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Evaluation of bait stations and management options for control of dama wallabies (*Macropus eugenii*), in the Bay of Plenty, New Zealand.
Evaluation of bait stations and management options for control of dama wallabies (*Macropus eugenii*), in the Bay of Plenty, New Zealand.

by

Dale Williams

A research report submitted in partial fulfilment of the requirements for the Diploma in Wildlife Management.

January 1997

University of Otago Wildlife Management
Report Number 85
5. FIELD ASSESSMENT OF BAIT STATION USE, BY WALLABIES. (A FIELD STUDY OF FERAL WALLABIES, OKATAINA SCENIC RESERVE AND PAEHINAHINA PENINSULA, LAKE ROTOITI)

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EXECUTIVE SUMMARY:

INVESTIGATION TITLE: Evaluation of bait stations and management options for dama wallabies (*Macropus eugenii*), in the Bay of Plenty, New Zealand.

STUDY VENUE: Rotorua.

INVESTIGATOR: Dale Williams.

OBJECTIVES:

1. Review information on the colonisation, impacts and past management of dama wallabies in the Bay of Plenty.
2. Identify an effective bait station for delivering cereal bait to dama wallabies.
3. Identify any physical or behavioural characteristics of dama wallabies that may influence the efficacy of using bait stations as a control technique.

METHODS:

This report is based on:

1. A review of the colonisation, impacts, past management practices, and possible options for the control of dama wallabies.
2. Time-lapse video equipment was used to observe captive wallabies at Rainbow Springs as they feed from three makes of bait station.
3. Rhodamine dyed non-toxic bait was placed in bait stations at the Okataina Scenic Reserve and Paehinahina Peninsula, Lake Rotoiti. Time-lapse video and faecal pellet searches were used to assess the feeding activity of feral wallabies and possums.

RESULTS AND RECOMMENDATIONS:

- Dama wallabies are continuing to spread within the Bay of Plenty. To prevent further expansion of their feral range, management action must be targeted at sites of highest priority, based on rate of spread, or their proximity to sites of high conservation value, or lands of all tenure.
Past aerial poisoning operations have achieved very high kills on wallabies, but to allow highly palatable plant species to recover, wallaby numbers will need to be kept at very low levels for a sustained period. The success of control should be judged on vegetation response therefore vegetation monitoring must also continue.

To make best use of pest control resources, management action on wallabies should be coordinated with the control of other pests and the impacts of control on other wildlife should be monitored.

To ensure control is efficient and sustainable, toxins, baits, and a variety of control options including bait stations need to be tested on wallabies.

A public awareness campaign on the impacts and dispersal of wallabies should be initiated, and public concerns about methods of control need to be addressed.

Captive wallabies were initially reluctant to feed from the “Philproof bait feeder”. Of the three stations tested, the Marley downpipe “hockey stick” station was the most preferred by wallabies.

Bait stations should be mounted with the entrance no higher than 400 mm above the ground, as this provides easy access to bait for all age classes of wallaby.

During observed interactions between wallabies and possums, wallabies were displaced from the bait station. At Paehinahina possum densities are low (8.5 possums/100 trap nights), there was very little overlap in feeding times and only 4 interactions between wallabies and possums were observed. At Okataina where possum densities are high (c.50 possums/100 trap nights), there was no evidence that wallabies were feeding from the bait stations, though I was unable to confirm that possums were preventing wallabies from accessing bait.

A well designed management experiments using toxic bait in bait stations, would be the most practical way to further investigate the efficacy and efficiency of bait stations for the control of wallabies. Suitable techniques for monitoring both wallabies and possums are needed. Bait containing a marker dye and time-lapse video are useful techniques for monitoring bait station use.
1. INTRODUCTION:

1.1 Why are dama wallabies a problem?

A feral population of dama wallabies (*Macropus eugenii*) has been established in the Bay of Plenty, New Zealand, since 1912. Dama wallabies have been responsible for severely depleting the understorey vegetation of indigenous forest, and compete with domestic stock for pasture. Despite substantial reductions in wallaby following aerial poisoning operations at the Okataina and Makatiti, it appears that wallabies to inhibit the regeneration of highly palatable plant species. If regeneration of highly palatable indigenous plant species is desired then wallaby numbers will have to be maintained at extremely low levels.

1.2 What do managers need to know about dama wallabies?

To develop an effective and efficient management programme for wallabies in the Bay of Plenty, it is important to identify any aspects of wallaby behaviour that may limit the effectiveness of a particular control technique, or lead to the development of more cost efficient control.

1.3 Why are toxins used in the control of wallabies?

Past aerial and natural foliage bait poisoning operations have achieved extremely good kills on dama wallabies. Night-shooting has been used as a method of control in the past, but is only practical at sites with vehicle access. Any benefit to indigenous forest, from night shooting is likely to be limited to farm/forest margins. Trapping techniques for wallabies are too labour intensive to be of use as a control measure. Given the high cost and time involved in the development of biological control strategies, it is likely that toxins will remain the key option for controlling wallabies for some time yet.

1.4 Why use bait stations?

Bait stations have a number of advantages over other control techniques and are being used more frequently on a variety of animal pests. Given a well designed station, bait can be protected from the weather, increasing the time that it is available to the pests. The amount of toxin used may be reduced, and any unused or spoiled bait can be removed from the site. Bait stations may reduce the risks to
non-target species, and facilitate the use of new toxins that are not suitable for aerial broadcasting.

Dama wallabies appear to be highly susceptible to sodium monofluoroacetate (1080). Past aerial poisoning operations have achieved extremely good kills, but due to increased public concern about the use of toxins for pest control, in particular the aerial broadcasting of 1080, alternative control techniques warrant investigation.

2. OBJECTIVES:

(1) Review information on the colonization, impacts and past management of dama wallabies in the Bay of Plenty.

(2) Identify an effective bait station for delivering cereal bait to dama wallabies.

(3) Identify any physical or behavioural characteristics of dama wallabies that may influence the efficacy of using bait stations as a control technique.
3. DAMA WALLABIES IN THE BAY OF PLENTY. (A REVIEW OF COLONISATION, IMPACTS AND MANAGEMENT OPTIONS):

3.1 Description:

Dama wallaby *Macropus eugenii* (Desmarset, 1817). Also called tammar, silver grey, or Kangaroo Island wallaby. For this report all references to “wallaby”, unless otherwise stated refer to *M. eugenii*.

![Photo. 1: Dama wallaby (Macropus eugenii), Flinders Chase National Park, Kangaroo Island, Australia. D.S. Williams 1991.](image)

Of the six species of wallaby introduced to New Zealand the dama is one of the smallest. Mature males weigh 4 to 7 kg while females weigh 3 to 5 kg (Williamson 1986). In comparison Bennett's wallabies (*M. rufogriseus*) which are found in South Canterbury can weigh more than 20 kg (Warburton & Sadlier 1990).

A marked difference in the size of mature dama wallabies from different habitats within the Bay of Plenty and from Kawau Island has lead to past speculation that two species of wallaby were liberated, however it is more likely that these size
differences are related to the quality of their diet (Williamson 1986, Warburton & Sadlier 1990)

3.2 Colonisation and distribution:

Dama wallabies were liberated in the Bay of Plenty around 1912. It is not clear whether the Bay of Plenty stock came from those released by Sir George Grey on Kawau Island in 1870 or originated from a separate introduction from Australia (Wodzicki & Flux 1967).

They have established in both exotic and indigenous forest, preferring habitat with access to pasture or grassed clearings. Their greatest concentrations occur near the original liberation site in the Okataina and Matakite Scenic Reserves and their initial rate of spread has been slow, 0.22 km²/yr (Warburton & Sadlier 1990).

A recent assessment of the distribution of wallabies in the Bay of Plenty suggests that the feral range of wallabies has remained relatively static since the last survey in 1978 (Strickland 1994). There is however a major discrepancy between the 1978 range indicated by Strickland (1994) and the 1979 distribution shown in Warburton & Sadlier (1990) (Map. 1.).

Discussion

The 1978 boundary of distribution that Strickland used appears to be from an unpublished report by Farmer & Moore (1980) which includes confirmed sightings of individual wallabies, whereas Strickland did not include these “itinerant sightings” when he defined the 1994 boundary of distribution. Warburton & Sadlier (1990) used the same base maps from by Farmer & Moore (1980) but adopted the more conservative protocol of not including “itinerant sightings”.

By transposing the 1979 distribution from Warburton & Sadlier (1990) onto Strickland’s maps a more dramatic increase in the feral range is indicated. The area within the 1979 and 1994 ranges are 74 296 and 98 430 hectares respectively. This is an increase of 16.08 km²/yr, (cf. 0.22 km²/yr from Warburton & Sadlier (1990)).
Map 1: Wallaby distribution

  see Warburton & Sadlier (1990)

Areas where detailed ground survey is required

1. South of the main Paeroa range to the Waikato river.
2. South of Rainbow Mountain through Waiotapu.
3. Southwest of Mount Ngongataha into the southern Mamaku range.
In some areas natural physical barriers such as large rivers and deeply incised gorges are preventing the spread of wallabies in the Bay of Plenty, however once these barriers are breached by animals crossing road bridges or via illegal liberations, active control is needed to prevent further extension of the current feral range.

Attempting to control wallabies on the margin of their current feral range presents a number of problems;

(i) The objectives of control are similar to that of eradication in that the desired outcome is no wallabies (on one side of an arbitrary line), however without a physical barrier, there is always the possibility of reinvasion, therefore control will need to be sustained in perpetuity.

(ii) Except were impassable physical barriers exist, control must be carried out along the entire margin of the feral range. This may mean that control needs to be carried out on land of low conservation or economic value. Initially priorities for control can be targeted at areas of the margin; (a) where spread, is most rapid, (b) closest to wallaby free areas of high conservation value, or (c) close to areas where wallaby control would be most difficult were wallabies to become established.

(iii) Wallabies may be at very low densities resulting in difficulty in monitoring their density and impact. Cost of control per animal killed normally increases proportionally as animal densities decrease.

(iv) To achieve effective control on wallabies, other animal pest such as possums (*Trichosurus vulpecula*), may also have to be controlled (section 5.5.1).

Strickland’s report identifies three areas where wallaby distribution has increased and more detailed ground survey is recommended; (1) South of the main Paeroa range to the Waikato river and possibly beyond. (2) South of Rainbow Mountain through Waiotapu. (3) Southwest of Mount Ngongataha into the southern Mamaku range.

Recent sightings of wallabies at Otawhainuku south west of Te Puke are also of concern to the Department of Conservation (DoC).
Recommendations

- High priority should be given to assessing wallaby density in areas with a high rate of spread, as identified in Strickland (1994).
- Determine sites requiring most urgent management action, by developing a priority ranking system.
- Reduction in the risks of illegal liberations of wallabies can be achieved through effective enforcement of legislation\(^1\) relating to live capture, keeping and conveyance of wallabies. DoC needs to review its administration of this legislation.
- A public awareness campaign on the impacts and dispersal of wallabies should be initiated.

3.3 Population biology and diet:

To date the most comprehensive study of wallabies in the Bay of Plenty, is (Williamson 1986). This research focused on the diet, population biology, and movements of wallabies. Of Williamson's conclusions those most relevant to the management of wallabies on land administered by the Department of Conservation (Conservation lands) are;

(i) Wallabies are preferential grazers, where they have access to pasture, upwards of 70% of their diet consists of pasture species;

(ii) In forest habitat, the preferred food of dama wallabies includes; mahoe (*Melicytus ramiflorus*), kamahi (*Weimannia racemosa*), hangehange (*Geniostoma rupestre*), porokaiwhiri (*Hedycarya arborea*), and kanuka (*Kunzea ericoides*).

(iii) Rhodamine trials indicate that wallabies may travel at least 400 m from within the forest to pasture margins to feed.

A radio telemetry study of wallaby daily home range, seasonal variation in home range and dispersal patterns, is currently being undertaken by a post graduate student from Massey University (Lentle et al. in prep.).

3.4 Impacts on vegetation:

Dama wallabies have been implicated in severely depleting the understorey vegetation of indigenous forests in the Okataina Scenic Reserve (Knowlton and Panapa 1982) and are identified as the primary agents inhibiting the regeneration of palatable understorey species (Llewellyn 1988a, Wallace 1996).

