The Control of Pest Wallaby Populations

by

Graham Gregory, B.V.Sc.

Submitted for the degree of

Master of Science.

University of Tasmania

Hobart

February 1989.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any tertiary institution, and to the best of my knowledge contains no copy or paraphrase of material previously published or written by any other person except where due reference is made in the text of the thesis.

G. G. Gregory

Department of Agriculture

Launceston

February, 1988.

THE CONTROL OF PEST WALLABY POPULATIONS

CONTENTS

Acknowledgements

Summary

Chapter 1 Introduction

1.1. Wallabies in Tasmania 1

1.2. The Management of Wallabies in Tasmania . 4

1.3. Population Monitoring 5

1.4. Damage Caused by Pest Populations . . . 6

1.5. Wallaby Poisoning 10

1.6. Objectives 11

Chapter 2 The Economic Effect of Wallabies on Pasture

2.1. Introduction 12

2.2. Materials and Methods 15

2.2.1. Pademelons 15

2.2.2. Bennett's wallabies 15

2.3. Results 16

2.3.1. Pademelons 16

2.3.2. Bennetts wallabies 16

2.4. Discussion 22

Chapter 3 Assessment of Conventional Techniques

3.1. Introduction 23

3.1.1. Rabbit Poisoning Techniques . . 23

3.1.2. Wallaby Poisoning 25

3.1.3. Concentration of 1080 in Bait . . 26

3.2. Materials and Methods 27

3.2.1. Trial Sites 27

3.2.2. Population Assessment . . . 27

3.2.3. Poisoning Techniques . . . 29

3.3. Results 29

3.4. Discussion 35

3.4.1. Mortality Rate 35

3.4.2. Population Estimates . . . 36

Chapter 4 Bait Acceptability Trials

4.1. Introduction 38

4.2. Methods 39

4.2.1. Study Areas 39

4.2.2. Bait Acceptance 40

4.2.3. Animal Populations 41

4.3. Results 41

4.3.1. Royal George 41

4.3.2. Waterhouse 43

4.3.3. East Tamar 46

4.4. Discussion 47

4.4.1. Bait Acceptance 47

4.4.2. Animal Behaviour 49

4.4.3. Bait Placement 49

Chapter 5 Field Evaluation of Alternative Techniques

5.1. Inroduction 50

5.2. Materials and Methods 51

5.2.1. Aspects Studied 51

5.2.2. Assessment of Wallaby Populations . 51

5.2.3. Trial sites and Poisoning Methods . 52

5.3. Results 56

5.3.1. Poisoning Operations . . . 56

5.3.2. Comparison of Treatments . . . 60

5.4. Discussion 60

5.4.1. Population Assessment . . . 60

5.4.2. Expected Mortality 63

5.4.3. Resurgence of Populations . . 64

5.4.4. Bait Type 64

5.4.5. Poison Concentration . . . 65

5.4.6. Bait Placement 66

5.4.7. Furrow Poisoning 66

5.4.8. Target Specificity 67

Chapter 6 Control Using Electric Fences

6.1. Introduction 69

6.1.1. Exclusion Fencing 69

6.1.2. Electric Fencing Principles . . 70

6.1.3. Wildlife and Electric Fences . . 72

6.1.4. Wallaby Control using ElectricFencing 73

6.2. Materials and Methods 76

6.2.1. Study Site 76

6.2.2. Fence Structure 76

6.2.3. Animal Population Monitoring . . 76

6.3. Stage One - June to September 1982 . . . 77

6.3.1. Fence Configuration 77

6.3.2. Results 78

6.3.3. Discussion 80

6.4. Stage Two - September 1982 to September 1983 . 80

6.4.1. Materials and Methods . . . 80

6.4.2. Results 82

6.4.3. Discussion 82

6.5. Stage Three - September 1983 to March 1985 . 84

6.5.1. Materials and Methods . . . 84

6.5.2. Results 85

6.5.3. Discussion 87

6.6. Summary 89

Chapter 7 Conclusion

7.1. Economic Effect of Wallabies 91

7.2. Population Assessment 93

7.3. Poisoning Techniques 94

7.4. Electric Fencing 97

Bibliography 99

Acknowledgements

These investigations were carried out as part of my work with the Department of Agriculture, Tasmania and were funded by that Department. Much technical assistance was provided by Department of Agriculture staff. In particular I would like to thank Mike Tyson and Sam Hughes for assistance with spotlight counts at North Lilydale, Sue Medlock for observations on poisonings at Royal George and Rushy Lagoon and for assistance with the electric fencing investigations, Doug Brooks and Bricky Hills for the construction of the electric fences, and Mick Middleton and Ken Bailey for the work on Flinders Island. Help with statistical analyses was provided by Terry Koen and Bob Gittins.

The National Parks and Wildlife Service, now part of the Department of Lands, Parks and Wildlife, provided permits for control operations. The assistance and cooperation of all property owners, particularly Brett and Liz Hooper was also grately appreciated. Dr Eric Guiler as my supervisor at the University of Tasmania assisted with his encouragement and the loan of the automated movie cameras, and Professor Mike Stoddart gave valuable advice on the preparation of this thesis.

I also wish to thank Sally Mancey, Carol Houghton and Susan Brown for assistance with typing and the preparation of figures.

This thesis would not have come to fruition without the encouragement and support of my wife, Libby, who proved to be a most inspiring influence.

Summary

Two species of wallabies present in Tasmania, *Macropus rufogriseus* and *Thylogale billardierii*, have been demonstrated to cause significant economic loss to the grazing industries. Preliminary investigations into quantifying the competition between wallabies and livestock have shown losses of 11.3 to 17.1 kg dry matter per ha per day, which can be converted to a gross cost of between $140 and $400 per ha per year. The need for the control of wallaby populations arises from these potential losses and will be justified from an analysis of the anticipated benefits and the anticipated costs.

One method of wallaby control that is commonly used in Tasmania is by poisoning with sodium monofluoroacetate (compound 1080). *T. billardierii* were shown to be susceptible to poisoning techniques developed for rabbit control. That is they readily find and consume chopped carrot bait distributed in a shallow furrow and are sufficiently sensitive to 1080 to be poisoned by a toxic loading of 0.014%. *M. rufogriseus* populations are however not as readily controlled using the same technique.

The acceptability of chopped carrot bait to *M. rufogriseus* is not as good as that of dry bran/pollard bait in spring when there is a plentiful supply of green pasture available. Bran or pollard bait is therefore recommended as an alternative bait for wallaby control. Although there is no significant evidence of birds eating this bait, it is considered by wildlife authorities that pelleted bait may be less attractive to birds. These were not found to be well accepted by wallabies although are commonly used in New Zealand and other Australian States so are worthy of further investigation.

Field investigations have shown that for the control of *M. rufogriseus* by poisoning with 1080 no significant differences in

mortality rates could be obtained by (1) using 0.028% 1080 on bait compared to the normally recommended 0.014%, (2) using or not using a furrow for marking the bait line, (3) baiting with chopped carrot or dry bran or pollard, or (4) placing the bait line in the bush compared to about 20 m into the paddock.

It is recommended that when attempting to control *M. rufogriseus* by poisoning, control should take place in summer or autumn when alternative food is not so readily available and that particular attention should be given to adequately free feeding and providing plenty of bait for all wallabies present. The concentration of 1080 on bait should remain at 0.014%. Further investigations are required to ascertain whether surviving wallabies have eaten any of the bait, or whether the mortality rate can be improved by other changes to the poisoning routine, such as repeated poisonings.

The protection of crops from wallabies by the use of electric fences is a promising alternative to poisoning. An effective fence must be evenly graded and have the lowest wire no more than 75 mm above the ground to prevent wallabies from creating a runway under the fence. The most effective fence design so far tested for wallaby control consists of six wires all with 75 mm spaces and the lowest 75 mm from the ground. The second, fourth and sixth wire from the ground should be electrified.

Further research is required to report in more detail the economic effects of competition between wallabies and agriculture, to further assess the effectiveness of improved poisoning techniques, and to further investigate the use of electric fencing for wallaby control.

Plate I

Macropus rufogriseus - Bennett's wallaby.

Plate II

Thylogale billardierii - red-bellied pademelon.

Chapter 1

Introduction

1.1. Wallabies in Tasmania

I am concerned in this thesis with two species of wallabies which are very common in Tasmania and are considered to be a pest to agricultural and forestry enterprises. Both of these species are widespread and are partially protected under the National Parks and Wildlife Act, 1970.

The larger of these is *Macropus rufogriseus** (Plate I), commonly called the red-necked wallaby, brush wallaby, Bennett's wallaby or, coloquially in Tasmania, the kangaroo. This is one of the large wallabies with a mean weight of 19.7 kg for males and 14.0 kg for females. The head and body length and tail length are about 70 to 80 cm (Green 1973, Calaby 1983). It is distributed over much of the eastern seaboard of Australia from central Queensland to Victoria, as well as being very common throughout Tasmania, including the larger islands of Bass Strait (Calaby 1983). It was introduced to New Zealand in 1870 and currently occurs in Canterbury (Ride 1970). It can be found in all vegetation types except extensive rainforest but prefers open forest and pasture near gullies, or tall coastal heath. It is predominantly a grass eater, being attracted to lucerne, clover or mown grass (Calaby 1983, Jarman *et al.* 1987, Southwell 1987).

The breeding cycle of the Tasmanian subspecies (*M. r. rufogriseus*) varies from the mainland subspecies (*M. r. banksianus*). On the mainland births are recorded in all months with a slight increase during summer. In Tasmania and New Zealand there is a well defined breeding season between late January and July, with most births in February and March, and young leave the pouch in November (Catt 1976, Calaby 1983). The

---

* Latin names for mammals are from The Australian Museum Complete Book of Australian Mammals (1983), Angus and Robertson, Sydney.

length of the oestrous cycle is 33 days and the gestation period 30 days. There is a post partum oestrous and embryonic diapause. The fertilized embryo in the uterus becomes dormant while the pouch is being occupied by the previous young, or during the non-breeding season. In females without a pouch young, that mate at the end of the breeding season, the embryo does not develop past the blastocyst stage until the next breeding season, up to 8 months later. The embryo may go into diapause for as long as 12 months if the previous young has an extended pouch life. The young is not born until 16-29 days after permanent emergence of the large pouch young. The pouch life is about 280 days and the young may continue to be suckled until they are 12-17 months old (Calaby 1983). Catt (1976) recorded that males were sexually mature at 21-22 months of age and females at 14-17 months. The birth rate was 0.581 per female in their first year and 0.947 per female over two years old.

Mooney and Johnson (1979) reported the results of estimating the home range of *M. rufogriseus* in Tasmania using radio-location. Five specimens had elongated home ranges with the long axis extending across the bush/pasture interface into the forest. The mean size of the home range area was 100.1 $\pm$ 49.1 ha, with a long axis mean of 1.85 $\pm$ 0.32 km. The greatest movement recorded into the forest was 1.70 km from the pasture interface. Johnson (1987) mapped home ranges of thirty seven recognisable individual *M. rufogriseus* in New South Wales by recording their day time locations. His results depict much smaller home ranges than Mooney and Johnson (1979). He recorded a median home range of 7.4 ha (n=9) for subadults and 16.3 ha (n=53) for adults. The median home range of females was greater in winter than summer (10.9 ha cf. 5.9 ha, $U=49$, $p<0.05$) and that of adult males (31.6 ha) was greater than adult females (11.8 ha, $U=220$, $z=3.49$, $p<0.001$). The home ranges were stable from year to year. Mooney and Johnson (1979) reported that individuals emerged on to the pasture on only 52% of nights, but there was remarkable consistency in the time of night when they emerged and returned to the forest. In June and July Bennett's wallabies emerged before 1930 h and returned into the forest after 0500 h in the morning.

The smaller wallaby is *Thylogale billardierii* (Plate II) which is variously known as the red-bellied pademelon, scrub wallaby or rufous wallaby. Males have a mean weight of 7 kg and females 3.9 kg. The head and body length is about 60 cm and the tail about 40 cm (Green 1973, Johnson and Rose 1983). It is extremely gregarious, occurring in large communities in moist gullies and dense forests. It is confined to Tasmania, being particularly common in the north-west and on some smaller islands in Bass Strait. It was previously recorded in Victoria and south-east South Australia (Ride 1970, Breckwoldt 1983) but has not been seen there for many years (Gould 1863, Johnson and Rose 1983).

The main breeding season appears to be in autumn-winter. Rose and McCartney (1982a) recorded a peak in births in April to June but a secondary season appears in December-January. This may be related to the young from the autumn mating leaving the pouch. Embryonic diapause is a feature of *T. billardierii* as with many other macropods. The gestation length is 30 days. Young leave the pouch at about 200 days old with a mean weight of 1029 g and continue to suckle for a further 3 months (Rose and McCartney 1982b).

Johnson (1978) investigated the spatial and temporal use of habitat in 4 male pademelons in southern Tasmania using radiotelemetry. The home ranges were found to be cigar shaped and varied from 138 to 169 ha (mean 156 $\pm$ 9.7 ha) with a long axis from 2200 to 2730 m (mean 2460 $\pm$ 219 m). He also studied the movements of the red-necked pademelon (*T. thetis*) in New South Wales, and found this species to have a home range of 13.9 $\pm$ 7.3 ha, although 90% of their time was spent in about 8 ha. The home range was divided into a nocturnal range on pasture and a diurnal range in the forest, as all animals moved to pasture about sunset and returned shortly before sunrise (Johnson 1980). In contrast *T. billardierii* in Tasmania gradually moved on to pasture at night and reached peak numbers about 3 h before sunrise. Peak numbers were present on pasture for about half the darkness period. The percentage of nights on which *T. billardierii* visited pasture varied between individuals from 26 to 87%, with a mean of 55%. There appeared to be a trend of increased visitation to pasture with increased age of pademelons (Johnson 1977, 1978).

1.2. The Management of Wallabies in Tasmania

The Department of Lands, Parks and Wildlife have four basic objectives in their management of wallabies and are attempting to balance the demands of conservation with those of crop protection (Anon 1984):

(i) each species must be maintained in viable numbers over their natural range;

(ii) pest populations may be reduced by shooting, or by poisoning where they are shown to be damaging crops;

(iii) they are regarded as a resource which can be exploited commercially; and

(iv) population trends State-wide are monitored to provide information for management decisions.

They consider three major classes of land use to be important in the survival of wallaby populations. Agricultural land covers about 1/3 of Tasmania, but the proportion of improved pasture is increasing at a rate of about 12% per decade. Although this may be considered to encroach upon suitable wallaby refuge areas, it also provides a very favourable food source and improved watering points. Wallaby populations appear to be thriving under these conditions.

A further 1/3 of Tasmania contains forests of potential commercial quality. Over 20,000 ha are clear felled for sawlogs and pulpwood annually, and this practice is considered to have the greatest potential impact in wallaby populations. Subsequent regrowth and reforestation on at least half of this provides favourable feeding conditions for wallabies. The overall effect of forestry activities on wallaby numbers is considered to be favourable.

State Reserves and Conservation Areas cover over 1/4 of Tasmania and, within these, populations of both wallaby species have satisfactory habitat and area in which to survive.

It is difficult to assess the number of wallabies in Tasmania, but as 75% of Tasmania is suitable wallaby habitat, and their density probably averages 1.5 per ha, it may be conservatively assumed that 6 million wallabies live in Tasmania. Each species is about equally prevalent (Anon 1984).

Both species of wallabies are native to Tasmania and are managed by the Department of Lands, Parks and Wildlife. They are listed as semi-protected species under Schedule 1 of the Wildlife Regulations, 1971. The taking of these species is allowable only during declared open seasons or at any other time under a special crop protection permit.

An open season for the hunting of wallabies in Tasmania was first introduced in 1923 for 3 months, and has operated ever since, except for 8 years. The open season was extended to 6 months in 1955 and 1956, and to 12 months from 1958 to 1969. Since 1977, the season has been open from the first week in April until the third week in February of the following year. There has been a 12 month open season on King and Flinders Island every year since 1944 (Anon 1984). Wallabies can be hunted by day only, with either a commercial or non-commercial licence. Commercial licence holders are permitted to sell the meat and skins. Crop protection permits may allow the shooting of wallabies by night with the aid of a spotlight. Trading in wallaby products is also strictly controlled, and all skins traded must be stamped and a royalty paid.

1.3. Population Monitoring

The Department of Lands, Parks and Wildlife monitors populations of wallaby in Tasmania by direct and indirect methods. The requirement for hunters to be licensed and furnish returns, and the control over trading in wallaby products, has given a mass of data which can be analysed in various ways. The number of commercial licences issued and the number of skins sold are recorded but depend so much on the market value of skins. During 1979 and 1980 when wallaby skins were bringing good prices, there was a dramatic increase in the number of commercial licences issued, the number of royalties paid and the number of skins sold. Unless information is available on time spent hunting, these figures cannot be used to monitor population trends. An analysis of non-commercial hunting statistics is more likely to give reliable information on trends in the wallaby population. The numbers of wallabies taken by holders of non-commercial licences has remained reasonably steady, at about 600,000 p.a., in recent years (Anon 1984). Spotlight surveys of wallabies are carried out each November on 50 transects throughout Tasmania. Each transect consists of 10 km of roadway. The wallabies seen per transect have been stable since 1976, although a temporary reduction occurred in 1980 and 1981 following the years of increased pressure from commercial hunters. Bennett's wallaby counts averaged about 8 and pademelon about 7 per 10 km transect. Since 1979 a standardised technique has been used to count the number of road kills per 1,000 vehicles per day using the road. This technique is considered to be reliable for monitoring trends in pademelon populations, but not for Bennett's wallabies as numbers are too low. There are several other factors which influence the number of road kills, such as the traffic at night and speed of traffic but these are assumed to be constant. The results from 1979 to 1982 suggest that the pademelon population is not declining (Anon 1984).

Further information can be obtained from an analysis of poisonings for wallaby control from the Department of Agriculture. This information is provided in Table 1.1. and shows an increasing trend in the use of 1080 to control wallaby populations both in forestry and agricultural areas. The two species of wallaby are not differentiated.

1.4. Damage Caused by Pest Populations

A review committee looking into the effects of vertebrate pests in New Zealand reported that *M. rufogriseus* compete with sheep for feed and foul pasture, destroy fences, compete with sheep for sheltered habitat, destroy shelter by thinning out tussocks and bush, browse new tree plantings and affect soil erosion (Anon 1983).

Table 1.1

Amount of 1080 Used for Wallaby Control in Tasmania 1978/79 to 1986/87.

	Number of Poisonings			Quantity of 1080 (L 1.5% Solution)		
	Forestry	Agriculture	Total	Forestry	Agriculture	Total
1978/79	52	61	112	58.2	109.1	167.3
1979/80	49	71	120	75.8	171.2	247.0
1980/81	53	61	114	101.4	118.7	220.2
1981/82	77	137	214	103.2	280.5	383.7
1982/83	82	244	326	151.5	369.2	520.7
1983/84	92	183	275	154.5	322.0	476.5
1984/85	127	201	328	218.5	383.8	602.3
1985/86	162	184	346	250.5	299.5	550.0
1986/87	224	275	499	392.1	383.9	776.0

In Australia the clearing of forests and development of land into improved pasture or crops creates a most favourable environment for wallabies, giving them an excellent source of food close to their forest shelter (as shown in Plate III). Under these conditions wallabies have a local deleterious effect on pastures and crops near the forest edge (McCann 1976, Anon 1984).

Tandy (1976) reported on the results of analysing pasture samples collected from inside and outside an exclosure plot erected by a farmer on Tasmania's east coast in 1975. The pasture was sown with ryegrass and clover in autumn and no stock were in the area until after the samples were collected in December. The area carries a high *M. rufogriseus* population. The results showed (1) a reduction in biomass of 65.7% dry weight of pasture, and (2) a change in pasture quality from 81% subterranean clover (*Trifolium subterraneum**) inside the exclosure to 85% toad rush (*Juncus bufonius*) outside the exclosure (see Table 1.2).

Johnson (1976) considered that the combined effect of pademelons (*Thylogale thetis*), swamp wallabies (*Wallabia bicolor*), parma wallabies (*Macropus parma*) and potoroos (*Potorous tridactylus*) in an oat crop in New South Wales was to reduce the dry matter by 2700 kg/ha which would maintain a 450 kg steer for about 400 days.

In eucalypt regeneration areas in Tasmania *M. rufogriseus* were found to be primarily grass eaters although their intake of tough-leaved dicotyledons increased in winter. Eucalypts formed an insignificant proportion of their diet but damage to seedlings was extreme. In *Pinus radiata* plantations *M. rufogriseus* were considered to be responsible for 90% of the browsing damage (Statham 1983).

---

* Botanical names are taken from W. Hartley (1979), A Checklist of Economic Plants of Australia, CSIRO, Melbourne.

Plate III

This brassica crop near Lilydale shows an example of the damage caused by wallabies to crops near the forest edge.

Table 1.2

Comparison of Weight and Composition of Pasture with and without Grazing by Wallabies at Cranbrook, 1975

(from Tandy, 1976)

	Within Exclosure	Outside Exclosure
Green weight (g)	961	265
Dry weight (g)	204	70
Trifolium subterraneum %	81	4
Trifolium repens %	3	3
Lolium perenne %	5	3
Weedy grasses %	3	2
Juncus bufonius %	5	85
Flat weed %	2	3

Investigations reported in Chapter 2 reinforce the nature and degree of this damage. The amount of pasture eaten within 200 m of the forest edge has been equated to $135 to $400 per ha.

There is a real need to assess the cost of damage caused by wallabies competing with livestock and forest industries so as to assess the necessity of wallaby culling and justify the expense of alternative protection measures.

1.5. Wallaby Poisoning

Shooting and poisoning are the only methods used to control pest populations of wallabies in Tasmania although the use of electric fencing to exclude wallabies from crops and pasture is gaining popularity.

Poisoning is carried out using sodium monofluoroacetate (1080) on chopped carrot bait. The bait is free-fed three times on alternate days in trails on the ground before the poison feed is laid. This is the same technique developed for rabbit poisoning (Carrick 1957, Poole 1963b). The concentration of 1080 in the carrot bait was initially 0.04%, but this was reduced to 0.02% in 1971 following a subjective assessment of the effectiveness of the lowered concentration, and further to 0.014% in 1975 due to Department of Agriculture policy.

Reports have been received by the Department of Agriculture from farmers of dissatisfaction with the effectiveness of the poisoning operations. Farmers considered that less carcases were found and that the mortality rate was lower after reduction of the 1080 loading to 0.014%. They have called for an increase in the concentration in bait.

The aim of a wallaby control program is to reduce the amount of damage to an acceptable level. In a forest environment control of browsing may require only a temporary reduction in the wallaby population over a critical period of growth. In an agricultural area the reduction in the population may need to be significant and long standing, but this may be difficult to achieve. A mortality rate over 70% is considered to be an achievable objective.

1.6. Objectives

A recent report into methods of wallaby culling in Tasmania has condemned the use of poisons purely on emotional grounds (RSPCA Australia 1987). Wallaby management in Tasmania has been criticized by American and European interests, leading to an embargo on the importation of wallaby products from Tasmania.

In the face of this increasing adversity it is essential to ensure that the reasons for culling pest wallaby populations are valid and that the methods used are effective and can be justified to the community. Consequently, some preliminary observations were made to assess the amount of pasture eaten by wallabies, and to equate this with the potential loss in income to the farmer. Several methods were used to assess the wallaby population before and after poisoning and so estimate the mortality rate following the poisoning program. A bait acceptance trial was then carried out, followed by field investigations of the effectiveness of poisoning programs with a choice of baits, bait placement and concentration of poison. Various electric fence designs were tested for their effectiveness in excluding wallabies from pasture.

Chapter 2

The Economic Effect of Wallabies on Pasture

2.1. Introduction

The impact of wild herbivores on native or improved vegetation is widely reported in the literature. Of animals present in Australia, there is much information on the effects of rabbits, some information on competition between sheep and kangaroos, but little information on the grazing behaviour of wallabies.

Rabbits have been shown to have a marked effect on the floristic composition of pasture in Britain. Farrow (1917) reported that vegetation protected from rabbits by fencing was higher, more luxuriant and had more inflorescences per unit area. Even on the protected side of the fence where relatively few rabbits existed the difference between vegetation inside and outside rabbit-proof cages was marked after three years. Even a few rabbits, therefore, have a considerable cumulative effect on vegetation. Plants with tall vertical shoots suffer more than plants with shoots close to the ground. Grazing by rabbits decreases the number of species of plant, and favours some species - usually the unpalatable or tougher plants. Thomas (1960) recorded a decrease in the quantity of *Senecio jacobaea* after removal of rabbits by myxomatosis although they often felled flowering stems, thus preventing them from fruiting. There was also better regeneration of woody plants. Thompson (1951, 1953) assessed the live-weight gain of sheep grazing rabbit-free and rabbit-infested pasture. In seven months on an area of less than three acres, the live-weight increase of sheep was 800 lb. on the rabbit-free plots and 650 lb. on the rabbit-grazed plots. Myers and Poole (1963) used 2 ac enclosures with 3 densities of rabbit populations. They explained how the change in pasture quality results from the grazing behaviour of rabbits and the biological response of various pasture components. Rabbits prefer soft, green, lush grass. They choose food items on ease and comfort of intake and mastication, lack of disagreeable odours and tastes, and water content in summer. High protein intake is a result of the above. They avoid those causing physical pain, or with high fibre and aromatic or bitter tastes. Rabbits were found to have a much more severe effect on new pasture if damage is early in the establishment rather than after it had become established (Phillips 1953). Changes in pasture quantity, or the economic effect of rabbits grazing the pastures, have been expressed as the percentage of pasture eaten by rabbits (Myers and Poole 1963, Gooding 1955) or the extra carrying capacity, wool yield, and income after controlling rabbit numbers (Fennessy, 1966). Reid (1953) assessed that the reduction in the rabbit population by myxomatosis had allowed an increase of 5.47% in the Australian wool clip, and that the value of extra wool and meat in 1952-53 was $68 million.

Large animals require less energy per kg body weight for maintenance than do small animals. Grass and herb digestion in sheep and cattle is more efficient than in the rabbit. Figures for base metabolism show that six doe rabbits require as much useful energy as a ewe for maintenance (Thompson 1951). Rabbits eat approximately 6-7% of their body weight per day compared to 2-3% for sheep (Short 1987). A population of 20 rabbits per acre is reported to reduce the sheep carrying capacity by 27% and the liveweight increase by 64% (Anon 1978). Foran *et al.* (1985) found that grazing by rabbits depressed the biomass by 300 kg per ha, or by 25%, in the arid zone of central Australia.

