THE DISTRIBUTION, ECOLOGY AND CONSERVATION OF THE SOUTHERN BROWN BANDICOOT (*Isoodon obesulus obesulus*) IN SOUTH AUSTRALIA

by

David James Paull
BA (Hons)

A thesis submitted for the degree of Master of Arts in Geography
University of Adelaide
July, 1992

Awarded 1993

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study investigated the distribution, ecology and conservation of the Southern Brown Bandicoot (*Isoodon obesulus obesulus*) in South Australia. Until now, virtually no information has been available on this species in this state, although *I. obesulus* has been the subject of field studies in Tasmania and Victoria.

The historical distribution of *I. o. obesulus* was determined by collating all available records of this species' occurrence in South Australia. Current distribution was then assessed by conducting extensive field surveys to locate sites which were being actively used by bandicoots. Trapping was conducted at 188 sites and ecological data was collected on aspects of: nesting and shelter requirements; diet; habitat selection; reproduction; and population structure. Radio-telemety was used to examine home range and movement patterns. Finally, an assessment was made of this species' conservation status and conservation requirements, based on an understanding of its distribution and ecology.

I. o. obesulus still occurs in the Mount Lofty Ranges, in the South East of the State and on Kangaroo Island but it has a very patchy distribution within its former range. A wide range of vegetation types are utilised by this species, with stringybark forests and woodlands being the most common communities. Moderately dense ground layer vegetation is preferred, as it offers protection from predators. *I. o. obesulus* can breed throughout the year in South Australia, with most births occurring in winter and spring. A high reproductive potential enables *I. o. obesulus* to reproduce rapidly when environmental conditions are favourable.

While seven bandicoot species have become extinct in South Australia this century, *I. o. obesulus* has managed to survive by being a dietary and habitat generalist, adapted to living in unpredictable environments. Feral predators, habitat fragmentation and fire all threaten the survival of this species in this State. Despite these threats, *I. o. obesulus* is not considered to be in danger of extinction.

DECLARATION

I hereby declare that none of the material in this thesis has been accepted for the award of any other degree or diploma in any institution and that, to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference has been made in the text of the thesis. I consent to this thesis being made available for photocopying and loan, if applicable, and if it is accepted for the award of the degree.

David James Paull (BA Hons)

ACKNOWLEDGEMENTS

I would like to express my gratitude to all those people who helped me research and produce this thesis. Many individuals who made small contributions to this study can not be mentioned here for the lack of space, but I am particularly indebted to:

The National Parks and Wildlife Service for funding the Mount Lofty Ranges field survey, for lending radio-telemetry equipment, for providing permits to conduct this research and for allowing access to various reserves;

World Wildlife Fund Australia for funding the South East and Kangaroo Island field surveys;

The Woods and Forest Department for providing accomodation at Penola Forest and Second Valley Forest, for allowing access to various reserves and for supplying unpublished wildlife survey data;

The South Australian Museum for lending traps, assisting with invertebrate identification and for supplying bandicoot occurrence records;

The Field Naturalists' Society of South Australia Mammal Club for supplying unpublished wildlife survey records;

Dr Sandra Taylor and Dr Catherine Kemper for their supervision;

Dr Tony Robinson, Mr Peter Copley, Mr Peter Canty, Mr Lindsay Best and Mr Brian Gepp for their comments, criticisms and guidance;

Mr Lee Belbin for an introduction to PATN;

Mr Tim Keynes for providing traps;

Ms Juliet Davies for assisting with field work and plant identification;

The University of Adelaide Department of Geography and The Australian Defence Force Academy Department of Geography and Oceanography for supporting the production of this thesis;

Dr Greg Gordon (Qld NPWS), Dr Catherine Kemper (South Australian Museum), Mr Tony Herbert (University of Adelaide), Mr Chris Baxter and Mr Terry Dennis (SA NPWS), Mr Fred Aslin (c/- Mt Gambier), Warrawong Sanctuary (Mylor, SA) and the management of the Millicent Golf Course whose personal communications are cited in this thesis; and

Numerous individuals who shared their knowledge of bandicoots and allowed me to work on their private properties.

CHAPTER 1

INTRODUCTION

1.1 Bandicoot Species in South Australia

Between 1893 and the early 1930s the Eastern Barred Bandicoot (*Perameles gunnii*), the Western Barred Bandicoot (*Perameles bougainville*), the Desert Bandicoot (*Perameles eremiana*), the Golden Bandicoot (*Isoodon auratus*), the Pig-footed Bandicoot (*Chaeropus ecaudatus*), the Lesser Bilby (*Macrotis leucura*) and the Bilby (*Macrotis lagotis*) all vanished from South Australia (Kemper, 1990). Three of these species (*C. ecaudatus*, *P. eremiana* and *M. leucura*) are now entirely extinct, while the other four only survive in other states, in diminished ranges and on island refuges (Figure 1.1). Many theories account for this tragic decline (Kemper, 1990). Nearly all of these blame the impacts of European settlement, such as the introduction of exotic competitors, widespread vegetation clearance and changes to pre-existing fire regimes. Yet, despite these compounding factors, one bandicoot species, the Southern Brown Bandicoot (*Isoodon obesulus*), has shown remarkable resilience and still persists in South Australia.

1.2 General Description of *Isoodon obesulus*

Jones (1924) described *Isoodon obesulus* as a compact and robust marsupial with a crisp hairy coat (Figure 1.2a). At a distance the pelage appears to be brown but on closer examination it is flecked all over with a very fine grizzle of black spiny bristle hairs and soft short yellow underfur. The inner sides of the limbs and the ventral surface are paler,

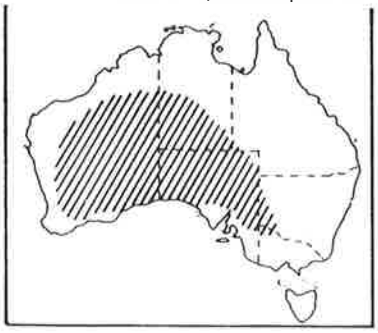
FIGURE 1.1

Distribution of South Australian Bandicoots

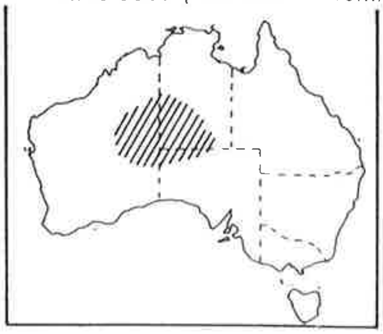
Source

Seebeck *et al.* (1990)

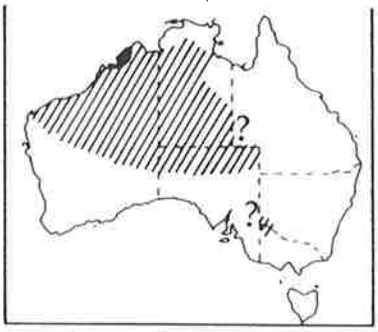
Pig-footed Bandicoot *(Chaeropus ecaudatus)*



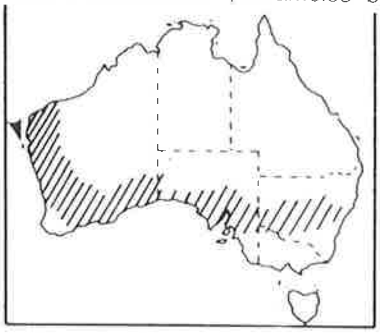
Desert Bandicoot *(Perameles eremiana)*



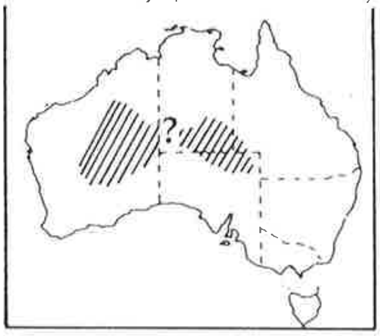
Golden Bandicoot *(Isoodon auratus)*



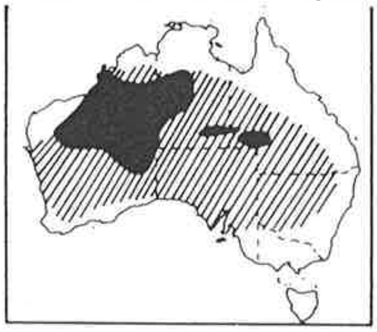
Western Barred Bandicoot *(Perameles bougainville)*



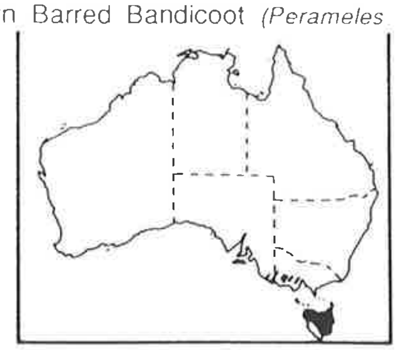
Lesser Bilby *(Macrotis leucura)*



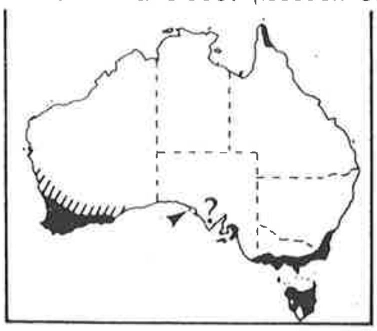
Greater Bilby *(Macrotis lagotis)*



Eastern Barred Bandicoot *(Perameles gunnii)*



Southern Brown Bandicoot *(Isoodon obesulus)*



<u>Notes</u>

Shaded areas indicate species' present ranges.

Hatched areas indicate where species' ranges have apparently contracted since European settlement.

? = Extent of distribution uncertain.

➤ = Island population.

FIGURE 1.2

Illustrations of *Isoodon*

Notes

1.2a An adult male *Isoodon obesulus obesulus*

1.2b Left manus and pes of *Isoodon obesulus nauticus*

Source

Jones (1924)

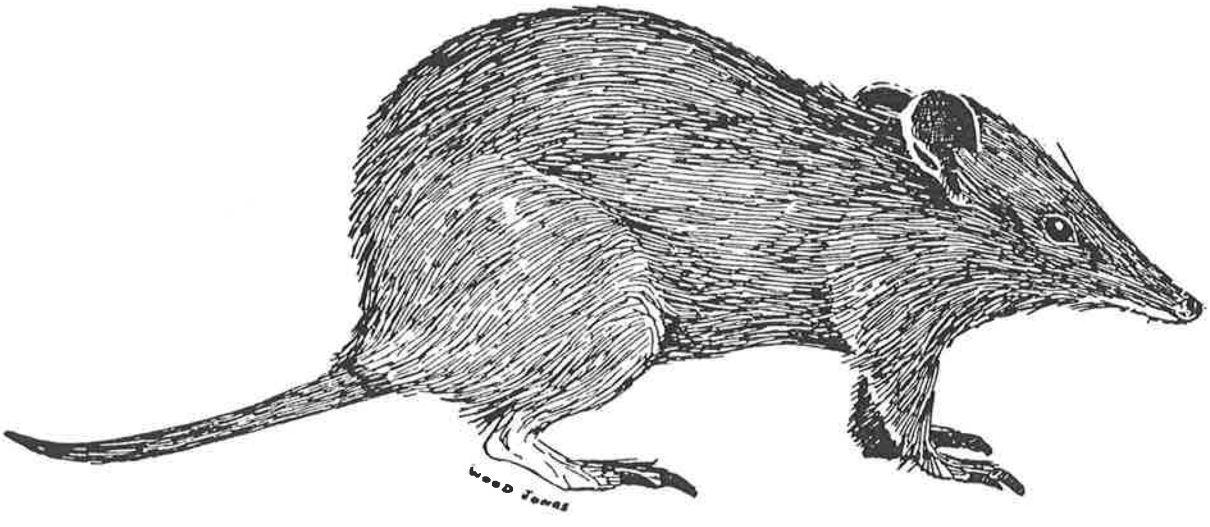


Figure 1.2a

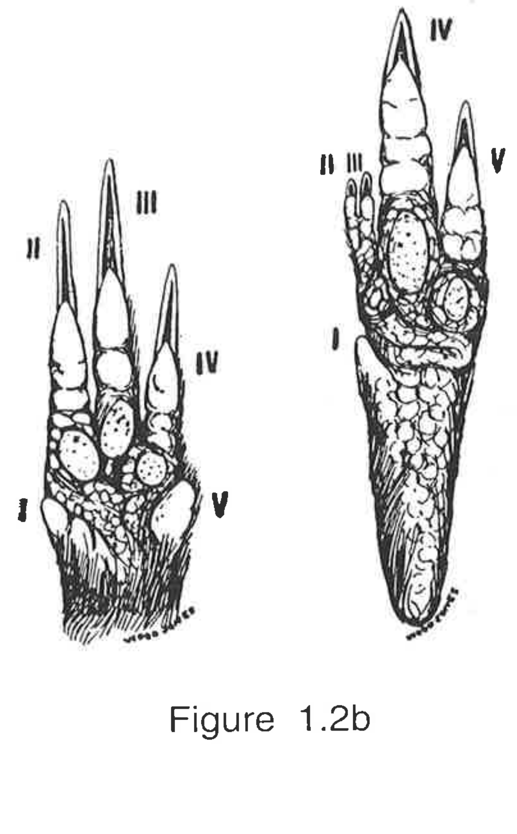


Figure 1.2b

being as a rule yellowish grey (Jones, 1924). The muzzle is elongated into a snout, the rhinarium is naked and the vibrissae are well developed. Ears are small and rounded, eyes are black and the tail is comparatively short (Jones, 1924).