In 1984 two exclosure plots, designed to differentiate the effects of deer and wallabies on the forest understorey\(^2\), were established near Oruaroa Point on the Eastern Shores of Lake Okataina. When remeasured in 1988 the vegetation response to the relief from browsing was marked (Llewellyn 1988a). The number of plant taxa within each exclosure had more than doubled and the stature and frequency of occurrence of some tree and shrub species had increased dramatically. In one exclosure there were 22 times as many stems taller than 15 cm, as on the associated control (experimental non-treatment) plot. From these results it was concluded that; wallabies have been responsible for severely inhibiting understorey development in kanuka (*Kunzea ericoides*) and kamahi (*Weinmannia racemosa*) forest associations. Deer (at low density) appear to limit stocking of stems taller than 75 cm (Llewellyn 1988a).

In 1992 the exclosure plots and 36 permanently marked 20 x 20 metre vegetation plots were remeasured (Wallace 1996). Results from the exclosure plots further reinforced the findings of Llewellyn in that since establishment; species diversity increased by 142% where both deer and wallabies were excluded, 57% where wallaby but not deer were excluded, and declined by 7% where browsing was not restricted.

Despite a large reduction in wallaby numbers at Okataina following an aerial poisoning operation in 1987 (section 3.5.3) and some ongoing ground based control (handspread 1080 pellets), there has been no significant increase in regeneration of palatable species in the understorey of kamahi and kanuka forests (Llewellyn 1988b, Wallace 1996). Factors such as the deep leaf litter and low light levels beneath the canopy of these forest types may also be responsible for inhibiting seedling germination, however corresponding increases in the

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\(^2\) Exclosure one is surrounded by a 2m fence, which excludes deer, and wallabies, (+ pigs). The fence around exclosure two is 1m high, which excludes wallabies, (+ pigs) but allows deer to jump in and out of the plot.
abundance of unpalatable species suggests that browsing mammals are still having a major adverse effect (Wallace 1996).

Williamson (1986) noted that dama wallabies in the forest habitat rely upon leaf-fall to supply some foods, in particular kamahi and mahoe. Wallace (1996) draws a comparison with the work of Nugent (1990) on fallow deer in the Blue Mountains and suggests; "If seedlings are preferred over litterfall then a reduction in wallaby numbers will only result in more litterfall remaining uneaten; palatable seedlings will still be preferentially removed by the few remaining wallaby. If regeneration of highly palatable species, in the kamuka forest understorey is the desired outcome then wallaby numbers will have to be maintained at a much lower level than at present".

Discussion

All of the above research indicates that wallabies and to a lesser extent other introduced animals (deer, possums, and feral pigs (Sus Scrofa)) are having an adverse impact on indigenous vegetation. To minimise these impacts introduced animal numbers must be reduced. Past aerial poisoning operations have been very effective at reducing wallaby numbers but have failed to achieve the desired response in vegetation. It appears that wallaby, and other herbivore, numbers
must be maintained at very low levels to allow highly palatable species to regenerate. Control not only needs to be very effective but it will need to be sustained in perpetuity.

If the objective of wallaby control is regeneration of highly palatable species (e.g. mahoe, kamahi, hangehange, and kanuka) these plants must be monitored. Success of a control operation must be judged on vegetation response, and not on the number of pests killed. As the remeasurement of 20 x 20 plots is time consuming and expensive the development of a simple yet robust monitoring technique that focuses on palatable seedlings would be desirable.

To define what density pest populations must be held below to achieve the desired goal, ("environmental damage threshold"), active management in conjunction with robust monitoring will need to be carried out over a number of years. Defining what the desired goal is and what level of damage can be tolerated is a value judgment that must be based on national and regional priorities.

The Department of Conservation (DoC) already uses a national priority ranking system for its possum and goat control. Because of their limited distribution wallabies could be viewed as a regional problem, however where wallabies are having an adverse impact on plant communities that are of national significance they are an issue of national importance.

The Lake Okataina, Tarawera, and Rotoiti Scenic Reserves are listed as priority sites in DoC’s National Possum Control Plan. Possum control in these areas is currently carried out by contract hunters and does not target wallabies.

**Recommendations**

- Evaluation wallaby impacts at sites where possum and goat control is being currently carried out. To do this DoC needs to review its pest control priorities in the Bay of Plenty.

- Review and rank, by the Regional Councils, the management of wallabies on private land containing indigenous forest and shrublands or adjacent to priority conservation lands.

- If wallaby control is to recommence at Okataina, it must include intensive maintenance control.

- Suitable methods of maintenance control need to be investigated.
• Vegetation monitoring must continue at Okataina, and if possible simplified monitoring techniques developed.

3.5 Control techniques:

3.5.1 Trapping:

There are several companies that capture and export live wallabies. They use a variety of capture techniques including; netguns, bulldoging or netting from vehicles, large box traps, and pit traps.

Wallabies are occasionally caught in leg-hold traps set for possums, but because of their powerful hind legs they often escape.

To catch wallabies for his radio telemetry study Massey University student Dr. Roger Lentle developed a pen and net capture technique (Lentle et al. in press).

All of these trapping techniques are very labour intensive and none are catch efficient enough to be used as a control measure. Commercial live capture operations are unlikely to reduce wallaby number sufficiently to produce conservation benefits.

3.5.2 Shooting:

Dama wallabies are predominantly nocturnal, where they have access to open pasture they generally leave forest cover to feed in the open after dark.

Night shooting, with the aid of a spotlight, to control wallabies has been carried out in the past by staff from the former Central Bay of Plenty Pest Destruction Board. In the early 1980's Pest Board staff were shooting in excess of 1000 wallabies per year (Warburton 1986). A report by Pest Board Supervisor, David Moore (1986) estimated the cost of night shooting from a motorcycle, at that time, at $4 to $12 per animal destroyed. Moore questioned the economics of this method of control, for small potential gains in agricultural or forestry production, and recommended that night shooting be discontinued.

Because night shooting is only practical at sites with vehicle access, any conservation benefit to indigenous forest, from this control technique would be limited to farm/forest margins.
Wallabies can be hunted during the day, and recreational hunters (including bow hunters) show a moderate level of interest in hunting them. Unfortunately few hunters complete their “kill returns”\(^3\) (<10%) so the annual harvest can not be accurately estimated.

A study of recreational hunting in New Zealand has shown surprisingly high estimates of annual harvest rate for various game animals (Nugent 1992). Though wallabies were the least hunted small-game animal (probably due to their limited distribution) this study estimated the annual harvest (for all species of wallaby) at 14,992.

**Discussion:**

Moore (1986) concluded that the cost of using paid staff on night shooting operations for wallabies outweighed the benefits of control at that time. Recreational hunters kill large numbers of browsing mammals, including wallabies with no direct cost to DoC. Though there are costs associated with issuing hunting permits, under current legislation these cost are unavoidable, and have little relationship with any outcome (benefit or otherwise) gained from recreational hunting.

Recreational hunting alone may not be sufficient to achieve “conservation benefits” at high priority sites. If vegetation responds in a “stepped” fashion to a reduction in browsing mammal numbers, as predicted in Nugent (1990), recreational hunting may be of some benefit, for moderately palatable plants, at sites where no other control is being carried out.

Recreational hunters can also provide useful information on animal distribution and relative density. A comparison of population indices derived from both faecal pellet counts and hunter diaries (kill returns) was carried out at Pureora (Fraser 1996). This study concluded that information gathered through hunter diaries was approximately 75% cheaper to collect than faecal pellet counts and results from both methods of assessment were similar.

\(^3\) The part of a hunting permit that the hunter completes and returns to DoC outlining; the length of time spent hunting and the number of animals seen or killed.
**Recommendations:**

- To determine annual harvest and trends in the relative density of wallabies, DoC Bay of Plenty should develop a hunter diary system, similar to that currently being used by DoC Waikato.

- A survey of recreational hunters could be conducted to gain more detailed information about the demographics of wallaby hunting and harvest.

Both of the above recommendations will require an increase in the current level of advocacy between DoC and recreational hunters.

**3.5.3 Aerial poisoning:**

Eight aerial 1080 operations, targeting wallabies, were carried out between February 1962 and August 1963. A large percentage of the wallaby feral range was treated with the operations covering much of the area between Lakes Rotoma, Rotoiti Tarawera and Rotorua. Follow-up control involving hand-laid 1080 baits and shooting was carried out on ratable land (Warburton 1986). I have no information on the effectiveness of these operations.

Subsequent aerial 1080 operations carried out by DoC achieved extremely good kills on wallabies. Aerial poisoning at Okataina in 1987 reduced the population by 96.6%. In 1988 at Makatiti a 93.3% kill was achieved. Both these operations used cereal based "Mapua" bait, surface coated with 1080 to achieve a toxic loading of 0.15% wt/wt. The bait was broadcast from a fixed wing aircraft at a sowing rate of 6 kg/ha. Assessment of the percent reduction was based on the recruitment of faecal pellets onto cleared plots (80 cm radius), prior to and after the poisoning (Llewellyn 1988b).

**Discussion:**

Over recent years organisations attempting to carry out aerial 1080 operations have faced a large amount of public opposition. In some cases there is concern about the toxin itself, while in others it is the perceived non-selective nature of the application technique. Because of these concerns, monitoring the impacts of poisoning operations on birds and to a lesser extent invertebrates, has become routine (Spurr 1994, Spurr 1996).
From a management perspective a toxin and application technique that controls more than one animal pest simultaneously is desirable, however adequate monitoring of other pest species through poison operations is often over looked (Fraser et al. 1995).

The impact of the Okataina and Makatiti poisoning operations on the deer pig population was not estimated by Llewellyn (1988b), presumably faecal pellet densities were too low. However it is interesting to note that the reduction in possum numbers following these operations were insignificant (0.9%).

Possible causes for the extremely poor kill on possums is outlined in Llewellyn (1988b);

(i) Poor bait distribution. Gaps of up to 250m between swathes occurred, this would have reduced the possum kill even in the absence of wallabies.

(ii) Wallabies competed for bait more effectively than possums. Wallabies are earth bound and feed by day and night, while possums are nocturnal and feed time is split between forest floor and canopy.

(iii) Possums spend a higher than normal proportion of their time in the canopy, than is normal for other possum populations. Because of the severely depleted state of the understorey at Okataina and Makatiti, there is little advantage for possums to spend much time feeding on the ground.

(iv) Rain immediately following the application of the bait would have reduced the time toxic baits were available to possums.

The bait application rate used at Okataina and Makatiti (6 kg/ha) was low. It has only recently become common practice to use application rates much below 10 kg/ha. Navigational aids such Differential Geographic Positioning Systems (DGPS) where not available when these operations were carried out so it is not surprising that gaps in the distribution occurred. The increased mobility of wallabies over possums would mean that wallabies were more likely to encounter bait, therefore the quality of bait distribution will influence the efficacy of control on possums more than on wallabies.
Recommendations:

- Public concern about aerial poisoning for wallaby control needs to be addressed.
- The impacts on deer and possums and pigs should be monitored using robust techniques. If further aerial poisoning is carried out to control wallabies.

3.5.4 Natural foliage bait poisoning:

An assessment of the effectiveness of 1080 gel on foliage, as a control technique for wallabies, was carried out by the Forest Research Institute (Warburton 1989). The trial was conducted on a pasture margin site adjoining the Okataina Scenic Reserve. The gel had a 5% concentration of 1080 and was produced by the Wanganui poison factory4, specifically for the former South Canterbury Wallaby Board.

The palatability of seven varieties of foliage baits were tested, the kill was assessed by counting the recruitment of faecal pellets on cleared plots, and the effectiveness and cost were compared with aerial control.

Where available kapuka (*Griselinia littoralis*) appears to be the best natural bait, because it has a high acceptance, and an ability to withstand desiccation and the phyto-toxic effect of 1080. The mean percent kill achieved was 87.2% (± 6.6%), which was not significantly different from the Okataina and Makatiti aerial poisoning operations. The cost of foliage baiting was estimated at $8.57 per ha compared with $11.86 per ha for aerial poisoning. Foliage baiting is labour intensive and the cost will increase if the terrain is steep or access is difficult.

Discussion:

Foliage baiting was used in an experimental control operation targeting white-tailed (*Odocoileus virginianus*) deer on Stewart Island. It reduced the deer population by over 90% (Challies and Burrows 1984). Estimates for

4Now known as Animal Control Products Ltd. Wanganui.
deer reductions following aerial 1080 operations range between 30 and 40% (Fraser 1989, Fraser et al. 1995).

Foliage baiting would be an option if a reduction in both wallaby and deer numbers were desired but it is likely that recreational deer hunters would rigorously oppose this form of control.