Kangaroos are considered by differing sections of the community as either a serious competitor for sheep and cattle pasture, a resource for harvesting, or as a part of Australia's heritage which should be totally protected. Studies on dietary intakes (Griffiths and Barker 1966, Kirkpatrick 1965) show that a kangaroo eats less than 70% of what a sheep eats per day. Kangaroos have been shown to eat mainly short green grasses and to prefer *Eragrostis* sp. and other species found almost exclusively in gilgais on treeless flats (Chippendale 1962). Grey kangaroos ate more grass than herbs or shrubs, but red kangaroos and sheep ate the same proportion throughout the year - mostly 1:1. Kangaroos had only green food in their stomachs but sheep stomach contents were yellow at dry periods (Griffiths and Barker 1966, Fennessy 1966). These findings are born out by Russell (1974) who concluded that large kangaroos eat mostly green grass, and are not always in competition with sheep. Ellis *et al.* (1977) reported that whilst kangaroos ate grasses most of the time a large proportion of sheeps' diet was flat-leaved chenopods or forbs. Grasses were a minor item. Newsome (1971) concluded that competition between kangaroos and sheep is so low that reducing kangaroo populations would not allow the sheep carrying capacity to increase. Both should be harvested. A dissociation between sheep and kangaroos was reported by Andrew and Lange (1986). This may be related to the relative attractiveness to kangaroos of pasture ungrazed by sheep, rather than antagonism. Griffiths and Barker (1966) did consider that in large numbers kangaroos would eat sufficient protein-rich dicotyledons, which comprise 50% of sheeps' diet, to reduce wool production. Kangaroos, rabbits and sheep eat approximately 60-80 g per $kg^{0.75}$ per day expressed on a metabolic weight basis when food is not limiting, but food intake declines at a biomass of about 250-300 kg per ha. Minimal competition is expected when the pasture biomass is above 300 kg per ha (Short 1987).

The quantity of information on the ecology of kangaroos is not available for wallabies. Apart from the details given in Section 1.4. from Johnson (1976) and Tandy (1976), there is no quantitative information available on the competition of wallabies with livestock.

In this chapter the results of some investigations into the amount of new pasture eaten by wallabies is reported, and an estimate is made of the potential value of this pasture to the farmer.

2.2. Materials and Methods

2.2.1. Pademelons

The effect of pademelons on a newly sown pasture was studied on a dairying property near Holwell on the West Tamar (see Figure 2.1.).

Two 5 ha paddocks about 1 km apart were sown with ryegrass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*), and clover (*Trifolium* spp.) in autumn 1982. On each area one "Weldmesh" exclosure (about 1 m diameter) was erected 20 m, and another at 40 m into the paddock from the bush/pasture interface in April.

Two samples each of 0.25 m^2 were taken from inside and outside these exclosures in September. They were oven-dried at 80^oC and weighed and the proportion of each species present was assessed.

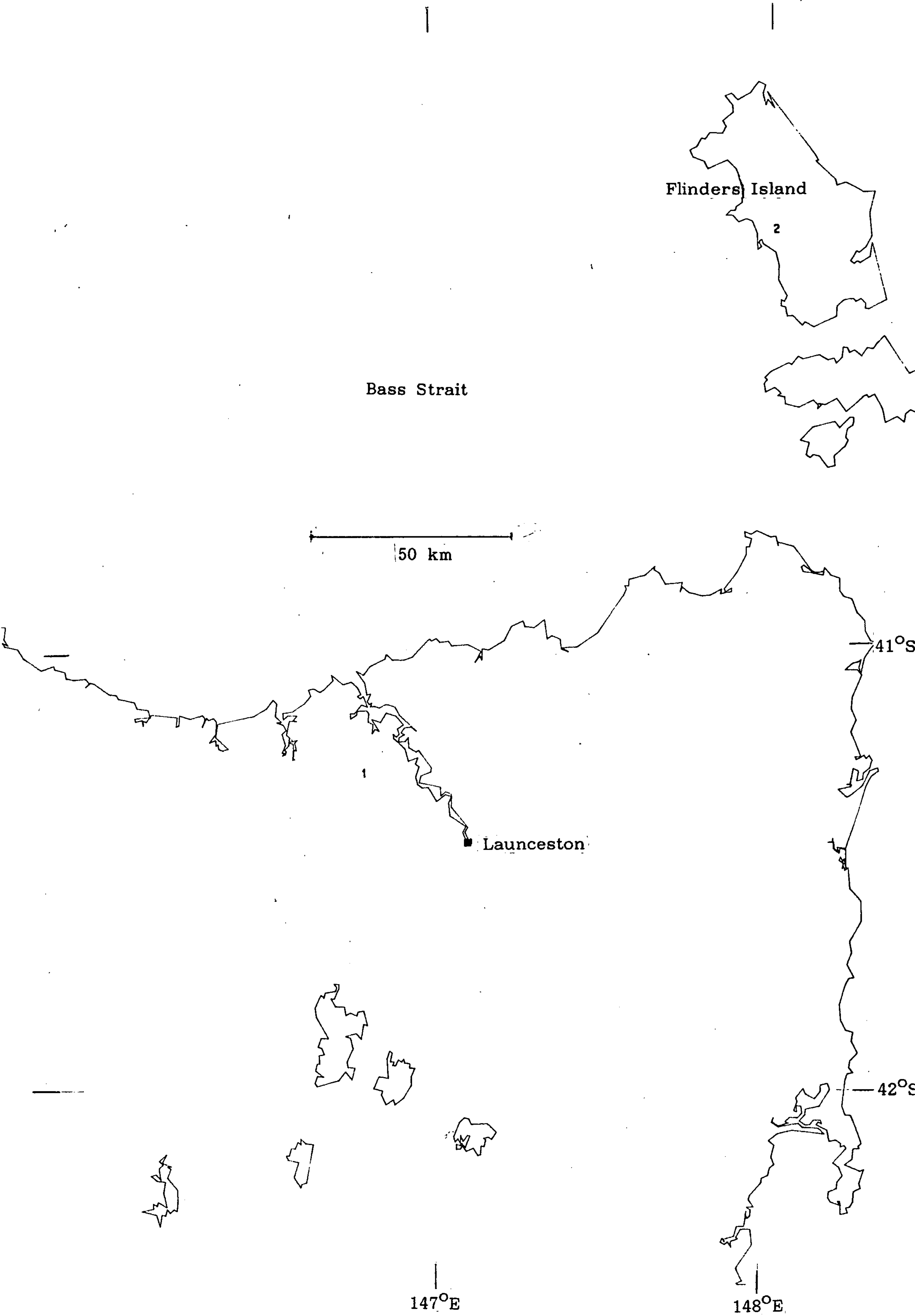
To gain an indication of the density and species of herbivores present ten plots each 20 m x 1 m were established on each paddock and cleared of all faeces. They were examined at monthly intervals and all faeces were identified, oven-dried at 80^oC and weighed.

2.2.2. Bennett's Wallabies

Three "Weldmesh" exclosures were established on a newly sown pasture of ryegrass, cocksfoot, phalaris (*Phalaris tuberosa*) and clover on a sheep property near Whitemark on Flinders Island in May 1983 (see Figure 2.1.). The exclosures were placed at 20, 100 and 200 m into the paddock from the bush. The paddock was about 400 m wide. Two pasture samples of 0.25 m^2 were collected inside and outside each exclosure and analysed for total oven-dried weight and species composition in August, when, because of the obvious effect of the wallabies, the owner laid poison.

Six dung plots each 20 m x 1 m were established near each exclosure, and the faecal deposit rate, expressed as the number of faecal pellets, was monitored monthly.

Figure 2.1. Location of trial sites in north eastern Tasmania used for assessing pasture loss from competition from wallabies.
1 - Holwell 2 - Whitemark


Flinders Island
2
Bass Strait
50 km
41°S
1
Launceston
42°S
147°E
148°E

2.3. Results

2.3.1. Pademelons

The composition of the pasture showed little difference between samples protected by the exclosure or grazed by wallabies, apart from a higher percentage of subterranean clover within the exclosures, as shown in Table 2.1. The mean difference in the amount of dry matter on grazed and ungrazed plots was 17.1 $\pm$ 4.0 kg per ha per day ($t = 3.40$, 6 d.f., $p < 0.02$) (see Table 2.2.). One exclosure was moved in June, so that 3 exclosures were in position for 154 days and the other for 89 days. There was no difference between the plots at 20 and 40 m from the bush in the pasture consumption by pademelons ($t = 0.28$, $p > 0.7$), or between the two paddocks ($t = 1.3$, $p > 0.3$).

Dung plots were established on 12 and 16 August and were subsequently cleared on 30 August, 20 September and 5 October. The faecal collections indicated that only pademelons were present in the area. Using square root transformations of data there was a significant difference in faecal deposit rates between collection dates ($F = 34.0$, 2 d.f., $p < 0.001$) and between paddocks ($F = 14.2$, 1 d.f., $p < 0.001$). Results are shown in Table 2.3.

It can be concluded that this population of pademelons which produced about 0.8 g dry weight of faeces per plot per day was responsible for the pasture loss equivalent to 17.1 kg/ha/day.

A 400 kg dairy cow in early lactation requires approximately 15 kg dry matter per day (Anon 1976). The pasture eaten by the pademelons could therefore readily be used to keep one extra dairy cow per ha, which would return $400 per ha per year.

2.3.2. Bennett's Wallabies

The results of sampling pasture from inside and outside the three exclosures on 16 August are shown in Table 2.4. Over the period from 21

Table 2.1

Percentage Occurrence of Each Plant Species in Pasture Inside and Outside Exclosures at Holwell

	20 m		40 m	
	Inside	Outside	Inside	Outside
Lolium perenne	54.0	71.0	69.0	73.5
Dactylis glomerata	2.5	2.5	3.5	2.5
Trifolium repens	10.5	10.0	4.5	12.0
T. subterraneum	28.0	1.5	16.5	1.0
Broad leafed weeds	1.0	2.5	4.5	2.5
Misc. grasses	4.0	12.5	4.5	8.0

Table 2.2.

Comparison of Dry Matter Inside and Outside Exclosures at Holwell

	Inside Exclosures ($g/0.25m^2$)	Outside Exclosures ($g/0.25m^2$)	Difference ($g/0.25m^2$)	kg/ha/day*
20 m plots				
A	31.5	5.5	26.0	6.8
D	71.5	14.5	57.0	25.6
40 m plots				
B	91.0	13.5	77.5	20.1
C	81.5	20.0	61.5	16.0
Mean $\pm$ S.E.				17.1$\pm$ 4.0

* Plot D had been erected for 89 days compared to 154 days for A, B and C.

Table 2.3.

Oven-Dried Weights (g) of Pademelon Faeces at Holwell

* Plots 1-10 were in the paddock containing exclosures A and B, plots 11-20 were in the paddock with exclosures C and D.

Plot*	30 August	20 September	5 October
1	15.3	2.5	15.1
2	18.5	0.0	15.1
3	15.4	0.0	13.2
4	16.8	0.0	4.4
5	16.6	4.0	10.4
6	16.9	0.0	2.7
7	37.5	8.2	20.2
8	21.1	9.4	17.2
9	12.9	0.0	7.1
10	6.9	4.0	17.0
Total	177.9	28.1	122.4
Days	18	21	15
Mean/plot/day	0.99 ± 0.44	0.13 ± 0.14	0.82 ± 0.39
11	0.0	0.0	7.1
12	3.5	0.0	11.8
13	16.6	0.0	17.5
14	6.7	6.0	11.9
15	2.9	2.7	10.8
16	2.1	0.6	4.4
17	0.0	0.0	10.7
18	3.2	0.0	16.0
19	5.0	0.0	10.5
20	0.0	0.0	14.6
Total	40.0	9.3	115.3
Days	15	20	15
Mean/plot/day	0.27 ± 0.29	0.05 ± 0.09	0.77 ± 0.26

Table 2.4

Dry Weight and Composition of Pasture Samples Grazed by and Protected from Bennett's Wallabies

(Means of two 0.25 m^2 samples)

	200 m		100 m		20 m	
	Inside	Outside	Inside	Outside	Inside	Outside
Dry Wt. (g)	37.0	24.0	45.0	24.0	57.5	17.5
% Lolium perenne	61.0	71.2	28.5	53.0	37.7	61.7
% Dactylis glomerata	7.0	6.2	2.5	2.5	3.5	6.7
% Phalaris tuberosa	6.5	3.0	2.5	2.0	4.5	2.0
% Trifolium repens	8.0	9.0	11.0	18.0	21.5	10.7
% T. fragiferum	1.7	0.5	2.0	1.2	1.2	2.0
% T. subterraneum	15.0	9.5	53.0	23.0	31.0	15.2
% weeds	0.7	0.7	0.7	0.2	0.5	1.5

May to 16 August (87 days) there was a total difference in dry weight of pasture between all samples taken from inside and outside the exclosures of 148 g, equivalent to 986.7 kg/ha, or 11.3 ± 3.7 kg per ha per day ($t = 4.94$. 10 d.f., $p < 0.001$). The differences were equivalent to 6.0 kg/ha/day at 200 m, 9.6 at 100 m and 18.4 at 20 m from the bush-pasture interface ($F = 0.7$, 2 d.f., $p = 0.5$). There was a significantly higher percentage of ryegrass outside the exclosures ($F = 15.5$, 1 d.f., $p = 0.008$) and a higher percentage of subterranean clover in samples taken from inside the exclosures ($F = 8.9$, 1 d.f., $p = 0.02$).

Dung plots were prepared on 19 April, and then cleared at 28 day intervals on 21 May, 18 June, 16 July, 13 August and 10 September. During this period there was some wallaby control by shooting, and the landholder decided to poison on 6 August because of the obvious damage to the pasture.

Table 2.5 gives the results of faecal collections from each plot. The number of Bennett's wallaby faecal pellets per plot increased from 18.7 to 54.1 before poisoning and then decreased to 7.7, a reduction of 85.8% ($F = 51.0$, 4 d.f., $p < 0.001$). The pasture loss of 11.3 kg dry matter/ha/day was therefore due to an increasingly large population of Bennett's wallabies. An analysis of variance of square root transformed data also showed a significantly higher faecal deposit rate at 100 m than from 20 or 200 m ($F = 5.2$, 2 d.f., $p = 0.008$).

2.4. Discussion

A wether requires about 1 kg dry matter/day for maintenance and wool growth (Anon 1976) so this pasture would have been able to support an extra 11 wethers per ha for the period of the trial. Each wether would cut about $15 worth of wool per year. Assuming that the results of pasture sampling could be repeated throughout the year, the amount of pasture eaten by wallabies is valued at 11 x 15 = $165 per ha per year.

From information gained elsewhere (see Chapter 3) the Bennett's wallaby density can be correlated with the faecal deposit rate. The mean

Table 2.5.

Mean Faecal Deposit Rates of Bennett's Wallabies on Flinders Island, Expressed as the Number of Faecal Pellets

Plot		21 May	18 June	16 July	13 Aug	10 Sept
20 m	Mean	14.0	28.2	49.7	38.7	7.5
	s.d.	7.9	6.4	15.2	6.3	7.7
100 m	Mean	19.8	23.0	56.7	73.8	9.7
	s.d.	5.9	7.7	17.1	31.6	7.6
200 m	Mean	22.2	15.8	35.0	49.8	5.8
	s.d.	3.6	4.2	13.0	25.5	8.3
Total	Mean	18.7	22.3	47.1	54.1	7.7
	S. E.	6.7	7.8	17.0	10.4	2.0
Total Pellets		336	402	848	974	138
Weight (g)		379	368	781	877	114

faecal deposit rates of Bennett's wallabies at Avoca and Palana were 0.67 g/plot/day, and this was equated to a mean density of 9.5 Bennett's wallabies per ha., using the lowest figure obtained from transect counts for density. According to Hume (1977) the daily intake of dry matter of penned sheep and Bennett's wallabies is 933 g and 333 g. Under these conditions a sheep therefore eats as much as 2.8 Bennett's wallabies. The faecal deposit rate in this investigation prior to poisoning was 1.74 g/plot/day which would be equivalent to 25 Bennett's wallabies, or nearly 9 sheep per ha. These would give a gross return of $135 per ha per year.

These pilot trials demonstrate that a very significant amount of pasture is eaten by wallabies near the forest edge. They were conducted over the autumn and winter months when competition for pasture is likely to be greatest. The livestock carrying capacity on a property is determined by the number that can be fed in autumn and winter when feed supplies are at there lowest. Future investigations must be extended to measure the longer term effect over at least 12 months, to assess how much of this pasture could be used by livestock under normal management conditions, and to estimate the net loss of production and loss of income involved.

Chapter 3

Assessment of Established Poisoning Techniques

3.1. Introduction

3.1.1. Rabbit Poisoning Techniques

In 1949 what was the C.S.I.R.O. Wildlife Survey Section began an intensive investigation into the biology of rabbits so as to maximise and refine control methods. As a result of this research the following factors were elucidated and could be applied to rabbit poisoning techniques:

(1) The initial reaction of rabbits to turned earth, or a furrow, is caution, but once a rabbit accepts it as being safe he returns regularly and runs along the furrow (Carrick 1957, Rowley 1958, Poole 1963b).

(2) Rabbits live in tightly knit social groups each with its own social territory. Intruders are not permitted access to the territory of another group. Consequently if the poison furrow does not pass through all social groups' territories, all rabbits will not find and feed in the furrow. The rate at which rabbits begin to use the furrow and take the free-feed depends mainly on how closely the furrow infringes on their existing feeding and movement pattern (Carrick 1957, Poole 1963a).

(3) Rabbits were found to prefer carrot bait to apple (Rowley 1963a,b). Carrot was also eaten more quickly than apple. Rabbits preferred their carrot in 5 g pieces rather than 2 g or 10 g (Rowley 1959).

(4) Rabbits were not instantly attracted to the poisoned bait, and indeed, it took many days for a large percentage of the population to find and accept the bait. It is therefore necessary to feed

unpoisoned bait in the furrow on several occasions to obtain a build up of rabbits accepting the bait prior to poisoning. Carrick (1957) recommended 3 day intervals between free-feeds.

(5) Early, more advanced feeders may eat all of the free-feed so none will remain for late, shy feeders. Free feed must therefore be offered in sufficient quantity to satisfy the appetites of early rabbits and leave some for those arriving later. A small amount should remain in the furrow after the first night (Carrick 1957).

(6) Sodium fluoroacetate (1080) was found to be readily accepted by rabbits and to be more toxic than other poisons. It was recommended as the poison of choice for rabbit control (Lazarus 1956). A concentration of 0.04% 1080 on bait was considered to be adequate for rabbit poisoning (Meldrum *et al*, 1957), although Rowley (1960) and Poole (1963b) both considered that it could be reduced to 0.02% without adversely affecting the mortality rate.

From these conclusions the following basic technique was developed and widely used for the control of rabbits by poisoning (Meldrum *et al.* 1957, Carrick 1957, Douglas *et al.* 1959):

- Run a shallow furrow throughout all feeding areas of the rabbits.
- Using chopped carrot, free-feed three times on alternate days. The amount fed will be small for the first feed and will quickly build up for the second and third feeds, depending on how the rabbits take the bait.
- Leave at least one night after the last free-feed before laying the poisoned bait, which is 0.04% 1080 on chopped carrot bait.

Variations to this basic recommendation have been adopted in some States and in New Zealand, for example:

(i) In New Zealand and Victoria poisoned bait is sometimes spread from the air. No free-feeding is done although sometimes the number of poisoned baits is diluted with unpoisoned baits (Douglas 1959a,b).

(ii) Pellet or jam baits are often used in New Zealand (Batcheler

1978, Ross and Bell 1979) and a bran-pollard pellet is used as an alternative to carrots in Victoria (Corr 1971, 1972).

(iii) A "one-shot" poison mix has been developed in Western Australia involving the vacuum impregnation of 1080 into oat grains. These are diluted with non-poisoned oats and no free-feeding is necessary (Gooding and Harrison 1964).

(iv) The concentration of 1080 in the bait has been reduced to 0.02% and further to 0.014% in Tasmania, and has been increased or decreased by other States and New Zealand, depending on the target species and bait type (Rammell and Fleming 1978). A concentration of 0.033% 1080 is used in New South Wales for rabbit control, although Rathore (1985) found that comparable results could be obtained using 0.0083%.

3.1.2. Wallaby Poisoning

The first report of poisoning wallabies was by Tomlinson *et al.* (1954) who used strychnine in bran-pollard pellet baits to control sand wallabies (*M. agilis*) in north Western Australia. Early trials in New Zealand showed that poisoning of wallabies with arsenic and strychnine was unsatisfactory, but good results were obtained using 1080 (Elgie 1961). In the early stages of using 1080 in Tasmania it was found that wallabies were susceptible to poisoning. On Flinders Island 0.04% 1080 in carrot bait "distributed in the conventional furrow after three free-feeds, proved most successful" (Meldrum *et al,* 1957). Control of *T. billardierii* with 1080 poison was first recorded on Three Hummock Island (Department of Agriculture, Tasmania, 1960).

From those early days permits to poison wallabies for crop protection were issued by the Animals and Birds Protection Board. This role was later taken over by the National Parks and Wildlife Service. The techniques used were the same as those used for rabbit control, except that the amount of free-feed and poisoned bait was increased to allow for the greater food consumption of larger animals.

3.1.3. Concentration of 1080 in Bait

Early experimental work with 1080 in Tasmania used powdered 1080 mixed in the baits - a technique that was quickly ascertained to be hazardous. The powder was then made into a 3.3% aqueous solution which was dispensed to field staff. This was mixed with the bait to give a concentration of 0.04% 1080. During 1970 1/2 strength solution was subjectively assessed for rabbit control. Following favourable results the concentration of 1080 in bait for all poisonings was reduced to 0.02% in 1971. A further reduction to 0.014% occurred in 1973.

These concentrations of 1080 were also used to control both species of wallabies under crop protection permits from the National Parks and Wildlife Service. Wallaby poisoning appeared to be effective until reports were received about 1978 from farmers who were unhappy with the results being achieved. Most of these reports were from Flinders Island which supports a large *M. rufogriseus* population. Farmers claimed that they were not finding as many carcasses as previously and that many wallabies were still present after poisoning. Some wallabies were suffering from the effects of poisoning 3 days later. These were weak and staggering and would collapse if chased. An increase in the concentration of 1080 in bait to at least 0.02% was requested.

The authorities controlling the use of 1080 (Department of Agriculture) and those controlling the management of wildlife (National Parks and Wildlife Service, now the Department of Lands, Parks and Wildlife) did not want to increase the concentration of 1080 in baits without firstly investigating to determine if there was a problem and pinpointing the cause of the problem. These investigations form the basis of this thesis.

The first part of these investigations was to assess the percent reduction in wallaby populations from an established poisoning procedure. Several methods of assessing the abundance of wallabies before and after poisoning were used.

3.2. Materials and Methods

3.2.1. Trial Sites

The effectiveness of two *M. rufogriseus* and two *T. billardierii* control poisonings were investigated. The trial sites for *M. rufogriseus* were at Avoca in the Fingal Valley and at Palana on Flinders Island. Both *T. billardierii* investigations were at North Lilydale (see Figure 3.1).

Avoca. Observations were made on 20 ha of pasture bordered on the southern side by gorse scrub on the edge of the South Esk River and on the north and east by thick sclerophyll scrub. Pasture areas to the west were also poisoned and included in the spotlight transect.

Palana. The trial site was a 15 ha paddock in northern Flinders Island with a good growth of grass and clover . It was separated from wallaby refuge by 300 m of native pasture to the west. A paddock of lucerne lay to the south of the trial area.

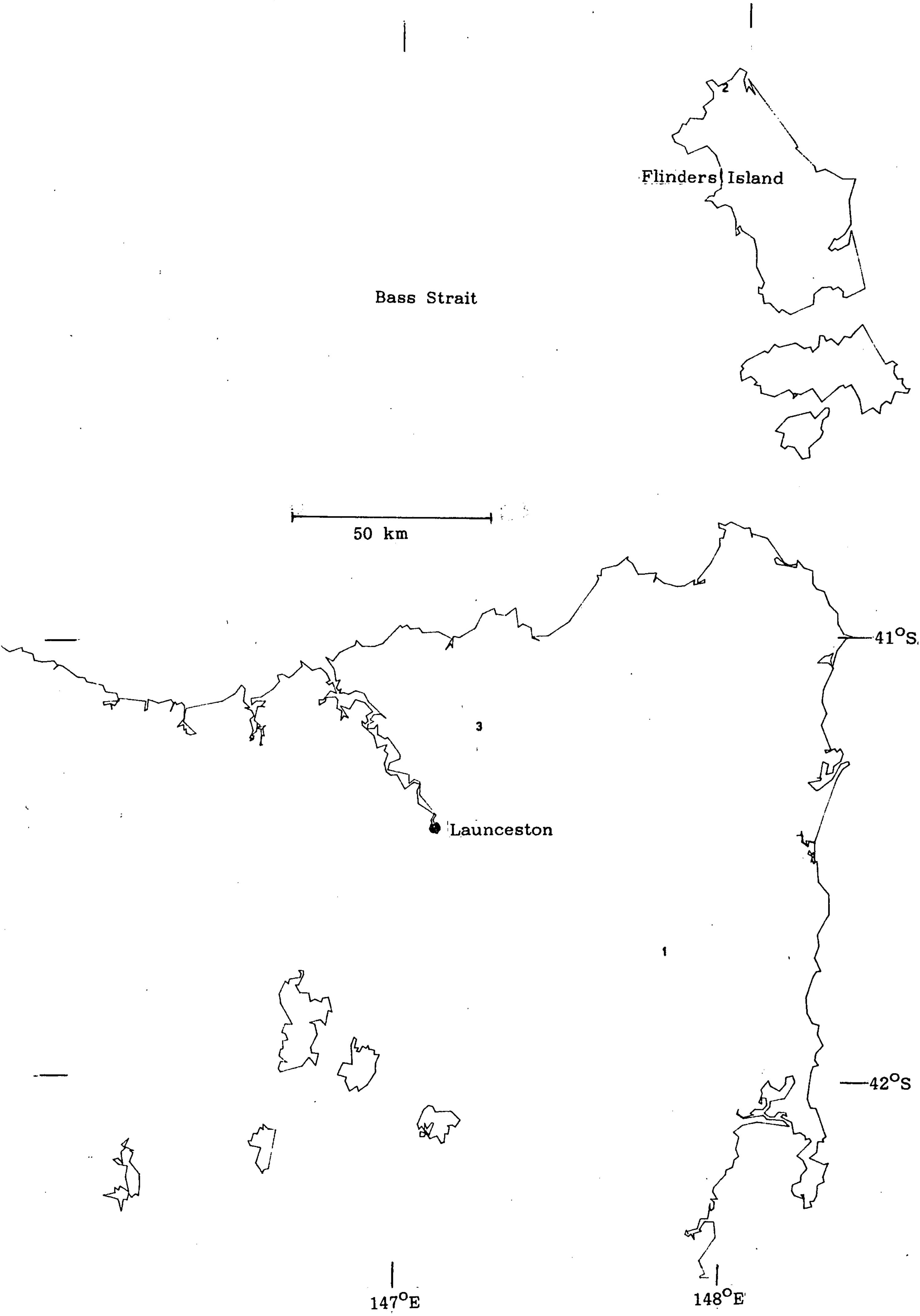
North Lilydale. Two areas on the same property but separated by at least 1 km of rain forest were used for two sets of intercurrent observations on *T. billardierii* poisoning. The first set of observations (trial 3) was on an area of pasture of about 50 ha bordered by rain forest to the south and west and low scrub consisting mainly of blackberries and bracken on steep gullies to the north and east. The second set (trial 4) was on a cleared area of about 15 ha surrounded by rain forest.