I. obesulus is sexually dimorphic, with males weighing 19% (Heinsohn, 1966) to 30% (Stoddart and Braithwaite, 1979) more than females. On average adult male *I. obesulus* weigh 850 g (range 500 to 1600 g) and adult females weigh 700 g (range 400 to 1100 g) (Braithwaite, 1983).

The forelegs of *I. obesulus* are shortened relative to the hindlegs and their thickset design and strong flattened foreclaws are well adapted for digging (Gordon and Hulbert, 1989). Their hindfeet display a syndactylous fusion of the second and third digits (Figure 1.2b) which is typically characteristic of the herbivorous marsupials (Macropodidae). However, bandicoots possess polyprotodont dentition (dental formula: I 5/3, C 1/1, P 3/3, M 4/4) which is a characteristic of the carnivorous and insectivorous marsupials (Dasyuridae). Quin (1985) considered that the intermediate nature of these two anatomical structures reflects the omnivorous dietary habits of bandicoots.

1.3 The Distribution of *Isoodon obesulus* in Australia

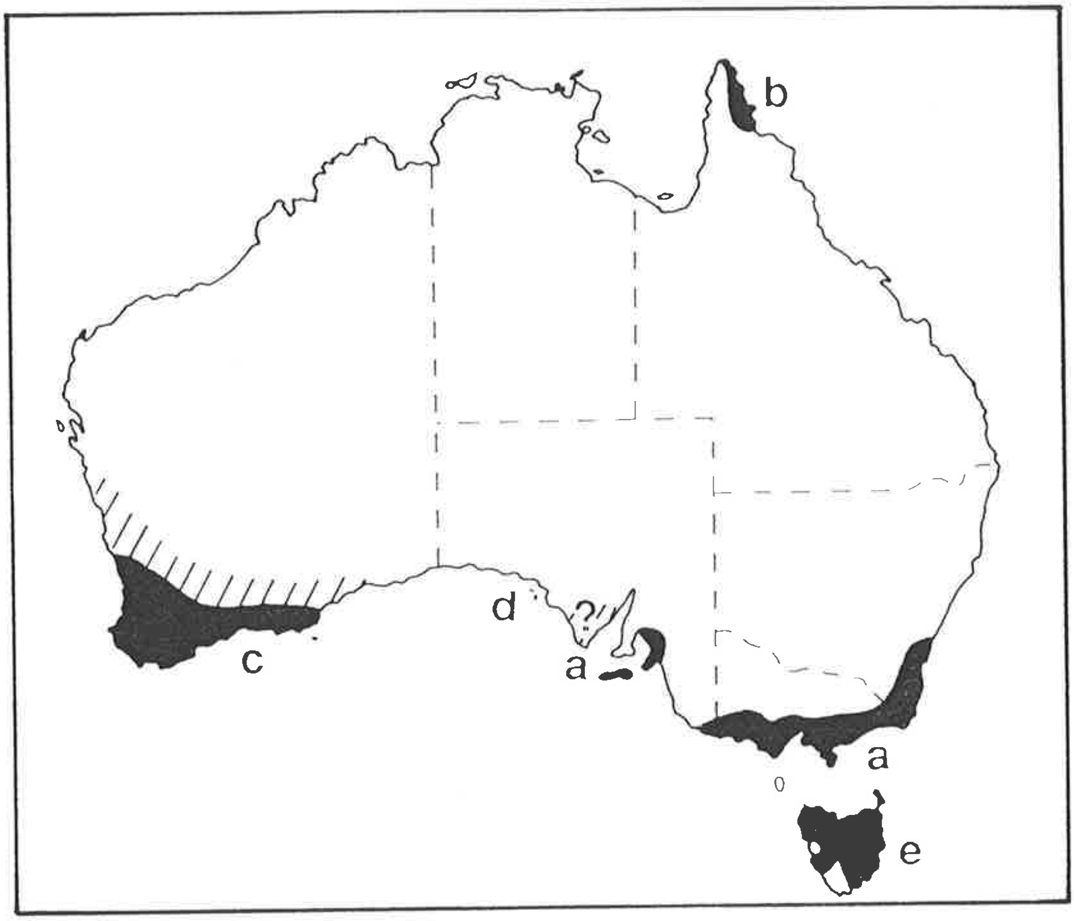
I. obesulus occurs over a widespread but discontinuous range in southern and eastern Australia (Figure 1.3). The eastern race *I. obesulus obesulus* is found in southern South Australia, southern Victoria and eastern New South Wales, south of the Hawkesbury River (Dixon, 1978; Gordon and Hulbert, 1989). Other populations are found in south western Western

FIGURE 1.3

Distribution of *I. obesulus* in Australia

Source

Seebeck *et al.* (1990)



Notes

Shaded areas indicate species' present range.

Hatched areas indicate where species' range has apparently contracted since European settlement.

? = Extent of distribution uncertain.

a = *I. o. obesulus*

b = *I. o. peninsulae*

c = *I. o. fusciventer*

d = *I. o. nauticus*

e = *I. o. affinis*

Australia (*I. obesulus fusciventer*), on South Australia's Nuyt's Archipelago (*I. obesulus nauticus*), in Tasmania (*I. obesulus affinis*) and on Queensland's Cape York Peninsula (*I. obesulus peninsulae*) (Aitken, 1979; Braithwaite, 1983; Collins,1973; Harrison, 1962; Ride, 1970).

There is some uncertainty about the accuracy of these taxonomic groupings. Braithwaite (1983) noted that *I. o. affinis* may not be a valid subspecies, while Gordon and Hulbert (1989) considered that *I. o. peninsulae* may be interpreted as part of the Golden Bandicoot (*Isoodon auratus*) group, which is sympatric with the Northern Brown Bandicoot (*Isoodon macrourus*) in the Kimberleys. Jones (1924), Troughton, (1973) and Lyne and Mort (1981) viewed *I. o. peninsulae* and *I. o. nauticus* as distinct species from *I. obesulus*. Close *et al.* (1990) conducted electrophoretic and chromosome surveys of *Isoodon* and found divisions between *I. obesulus* from south eastern Australia and *I. obesulus* from Western Australia. In this study, *I. o. obesulus* from New South Wales and Victoria were found to be electrophoretically similar to *I. o. affinis* from Tasmania; *I. o. obesulus* from the Mount Lofty Ranges in South Australia aligned with *I. o. fusciventer* from Western Australia and with *I. o. nauticus* from Nuyt's Archipelago; and *I. o. peninsulae* emerged as the most distinct taxon (Close *et al.*, 1990). Affinities were also shown to exist between *I. auratus barrowensis* (a sub-species of the Golden Bandicoot which is found only on Barrow Island, Western Australia) and *I. o. obesulus* from south eastern Australia (Close *et al.*, 1990).

1.4 Aims of the Present Study

Previous bandicoot research in South Australia has focussed on the Nuyt's Archipelago Bandicoot (*I. o. nauticus*), a small insular form of the Southern Brown Bandicoot, found only on Saint Francis Island and the Franklin Islands in the Great Australian Bight (Figure 1.3). This species is abundant on East and West Franklin Islands where approximately 1,000 animals occupy a total area of 240 ha (Copley *et al.*, 1990), but it is considered to be rare on St Francis Island (Jones, 1924; Kemper, 1990). *I. o. nauticus* is totally protected within the Nuyt's Archipelago Conservation Park but Kemper (1990) stressed that these island populations are particularly vulnerable because of their extremely restricted distribution.

In comparison little is known about *I. o. obesulus* in South Australia. Kemper (1990) described the historical occurrence of *I. o. obesulus* in South Australia, by collating museum specimen collection records, literature records and some limited anecdotal evidence. However, this study provided little information on the current distribution of this species, or on the specific localities at which it still occurs. Therefore, the initial aim of the present study was to examine the distribution of *I. o. obesulus* in South Australia by mapping the location of existing bandicoot colonies and comparing this with the historical occurrence of this species.

The ecology of *I. obesulus* has been the subject of a number of field studies but most of these have been conducted in Tasmania on *I. o. affinis* (Guiler, 1958; Heinsohn, 1966; Maloney, 1982; Quin, 1985) and in Victoria on *I. o. obesulus* (Braithwaite and Gullan, 1978; Lobert, 1985; Lobert and Lee, 1990; Stoddart and Braithwaite, 1979). In South Australia the ecology of *I. o. nauticus* has been described by Watts (1974) and Copley *et al.* (1990), but the ecology of *I. o. obesulus* has never been closely examined. Therefore, the second aim of the present study was to describe the ecology of *I. o. obesulus* in South Australia by reviewing relevant literature and by conducting field surveys.

In the past the conservation of *I. o. obesulus* has been largely ignored in South Australia, although concern over this species' increasing rarity has been voiced for many years. While Krefft (1865) considered *I. o. obesulus* to be the most common bandicoot inhabiting southern Australia, Jones (1924, p 140) observed that "this once familiar little animal [*I. o. obesulus*] is now extremely rare in South Australia." Therefore, the final aim of the present study was to evaluate the conservation status and conservation requirements of *I. o. obesulus* in South Australia, based on an understanding of its distribution and ecology.

In summary, the aims of the present study were to:

1. examine the distribution of *I. o. obesulus* in South Australia;

2. describe the ecology of *I. o. obesulus* in South Australia; and

3. evaluate the conservation status and conservation requirements of *I. o. obesulus* in South Australia.

CHAPTER 2

THE DISTRIBUTION OF *Isoodon obesulus obesulus* IN SOUTH AUSTRALIA

2.1 Introduction

I. o. obesulus has a patchy distribution in South Australia (Kemper, 1990). In the past century, bandicoots have been recorded from the South East of South Australia, the Mount Lofty Ranges, Kangaroo Island, the Eyre Peninsula and the Yorke Peninsula (Figure 2.1). However, the current distribution and status of bandicoots within each of these regions is poorly understood.

Aitken (1983) felt that the future of bandicoots in the South East was seriously threatened as they were not known to occur in any Conservation Parks and the few forestry reserves which they inhabited were being degraded by frequent burning. Kemper (1990) felt that, since Aitken's (1983) study, the Ash Wednesday bushfires in February 1983 may have caused more local extinctions in this region. Large areas of the Mount Lofty Ranges were also burnt on Ash Wednesday, and Thompson *et al.* (1989) recorded the local extinction of one bandicoot colony from this region as a direct result of these fires.

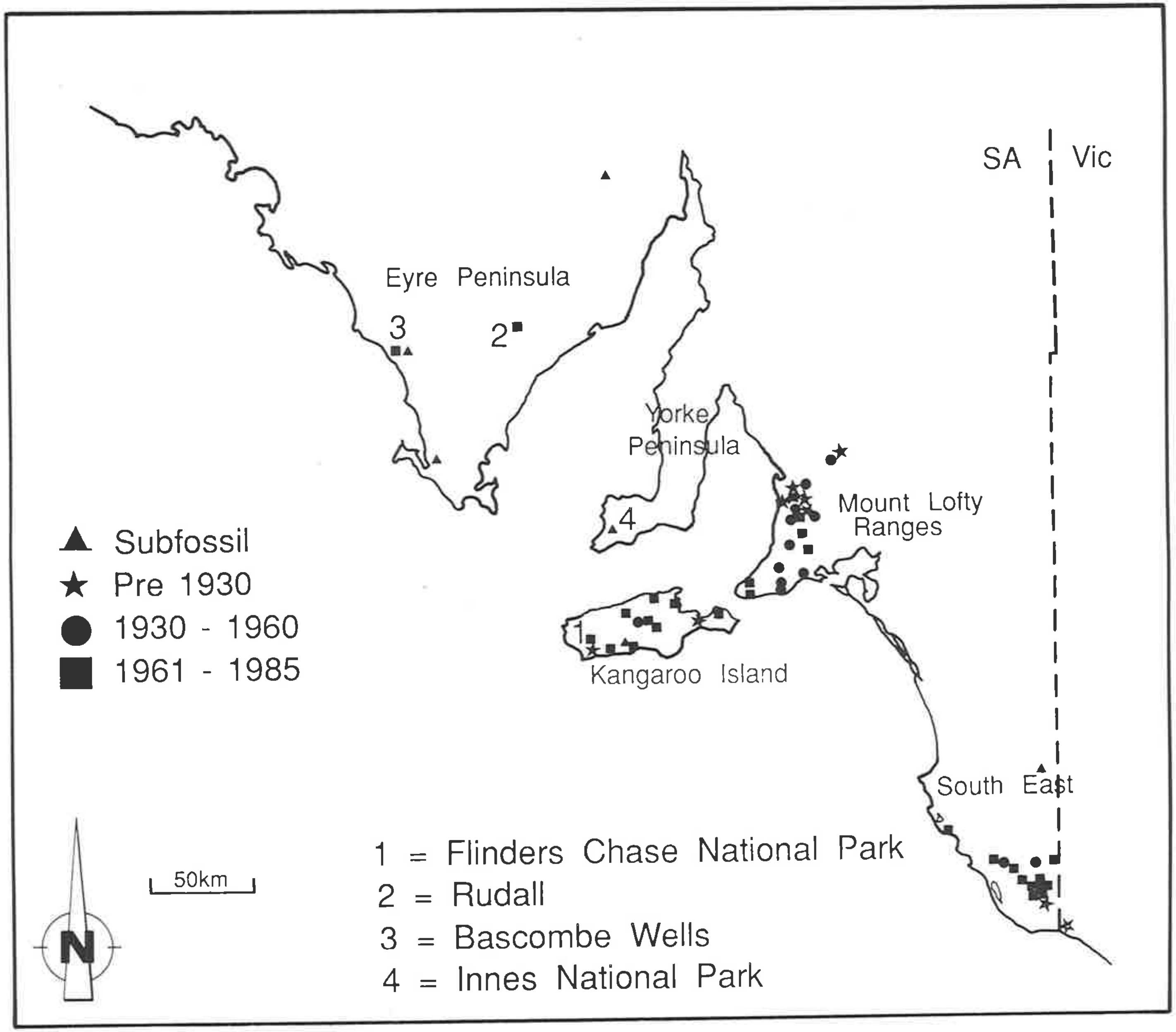
During the last few decades the South Australian Museum (SAM) has lodged a number of specimens of *I. o. obesulus* from Kangaroo Island in its collection (Kemper, 1990). These specimens show that bandicoots are widespread on the island (Figure 2.1), and they are known to live in at least one large reserve, Flinders Chase National Park (Kemper, 1990).

