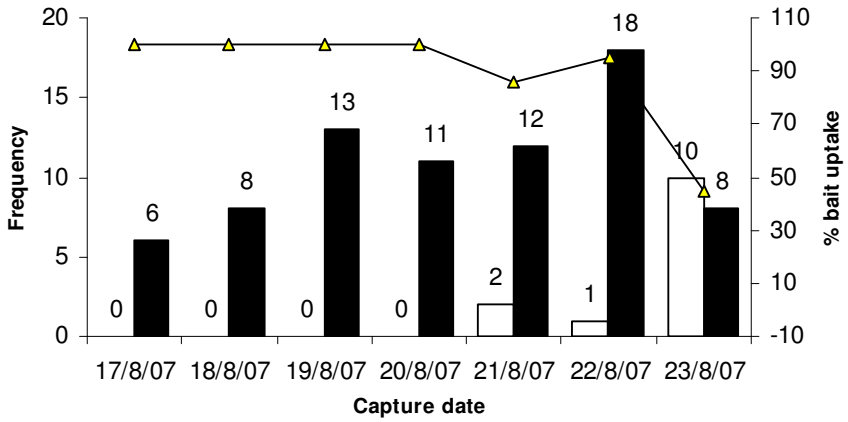

Fig. 19. Numbers of mice in grids other than grid 1 recording positive (solid bars) and negative (hollow bars) pyranine fluorescence by day through the trapping period, and the percentage of inferred bait uptake (line)

Numbers of adult rats captured in the 5.5 mm bait area showed an increase towards the end of the trapping period with more captured in the final 2 days of trapping than in the previous five (Fig. 20). Juvenile rats showed a similar, non-significant pattern (Fig. 20), while mice, after the first day, showed no difference in capture rates through the period. (Fig. 21). In the 10 mm area, the total numbers of captures were very low (13 rats and mice), but numbers of adult rats showed an increase on the final day of captures (Fig. 22).