3.2.2. Population Assessment

The absolute or relative size of the wallaby population on the paddock to be poisoned was assessed just before and just after poisoning. Three methods of assessment were chosen from those described by Johnson (1977).

Figure 3.1. Location of trial sites in north eastern Tasmania used for assessing the effectiveness of poisoning operations.

1 - Avoca 2 - Palana 3 - North Lilydale



2
Flinders Island
Bass Strait
50 km
41°S
3
Launceston
1
42°S
147°E
148°E

Stake-Out Counts. From a vantage point in the observation area a spotlight count of all wallabies in an area of about 6 ha was made at 30 minute intervals from just after dark for about 6 hours. Binoculars were used to assist sighting wallabies. The mean maximum number of wallabies seen per night for four nights was taken as the population index.

Spotlight Transect Counts. At a standard time each night (usually about 0200 after stake-out counts ceased), a set transect path was walked and examined with a spotlight and binoculars. The angle from the transect path and the radial distance from the observer of each wallaby seen was recorded on a cassette recorder.

The mean number of wallabies counted per night for four nights was used as the population index. An absolute density of wallabies grazing the pasture was calculated using three formulae. The mean density from four nights observations was used as the pre-poisoning or post-poisoning density. The formulae used were:

$d_1 = n/2L\bar{R}\sin\bar{T}$ (Webb, 1942)

$d_2 = n/2L\bar{G}$ (Gates, 1969)

$d_3 = n/2L\bar{H}$ (Hayne, 1949)

where
d = estimated density of animals in the census area.
n = number of animals seen during the transect
L = length of the transect path
$\bar{H}$ = harmonic mean of sighting distances
$\bar{G}$ = geometric mean of sighting distances
$\bar{R}$ = mean radial sighting distance
$\bar{T}$ = mean sighting angle

Faecal Deposit Rates. The rate of deposition of faeces was assessed on 20 plots each 20 m long x 1 m wide in the observation area - the same area used for stake-out counts. These plots were cleared initially of all faeces and collections made at specified intervals thereafter. Faecal pellets were oven-dried at 80°C for four days and weighed. The quantity of faeces expressed as g dry weight per day was used as the density index. The percentage difference before and after poisoning was a measure of the mortality rate from poisoning.

3.2.3. Poisoning Techniques

Conventional techniques as previously described were used. Carrot was used as bait and 1080 was added to a concentration of 0.014%. The furrow was placed 10 to 20 m into the paddock. For observations on *M. rufogriseus* the rate at which each feed was distributed was at the discretion of the farmer who carried out all free-feeding and laying of the poison. The *T. billardierii* poisonings were carried out under the complete control of the author.

3.3. Results

Avoca. The observations were made in late January to mid February, 1978 when darkness fell about 2100 h. Stake-out counts were made from 2130 to 0200 h. Transect counts were then made from 0215 h over a distance of 1.8 km in 1.5 h. Only 2 transect counts were made pre-poisoning due to misty rain and fog hampering visibility. Faecal plots were cleared after 6 days before and 10 days after poisoning.

Poison bait was laid on 1 February after three free-feeds on 26, 28 and 30 January. The bait was well accepted.

Pastures were short and dry when observations began but 60 mm of rain 4 days after poisoning stimulated pasture growth.

All methods of assessment demonstrated a poor effectiveness of the poisoning program (Table 3.1) with the mortality rate varying from nil (as assessed by faecal deposit rates) to 28% (as assessed by the spotlight transect count). Stake-out count data gave an estimated mortality of 14% and transect count data used to estimate absolute densities assessed the mortality at 20%. The initial density of 3 per ha was reduced to only 2.4 per ha.

Palana. Observations were made in April, 1978. Darkness fell at 1830. Stake-out counts were made from then until 0200. Transect counts began at 0215 and followed the furrow and the internal perimeter of the paddock over a distance of 1 km in 1 hour. Faecal plots were cleared after 10 days before and 10 days after poisoning.

Free-feed was reasonably well accepted but the poisoned bait was poorly accepted on the first night, but well accepted on the second night. Table 3.2 shows that the reduction in population was assessed as 15% using stake-out counts, 19-25% using transect counts and 40% using faecal deposit rates. The initial density of 18 per ha was reduced to about 14 per ha.

North Lilydale Observations in both trials were carried out in February-March 1978. Darkness fell at 2000, stake-out counts were made from 2100 to 0300 h, when transect counts began.

In trial 3 the stake-out counts were made over a steep gully to a well grassed hill. Faecal plots were also established on the hill but transect counts took in a greater area in the opposite direction from 1.5 km. In trial 4 the furrow and transect followed the perimeter of a large cleared area for 1.3 km.

Mortality rates of *T. billardierii* of >70% (see 1.5.) were achieved in both trials, although in trial 3 transect count data indicated only 45 to 50% mortality. All other estimates exceeded 70% with stake-out counts in trial 4 indicating a reduction of 89%. Initial densities were estimated to be 10 per ha in both areas (Tables 3.3. and 3.4.).

Figure 3.2 shows the relationship between the stake-out counts and hours after dark. *M. rufogriseus* started moving into the paddock as

Table 3.1.
Effectiveness of *M. rufogriseus* Poisoning at Avoca.

The transect length was 1.8 km. n = number of animals counted. d_1 d_2 d_3 are densities in animals per ha as described in the text.

Date	Stake-out Count Nightly Maximum	Transect Counts n	d_1	d_2	d_3	Faecal Deposit Rate g dry wt/plot/day
Prepoisoning						
27.i.78	31					
28.i 78	18					
30.i.78	35	66	2.6	2.6	2.8	
31.i.78	30	79	3.4	3.2	3.6	
Mean	28.5	72.5	2.9	2.9	3.2	0.23
s.d.	7.3	9.2	0.5	0.4	0.5	0.24
Postpoisoning						
8.ii.78	26	40	1.5	1.6	1.8	
13.ii.78	29	60	2.4	2.5	2.6	
14.ii.78	20	49	2.4	2.3	2.4	
15.ii.78	23	60	2.8	3.0	3.1	
Mean	24.5	52.2	2.3	2.4	2.5	0.28
s.d.	3.9	9.7	0.6	0.6	0.6	0.24
% Mortality	14.0	28.0	20.7	17.2	21.9	nil
t	0.97	2.5	1.5	1.3	1.5	
p	>0.01	<0.05	>0.1	>0.1	>0.05	

Table 3.2.
Effectiveness of *M. rufogriseus* Poisoning at Palana

The transect length was 1.0 km. n = number of animals counted. d_1 d_2 d_3 are densities in animals per ha as described in text.

Date	Stake-out Counts Nightly Maximum	Transect Counts n	d_1	d_2	d_3	Faecal Deposit Rate g dry wt/plot/day
Prepoisoning						
4.iv.78	118	114	12.2	13.6	14.1	
5.iv.78	57	100	11.7	12.8	14.0	
6.iv.78	49	142	17.1	20.9	19.4	
10.iv.78	53	212	23.3	24.8	27.0	
Mean	69.2	142	16.1	18.0	18.6	1.11
s.d.	32.7	50	5.4	5.8	6.1	0.83
Postpoisoning						
23.iv.78	43	50	5.9	6.1	6.4	
26.iv.78	53	74	7.9	8.4	9.3	
30.iv.78	79	158	17.4	18.8	20.9	
1.v.78	60	169	19.2	20.7	23.7	
Mean	58.7	113	12.6	13.5	15.1	0.67
s.d.	15.2	20	6.7	7.3	8.5	0.48
% Mortality	15.1	20.4	21.6	25.1	19.1	39.6
t	0.58	0.75	0.82	0.97	0.68	2.62
p	>0.05	>0.05	>0.05	>0.05	>0.05	<0.01

Table 3.3.
Effectiveness of T. billardierii Poisoning at North Lilydale
Trial 3.

The transect length was 1.5 km. n = number of animals counted. d_1 d_2 d_3 are densities in animals per ha as described in text.

Date	Stake-out Counts Nightly Maximum	Transect Counts n	d_1	d_2	d_3	Faecal Deposit Rate g dry wt/plot/day
Prepoisoning						
23.ii.78	101	108	6.4	6.7	7.3	
24.ii.78	111	180	10.4	10.8	11.5	
25.ii.78	61	231	13.8	14.5	15.6	
4.iii.78	136	169	9.5	10.0	10.6	
Mean	102.2	172	10.0	10.5	11.2	2.96
s.d.	31.2	50	3.0	3.2	3.4	1.48
Postpoisoning						
12.iii.78	15	67	4.4	4.3	4.5	
13.iii.78	14	62	3.4	3.6	3.9	
18.iii.78	44	95	6.8	7.3	7.4	
23.iii.78	23	109	7.2	7.7	8.3	
Mean	24.0	83.2	5.5	5.7	6.0	0.75
s.d.	13.9	22.5	1.9	2.1	2.1	0.56
% Mortality	76.5	51.6	45.4	45.5	46.6	74.6
t	4.58	3.21	2.56	2.50	2.59	6.63
p	<0.005	<0.01	<0.05	<0.05	<0.05	<0.001

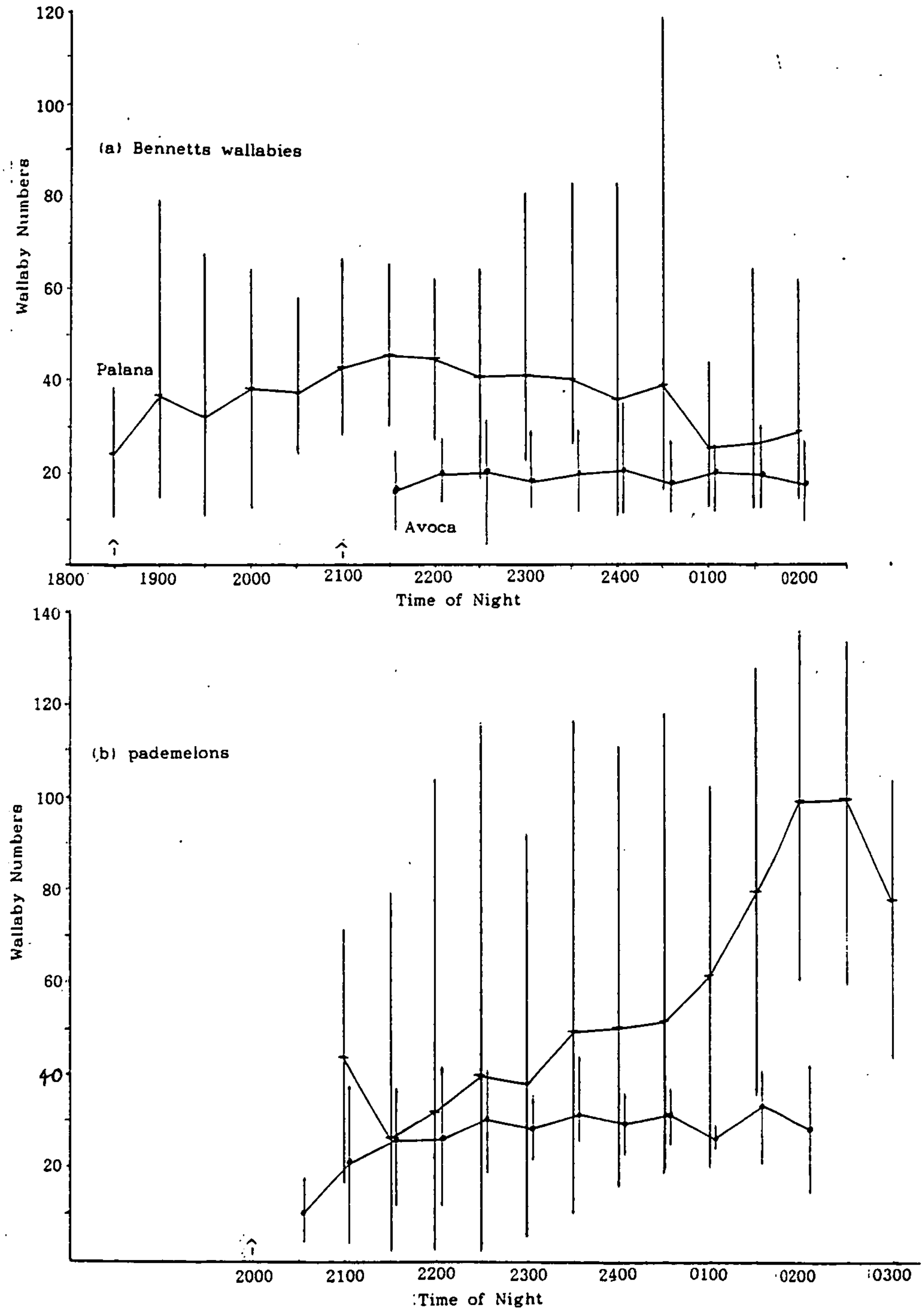
Table 3.4.
Effectiveness of *T. billardierii* Poisoning at North Lilydale Trial 4.

The transect length was 1.3 km. n = number of animals counted. d_1 d_2 d_3 are densities in animals per ha as described in the text.

Date	Stake-out Counts Nightly Maximum	Transect Counts n	d_1	d_2	d_3	Faecal Deposit Rate g dry wt/plot/day
Prepoisoning						
28.ii.78	38	166	13.5	14.6	16.0	
1.iii.78	36	116	7.3	7.9	9.0	
2.iii.78	26	96	7.7	7.8	8.2	
3.iii.78	42	146	9.8	10.5	10.5	
Mean	35.5	131	9.6	10.2	10.9	1.05
s.d.	6.8	31	2.8	3.2	3.5	0.92
Postpoisoning						
10.iii.78	2	26	2.2	2.3	2.5	
11.iii.78	3	17	1.5	1.6	1.7	
16.iii.78	4	27	2.8	2.9	3.2	
17.iii.78	6	57	4.6	4.9	5.2	
Mean	3.7	32	2.8	2.9	3.1	0.25
s.d.	1.7	17	1.3	1.4	1.5	0.26
% Mortality	89.4	75.8	71.2	71.6	71.4	76.3
t	9.05	5.57	4.33	4.18	4.06	3.78
p	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005

Figure 3.2. Mean numbers and range of Bennett's wallabies and pademelons counted at each 30 minute interval stake-out count at each trial. Wide variations were recorded in trial 2 at Palana and trial 3 at North Lilydale.

↑ Darkness fell at 1830 at Palana, 2000 at North Lilydale and at 2100 at Avoca.


(a) Bennetts wallabies
Wallaby Numbers
Palana
Avoca
Time of Night
1800
1900
2000
2100
2200
2300
2400
0100
0200
(b) pademelons
Wallaby Numbers
Time of Night
2000
2100
2200
2300
2400
0100
0200
0300

x Although texts on experimental design stress the need for an experimental control for comparison with the area under investigation, there are several reasons why this was not done.

The control should match the treatment, but in experiments involving wildlife under natural conditions it is very difficult to find a matching area. They must be matched for such factors as wallaby density, depth and type of bush, area and type of pasture, species and density of livestock present, amount of human interference, water availability, soil type and topography.

The control must be at a sufficient distance so as not to be influenced by wallaby movements in the observation area.

Lastly, the inclusion of a control increases the work load, making observations more expensive and stressing resources.

The results were therefore analysed by comparing data collected before and after poisoning on each site. The possible biases in this analysis from local population changes during the observation period are accepted.

darkness fell and numbers were reasonably stable from 30 minutes after dark until counts finished at 0200. The mean peak numbers were reached about 3 hours after last light. *T. billardierii* numbers increased steadily after dark and reached a peak at 0200 in trial 3 and by 2130 in trial 4. A difference in behaviour between the two species was noted in that *M. rufogriseus* quickly move well into the paddock whereas *T. billardierii* generally remain close to the forest edge.

3.4. Discussion

X

3.4.1. Mortality Rate

An effective poisoning program depends upon a large proportion of the target species -

(i) detecting the bait,

(ii) eating sufficient quantity of the bait, and

(iii) being poisoned by the concentration of toxic substance in the bait.

The results of these experiments indicate that *T. billardierii* may be effectively poisoned using these techniques, whereas some modification of techniques is needed to control *M. rufogriseus* populations.

At Avoca *M. rufogriseus* was seen to be feeding along the furrow so that under the conditions at that time the chopped carrot appeared to be attractive and palatable and detected by at least some of the population. We have insufficient information to say that a large proportion of the population ate the poison. These observations and those of Johnson (1977) indicate that *M. rufogriseus* graze further into the paddock, whereas *T. billardierii* are more timid and remain closer to shelter. As an indication that sufficient poison bait has been distributed, a small proportion should remain in the furrow after the first night. As all bait was readily eaten at Avoca it is possible that no bait was available for those wallabies arriving on the feeding area late in the night. Thus the poor poisoning result at Avoca could have been due to failure of a large proportion of the target species to detect and eat the bait, to insufficient bait laid so that some is left for late feeders or to a low concentration of poison in the bait.

The poor poisoning result at Palana appears to be primarily due to poor bait acceptability, which in turn may be due to the abundance of alternative green feed available at that time. Mollison (1960b) reported that *M. rufogriseus* ate less bait in spring when alternative green feed was abundant.

The information on stake-out counts at varying times during the night (Figure 3.2) indicates that the assessment of *M. rufogriseus* populations may reasonably be confined to the first three hours of darkness, whereas observations on *T. billardierii* should be extended until at least 0130 h.

3.4.2. Population Estimates

Transect counts were thought to underestimate populations, especially in high density populations. This is because animals move position, often initiating stampedes. Some may be counted twice but more often they miss being recorded. A comparison of the densities as calculated by the three formulae shows that d_3 (Hayne 1949) is consistently higher than d_2 (Gates 1969), which is consistently higher than d_1 (Webb 1942). All methods give almost identical results of the efficiency of poisoning, so either may be used in further trials. The method of Hayne is preferable in that the angle from the transect path is not required. Eberhardt (1978), in reviewing transect methods, considered that Hayne's formula is robust and offers the safest approach when working with animals that flush.

Transect count data gave lower percentage mortalities than stake-out counts at North Lilydale. This difference is probably due to under-estimating pre-poisoning populations as mentioned. It is also possible that a lower mortality resulted in some parts of the transect path in trial 3 because insufficient bait may have been distributed in pockets of very dense population.

Faecal deposit rates should be expected to give a more accurate index of wallaby populations as they assess the average population over a period of many days. Direct observations are susceptible to nightly fluctuations and the accuracy will depend upon the number of nights on which observations were made. Mortality rates recorded from faecal deposit rates generally agreed with those from direct estimation for *T. billardierii*, but were erratic in the *M. rufogriseus* trials.

Chapter 4

Bait Acceptability Trials

4.1. Introduction

The previous chapter has demonstrated that although populations of *T. billardierii* can be readily reduced using conventional poisoning techniques, *M. rufogriseus* populations cannot. One of the reasons proposed for the ineffectiveness of 1080 poisoning was that chopped carrot bait is not well accepted by Bennett's wallabies especially when alternative green feed is available.

It is also possible that the bait line was too close to the forest edge, so that some Bennett's wallabies hopped over it on their way to the open part of the paddock without becoming aware of it.

These and other aspects should be studied before allowing an increase in the poison concentration of the bait.

Chopped carrot has always been the bait of choice for rabbit control in Tasmania although significant quantities of apple bait are also used. Authorities prefer carrot bait as it is less acceptable to non-target species, especially birds (Brunner and Browne 1979). Crop protection permits to poison wallabies issued by the Department of Lands, Parks and Wildlife always specify chopped carrot as the bait. A few permits have allowed the use of apples dyed green if carrots are not available.

Other States and New Zealand use a variety of baits for rabbit control. Western Australia uses carrots or oats; South Australia, oats; Victoria, carrots, oats or bran-pollard pellets; New South Wales, carrots; New Zealand, carrots, oats, bran-pollard pellets, jam. In New Zealand natural foods (leaves) are poisoned for the control of deer, possums and wallabies.

Mollison (1960a) tested the acceptability of a variety of baits to *T. billardierii, M. rufogriseus* and brush-tailed possums (*Trichosurus* *vulpecula*) in a rainforest environment in Southern Tasmania. He concluded that the best universal bait for these species is a dry bran-pollard mixture.

This chapter reports results of field investigations into the acceptability of a variety of baits by wallabies. Both the bait acceptance and faecal deposit rates are used to assess the activity of wallabies at various distances from the bush/pasture interface, and hence the optimal distance at which the bait line should be placed.

4.2. Methods

4.2.1. Study Areas

Investigations were carried out on properties in three areas in north eastern Tasmania as shown in Figure 4.1.

Royal George. The area was a long, narrow clearing surrounded by native forest. It was cleared and sown to improved pasture several years earlier. Sheep were grazed initially but were taken off because of competition from wallabies. The pasture has now reverted to mosses, rushes and reeds (see Plate IV). The area maintained a very heavy *M. rufogriseus* and moderate rabbit population.

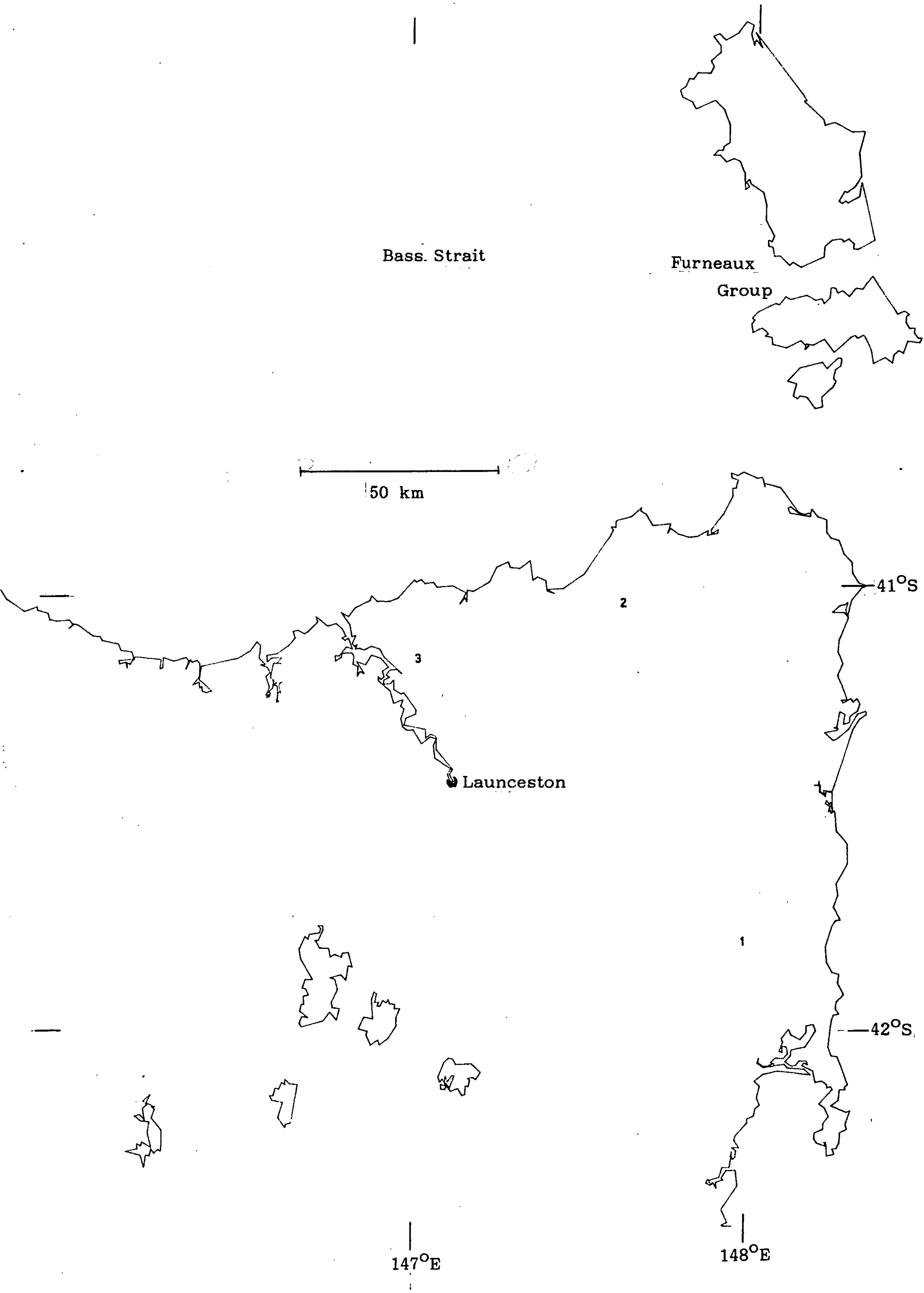
Waterhouse. The observation area was a large well grassed-paddock bordering low scrub. The whole area was very wet and had a permanent flow of water in a shallow ditch. Bennett's wallabies and pademelons were both plentiful.

East Tamar. The observation area was recently developed pasture backing on to bushland. The terrain dropped to a very wet area 50 m from the fence. *T. billardierii* was the predominant species.

Plate IV

The trial area at Royal George.

Figure 4.1. Location of trial sites in north eastern Tasmania used for bait acceptability investigations.
1 - Royal George 2 - Waterhouse 3 - East Tamar



Bass Strait
Furneaux
Group
50 km
41°S
42°S
2
3
1
Launceston
147°E
148°E

4.2.2. Bait Acceptance

In each area bait lines were marked at 5, 15, 30, 50, 75 and 100 m from the bush/pasture interface. At Royal George this was modified as the paddock is only about 70 m wide. Bait lines were therefore marked at 5, 15 and 30 m from each side. At Waterhouse an extra bait line was marked at 150 m from the bush/pasture interface.

Baits were offered to the animal population by placing small piles (approximately 100 g) at 4 to 5 m intervals along each line. The following bait types were used: apples, carrots, potatoes, oats, bran-pollard pellets, loose bran-pollard and barley. The bran-pollard pellets were a 50:50 mixture of bran and pollard 15 mm long and 5 mm diameter and were manufactured by Clements and Marshall Pty. Ltd., in Launceston. Vegetable and fruit baits were cut into about 5 g pieces and 20 pieces placed at each site. The number of pieces remaining was recorded. Grain-type baits and pellets were placed in piles of about 100 g and the percentage remaining was subjectively assessed. Each bait type was repeated 3 or 4 times in each line, the order of bait placement being randomly chosen for each line.