FIGURE 2.1

Occurrence of *I. o. obesulus* in South Australia

Source

Adapted from Kemper (1990)


SA
Vic
Eyre Peninsula
3
2
Yorke Peninsula
4
Mount Lofty Ranges
Kangaroo Island
1
South East
Subfossil
Pre 1930
1930 - 1960
1961 - 1985
50km
N
1 = Flinders Chase National Park
2 = Rudall
3 = Bascombe Wells
4 = Innes National Park

Kemper (1990) recorded sub-fossil remains of *I. o. obesulus* from three sites on the Eyre Peninsula (Figure 2.1) but only two modern specimens have ever been collected from this region. These specimens were obtained by the SAM from the Cleve Fauna Park in the early 1970's. Both individuals were collected from the wild in the Rudall area. Bandicoots have not been recorded from the Eyre Peninsula since then and available evidence suggests that these animals were exceptionally rare finds for this region (Appendix 1.1). Kemper (1990) also recorded Bascombe Wells on the Eyre Peninsula as the collection locality of a modern specimen of *I. o. obesulus* (Figure 2.1). However, Kemper now believes this record to be an error (Kemper, personal communication) and the only known collection sites for modern specimens of *I. o. obesulus* on the Eyre Peninsula are both in the Rudall area.

Sub-fossil remains of *I. o. obesulus* were recorded from the Yorke Peninsula for the first time in the late 1980's at Innes National Park (C. Kemper, Personal Communication). No modern specimens have ever been recorded from this region and, until very recently, there has been no indication that *I. o. obesulus* ever occurred on the Yorke Peninsula.

Specimens lodged in the SAM in recent years show that *I. o. obesulus* still occurs in the Mount Lofty Ranges, in the South East and on Kangaroo Island. No recent records of bandicoot occurrence are available from the Eyre Peninsula and, while it would be premature to label this population as extinct, it is considered by the present study to be awaiting rediscovery. There is no evidence to suggest that *I. o. obesulus* has occurred on the Yorke Peninsula since the time of European settlement.

2.2 Method of Examining Distribution

2.2.1 Historical Distribution

The historical distribution of *I. o. obesulus* was determined by compiling bandicoot occurrence records from the following four sources.

(a) Anecdotal Records

Eyewitness accounts of bandicoot sightings were obtained by the author from interviews with National Parks and Wildlife Service (NPWS) Officers, Woods and Forests (W&F) Department employees, land owners and local residents. Also, an article which described the present study was published in three South Australian country newspapers in April 1990 (*Naracoorte Herald, Border Watch* and *The Islander*) and this prompted several members of the public to come forward with reports of bandicoot sightings.

(b) Field Naturalist's Society Mammal Club Records

Trapping surveys conducted by the Field Naturalists' Society of South Australia Mammal Club (FNS Mammal Club) since 1966 have produced a number of bandicoot locality records, mostly from the Mount Lofty Ranges. These records document sites at which the FNS Mammal Club encountered bandicoots or traces of bandicoots.

(c) Woods and Forests Department Records

Much of the native vegetation remaining in the South East is managed by the Woods and Forests Department of South Australia (W&F Department) as Native Forest Reserves. Ecological surveys were conducted of these reserves in the early 1980s by Mr. Keith Bellchambers and by a survey team funded by the Commonwealth Employment Programme (CEP Survey Team) in 1984 and 1985. The results of these surveys were obtained by courtesy of Mr B. Gepp (W&F Department).

(d) South Australian Museum *I. o.obesulus* Collection

The SAM has about 100 specimens of *I. o. obesulus* from South Australia lodged in its collection. While some of these specimens are up to a century old, half have been obtained since the 1960s. Kemper (1990) considered that this reflects the increased awareness of collectors rather than an increase in bandicoot abundance. This collection provided the majority of occurrence records which Kemper (1990) used to describe the distribution of *I. o. obesulus* in South Australia.

2.2.2 Current Distribution

Field surveys were conducted of the Mount Lofty Ranges, the South East and Kangaroo Island to determine the present occurrence of *I. o. obesulus.* The Eyre Peninsula and Yorke Peninsula were not surveyed due to their paucity of bandicoot occurrence records. These surveys were designed to map the location of existing bandicoot colonies and to trap bandicoots at as many sites as possible.

Historical bandicoot occurrence records were plotted onto vegetation base maps of each region. Areas of native vegetation in the vicinity of past bandicoot occurrences were then surveyed on foot for the distinctive conical diggings which indicate points of bandicoot feeding activity. Bandicoots gather much of their food by digging in the soil and probing for food items with their snouts. This activity creates conical holes in the ground in areas where bandicoots feed (Gordon and Hulbert, 1989; Lee and Cockburn, 1985; Ride, 1970; Stodart, 1966, 1977; Triggs, 1984). Diggings of other species, such as Echidna (*Tachyglossus aculeatus*), Rabbit (*Oryctolagus cuniculus*), Goanna (*Varanus gouldii* and *V. rosenbergi*) and White-winged Chough (*Corcorax melanorhamphos*), which may have been confused with *I. o. obesulus* could all be confidently distinguished by the author.

Sites were selected for trapping if they displayed concentrations of typical bandicoot diggings. On this basis it was assumed that bandicoots could potentially be caught at all trapping sites, but with varying probabilities depending on the habitat resources which they offered and the trapping effort invested. The location of all sites which displayed bandicoot diggings were recorded. Most of the feeding sites located during the present study were eventually trapped, although a few areas were considered too inaccessible.

Trap stations were established across feeding sites at approximately ten metre intervals. At each station a Type A Elliott Trap (320 x 90 x 100 mm) was set beside a large wire mesh Cage Trap (560 x 250 x 330 mm), a small wire mesh Cage Trap (460 x 200 x 250 mm) or a Type B Elliott Trap (450 x 150 x 150 mm). Type A Elliott Traps were used principly to catch small mammals such as the Yellow-footed Antechinus (*Antechinus flavipes*), House Mouse (*Mus musculus*), Bush Rat (*Rattus fuscipes*), Swamp Rat (*Rattus lutreolus*) and Black Rat (*Rattus rattus*) which often set off the larger traps and excluded bandicoot captures. Most sites were trapped only once, over a period of one to four consecutive nights. Bait consisted of a mixture of rolled oats, peanut paste, honey and sardines.

The Mount Lofty Ranges field survey was carrried out between June 1986 and August 1988. During this period a total of 148 days were spent searching for bandicoot feeding sites. Trapping was conducted over 68 nights, with surveys for diggings occurring concurrently in the daytime. The South East was surveyed in April 1990. A total of 30 days were spent searching for diggings, with trapping occurring concurrently on 28 nights. Kangaroo Island was surveyed for 27 days in June 1990, with trapping being conducted on 22 of these nights.

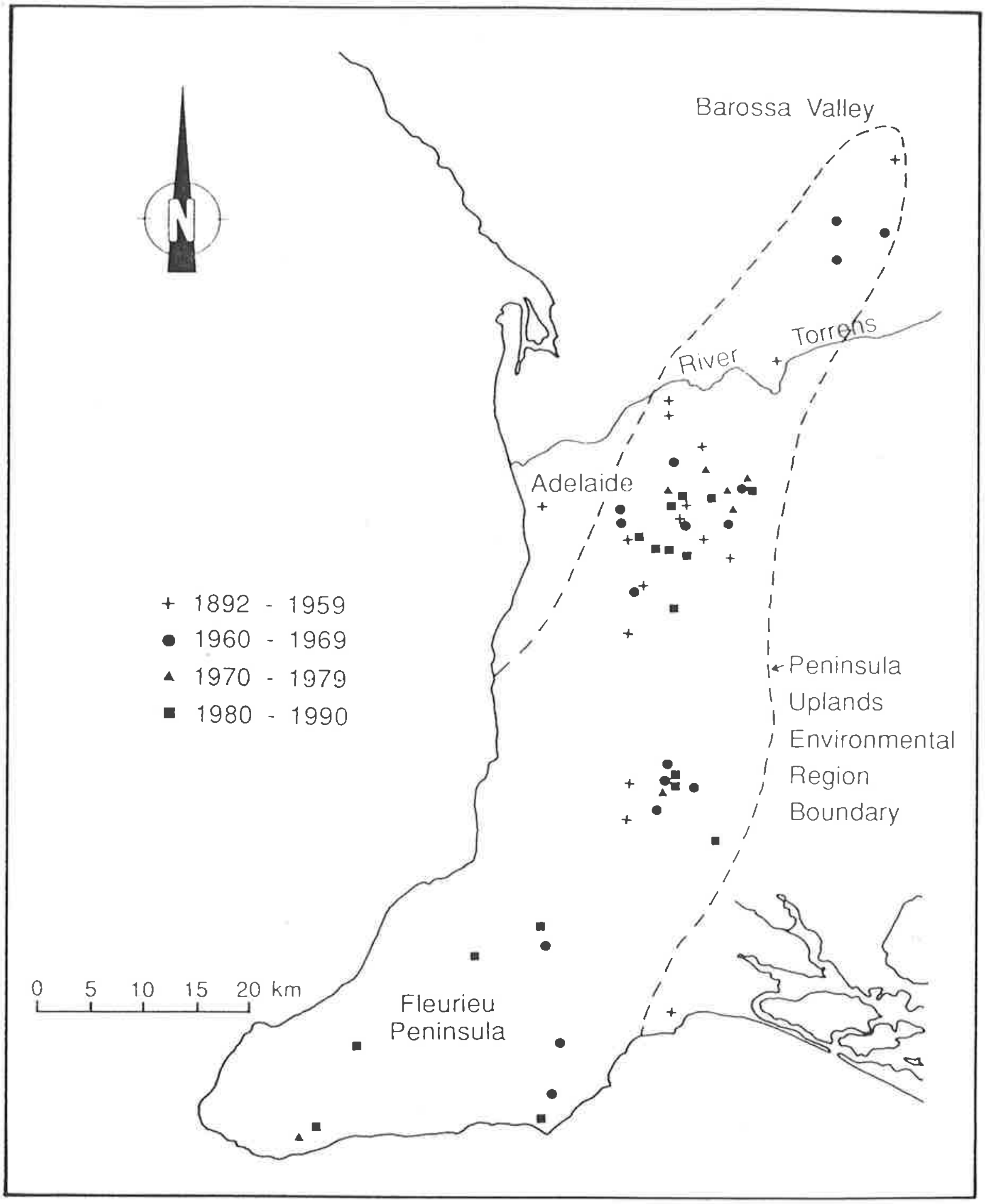
2.3 Results and Discussion

2.3.1 Mount Lofty Ranges Historical Distribution

Figure 2.2 shows the historical distribution of *I. o. obesulus* in the Mount Lofty Ranges. Bandicoot occurrence records for this region are compiled in Appendix 1.2. In the last 100 years *I. o. obesulus* has been recorded from many parts of the Mount Lofty Ranges, from the southern Barossa Valley to the southern Fleurieu Peninsula. Most of these localities lie within the Peninsula Uplands Environmental Region of the Mount Lofty Block Province (Laut *et al.*, 1977). This region is predominantly a low hilly

FIGURE 2.2

Historical Distribution of *I. o. obesulus* in the Mount Lofty Ranges



Barossa Valley
River Torrens
Adelaide
+ 1892 - 1959
● 1960 - 1969
▲ 1970 - 1979
■ 1980 - 1990
Peninsula
Uplands
Environmental
Region
Boundary
0 5 10 15 20 km
Fleurieu
Peninsula

tableland representing the dissected remnants of a former undulating laterite capped land surface which was uplifted during the Tertiary (Laut *et al.*, 1977). The most commonly occurring soils in this region are mottled yellow duplex soils with some limited areas of red duplex soils (Laut *et al.*, 1977). Mean annual rainfall in the Peninsula Uplands varies from 400 mm to 1100 mm (Laut *et al.*, 1977) (Figure 2.3). All localities from which *I. o. obesulus* has been recorded receive at least 550 mm per annum.