3.5.5 Bait stations:

The former New Zealand Forest Service investigated the use of bait stations for the control of wallabies on Kawau Island (in the Hauraki Gulf). The bait used contained the anti-coagulant toxin pindone. Because of the extremely sparse forest understorey (i.e. food resources were very limited), wallabies fed freely from the stations, however the work was abandoned because it appeared that the wallabies were consuming an “uneconomically” large amount of bait before dying (D. Hunt, pers. comm.).

The Bay of Plenty Regional Council (Environment Bay of Plenty) trialed bait stations and “Double strength” pindone (0.05% wt/wt pindone in cereal based "Agtec" pellets) for wallaby and possum control at Okataina (Moore 1991).

Approximately 700 kg of bait was used and the carcasses of; 64 wallabies, 106 possums and 25 rats (Rattus sp.) were located.

The trial’s experimental design had a number of weaknesses;

(i) Pre-poisoning animal densities were not estimated. The effectiveness of control was assessed by searching for dead animals. Therefore a percent kill can not be estimated.

(ii) Bait was not only dispensed through the bait stations but was also scattered by hand (because they thought possums were dominating access to the stations). Therefore the effectiveness of bait stations can not be determined from this work.
Discussion:

Despite the poor experimental design, the results from Moore’s work and that from Kawau Island indicate that the effectiveness of bait stations as a control technique for wallabies warrants further investigation.

Bait stations have a number of advantages over other control techniques (Thomas 1994);

(i) bait can be protected from the weather, increasing the time that toxin is available to the pests,

(ii) the amount of toxin used may be reduced,

(iii) unused or spoiled bait can be removed from the site,

(iv) bait stations may reduce the risks to non-target species,

(v) new toxins that are not suited for aerial broadcasting can be used, and

(vi) bait consumption can be used as an indication of animal numbers.

Recommendations:

• Conduct a robustly designed management experiments using toxic bait in bait stations.

• Further investigate; bait station spacing and type, toxins (section 3.6) seasonality and different habitat type on the efficacy and efficiency of control.

• Suitable monitoring techniques for both possums and wallabies need to be used.

• Monitoring the impacts of various baiting strategies on shiprats (Rattus rattus) would be desirable but as specific monitoring techniques are required this would involve extra cost.

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5 The validity of using bait consumption to monitor animal density is undermined if more than one species has access to the bait.
Photo. 3: Marley downpipe bait station, Paehinahina, Rotoiti. D.S. Williams
3.6 Toxicology, baits and baiting strategies for wallabies:

Formal toxicology experiments involving wallabies are rare.

The majority of recent research into toxins, baits and control strategies in New Zealand has focused on possums. They are much more widespread than wallabies, and are causing significant damage to indigenous ecosystems throughout the country. Possums and other animal pests not including wallabies pose a threat to the beef and dairy industry, through the transmission of bovine tuberculosis.

Given the high cost and time involved in the development/testing of biological control strategies for mammals, it is understandable that research in this field is also focusing on possums and agricultural pests such as rabbits (*Oryctolagus cuniculus*). It is therefore likely that toxins will remain the key option for controlling wallabies for some time yet.

3.6.1 Acute toxins:

**Sodium monoflouroacetate (1080):** Peters (1984) gives an “average full lethality” for Bennett’s wallabies (*Macropus rufogriseus*) of 0.5 mg 1080 per kg of body weight. Peters used captive animals, captured from the wild, and estimated that for an average 10 kg animal the full lethal dose would be c. 5 mg/animal. Of 14 animals tested all died within 72 hours (10 died within 24 hours). Peters recommended that a toxic load of 6 mg 1080/bait (0.15% wt/wt) be provisionally adopted for Bennett’s wallaby control.

Peters’ recommendations are in line with the practice of ensuring that each bait contains a lethal dose for the target animal. Provided the animal can not detect the toxin at this dose rate, and consumes one whole bait, it will die. Optimizing the toxic loading of the bait may reduce the risks animals of developing “learned bait aversion”. Learned aversion or “bait shyness” is where a particular food (i.e. bait) is rejected on subsequent exposure following illness, in this case though consumption of a sublethal dose of poison (Morgan et al. 1996, O’Connor & Matthews 1996). Learned bait aversion in possums is probably responsible for poor possum kills in areas where possums had been previously exposed to low-strength (0.02% 1080) rabbit baits (Hickling 1994).

Of 21 species of animals listed in McIlroy (1994), Bennett’s wallaby (*M. rufogriseus*) is ranked the most sensitive to 1080 (c. 0.21 mg/kg).
Comparison between animals of a different genus (or even individuals of the same genus, particularly when they are from different localities) should be treated with caution, however as dama wallabies are approximately half the average weight of Bennett’s wallabies, it is a reasonable assumption that a standard possum bait loaded with 6 mg of 1080 (0.15% wt/wt) will contain a lethal dose for a dama wallaby.

Twigg (1993) lists an LD₅₀ of 0.3 mg/kg for *M. eugenii* and 0.2 mg/kg for *M. rufogriseus* which supports the above assumption.

Where dama wallabies (*M. eugenii*) co-exist or have had past exposure to plants containing flouroacetate the LD₅₀ could be as high as 20 mg/kg (Twigg 1994). The exact origin of the Bay of Plenty population of dama wallabies is not clear (Wodzicki & Flux 1967a), but provided they originated from South Australia, Victoria, or New South Wales (States without flouroacetate-bearing plants) the assumption of high susceptibility to 1080 is valid.

**Cyanide:** Cyanide paste, which has been commonly used for killing possums, kills wallabies (D. Moore pers. comm.), but I could not locate any documented estimates of what proportion of a wallaby population are susceptible to this method of poisoning. Cyanide kills very quickly which is an advantage where recovery of dead animals is important (hence its use by hunters working in the possum fur industry), but because of its rapid action, bait aversion in possum populations exposed to cyanide is common.

An encapsulated cyanide bait designed to overcome aversion by eliminating emissions of cyanide gas (which is highly volatile), is currently under development. Once released this product should be tested on wallabies, as it may prove to be a cost effective technique for both wallabies and possums. It may also be useful as a monitoring technique.

### 3.6.2 Chronic toxins:

Chronic toxins, in particular the anti-coagulants pindone and Talon®, which were primarily developed as rodenticides, are being used more commonly in New Zealand for control of a variety of animal pests. These toxins have a number of advantages; they are available to pest control agencies and the public, and are less likely to cause learned bait aversion, because the delay
in the onset of poisoning symptoms is sufficient to ensure that a toxic dose is consumed (Eason 1996, Hickling et al. 1996).

**Brodifocoum (Talon®):** The single dose oral toxicity (LD₅₀) of brodifocoum (Talon®) for Bennett’s wallabies as 1.3 mg/kg. This is alarmingly high when compared with the listed LD₅₀ for possums (0.17 mg/kg) (Godfrey 1985). It is also considered that the lethal dose required for animals in the field may be double that of the caged animals normally used in for such experiments (R. Henderson, pers. comm., Eason & Warburton 1996).

Based on an average weight of 10 kg for Bennett’s wallabies and an LD₅₀ of 1.3 mg/kg, 50% of the population would need more than 13 grams of toxin to receive a lethal dose. Talon® 20P possum bait contains 20 milligrams of brodifocoum per kilogram of bait. To ingest a lethal dose, on average a Bennett’s wallaby would need to consume 648 g of bait (or 433 individual 1.5 g Talon® 20P possum baits, each containing 0.03 mg of toxin).

Dama wallabies are approximately half the size of Bennett’s wallabies. If you assume a similar susceptibility for both species, 50% of a dama wallaby population would need more than 324 grams of Talon® 20P (or 216 baits) to receive a lethal dose.

It is currently considered uneconomic to use Talon® for possum control unless densities are moderately low (10 possums per 100 trap nights or less) (M Thomas, pers. comm.). Given the above calculations the economics of using Talon® for wallaby control are likely to be marginal unless densities are very low.

**Pindone:** Pindone has been used in New Zealand to control rabbits and to a lesser extent possums. Eason & Jolly (1993) concluded that possums are relatively tolerant to pindone, “even after daily administration for 5 days, until given at 64 mg/kg per day (equivalent to 400 g bait/possum per day for 5 days). 8 out of 10 possums presented with double strength pindone over 10 days survived, including two that had eaten over 1 kg of pindone bait”.

Though pindone appears to be ineffective against possums, it costs less and is less persistent than Talon®, therefore its acute toxicity on wallabies may warrant investigation.
Cholecalciferol (Campaign®): Cholecalciferol was introduced for possum control in 1995, and investigations carried out prior to it being made available to the public indicate that possum kills as high as 97% can be achieved with this toxin (Henderson et al. 1994). The action of cholecalciferol is intermediate between an acute and chronic toxin. It acts relatively quickly, inducing anorexia after the animal has consumed only a small quantity of bait. Eason & Warburton (1996) estimate that most possums take 4-7 days to die.

It has yet to be tested for control of wallabies, and I could find no lethal dose estimates for wallabies.

The advantages of Campaign® are; it is faster acting than anticoagulants, has a low direct risk for birds, has a low risk of secondary poisoning for dogs, and is available to the general public (Eason 1996).

Its main disadvantage is that it is extremely expensive (c.$40/kg). The manufacturers claim that it is more cost effective than Talon®, because the possum stops feeding after ingesting the lethal dose of 10-15 grams, however it still remains relatively untested in the field and any bait spoiled by the weather will added significantly to the cost of a control operation.

Recommendations:

- Test the susceptibility of dama wallabies to; 1080, Talon®, Campaign® and pindone.

- Evaluate encapsulated cyanide for control and monitoring wallabies and possums.

3.6.3 Bait acceptance/preference:

Llewellyn (1985) tested the acceptability of three types of bait for use in aerial poisoning operations targeting wallabies. Carrot, Mapua pollard baits and Wanganui No.7 baits were coated with rhodamine dye then spread along the Okataina loop road in Rotoiti 15 Forest. On the second night after the bait was spread, wallabies and possums were shot and necropsied the following day. The cereal based Mapua pellets had the highest acceptance at 97.2% (n=72), and 75% of these wallabies appeared to have fed solely on bait. Carrot had an 80% acceptance (n=43). Wanganui No.7 pellets were
the least accepted at 45.3% (n=53) and most of the wallabies that feed on this bait had consumed only one or two baits.

Earlier work by Round (1984) on Kawau Island identified; "Mapua and carrot as excellent baits with high palatability to parma (Macropus parma) and dama wallabies". Round described Wanganui No.7 "as having high acceptance among parmas and damas", and recorded a "60% acceptance rate for RS5 bait for parmas, slightly higher for damas".

In trials carried out at Massey University, wallabies preferred carrot over all other food types tested, with individual wallabies consuming up to 1 kg of carrot per night (R. Lentle, pers. comm.).

Discussion:

Both Wanganui No.7 and RS5 are cereal baits manufactured by Animal Control Products Ltd. in Wanganui. Wanganui No.7 is currently the most commonly used bait for aerial poisoning of possums on conservation lands. RS5 is the bait used in Campaign®, and Talon® 20P possum baits.

Unfortunately Mapua baits are no longer manufactured.

While videoing feeding activity at Paehinahina peninsula on Lake Rotoiti (site 8 on map 2) I took advantage of the dual bait station6 set up (section 5.4.1) to test preference7 between;

(i) rhodamine dyed, cinnamon lured, Wanganui No.7, and
(ii) undyed, unlured, “Agtec” RS5 (manufactured by ACP in Waimate)

Wallabies preferred Wanganui No.7 taking this bait with ratio of 3.2 : 1 over RS5 (most of the RS5 was eaten by juvenile wallabies8). Conversely ship rats showed a preference for the Waimate RS5 taking this bait with a ratio of 2.6 : 1 over Wanganui No.7.

6 Two Marley downpipe (2 kg) bait stations were mounted side by side to ensure that bait did not run out during the 72 hour recording period.

7 Bait preference = the ratio of bait consumed when compared to one or more alternative baits.

8 This may have been one individual. Age classes could be identified by size and some adults had distinctive marks of damaged fur, but no attempt was made to separate individual in this study.
Possums feed almost exclusively on Wanganui No.7. During three nights of video an individual possum took 2 RS5 baits. During the same period possums took a total of 544 Wanganui No.7 baits from the bait station.

Table 1: Bait preference trial.