Birds were suspected of eating some of the baits, so malachite green was added to apples, oats and bran-pollard on occasions. Green-dyed grain has been shown to be less attractive than undyed grain to birds (Kalmbach and Welch 1946, Brunner and Coman 1983, Bryant *et al.* 1984).

Sand was spread around some baits so that tracks of animals could be seen, and the animal species responsible for interfering with baits could be clarified.

To see if a ploughed furrow has any value in attracting wallabies to a bait line, a single furrow was ploughed along half of each bait line at the first trial at Royal George and baits were laid along the furrow.

4.2.3. Animal Populations

The animal population present in the area was assessed from faecal deposit rates. Near each bait line, usually about 1 m closer to the bush, a plot was marked 30 m long x 1 m wide, and these were each divided into six sub-plots. All faecal pellets from each sub-plot were collected at monthly intervals and the number and the oven-dried weight of *M. rufogriseus* and *T. billardierii* pellets from each plot was recorded. Statistical analyses were made by the analysis of variance of $\log_e(x + 1)$ transformations.

4.3. Results

4.3.1. Royal George

4.3.1.1. Animal Population

The initial clearance of faecal plots indicated a very high density of Bennett's wallabies with more than 60 pellets per m^2 being present in some plots. Faeces of pademelons, brush-tailed possums, rabbits, wombats (*Vombatus ursinus*) and Tasmanian devils (*Sarcophilus harrissii*) were also present.

Plots were cleared ten times in the next 12 months. The mean dry weights of faeces in each sub-plot over this period are given in Table 4.1. An analysis of variance on transformed figures ($\log_e(x + 1)$) shows significant differences between plots. The plot 5 m from the right hand edge consistently had less faeces on it than others, and the four central plots generally were used more than the two outer plots.

4.3.1.2. Bait Acceptance

A variety of baits was offered on three occasions. The percentage overall take of each bait type in each trial is shown in Table 4.2. The

Table 4.1.

Mean Dry Weight (g) of Wallaby Faeces per Sub-plot at Varying Distances from the Bush/Pasture Interface.

Figures in parentheses are $\log_e(x + 1)$ transformations

L,R denote m from left and right margins as described in text

			Royal George				
5L	15L	30L	30R	15R	5R		L.S.D.
M. rufogriseus							
5.9	14.6	14.4	14.6	9.9	1.6		
(1.7)	(2.5)	(2.4)	(2.5)	(2.1)	(0.7)		(0.2)
			Waterhouse				
5 m	15 m	30 m	50 m	75 m	100 m	150 m	L.S.D.
M. rufogriseus							
1.0	12.1	16.7	3.9	6.6	5.6	6.8	
(0.4)	(2.4)	(2.5)	(1.2)	(1.6)	(1.5)	(1.5)	(0.5)
T. billardierii							
1.4	9.8	8.0	7.1	7.2	4.1	3.4	
(0.5)	(2.1)	(2.0)	(2.0)	(2.0)	(1.3)	(1.1)	(0.5)
			East Tamar				
5 m	15 m	30 m	50 m	75 m	100 m		L.S.D.
M. rufogriseus							
0.0	0.1	4.9	0.04	0.2	0.0		
(0.0)	(0.1)	(1.4)	(0.03)	(0.1)	(0.0)		(0.3)
T. billardierii							
1.5	8.7	6.1	1.4	0.7	0.4		
(0.7)	(2.0)	(1.7)	(0.6)	(0.3)	(0.1)		(0.4)

first trial, in winter, showed that significantly more apple was taken than any other bait. Peck marks were seen in pieces of apple, however, so there was some doubt as to which animals were eating the baits. Carrots, bran-pollard and oats were also well accepted but pellets and potatoes were poorly accepted.

At the second trial, in spring, all baits were well taken after two nights, and there was little significant difference between baits. Sand was spread around some baits and wallaby, rabbit and bird tracks were seen. It appeared that *M. rufogriseus* were the predominant species in the area but it could not be shown that they were responsible for eating the baits.

Apples were not offered at the third trial, in autumn. Bran and pollard were individually well accepted and pellets again were poorly accepted. Apart from pellets no bait acceptance was significantly different from carrots.

Table 4.3. shows the percentage of all baits eaten from each bait line at each trial. The main differences were a generally higher take of bait from the 5 m left and low take from the 5 and 15 m right bait lines.

The percentage of carrots, oats and bran-pollard eaten from furrowed and non-furrowed areas was 71.4 and 68.9 respectively. This difference is not statistically significant ($F = 0.16$, $n = 36$).

4.3.2. Waterhouse

4.3.2.1. Animal Population

As can be seen in Table 4.1. a reasonably large population of both wallaby species used the trial area at Waterhouse. Possum faeces were also common. *M. rufogriseus* faeces were most prevalent on the plots 15 and 30 m into the paddock, whereas *T. billardierii* faeces were most prevalent on plots 15, 30, 50 and 75 m into the paddock.

Following the faecal collections in October the area was subject to intensive hunting pressure. It was subsequently ploughed and the trials

Table 4.2.

Mean Percentage of Each Bait Type Eaten and Results of Analysis of Variance

Baits underscored by the same line are not significantly different at 5% level. B/P = loose bran-pollard. (g) = dyed with malachite green

Royal George

31 July to 3 August

Apples	Carrots	B/P	Oats	Pellets	Potato	L.S.D.
100	76.2	69.6	63.3	12.5	2.7	14

1 to 3 October

Oats	B/P	Carrots	Pellets	B/P(g)	Apples(g)	
95.8	94.7	87.8	85.0	83.6	81.1	14

15 to 16 April

Bran	Pollard	Carrots	Barley	Oats	Pellets	
77.9	76.9	62.1	60.7	55.2	11.9	16

Waterhouse

7 to 10 August

Oats	B/P	Apples	Carrots	Pellets	Potato	
62.8	58.4	29.1	18.3	2.8	0	17

9 to 12 October

B/P(g)	Oats	Apples	B/P	Carrots	Pellets	
67.6	66.2	62.4	51.7	22.9	15.7	21

East Tamar

21 to 27 August

Apples	B/P	Apples(g)	Carrots	Oats	Pellets	Potato	
95.3	87.8	62.2	61.7	40.0	4.4	0.3	18
	81.4(g)			33.6(g)			

16 to 19 November

B/P(g)	Oats	Apples(g)	Barley	Pellets	Carrots	
88.4	74.1	62.2	50.0	46.9	44.1	25

Table 4.3.

Bait Lines Ranked in Order of Percentage Total Bait Eaten and Results of Analysis of Variance

Bait lines underscored by the same line are not significantly different at the 5% level

Royal George

31 July to 3 August

5L	30L	30R	15L	5R	15R	L.S.D.
68.5	58.5	53.7	50.4	48.3	44.8	14

1 to 3 October

30L	15L	5L	30R	15R	5R	L.S.D.
96.4	90.6	90.3	88.9	88.1	78.6	14

15 to 16 April

5L	15L	30L	30R	15R	5R	L.S.D.
74.6	65.2	64.0	51.9	46.0	45.9	16

Waterhouse

7 to 10 August

50m	15m	5m	100m	30m	150m	75m	L.S.D.
48.1	46.6	42.9	42.8	39.7	38.8	36.3	22

9 to 12 October

5m	100m	50m	150m	75m	15m	30m	L.S.D.
63.6	50.3	47.5	46.9	44.4	42.2	39.2	23

East Tamar

21 to 27 August

5m	30m	15m	50m	100m	75m	L.S.D.
64.6	64.6	61.7	54.8	32.8	32.6	15

16 to 19 November

15m	5m	30m	50m	L.S.D.
76.2	69.6	64.2	33.8	21

were then abandoned in this area.

4.3.2.2. Bait Acceptance

In the first observations on bait acceptance, in winter, oats and bran-pollard were significantly better accepted than other baits (see Table 4.2.).

Some green-dyed baits and some sand-tracking observations were used in the spring observations. Heavy rain fell and made the interpretation of tracks difficult, but many wallaby tracks were seen. There was little evidence of bird tracks. Apples and carrots appeared to have been nibbled by mammals rather than pecked by birds. Apple skins were rejected. Bran-pollard, oats and apples were all significantly better accepted than carrots and pellets. Green dye in the bran-pollard did not impair its acceptability. Carrots and pellets were poorly accepted.

There was no significant difference in the percentage of all baits eaten between bait lines on the first occasion and only a small difference between the 5 m and 30 m bait lines on the second occasion (Table 4.3.).

4.3.3. East Tamar

4.3.3.1. Animal Population

The predominant faeces in the area were those of pademelons, although Bennett's wallabies and rabbits were also present. Dry weights of faeces were significantly higher on plots at 15 and 30 m for *T. billardierii* and on the 30 m plot for *M. rufogriseus* (see Table 4.1.).

Following the clearance of plots in November the bush area was cleared, thus interfering with wallaby habitat. The trial area was therefore abandoned.

4.3.3.2. Bait Acceptance

A choice of baits was offered in late winter and in late spring. The results are shown in Table 4.2.

In August apples, bran-pollard and green bran-pollard were all significantly more acceptable than green apples and carrots. Oats, green oats, pellets and potatoes were significantly less accepted. There were bird peck marks in both the apples and green apples.

At the trial in November, sand was placed around some of each type of bait. Bird tracks were found around some apples, bran-pollard, oats and barley. Pademelon and rabbit tracks were also common. Results show that green bran-pollard was significantly better accepted than green apples, barley, pellets and carrot, but was not significantly better than oats.

The bait lines at 5, 15, 30 and 50 m had a significantly higher bait take than those at 75 and 100 m in August. By November the bait lines at 75 and 100 m were water-logged and in high lush grass so were not used. The 5, 15 and 30 m lines had a higher bait take than the 50 m line at this test (see Table 4.3).

4.4. Discussion

4.4.1. Bait Acceptance

Apples, carrots, bran-pollard, barley and oats were each well accepted at some time during the observations. Potatoes and the bran-pollard pellets were usually poorly taken and show no promise as a potential bait.

The large difference in acceptability of loose bran-pollard and bran-pollard pellets was not expected. They have the same contents, so it appears that the pelletising process in this case has made the bait unpalatable. Corr (1972) reported that commercial stock feed pellets were not satisfactory for rabbit poisoning, but a "special formulation of pollard and bran made by a special process" was very effective. Ross and Bell (1979) tested seven formulations of pollard and bran bait and found that a basic mixture of 5 parts of pollard to 1 part of bran rolled into a spherical shape with a smooth surface was the most preferred by rabbits. Tomlinson *et al.* (1954) considered that a pellet made of 2 bran : 1 pollard was more suitable than 1 bran : 2 pollard for poisoning wallabies. The latter pellets were harder, did not crumble as easily under moist conditions and were not so well accepted.

Although Brunner and Coman (1983) and Bryant *et al.* (1984) found that birds ate less dyed than undyed grain, Hone *et al.* (1985) could find no difference. Evidence of bird peck marks was common whether they were dyed green or not, and apart from the first trial at Royal George, they were no better accepted than other baits. Because of this they were discarded as a possible alternative to carrots. The only significant difference in acceptability of dyed and undyed bait was recorded at the East Tamar trial in August with apples, when 95.3% of plain apples and 62.2% of green dyed apples were eaten.

Loose bran-pollard, or bran or pollard was always well accepted. At Royal George where alternative food was in short supply carrots were equally acceptable, but at Waterhouse and East Tamar sites where green grass was plentiful, bran-pollard was regularly better accepted than carrots. Carrots in fact were very poorly taken on both occasions at Waterhouse (18.3% and 22.9%).

The acceptability of oats was in most cases equivalent to that of bran-pollard, but significantly less was eaten at the first trial at East Tamar and at the third trial at Royal George. On only one occasion was it significantly less acceptable than carrots. Barley was offered only once, at Royal George in autumn, and was accepted as well as pollard, carrots and oats.

The universal bait of choice appears to be loose dry bran-pollard. This is in agreement with Mollison (1960a) who tested the acceptability of a variety of baits to *M. rufogriseus*, *T. billardierii* and *T. vulpecula* in a forest environment, and found loose dry bran-pollard to be well accepted by all species. This type of bait is readily available, easily stored and does not require cutting prior to use.

4.4.2. Animal Behaviour

In every trial the differences in faecal counts between distances from the bush interface were significant. At Royal George counts were generally higher 15 and 30 m into the paddock than nearer to the edge. At Waterhouse *M. rufogriseus* appeared to preferentially graze about 15 to 30 m and *T. billardierii* 15 to 75 m into the paddock. At the East Tamar site *M. rufogriseus* faecal counts were significantly higher in the 30 m plots than elsewhere, whereas *T. billardierii* appeared to favour the 15 and 30 m plots.

4.4.3. Bait Placement

One may expect that significantly more bait would be eaten from the bait lines 15 and 30 m into the paddock to correspond with the density of faeces. At Royal George and East Tamar however, there was a greater acceptance of bait from the 5 m left bait line than would be expected, and at Waterhouse bait was well taken from all bait lines.

Faecal counts are species specific and therefore should be regarded as a more reliable indication of preferred areas of wallaby activity. Bait should therefore be placed between 15 m and 30 m from the bush/pasture interface. At this distance from the forest edge the bait should not endanger small non-target mammals and forest-dwelling birds.

The results of comparing bait take with and without a furrow do not indicate that the furrow has any intrinsic value in improving the efficiency of poisoning operations. It is of value though in marking the bait line.

Chapter 5

Field Evaluation of Alternative Techniques

5.1. Introduction

In Chapter 3 it was shown that some improvements were required in techniques used to poison *M. rufogriseus*. One option was to consider alternative baits to chopped carrots, and in Chapter 4 loose bran-pollard was found to be well accepted by wallabies. Rowley (1957) and Carrick (1957) showed that once rabbits had become used to a turned furrow they readily returned to it for bait, and ran along the furrow looking for more bait. Do wallabies react in the same way?

Results reported in Chapter 4 showed that wallaby faeces are more common between 15 and 30 m into the paddock, and this is suggested as the best place to site the bait line. It is not known whether bait sited in the bush will be well accepted by wallabies. Farmers have requested that the concentration of 1080 be increased in poison bait. So far the authorities have refused as higher concentrations may produce greater hazards to the safety of operators, non-target species and to the environment.

To complete these investigations the effectiveness of bran/pollard bait should be compared to carrots under field conditions. A comparison should be made between a bait line placed well into the paddock and one placed closer to the bush. It should be ascertained whether a fresh furrow has any intrinsic value in attracting wallabies to the bait. The concentration of 1080 in bait material should be further investigated to see whether increasing the concentration will in fact lead to higher mortalities.

The objectives of this section are to compare the mortality rate of Bennett's wallaby poisoning operations using variations in the siting of the bait line, and variations in the bait type and concentration of 1080.

In some cases a furrow was not used to mark the bait line. The population was monitored after some poisonings to assess the rate at which wallabies re-colonised the area.

5.2. Materials and Methods

5.2.1. Aspects Studied

The various factors of the poisoning routine that were investigated were:

(i) Bait placement. The normal position of the bait line, about 20 m into the pasture from the bush, was compared with a bait line in the bush.

(ii) Bait type. Chopped carrot bait was compared with a dry wheat-based bait.

(iii) Furrowing. In some instances a furrow was not used to mark the bait line.

(iv) Poison concentration. The normally used poison concentration of 0.014% was compared with a concentration of 0.028%

(v) Resurgence of wallaby populations. The wallaby population was monitored on several properties to determine the rate at which the area was repopulated.

No attempt was made to study any set combinations of these aspects. In most cases the poisoning operations were carried out by the farmer using his favoured methods, and the results of these were recorded.

5.2.2. Assessment of Wallaby Populations

The relative changes in wallaby populations were estimated on faecal deposit rates. Twenty plots, each 20 m long and 1 m wide, were marked on each of 11 trial sites. All wallaby faeces were collected usually at 14 to 28 day intervals. Either pellets were counted or the faeces were oven-dried at 80°C for four days and weighed.

5.2.3. Trial Sites and Poisoning Methods

Poisonings were monitored on three properties on the Tasmanian mainland and on eight properties on Flinders Island (Figure 5.1.). The wallaby population was monitored for two years on six properties. On some properties observations were made on the effectiveness of poisonings over two successive years.

1 Royal George

A paddock near Royal George was sown with a mixture of oats and clover on 9 March 1981. Growth was slow possibly due to dry weather and grazing by wallabies. Both *M. rufogriseus* and *T. billardierii* were common on and around the crop, which was surrounded by dry sclerophyll forest.

For poisoning a furrow was made around the edge of the crop, free-fed three times with chopped carrot and poisoned with 0.028% 1080 in mid May. Faeces were collected from the plots after nine days both prepoisoning and postpoisoning.

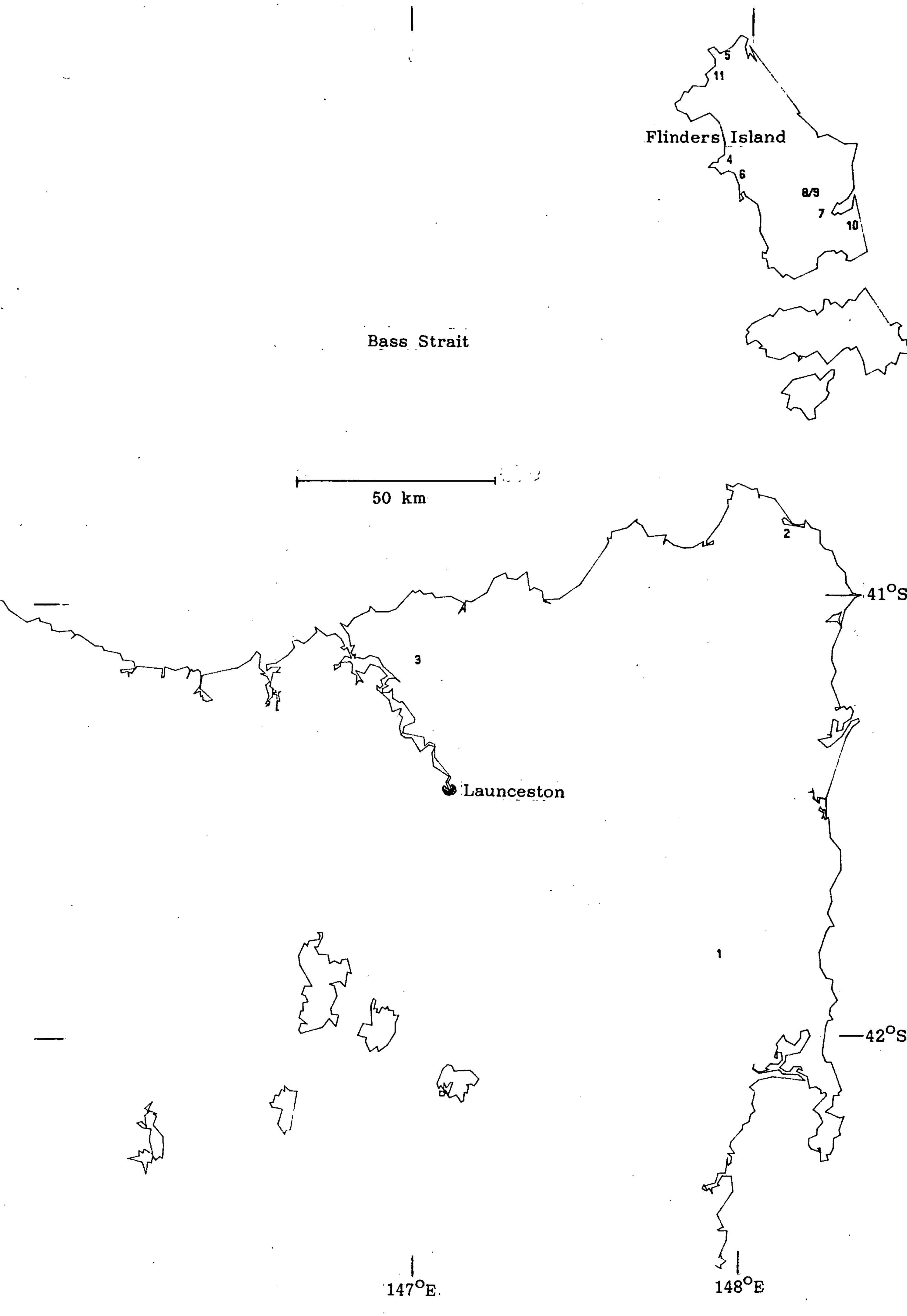
2 Rushy Lagoon

The area poisoned was an 800 ha paddock at Rushy Lagoon near Gladstone in north east Tasmania. Faeces were collected from 30 plots after 11 day intervals both prior to and after the poisoning.

Three free-feeds of chopped carrot were laid in a 20 km furrow on three nights between 29 June and 6 July, 1981, followed by two poison feeds of 0.028% 1080 on carrot on July 10 and 15.

The faecal deposit rate was recorded as both the number of faecal pellets and the oven-dried weight of faeces per day for both *T. billardierii* and *M. rufogriseus*. Data was collected also on the number of faecal pellets of brush possums, Forester kangaroos (*M. giganteus*) and wombats.

Figure 5.1. Location of trial sites in north eastern Tasmania used to investigate the effectiveness of variations to the poisoning procedure.
1 - Royal George 2 - Rushy Lagoon 3 - Pipers River
4 - Emita 5 - Palana 6 - Blue Rocks 7 - Lackrana
8,9 - Lackrana 10 - Logan's Lagoon 11 - Killiecrankie


Flinders Island
5
11
4
6
8/9
7
10
Bass Strait
50 km
2
41°S
3
Launceston
1
42°S
147°E
148°E

3 Pipers River

The trial was conducted during October 1981 on a small property near Pipers River. An 8 ha paddock had been sown with ryegrass and clover in autumn 1979 and again in 1980. Insufficient pasture became available to sustain stock grazing, due to heavy grazing by wallabies harbouring in adjacent bush. A wire exclosure plot was set up in 1980 and this indicated that pasture would grow if grazing pressure was reduced. Bennett's wallabies, pademelons and rabbits were present in the area.

The poisoning operation was performed by the researcher laying three free-feeds of bran in a furrow on alternate days. Three days later 1080 poison was mixed with pollard to a concentration of 0.014% and laid at a rate of 3/4 of a cup at five pace intervals.

The postpoisoning faecal collection was made in November and further collections in December and January to assess the short term resurgence of wallabies on the area.

4 Emita

The property of 250 ha at Emita on Flinders Island carries a large population of *M. rufogriseus*. A furrow was ploughed about 1500 m long between 20 and 50 m from the scrub line in February 1982. A 1:1 mixture of dry bran and pollard was used as the bait and was laid on three alternate days as free-feed. The amount fed increased each time and the acceptance was very good. The 1080 was mixed to 0.028% in the bran-pollard and laid three days after the third free-feed. Acceptance was poor after the first night but increased to about 90% after the second night.

A second poisoning operation was carried out 47 days after the first, using 0.014% 1080 on carrot bait. Monthly faecal collections were made for a further 8 months. The area was re-poisoned in the following summer (March 1983) using "Pollad" (a drought feed based on wheat) and 0.014% 1080, and the resurgence assessed for the next 8 months.

5 Palana

This property of 500 ha is at the far north of Flinders Island. The pasture borders large areas of dense scrub. *M. rufogriseus* were damaging a lucerne crop near the house, at least 300 m from their daytime refuge. They were attracted to this because pasture at the time was very short and dry.

Twenty-seven faecal plots were established and the faecal deposit rate was assessed at intervals of 14 days before and after poisoning. Chopped carrot was used as bait. Acceptability of the first feed was poor, but improved to about 80% for the second and 95% for the third. The poison feed of 0.014% 1080 was laid in February 1982 and was well accepted after two nights. About 50 dead wallabies were detected. Further monitoring of the population was not continued.

6 Blue Rocks

The area poisoned was 200 ha on the western coast of Flinders Island. Despite annual poisoning and extensive shooting this property still harbours a moderate wallaby population.

Carrots were grown on this property so were freely available. Consequently liberal free-feeding was offered on 7 days in a 15 day period in a furrow. One poison feed using 0.028% 1080 was then given in February 1982 and 95% of this was taken after two nights. Monitoring of the wallaby population was not continued.

7 South Lackrana

This property is in the south Lackrana area of Flinders Island. Only one paddock of about 40 ha was poisoned.

Dry bran-pollard (1:1) was placed in heaps about 20 m from the fence in the paddock. No furrow was used. Three free-feeds at two day intervals were given in March 1982 with 100% acceptability. Wallabies scratched at the ground looking for bait. Poison was mixed to 0.028% 1080 and an extra amount of bait laid. This was 100% accepted, so more poison was laid 2 days later.

A larger area was poisoned in March 1983, but including the 1982 area. After two free-feeds of pollard, 1080 was added at 0.014%. No furrow was used. The population was monitored in both years to assess long term effects of poisoning.

8 and 9 Lackrana

Two properties in close proximity on the Eastern side of the Darling Range were poisoned. A furrow about 6 km long was ploughed along a track in the bush 20m outside the boundary fence (see Plate V). Three free-feeds of chopped carrot were given and acceptance was judged to be 70, 95 and 100% respectively. Poison was mixed to 0.014% 1080 and laid in March 1982.

In April 1983 the same area was poisoned using 0.014% 1080 on chopped carrot after two free-feeds.

10 Logan's Lagoon

The property poisoned is in the south-east of Flinders Island near Logan's Lagoon. A block of 100 ha was poisoned of which 70 ha is improved pasture. The bait line was established on a track outside the boundary fence, at places up to 200 m from the pasture. Three free-feeds of pollard were placed in piles along the bait line on alternate days in March 1982. A furrow was not used. The distance between bait piles for each feed was 7, 5 and 4 m respectively and the acceptance of the third feed was 100%. Three days later 1080 was mixed to 0.014% and laid at 2 m spacings. After two nights 95% was taken and more than 130 dead wallabies were readily found in the scrub, some up to 2 km from the bait line. The faecal deposit rate was monitored following poisoning.

Poisoning was repeated in February and August 1983 using 0.014% 1080 after two free-feeds of pollard over a larger area. The bait line was again outside the boundary fence, and no furrow was used.

Plate V

The bait line for the observations at Lackrana was placed along this track in the bush.

11 Killiecrankie

The area poisoned was 800 ha of hilly country at the north west of Flinders Island. The pasture is surrounded by large areas of low heathland of high fire frequency. A furrow was run about 20 m from the scrub line on the edge of all areas of pasture. Carrot was used as bait for three free-feeds on alternate days. Poisoning with 0.014% 1080 followed three days later in March 1982. Despite some worry that the quality of the carrots was deteriorating all poisoned bait was eaten after two nights. The faecal deposit rate was monitored for 18 months.

5.3. Results

5.3.1. Poisoning Operations

1 Royal George

Reductions in the dry weights of *M. rufogriseus* and *T. billardierii* faeces following poisoning indicated mortalities of 34% and 43% respectively. Calculations based on the number of faecal pellets per day gave similar results (see Table 5.1).