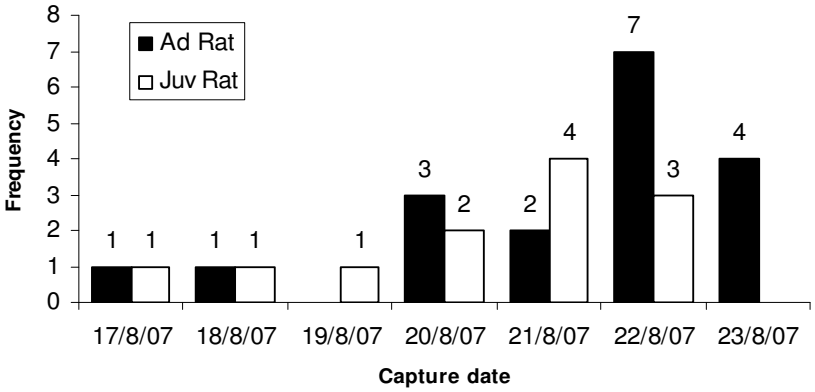

Fig. 20. Daily captures of juvenile and adult rats in the 5.5 mm bait area

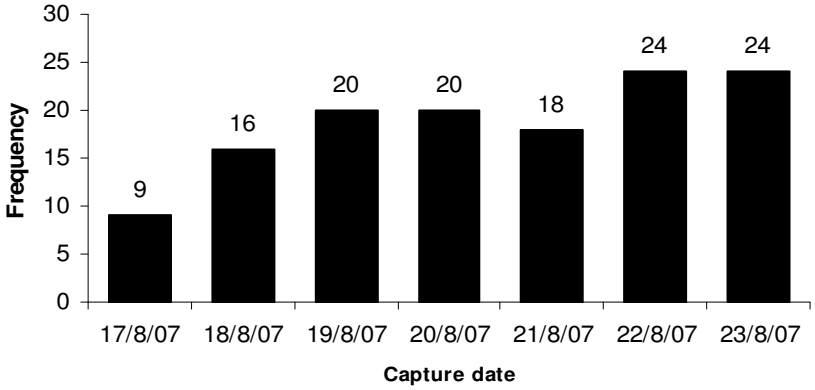

Fig. 21. Daily captures of mice in the 5.5 mm bait area

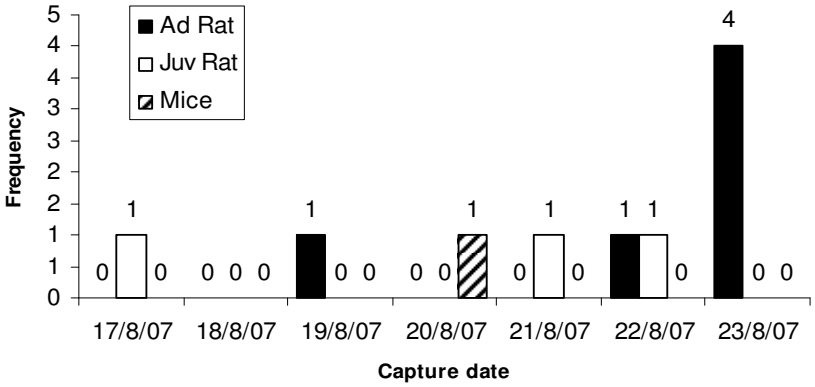

Fig. 22. Daily captures of juvenile and adult rats, and mice in the 10 mm bait area

Non-target bait uptake

11 species of birds were examined during the study for indication of bait uptake (Table 5). Woodhens, Buff banded rails, blackbirds and Mallards all provided fluorescing faecal samples (Fig. 23) indicating consumption of the dyed bait. In addition to the confirmation provided by the positive faecal samples, woodhens and mallards were both seen feeding directly on baits, while a single case of an emerald dove picking up bait and then discarding it was recorded. The remains of an owl kill were found on the golf course and the gizzard fluoresced brightly indicating that the owl's prey had ingested bait. The identity of the prey species was thought to be a woodhen.

Table 5. Results of pyranine fluorescence to assess uptake of bait for bird species caught in mist nets and traps, for faecal samples of known source, and autopsied* animals.

Species	Pyranine Fluorescence	
	No	Yes
Currawong	7	0
Emerald dove	7	0
Silvereye	4	0
Buff Banded Rail	3	1
Whistler	4	0
Woodhen	2	1
Kingfisher	3	0
Blackbird*	0	2
Mallard	0	1
Owl Kill - Gizzard (Woodhen?)	0	1
Magpie Lark	1	0
Purple swamp hen*	1	0
Totals	32	6

Fig. 23. Duck faeces under natural light (left), and fluorescing under ultra violet light confirming ingestion of bait (right).

Seven currawongs captured in clap traps showed no signs of pyranine fluorescence, either in faecal samples, or during physical inspection of their mouth or cloaca. Physical inspection of the 21 large forest bats captured in the harp trap provided no positive results (Fig. 24).

Fig. 24. All 21 large forest bats captured showed no signs of pyranine fluorescence in the mouth or anus during physical inspections.

Baits, both 10 mm and 5.5 mm, presented directly to buff banded rails, emerald doves, currawongs and whistlers elicited no response. Similar non-toxic bait dyed red, or un-dyed (beige in colour) was immediately taken when presented to buff banded rails.

Observations of baits in the field showed invertebrate damage occurred within a day of the bait drop. Several species of invertebrates were scanned externally with UV light to determine if they had ingested bait. Slugs, and snails (not *Placostylus*) fluoresced brightly indicating bait uptake (Fig. 25), and ants, cockroach and slugs were observed feeding directly on bait (Table 6). A single delicate skink, *Lampropholis delicata,* was scanned with UV light but did not show any evidence of bait consumption.

Fig. 25. Slug sp. feeding on bait viewed in natural light (left) and viewed under UV light (right), fluorescence indicates bait consumption.

Table 6. Results of pyranine fluorescence to assess uptake of bait for non-avian species collected, and * those observed feeding directly on baits.

Species	Pyranine Fluorescence	
	No	Yes
Slug spp.	1	2*
Snails (not *Placostylus*)	4	1
Delicate Skink	1	
Millipede sp	1	
Termite sp.	1	
Ant sp.		*
Large wing Cockroach (Sp. A)	1	
Cockroach sp B		*

Bait longevity

Observations of bait integrity showed that 5.5 mm baits in the medium cover site had completely broken down after 55 days, and 164.2 mm of rainfall (Table 7). The other 5.5 mm sites showed advanced decomposition by this time, but still retained recognisable pieces of bait (code 5). All samples of 10 mm baits showed less decomposition than the corresponding 5.5 mm baits after 55 days in the field.