<table>
<thead>
<tr>
<th>Paehinahina peninsula</th>
<th>wallaby</th>
<th>possum</th>
<th>ship rat</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. baits eaten</td>
<td>No.7</td>
<td>RS5</td>
<td>No.7</td>
</tr>
<tr>
<td>2-3 Dec. 1996</td>
<td>56</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4-5 Dec</td>
<td>97</td>
<td>49</td>
<td>165</td>
</tr>
<tr>
<td>5-6 Dec</td>
<td>100</td>
<td>43</td>
<td>168</td>
</tr>
<tr>
<td>6-7 Dec</td>
<td>137</td>
<td>26</td>
<td>211</td>
</tr>
<tr>
<td>Total</td>
<td>390</td>
<td>119</td>
<td>544</td>
</tr>
</tbody>
</table>

Though the sample size in this trial was very small and only two types of bait were compared, time-lapse video appears to be a useful tool for assessing bait preference for a variety of pest species, in a field situation. Time-lapse video is not particularly useful for testing bait acceptance unless a known proportion of the population are marked so that they are identifiable in the video.

**Recommendations:**

- Statistically robust bait preference and acceptance trials should be carried out to test a variety of baits and lures, before recommencing large scale control of wallabies.

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*9 bait acceptance = the percentage of individuals taking some bait.*
3.6.4 Baiting strategies:

**Timing of control:** Sadleir (1985) recommends timing control between March and October because every female killed will almost certainly result in the death of her young. Sadleir is probably referring to control by shooting because he goes on to recommend that wallabies of all sizes should be shot with more effort on smaller wallabies than larger ones. The basis for this recommendation is that almost every female breeds for the first time within a few weeks of leaving the pouch, and smaller (younger) wallabies obviously have a greater life expectancy than larger (older) ones. With poisoning as the control technique Sadler’s recommendations may be less applicable provided independent juveniles are as vulnerable to poisoning as are adults.

One of the most frequent visitors to the bait station at Paehinahina was a juvenile wallaby, and despite being occasionally displaced from the station by more dominant animals it had ample chance to consume bait (section 5.4.4).
Poisoning operations for other pests such as possums are usually timed for mid-winter because it is perceived that at this time of year food resources will be limited, therefore possums will be more likely to consume a lethal quantity of toxic bait. For pest species such as rats, poisoning operations have the potential to kill a large proportion of the population, but due to their high rate of reproduction, populations take only 4-5 months to recover (Innes et al. 1995). For this reason poison operations targeting rats are timed to maximise the benefits of control (i.e. coinciding with the onset of nesting).

Wallabies have a breeding system that incorporates a phenomenon called "embryonic diapause". This increases their reproductive potential by allowing female wallabies to replace the loss of a "joey" (pouch young) with an already fertilised "blastocyst" (foetus) retained within the uterus (Sadleir 1985, Warburton and Sadleir 1990). Despite this reproductive advantage wallabies raise only one young per year therefore timing of control should focus on maximising the likelihood of them consuming bait.

**Bait distribution/bait station spacing:** With bait stations and to a lesser extent aerial sown baits the likelihood of an animal encountering bait may differ among age classes if home range or dispersal differs between age classes. Lentle et al. (in prep.) concluded that home ranges were significantly greater in adults than in juveniles. The most conservative estimate from this report for a juvenile wallaby's maximum home range is 2.3 hectares. A commonly used bait station layout for possum control is a 150 by 150 metre grid. At this rate there is 1 bait station for every 2.25 hectares therefore all age classes of wallabies should encounter a bait station.

**"Prefeeding" and "pulsing" bait:** When chronic toxins such as 1080 are used in bait stations, non-toxic "prefeed" bait is normally placed in the station for 3-4 weeks prior to a single pulse of toxic bait (Thomas 1992, Thomas 1994). This allows time for animals to locate and recognise the bait as a food source, so that following application of toxic bait a high percent of the population will consume a lethal quantity of bait. The cost effectiveness of "prefeeding" prior to aerial is poisoning with 1080 remains unresolved.

If slow acting, chronic toxins such as Talon are used, there is a low risk of "learned aversion" so "prefeeding" with non-toxic bait is not required.
Because Talon is an accumulative toxin, stations can remain empty for intervals to prevent animal from eating excessive amounts of bait by allowing them to die (they can accumulate many times a lethal dose). Those that have not eaten a lethal dose will accumulate more toxin during subsequent “pulses” of bait. As anticoagulant bait are generally expensive “pulsing” helps to reduce the cost of control.

The implications of wallaby and possum behaviour for baiting strategies are discussed in section 5.5.

**The effects of habitat:** Pasture margins tend to hold the highest wallaby densities, but to achieve conservation benefit control must also be effective in forest where wallabies do not have access to pasture. Wallabies living totally within the forest may also behave differently (home range, and movements in response to food sources). If wallabies can be drawn to key sites such as forest clearings, the efficiency of bait station operations in forest would be improved.
4. EVALUATION OF THREE BAIT STATIONS FOR DELIVERING CEREAL BAITS TO WALLABIES. (PEN TRIALS WITH CAPTIVE WALLABIES AT RAINBOW SPRINGS, ROTORUA).

4.1 Background:

Rainbow Springs Ltd. is a tourist park in Rotorua, well know for natural fresh water springs and trout pools. They also display a variety of wild life including kiwi (Apteryx sp) and wild animals including various species of deer, Himalayan tahr (Hemitragus jemlahicus) and wallabies.

The 36 x 28 metre wallaby enclosure contained seven wallabies, (1 adult male, 1 sub-adult male, and 5 females of various ages), a domestic rabbit and sundry poultry, ducks and peafowl. A 2 x 8 m wooden structure and a large pampus (Cortaderia sp) provide shelter for the wallabies.

As well as grazing the (closely cropped) grassed interior of the enclosure and the occasional windfallen branch from surrounding trees, the wallabies are normally fed NRM multi-feed pellets. These are supplied to the animals by tourists visiting the park (by hand through the fence) and by park staff who normally throw c. two kg, into the pen first thing in the morning. During the course of my study, park staff discontinued the usual feeding of the wallabies. I made no attempt to stop the tourists hand feeding the wallabies.

4.2 Objectives:

1. Evaluate three types of possum bait station, for delivering cereal baits to wallabies.

2. Identify any physical or behavioural characteristics of wallabies that may influence the efficacy of using bait stations as a control technique.

4.3 Methods:

A diary for the pilot study at Rainbow Springs is shown in appendix 2

4.3.1 The bait stations:

On 28 July 1996, I mounted three types of possum bait station; side by side on a sheet of plywood and placed them inside the wallaby enclosure. The
stations chosen for the trial were; the “Philproof bait feeder”, the ACP, and a “hockey stick” type station made from Marley down-pipe (appendix 1). The stations were mounted with their entrance holes c. 400 mm above the ground.

I initially placed approximately 500 grams of “NRM multi-feed pellets” (bait) in each station, and to encourage the wallabies to feed in the vicinity of the stations I also hand spread 500 grams of bait on the ground beneath the stations. I subsequently filled each station with 1 kg of bait and none was spread on the ground.

4.3.2 Time-lapse video:

I recorded activity at the stations with remote time-lapse video equipment (Innes et al. 1994). The video runs on 12 volt sealed batteries, and I set it to record continuously for 72 hours on a 3 hour cassette. After dark the bait stations were illuminated by an infra-red light source, which is activated by a light sensitive switch.

From the video tapes, I calculated the feeding rate by counting the number of baits taken from each station (per hour) by wallabies (all wallabies collectively). As a variety of animals had access to the bait stations, daily bait take was not recorded.

During the majority of the study at Rainbow Springs the individual wallabies were not identifiable (except by size). As the study progressed it became apparent that marking the animals may help me to interpret social interactions. On 13/8/96, staff from Rainbow Springs assisted in capturing all seven wallabies, so that I could attach 15 mm wide velcro collars, marked with white painted bar codes. This proved to be of limited use because the wallabies’ fur often obscured the collar. A wider collar (c. 30 mm) would have been more effective.

4.4 Results:

4.4.1 Bait station preference (ACP, Pp, Mdp):

A wallaby successfully removed the first bait from the ACP station, at 21:45 on the 28/7/96, 5 hours 50 minutes after the bait stations were placed in the enclosure. A further 2 hours 30 minutes elapsed before the first bait was
taken from the Mdp station. It was not until both the ACP and Mdp stations had been emptied (30 hours and 18 minutes later) that the first bait was taken from the Pp station.

Though the first baits were taken from the ACP station the feeding rate (average number of baits taken per hour of feeding) was higher for the Mdp station (14.8 \((\pm 2.4)\) baits/hr cf. 8.6 \((\pm 2.0)\) baits/hr) (Table 2.). The ACP station was emptied first but this primarily resulted from the floor of the station becoming detached, allowing some of the bait to spill onto the ground.

**Table 2: Bait station preference, first night.**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Total no. of baits taken</td>
<td>138 baits</td>
<td>1 bait</td>
<td>296 baits</td>
</tr>
<tr>
<td>No. of hours that feeding occurred</td>
<td>16</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Max no. of baits in 1 hour</td>
<td>24</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Av. no. baits/hours of feeding</td>
<td>8.6 baits/hr</td>
<td>14.8 baits/hr</td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>((\pm 2.0))</td>
<td>((\pm 2.4))</td>
<td></td>
</tr>
<tr>
<td>Average daily bait take</td>
<td>2.9 baits/hr/day</td>
<td>6.2 baits/hr/day</td>
<td></td>
</tr>
</tbody>
</table>

For some reason the wallabies were reluctant to take bait from the Pp station. Both the Mdp and ACP stations were emptied before any bait was taken from the Pp station.

The wallabies frequently sniffed the Pp station entrance and would have been able to see bait inside the station but may have been reluctant to place their head inside the station as this involves completely covering their eyes and ears.

I wanted to further examine the suitability of the Pp station for use with wallabies, so I removed the ACP and Mdp stations giving the wallabies no choice. Unfortunately the video failed just on dark, but the wallabies appeared to have no problem feeding from the station as it was emptied of
bait over the subsequent 2 days (the first video indicated other animals were only taking small quantities of bait).

Assuming the wallabies had become accustomed to feeding from the Pp station, I repeated the first part of the experiment, comparing the Pp ACP and Mdp stations.

The Mdp station was emptied within 11 hours with an average feeding rate of 45.5 (± 8.7) baits/hr (Table 3.). The respective average feeding rates for the ACP, and Pp stations were 10.9 (± 2.5) and 8.0 (± 2.3) baits/hr, indicating that there was no longer a significant difference in the wallabies preference between these two stations.

Table 3: Bait station preference, 2nd replicate.

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of baits taken</td>
<td>174 baits</td>
<td>104 baits</td>
<td>500 baits</td>
</tr>
<tr>
<td>No. of hours that feeding occurred</td>
<td>16</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Max no. of baits in 1 hour</td>
<td>32</td>
<td>26</td>
<td>86</td>
</tr>
<tr>
<td>Av. no. baits/hours of feeding</td>
<td>10.9 (± 2.5)</td>
<td>8.0 (± 2.3)</td>
<td>45.5 (± 8.7)</td>
</tr>
<tr>
<td>Standard error</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average daily bait take</td>
<td>7.3 baits/hr/day</td>
<td>4.3 baits/hr/day</td>
<td>20.8 baits/hr/day</td>
</tr>
</tbody>
</table>

The following night with the Mdp station empty, the respective average feeding rates for the ACP, and Pp stations were 10.9 and 11.7 baits/hr, confirming earlier results that there was no real preference for either of these two stations (Table 4.).
Table 4: Bait station preference, ACP & Pp only.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of baits taken</td>
<td>413 baits</td>
<td>446 baits</td>
<td></td>
</tr>
<tr>
<td>No. of hours that feeding occurred</td>
<td>38</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Max no. of baits in 1 hour</td>
<td>45</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Av. no. baits/hours of feeding</td>
<td>10.9 baits/hr</td>
<td>11.7 baits/hr</td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>(± 2.0)</td>
<td>(± 2.8)</td>
<td></td>
</tr>
<tr>
<td>Average daily bait take</td>
<td>8.6 baits/hr/day</td>
<td>9.3 baits/hr/day</td>
<td></td>
</tr>
</tbody>
</table>

I repeated the comparison of the three bait stations a third time on 13-14/8/96 (Table 5.). Now that the wallabies were feeding from all three stations their preference for the Mdp station was less marked, yet still significant. The feeding rate had dropped to 16.7 (± 2.9) baits/hr compared with 7.5 (± 2.9) and 5.3 (± 1.8) baits/hour for the ACP and Pp stations.