2 Rushy Lagoon

As shown in Table 5.1 the estimated mortality of *M. rufogriseus* and *T. billardierii* was 63 and 85% respectively. The number of faecal pellets of *M. giganteus*, *T. vulpecula* and *V. ursinus* collected was 15, 7 and 2 before poisoning and 17, 74 and 11 after poisoning respectively.

3 Pipers River

About 42% of the first feed was eaten after 2 nights but the second and third feeds were totally eaten. The poison was 83% eaten after two nights thus indicating a high acceptability for either bran or pollard bait.

As shown in Table 5.1 the initial reduction of the *M. rufogriseus* population was 78% but it increased over the next two months to a level

Table 5.1.

Mean Number of Faecal Pellets and Dry Weight per Day of Wallaby Faeces Before and After Poisoning at Royal George, Rushy Lagoon and Pipers River

Figures in parentheses are the percentage reductions compared to prepoisoning levels

	Number of Pellets	Oven-dried Weight (g)
	Royal George	
M. rufogriseus		
Pre-poisoning	29.5 ± 17.2	14.0 ± 8.5
Post-poisoning	21.4 ± 10.5 (27.4%)	9.2 ± 5.0 (34.0%)
T. billardierii		
Pre-poisoning	10.4 ± 7.8	2.9 ± 2.1
Post-poisoning	6.1 ± 5.8 (41.4%)	1.6 ± 1.8 (43.7%)
	Rushy Lagoon	
M. rufogriseus		
Pre-poisoning	15.7 ± 11.0	7.5 ± 5.0
Post-poisoning	5.8 ± 3.9 (62.8%)	2.7 ± 2.0 (63.7%)
T. billardierii		
Pre-poisoning	23.4 ± 20.6	7.6 ± 6.3
Post-poisoning	3.8 ± 5.4 (83.6%)	1.1 ± 1.7 (85.3%)
	Pipers River	
M. rufogriseus		
Pre-poisoning (14 Oct.)	10.1 ± 7.1	4.2 ± 3.0
Post-poisoning (9 Nov.)	2.3 ± 2.8 (77.2%)	0.9 ± 1.1 (78.6%)
Post-poisoning (3 Dec)	7.6 ± 8.2 (24.8%)	3.1 ± 2.9 (26.2%)
Post-poisoning (5 Jan)	6.2 ± 5.0 (38.6%)	3.2 ± 2.6 (23.8%)
T. billardierii		
Pre-poisoning (14 Oct.)	45.8 ± 26.8	13.8 ± 8.5
Post-poisoning (9 Nov.)	13.2 ± 8.7 (71.3%)	3.8 ± 2.9 (72.5%)
Post-poisoning (3 Dec)	7.6 ± 8.2 (83.4%)	3.1 ± 2.9 (77.5%)
Post-poisoning (5 Jan)	6.2 ± 5.0 (86.5%)	3.2 ± 2.6 (76.8%)

only 24% lower than the original population. The *T. billardierii* population was reduced by 73% and was still significantly low two months later.

4 Emita

The faecal deposit rate prior to the first poisoning was 82 pellets per day over the 20 plots. This was reduced to 18 after the first poisoning and to 7 after the second. Using these figures the population was reduced by 78% by the first poisoning and by 55% after the second. The combined effect was to reduce the population by 91%.

The population remained at less than 10% of the original estimate for three months, and began to increase in August. By November it was up to 42% of the original.

Prior to the summer 1983 poisoning the faecal deposit rate was 58 pellets per day. It was reduced to 14 per day by the poisoning and it further decreased to remain at less than 3% of the summer 1982 level (see Figure 5.2.).

5 Palana

The faecal deposit rate decreased from 65 to 37 pellets per day indicating only a 44% reduction in population of Bennett's wallabies after the first poisoning.

6 Blue Rocks

The number of faecal pellets per day decreased from 31 before poisoning to 10 after poisoning, a reduction of 67%.

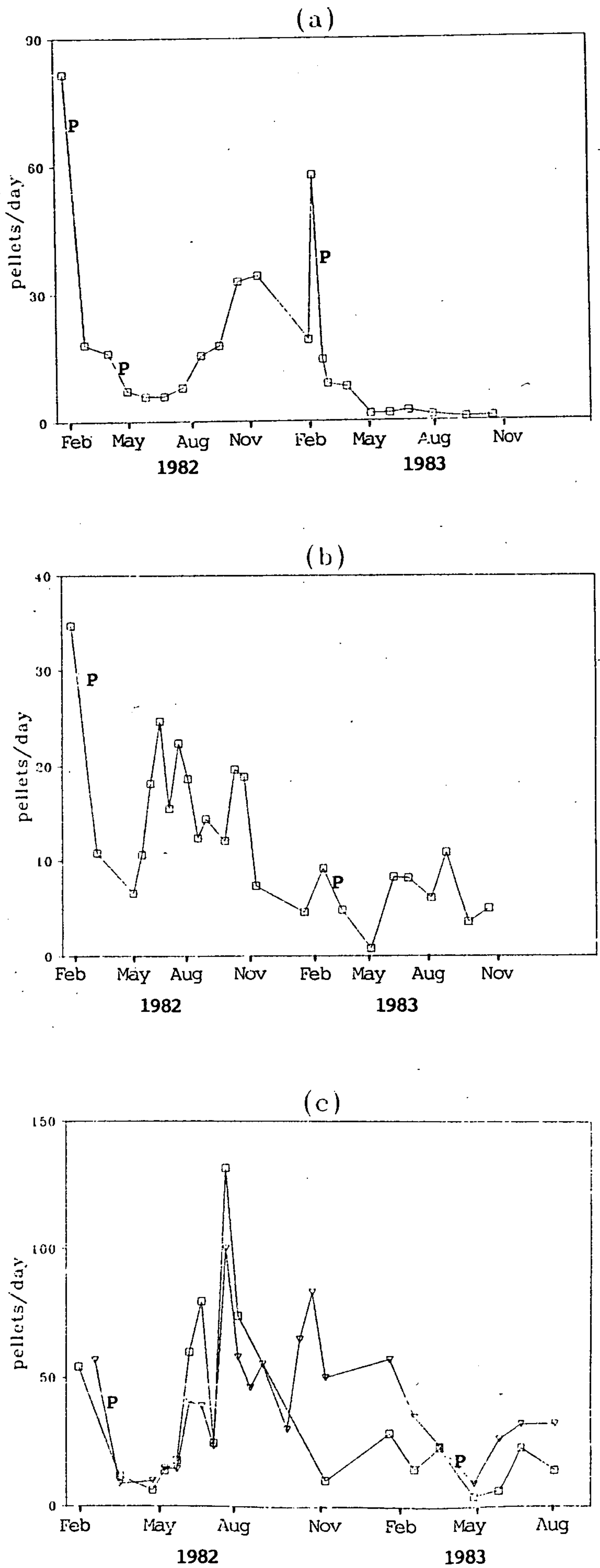
7 South Lackrana

The prepoisoning faecal deposit rate of 35 pellets per day decreased to 11 per day immediately after poisoning, indicating a mortality of 69%. It then increased to a peak in July and decreased to 7 per day in November.

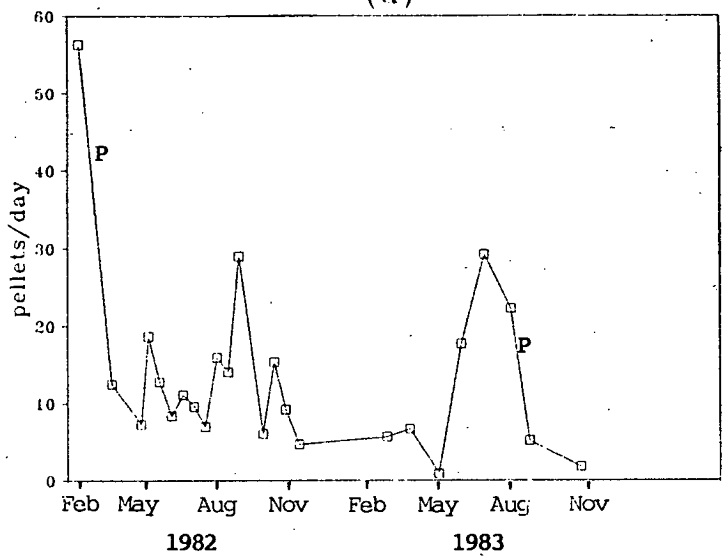
A poisoning in March 1983 resulted in a reduction in faecal deposit

Figure 5.2. Faecal deposit rates (number of faecal pellets per day) collected on all plots to assess the effectiveness of the poisoning program and the rate of re-colonisation of wallabies on the property after poisoning.
(a) Emita (b) South Lackrana (c) Lackrana
(d) Logan's Lagoon (e) Killiecrankie
P = poisoning

Young join the population about November so the effect of a natural increase in the population would be seen only at that time.

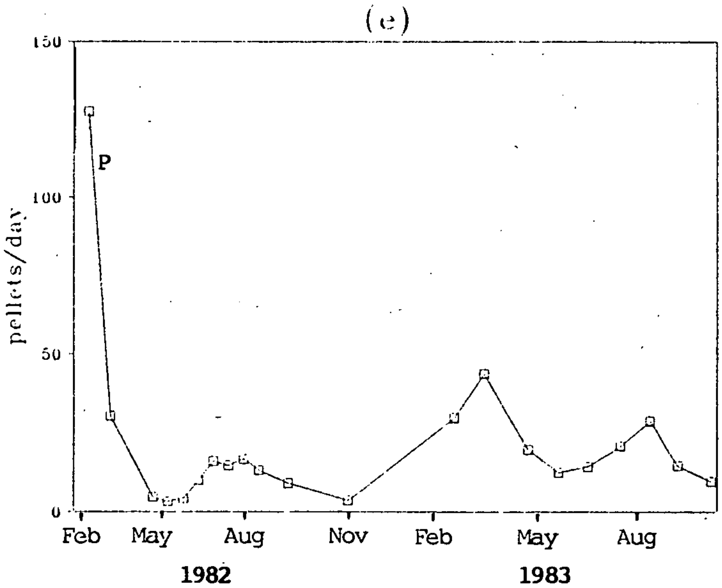

(a)
90
60
30
0
pellets/day
P
P
P
Feb
May
Aug
Nov
Feb
May
Aug
Nov
1982
1983
(b)
40
30
20
10
0
pellets/day
P
P
Feb
May
Aug
Nov
Feb
May
Aug
Nov
1982
1983
(c)
150
100
50
0
pellets/day
P
P
Feb
May
Aug
Nov
Feb
May
Aug
1982
1983

(d)



60
50
40
30
20
10
0
pellets/day
P
P
Feb
May
Aug
Nov
Feb
May
Aug
Nov
1982
1983

(e)



150
100
50
0
pellets/day
P
Feb
May
Aug
Nov
Feb
May
Aug
1982
1983

rate from 9 to 5 pellets per day. It subsequently increased in June and July but by November had decreased to 5 per day (Figure 5.2.).

8 and 9 Lackrana

A very similar result was obtained on each property (Figure 5.2.). An initial faecal deposit rate of about 55 pellets per day was reduced to about 10 pellets per day after the initial poisoning. There was an increase to over 100 pellets per day in July followed by a significantly high fluctuating population for the rest of the year.

A poisoning in the following April produced only a temporary reduction in the wallaby population. The faecal deposit rate was reduced from 24 to 4 pellets per day on one property and from 24 to 9 pellets per day on the other. This indicated mortality rates of 82% and 61%, but populations were back to the prepoisoning level by July and June respectively on the two properties.

10 Logan's Lagoon

The initial faecal deposit rate of 56 pellets per day was reduced to 12 per day immediately post poisoning. For the next 7 months it fluctuated reaching a peak of 29 per day in September, but had decreased to 5 per day in November (Figure 5.2.).

An assessment was not made prior to the March 1983 poisoning. Subsequent faecal deposit rates ranged from a low of 1 per day in May to a high of 29 per day in July. The August poisoning reduced the faecal deposit rate from 22 to 5 pellets per day, that is, by 77%.

11 Killiecrankie

There was an initial decrease in faecal deposit rate from 128 to 30 pellets per day, indicating a mortality of 77%. During the following 18 months the faecal deposit rate fluctuated to a low of 3 per day in June, then up to 44 in March 1983 and had decreased to 10 per day when observations ceased in October (Figure 5.2.).

5.3.2. Comparison of Treatments

A summary of results is shown in Table 5.2. Table 5.3. shows the results of analysis of each of the treatments. The data provide no support for any significant difference within any set of factors.

5.4. Discussion

5.4.1. Population Assessment

In these trials faecal deposit rates have been the chosen method for assessing relative changes in the size of the wallaby population on a given paddock. This choice was made despite the findings reported in Chapter 3, that for *M. rufogriseus* population changes using faecal deposit rates, were not in agreement with assessments using direct spotlight observations. As the faecal deposit rate gives an average density index over a period of time (usually 14 - 28 days) and does not disturb normal wallaby activity it is considered to be a more reliable method than direct observations which are subject to nightly fluctuations.

Coulson and Raines (1985) reported that counting of individual pellets of eastern grey kangaroos gives a good estimation of the population size present, whereas counting of pellet-groups gives a substantial positive bias leading to an over estimation of population size. Johnson (1977) recommended that pellet counts and not pellet-group counts should be used in assessing Bennett's wallaby, pademelon and brush possum populations. He considered circular plots and belt plots to be equally accurate. Perry and Braysher (1986) also recommended counting kangaroo faecal pellets rather than pellet-groups.

In these observations we have used individual pellet counts or the oven-dried weight of faeces from plots. The Royal George, Rushy Lagoon and Pipers River trials report figures for both pellet counts and oven-dried weights, with comparable results in terms of mortality (see Table

Table 5.2.

A summary of results of *M. rufogriseus* poisoning observations

Property No.	Month	Furrow	Bait Line	Bait	1080 %	Mortality %
1	May	yes	paddock	carrot	0.028	34
2	July	yes	paddock	carrot	0.028	63
3	Oct.	yes	paddock	pollard	0.014	78
4	Feb.	yes	paddock	pollard	0.028	78
	Mar	yes	paddock	pollard	0.014	75
5	Feb.	yes	paddock	carrot	0.014	44
6	Feb.	yes	paddock	carrot	0.028	67
7	Mar	no	paddock	pollard	0.028	69
	Mar	no	paddock	pollard	0.014	48
8	Mar	yes	bush	carrot	0.014	78
	Apr.	yes	bush	carrot	0.014	82
9	Mar	yes	bush	carrot	0.014	84
	Apr.	yes	bush	carrot	0.014	61
10	Mar	no	bush	pollard	0.014	80
	Aug.	no	bush	pollard	0.014	77
11	Mar	yes	paddock	carrot	0.014	77

Table 5.3.

Comparison of Each Set of Treatments in the Effectiveness of Bennett's Wallaby Poisonings.

Treatment		n	$\bar{x}$	t	$t_{0.05}$
Bait	carrot	9	66		
	bran/pollard	7	72	0.28	2.35
Furrow	yes	12	68		
	no	4	68	0.94	2.91
Bait line	in bush	6	77		
	in paddock	10	63	0.66	2.36
1080	0.014%	11	71		
	0.028%	5	62	0.70	2.65

5.1).

As no reliable data are available the faecal deposit rates have not been converted into animal densities. The number of faecal pellets produced per day for *M. rufogriseus* is recorded as 128 by Johnson (1977) for captive animals and as 311 by Johnson *et al.* (1987) for quiet unconfined animals. Johnson *et al.* (1987) recorded the mean weight of *M. rufogriseus* faecal pellets as 2.65 g when wet and 0.67 g after drying. Information obtained from Tasmania shows that the mean oven-dried weight of *M. rufogriseus* faecal pellets on Flinders Island (Table 2.5.) is 0.93 $\pm$ 0.11 g (n=2698) and on the Tasmanian mainland (Tables 4.1. and 5.1.) is 0.47 $\pm$ 0.05 g (n=24724). This difference is significant (t=9.8, $p<0.001$). The accuracy of faecal deposit rates in the assessment of population indices is affected by decay caused by weather or insect damage. For the purposes of these trials where most observations were made over short time intervals the amount of decay was considered to be negligible. Statham (1983) observed wallaby faecal pellets for four months in a forest environment and reported that the disappearance rate was not significant. Johnson and Jarman (1987) found that faecal pellet decay rate was negligible in winter months over a 30 day period, but may be significant in warm wet conditions due to insect damage.

The wallaby populations as assessed in this way do show great variation independent of any applied control. In these observations only one estimate of an index to the wallaby density on that paddock was possible before the poisoning program and this was compared to the next estimate after poisoning to assess the mortality. Thus some of the difference may be due to a natural temporary decrease in the density or conversely a natural increase in population density may have produced a false low estimate of mortality caused by the poison. Statham (1983) collected data on faecal deposit rates for three months prior to poisoning, but because of fluctuations during this time chose to use only the latest prepoisoning count in calculations.

The factors affecting the number of wallabies grazing a paddock are unknown and likely to be complicated. Johnson (1978) and Mooney and

Johnson (1979) reported that the numbers of wallabies moving on to pasture increased with an increase in green matter component in the pasture, but decreased with the presence of livestock. Wind and rain also inhibit movement on to pasture. They recorded that slightly more than 50% of the local population of both species graze an area on any one night.

5.4.2. Expected Mortality

The real objective of wallaby control is to reduce the grazing pressure to an insignificant level of economic loss, but this cannot be readily assessed objectively. For the purposes of the exercise an arbitrary achievable objective of 70% mortality has been selected, above which the effectiveness of the poisoning program is deemed acceptable. A level below 70% is considered to be sub-optimal (see Chapter 1).

Johnson (1978) and Mooney & Johnson (1979) reported the results of two investigations into the effectiveness of a 1080 poisoning program in a pine plantation. Spotlight transect counts were used to assess an index to population size. Two free-feeds of carrot bait were used on each occasion. The first trial showed a 60% reduction in the *M. rufogriseus* population, but few wallabies were seen per transect before poisoning and the results must be viewed cautiously. An 86% reduction was obtained at the second trial which involved three poison feeds, at intervals of four and six days.

Statham (1983) obtained 34% and 65% reductions in *M. rufogriseus* populations after routine poisonings in pine plantations, as assessed by spotlight transect counts. In an area of eucalypt regeneration using mainly faecal deposit rates and some spotlight transect counts to assess changes in population she recorded mortalities of 50 and 80%.

5.4.3. Resurgence of Populations

In these investigations the wallaby population was continually monitored after poisoning on six properties. The populations increased to a significant level in from three to seven months on five properties and remained at a low level on the other for at least nine months.

If poison is laid on a small area of pasture surrounded by a large area of bush a rapid re-colonisation of the area is expected. This appears to have happened at Pipers River.

There is a significant natural fluctuation in the wallaby population in a paddock throughout the year. It is therefore difficult to assess the value of the control methods in reducing the population size and in keeping it at a lower level.

5.4.4. Bait Type

Mollison (1960a) investigated the acceptability of several bait types to *T. vulpecula, T. billardierii* and *M. rufogriseus* in a rain forest environment of the Florentine Valley in southern Tasmania. He reported that apples, oats, loose bran/pollard and carrots were all acceptable to *M. rufogriseus* except in spring when acceptability of any bait was poor. By contrast both *T. billardierii* and *T. vulpecula* showed a preference for apple followed by bran/pollard and carrot, but oats were not well accepted. He recommended loose bran-pollard as the best for control of all of these species.

Both the trial work and subsequent experience with bran or pollard baits have shown such baits to be effective in wallaby poisoning. There appears to be no difference in the efficiency of poisoning using these baits as opposed to the traditional carrot bait (Table 5.3.). The advantages of bran or pollard baits are their good acceptability, ready availability, easy storage and ease of use. Their main disadvantage is the difficulty to handle them in windy weather. Despite this, once baits are laid they are not susceptible to wind or rain damage.

It was noted on Flinders Island that Bennett's wallabies were slower to accept the first free-feed of bran/pollard bait than the first free-feed of carrot. Subsequent free-feeds were readily eaten (M. Middleton and K. Bailey, personal communication).

M. rufogriseus have been shown to be less attracted to these baits during the spring months of September to December (Mollison 1960b). This may lead to ineffective poisonings at that time of the year, although the two poisonings in August and October gave acceptable results.

5.4.5. Poison Concentration

It has also been demonstrated that the effectiveness of poisoning operations is not improved by increasing the concentration of 1080 in the bait. Even with two poisonings at five day intervals with a high poison concentration only a moderate level of control of *M. rufogriseus* was attainable at Rushy Lagoon. *T. billardierii* were much more readily controlled.

Wallabies eat 100 g bran/pollard bait in 15 minutes and commonly feed on bait for 10-15 minutes without pause and up to 2.5 h at one period (Mollison 1960b). A lethal dose must be contained in not more than 100g bait.

A large *M. rufogriseus* (20 kg) has an LD_{50} of 0.2 mg/kg (McIlroy 1982) or 4 mg 1080. This is contained in 28 g bait. A large *T. billardierii* (8 kg) has an LD_{50} of 0.13 mg/kg (McIlroy 1982) or 1.04 mg 1080. This is contained in 7.5 g bait. A concentration of 0.014% 1080 in bait is therefore theoretically adequate to effectively reduce wallaby populations. It may be possible that the LD_{50} value calculated by McIlroy for captive wallabies is lower, because of stress, than the actual LD_{50} of non-captive animals, but this is not confirmed by the results of using a higher toxic loading.

Landowners sometimes consider that a poisoning program is ineffective if only a few carcasses are detected close to the bait line. With 1080 poisoning there is a latent period between consuming the bait and death, so that most animals are able to find refuge in the bush prior to death. McIlroy (1982) reported that the time to death varies inversely with the amount of poison consumed by wallabies with a minimum of 8 hours. Mollison (1960b) reported that even at high doses of 1080 there was a 9 hour delay before death.

5.4.6. Bait Placement

As shown in Table 5.3. mortalities achieved from the observations when the bait line was placed in the bush were as high as from bait lines in the paddock (77 cf. 63), so placement of the bait in the bush is an acceptable alternative to paddock feeding. It should be discouraged however, as it may lead to higher mortalities of small non-target mammals (Brunner 1983).

At Royal George and at Palana a considerable area of open woodland or pasture separated the wallaby shelter area from the crop to be protected. The bait line was placed on or around the crop. Better results may have been achieved by placing the bait nearer the shelter as movements to the crop, and hence to the bait line, are probably erratic.

5.4.7. Furrow Poisoning

Only four investigations on two properties did not use a furrow to mark the bait line. The mean reduction in wallaby populations in these was equivalent to that when a furrow was used (Table 5.3.). The value of a furrow in increasing the effectiveness of the poisoning operation is therefore doubtful, but the furrow also serves a useful purpose in marking the bait line for free-feeding, poisoning, post-poisoning pick up and evaluation of bait take. Gooding (1963) also considered that a furrow is not necessary for wallaby poisoning, but is useful to mark the bait line.

5.4.8. Target Specificity

The susceptibility of non-target species to 1080 poisoning will depend upon several factors, in particular, the sensitivity to 1080 and the acceptability of the bait. McIlroy (1986) has reported on the differences in the sensitivity of different groups of animals to 1080. Eutherian carnivores are most sensitive followed by eutherian and marsupial herbivores. Marsupial carnivores and birds are relatively tolerant to 1080. Mollison (1960a,b) considered that dry bran/pollard had little attraction for birds in the rain forest environment of the Florentine Valley, although black currawongs (*Strepera fuliginosa**) and silver gulls (*Larus novaehollandiae*) were reported to have died after eating bran/pollard baits. At least 5 species of native birds were seen to die following poisonings using apple bait, and black currawongs were also killed after eating carrot bait.

At the low concentration of 1080 currently used in Tasmania mortalities amongst bird populations are rarely seen. They are more common when apple baits, rather than carrots, are used.

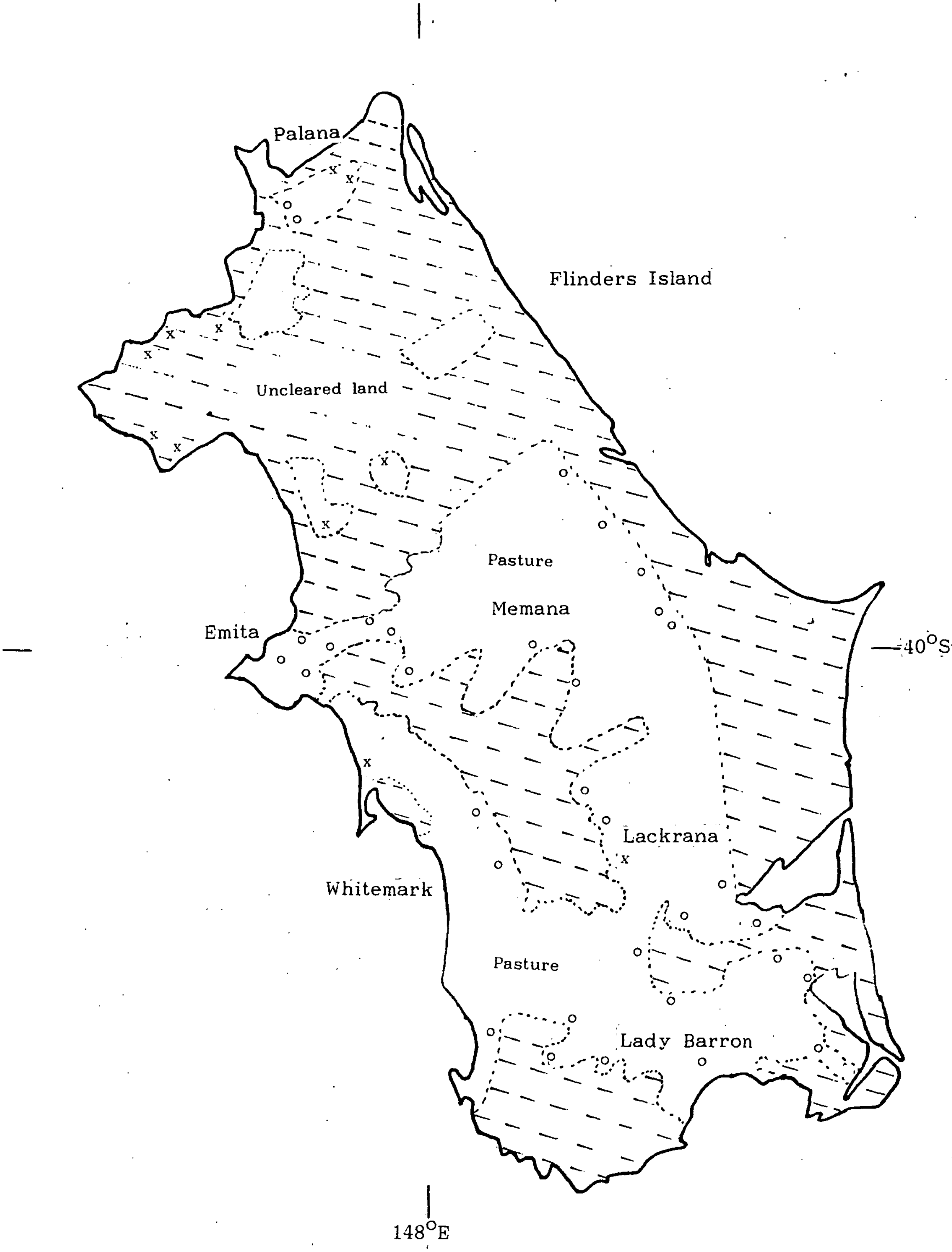
Brunner and Browne (1979) observed the behaviour of birds near bait lines in an open forest area in Victoria. Of 72 bird species observed in the area, 11 were seen to eat lightly milled oats and one was seen eating bran/pollard pellets. Carrots were not eaten. Brunner and Coman (1983) reported that the acceptability of these baits to birds may be further reduced by the addition of green or blue dye.