Table 7. Rates of decomposition of bait following NZ Department of Conservation scale measured at intervals up to 55 days after being placed in decomposition cages on 10 August. Rainfall figures provided by the Bureau of Meteorology.

Date	Day	Rainfall (mm)	5.5 mm bait			10 mm bait		
			Open	Medium cover	Full cover	Open	Medium cover	Full cover
10/08/07	1	0	1	1	1	1	1	1
31/08/07	21	14.2	2	1	2	3	1	2
10/09/07	31	70.8	3	2	2	3	3	2
14/09/07	35	76.2	3	3	3	3	3	3
29/09/07	50	164.2	5	5	3	3	4	4
5/10/07	55	164.2	5	6	5	4	4	4

Discussion

The primary goals of the non-toxic bait trial were four fold, to determine uptake rates of 5.5 mm and 10 mm bait by rodents, uptake of bait by non-targets, to determine longevity of bait in the environment, and to trial the use of aerial baiting techniques on Lord Howe Island. While some of the results in the study are equivocal they provide important data on which further planning towards an eradication can be based.

The motivation for comparing two size baits in the trial was a direct result observations from global eradications which indicate that mouse operations are less successful than those for rats and the failures for mice have been linked with inadequate baiting densities which reduce encounter rates (Howald et al.

2007). Changes to bait densities can be addressed by increasing the amount of bait distributed (kg/ha), or by reducing the size so that each individual bait is smaller, and there are more for a similar baiting rate (kg/ha). By using 5.5 mm baits weighing ~0.5 g it is possible to achieve 400% of the coverage, in terms of numbers of baits, that you achieve with 10 mm (~2 g) baits, for the same baiting rate i.e. 10 kg/ha.

Live capture of rodents and bait uptake

The justification for conducting trapping prior to aerial baiting in the current study was to provide a pool of marked individuals that we knew were present in the grid areas, and thus would be exposed to the baits when dropped. Given that all marked animals were recaptured in the grid in which they were marked, there is likely to be very limited movement by both species on LHI, and based on that observation allows conclusions to be drawn from the entire capture sample, as they are likely to have been 'resident' in the grid areas at the time of the baiting and thus exposed to bait. Previous work on LHI rats found that 70% of animals were recaptured within 40 m of the initial capture site, and mean dustance moved was approximately 45 m, with a maximum distance moved of 450 m (Billing 1999). The high rate of residency found in the current study is consistent with previous data.

The lack of mouse captures on the 10 mm bait grids, 1 was caught, prevented a robust comparison of palatability of 5.5 mm and 10 mm baits. During the live trapping, prior to aerial baiting, there was evidence that mice were present but not being caught, this included numerous observations of cage traps being triggered and associated bait removal, and removal of bait from untriggered cage traps by burrowing under the trap to access the bait sitting on the floor of the cage. In the case of the closed traps, mice are able to squeeze between through bars of the cage to escape, and burrows under cages were too small to have enabled a rat to access the bait. Assuming that mice were present on the grids it is puzzling that there was only a single capture in an Elliot trap on 686 trap nights on grid 6, and on a combined total of 1960 trap nights in the 10 mm bait area. Despite the lack of mice captured in the area it had been hoped that the use of snap traps to catch animals after aerial baiting would result in the capture of mice that were believed to be in the area, and have escaped from cage traps and avoided Elliot traps. This did not occur and only one mouse was captured during this period.

The ability to assess the uptake of bait by these species is also dependent on trapping animals to examine them for pyranine fluorescence with a UV light. Post baiting trapping was characterised by very low captures of rats with only 7.5% of those marked being recaptured, compared to 58.3% of marked mice. However, similar proportions of marked to unmarked adult rats and mice (41.7% c.f. 42.4%) were captured indicating that the low overall rate of marked rats in the sample was not a result of their previous capture experience, but rather a consequence of the low trapping rates.

Captures of rats were almost zero for first 5 days of trapping, i.e. 7 days from aerial baiting. One explanation is that rats were foraging as normal during this

period but were feeding entirely on the abundant cereal baits that were dropped, and were not attracted to the peanut butter and rolled oat baited traps. As the availability of the preferred food, in this case the bait, declined animals would have been more likely to seek alternative food and increase their probability of approaching a trap baited with peanut butter which would have increased probability of capture and translated to more captures.