Table 5: Bait station preference, 3rd replicate.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of baits taken</td>
<td>45 baits</td>
<td>48 baits</td>
<td>217 baits</td>
</tr>
<tr>
<td>No. of hours that feeding occurred</td>
<td>6</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Max no. of baits in 1 hour</td>
<td>15</td>
<td>19</td>
<td>43</td>
</tr>
<tr>
<td>Av. no. baits/hours of feeding</td>
<td>7.5 baits/hr</td>
<td>5.3 baits/hr</td>
<td>16.7 baits/hr</td>
</tr>
<tr>
<td>Standard error</td>
<td>(± 2.9)</td>
<td>(± 1.8)</td>
<td>(± 2.9)</td>
</tr>
<tr>
<td>Average daily bait take</td>
<td>1.9 baits/hr/day</td>
<td>2.0 baits/hr/day</td>
<td>9.0 baits/hr/day</td>
</tr>
</tbody>
</table>
Management implications

Once the wallabies become accustomed to feeding from the Pp station, the feeding rate from that station did not differ significantly from that of the ACP, station. However on the initial night that the wallabies were exposed to the three bait stations, it was the ACP followed by the Mdp station that they fed from. Only one wallaby removed a single bait from the Pp station. The wallabies at Rainbow Springs are used to feeding on the NRM multi-feed pellets, so can presumably recognise them by sight and smell. In a control operation targeting feral wallabies the bait will probably be foreign to them. Any reluctance to feed from a station, could prevent them from identifying the bait as a food source. Bait spilt beneath the station (e.g. by possums), would provide a wallaby with an opportunity to sample the bait without using the station. However if an acute toxin is being used (section 3.6.1) and the wallaby consumes only a small quantity of bait, the resulting illness from a sublethal dose could cause it to avoid eating further bait. Likewise if a wallaby is reluctant to take sufficient bait from a station because of that station’s design, bait aversion could result.

The best of the three bait stations tested for delivering baits to wallabies is the Mdp, because the wallabies began feeding from it on the first night and the feeding rate from this station was repeatedly higher than the other two stations.

4.4.2 Modifications to Pp station:

To investigate the possibility of improving the feeding rate from the Pp station, I compared a standard Pp station with two Pp stations that had been modified to increase the size of the entrance (appendix 1). The stations were mounted side by side on the plywood stand for 3 nights then their relative positions were switched in case position had an influence on feeding rate.

The feeding rate from the Mod. 1. Pp, which had the largest entrance, was higher than the other two stations. Variation in the other parameters (Table 6) suggests that these data warrant more detailed interpretation to determine if the differences are significant.
Table 6: Bait station preference, modified Pp.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of baits taken</td>
<td>388 baits</td>
<td>384 baits</td>
<td>318 baits</td>
</tr>
<tr>
<td>No. of hours that feeding occurred</td>
<td>37</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Max no. of baits in 1 hour</td>
<td>36</td>
<td>57</td>
<td>39</td>
</tr>
<tr>
<td>Av. no. baits/hours of feeding</td>
<td>10.5 baits/hr</td>
<td>14.8 baits/hr</td>
<td>12.2 baits/hr</td>
</tr>
<tr>
<td>Standard error</td>
<td>(± 1.4)</td>
<td>(± 2.2)</td>
<td>(± 2.4)</td>
</tr>
<tr>
<td>Average daily bait take</td>
<td>5.4 baits/hr/day</td>
<td>4.4 baits/hr/day</td>
<td>5.3 baits/hr/day</td>
</tr>
</tbody>
</table>

Photo. 5: Wallaby with taking bait from standard "Philproof" bait station, Mod. 1. is in the centre. D.S. Williams 1996.
4.4.3 Behaviour:

The wallabies at Rainbow Spring were born in captivity and are essentially a family group, therefore their behaviour may not be typical of feral animals. However as they are physically similar to feral wallabies the “mechanics” of feeding from bait stations should be comparable.

“Mechanics” of feeding

With the bait station entrances c.400 mm off the ground, all of the wallabies including the sub-adults could access bait.

It was clear from the video that wallabies prefer to extract bait from the stations with their teeth rather than their forepaws. Only on one occasion was a wallaby observed placing its forepaw inside a station and this was when the station was almost empty. Once they had taken a bait from the station they would frequently remove the bait from their mouth with their forepaws and hold it, usually in one paw, while consuming it.

Due to the shape of the entrance hole in the ACP station (a wide but low slot), wallabies had greater difficulty removing bait from this station than the Mdp. The wallabies would often rock their head from side to side in their attempt to remove bait from the ACP station.

Once the wallabies became accustomed to feeding from the Pp station they had no physical difficulties removing bait. Analysis of skull measurement of wallabies would determine whether large individuals or wallabies of other species would have physical difficulties extracting bait from Pp stations.

The wallabies appeared to be constantly alert. When feeding they often sat upright on their hind legs, with their back to the stations (which were mounted close to the fence of the enclosure). Their ears were continuously moving. This may help explain their reluctance to feed from the Pp station as covering their ears and eyes results in a brief shutdown of their “predator/competitor warning system”.

As the veranda on the Pp station is primarily designed to give the bait protection from the weather a better solution may be to design a more weather resistant bait.
Intraspecies interactions

Very little aggressive behaviour was observed between the wallabies while feeding at the stations, though some individual wallabies took baits from the forepaws of others. This appeared to be limited to the sub-adult animals. Due to the difficulties of identifying individuals I was unable to interpret whether they were stealing or begging food. Observations of captive dama wallabies at Massey University suggest that it is more likely to be a dominant animal stealing food from a subordinate (R. Lentle pers. comm.).

Though the wallabies were free to access bait from the station at any time, the majority of feeding occurred after dark. Feeding was spread throughout the night, with a peak in the average feeding rate (48.6 baits per hour) between 17:00 and 18:00 hrs.
**Interspecies interactions**

On 28/7/96 (the first night of video at Rainbow Springs) a “free ranging” possum climbed into the wallaby enclosure and fed from the station. It acted “aggressively”, standing up on its hind legs and raising its forepaws, toward the first wallaby to approach the feeding station. During the course of the video work at the Springs a possum visited the feeding station on most nights. The wallabies sometimes approached the station while the possum was present but despite being larger in size than the possum they made no attempt to displace it from the station. Usually the wallabies remained at a distance (sometimes just in the field of view of the camera) while the possum was feeding, and would return to feed from the station soon after the possum left. A fight involving physical contact was recorded on 13/8/96, once again the wallaby was displaced from the station.

*Photo. 7: Aggressive encounter between a possum and a wallaby. Note the base of the ACP station (on left) is partly detached. D.S. Williams 1996.*
Photo. 8: Possum drops onto the on veranda of Pp station from tree above. D.S. Williams 1996.

Photo. 9: Aggressive encounter resulting in the wallaby being displaced from the feeding station. D.S. Williams 1996.
Ship rats (*Rattus rattus*) were also recorded feeding from the stations, though no inter species interactions were observed. The video showed that rats are extremely agile climbers. It is unlikely the attachment height, orientation, and type of station would make any difference to a rat’s ability to access bait. It was also interesting to note that on 2/8/96, between 20:35 and 21:08 hours, an individual rat (identified by its identical approach pattern) removed and cached 28 baits.

4.5 Conclusions:

Though only three types of bait station were tested in this pilot study, some general conclusions can be drawn that would equally apply to other commercially available possum bait stations. Because this wallabies were born in captivity, any behavioural observation made here require validation with feral animals.

- When given a choice wallabies prefer to feed from a station that provides easy access to the bait without obscuring their eyes and ears.

- Mounting bait stations with the entrance at c.400 mm above the ground will allow most wallabies (including subadults) to access bait.

- Wallabies fed from the stations mostly after dark with a peak in feeding activity between 17:00 and 18:00 hrs (the first hour after sunset).

- Wallabies show little aggression toward each other and all age classes of wallabies fed from the stations.

- During interspecies interactions with possums, wallabies appeared to avoid contact with the possum, but recommenced feeding once the possum vacated the station.

- Ship rats easily access bait from stations and may cache substantial amounts of bait.

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10 I identified the rats as *R. rattus* by their tail length (longer than their body length).
5. FIELD ASSESSMENT OF BAIT STATION USE, BY WALLABIES.
(A FIELD STUDY OF FERAL WALLABIES, OKATAINA SCENIC RESERVE AND PAEHINAHINA PENINSULA, LAKE ROTOITI).

5.1 Background:

5.1.1 Study sites:

I chose the Okataina Scenic Reserve as the location for my field study because it holds moderate to high numbers of wallabies and possums, and has a good history of previous work on introduced mammals (including wallabies) and their impact on the vegetation (Map 2). From 28/11/96 onwards I transferred the focus of my study to the Paehinahina peninsula adjacent to the Rotoiti Scenic Reserve.

The three main study sites were;

The Okataina Outdoor Education Centre. The grassed area surrounding the centre is used by numerous wallabies. Access to the site is good which was important to allow easy installation and servicing of the video equipment (the batteries and tape need to be changed every three days).

"The plateau" site is within forest (tawa - rewarewa-mangeao/porokaiwhiri-mahoe-rangiora/treeferns)11 15 minutes walk from the road. I chose this site because it has low public use, and moderate numbers of wallabies.

Paehinahina, is a forest covered peninsula on the southern shore of Lake Rotoiti, immediately west of Piropiro (Cherry Bay). The forest is predominantly rewarewa-kamahi-mangeao/mahoe-rangiora-hangehange-mapou-treeferns12. The western margin of the peninsula (part of the Lake Rotoiti Scenic Reserve) is fringed with pohutukawa (Metrosideros excelsa).

11 Tawa (Beilschmedia tawa), rewarewa (Knightia excelsa), mangeao (Litsea calicaris), rangiora (Brachyglottis repanda), treeferns (Cyathea and Dicksonia sp.).

12 Mapou (Myrsine australis)
3. Anaha track
4. Outdoor Education Centre
5. Bullring
6. Helipad
7. Waione
8. Pachinahina
A contract possum hunting operation had recently been completed at Paehinahina, therefore possum numbers were low by comparison with the other sites at Okataina (8.5 possums per 100 trap nights). The amount of wallaby sign I saw when I initially inspected this site suggested that it held moderate to high wallaby numbers.

All sites and the activities carried out at them are listed in Appendix 3.

5.2 Objectives:

1. Evaluate bait stations for delivering cereal baits to feral wallabies.

2. Identify any behavioural characteristics of feral wallabies that may influence the efficacy of using bait stations as a control technique.

5.3 Methods:

A diary for the field study at Okataina and Paehirahina is shown in Appendix 4.

5.3.1 Bait stations and rhodamine dyed non-toxic bait:

Between 7-8/9/96 I placed Marley down-pipe “hockey stick” bait stations at seven sites within the Lake Okataina Scenic Reserve (Map 2). I placed a single station at each site and filled them with undyed non-toxic baits supplied by Animal Control Products Ltd., Wanganui. After one week bait-take was checked, as this was similar for each site the choice of study site was based on the criteria laid out in section 5.1.1.

Non-toxic, cinnamon lured\textsuperscript{13}, Wanganui No. 7 (5 mm diameter, 1.5 gram) bait coated with rhodamine dye was used in this study because;

(i) it is the most commonly used bait for possum control on Conservation lands.

(ii) it was readily available.\textsuperscript{14}

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\textsuperscript{13} Cinnamon is normally added to 1080 baits because it acts as a “mask”, reducing the chance of possums detecting the 1080, and it repels some bird species (Morgan 1990).

\textsuperscript{14} Wanganui No. 7 was being used in a 1080 bait station operation, targeting possums, at Minginui, within the BoP Conservancy.
(iii) The rhodamine dye would allow me to identify what animals were accessing bait from the stations (by identification of dye marked faecal pellets).

Rhodamine is a bright red dye that stains the paws, mouth, gut and faeces of animals that feed on or handle the bait (Morgan 1981). It is fluorescent under ultra-violet light, but in most situations the red staining can be seen with the naked eye under normal light. I manually applied the dye to the bait with a handsprayer.

Other objectives for using rhodamine dyed bait, were to estimate;

(i) the distance traveled by animals to feed at the stations (i.e. the distance from the bait station to dye marked faeces), and

(ii) the proportion of animals feeding from the stations (i.e. the proportion of shot or trapped animals marked with dye).


5.3.2 Faecal pellet counts/searches:

At the “plateau” (site 2); between 25-29/9/96, I searched and cleared 280 faecal pellet plots of 80 cm radius, located 10m apart, along lines of various length (max. 370 m), radiating out from the station. On 5/10/96 I assessed recruitment of faecal pellets on 100 plots, noting the numbers of dyed and undyed pellets.