Laut *et al.* (1977) suggested that bandicoot numbers in the Mount Lofty Ranges may have diminished greatly as a result of habitat destruction. The open forest and woodland communities which originally covered most of this region have now been reduced to scattered remnants (Figure 2.4) and large areas of continuous vegetation no longer exist (Laut *et al.*, 1977). Dendy (1985) calculated that less than 4.0% of native vegetation cover now remains in the Mount Lofty Ranges. Many conservation reserves have been established in the Mount Lofty Ranges but they are mostly small (Laut *et al.*, 1977).

Despite this habitat fragmentation, *I. o. obesulus* still occurred throughout much of its historical range in the 1960s when bandicoots were recorded from 17 localities, lying between the southern Barossa Valley and the southern Fleurieu Peninsula (Figure 2.2; Appendix 1.2). However, during the 1970s bandicoots were only reported from seven localities, lying between the Adelaide Hills and the southern Fleurieu Peninsula. Since 1980, *I. o. obesulus* has been recorded from 17 localities, lying between the Adelaide Hills and the southern Fleurieu Peninsula.

FIGURE 2.3

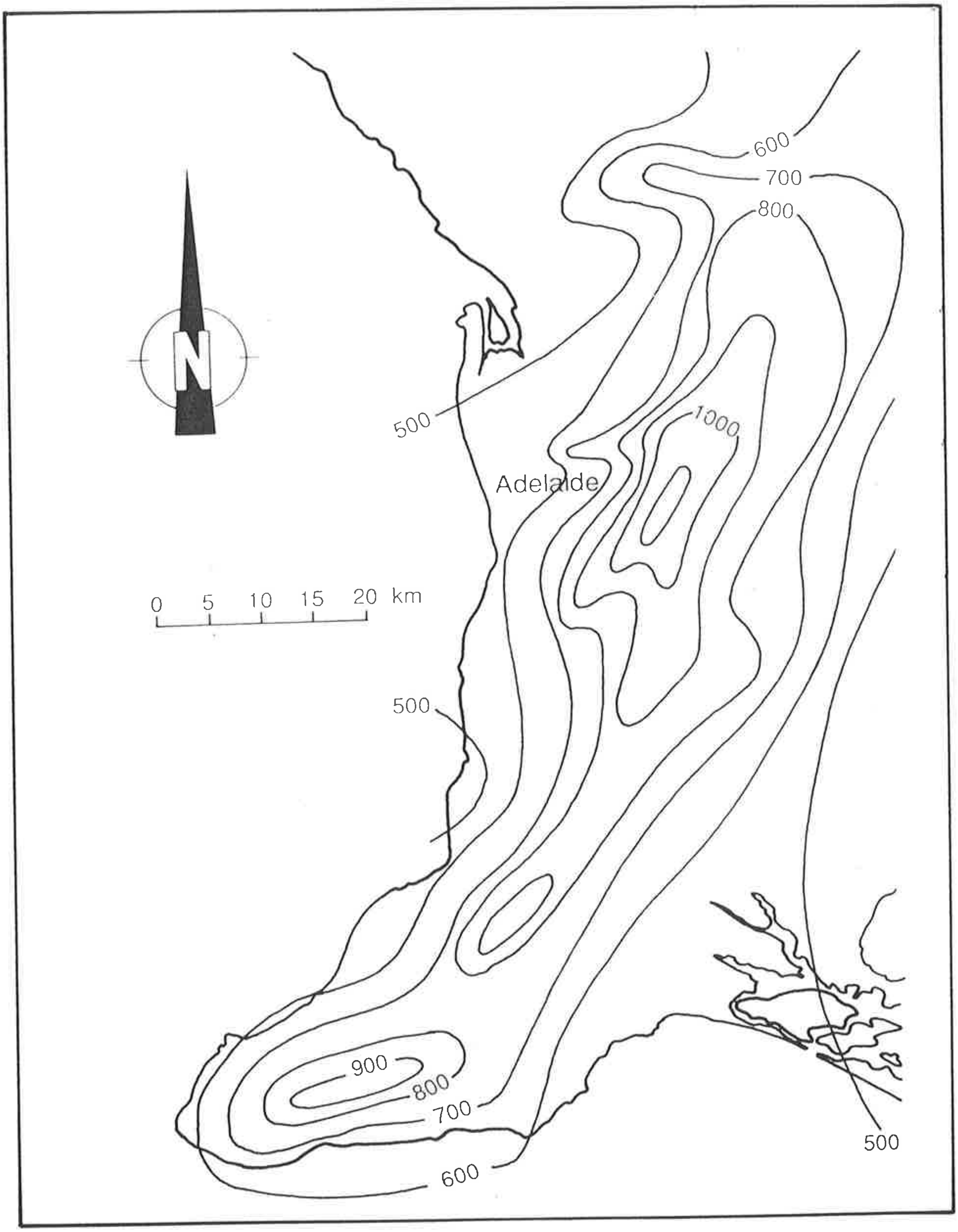
Mean Annual Rainfall in the Mount Lofty Ranges

Notes

Isohyetal Interval = 100 mm

Source

Adapted from Laut *et al.* (1977)



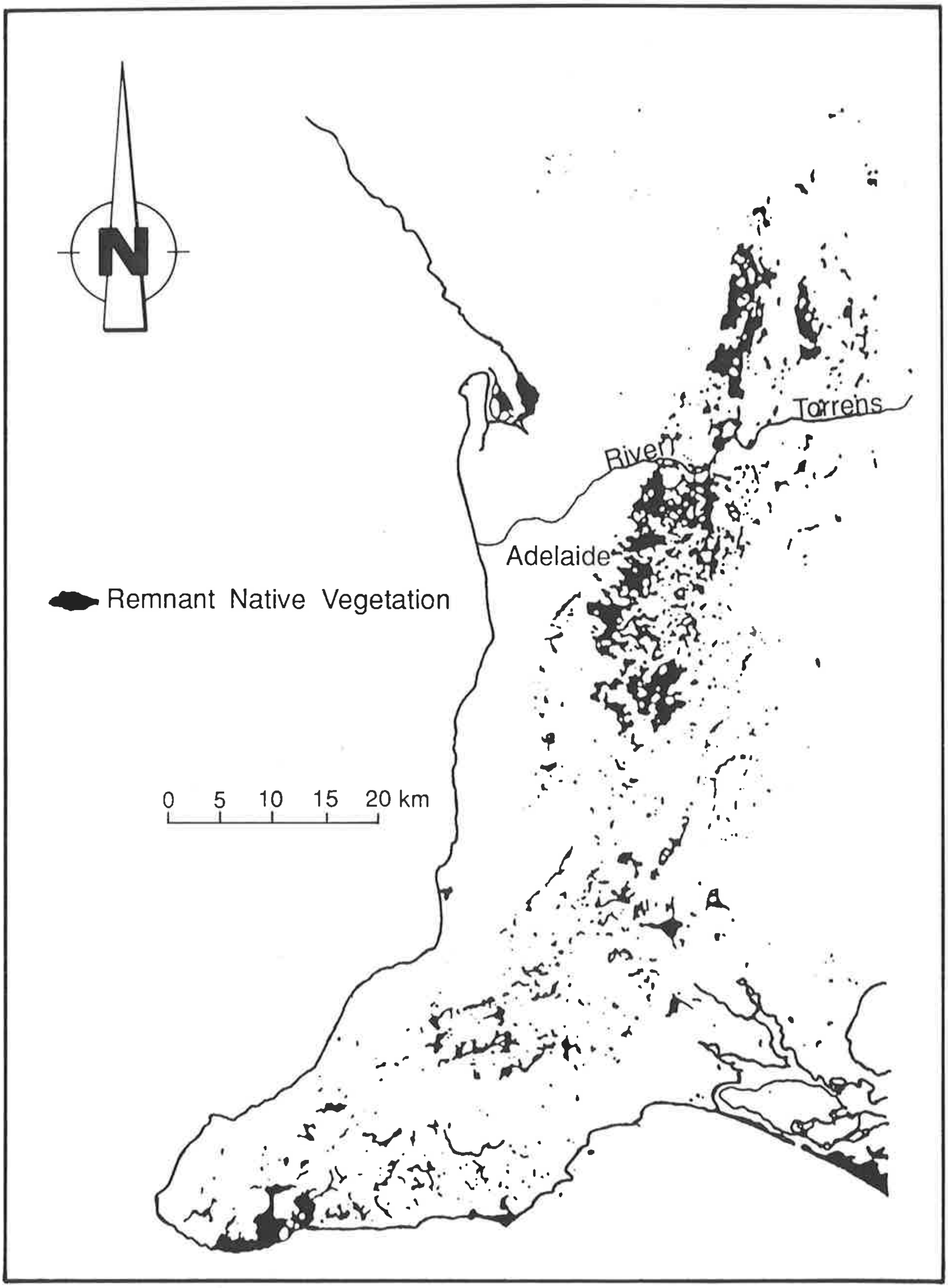
N
0 5 10 15 20 km
500
600
700
800
1000
Adelaide
500
900
800
700
600
500

FIGURE 2.4

Native Vegetation in the Mount Lofty Ranges

Source

Department of Environment and Planning of South Australia


N
Torrens
River
Adelaide
Remnant Native Vegetation
0 5 10 15 20 km

In the early 1980s approximately half of these localities were burnt by severe bushfires. This included the isolated Kuitpo and Kyeema bandicoot colonies which the FNS Mammal Club monitored between 1980 and 1983 (Thompson *et al.*, 1989). Regular trapping efforts by the FNS Mammal Club following the Ash Wednesday bushfire of February 1983 have proved unsuccessful at Kuitpo and Kyeema, and there is still no indication that bandicoots have been able to recolonise these sites (Thompson *et al.*, 1989).

2.3.2 Mount Lofty Ranges *I. o. obesulus* Survey Results

Table 2.1 summarises the results of the Mount Lofty Ranges *I. o. obesulus* survey. Grid references of bandicoot feeding sites and trapping sites are provided in Appendix 2.1. The names of localities and areas of potential bandicoot habitat are shown in Figure 2.5. Potential bandicoot habitat is defined as those areas from which bandicoots have been recorded since 1950, and which still possess native vegetation cover. Bandicoot habitat requirements and usage patterns are examined in detail in Chapter 5 of this thesis.

Bandicoots were captured at Wotton Scrub Conservation Park (CP), Upper Sturt, Scott Creek CP, Myponga Tiers, Second Valley Native Forest Reserve (NFR) and Deep Creek CP. Trapping was unsuccessful at Kenneth Stirling CP, Cleland CP, Loftia Recreation Park (RP) and Springmount CP but the presence of diggings and recent records of bandicoot occurrence indicate that *I. o. obesulus* still exists in these areas. Diggings were also recorded by the author at Horsnell Gully CP, Belair RP, Mount Bold and Cox Scrub CP but no trapping was conducted in these

TABLE 2.1

Mount Lofty Ranges Trapping Survey Results

Patch Name	Latest Record	Diggings Observed?	Patch Trapped?	Bandicoots Captured?	Bandicoot Status
Hale CP	1960	No	No		Absent
Warren CP	1969	No	No		Absent
Mt Crawford NFR	1960	No	No		Absent
Horsnell Gully CP	1967	Yes	No		Present
Ken Stirling CP	1980	Yes	Yes	No	Present
Wotton Scrub CP	1970	Yes	Yes	Yes	Present
Ashton	1970	No	No		Absent*
Uraidla	1983	No	No		Absent*
Cleland CP	1990	Yes	Yes	No	Present
Mount Lofty	1988	No	No		Present
Bridgewater	1968	No	No		Absent*
Crafers	1960	No	No		Absent*
Belair RP	1988	No	No		Present
Upper Sturt	1988	Yes	Yes	Yes	Present
Loftia RP	1988	Yes	Yes	No	Present
Scott Creek CP	1985	Yes	Yes	Yes	Present
Mount Bold	------	Yes	No		Present
Kuitpo NFR	1983	No	No		Absent*
Kyeema CP	1983	No	No		Absent*
McHarg Creek	1969	No	No		Absent*
Mt Magnificent CP	1969	No	No		Absent*
Cox Scrub CP	1989	Yes	No		Present
Myponga Tiers	1987	Yes	Yes	Yes	Present
Myponga CP	1987	No	No		Present
Springmount CP	1968	Yes	Yes	No	Present
Second Valley NFR	1981	Yes	Yes	Yes	Present
Deep Creek CP	1988	Yes	Yes	Yes	Present
Newland Head CP	1986	No	No		Present