During 1983 there were 45 wallaby poisoning operations on Flinders Island of which 11 used chopped carrot bait and 34 used a pollard based bait. These poisonings were well distributed over the island (see Figure 5.3). Casual observation and questioning of landholders revealed a high degree of satisfaction in the effectiveness of pollard-based baits and no evidence of mortality to any bird life. Observations of loose pollard

---

* Latin names for birds are taken from R. H. Green (1973), Birds of Tasmania, Foot and Playsted, Launceston.

Figure 5.3. Location of wallaby poisonings on Flinders Island in 1983. x = carrot bait, o = pollard type bait


Palana
Flinders Island
Uncleared land
Pasture
Memana
Emita
40°S
Lackrana
Whitemark
Pasture
Lady Barron
148°E

and bran/pollard pellet bait lines on Flinders Island showed that Cape Barren geese (*Cereopsis novaehollandiae*) and black swans (*Cygnus atratus*) were not attracted to either bait on pasture land, but superb blue wrens (*Malurus cyaneus*) and rufous fantails (*Rhipidura rufifrons*) were seen to peck and eat pellet baits near the forest edge (P. Mooney, unpublished report). M. Statham (personal communication) placed dyed and undyed pollard bait in a paddock for 3 days and observed the acceptability to birds using an automated movie camera. During this period only one bird (a wren) was observed near the bait line. No sign of pecking at the bait was seen and all pollard baits remained intact at the end of the three days.

Brunner (1983) studied the acceptability of bait types to various mammalian species. Although he found that macropods and possums preferred bran/pollard pellets, rabbits and wombats preferred carrots and rats preferred oats, he concluded that it is more likely the position of the bait placement that determines the access of animals to baits. Baits placed in an open paddock will be safer to small rodents, possums and birds than baits placed within the bush line.

It is interesting to note that the poisoning at Rushy Lagoon using 0.028 % of 1080 on chopped carrot bait did not diminish evidence of *M. giganteus, T. vulpecula* or *V. ursinus* populations.

It has been mentioned that loose bran-pollard presents a hazard to the operator when 1080 is mixed in windy weather. Pelleted bran-pollard may be better in this regard, but they inexplicably performed poorly in bait acceptance trials (Chapter 4). They may be worthy of extra investigation.

Chapter 6

Electric Fencing for Wallaby Control

6.1. Introduction

6.1.1. Exclusion Fencing

Most methods of pest control involve killing a large proportion of the pest population, by shooting, snaring or poisoning. This may be considered to be acceptable for non-indigenous species (rats, rabbits) but is certainly unpopular when the pest species is a native animal. So many species of Australian native animals have become extinct since European settlement (Frith 1973) that the community must be ever aware of declining numbers and distribution of any species. Any method of preventing depredations of native pest species without reducing their numbers will have a high degree of community support. The main methods of achieving such an aim are by capture and relocation and by the use of exclusion fencing.

Fencing is expensive, especially a netting fence that will provide a solid physical barrier to large pest species. They are also subject to damage from wombats and wallabies. And yet, at great expense , and usually without great success, Australia has a history of attempting to fence pests out of certain areas (Rolls 1969).

The cost of fencing has been considerably reduced with the introduction of electric fencing, which can be temporary or permanent. Dairy cattle and horses can be kept under good control with a single electric wire, instead of a 7 or 8 plain wire permanent fence. Electric fencing is also used by farmers for sheep, goat and pig control.

Electric fencing is also widely accepted as a means of excluding many species of feral and native animals from farmland. Fence designs have been reported for the control of possums (Nelson 1982), feral dogs (Breckwoldt 1983), feral pigs (Hone and Atkinson 1983), wallabies (Wright

1978, Howard 1978), emus, kangaroos, deer and wombats (McCutchan 1980).

6.1.2. Electric Fencing Principles

An electric fence is "a fence designed to obstruct the passage of animals, in which at least one wire is electrified with respect to other wires and/or earth with the intention of delivering an electric shock to any animal attempting to penetrate the fence" (McCutchan 1980). Rather than present a physical barrier to the animals, electric fences produce a mental or psychological barrier, and induce a state of fear from previous exposure.

Modern electric fences are energised by imparting high voltage impulses of up to 6 kv at 1 second intervals. Energisers are usually powered by the 240 v mains electricity supply, but in areas where this is not available, car batteries or solar powered systems are used. Small private hydro-electric or wind powered generators are possible alternatives.

The electric pulse in the fence should satisfy the following factors (McCutchan 1980):

- to produce a strong reaction in the animal
- to minimise the risk of injury to animals or persons
- to travel for long distances along fence wires with minimum loss of strength.
- to require minimum energy input, unless derived from supply mains.
- to minimise the risk of starting a fire.

As some of these factors are in conflict a compromise must be reached.

As with most other electrical equipment certain standards and specifications must be met by the manufacturers of electric fence energisers. These are enshrined in Australian Standard C129 of 1959. This restricts the allowable peak voltage to 5 kv, although McCutchan (1980) considers that higher voltages should be allowed and that this restriction is "an unnecessary emotional limit". Danger, he says, comes from the electric current, not from the voltage.

The output current, as measured in a standard way, must not exceed 300 mA for more than 300 ms (microseconds). The duration of the pulse must not exceed 0.1 seconds and the interval between pulses must be at least 0.75 seconds. The current between pulses (assessed in a specified way) must not exceed 0.7 mA. The quantity of electricity per pulse must not exceed 2.5 millicoulombs (= 2.5 mA-seconds).

The effectiveness of an electric fence relies upon the electrical circuit being completed from the energiser to all parts of the electric fence and returned back to the energiser. An animal touching the electrified wire will not receive a shock unless the current returns to the energiser. This may happen in two ways.

(1) If the earth terminal on the energiser is connected to an earthed peg in damp ground, the current may pass from the fence through the animal to the ground, thence through damp earth to the earthed peg. Usually the earthed peg consists of several galvanised posts or pipes each driven deep into the ground and connected together. This earth-return system will be effective provided

- current passes readily from the fence to the animal, preferably through an area of skin having little or no hair, and
- current passes readily from the animal to the ground surface either directly or through vegetation or water, and
- the soil from the animal to the earthed peg is sufficiently moist to provide a low resistance path.

These conditions may readily be met in irrigated dairy farms or in temperate climates in winter, but may not occur in hot dry climates.

(2) A more reliable path for the electric current to return to the energiser may have to be provided by having an earth wire on the fence being directly connected to the earth terminal of the energiser. The current then passes from the electrified wire through the animal to an earthed wire in the fence to the energiser. The animal must contact an electrified and an earthed wire at the same time, both on areas of the animal having not much hair or wool.

There is a variety of wire types, insulators and other hardware which can be used for electrified fences, but there is no need to discuss these here. Different situations will require different strategies.

6.1.3. Wildlife and Electric Fences

Controlling wildlife with electric fences does impose several problems not met with domestic animals (McCutchan 1980):

- any wildlife are difficult to study as they cannot be easily identified individually,
- it is difficult to determine how many animals are in the population and the size of their home range,
- many are nocturnal, necessitating night time studies and perhaps the use of image intensifiers,
- the intention is to exclude them from the crop rather than keep them in, and it is difficult to see them approaching the fence from the bush,
- their pattern of movement is irregular and not understood,
- individuals are difficult to trap and handle without affecting the animals subsequent behaviour or health, and
- research into wildlife problems is often very expensive and funding is not readily available.

Movement of most kangaroos will be restricted by a normal 3ft. 6in. (1050 mm) fence although under pressure they may clear 6ft. (1800 mm) or even 8ft. (2400 mm) fences. Despite their great jumping ability undisturbed kangaroos prefer to crawl under a fence or go between the wires. They tend to drift along a fence if there is no easy passage until they come to an internal corner, where they force their way through (Frith and Calaby 1969). McCutchan (1980) found that even under pressure at night kangaroos would not jump a 1050 mm fence, but would head for the nearest hole. In the daytime, however, the largest kangaroos did jump the fence, while undisturbed.

McCutchan's (1980) first electric fence design to control the movement of kangaroos through fences was a 5 wire fence with the lowest 180 mm from the ground and then spaces of 200, 230, 250 and 260 mm. The second and fourth were earthed. Posts were 30 m apart and the wire had a high tension (1800 N). Kangaroos readily passed under the bottom wire which was electrified, as they dug holes where there was a small depression. At the beginning (summer) the soil was dry and later when the rains came the fence voltage was reduced by short circuits through wet grass. The lowest wire was then raised to 250mm above the ground, which overcame the fence voltage problem but still allowed the kangaroos to go under. Variations in the gap under the lowest wire were reduced by removing tussocks, putting logs in hollows and adding extra posts at critical points. Adult kangaroos were found to jump over this fence but joeys had to jump through the lower wire spaces and risk getting a shock.

The next development was a major innovation in fence design. McCutchan (1983) describes a kangaroo proof fence consisting of a sloping section of 8 wires topped by a vertical section of 2 more wires. The fence slopes downwards at 45^{O} in the direction of approaching kangaroos from 1050 mm above the ground. The eight wires are positioned at distances of 150, 300, 450, 625, 800, 1000, 1200 and 1450 mm along the sloping post from the ground. The lowest wire is earthed and alternate wires are electrified. The sloping posts and intermediate droppers are pivoted from vertical posts so can be raised to pass sheep through or to graze beneath the fence. Above this is a vertical extension from the posts which carries two extra wires 1400 and 1800 mm above the ground. This section has an overload mechanism so that a span will pivot if hit hard by a kangaroo.

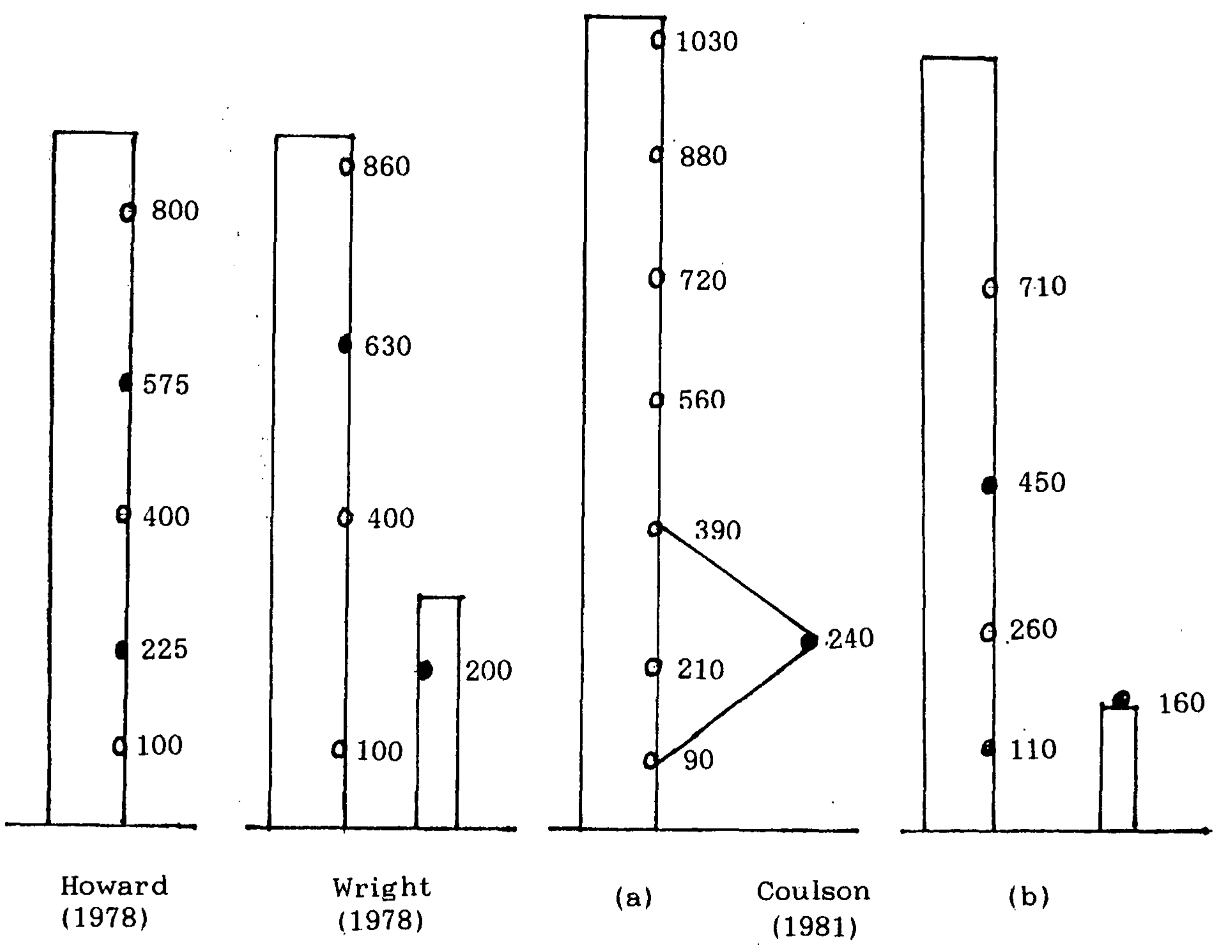
6.1.4. Wallaby Control using Electric Fencing

Electric fencing is reported to have been successful in excluding wallabies from crops in Queensland. The basic design of these fences consists of 5 plain wires with each alternate wire being electrified. Howard (1978) stressed the importance of having a low wire 100 mm from the ground and claimed good results with a 5 wire fence with wires at 100, 225, 400, 575 and 800 mm from the ground, the second and fourth being electrified. Wright (1978) recommended a fence very similar to Howard's except the second wire was offset, 200 mm high and 150 mm outside the fence line (Figure 6.1.). Both of these Queensland reports were probably dealing with *M. rufogriseus*, the same species as Tasmania's Bennett's Wallaby. Howard claimed that of 12 wallabies which regularly grazed the crop 11 were stopped from entering the paddock and the other, younger wallaby passed under the lowest wire. Wright claimed that his fence design "almost completely" stopped movements of wallabies and kangaroos on to the crop.

Coulson (1981) tested two electric fence designs (see Figure 6.1.) in excluding Bennett's wallabies from a pasture in south-east Tasmania, and used spotlight counts of wallabies and faecal deposit rates to assess the effectiveness. In his first trial he tested the effect of adding an electrified wire 240 mm above the ground and offset 260 mm in the direction of approaching wallabies to an existing 7 wire fence. The fence was powered by an Electra 6 v solar unit which delivered a consistent 3750 v when the circuit was completed via earth wires but a variable 500 to 3750 v when allowing for a ground return. Before applying the electrified outrigger the wallabies were seen to pass under the lowest wire or between the lowest two wires. On the night the offset wire was added, wallabies were seen to sniff it and move away, but thereafter wallabies went under the wire and under or through the fence without obvious discomfort. Spotlight counts showed weekly fluctuations with a mean of 16.3 in the 5 weeks before to about 9.2 in the four weeks after the electric wire was added, giving a reduction of 43%. Faecal pellet counts on 25 circular plots each 20 m^2 gave a reduction of 63% after the fence was electrified. Similar counts of pellet-groups gave a 73% reduction. Coulson considered faecal counts to be more meaningful as they were an index of grazing activity each night for a longer period and should be subject to less fluctuations.

Coulson's second trial tested a four wire fence with electrified

Figure 6.1. Electric fence designs for wallaby control as reported in the literature. Wire heights are in mm above the ground. o = earthed wire, ● = electrified wire.


800
575
400
225
100
860
630
400
100
200
1030
880
720
560
390
240
210
90
710
450
260
160
110
Howard
(1978)
Wright
(1978)
(a)
Coulson
(1981)
(b)

wires 110 and 450 and earthed wires 260 and 710 mm from the ground. This was later modified by adding an electrified offset wire 160 mm from the ground (Figure 6.1.). This fence was powered from a 12 v car battery which through the energisers delivered 4700 v through the earth wire return but down to 2000 v through the soil return. Before the power was turned on most wallabies were seen to squeeze under the lowest wire or between that and the next wire. Some passed between the second and third but more jumped over the fence. After the power was connected wallabies were seen to nose the live wire and shy away. Many then moved along the fence, testing it with their nose. Eventually, however, all wallabies went through the fence, generally between the lowest and second lowest wires. After the offset wire was added there was similar reaction by the wallabies but all that were seen to approach the fence passed through. The population using the paddock as assessed by spotlight counts was not affected initially but decreased by 62% after the offset wire was added. Faecal counts showed small differences early and then faecal pellets decreased by 55% of the original level and pellet groups decreased by 64%.

Coulson's report gave a good description of his study sites and techniques and attempted to assess the effectiveness in terms of objective quantitative observations of wallaby populations before and after electrifying the fences. It unfortunately does not indicate the long term effect. In the short term a reasonable but probably insufficient exclusion of Bennett's wallabies is indicated.

The objective of this Chapter is to report the results of investigations designed to find an electric fence configuration which will act as an effective barrier to pademelons. Whilst the ideal fence would give 100% protection from wallabies, the fence must be cost effective. Consequently, it was the aim of these investigations to find a fence which was not excessively expensive yet gave about 80% protection.

6.2. Materials and Methods

6.2.1. Study Site

A paddock on a property near Mt. Direction, East Tamar was selected for this work. The paddock was about 400 m wide x 500 m long and was bordered by thick scrub consisting of eucalypts and thick understorey for at least 1 km deep.

Three paddocks were established within this paddock, each bounded by a different configuration of wires. As shown in Figure 6.2 the central paddock had common boundaries with the outer two. The configuration considered to be most secure was therefore used in the central paddock and was used on all four sides. The outer paddocks were fenced with the test configuration on the other three sides.

6.2.2. Fence Structure

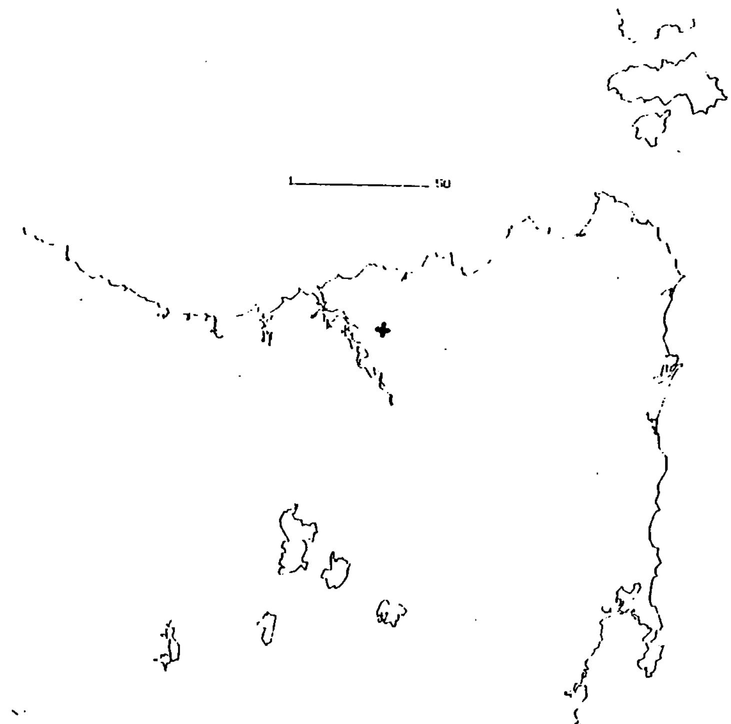
The fence was built of round treated pine posts at 20 m intervals with three droppers at 6-7 m intervals between posts. The existing fence was used on the north and west sides of Paddock A, but a new fence was built on the western end of Paddocks B and C about 2 m inside the existing fence. High tensile 2.5 mm wire was used. Tyeasy was used for later additions and modifications. Black plastic insulators were used on posts and porcelain end insulators were used at the end of live wires. A mains energised electric fence unit (Gallagher BEV 3) provided the current from about 1 km. The circuit was completed via the soil return through earth pegs at the fence and at the unit.

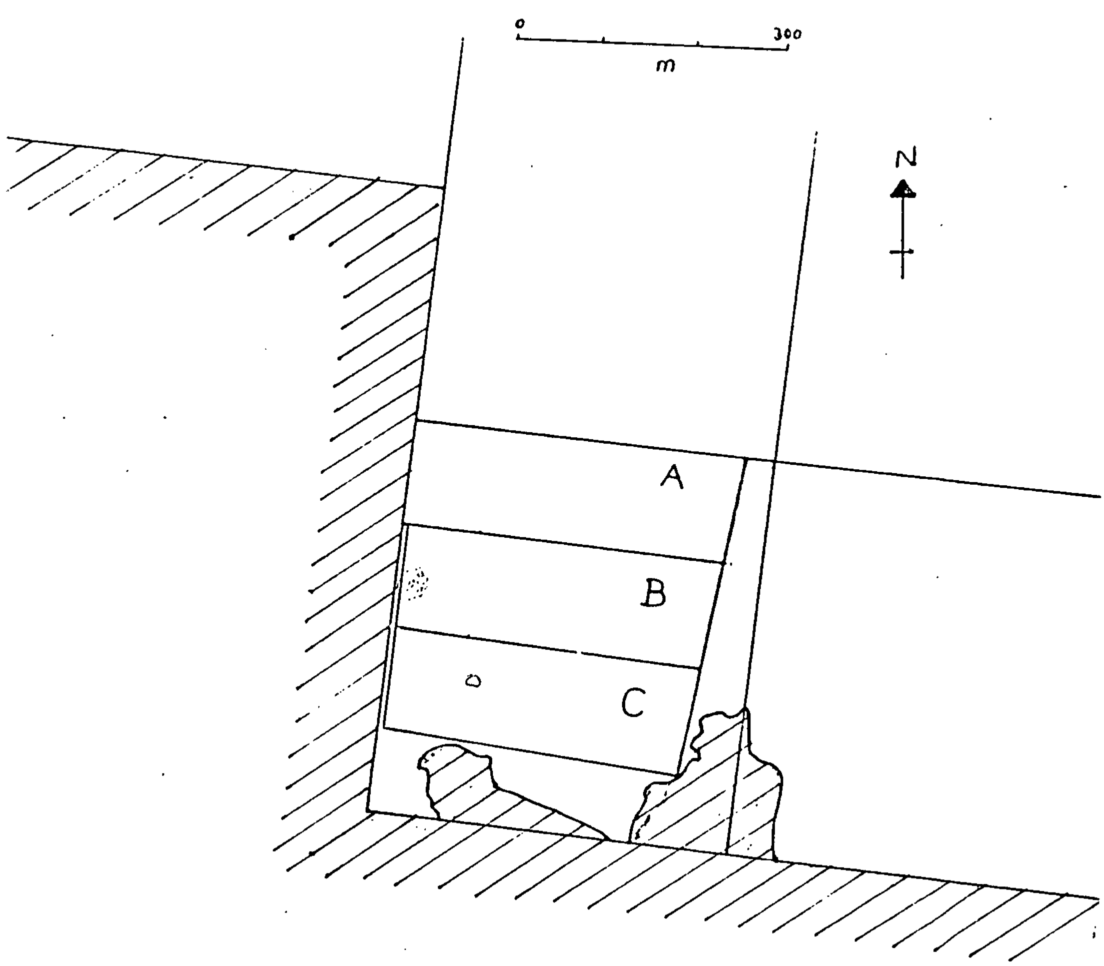
6.2.3. Animal Population Monitoring

The predominant wildlife species present were pademelons, but some Bennett's wallabies, rabbits, possums and wombats were also present.

Some spotlight observations (stake-out counts) were made in the

Figure 6.2. Diagram of study site at Mt Direction. The area was divided into paddocks A, B and C, as shown. Most of the wallabies (*T. billardierii*) approached the pasture from the thick bush to the west and south, so that those fences came under considerable pressure. A low lying wet area in paddOck B was very attractive to pademelons.





0
300
m
N
A
B
C

early stages at the western end of the paddocks, which is the area of greatest density of pademelons. These were limited in number and limited to the first 1.5 hours after dark.

The populations were monitored throughout using 14 marked plots (20 x 1 m) at 20 m intervals in each paddock to measure the faecal deposit rate. As pademelon faecal pellets are often fused and individual pellets not always easy to differentiate, the oven-dried weight of all faeces per plot was used as the population index. Plots were first established on June 9 1982 and cleared at intervals of about 30 days. Five control plots were also established outside the paddocks.