At sites; 2, 3, 4, 5, and 7 I carried out casual searches for dyed faeces, within 50 m of the bait station.

At Pachtsahina the 80 pellet plots were located 5 metres apart on lines radiating out to 50 metres from the station. They were established on 10/10/96 and remeasured on 16/11/96. I adopted this plot layout so that; all of the plots could be cleared in one day and it concentrated sampling near to the bait station where I most expected to find dye-marked faeces. At this stage I had abandoned the objective of estimating the distance traveled by animals to feed at the station, I simply wanted to know if wallabies where feeding from the station or not, before committing myself to transporting the video equipment to the site (the equipment weighs > 90 kg).

Because defecation rate may differ between individual animals a comparison of the proportion of dyed versus undyed faecal pellets would give only a coarse estimate the percentage of animals accessing bait. A better estimate would be gained by trapping or shooting animals and checking for dye (section 5.3.3).

Because I have no estimates of the defecation rate for wallabies the faecal pellet counts can only be used to compare relative density (between sites or over time). Appendix 3.

5.3.3 Trapping and shooting:

On 11/10/96 I set 49 “Victor No.1” leg-hold traps, along the pellet lines (to a maximum distance of 200 metres). The following day I killed the trapped possums and checked them for signs of dye. I noted the distance from the bait station, and the possum’s sex.

As it became apparent that it would be difficult to shoot more than two or three wallabies at any one site, I decided a sample of this size would be too small to warrant sacrificing the animals.
5.3.4 **Time-lapse video:**

Time-lapse video was used to record feeding activity at sites; 3, 4, and 8. (Appendix 3.).

I used three methods for quantifying feeding activity at the bait stations;

(i) Counting the number of baits taken\(^{15}\) from the station, per hour, for each animal species.

(ii) Counting the number of feeding sessions\(^{16}\) and the number of baits taken in each feeding session, for each animal species.

(iii) Sampling activity at 2 minute intervals, recording the number of animals; (i) within 2 m of the bait station, (ii) taking a bait from the station, (iii) feeding on a bait taken from the station, and (iii) feeding from the ground within 2 m of the bait station.

Some behavioural observations were noted but without marked animals\(^{17}\) these were mostly speculative.

5.4 **Results:**

5.4.1 **Faecal pellet counts/searches:**

No dyed marked wallaby faeces were located during any of the casual searches at Okataina (sites; 2, 3, 4, 5, and 7).

Between one and two kg of dyed bait was being consumed from each station in one night and the number of dye-marked possum faeces and clumps of possum fur in the immediate vicinity of the stations, suggested that possums activity was intense.

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\(^{15}\) I counted a bait as “taken” if an animal placed its head or paw into the station, unless it obviously dropped the bait or just sniffed the station.

\(^{16}\) I defined a “feeding session” as a continuous interval of feeding by an individual animal. As they were not individually marked I made no attempt to group multiple feeding sessions for individuals animals.

\(^{17}\) Some of the adult wallabies at Paehinahina had distinctive marks on their fur that enabled them to be identified.
No dye marked wallaby faeces were located on any of the systematically located plots at the “plateau”. Undyed wallaby faeces were recruited onto 6% of plots \( (n=50) \). \(^{18}\)

Possum faeces were recruited onto 34% \( (n=50) \) of the plots at the “plateau”, and dye marked possum faeces were recorded on 26% of plots.

The faecal pellet counts at Paehinahina confirmed my initial impressions that wallaby numbers were much higher and possum number much lower at this site relative to the “plateau”. Wallaby faeces were recorded on 53% of the plots \( (n=80) \).

Dye marked wallaby faeces were found on 2 of the 80 plots. Five weeks had elapsed since the plots were cleared.

Possum faeces were found on 11% of the plots \( (10\% \text{ dyed}) \).

5.4.2 Trapping:

Eight of the 24 possums trapped at the “plateau” were dye marked. One of the dye marked possums was trapped 100 m from the station. Expressed as a catch rate this equates to 51.5 possums/100 trap nights \(^{19}\).

The result of the trap-catch assessment for Paehinahina was 8.5 possums/100 trap nights. The trap-catch protocol \(^{20}\), used at Paehinahina differed from the layout of traps I used at the “plateau” (section 5.3.3), however a comparison of relative density for the two sites supports the results of the faecal pellet counts i.e. possum densities were much lower at Paehinahina than at the “plateau”.

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\(^{18}\) because the plot layout at the plateau differed from that at Paehinahina only the plots within 50m were used in these calculations.

\(^{19}\) 24 possums (plus one sprung trap with possum fur in it), 49 traps for one night (less half a trap night for a sprung trap without possum fur in it).

\(^{20}\) 80 traps set for 3 fine nights. 4 separate lines with traps 20m apart.
5.4.3 *Time-lapse video (Okataina):*

No wallabies were recorded at either of the two stations at the Outdoor Education Centre or the single station at the Anaha track, during a total of 211 hours of video monitoring. Almost continuous feeding by possums was recorded at all three stations.

To investigate the possibility that possums were excluding the wallabies from the bait stations, I attempted to reduce possum numbers at the Outdoor Education Centre by filling one of the stations with Campaign® possum bait (section 3.6.2). I chose to use Campaign®, because its use is less restricted than 1080 and it is faster acting than Talon®. As a safety precaution I ensured the station was empty during the day if children were at the Centre.

I kept toxin in the station for 4 nights, with another one night pulse of toxin a week later. I continued to monitor bait take and ran the video again two weeks later to check visitation rate. Though bait take initially declined, after two weeks possum activity at the station was once again intense, and no wallabies were recorded.

I also used the video to record feeding activity with bait placed on the ground. Piles of bait were laid out in a grid pattern, with 10 baits per pile, on an area of grass at the Outdoor Education Centre that appeared to be used by wallabies.

No wallabies were recorded, only possums. Because the infra-red light source was only capable of illuminating a few square metres of ground, the quality of the video image was poor. I discontinued this work after the second night.
Observations of possum activity, at bait stations:

Some possums defended the station from others chasing them off or swotting them with a forepaw, (a large female with a juvenile “backrider” feed from the station for 42 minutes, preventing other possums from approaching the while she feed).

There were few fights involving physical contact observed, despite a large number of occasions where more than one possum was within 2 m of the bait station. Conflict was usually avoided by one animal moving away if another acted aggressively. Often one possum would be feeding from the station while another consumed baits that had been spilt onto the ground. A juvenile “backrider” was observed feeding from the station while on its mothers back.

To investigate social behaviour in more detail, individual possums would need to be identifiable in the video (i.e. they would need to be trapped and marked in some way).
5.4.4 Time-lapse video (Paehinahina peninsula):

I set up the video equipment on a pair of bait stations, at Paehinahina, on 28/11/96, following confirmation that wallabies were taking bait from the station (dye marked faeces). That evening at 19:33 hours I recorded the first video evidence of feral wallabies feeding from a bait station.

Several wallabies of various age/size classes feed from the station including a small unweaned juvenile. I had mounted two bait stations side by side to ensure bait would not run out during the 72 hour video sessions. They were mounted with the openings 400 mm off the ground. All wallabies could freely access with the station at this height, though juveniles had to straighten their hind legs completely to reach the bait.
At 02:00 on the first night of video, a possum caused one station to slide in the mounting brackets. Wallabies continued to feed from this station despite the opening being at ground level.

The wallabies usually approached the bait station using a "pentapedal" gait with their head close to the ground. They almost always fed off the ground prior to taking bait from the station. When close to the station they were most probably feeding on spilt baits, however it was not always possible to determine this from the video, and in some cases they may have been feeding on leaf-fall or just sniffing the ground.

There were few aggressive/displacement interactions between wallabies at the bait station, and most of these involved an adult and a juvenile/subadult. The adult would displace the smaller animal from the station by moving toward it without actually coming into physical contact. Interactions where two wallabies feed from the station/s simultaneously were also observed. These were mostly involved an adult and a juvenile, suggesting a
parent/offspring relationship (during one sequence of video the juvenile appeared to suckle from the adult\textsuperscript{21}).

Two large adult male\textsuperscript{22} wallabies fought at the bait station. They touched their noses together, then began sparring with their forepaws grasping at each others chest, neck and face. On the two occasions that aggressive interactions were recorded, between adult males at the bait station, an adult female was also percent. Sparring between two adults was also recorded more than 5 metres away from the stations, so it is possible that they were contesting access to a female rather than the bait station.

\textsuperscript{21} This female also had a easily identifiable dark patch of fur on her right flank.

\textsuperscript{22} There is a distinct size difference between mature males and females.

Photo. 19: Adult male wallabies “sparring”. D.S. Williams 1996.
During the course of videoing at Paehinahina, only 4 interactions between possums and wallabies were recorded. All of these involved a juvenile/subadult wallaby being displaced from the station by a possum. The majority of wallaby feeding activity occurred at dawn and dusk, while the possums tended to arrive at the station an hour after dark. As the result there was very little overlap in the time that both wallabies and possums were observed feeding at the station. The average hourly bait take for each species also illustrates this point (Appendix 5).

Table 7: Feeding times for wallabies and possums.

<table>
<thead>
<tr>
<th>Pachinahina</th>
<th>28 Nov. - 7 Dec. 1996</th>
<th>Average (minutes)</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>wallabies start feeding (minutes before dark)</td>
<td>143.5</td>
<td>±18.0</td>
<td></td>
</tr>
<tr>
<td>wallabies stop feeding (minutes after dark)</td>
<td>26.3</td>
<td>±36.0</td>
<td></td>
</tr>
<tr>
<td>possums start feeding (minutes after dark)</td>
<td>57.0</td>
<td>±20.3</td>
<td></td>
</tr>
<tr>
<td>possums stop feeding (minutes before sunrise)</td>
<td>145.7</td>
<td>±5.1</td>
<td></td>
</tr>
<tr>
<td>wallabies start feeding (minutes before sunrise)</td>
<td>39.4</td>
<td>±25.1</td>
<td></td>
</tr>
<tr>
<td>wallabies stop feeding (minutes after sunrise)</td>
<td>89.0</td>
<td>±13.7</td>
<td></td>
</tr>
</tbody>
</table>

Because these data were collected from only one site, it would not be wise to conclude that wallabies are “crepuscular”\(^{23}\). It may be that wallabies simply visit this site at that time as part of a habitual travel routine.

\(^{23}\) Crepuscular - active at twilight or just before dawn.
Photo. 20: Juvenile wallaby at bait station 1:45:54 hrs. D.S. Williams 1996.

Photo. 21: Two seconds later possum charges through, displacing the wallaby. D.S. Williams 1996.
A radio telemetry study on wallabies at Okataina has shown wallabies feed almost continuously day and night. Some wallabies travel over 1 kilometre from within the forest to feed on pasture each night. They remain in the open during the hours of darkness, then return to their daily home range at dawn (R. Lentle pers. comm.). It may be that the wallabies recorded at Paehinahina were passing through the bait station site on the way to feed on either; pasture at the base of the peninsula (c. 800 m to the south) or on grassed clearings (c. 300 m to the north-east). Sampling at more sites over a longer period would be needed to investigate this further.

Photo. 22: Grassed clearing 300 m NE of the bait station at Paehinahina. D.S. Williams 1996.
Ship rats were recorded visiting the feeding station every night that the camera was operating. Rats could easily access bait from both stations, but feed mainly from bait spilt on the ground, (particularly when possums were present). Two aggressive interactions were observed between rat and possums, where the possum lunged at a rat.

Photo. 23: Possum about to lunge at a shiprat. Note the bait in rat’s mouth. D.S. Williams 1996.

On 5/12/96 a feral cat was recorded at the bait station. A juvenile wallaby had been feeding from the station 7 minutes prior to the cat arriving. The cat placed its head inside the station that the wallaby had been feeding from (the station containing the RS5 bait) but it did not remove a bait. The cat returned to the site 78 minutes later. An adult and a juvenile possum were feeding at the station. They appeared to be alert to the approaching cat, and departed 5 seconds prior to the cat arriving.
Feeding rate and visitation rate: Though wallabies were not captured and marked in this study, some individual wallabies carried marks on their fur that enabled them to be recognised in the video. Eight nights of video at Paehinahina showed that more individual wallabies visited, and some spent longer at the bait station as time progressed.

The number of feeding sessions and average amount of bait taken per feeding session (section 5.3.4) is illustrated in appendix 6. The average hourly bait take (combined by species) is summarised in Appendix 7.