Notes

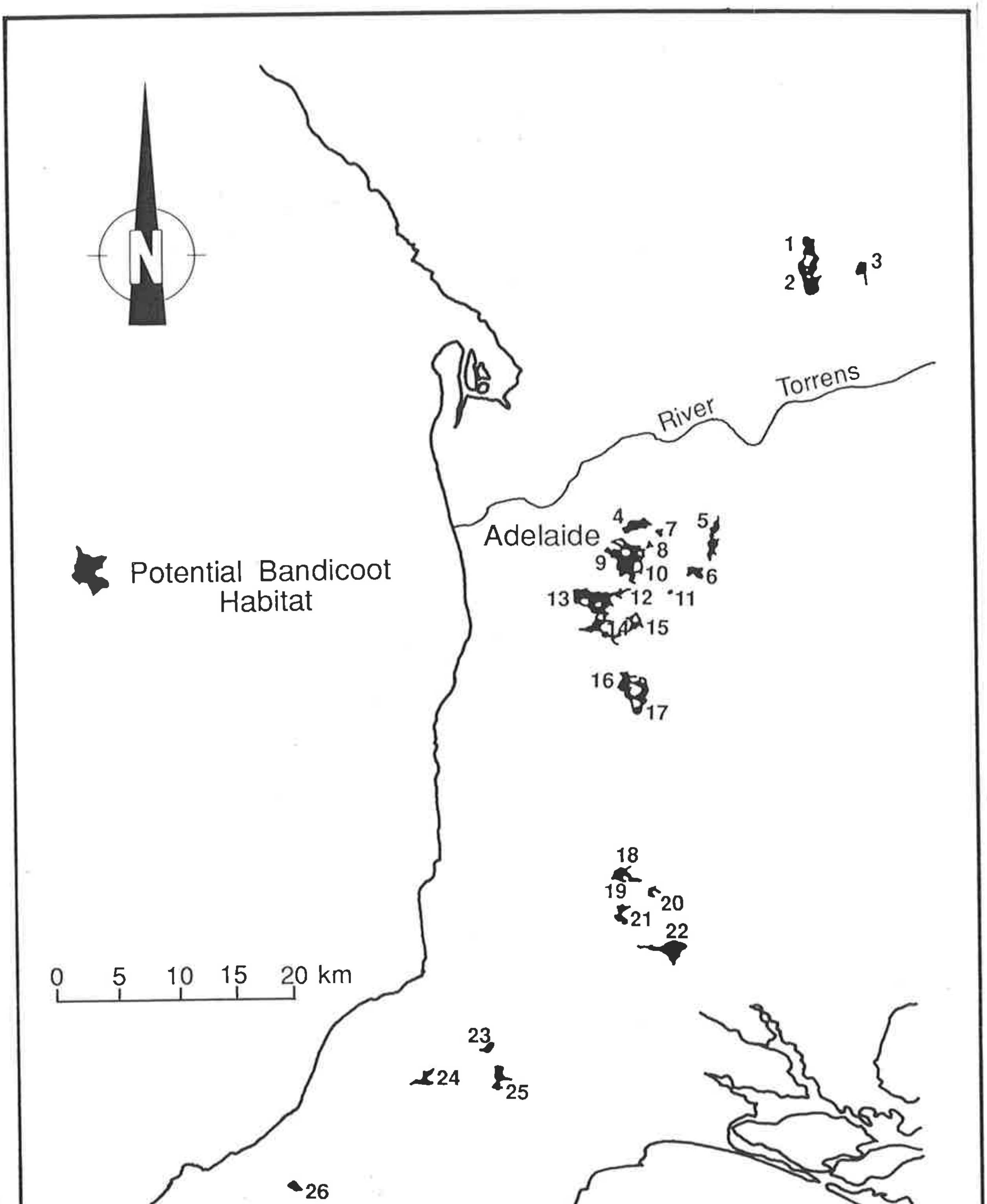
Present = Bandicoots present at the time of survey.
Absent = Bandicoots apparently absent at the time of survey.
Absent* = Bandicoots apparently absent but recolonisation may occur from neighbouring sites.

FIGURE 2.5

Potential *I. o. obesulus* Habitat in the Mount Lofty Ranges

<u>Notes</u>

1 = Hale CP
2 = Waren CP
3 = Mount Crawford NFR
4 = Horsnell Gully CP
5 = Kenneth Stirling CP
6 = Wotton Scrub CP
7 = Ashton
8 = Uraidla
9 = Cleland CP
10 = Mount Lofty
11 = Bridgewater
12 = Crafers
13 = Belair RP
14 = Upper Sturt
15 = Loftia RP
16 = Scott Creek CP
17 = Mount Bold
18 = Kuitpo NFR
19 = Kyeema CP
20 = McHarg Creek
21 = Mount Magnificent CP
22 = Cox Scrub CP
23 = Myponga Tiers
24 = Myponga CP
25 = Springmount CP
26 = Second Valley NFR
27 = Deep Creek CP
28 = Newland Head CP


N
Potential Bandicoot Habitat
0 5 10 15 20 km
River Torrens
Adelaide
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28

patches. Diggings were not found at Mount Lofty, Belair RP, Myponga CP and Newland Head CP but recent occurrence records indicate that bandicoots are still present in these areas.

Hale CP, Mount Crawford NFR, Warren CP, Ashton, Uraidla, Crafers, Bridgewater, Kuitpo NFR, Kyeema CP, McHarg Creek and Mount Magnificent CP all failed to display bandicoot diggings and the lack of recent occurrence records suggests that *I. o. obesulus* is absent in these areas. However, each of these patches, with the exception of Hale CP, Mount Crawford NFR and Warren CP, lies in the vicinity of existing bandicoot colonies and they may be recolonised in the future. Hale CP, Mount Crawford NFR and Warren CP are isolated from existing colonies and they are considered unlikely to experience future natural recolonisation.

2.3.3 Current Distribution in the Mount Lofty Ranges

Table 2.2 summarises the area, tenure and status of potential bandicoot habitat in the Mount Lofty Ranges. A total of 11,930 ha of potential bandicoot habitat remain in this region. Since 1966, all bandicoot occurrence records have been recorded from at least ten km south of the River Torrens. It therefore seems likely that *I. o. obesulus* has suffered a reduction to the northern limit of its range.

The present study confirmed that bandicoots still occur in 17 habitat patches, representing 87.4% (10,430 ha) of the total potential bandicoot habitat available in the Mount Lofty Ranges. Lack of recent historical occurrence records and the absence of diggings suggests that bandicoots

TABLE 2.2

Area, Tenure and Status of Potential Bandicoot Habitat in the Mount Lofty Ranges

Patch Name	Approximate Area (ha)	Land Tenure	Bandicoot Status
Hale CP	200	NPWS	Absent
Warren CP	350	NPWS	Absent
Mt Crawford NFR	150	W&F	Absent
Horsnell Gully CP	250	NPWS	Present
Kenneth Stirling CP	400	NPWS	Present
Wotton Scrub CP	200	NPWS	Present
Ashton	<50	Private	Absent*
Uraidla	<50	Private	Absent*
Cleland CP	950	NPWS	Present
Mt Lofty	<50	Bot Gdns	Present
Bridgewater	<50	NPWS	Absent*
Crafers	<50	Private	Absent*
Belair RP	800	NPWS	Present
Upper Sturt	100	Private	Present
Loftia RP	130	NPWS	Present
Scott Creek CP	700	NPWS	Present
Mount Bold	500	E&WS	Present
Kuitpo NFR	<50	W&F	Absent*
Kyeema CP	350	NPWS	Absent*
McHarg Creek	100	Private	Absent*
Mt Magnificent CP	100	NPWS	Absent*
Cox Scrub CP	550	NPWS	Present
Myponga Tiers	200	Private	Present
Myponga CP	150	NPWS	Present
Springmount CP	250	NPWS	Present
Second Valley NFR	150	W&F	Present
Deep Creek CP	4,100	NPWS	Present
Newland Head CP	950	NPWS	Present
Total Area of Habitat	**11,930**		

Notes

NPWS (National Parks & Wildlife Service) = 10,480 Ha (87.9% of habitat)
Private = 550 Ha (4.6% of habitat)
E&WS = (Engineering & Water Supply Dept) = 500 Ha (4.2% of habitat)
W&F (Woods & Forest Dept) = 350 Ha (2.9% of habitat)
Bot Gdns (Botanic Gardens) = <50 Ha (0.4% of habitat)
Bandicoots Present = 10,430 Ha (87.4% of habitat)
Bandicoots Absent*= 800 Ha (6.7% of habitat)
Bandicoots Absent = 700 Ha (5.9% of habitat)
Key to status as per Table 2.1.

have vanished from 11 patches, representing 12.6% (1,500 ha) of this total area. Three of these patches (with a combined area of 700 ha or 5.9% of the total area) stand little chance of natural recolonisation due to the lack of nearby extant bandicoot colonies, but eight of these patches (with a combined area of 800 ha or 6.7% of the total area) lie near bandicoot colonies and may experience future recolonisation.

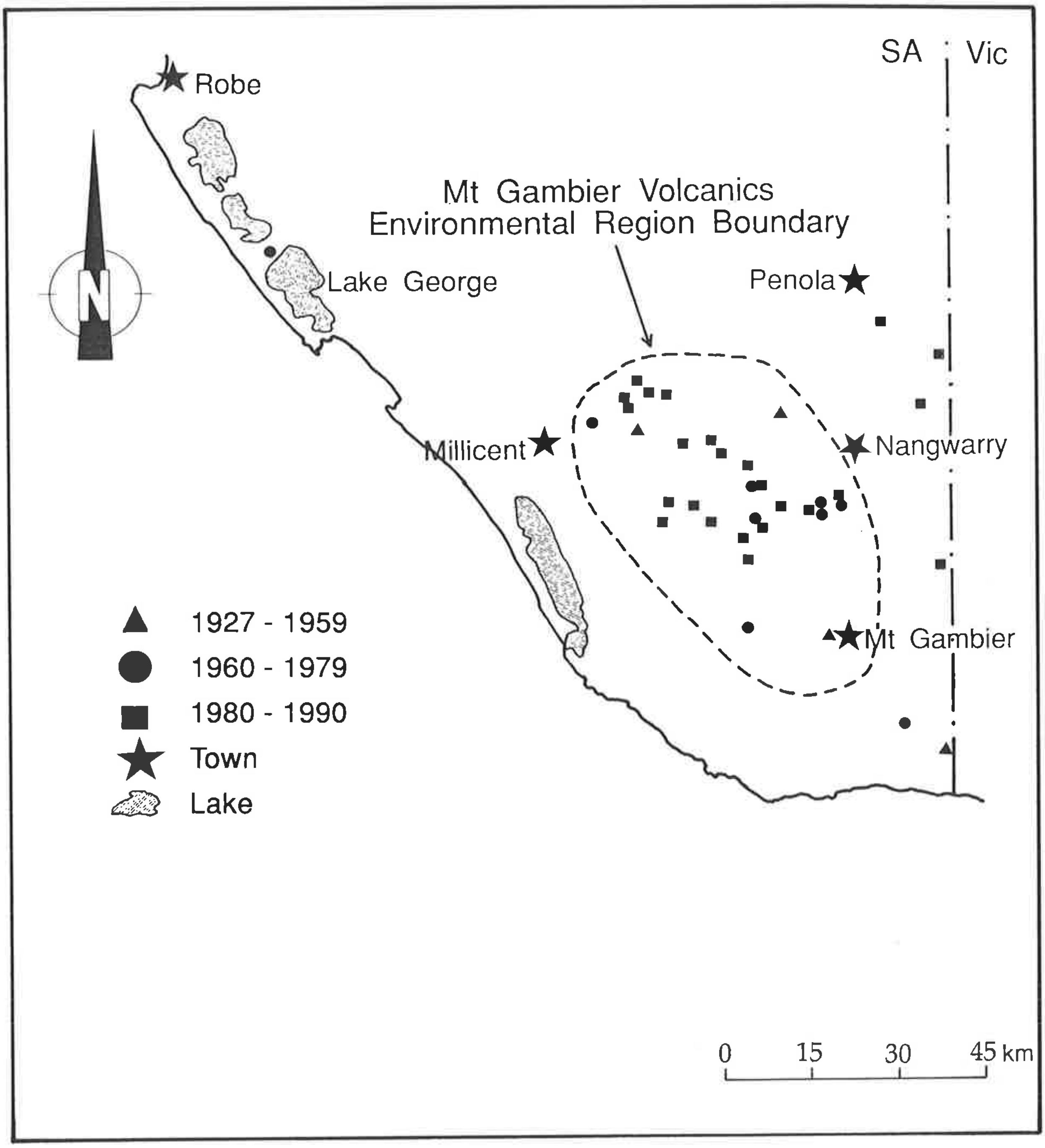
Most of the bandicoot habitat remaining in the Mount Lofty Ranges is now managed for conservation and vegetation clearance no longer threatens *I. o. obesulus*. However, habitat fragmentation has divided the Mount Lofty Ranges' *I. o. obesulus* population into a series of discrete colonies. Bushfires now have the potential to cause local extinctions of *I. o. obesulus* from isolated sites, such as Kuitpo and Kyeema. Less isolated sites, such as Cleland CP, Mount Lofty, Loftia RP, Cox Scrub CP, Myponga Tiers and Deep Creek CP, which were also burnt on Ash Wednesday have all been recolonised by bandicoots.

2.3.4 South East Historical Distribution

Figure 2.6 shows the recorded historical distribution of *I. o. obesulus* in the South East. Bandicoot occurrence records for this region are compiled in Appendix 1.3. Aitken (1983) described the distribution of *I. o. obesulus* as occurring within the area enclosed by Nangwarry, Millicent and Mount Gambier (Figure 2.6). However, all bandicoot occurrence records, except one, compiled during the present study have been located within a triangle running from Millicent through Penola to the SA/Vic border, southward along the border to the coast and then northwest back to Millicent. A single bandicoot skull found at Lake George in 1965 suggests

FIGURE 2.6

Historical Distribution of *I. o. obesulus* in the South East



SA
Vic
Robe
Lake George
Mt Gambier Volcanics
Environmental Region Boundary
Penola
Millicent
Nangwarry
Mt Gambier
1927 - 1959
1960 - 1979
1980 - 1990
Town
Lake
0
15
30
45 km

that *I. o. obesulus* also occurred further north in the past (Figure 2.6). This is supported by a sub-fossil specimen lodged with the SAM from the upper South East, near to the SA/Vic border (Figure 2.1).