6.3. Stage One - June 9 to September 10, 1982.

6.3.1. Fence Configurations (see Figure 6.3.)

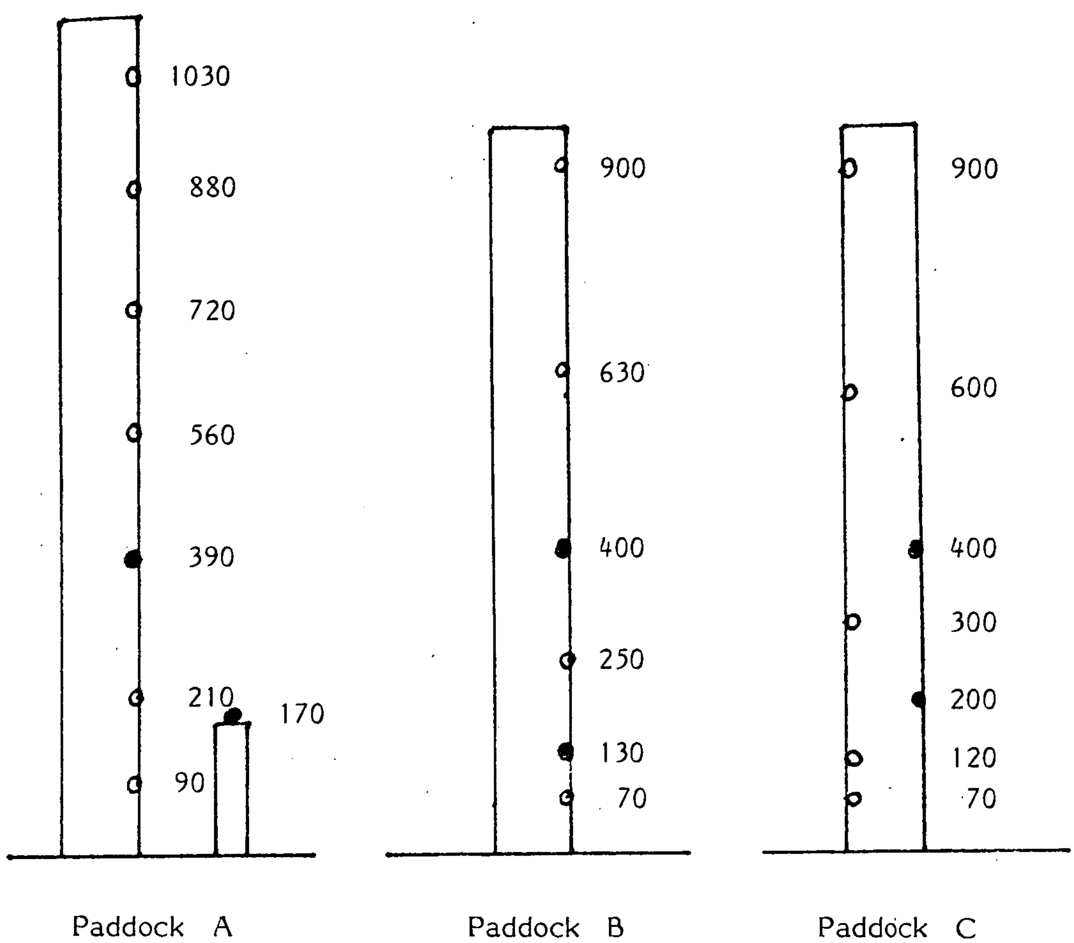
Paddock A was already fenced on two sides with a conventional 7 wire fence. This paddock was therefore used to test a simple modification of an existing fence by electrifying the third wire from the ground and adding an offset wire 170 mm from the ground and 150 mm outside the fence line. The new piece of fence at the eastern end was also fenced in this style.

Paddock B , the central paddock, was fenced on 4 sides with a six wire fence. Wires were placed at 70, 130, 250, 400, 630 and 900 mm from the ground with the second and fourth electrified. With small gaps under and over the bottom wire this fence should prevent wallabies passing through at their preferred height.

Paddock C was fenced on three sides with a design similar to one proposed by Coulson (1981) but incorporating two low earthed wires intended to provide a physical barrier. Earthed wires were placed at 70, 120, 300, 600 and 900 mm from the ground on the inside of the posts and two electrified wires at 200 and 400 mm from the ground were placed on the outside.

The fences were completed and the electricity connected on July 28,

Figure 6.3. Configurations used for fencing the three paddocks during Stage One.
● = electrified wire, o = earthed wire.
Wire heights are in mm above ground level.


1030
880
720
560
390
210
170
90
Paddock A
900
630
400
250
130
70
Paddock B
900
600
400
300
200
120
70
Paddock C

1982. The voltmeter read 4.6 to 4.8 kv.

6.3.2. Results

Some direct spotlight observations on wallaby activity were made before and after dusk (see Table 6.1.). Unless otherwise stated there was no moon, no wind and low temperature, and observations were made with a spotlight and binoculars.

July 13 - Counts were made at 15 minute intervals from a point in paddock B next to paddock C, so that a reliable indication of wallabies could be obtained. The maximum number of pademelons seen was 32 in paddock B at 1830 and 26 in paddock C at 1900.

July 14 - Observations were made from the boundary of paddocks A and B. Maximum counts were 8 in A at 1845 and 25 in B at 1900.

July 15 - From a position in paddock C near the dam counts were made from 1730 to 1900. Maximum counts were 39 in C at 1845 and 24 in B at 1900.

July 21 - From a position near the fence between paddocks A and B observations were made from 1730 to 1915. An image intensifier borrowed from the National Parks and Wildlife Service was used but the range was too small. Using a spotlight and binoculars maximum counts were 22 in A at 1830 and 18 in B at 1845.

July 22 - Limited observations without a spotlight from paddock C showed 29 pademelons at 1745. Observations then ceased due to light rain.

July 28 - The fence was electrified. Counts were made from paddock C near the dam. There was light wind and 3/8 cloud. Maximum counts were 6 in C at 1845 and 7 in B at 1830.

August 30 - The fence voltage was 4.5 kv. Observations were made from paddock A near the fence with B. It was a still cool night with 1/2 moon. About 4 pademelons were disturbed in paddock A and these appeared to move without difficulty back through the fence. Eight were seen in B. They appeared to go between the wires at 130 to 250 and 250 to 400 mm

Table 6.1

Maximum Number of Pademelons Seen in Each Paddock Using Spotlight and Binoculars at Early Evening Stake-out Counts

Date	Paddock A	Paddock B	Paddock C
Pre-electrification			
July 13	–	32	26
July 14	8	25	–
July 15	–	24	39
July 21	22	18	–
July 22	–	–	22
Post-electrification			
July 28	–	7	6
Aug 30	4	8	6

– = no observations made

from the ground. Six pademelons could be seen in C.

As shown in Table 6.2 the faecal deposit rates were relatively even in each paddock, and no significant change occurred after electrifying the fence.

6.3.3. Discussion

From the spotlight observations some wallabies were still passing through the fences with apparent little difficulty. Faecal deposit rates also showed no significant reduction in pademelon activity.

The outrigger wire around paddock A was considered to be too high to worry the pademelons. There was ample evidence that they were passing under it in several places.

The electrified wires on the outside of posts around paddock C were considered to create a larger actual gap between the wires through which the pademelons may have been passing.

6.4. Stage Two - 10 September, 1982 to 1 September, 1983.

6.4.1. Materials and Methods

The following alterations were made to the fence designs:

Paddock A: The outrigger was lowered from 150 to 70 mm from the ground on the three external sides.

Paddock B: An electrified outrigger was added to the western fence only, adjacent to the bush. This was 150 mm outside the fence line and 75 mm above the ground. The other three sides were unchanged.

Paddock C: The electrified wires on the outside of the fence posts were replaced on the inside of the posts and the lowest wire, 70 mm from the ground, was electrified. The three external sides were changed.

Dung plots were cleared initially at fortnightly intervals and later at monthly intervals and the fence checked on each occasion. The voltage was maintained at more than 4.0 kv during the period.

Table 6.2

Mean Weights (g) ± 1 s.d. of Pademelon Faeces per Plot per Day in Each Paddock During Stage 1

Date of Collection	Paddock A	Paddock B	Paddock C
July 12	0.64 ± 0.32	0.68 ± 0.56	0.59 ± 0.42
July 28	0.73 ± 0.36	1.08 ± 0.74	1.06 ± 0.73
Mean of all plots pre-electrification	0.69 ± 0.33	0.88 ± 0.67	0.82 ± 0.63
Aug 10	0.56 ± 0.35	0.44 ± 0.41	0.53 ± 0.41
Aug 23	0.65 ± 0.44	0.78 ± 0.52	0.63 ± 0.48
Sept 6/10	0.30 ± 0.43	0.66 ± 0.52	0.80 ± 0.66
Mean of all plots post-electrification	0.50 ± 0.43	0.63 ± 0.49	0.65 ± 0.52
t	1.33	1.35	0.94
d.f.	3	3	3
p	n.s.	n.s.	n.s.

Grease was applied to all wires in the fence at strategic places where it appeared that wallabies were passing through the fence. When wallabies pushed their way through the fence hair was left stuck to the appropriate wires on the fence.

6.4.2. Results

Pademelon activity was apparently lowest in paddock A from September to November and in paddock C from then until September 1983. The control area, outside the electrified fences consistently demonstrated the highest activity according to faecal deposit rates (see Table 6.3.).

A well used track became worn on the inside of the fence at the western and southern sides of paddock C by animals trying to find a safe way out (Plate VI).

There was a very low to nil level of runway development under the lowest wire in paddocks B and C during this period, but obviously some pademelons were still passing through the fences.

In places where grease was applied to wires hair was detected on wires 2, 3 and 4 in paddock B., and on wires 2, 3, 4, 5 and 6 in paddock C. The actual spacing between these wires at the points of passage were :-

Paddock B:

between wires 2 and 3 - 100, 115, 120 mm
3 and 4 - 150, 150, 160, 170, 175 mm

Paddock C:

between wires 2 and 3 - 65, 90 mm
3 and 4 - 90, 100, 110 mm
4 and 5 - 95, 95, 115, 120 mm
5 and 6 - 165 mm

6.4.3. Discussion

The low wires at 70 mm from the ground in paddocks B and C did

Plate VI

The electric fence around paddock C during Stage Two showing the track worn by wallabies trying to move out of the paddock.

Table 6.3

Summary of Mean Pademelon Faecal Deposit Rates (g/plot/day) in Each Paddock with Percentage of Total During Stage 2

Date of Collection	Paddock A	Paddock B	Paddock C	Control D
Sept 21	0.12 (6.3)	0.46 (24.2)	0.24 (12.6)	1.08 (56.8)
Oct 6	0.10 (2.8)	0.54 (15.2)	1.00 (28.1)	1.92 (53.9)
Oct 20	0.11 (5.6)	0.43 (21.8)	0.54 (27.4)	0.89 (45.2)
Nov 4	0.02 (1.7)	0.21 (17.5)	0.25 (20.8)	0.72 (60.0)
Nov 19	0.09 (8.0)	0.30 (26.8)	0.19 (17.0)	0.54 (48.2)
Dec 16	0.17 (18.9)	0.19 (21.1)	0.15 (16.7)	0.39 (43.3)
Jan 13	0.24 (22.2)	0.29 (26.8)	0.10 (9.3)	0.45 (41.7)
Feb 9	0.11 (19.0)	0.17 (29.3)	0.03 (5.2)	0.27 (46.5)
Mar 30	0.10 (26.7)	0.13 (21.7)	0.02 (3.3)	0.35 (58.3)
May 19	0.09 (12.0)	0.25 (33.3)	0.03 (4.0)	0.38 (50.7)
Jun 2	0.46 (21.9)	0.47 (22.4)	0.03 (1.4)	1.14 (54.3)
Jun 23	0.25 (15.9)	0.33 (21.0)	0.08 (5.1)	0.91 (58.0)
July 7	0.09 (6.4)	0.41 (29.3)	0.11 (7.9)	0.79 (56.4)
Aug 2	0.21 (16.5)	0.28 (22.0)	0.11 (8.7)	0.67 (52.8)
Sept 1	0.24 (23.5)	0.20 (19.6)	0.07 (6.9)	0.51 (50.0)
Total Mean	0.16 (11.4)	0.31 (22.1)	0.20 (14.2)	0.73 (52.0)

appear to prevent wallabies from passing under the fence, and such a wire does appear to be a necessary factor in a wallaby-proof fence. The well marked runways along the inside of the fence around paddock C indicate that wallabies were having considerable difficulty in making their way back through the fence. From the results of hair sticking to the greasy wire it was concluded that pademelons would easily pass through wire spacings of 100 mm, and that spacings of about 75 mm may be effective. The converted boundary fence around paddock A had spacings between the wires of 90, 120 and 180 mm up to the third wire so was unlikely to be an effective barrier to the pademelons.

These differences in faecal deposit rates between paddocks A, B, and C may be due to the effectiveness of fence designs in preventing access of wallabies, but many other factors may be involved, such as the soil type, drainage, pasture quantity and quality. A low lying wet area at the western end of paddock B contained abundant green grass which other paddocks lacked in summer. This paddock therefore was much more attractive to wallabies. Paddocks A and C were much drier although a water hole in paddock C was attractive to wallabies. The low faecal deposit rate in paddock C is probably, however, a true indication of the effect of the fence in preventing incursions by wallabies, as there was evidence of considerable difficulty in wallabies leaving the paddock.

6.5. Stage Three - 10 September, 1983 to 11 March, 1985.

6.5.1. Materials and Methods

It was considered that major alterations would be necessary to convert the boundary fence around paddock A to prevent incursions by wallabies, so the outrigger was disconnected and this fence acted as an unelectrified control.

The fences enclosing paddock B were completely altered to a configuration of 6 wires at 75 mm spacings. The lowest was within 75 mm of the ground and was earthed. The second, fourth and sixth were electrified (see Figure 6.4.).

Following reports from Victoria of sloping electric fences deterring kangaroos (McCutchan 1983), the fences of paddock C were altered to a configuration of 4 wires on droppers sloping downwards and outwards from 400 mm. The wires were spaced as shown in Figure 6.4., with the second and fourth being electrified.

Further attempts were made to elucidate the method used by wallabies in passing through the fences by mounting two super 8 movie cameras about 2 m from places along the fence where pademelons were suspected of passing through. The cameras were triggered by interrupting an electronic beam, about 2 m long just outside the fence line. The beam and camera were powered by 6 v dry cell batteries. The area was illuminated by two car lights powered by a 12 v car battery. The cameras when automated ran for about 36 frames, with a built in delay of about 3 minutes before resetting. The beams were so placed as to automate the lights and camera as the pademelons were approaching the fence from the bush, and it was hoped to have clear film of them as they passed through, with evidence of the height and method of passage.

To even out some of the differences between paddocks and so to make each paddock equally attractive to wallabies a section at the western end of each paddock was ploughed and sown with Nile oats (100 kg/ha) and topdressed with superphosphate (250 kg/ha) on 16 May. This area was fenced off with cyclone fencing to keep sheep off. Ten dung plots were established to assess the faecal deposit rate on each area.

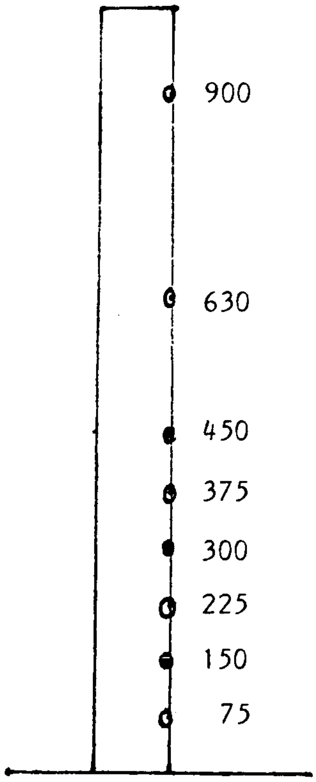
6.5.2. Results

Faecal deposit rates in each paddock on four occasions from July to November 1984 indicate that wallaby activity in paddock B was 50 to 88% of control paddock A, and in paddock C was 24 to 90% of paddock A (Table 6.4.). The apparent effectiveness of the sloping fence improved from 24% in July after an effort was made to block runways under the fence and keep them under control. The apparent effectiveness of the paddock B

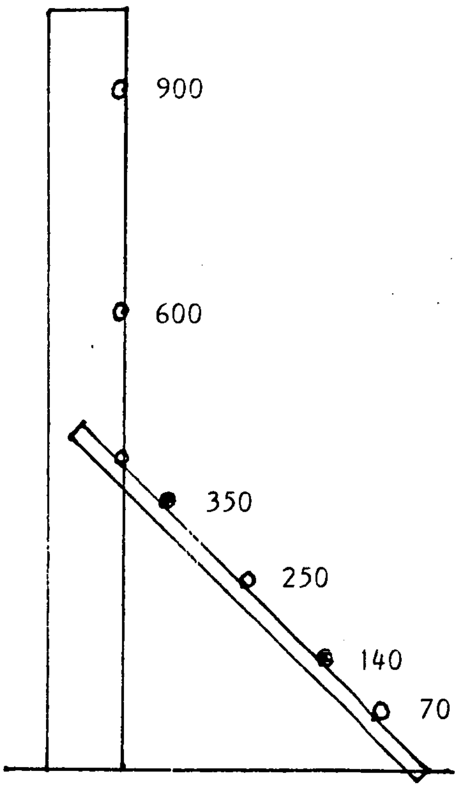
Figure 6.4 Configurations used for fencing paddocks B and C during Stage Three.

● = electrified wire, o = earthed wire.

Wire heights are in mm above ground level.



Paddock B



Paddock C

Table 6.4

Mean Faecal Deposit Rates (g per plot per day) in Each Paddock During Stage 3 Showing Percentage Reduction Compared to Control

Date of Collection	Paddock A	Paddock B	Paddock C
July 11	0.33	0.10 69.7%	0.25 24.2%
August 14	0.17	0.02 88.2%	0.06 64.7%
September 26	0.21	0.03 85.7%	0.02 90.5%
November 15	0.10	0.05 50.0%	0.01 90.0%

fence decreased to 50% when the voltage decreased to 1.1 kv. This voltage reduction was shown to be caused by a shortage through grass growth mainly along the fence between paddocks B and C. The voltage increased following the use of a weed killer (Roundup) along fence lines.

Within the fenced area at the western end where the oats were sown, faecal deposit rates on the 10 plots per paddock were lower on paddocks B and C compared to the control A (see Table 6.5.). In June, July and August the paddock B activity was 43 to 65% less than that of A, and paddock C up to 40% less than A. Wallabies were passing through runways under fence C for some of this time. The figures in Table 6.5. for the March 1985 collection followed a 24 day period in which the voltage remained about 5.0 kv and no active runways were obvious under either fence. Under these conditions at that time the vertical fence gave 53% and the sloping fence gave 46% protection.

Although the cameras were activated on many occasions, no clear pictures of animals passing through the fence were obtained. The wallabies were either deterred by the electric fence or by a fear of the lights or the noise of the camera whirring, as film showed the pademelons quickly turning and bounding away (Plate VII). On two occasions the film showed a small pademelon quickly moving away, without first seeing it approach the fence. These were interpreted as being occasions when the pademelons passed through the fence from within the paddock, and did not automate the equipment until too late.

There was an obvious visual difference in growth of oats inside and outside exclosures, and grazing of oats was obvious in each paddock.

6.5.3. Discussion

The results demonstrate the difficulty in maintaining this type of electric fence so that it retains its effectiveness in preventing the passage of wallabies. Runways are quickly made under the fence if the opportunity allows and are readily used by the wallabies. They must be blocked as soon as they develop, as shown in Plate VIII. The voltage must

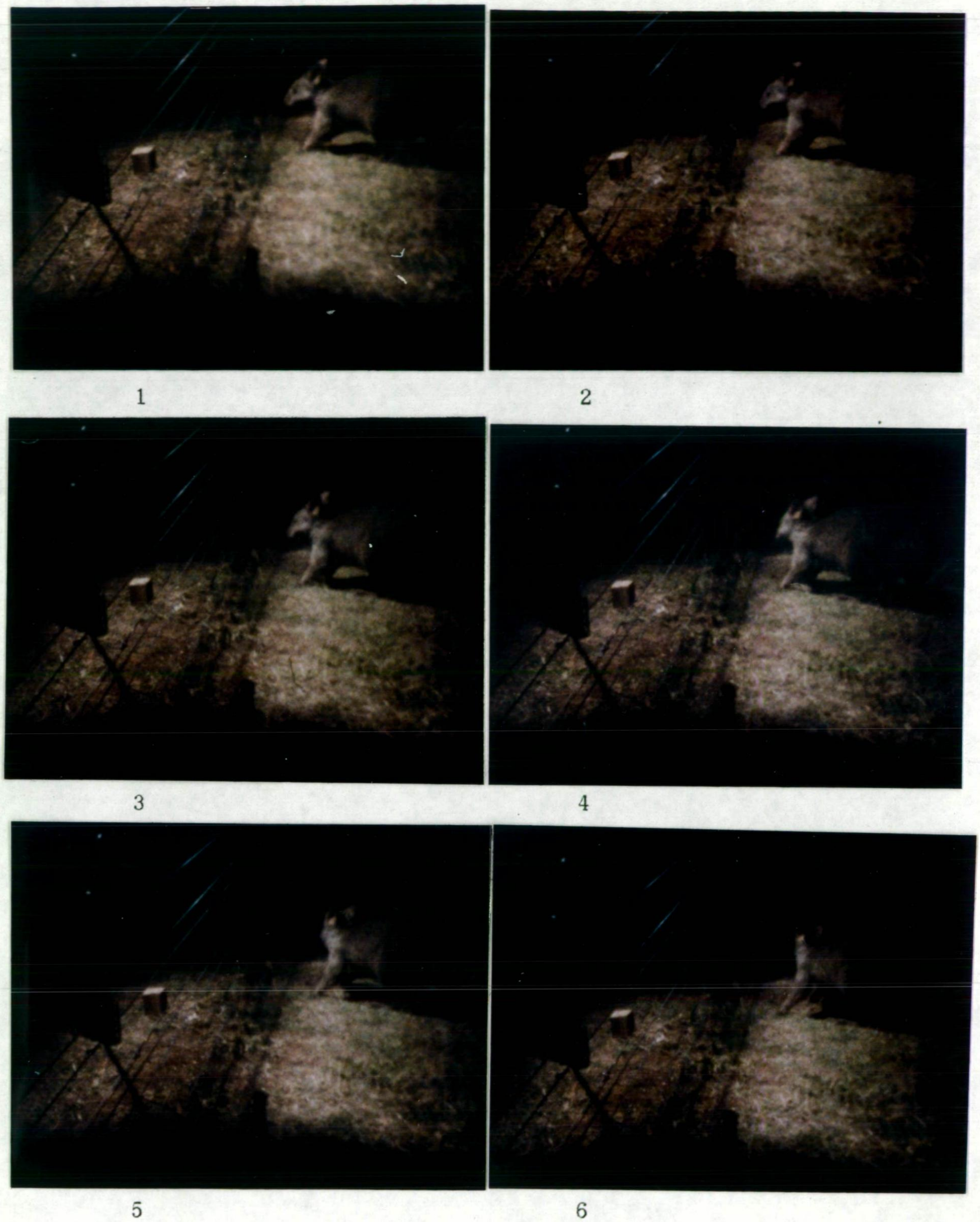


Plate VII

A series of photographs taken from an 8 mm movie showing the reaction of a pademelon to an electric fence.

Table 6.5.

Mean Faecal Deposit Rates (g/plot) ± 1 s.d. in Each Paddock on the Oat Crop During Stage 3, with Percentage Reduction Compared to Control

	Paddock A (Control)	Paddock B (Vertical fence)	Paddock C (Sloping fence)
June 28	7.4 ± 5.2	4.2 ± 3.5 42.9%	4.5 ± 2.2 39.9%
July 24	5.2 ± 3.1	2.4 ± 2.4 54.0%	4.5 ± 2.5 13.3%
August 29	6.6 ± 4.5	2.3 ± 1.5 64.9%	5.0 ± 1.4 23.2%
March 11	19.3 ± 9.4	9.1 ± 5.2 52.8%	10.4 ± 2.6 46.1%

Plate VIII

Wallabies readily develop runways under electric fences. These should be blocked as soon as possible. Logs are used here to block gaps under the sloping fence around paddock C.

also be regularly checked as vegetation can readily cause a leakage of electricity and consequent loss of effectiveness of the fence.

6.6. Discussion and Summary

Two of these fence designs did appear to meet the objectives and stop 80% of wallabies (see Table 6.4.), although later observations showed them to be only about 50% effective (see Table 6.5.).

It is difficult to compare these results with those of Howard (1978), Wright (1978) and Coulson (1981) as they were all dealing with a larger wallaby, probably *M rufogriseus*. It appears that for that species 100 mm spacings are adequate (Howard 1978), but that larger gaps of 110 mm and 150 mm (Coulson 1981) allow the passage of these wallabies.

The importance of selecting trial sites was demonstrated, as differences in the environment within paddocks A, B and C no doubt confounded results. Results would have been biased against the paddock B fence in which a swampy area and its consequent green vegetation was more attractive than the other paddocks. Despite this the fence around paddock B gave a good degree of protection against wallabies and appears to be the design of choice.

Whilst the sloping fence around paddock C also shows some promise, sloping fences as developed for kangaroos by McCutchan (1983) do not appear to have an application for Tasmanian wallabies, as simpler fences are equally effective.

The earlier fence around paddock C as used in stage two obviously gave wallabies some problems, judging by the well worn track inside the fence, and should also be considered to have potential.

The inadequacy of an offset electric wire on a conventional existing fence as found for paddock A in Table 6.2. and Table 6.3. confirmed the results of Coulson (1981). Outriggers also do not appear to be effective. There is no way of simply electrifying an existing stock fence to make it effective in preventing the passage of wallabies. The fence must be purposively built on a graded fence line.

The degree to which wallabies learn how to cope with an electric fence is not known. Wallabies may listen for the pulses and quickly pass through between pulses, although McCutchan (1980) considered that cattle were not able to hear pulses. Wallabies may also be able to use the insulative value of their hair to advantage, and avoid contact of the electric wire with bare areas such as the underside of the tail.

The important factors to consider in designing a wallaby-resistant fence are:

- a level or graded surface without natural depressions in which wallabies can develop runways,
- the lowest wire should be no more than 75 mm from the ground, as wallabies prefer to go under a fence than through it,
- several wires will be required up to about 300 mm with gaps of no more than 75 mm, as pademelons readily pass through spaces of 100 mm,
- although the lowest wire may be electrified more problems can be expected from leakage through vegetation. The second and subsequent alternate wire should be electrified.

Chapter 7

Conclusions

7.1. Economic Effect of Wallabies

Although the investigations reported in Chapter 2 were of short term trials the results of which were extrapolated over the rest of the year, they do show that wallabies eat a significant amount of pasture, thus reducing the income of the farmer. The trials were conducted over the autumn-winter period when there is the greatest demand on available pasture, and therefore are likely to reflect a reasonably accurate measure of the effect of wallabies. The carrying capacity of a property is determined by the number of animals that can be fed during that period. During spring, when pastures are at maximum growth, there is more likely to be plenty of food available for all of the sheep and wallabies. That is, there would be no competition for pasture.

It has been assumed that all pasture eaten by wallabies would be available for livestock and that the farmer could obtain 100% benefit from that pasture. In fact a certain amount can not be eaten, but would be wasted in some way.

Further investigations are urgently needed and are essential to provide an accurate assessment of the economic damage caused by wallabies to pasture and crops. The information required is of the quantity of pasture, converted to livestock equivalents eaten by wallabies at varying distances from the bush/pasture interface. It is needed for the following purposes:-

(i) to respond to concern from animal welfare groups who disapprove of wallaby culling methods,

(ii) to justify the need to cull wallabies in the face of concern from conservation groups who consider that wallabies should be preserved at all costs and should not be subject to culling, and

(iii) to justify the expense of culling methods and in particular the expense of exclusion fencing.

The amount of damage should be related to the wallaby density, which may be affected by many other factors. The density of wallabies on pasture is related to the density in adjacent bush land and the availability of alternative feed. In a good season there may be plenty of ground vegetation within the bush, so that wallabies have less need to venture on to pasture.