To interpret this information in more detail would require sampling over a longer time interval at more sites. The two minute sampling data is yet to be fully analysed.
5.5 Discussion:

5.5.1 Why didn't wallabies feed from the stations at Okataina?

The results from the faecal pellet counts and casual searches at sites; 2, 3, 4, 5, and 7 indicated that wallabies were not accessing bait (No dyed wallaby faeces were found). Direct observations from the time-lapse video confirmed that wallabies were not accessing bait at sites; 3 and 4, (No wallabies were seen feeding from the stations).

Assuming my methods were good enough to detect “bait station use” by wallabies had it occurred (Section 5.5.2), there are a number of possibilities for why wallabies were not accessing bait from the stations at Okataina;

(i) they didn’t encounter the bait stations,

(ii) they were not interested in the bait and were preferentially feeding on grass other vegetation, or

(iii) possums were excluding the wallabies from the stations.

Did wallabies encounter the bait stations?

The likelihood of a bait station being visited by a wallaby is dependent upon the number of wallabies in the area (few wallabies = low chance of an encounter), and the proximity of the station to an area that wallabies are likely to be.

Studies on feral pigs in Australia have noted significant increases in bait take when “feed lines” were placed near areas of recent pig activity (McIlroy et al. 1993).

The time taken for an animal to locate a food source such as a bait station will also be influenced by the size of the range over which animals feed i.e. animals that forage over a large area will locate bait faster than those that
have a more restricted home range. The most conservative estimate of wallaby home range (for a juvenile)\(^2\) is 2.3 hectares (Lentle et al. in prep.).

Wallaby numbers at the “plateau” are typical of much of the Okataina Scenic Reserve, and will be higher than in areas of high public use (C. Davey pers. comm.). Wallabies used the track that ran past the bait station as their footprints were visible in the soft earth, and there is heavily grazed canopy opening within 100 m of the bait station site.

Wallabies were abundant in the vicinity of the Outdoor Education Centre at the time of my study, though their numbers vary a lot with season and weather (M. Taia pers. comm.). More than 30 were seen feeding on the grass when I visited the site after dark to focus the camera. The stations were also within 1-2 m of well used animal tracks (pad runs).

I believe the chances of a wallaby encountering one of the bait stations at Okataina were reasonably high, yet at the sites that were monitored with the video, no wallabies were recorded visiting the station (the field of view of the camera usually included an area of c. 2 m either side of the station). Further video monitoring at an increased number of sites would be desirable.

Social factors can effect an animals ability to locate distant food sources (Waltz 1982). Saunders et al. (1993) noted that continued use of pads leading to a bait line by pigs lead others to follow. Hopefully the current study by Lentle et al (in prep) will highlight aspects of wallaby social behaviour, that will be useful management options for wallabies.

The important aspects related to the “chances of an encounter” than need further investigation are; what density (spacing) of bait stations is required to ensure a high percentage of the wallaby population encounter a station, and does the location of individual stations relative to signs of recent wallaby activity influence visitation rate (i.e. should the layout of the stations be flexible to enable them to located near pad runs or feeding sites).

\(^2\) Lentle et al. (in prep.) concluded that home ranges were significantly greater in adults than in juveniles.
Were wallabies interested in eating the bait?

Wallabies are preferential grazers (Williamson 1986). Choquenot & Lukins (1996) have shown that pasture availability can significantly decrease bait uptake by feral pigs.

The large number of wallabies at the Outdoor Education Centre can be attributed to the availability of grass, and it is highly likely that wallabies will feed on the grass in preference to cereal baits (though this didn’t seem to be the case with possums). However at the “plateau”, the forest understorey is very sparse. Seedlings of “wallaby preferred” plant species are extremely rare. It is likely that wallabies rely heavily upon leaf-fall at this site, therefore they are more likely to be “dietary stress”, than those at the Outdoor Education Centre. The Anaha track site is intermediate between the other two; the forest understorey is sparse but there is a, heavily gazed, grassed track within 50 m of the station.

Given the level of effort put into searches for dyed faeces at the “plateau” I am reasonably confident that I would have located dyed wallaby faeces if there were any.

The work I carried out at Paehinahina showed that wallabies would eat the dyed Wanganui No.7 bait. Though they preferred this bait over RS5 (section 3.6.3), earlier work by Llewellyn (1985), would suggest that Wanganui No.7 is not the idea bait for wallabies.

Further investigation is needed to evaluate; bait preference, and the influence of alternative food on bait acceptance (i.e. can key feeding areas such as pasture margins or grassed clearing be used to advantage by targeting them for control or is the availability of a preferred food likely to reduce the effectiveness of control).

Did possums exclude wallabies from the stations?

Earlier work with bait stations at Okataina suggested that possums are more aggressive than wallabies and will dominate access to the stations (Moore 1991).

Evidence from the video work at Rainbow Springs (section 4.4.2) and Paehinahina (section 5.4.4) showed that, during interactions between wallabies and possums, wallabies are displaced from the station. At
Paehinahina possum densities are low and generally the feeding times of possums and wallabies didn’t overlap so the wallabies were able to access bait while the possums were absent.

As possum densities were higher at the Okataina sites, there was less chance of wallabies encountering a station without a possum being present. It is possible that possum activity in the vicinity was enough to discourage wallabies from approaching the stations (i.e. coming with the field of view of the camera).

Had I persisted with the poisoning at the Outdoor Education Centre, or “trapped to extinction” at the “plateau” I may have been able to determine if wallabies would start using the station once possum numbers were reduced. However reinvasion of possums would probably remain to be a problem unless a sufficiently large area was treated. A better method would be to monitor wallabies through a large scale bait station poisoning operation.

As well as increasing the number sites monitored it would be desirable to record wallaby activity in other habitats such as open pasture or clearings, however to use the video in this situation a more powerful light source would be required.

5.5.2 How useful were the monitoring methods?

The efficacy of both monitoring techniques, (searching for dyed faeces and video monitoring) are limited by sample size, which is influenced by the numbers of wallabies in the study area (i.e. at low densities the chances of recording a dyed face or observing an encounter will be low, therefore sampling will have to be more intense).

This pilot study was limited by its short duration and the small number of sites sampled, however it did provide an opportunity to evaluate some relatively various monitoring techniques.

A major advantage of faecal pellet counts is that they can be used to simultaneously determine the abundance of number of animal species (wallabies, possums, goats, deer and pigs). They are however very labour intensive. Observers must be motivated and have the ability to differential the faeces of the various species. For the less common species like wallabies their are no estimates for deification rate or decomposition rate.
This limits the use of this technique to estimates of relative abundance. Cleared plot faecal pellet counts are probably the most robust technique for monitoring wallabies within forest, though it would be worthwhile to evaluate "encounter" rate or "kill" rate, from hunting permit kill returns.

Dye-marking the bait with rhodamine proved to be a useful method for identifying which animals had been accessing bait. This is important where more than one pest species is being monitored. By law toxic baits must be dyed green, as rhodamine is red, if this technique is to used to during a poisoning operation an alternative marker such as pyranine would be required.

Time-lapse video is a useful technique for monitoring activity at bait stations, particularly if animals are marked to make them individually identifiable. Making the video equipment more portable, reducing power consumption, and in some situations, improving the output of the light source, would increase the utility of this technique. Evaluating the data from the videos can be extremely time consuming.
6. CONCLUSIONS & RECOMMENDATIONS:

6.1 Stopping the spread of wallabies:

The feral range of dama wallabies in the Bay of Plenty is continuing to increase. To limit the spread of wallabies a management strategy must be developed, that covers lands of all tenure. In developing this strategy the following considerations are need;

- High priority should be given to assessing wallaby density in areas with a high rate of spread, as identified in Strickland (1994) (Map 1).
- Sites requiring most urgent management action, should be determined through a priority ranking system.
- Reducing the risks of illegal liberations of wallabies requires enforcement of legislation relating to live capture, keeping and conveyance of wallabies. The Department of Conservation (DoC) needs to review its administration of this legislation.
- A public awareness campaign on the impacts and dispersal of wallabies should to be initiated.

6.2 Minimising wallabies impacts:

A management strategy for wallabies must focus on reducing wallabies impacts, and the success of control must be judged by monitoring the response in wallaby “preferred” vegetation. To maximise the benefit from pest control resources, management action should be coordinated with existing pest control operations for possums, goats and rabbits, therefore the strategy needs to;

- Evaluate wallaby impacts at sites where pest control is being currently carried out.
- Review and rank the management of wallabies on lands of all tenure containing or adjacent to priority areas.
- Include provision for intensive maintenance control.
- Vegetation monitoring must continue, and if possible simplified monitoring techniques developed.
6.3 Assessing control options and new technology:

Past control operation have successfully reduced wallaby numbers, however to protect highly preferred plant species, wallaby numbers will have to be kept at low levels indefinitely. Suitable control methods for sustainable management of wallabies need to be further investigation.

Some methods of control will effect other animals. These impacts will need to be assessed so that the costs and benefits of these techniques can be evaluated and public concerns addressed.

The testing of new pest control technology tends to focus on pests; that have a wide distribution, or threaten resources of high economic value. Many new methods of control, particularly toxins, remain untested on wallabies.

I therefore recommend that before recommencing large scale control of wallabies, the management agencies (DoC and the Regional Councils) carry out the following;

• Assess annual wallaby harvest by recreational hunters.

• Test the susceptibility of dama wallabies to; 1080, Talon®, Campaign® and pindone.

• Evaluate encapsulated cyanide for control and monitoring of wallabies and possums.

• Conduct statistically robust bait preference and acceptance trials to test a variety of baits and lures.

• Evaluate further the effectiveness of bait stations for wallaby control.

In choosing suitable methods for wallaby control the management agencies must;

• Address public concern about control techniques for wallabies.

• Assess the impacts of control on other wildlife using robust techniques.

6.4 Evaluation of bait stations:

Bait stations have a number of advantages over other control techniques; bait can be protected from the weather, less toxin is used, unused or spoiled bait can be
removed from the site, the risks to non-target species may be reduced, and new toxins not suitable for aerial broadcasting can be used.

The findings of this study show that wallabies will feed from bait stations.

Trials with captive wallabies at Rainbow Springs, showed that they were initially reluctant to feed from one make of station. The most likely explanation for this is that given an alternative, wallabies prefer to feed while retaining full use of their senses. Removing bait from the least preferred station, required the wallabies to place their head completely inside the station, briefly covering their eyes and ears. Of the three stations tested, the Marley downpipe “hockey stick” station was the most suitable for delivering cereal bait to wallabies.

- Bait stations for wallaby control, should provide easy access to the bait without obscuring the wallaby’s eyes and ears.

Feral wallabies were recorded feeding from bait stations at only one of my study sites, (Paehinahina). A variety of age/size classes fed from the stations which were mounted with the entrance hole 400 mm above the ground. As juveniles had to straighten their hind legs completely to remove bait from the station, 400 mm should be taken as maximum height for mounting bait stations.

- Bait stations should be mounted with the entrance no higher than 400 mm above the ground.

When grazing wallabies normally adopt a “pentapedal” gait. During my observations wallabies almost always fed from the ground as they approached the bait station. This behaviour may explain wallabies high susceptibility to aerially broadcast 1080, but could have an adverse effect during a bait station operation. This will be particularly important if acute toxins such as 1080 are to be used. Any animals consuming sub-lethal amounts of bait, by eating only fragments of bait from beneath the station, may survive, and avoid eating further bait due to “learned aversion”. There is less risk of this occurring with chronic toxins such as Talon®, but wallabies may have to consume a large amount bait to accumulate a lethal dose from this toxin. Further research is needed to resolve this issues.

- Investigate in more detail the amount of bait consumed by individual animals, and social interactions that may limit the effectiveness of bait stations as a control technique.
All of the interactions between wallabies and possums observed in this study (at Rainbow Springs and Paehinahina), resulted in the wallaby being displaced from the bait station.

I was unable to confirm whether possums were excluding wallabies from the bait stations at Okataina.

If possums prevent wallabies from accessing bait this will seriously decrease the efficacy of control operations using bait stations. However once possum numbers have been reduced, wallabies may then begin to feed from the station. If this is the case alternative baiting strategies will be required.

- Bait station operations using acute toxins (e.g. 1080), may need to be followed up with more non-toxic “prefeed” and a second pulse of 1080.
- Bait station operations using chronic toxins (e.g. Talon®), may need to be continued for longer than would normally be expected for possum control alone.