Very few of these occurrence records existed before the 1960s and the vast majority of records come from the 1980s. It is unlikely that this increased rate of reporting is due to an increase in bandicoot abundance. Rather, it is due to the locality records obtained during by Bellchambers and the CEP Survey Team, as well as a number of anecdotal records obtained by the author during the present study. Since 1980 bandicoots have been recorded from 24 locations in the South East (Figure 2.6; Appendix 1.3).

Nearly all of these localities lie within the Mount Gambier Volcanics Environmental Region (Laut *et al.*, 1977) which consists of a slightly uplifted volcanic plain covered with deep sands and ash soils. Several volcanic cones and areas of calcarenite dunes are also features of this region. The Mount Gambier Volcanics Region has a distinctively higher relief and altitude to surrounding areas (Laut *et al.*, 1977) and it includes the wettest parts of the South East (Figure 2.7). All sites from which *I. o. obesulus* has been recorded receive between 650 and 850 mm of rainfall annually.

Native vegetation in the lower South East has been severely reduced to less than 5.0% of its original cover (Dendy, 1985) (Figure 2.8). Large areas of cleared land have now been turned over to agriculture and approximately 80,000 ha of softwood plantations have been established (Laut *et al.*, 1977). The Mount Gambier Volcanics Region is poorly conserved and Laut *et al.* (1977) considered that there are no areas of

FIGURE 2.7

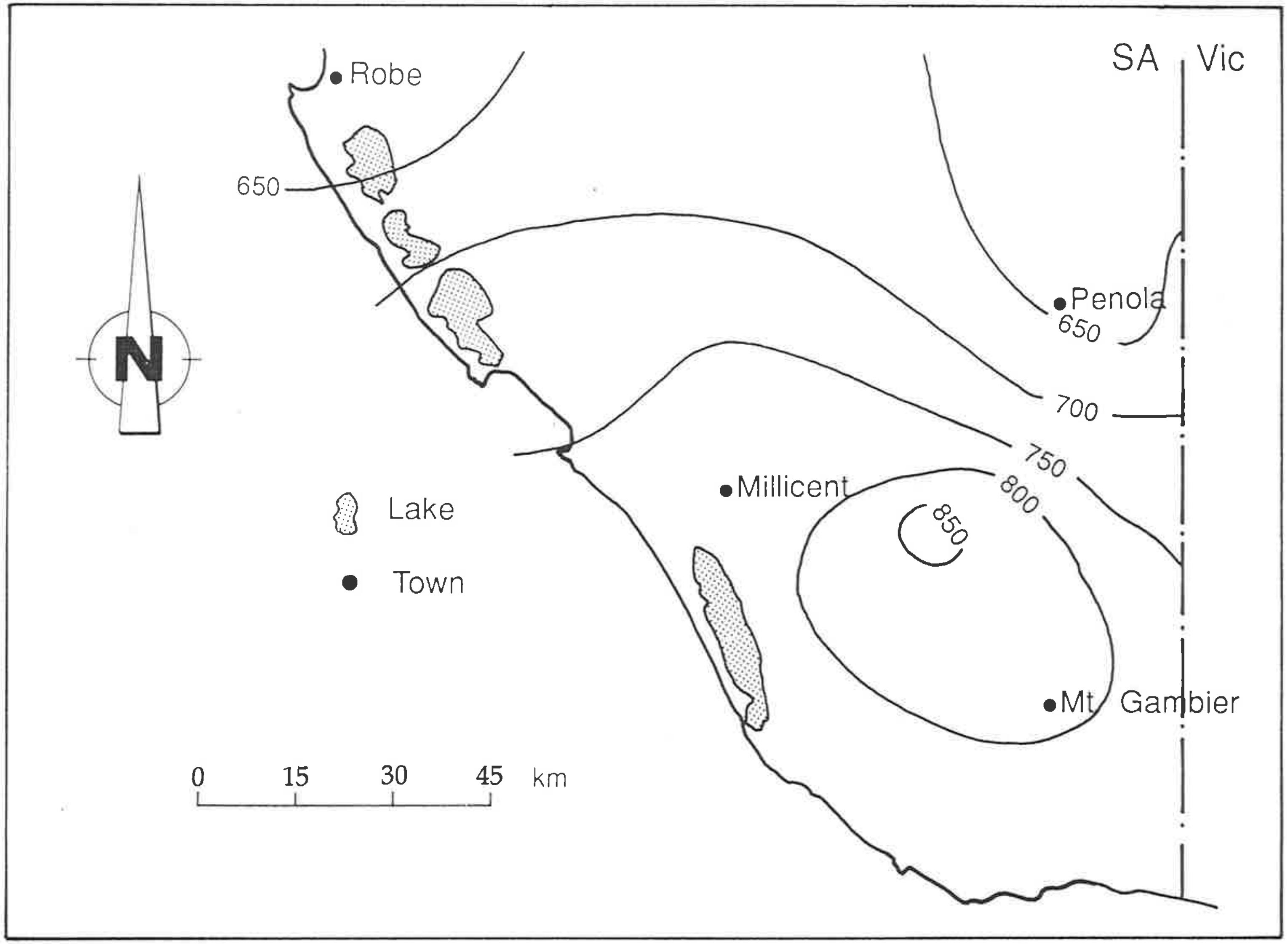
Mean Annual Rainfall in the South East

Notes

Isohyetal Interval = 50 mm

Source

Adapted from Laut *et al.* (1977)



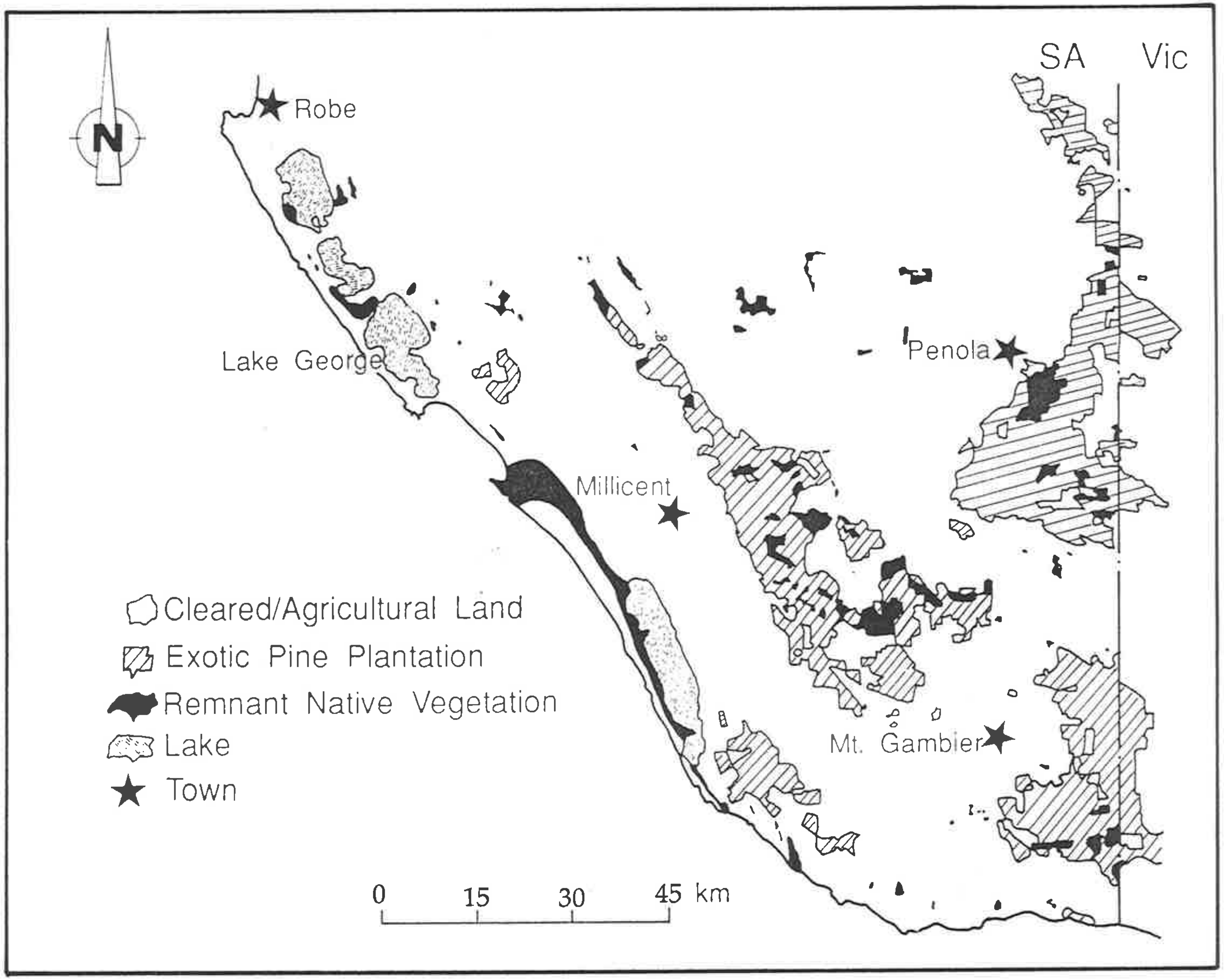
Robe
SA
Vic
650
Penola
650
700
750
800
850
Millicent
Lake
Town
Mt Gambier
0
15
30
45
km

FIGURE 2.8

Native Vegetation in the South East

Source

Adapted from W&F Dept Base Map


N
SA
Vic
Robe
Lake George
Millicent
Penola
Mt. Gambier
Cleared/Agricultural Land
Exotic Pine Plantation
Remnant Native Vegetation
Lake
Town
0
15
30
45 km

habitat which, in the long term, would constitute ecologically viable reserves.

2.3.5 South East *I. o. obesulus* Survey Results

Table 2.3 summarises the results of the South East *I. o. obesulus* survey. Grid references of bandicoot feeding sites and trapping sites are provided in Appendix 2.2. Locality names and areas of potential bandicoot habitat are shown in Figure 2.9.

Bandicoots were captured at Marshes NFR, Hackett Hill NFR, Long's NFR, Woolwash NFR, Mount Lyon NFR, Honan's NFR, Grundy Lane NFR, Wandilo NFR, North Windy Hill NFR, South Windy Hill NFR, Mount Watch NFR, Native Wells NFR, Frill West NFR, Brooksby Road, Mount McIntyre NFR and Aslin's. Trapping was unsuccessful at Kalangadoo Road, Telford CP, Whennan's NFR, Gower CP, The Bluff NFR, Glencoe Hill NFR, Burr Slopes NFR, East McRosties NFR, West McRosties NFR and Byrne's but the presence of diggings and recent occurrence records indicates that bandicoots still exist in these patches. Diggings were also recorded at the Millicent Golf Course, Diagonal Road NFR, Penola HQ NFR, Mount Burr Mill Drop NFR and Turkey Heath, but no trapping was conducted in these patches. The presence of *I. o. obesulus* could not be confirmed at Yeate's NFR and Pernamble CP as no diggings were found and no recent occurrence records exist for these patches.

TABLE 2.3

South East Trapping Survey Results

Patch Name	Latest Record	Diggings Observed?	Patch Trapped?	Bandicoots Captured?	Bandicoot Status
Penola HQ NFR	1984	Yes	No		Present
Yeate's NFR	1982	No	No		?
Byrne's	------	Yes	Yes	No	Present
Turkey Heath	------	Yes	No		Present
Millicent Golf Course	1990	Yes	No		Present
Mt Burr Mill Drop NFR	1982	Yes	No		Present
Whennan's NFR	1982	Yes	Yes	No	Present
Mt McIntyre NFR	------	Yes	Yes	Yes	Present
E McRostie's NFR	------	Yes	Yes	No	Present
W McRostie's NFR	------	Yes	Yes	No	Present
Brooksby Rd	------	Yes	Yes	Yes	Present
Burr Slopes NFR	------	Yes	Yes	No	Present
Marshes NFR	1985	Yes	Yes	Yes	Present
Mt Lyon NFR	1985	Yes	Yes	Yes	Present
Frill West NFR	------	Yes	Yes	Yes	Present
Native Wells NFR	------	Yes	Yes	Yes	Present
Glencoe Hill NFR	1985	Yes	Yes	No	Present
Mt Watch NFR	------	Yes	Yes	Yes	Present
N Windy Hill NFR	------	Yes	Yes	Yes	Present
S Windy Hill NFR	------	Yes	Yes	Yes	Present
Gower CP	1984	Yes	Yes	No	Present
The Bluff NFR	------	Yes	Yes	No	Present
Long's NFR	1985	Yes	Yes	Yes	Present
Woolwash NFR	1984	Yes	Yes	Yes	Present
Honan Scrub NFR	1985	Yes	Yes	Yes	Present
Diagonal Rd NFR	1985	Yes	No		Present
Kalangadoo Rd	1987	Yes	Yes	No	Present
Hackett Hill NFR	1982	Yes	Yes		Present
Wandilo Scrub NFR	1985	Yes	Yes	Yes	Present
Aslin's	1970	Yes	Yes	Yes	Present
Grundy Lane NFR	1985	Yes	Yes	Yes	Present
Telford CP	1980	Yes	Yes	No	Present
Pernamble CP	1975	No	No		?