An indication of bait available to each animal can be determined by estimating the numbers of animals inhabiting each grid. If we consider a mouse (mean wt 19.2 g) to be equivalent to ~0.1 rats (mean mass 207.4 g), and assume the population inhabiting the grid equates to the numbers of marked individuals (rats + mice – see Table 1), and then divide this into the product of the number of baits dropped per hectare (Table 2) and the size of the trapping grid (Table 1) then rats in the 5.5 mm zone had between 310 and 580 pellets (155 – 290 g) available to each of them, while mice had 31 and 58 pellets (15.5 – 29.0 g) and in the 10 mm zone rats had between 70 and 75 of the larger pellets (140 - 150 g), and mice 7 to 8 (14 – 15g).

An alternative suggestion is that rats cached pellets in the first few days after the bait drop, and then were not active on the grid until several days later when again searching for food, with the associated higher risk of capture. It would seem from the low proportion of marked rats caught compared to mice, that rats may show a stronger preference for the cereal baits to the exclusion of other food sources, which is beneficial in an eradication to ensure bait is consumed. If the rats did cache baits it increases the probability that during a toxic bait drop they would be more likely to succumb to toxicosis underground, and thus not pose a secondary poisoning threat to species that prey upon them.

The situation with mice differed in that captures did not show any changes during the trapping period, suggesting that while mice fed on the bait, they were also willing to take other available food as evidenced by their attraction to peanut butter in the traps.

Despite the apparent willingness of mice to take alternative food when bait is in abundance, uptake of 5.5mm bait was still 100% up to 6 days after the bait drop (Fig. 18), with the rate declining to 44% by day 9. In the context of an eradication operation, even if bait is in abundance and mice eat both bait and alternative food, based on a lethal dose of brodifacoum, (the toxin of choice for current eradications) of 0.4 mg/kg (Haydock and Eason 1997), a 20 g mouse would have to consume only 80% of a single 5.5 mm bait or 20% of a 10 mm bait to get a lethal dose of the toxin. Based on the uptake rates in the first days after the bait drop, it would appear that as long as bait is available at sufficient density to mice they will ingest it, and succumb to the effects of the toxin. At a baiting rate of 10 kg/ha, 20000 5.5 mm baits would fall per hectare, and 5000 10 mm baits. Given a combined rat and mouse density of 85 (75 rats and 100 mice rat equivalents based on a mouse being ~0.1 rat) each rat would have access to approximately 200 small baits and 50 larger baits, while the figures for mice would be 20 and 5. The available baits represent 25 times the lethal dose for mice, suggesting that there would be sufficient bait available.

The supposition in the study that rats are feeding intensively on the baits provides confidence that they would consume the required quantity of a toxic bait to facilitate eradication. A lethal dose of brodifacoum in ship rats is 0.46 mg/kg (O'Connor & Booth 2001), and therefore a 200 g rat would need to consume 2.5, 10 mm baits or 9, 5.5 mm baits to ingest this amount of toxin. Calculations above of bait availability to rats at a baiting rate of 10 kg/ha indicate that there would be around 20 times the required level of toxin available to kill animals. It is unclear why the marked adult rat captured in grid 3 on the second night after baiting had not consumed bait, but it may be reasonable to expect that if it had not been trapped it would have had the opportunity to consume the amount of bait required to receive a lethal dose. The marked juvenile rat that had not ingested bait was trapped in grid 1 which was only part baited during the aerial operation, and so during its movements it may not have encountered bait. This would not occur during an eradication given the comprehensive coverage across the entire island

In addition to the single mouse capture in the 10 mm bait area compromising the bait size comparison, the low numbers of rats captured at the two sites also prevented a statically robust assessment. Despite this shortcoming in the data, it is important to note that all rats and the single mouse captured in the 10mm bait area had consumed the bait, while uptake in the 5.5 mm bait area is discussed above.

Bait longevity

The period during which bait remains intact in the field is a critical factor in operational planning for any proposed eradication to be undertaken on LHI. The primary requirement is that the bait remains intact for long enough for the target species to encounter and consume it, once that criterion is met, any undue delay in decomposition of the remaining bait increases the risks to non-target species. In the case of LHI persistence of toxic bait will determine the period of high risk to human residents and pets, it will also determine when non-targets being held in captivity can be returned to the wild, and livestock returned to paddocks.