The density (spacing) of bait stations will influence the chance of a wallaby encountering the station. I made no attempt to determine the distance that wallabies were traveling to feed from the bait station at Paehinahina, however a control operation targeting more than one species will have to focus its design on the least mobile species. Estimates of wallaby home range from a radio telemetry study indicate that a commonly used bait station layout for possum control (150 x 150 m grid) would be sufficient for wallabies.

As a number of aspects warrant further investigation to fully evaluate the effectiveness of bait stations as a control technique for wallabies. A well designed management experiment using toxins, would achieve a dual role in testing the technique while hopefully reducing wallaby impacts.

- Conduct a robustly designed management experiments using toxic bait in bait stations. Suitable techniques for monitoring both wallabies and possums need to be used.
- Further investigate; bait station design and spacing, toxins, and the effects of seasonality and habitat type on the efficacy and efficiency of control.
Monitoring the impacts of various baiting strategies on shiprats would be desirable but as specific monitoring techniques are required this would involve extra cost.

6.5 Monitoring techniques:

- An advantage of faecal pellet counts is that they can be used to monitor the abundance of variety of animals simultaneously.

- As there are no estimates for deification rate or decomposition rate for wallabies, the use of faecal pellet counts is limited to estimates of relative abundance. They are labour intensive and observers must have the ability to differential the faeces of the various species.

- Dye-marking bait with rhodamine is a useful method for identifying bait take at a species level, but during poisoning operations an alternative marker such as pyranine would be required.

- Time-lapse video is a useful technique for monitoring activity at bait stations, particularly if animals are marked to make them individually identifiable. Making the video equipment more portable, and improving the output of the light source, would increase its utility.

7. ACKNOWLEDGMENTS:

I would like to thank; Liz Slooten, and Graham Hickling for supervising this project. The staff at Rainbow Springs Ltd. for access to observe their captive wallabies. Phil Thomson, Colin Turnbull and Animal Control Products Ltd. for providing me with bait stations. Colin & Pauline Davey for sharing their knowledge of wallabies and the Okataina area. The Okataina Scenic Reserve Board, in particular Matt Taia for allowing me to work within the Reserve. Dave Paine, David Moore and staff from the Bay of Plenty Regional Council for providing bait and advice. David Hunt and Mark Kimberley for technical advice and editing. Hilary Williams and my work colleagues at the Department of Conservation, Bay of Plenty, for supporting me throughout this project.
8. REFERENCES:

As many of the listed references are unpublished, copies can be obtained by writing to:

Dale Williams at the Department of Conservation, P.O. Box 1146, Rotorua.


Lentle, R.; Springett, B. (in prep): The Behaviour of Tammar Wallaby (*Macropus eugenii*) in the Okataina district of Rotorua, New Zealand. A radio tracking study carried out on behalf of the Department of Conservation under Research Grant 1908. (draft contract report.)


9. APPENDICES:

Appendix one: The bait stations evaluated Rainbow Springs.

The “Philproof bait feeder” (Pp) is currently the most commonly used bait station for possum control on conservation lands in the Bay of Plenty. This station is manufactured by Phil Thomson of Bankier Road RD 1, and its design eliminates many of the faults found in other commercially manufactured bait stations. Pp stations are filled via the removable base plate. They are inverted during the filling process and when return to their normal position the “wider at the bottom” shape reduces the chance of bait flow becoming restricted. The shape of the station also allows them to be stacked for transport with 10-15 stations fitting into a large pack. They are made of heavy gauge recycled plastic which can withstand being chewed possums. The large verandah over the opening, gives greater weather protection to the bait than most other stations. The station tested had a 1.5 kg capacity. The entrance dimensions are approximately 110 wide x 60 mm high.

I also tested the feeding rate from two modified Pp stations. On the (Mod 1 Pp) the dimensions of the entrance holes had been enlarged to 120 x 110 mm. On the (Mod 2 Pp) the entrance was 120 x 90 mm and the lip had been removed from the baseplate to further enlarge the entrance.

The ACP bait station is manufactured by Animal Control Products of Wanganui. The ACP station was supplied to me by the manufacturer as they were not available for retail sale at the time of this experiment. It is similar to the Pp station in that it is, stackable, inverted for filling via a removable baseplate, and is wider at the base. It is smaller than the Pp station having a 1 kg capacity. The entrance is c.120 x 35 mm.

The Marley PVC down-pipe station (Mdp) is a “hockey stick” type station made from, commercially manufactured storm piping with a 90° elbow near the base. Before Pp stations became available, Mdp stations would have been the most commonly used possum station in the Bay of Plenty. Mdp stations were used by the Regional Council during the trials with wallabies at Okataina (section 3.5.5). The 85 mm diameter PVC down-pipe is a robust material that can withstand being chewed by possums and rats. A major disadvantage of down-pipe stations is that they are made from commercially available materials, but have to be assembled which involves additional labour costs. Other problems common to “hockey stick” stations are; bait often becomes jammed (“bridged”) in the elbow section, they are bulky to carry, less weatherproof and harder to fill than some of the alternative types of station. The capacity of Mdp stations is dictated by the length of the main tube. Those used in this study held c. 2 kg of bait. The entrance diameter is c. 85 x 60 mm.
## Appendix 2: Diary of events for trials with captive wallabies (Rainbow Springs)

<table>
<thead>
<tr>
<th>Rainbow Springs (events diary)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>28 - 30 July</strong></td>
</tr>
<tr>
<td><strong>30 July - 2 August</strong></td>
</tr>
<tr>
<td><strong>2 - 5 August</strong></td>
</tr>
<tr>
<td><strong>5 - 11 August</strong></td>
</tr>
<tr>
<td><strong>13 August</strong></td>
</tr>
<tr>
<td><strong>13 - 14 August</strong></td>
</tr>
<tr>
<td><strong>17 August</strong></td>
</tr>
</tbody>
</table>
Appendix 3: Site locations and methods used during field trials at Okataina Scenic Reserve and Paehinahina peninsula

<table>
<thead>
<tr>
<th>Field study site locations</th>
<th>Grid reference NZMS260</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mahoe gully</td>
<td>V15 112428</td>
<td>Filled bait station once only to check visitation rate.</td>
</tr>
<tr>
<td>2. Plateau</td>
<td>V15 110423</td>
<td>Filled bait station with dyed bait at c. weekly intervals. Faecal pellet counts on systematically located 80 cm radius plots 10m apart, along lines of various length (max. 370m), radiating out from the station. Trapped possums, Victor #1 traps 20m apart along pellet lines</td>
</tr>
<tr>
<td>4. Outdoor Education Centre</td>
<td>V15 100410</td>
<td>2 bait station (at 100m apart) filled with dyed bait. Feeding activity monitored with video (211 hrs). Casual searches for dyed faeces. Toxic bait (Campaign®) used to reduce possum numbers. Videoed bait take from ground.</td>
</tr>
<tr>
<td>5. Bullring</td>
<td>U15 099421</td>
<td>Bait station periodically filled with dyed bait. Casual searches for dyed faeces.</td>
</tr>
<tr>
<td>6. Heli-pad</td>
<td>U15 095425</td>
<td>Filled bait station once only to check visitation rate.</td>
</tr>
<tr>
<td>7. Waione</td>
<td>U15 089416</td>
<td>Bait station periodically filled with dyed bait. Casual searches for dyed faeces.</td>
</tr>
<tr>
<td>8. Paehinahina</td>
<td>U15 083466</td>
<td>2 bait stations (at 1 site) filled with dyed bait at c. weekly intervals. Faecal pellet counts on systematically located plots 5m apart, along lines radiating out to 50m from the station. Feeding activity monitored with video (169 hrs). Alternative bait (unflavoured, undyed, RS5) trialed.</td>
</tr>
</tbody>
</table>
Appendix 4: Events diary for field trials at the Okataina Scenic Reserve and Paehinahina peninsula.

<table>
<thead>
<tr>
<th>Field study</th>
<th>(events diary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 - 8 September</td>
<td>Placed bait stations at 7 sites in the Lake Okataina Scenic Reserve</td>
</tr>
<tr>
<td>15 September</td>
<td>Checked bait consumption and chose main study sites</td>
</tr>
<tr>
<td>25-29 September</td>
<td>Started faecal pellet plots at the “plateau” site</td>
</tr>
<tr>
<td>30 September</td>
<td>Set up the time-lapse video equipment at the Outdoor Education Centre.</td>
</tr>
<tr>
<td>2 October</td>
<td>Moved the video to 2nd site at the Outdoor Education Centre (stopped feeding at 1st site).</td>
</tr>
<tr>
<td>4-5 October</td>
<td>Recounted 100 faecal pellet plots at “plateau” site.</td>
</tr>
<tr>
<td>8-11 October</td>
<td>Toxic bait (Campaign®) used at the Outdoor Education Centre.</td>
</tr>
<tr>
<td>9 October</td>
<td>Visited Paehinahina peninsula (monitoring contract hunting operation).</td>
</tr>
<tr>
<td>10 October</td>
<td>Filled bait stations at Paehinahina and established faecal pellet plots.</td>
</tr>
<tr>
<td>11 - 12 October</td>
<td>Trapped possums at “plateau” site.</td>
</tr>
<tr>
<td>19-20 October</td>
<td>Second pulse of (Campaign®) at the Outdoor Education Centre</td>
</tr>
<tr>
<td>26 October</td>
<td>Videoed at Outdoor Education Centre (still lots of possums!)</td>
</tr>
<tr>
<td>5 - 7 November</td>
<td>Videoed bait on ground at OEC.</td>
</tr>
<tr>
<td>16 November</td>
<td>Recounted faecal pellet plots at Paehinahina (located dyed wallaby faeces).</td>
</tr>
<tr>
<td>28 November</td>
<td>Set up the time-lapse video equipment at Paehinahina.</td>
</tr>
<tr>
<td>10 - 11 December</td>
<td>Ran video for 1 night at “Anaha track” site (demo for other staff).</td>
</tr>
</tbody>
</table>
Appendix 5: Average hourly bait take at Paehinahina
Appendix 6: Number of feeding sessions and bait take at Paehinahina
Appendix 7: Summary of hourly bait take at Pachinahina
Average hourly bait take, Paehinahina

Hours from midday

Average No. baits/hr

wallaby
possum
rat
Appendix 6: Number of feeding sessions and bait take at Pachinahina

Wallaby

Possum
## Appendix 7: Summary of hourly bait take at Paehinahina

<table>
<thead>
<tr>
<th></th>
<th>28/11</th>
<th>29/11</th>
<th>30/11</th>
<th>1/12</th>
<th>2/12</th>
<th>4/12</th>
<th>5/12</th>
<th>6/12</th>
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<tbody>
<tr>
<td><strong>Wallaby</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Total no. of baits taken</td>
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<td>29</td>
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<td>3</td>
<td>6</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Max. no. of baits in 1 hour</td>
<td>14</td>
<td>39</td>
<td>35</td>
<td>16</td>
<td>19</td>
<td>45</td>
<td>22</td>
<td>74</td>
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<tr>
<td>Av. no. baits in 1 hour</td>
<td>7.5</td>
<td>16.8</td>
<td>12.8</td>
<td>9.7</td>
<td>13</td>
<td>24.3</td>
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<td>20.7</td>
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<td>8.5</td>
<td>5.8</td>
<td>5.2</td>
<td>4.5</td>
<td>5.5</td>
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<td>Average daily bait take</td>
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<td>1.8</td>
<td>1.7</td>
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<td>1.1</td>
<td>2.6</td>
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<td>Standard error</td>
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<td>0.8</td>
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<td>6</td>
<td>5</td>
<td>7</td>
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<td>46</td>
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<td>Av. no. baits in 1 hour</td>
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<td>15.9</td>
<td>16.3</td>
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<td>33.4</td>
<td>18.9</td>
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<td>5.4</td>
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<tr>
<td><strong>Rat</strong></td>
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<td></td>
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<td>No. of hours that feeding occurred</td>
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<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Max. no. of baits in 1 hour</td>
<td>16</td>
<td>24</td>
<td>11</td>
<td>1</td>
<td>34</td>
<td>13</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Av. no. baits in 1 hour</td>
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<td>24</td>
<td>11</td>
<td>1</td>
<td>20.3</td>
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<td>7.1</td>
<td>3.2</td>
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<td>0.8</td>
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<td>Average daily bait take</td>
<td>0.7</td>
<td>1</td>
<td>0.9</td>
<td>0.8</td>
<td>3.4</td>
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<tr>
<td>Standard error</td>
<td>0.7</td>
<td>0.6</td>
<td>1.9</td>
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<td>1</td>
<td>0.6</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Yes, I did get bitten!!!