Notes

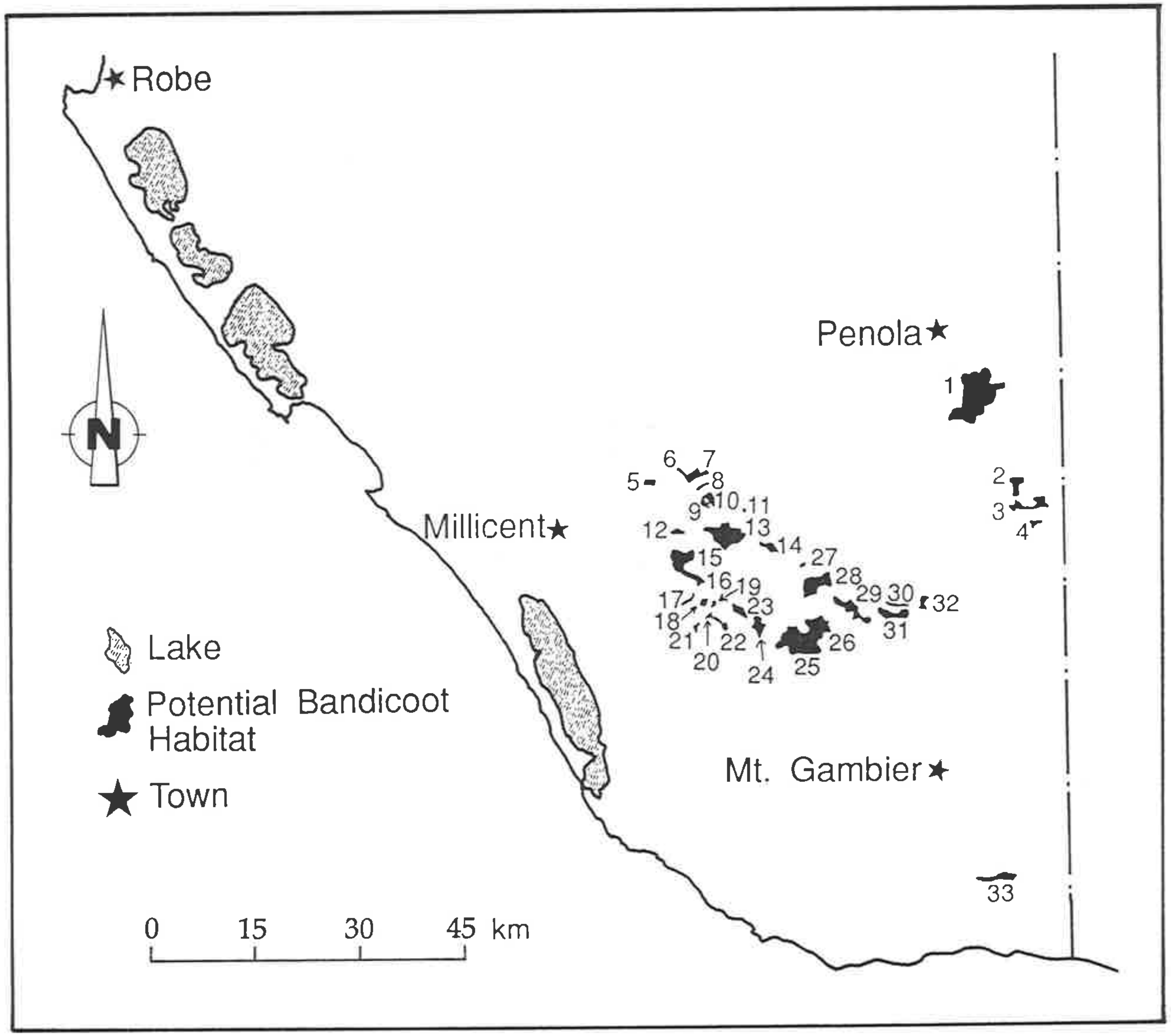
Present = Bandicoots present at the time of survey.
? = Presence of bandicoots not confirmed.

FIGURE 2.9

Potential *I. o. obesulus* Habitat in the South East

Notes

1 = Penola HQ NFR
2 = Yeate's NFR
3 = Byrne's
4 = Turkey Heath
5 = Millicent Golf Course
6 = Mt Burr Mill Drop NFR
7 = Whennan's NFR
8 = Mt McIntyre NFR
9 = East McRosties NFR
10 = West McRosties NFR
11 = Brooksby Road
12 = Burr SlopesNFR
13 = Marshes NFR
14 = Mt Lyon NFR
15 = Frill West NFR
16 = Native Wells NFR
17 = Glencoe Hill NFR
18 = Mt Watch NFR
19 = North Windy Hill NFR
20 = South Windy Hill NFR
21 = Gower CP
22 = The Bluff NFR
23 = Longs NFR
24 = Woolwash NFR
25 = Honan's NFR
26 = Diagonal Road NFR
27 = Kalangadoo Road NFR
28 = Hackett Hill NFR
29 = Wandilo NFR
30 = Aslin's
31 = Grundy Lane NFR
32 = Telford CP
33 = Pernamble CP



Robe
Penola
Millicent
Mt. Gambier
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
Lake
Potential Bandicoot Habitat
Town
0 15 30 45 km

2.3.6 Current Distribution in the South East

Table 2.4 sumarises the area, tenure and status of potential bandicoot habitat in the South East. A total of 7,000 ha of native vegetation from which *I. o. obesulus* has been historically recorded remain in this region. This habitat is now fragmented into approximately 33 small remnant patches, separated from each other by large expanses of cleared land and mature softwood plantations. The present study confirmed that bandicoots still occur in at least 31 of these patches, representing 94.1% (6,750 ha) of the total potential habitat available in the South East. The presence of bandicoots could not be confirmed in two patches (5.9% or 420 ha of this total area) due to the apparent lack of diggings.

Despite the vast destruction of habitat in the South East, bandicoots can still be found in most patches of native vegetation lying east of Millicent, north of Mount Gambier and south of Penola. However, the historical range of *I. o. obesulus* may have diminished somewhat as bandicoots have not been recorded from south of Mount Gambier for 16 years or from the Lake George area for 26 years. Most of the potential bandicoot habitat remaining in the South East is managed by the W&F Department as NFRs. These reserves are secure from further clearance but they are subjected to a regime of fuel reduction burning, designed to protect softwood plantations from wildfires, without paying much regard to faunal habitat requirements.

TABLE 2.4

Area, Tenure and Status of Habitat in the South East

Patch Name	Approximate Area(ha)	Land Tenure	Bandicoot Status
Penola HQ NFR	1,500	W&F	Present
Yeate's NFR	170	W&F	?
Byrne's	300	Private	Present
Turkey Heath	50	Private	Present
Golf Course	50	Private	Present
Mt Burr Mill Drop NFR	15	W&F	Present
Whennan's NFR	170	W&F	Present
Mt McIntyre NFR	50	W&F	Present
E McRostie's NFR	50	W&F	Present
W McRostie's NFR	100	W&F	Present
Brooksby Rd	<5	Private	Present
Burr Slopes NFR	140	W&F	Present
Marshes NFR	475	W&F	Present
Mt Lyon NFR	90	W&F	Present
Frill West NFR	120	W&F	Present
Native Wells NFR	450	W7F	Present
Glencoe Hill NFR	70	W&F	Present
Mt Watch NFR	30	W&F	Present
N Windy Hill NFR	10	W&F	Present
S Windy Hill NFR	80	W&F	Present
Gower CP	40	NPWS	Present
The Bluff NFR	70	W&F	Present
Long's NFR	100	W&F	Present
Woolwash NFR	250	W&F	Present
Honan Scrub NFR	1,000	W&F	Present
Diagonal Rd NFR	250	W&F	Present
Kalangadoo Rd	<5	Private	Present
Hackett Hill NFR	400	W&F	Present
Wandilo Scrub NFR	420	W&F	Present
Aslin's	10	Private	Present
Grundy Lane NFR	300	W&F	Present
Telford CP	150	NPWS	Present
Pernamble CP	250	NPWS	?
Total Area of Habitat	**7,170**		

<u>Notes</u>

W&F (Woods & Forest Dept) = 6,310 ha (88.0% of habitat)
NPWS (National Parks & Wildlife Service) = 440 ha (6.1% of habitat)
Private = 420 ha (5.9% of habitat)
Bandicoots Present = 6,750 ha(94.1% of habitat)
? = 420 ha (5.9% of habitat)
Key to status as per Table 2.3.

2.3.7 Kangaroo Island Historical Distribution

Figure 2.10 shows the historical distribution of *I. o. obesulus* on Kangaroo Island. Bandicoot occurrence records for this region are compiled in Appendix 1.4. Many of these historical records concern bandicoot roadkills or bandicoot sightings on roadsides, so localities are biassed around those roads which are most often travelled. Patchiness of these occurrence records therefore does not necessarily reflect patchiness of bandicoot distribution.

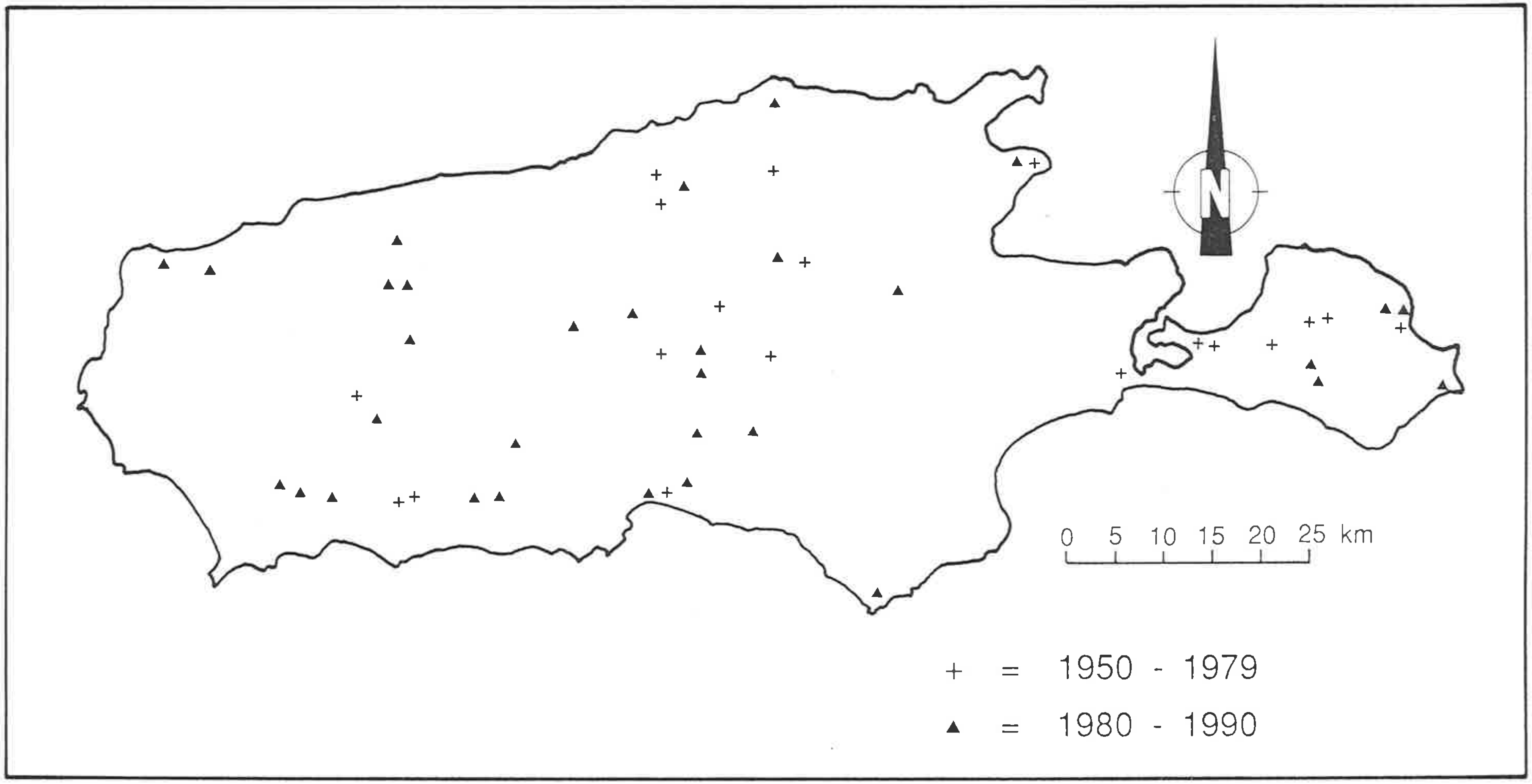
I. o. obesulus has been recorded from many areas of Kangaroo Island. Most records obtained prior to 1980 were SAM specimens (Appendix 1.4). One record was also provided by the FNS Mammal Club. During the present study many recent anecdotal records were obtained by the author, showing that *I. o. obesulus* still occurs in many parts of the island. Since 1980 *I. o. obesulus* has been recorded from 32 locations (Figure 2.10)

Laut *et al.* (1977) included Kangaroo Island in the Mount Lofty Ranges Environmental Province as the laterite surface which is found in the Peninsula Uplands Environmental Region extends on to the island and is well preserved there. Shallow red sandy soils are dominant in the south of the island and reflect the depth of the calcarenite parent material (Laut *et al.*, 1977). Inland, in steep hilly country, shallow mottled yellow duplex soils, shallow red loams and grey sands are found (Laut *et al.*, 1977).