The observations suggest that both sizes of bait will persist for at least 55 days which is long enough for uptake by the target rodent species, but the more rapid breakdown of the 5.5 mm bait would facilitate a shorter holding period for island endemics such as Woodhen and Currawong, and livestock. At the time of writing this report, baits had been observed in the field for 55 days, after 164.2 mm rainfall. The only baits that had completely degraded (decomposition code 6) within this period were the 5.5 mm baits in medium cover, but all 5.5 mm baits were at a more advance rate of decomposition than the larger 10 mm baits (Table 7).

Decomposition rates may be slower than would be expected during an eradication operation as the cages in which they were held kept the baits off the ground which may reduce invertebrate and microbial breakdown. The elevation of baits off the ground also facilitates the drying of bait through air movement

after rainfall events, which assists in maintaining bait integrity. This may explain why baits in the open test area seemed to exhibit slower rates of decomposition than those in the higher humidity medium and full canopy cover areas.

All planning of captive management of island endemics and holding periods for livestock will utilise the slowest decomposition rates for a given bait size in the current study. Given the observation of the delayed decomposition of caged baits utilising the slowest decomposition rates will provide a conservative and safe estimate of the point at which risk to livestock and endemics is eliminated.

While final figures for decomposition times (in excess of 55 days) will only be known after this report has been submitted, it would appear that from an environmental risk standpoint, the more rapid breakdown of the smaller 5.5 mm baits would enable shorter captive periods for island endemics, livestock and risks posed to island residents through the presence of the toxin in the environment.

Non-target impacts

The potential for impact on non-target species is a very important planning issue for rodent eradications. While brodifacoum has been widely shown to be effective in eradicating mice and rats (Howald et al. 2007), it can pose risks to non-target species, both through primary and secondary poisoning (Eason and Spurr 1995, Towns and Broome 2003). These non-target issues are particularly important when the at-risk species are threatened endemic species such as the case with the Lord Howe Island Woodhen *Gallirallus sylvestris,* and LHI Currawong *Strepera graculina crissalis*. While the impacts of invasive rodents on offshore islands are widely accepted (Towns et al. 2006), and have been the catalyst for many eradications globally (Howald et al. 2007), non-target issues must be taken into consideration and methods of mitigating risk be incorporated into eradication planning processes.

The iconic status of woodhens on LHI, and their probable vulnerability to both primary and secondary brodifacoum poisoning, given the succeptibility of the congeneric New Zealand weka, *Gallirallus australis*, (Eason and Spurr 1995), focuses attention during any planned rodent eradication on non-target issues. On Tawhitinui island in New Zealand the entire weka population was exterminated during a brodifacoum baiting for ship rats (Taylor 1984).

The observation of woodhens consuming non-toxic bait during the study, and producing faeces that fluoresced confirmed expectations for this species. While the techniques used in the non-toxic trial do not enable us to determine the quantity of bait consumed, given the threatened status of this species it is prudent to prepare mitigation measures. In New Zealand weka were captured prior to a rodent eradication on Kapiti Island and successfully housed in captivity until release after bait disintegration (Empson and Miskelly 1999). A similar solution is suggested for woodhens on LHI. In addition to woodhens, currawongs are also thought to be at high risk of exposure to brodifacoum. The current study examined seven currawongs and none showed signs of bait ingestion. Despite the lack of evidence of either primary or secondary exposure

to bait, the potential risks posed to this threatened species during an eradication can not be ignored given the high probability of birds feeding on either dead or moribund brodifacoum poisoned rats and mice. Captive management of currawongs during any eradication operation is recommended.

Other bird species which showed signs of bait ingestion species during the study were blackbirds, mallards and buff banded rails. Both blackbird and mallard mortality resulting from brodifacoum poisoning have been recorded in New Zealand eradications (Dowding et al. 1999). None of these three species is threatened, nor are they endemic to LHI. It is not recommended that any measures be taken to mitigate impacts of toxins. Island endemics the LHI Golden Whistler, *Pachycephala pectoralis contempta*, and the LHI Silvereye, *Zosterops lateralis tephropleur* were both negative for bait uptake.

Several emerald ground doves were examined during the trial and despite the expectation that they would be vulnerable to ingestion of the bait, there was no evidence collected to support that view. An individual was also observed picking up bait, but soon dropped it and showed no further interest. Kingfishers, magpie lark and purple swamp hen also showed no evidence of bait uptake, although kingfishers may be vulnerable through secondary poisoning, and purple swamp hens are known to suffer significant (~50%) mortality during New Zealand rodent eradications (Dowding et al. 1999).