Mooney and Johnson (1979) conclude that the number of wallabies grazing pasture is dependent upon the available feed in the paddock. There is also evidence of dissociation between sheep and wallabies (Mooney and Johnson 1979) as reported with sheep and kangaroos (Andrew and Lange 1986). It may be possible to give sheep the first choice of pasture closer to the bush land at strategically important times of the year.

To relate the figure obtained in one trial to other areas would require a comparison of pasture or crop type and the density of wallabies. It would be difficult and expensive to obtain a figure for the cost of damage for all different pasture and crop types used in Tasmania. The effect of wallabies on newly established pasture will probably differ from a well established pasture, as Phillips (1953) reported for rabbits. Initially it should be possible to assess the cost of damage on a recently established ryegrass-clover pasture. This could be readily related to many other new Tasmanian pastures. The wallaby density needs to be ascertained in each case, so there is a need to define a technique for readily assessing an index to the population present.

Another aspect of competition between wallabies and sheep which should receive attention is their selection of different pasture species. The plant species in sheep and wallaby stomachs grazing on the same pasture at varying times of the year should be compared.

7.2. Population Assessment

The preferred method of assessing wallaby populations in these investigations has been by counting the number of faecal pellets or on the oven-dried weights of faeces collected on marked plots. Faecal deposit rates measure the average population size over the period since last clearance of the plots in an undisturbed situation. Spotlight counts vary greatly from night to night, so counts must be made over several nights to obtain a reasonably accurate mean population index. The presence of an observer in the area may disturb the population and interfere with their normal grazing pattern. Other methods of assessing the population of animals in a small area, such as trapping-retrapping or mark-recapture, are too expensive in terms of resources. Faecal deposit rates are considered the best method for the desired accuracy and labour input.

The accuracy of faecal deposit rates is affected by the size, shape and number of plots used and by the rate of decay of faeces. The shape chosen, whether belt or circular, is a personal choice. Factors such as fatigue, boredom, lack of experience or visual skills give observer bias (Neff 1968). Small plots are usually associated with higher estimates as faecal pellets are easier to overlook on larger plots. Belt plots gave a higher estimate than circular plots of the same area (Batcheler 1975). The number of plots used will depend on the accuracy required, as there is considerable variation between plots. For a large area the sampling intensity does not have to be as great as for a smaller area (Smith 1968).

In these investigations 20 x 1 m belt plots have been preferred and are considered to be easy to search. In most cases twenty plots were used, because it was considered that any more would lead to observer boredom and less accuracy.

The faecal deposit rate as measured from dung plots should be corrected for the amount of dung which may have been deposited but since rotted away, been washed away or eaten by various insects since the last clearance of plots. Corrections can be made by assessing decay rates by placing a known number of faecal pellets in a marked position and counting them at the time of surveying. As decay rates of faecal pellets are generally negligible in short term trials no corrections for decay were done in this study. Perry and Braysher (1986) reported negligible decay of kangaroo faecal pellets in the first two months. Fresh pellets may be destroyed by heavy rain but older pellets are resistant. Much decay is due to dung beetle activity, particularly in summer conditions.

The natural variation between monthly faecal deposit rates makes it difficult to assess how much of the difference in pre- and post-poisoning is due to chance variation.

7.3. Poisoning Techniques

Conventional poisoning techniques as developed for poisoning rabbits appear to be satisfactory for the control of pademelons. This infers that chopped carrot is well accepted as bait and that it is readily found by pademelons grazing near the forest edge. Three free-feeds appear to be adequate to attract the majority of the pademelon population to the bait, and the amount of poisoned bait eaten apparently carries a sufficiently high toxic loading of 1080.

The same techniques do not however always produce the same satisfactory mortality rate in Bennett's wallabies. This may be because they do not as readily accept bait provided as an alternative food source, or because they quickly move well into the paddock and so do not graze in the vicinity of the bait line, or because the toxic loading is not sufficient.

The results of these investigations have shown that bran/pollard is the most acceptable alternative bait type, and that field poisonings result in mortality rates similar to those for chopped carrot. It has been demonstrated that placing the bait line in the bush rather than in the paddock, or doubling the toxic loading of 1080 results in no significant difference to the effectiveness of the poisoning. The furrow has no practical effect in attracting wallabies to the bait.

The problem does not appear to be one of bait acceptability, as in field trials both chopped carrot and loose bran/pollard baits have been well accepted. Wallabies have scratched at the ground in search of more bran/pollard baits. These baits may not be as well accepted, however, in the presence of lush pasture, as reported by Mollison (1960b). Bran-pollard pellet bait were not well accepted by wallabies in these investigations despite their acceptance elsewhere (Corr 1971, 1972, Ross and Bell 1979). Corr (1971) reported that commercial stock feed pellets were poorly accepted by rabbits, but that good results were obtained by incorporating molasses in a pellet made from 10 parts pollard to 2 parts bran. Further work in this area appears to be necessary.

According to the results of McIlroy (1982) the LD_{50} of 1080 for Bennett's wallabies is about 0.2 mg/kg and this should be present in 28 g of bait. Mollison (1960a) reported that Bennett's wallabies eat 100 g of bran/pollard bait in 15 minutes and commonly feed on bait for 10 to 15 minutes without pause. If these figure are correct the toxic loading in baits is adequate to obtain high mortality rates from 1080 poisoning of wallabies. It is possible that the sensitivity of Bennett's wallabies living in their natural state may differ from those in captivity, and that a higher toxic loading may be required. No evidence could be demonstrated in field trials to suggest that a higher concentration of 1080 in bait would lead to higher mortalities.

There is no doubt that 1080 is the safest and most effective poison available to use. It is relatively target specific although eutherian carnivores are very sensitive to 1080, and all herbivores have a high susceptibility to the poison. Marsupial carnivores, birds, bandicoots, reptiles and fish have low susceptibility (McIlroy 1986). 1080 has most of the important properties of a safe and effective poison. It is tasteless, humane when used to control herbivores, easy to use and does not persist in the environment. Dogs are, however, most susceptible to accidental 1080 poisoning and are readily killed from eating a poisoned carcase.

The poison routine of three free-feeds followed by the poison feed, all at two day intervals has been the standard routine for poisoning rabbits for many years. Extending the period between free-feeds or the poison feed has been shown not to affect the poisoning as rabbits have a good memory for the bait (Rowley 1957). In Western Australia 1080 is vacuum-impregnated into oats which are mixed with unpoisoned oats and fed as one feed, so that no free-feeding is necessary (Gooding and Harrison 1964). Free-feeding is not used when poisoned baits are spread from the air. In both of these cases one piece of bait carries a toxic dose for the target species. There may be other variations to the poison routine which can be used with advantage for poisoning wallabies. Mooney and Johnson (1979) recorded an 86% reduction in Bennett's wallabies after three poison feeds at intervals of four and six days. Further investigations along this line appear to be warranted.

Low mortalities in rabbit poisoning operations in Western Australia and New Zealand have been thought to be associated with selection for neophobia, a dislike for anything new. It is possible that some rabbits which survive poisoning do so because they will not eat the bait material and that this factor has been genetically selected (Oliver *et al.* 1982, Bell 1975).

Research needs to be conducted to find out whether wallabies which survive a poisoning operation have eaten any bait, and to determine how much bait is eaten by those that are poisoned.

Mooney and Johnson (1979) reported that individuals of a Bennett's wallaby population visit pasture on an average of 52% of nights. If poison is available on one night only it could therefore be expected that only 52% of wallabies are poisoned. Perhaps this percentage is increased by attracting wallabies to the paddock by free-feeding.

It is likely that the presence of wallabies on pasture is a factor of the ratio of pasture land to bush land in the area, and to the amount of feed available in the bush. It has been mentioned that poisoning a small paddock surrounded by a large area of bush is likely to have little effect on the population, either because only a small proportion of the population will be present on the paddock on the night of poisoning, or because there is quick re-colonisation of the area near the pasture.

Another problem which was seen at Royal George and at Palana is that of attempting to protect a crop at some distance from the wallabies' habitat. If wallabies must move over a distance of open ground to reach the crop their movements are likely to be more erratic, and perhaps individuals would feed upon that crop on much less than 52% of nights. To protect such a crop it may be better to place the bait line close to the habitat, rather than, or as well as, near the crop.

7.4. Electric Fencing

The exclusion of wallabies from crops and pastures using electric fencing must be pursued as an option in the protection of crops. The trials described did not reach a conclusion on a recommendation for wallaby exclusion but they did demonstrate that a significant degree of protection can be obtained. Further trials are continuing in the Department of Agriculture initially using a captive population.

Some basic features of a successful electric fence have been elucidated, and previously reported habits of kangaroos and wallabies have been confirmed. Kangaroos or wallabies prefer to pass under a fence or between the lower wires although some may jump over the top especially in daylight. Even when disturbed at night they prefer to pass through the lower levels of the fence. In erecting an electric fence the fence line must be evenly graded so as to leave no depressions where wallabies will be able to dig under. Any runways which do develop under a fence must be quickly blocked.

A fence in Tasmania in most areas will need to exclude both wallaby species. A fence which will stop pademelons will also be effective in excluding Bennett's wallabies. It appears that pademelons can readily pass between wires 100 mm apart and that wire spacings of no more than 75 mm are required, and the lowest wire must be no more than 75 mm from the ground. Six wires at 75 mm intervals should be an effective barrier for most pademelons, but further work is required to assess this. No doubt some will pass through a fence at or above 450 mm above the ground.

With such a configuration the lowest wire at 75 mm above the ground will be susceptible to leakage of electricity through vegetation growth if it were electrified. It is therefore better to have the lowest wire earthed and the second, fourth and sixth electrified.

These investigations have not been able to identify how wallabies pass through an electric fence. Their fur would give some insulation against the electric current, so if they are able to pass between the wires so that the electrified wire contacts only thick fur they may not receive a shock. The susceptible parts of a wallaby are its nose, carpus, tarsus and the underside of its tail. It is probable that wallabies would more easily pass between a lower earthed wire and upper live wire, than over an electrified wire.

Wallabies at times preferred to pass through the fence near the corner post (Frith and Calaby 1969). This may have been due to necessity as they were 'cornered' or because they were able to pass through a short section of the fence, between the post and end insulators which carried no electric wires. It is important that this be as short as possible or extra netting added to block this possibility.

BIBLIOGRAPHY

Andrew, M.H. and Lange, R.T. (1986). The spatial distribution of sympatric populations of kangaroos and sheep: Examples of dissociation between these species. Australian Wildlife Research 13, 367-73.

Anon (1976). Energy Allowances and Feeding Systems. Technical Bulletin 33. Ministry of Agriculture, Fisheries and Food, Great Britain.

Anon (1978). The wild rabbit. Advisory leaflet 534, Ministry of Agriculture, Fisheries and Food, United Kingdom.

Anon (1983). Agricultural Pest Destruction. Report of a review committee, Wellington, New Zealand. 55 pp.

Anon (1984). The status and management of Bennett's wallaby (*Macropus rufogriseus*) and rufous wallaby (*Thylogale billardierii*) in Tasmania. In "Kangaroo Management Programs of the Australian States", Commonwealth of Australia.

Batcheler, C.L. (1975). Development of a distance method for deer census from pellet groups. Journal of Wildlife Management 39, 641-52.

Batcheler, C.L. (1978). Compound 1080, its properties, effectiveness, dangers and use. New Zealand Forest Service, Wellington.

Bell, J. (1975). Search for causes of poison failures. Agricultural Pests Destruction Council Newsletter No. 1, February 1975.

Breckwoldt, R. (1983). Wildlife in the Home Paddock. Angus and Robertson. 348 pp.

Brunner, H. (1983). Bait acceptance by non-target mammal species in simulated rabbit poisoning trials. Australian Wildlife Research 10, 129-38.

Brunner, H. and Browne, C. (1979). Vermin control and hazards to non target species. I Rabbit bait acceptance by birds in a southern Victorian forest. Bird Observer No. 576, 77-8 also Victorian Naturalist 96, 222-8.

Brunner, H. and Coman, B. J. (1983). The ingestion of artificially coloured grain by birds, and its relevance to vertebrate pest control. Australian Wildlife Research 10, 303-10.

Bryant, H., Hone, J. and Nicholls, P. (1984). The acceptance of dyed grain by feral pigs and birds. I. Birds. Australian Wildlife Research 11, 509-16.

Calaby, J.H. (1983). Red-necked Wallaby. In "The Australian Museum Complete Book of Australian Mammals". R Strahan Ed. pp 239-41. Angus and Robertson.

Carrick, R. (1957). What is the best free-feeding system for furrow poisoning the rabbit? CSIRO Wildlife Research 2, 78-84.

Catt, D. (1976). Breeding biology of Bennett's or the red-necked wallaby in South Canterbury. Proceedings of the New Zealand Ecological Society 23, 122-3.

Chippendale, G. (1962). Botanical examinations of kangaroo stomach contents and cattle rumen contents. Australian Journal of Science 25, 21.

Corr, P.V. (1971). The acceptability and effectiveness of pellet baits for poisoning rabbits. Australian Journal of Experimental Agriculture and Animal Husbandry 11, 407-14

Corr, P.V. (1972). Pellet baits for rabbit poisoning. General information and use in the field. Pamphlet No. 26a, Vermin and Noxious Weeds Destruction Board, Department of Crown Lands and Survey, Victoria.

Coulson, G.M. (1981). A preliminary appraisal of electric fencing for wallaby control in Tasmania. Project Report 1980/2, Centre for Environmental Studies, University of Tasmania.

Coulson, G.M. and Raines, J.A. (1985). Methods for small-scale surveys of grey kangaroo populations. Australian Wildlife Research 12, 119-25.

Department of Agriculture, Tasmania (1960). Control of Bennett's wallaby and the rufous breasted wallaby by poisoning. Proceedings of the Vermin Control Conference, Hobart. CSIRO, Melbourne.

Douglas, G.W. (1959a). Aerial poisoning of rabbits and its development in Australia. The Rabbit Problem in Australia. CSIRO, Melbourne, pp 93-102.

Douglas, G.W. (1959b). Rabbit control by aerial baiting: effective new method. Journal of the Department of Agriculture, Victoria 57, 145-53.

Douglas, G.W., Woodfield, B.R.G. and Tighe, F.G. (1959). 1080 poison: A major weapon in rabbit control. Journal of the Department of Agriculture, Victoria 57, 279-327.

Eberhardt, L.L. (1978). Transect methods for population studies. Journal of Wildlife Management 42, 1-31.

Elgie, H.J. (1961). Wallaby eradication by aerial poisoning. New Zealand Journal of Agriculture 102, 25-31.

Ellis, B.A., Russell, E.M., Dawson, T.J. and Harrop, C.J.F. (1977). Seasonal changes in diet preferences of free-ranging red kangaroos, euros and sheep in western New South Wales. Australian Wildlife Research 4, 127-44.

Farrow, E.P. (1917). On the biology of the vegetation of Breckland. III. General effects of rabbits on vegetation. Journal of Ecology 5, 1-18.

Fennessy, B.V. (1966). The impact of wildlife species on sheep production in Australia. Proceedings of the Australian Society of Animal Production 6, 148-153.

Foran, B.D., Low, W.A. and Strong, B.W. (1985). The response of rabbit populations and vegetation to rabbit control on a calcareous shrubby grassland in central Australia. Australian Wildlife Research 12, 237-47.

Frith, H.J. and Calaby, J.H. (1969). Kangaroos. F.W. Cheshire, Melbourne. 209 pp.

Frith, H.J. (1973). Wildlife Conservation. Angus and Robertson, Sydney. 414 pp.

Gates, C.E. (1969). Simulation study of estimators for the line transect sampling method. Biometrics 25, 317-28.

Gooding, C.D. (1955). Rabbit damage to pasture. Journal of Department of Agriculture, Western Australia 4, 753.

Gooding, C.D. (1963). Wallaby control in the Kimberleys. Journal of Department of Agriculture, Western Australia 4, 611-13.

Gooding, C.D. and Harrison, L.A. (1964). "One-shot" baiting - how it works. Journal of Department of Agriculture, Western Australia 5, 12-5.

Gould, J. (1863). The Mammals of Australia. Volume II. Reprinted as Kangaroos (1973) with modern commentaries by Joan M. Dixon. Macmillan, Australia.

Green, R.H. (1973). The Mammals of Tasmania. R.H. Green, Launceston. 74 pp.

Griffiths, M. and Barker, R. (1966). The plants eaten by sheep and kangaroos grazing together in a paddock in south-western Queensland. CSIRO Wildlife Research 11, 145-167.

Hayne, D.W. (1949). An examination of the strip census method for estimating animal populations. Journal of Wildlife Management 13, 145-157.

Hone, J. and Atkinson, W. (1983). Evaluation of fencing to control feral pig movement. Australian Wildlife Research 10, 499-505.

Hone, J., Bryant, H., Nicholls, P., Atkinson, W. and Kleba, R. (1985). The acceptance of dyed grain by feral pigs and birds. III. Comparison of intakes of dyed and undyed grain by feral pigs and birds in pig-proof paddocks. Australian Wildlife Research 12, 447-54.

Howard, K.F. (1978). Electric fence controls wallabies. Queensland Agricultural Journal 104, 237-8.

Hume, I.D. (1977). Production of volatile fatty acids in two species of wallaby and in sheep. Comparative Biochemistry and Physiology 56A, 299-304.

Jarman, P.J., Johnson, C.N., Southwell C.J. and Stuart-Dick, R. (1987). Macropod studies at Wallaby Creek. I. The area and the animals. Australian Wildlife Research 14, 1-14.

Johnson, C.N. (1987). Macropod studies at Wallaby Creek. IV. Home range and movements of the red-necked wallaby. Australian Wildlife Research 14, 125-32.

Johnson, C.N., Jarman, P.J. and Southwell, C.J. (1987). Macropod studies at Wallaby Creek. V. Patterns of defaecation by eastern grey kangaroos and red-necked wallabies. Australian Wildlife Research 14, 133-8.

Johnson, C.N. and Jarman, P.J. (1987). Macropod studies at Wallaby Creek. VI. A validation of the use of dung-pellet counts for measuring absolute densities of populations of macropodids. Australian Wildlife Research 14, 139-45.

Johnson, K.A. (1976). Aspects of macropod problems on the Dorrigo Plateau. In "Proceedings of a Workshop on Agriculture, Forestry and Wildlife: Conflict or Coexistence?". University of New England, Armidale.

Johnson, K.A. (1977). Methods for the census of wallaby and possum in Tasmania. Wildlife Division Technical Report No. 77/2, National Parks and Wildlife Service, Tasmania.

Johnson, K.A. (1978). Methods for the census of wallaby and possum in Tasmania. Wildlife Division, National Parks and Wildlife Service, Tasmania.

Johnson, K.A. (1980). Spatial and temporal use of habitat by the red-necked pademelon, *Thylogale thetis* (Marsupialia: Macropodidae). Australian Wildlife Research 7, 157-66.

Johnson, K.A. and Rose, R. (1983). Tasmanian pademelon, *Thylogale billardierii*. In "The Australian Museum Complete Book of Australian Mammals". R. Strahan Ed. p. 226. Angus and Robertson, Sydney.

Kalmbach, E.R. and Welch, J.F. (1946). Coloured rodent baits and their value in safeguarding birds. Journal of Wildlife Management 10, 353-60.

Kirkpatrick, T.N. (1965). Grey kangaroos being studied. Queensland Agricultural Journal 91, 454.

Lazarus, M. (1956). The toxicity and relative acceptability of some poisons to the wild rabbit, *Oryctolagus cuniculus* (L.). CSIRO Wildlife Research 1, 96-100.

McCann, J.C. (1976). Agriculture, forestry and wildlife in the upper Clarence Region of New South Wales with particular reference to macropods and the edge effect. In "Proceedings of a Workshop on Agriculture, Forestry and Wildlife: Conflict or Co-existence?" University of New England.

McCutchan, J. (1980). Electric Fence Design Principles. Electrical Engineering Department, University of Melbourne. 460 pp.

McCutchan J. (1983). A pivoted electric fence for kangaroos. Unpublished report.

McIlroy, J.C. (1982). The sensitivity of Australian animals to 1080 poison. III. Marsupial and eutherian herbivores. Australian Wildlife Research 9, 487-503.

McIlroy, J.C. (1986). The sensitivity of Australian animals to 1080 poison. IX. Comparisons between the major groups of animals, and the potential danger non-target species face from 1080-poisoning campaigns. Australian Wildlife Research 13, 39-48.

Meldrum, G.K., Bignell, J.T. and Rowley, I. (1957). The use of sodium fluoroacetate (compound 1080) for the control of the rabbit in Tasmania. Australian Veterinary Journal 33, 186-96.

Mollison, B. (1960a). Progress report on the ecology and control of marsupials in the Florentine Valley. APPITA 14, 21-7.

Mollison, B. (1960b). A study of the biology, ecology and control of marsupials in a temperate rain-forest environment. CSIRO unpublished reports.

Mooney, N.J. and Johnson, K.A. (1979). Methods for the census of wallaby and possum in Tasmania. Wildlife Division, National Parks and Wildlife Service, Tasmania.

Myers, K. and Poole, W.E. (1963). A study of the biology of the wild rabbit, *Oryctolagus cuniculus* (L.), in confined populations. IV. The effect of rabbit grazing on sown pasture. Journal of Ecology 51, 435-451.

Neff, D.J. (1968). The pellet-group count technique for big game trend, census and distribution: A review. Journal of Wildlife Management 32, 597-614.

Nelson, P.C. (1982). "Live wire" controls for vertebrate pests. New Zealand Journal of Agriculture 144, 18-20.

Newsome, A.E. (1971). Competition between wildlife and domestic livestock. Australian Veterinary Journal 47, 577-86.

Oliver, A.J., Wheeler, S.H. and Gooding, C.D. (1982). Field evaluation of 1080 and pindone oat bait, and the possible decline in effectiveness of poison baiting for the control of the rabbit, *Oryctolagus cuniculus*. Australian Wildlife Research 9, 125-34.

Perry, R.J. and Braysher, M.L. (1986). A technique for estimating the numbers of eastern grey kangaroos, *Macropus giganteus*, grazing a given area of pasture. Australian Wildlife Research 13, 335-8.

Phillips, W.M. (1953). The effect of rabbit grazing on a reseeded pasture. Journal of the British Grassland Society 8, 169-81.

Poole, W.E. (1963a). Field enclosure experiments on the techniques of poisoning the rabbit, *Oryctolagus cuniculus* (L.). II. A study of territorial behaviour and the use of bait stations. CSIRO Wildlife Research 8, 28-35.

Poole, W.E. (1963b). Field enclosure experiments on the technique of poisoning the rabbit, *Oryctolagus cuniculus* (L.). III. A study of territorial behaviour and furrow poisoning. CSIRO Wildlife Research 8, 36-51.

Rammell, C.G. and Fleming, P.A. (1978). Compound 1080. Properties and Use of Sodium Monofluoroacetate in New Zealand. Animal Health Division, Ministry of Agriculture and Fisheries, Wellington, New Zealand.

Rathore, A.K. (1985). Influence of 1080 bait colour on acceptability by target species and removal by non-target animals. Australian Rangeland Journal 7, 140-2.

Reid, P.A. (1953). Some economic results of myxomatosis. Quarterly Review of Agricultural Economics 6, 93-4.

Ride, W.D.L. (1970). A Guide to the Native Mammals of Australia. Oxford University Press. 249 pp.

Rolls, E.C. (1969). They All Ran Wild. Angus and Robertson. 444 pp.

Rose, R.W. and McCartney, D.J. (1982a). Reproduction of the red-bellied pademelon, *Thylogale billardierii* (Marsupialia). Australian Wildlife Research 9, 27-32.

Rose, R.W. and McCartney, D.J. (1982b). Growth of the red-bellied pademelon, *Thylogale billardierii*, and age estimation of pouch young. Australian Wildlife Research 9, 33-8.

Ross, W.D. and Bell, J. (1979). A field study on preference for pollard and bran pellets by wild rabbits. New Zealand Journal of Experimental Agriculture 7, 95-7.

Rowley, I. (1957). Field enclosure experiments on the techniques of poisoning the rabbit, *Oryctolagus cuniculus* (L.). I. A study of total daily take of bait during free feeding. CSIRO Wildlife Research 2, 5-18.

Rowley, I. (1958). Behaviour of a natural rabbit population poisoned with 1080. CSIRO Wildlife Research 3, 32-9.

Rowley, I. (1959). Bait size for rabbits. CSIRO Wildlife Research 4, 27-30.

Rowley, I. (1960). The effect of concentration on the ingestion of "1080"-poisoned baits by the rabbit. CSIRO Wildlife Research 5, 126-33.

Rowley, I. (1963a). Bait materials for poisoning rabbits. I. Studies on the acceptance of bait materials by caged rabbits. CSIRO Wildlife

Research 8, 56-61.

Rowley, I. (1963b). Bait materials for poisoning rabbits. II. A field study on the acceptance of carrots and oats by wild populations of rabbits. CSIRO Wildlife Research 8, 62-77.

RSPCA Australia (1987). Incidence of cruelty to wallabies in commercial and non-commercial operations in Tasmania. Report to ANPWS, May 1987.

Russell E.M. (1974). The biology of kangaroos. Mammalian Review 4, 1-59.

Short, J. (1987). Factors affecting the food intake of rangelands herbivores. In "Kangaroos; their ecology and management in the sheep rangelands of Australia." Eds. G. Caughley, N. Shepherd and J. Short, Cambridge University Press. 253 pp.

Smith, R.H. (1968). A comparison of several sizes of circular plots for estimating deer pellet-group density. Journal of Wildlife Management 32, 585-91.

Southwell, C.J. (1987). Macropod studies at Wallaby Creek. II. Density and distribution of macropod species in relation to environmental variables. Australian Wildlife Research 14, 15-23.

Statham, H.L. (1983). Browsing damage in Tasmanian forest areas and effects of 1080 poisoning. Bulletin No. 7, Forestry Commission, Tasmania.

Tandy, M.J.B. (1976). The effect of wallabies on pasture. Department of Agriculture, Tasmania, unpublished records.

Thomas, A.S. (1960). Changes in vegetation since the advent of myxomatosis. Journal of Ecology 48, 287-306.

Thompson, H.V. (1951). Rabbits and other rodents. Annals of Applied Biology 38, 725-7.

Thompson, H.V. (1953). The grazing behaviour of the wild rabbit. *Oryctolagus cuniculus* (L.). British Journal of Animal Behaviour 1, 16-9.

Tomlinson, A.R., Gooding, C.D. and Harrison, L.A. (1954). The wallaby menace in the Kimberleys. Journal of Agriculture, Western Australia 3, 609-617.

Webb, W.L. (1942). Notes on a method for censusing snowshoe hare populations. Journal of Wildlife Management 6, 67-9.

Wright, G.N. (1978). Electric hopper stopper. Queensland Agricultural Journal 104, 348-50.