While no Masked Owls (*Tyto novaehollandiae*) were captured during the trial an opportunistic discovery of the remains of an owl kill indicated it had fed on a bird which had ingested bait. In cases where such prey species had fed on toxic baits predators are vulnerable to secondary poisoning. Work in New Zealand has shown that Moreporks (native owls), *Ninox novaeseelandiae,* have been killed during brodifacoum operations (Stephenson et al. 1999). The removal of rodents as a source of prey for Masked owls will result in them switching prey, possibly to endemic species, and it would be appropriate to undertake a cull or attempted eradication of the owl during any rodent eradication. In addition to avian non-target species, 21 large forest bats were examined and found negative for bait uptake. This species is potentially at risk from secondary poisoning from invertebrates it may consume.

Several invertebrates either fluoresced under UV light, or were observed feeding on the bait. While invertebrates are known to consume anticoagulant baits (Ogilvie *et al.* 1997, Spurr and Drew, 1999) they do not have the same blood clotting systems as vertebrates and are therefore thought to be at low risk of toxicosis from ingesting brodifacoum. Indeed a review of brodifacoum impacts on non-target species in New Zealand reported no mortality to invertebrate species as a result of brodifacoum baiting (Hoare and Hare 2006). More importantly brodifacoum residues of up to 7.47 µg/g have been recorded in NZ terrestrial invertebrates (Craddock, 2003). Residue levels take in excess of four weeks to return to background levels, and trace levels are detectable up to ten weeks following brodifacoum baiting operations, which potentially poses a risk to insectivorous bird species (Booth *et al.*, 2003; Craddock, 2003).

Notwithstanding the potential risk of secondary poisoning, the only reported case of insectivorous birds succumbing to brodifacoum poisoning was in a zoo, where several species died in an aviary after feeding on pavement ants and cockroaches that had eaten brodifacoum baits (Godfrey 1985).

While brodifacoum clearly impacts non-target species (Hoare and Hare 2006), short term losses of individuals are more than offset by population level benefits resulting from rodent eradication (Towns and Broome 2003).

Aerial baiting

Aerial broadcast by helicopter is becoming the most common method of rodenticide delivery (Towns & Broome 2003), and the current study provided valuable experience in planning and conducting an aerial baiting operation. The spreader bucket worked flawlessly, and we were able to establish the correct flight configuration: air speed and aperture ring size to produce the required flow rate of bait during operations. Methodologies for loading procedures, and determination of bait usage on flight runs were developed for use in future baiting operations.

Problems with the interface between office computers and the aircraft's onboard digital GPS system to allow the uploading of baiting areas and flight lines have been resolved since the trial and will be incorporated into all future operations.

The aerial baiting operation attracted considerable attention from island residents, and provided an opportunity to further discuss eradication plans with them.

Conclusions

While the primary function of the bait used in an eradication attempt is to remove rodents, its impacts on non-target species must be taken into consideration when planning an operation. Results on uptake of bait while equivocal, suggest that both are palatable to both species of rodents. Further testing of the two sized baits should be undertaken, with some modifications to experimental design to try to achieve 100% bait uptake. Assuming both bait sizes produce the required result relating to uptake, then what other factors should be considered when choosing the bait for an eradication?

Risk to non-target species can largely be mitigated in an operation on LHI by putting populations of high risk species (woodhens, currawongs and possibly *Placostylus* snails) into captivity to prevent them accessing baits, or consuming dead and dying poisoned rodents. However, captive management poses its own risks and periods of captivity should be kept to a minimum. The period of captivity will be determined by the length of time that uneaten baits remaining in the environment take to break down to a point at which they are no longer in a form that they may be ingested. Preliminary data on bait decomposition suggests that the smaller 5.5 mm baits decompose at a more rapid rate than the larger 10 mm baits, thus posing a risk for a shorter time period.

The success of the aerial baiting operation during this project confirms that this technique can be used to bait a significant proportion of the island outside of the settlement area during an eradication. Problems associated with uploading of bait areas during the project have subsequently been solved, and future aerial baiting will utilise accurate bait maps prepared prior to flying uploaded onto the aircraft's GPS system.

Work conducted during the project has provided valuable input to the planning of a future rodent eradication on LHI.

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