Rainfall on Kangaroo Island varies from 500 mm in the east to 800 mm in the west with most parts of the island receiving less than 650 mm (Figure 2.11). In the Mount Lofty Ranges and the South East *I. o. obesulus* only

FIGURE 2.10

Historical Distribution of *I. o. obesulus* on Kangaroo Island



N
0 5 10 15 20 25 km
+ = 1950 - 1979
▲ = 1980 - 1990

FIGURE 2.11

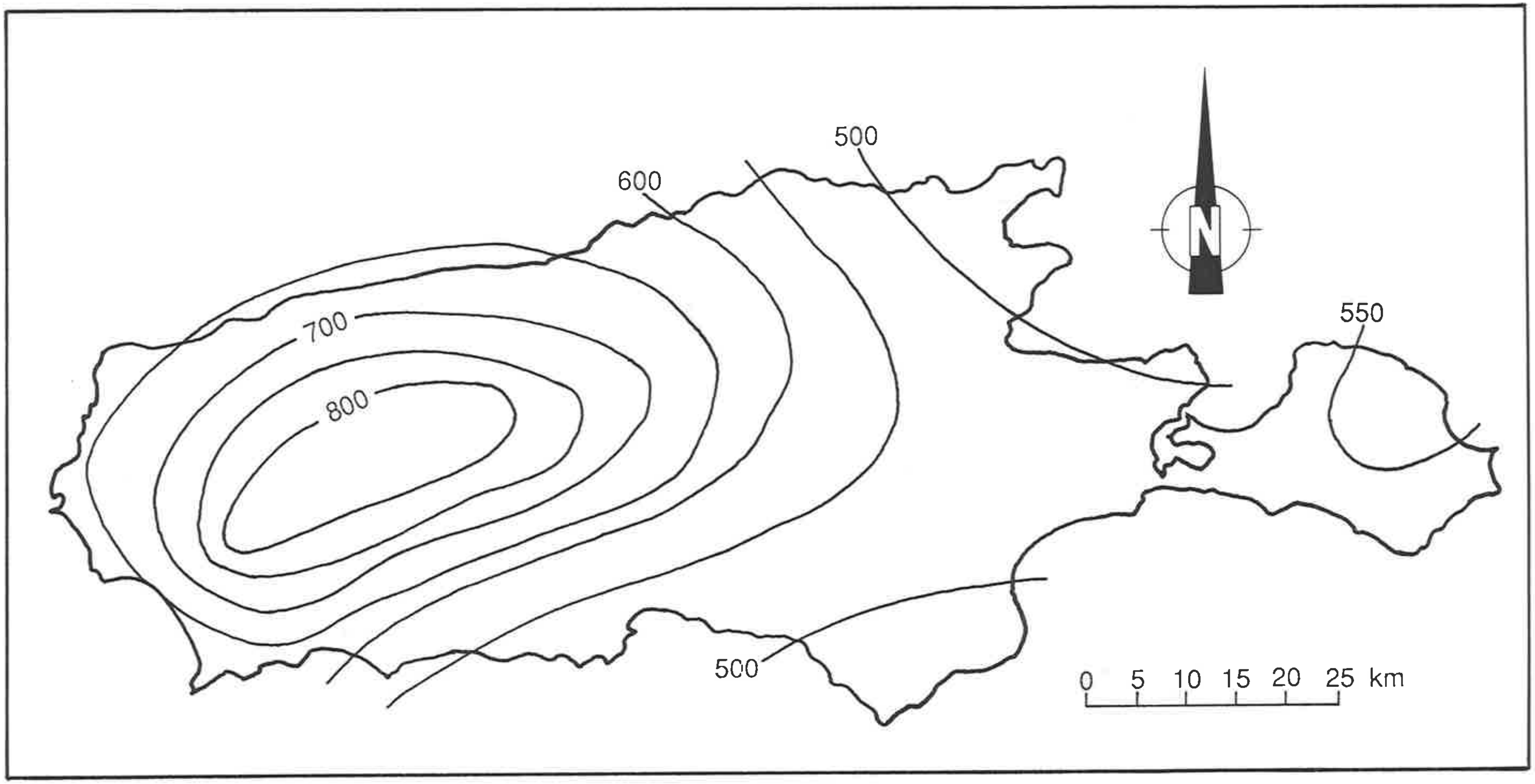
Mean Annual Rainfall on Kangaroo Island

Notes

Isohyetal Interval = 50 mm

Source

Laut *et al.* (1977)



500
600
550
700
800
500
0 5 10 15 20 25 km
N

occurs in areas which receive at least 550 mm. Bandicoots on Kangaroo Island therefore inhabit drier areas than those in the Mount Lofty Ranges and in the South East.

Unlike the Mount Lofty Ranges and the South East, some relatively large areas of native vegetation have been left intact on Kangaroo Island (Figure 2.12) and approximately 38% of the island is still covered by native vegetation (Dendy, 1985). This includes a complex network of vegetation corridors along creeks, rivers and roadsides, interconnecting most of the major vegetation blocks.

2.3.8 Kangaroo Island *I. o. obesulus* Survey Results

Table 2.5 summarises the results of the Kangaroo Island *I. o. obesulus* survey. Grid references of bandicoot feeding sites and trapping sites are provided in Appendix 2.3. Locality names and areas of potential bandicoot habitat are shown in Figure 2.12.

Bandicoots were captured only at Kelly Hill Caves CP and Southern Flinders Chase National Park (NP). Trapping was unsuccessful at Parndana CP, Cape Cassini, Latham CP, Kelly's, Middle River, Northern Flinders Chase NP, Western River CP, Davis', Mount Taylor CP, Rees', Eleanor River, Little Sahara, Gregor Road, Hickman Road, Seddon CP, Pennington Bay, Black Point and Moffat Road, but the presence of diggings and recent occurrence records suggests that bandicoots can still be found in these areas. Diggings were also recorded at Lashmar's but no trapping was conducted at this site. It was not possible to confirm the

FIGURE 2.12

Native Vegetation and Potential *I. o. obesulus* Habitat on Kangaroo Island

Source

LANDSAT Multi Spectoral Scanner (1989)

Notes

1 = Kelly Hill Caves CP
2 = Southern Flinders Chase NP
3 = Parndana CP
4 = Cape Cassini
5 = Latham CP
6 = Kelly's
7 = Middle River
8 = Northern Flinders Chase NP
9 = Western River CP
10 = Davis'
11 = Mount Taylor CP
12 = Rees'
13 = Eleanor River
14 = Little Sahara
15 = Gregor Road
16 = Hickman Road
17 = Seddon CP
18 = Pennington Bay
19 = Black Point Road
20 = Moffat Road
21 = Lashmar's
22 = Dudley CP

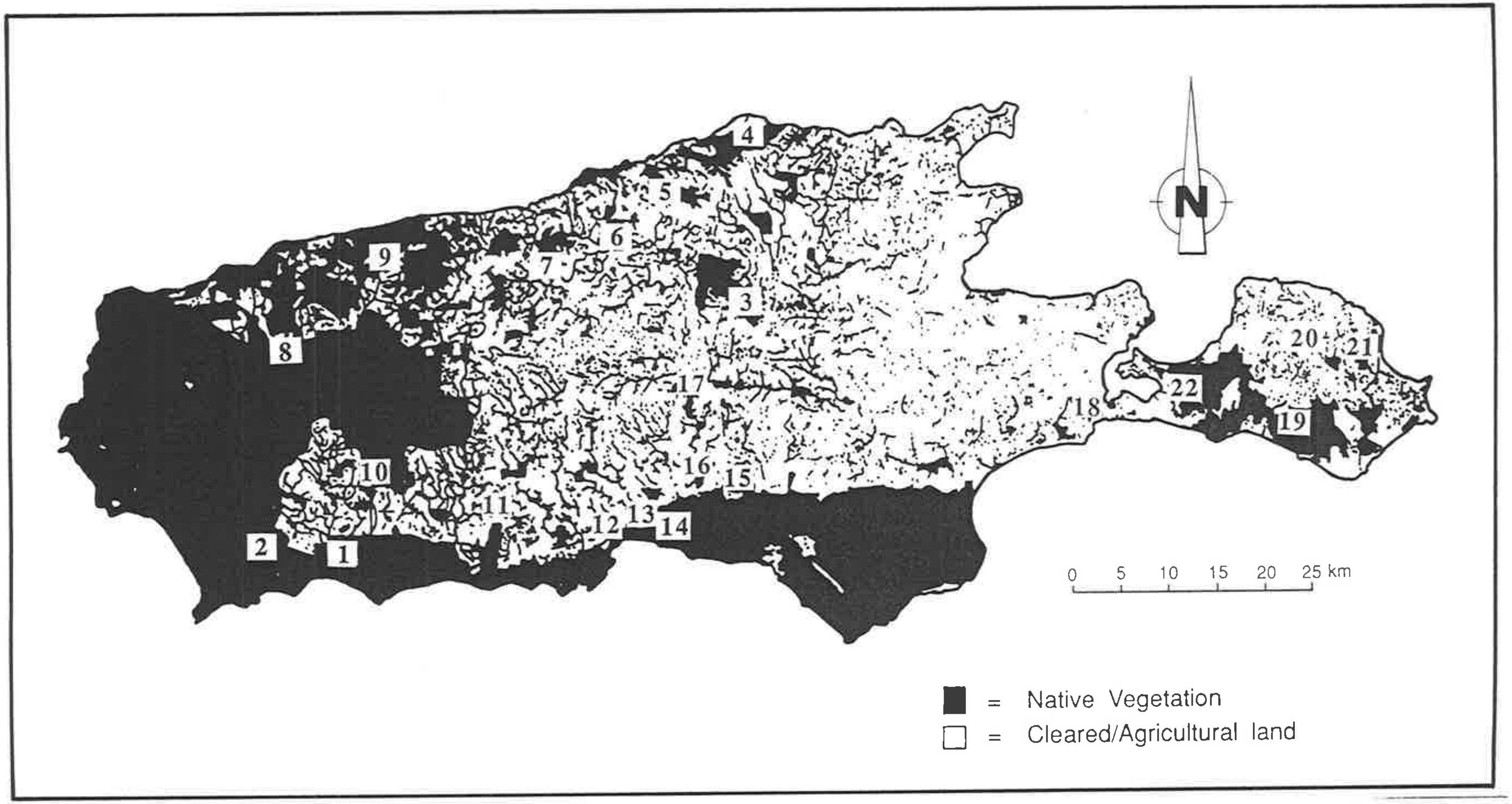

N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
0 5 10 15 20 25 km
= Native Vegetation
= Cleared/Agricultural land

TABLE 2.5

Kangaroo Island Trapping Survey Results

Patch Name	Latest Record	Diggings Observed?	Patch Trapped?	Bandicoots Captured?	Bandicoot Status
Parndana CP	1985	Yes	Yes	No	Present
Cape Cassini	1986	Yes	Yes	No	Present
Latham CP	------	Yes	Yes	No	Present
Kelly's	1980	Yes	Yes	No	Present
Middle River	------	Yes	Yes	No	Present
N Flinders Chase NP	1990	Yes	Yes	No	Present
Western River CP	------	Yes	Yes	No	Present
S Flinders Chase NP	1990	Yes	Yes	Yes	Present
Davis's	1990	Yes	Yes	No	Present
Kelly Hill Caves CP	------	Yes	Yes	Yes	Present
Mt Taylor CP	1990	Yes	Yes	No	Present
Rees's	1990	Yes	Yes	No	Present
Eleanor River	1990	Yes	Yes	No	Present
Little Sahara	1990	Yes	Yes	No	Present
Gregor Rd	------	Yes	Yes	No	Present
Hickman Rd	1989	Yes	Yes	No	Present
Seddon CP	------	Yes	Yes	No	Present
Pennington Bay	1955	Yes	Yes	No	Present
Dudley CP	1970	Yes	Yes	No	?
Black Point	1990	Yes	Yes	No	Present
Moffat Rd	1979	Yes	Yes	No	Present
Lashmar's	1982	No	No		Present

<u>Notes</u>

Present = Bandicoots present at the time of survey.
? = Presence of bandicoots not confirmed.
Total Area of Island = 443,000 ha.
Total Area Covered by Native Vegetation = 170,000 ha.
NPWS (National Parks & Wildlife Service) = 108,000 ha or 24 % of the island's total area (including Flinders Chase NP (73,662 ha) and Cape Gantheaume CP (21,254 ha)).

presence of *I. o. obesulus* at Dudley CP as no diggings were found and no recent occurrence records exist for this area.

2.3.9 Current Distribution on Kangaroo Island

Widespread diggings and recent occurrence records show that *I. o. obesulus* occurs in most patches of native vegetation on Kangaroo Island. Many sightings have also been reported from roadside vegetation strips which are often long distances away from major habitat patches. From these observations it can be concluded that *I. o. obesulus* is currently widespread on Kangaroo Island and can be expected to occur virtually wherever native vegetation exists.

Kangaroo Island covers approximately 443,000 ha (Laut *et al.*, 1977), 38% of which is covered by native vegetation (Dendy, 1985). Therefore, approximately 170,000 ha of the island can be considered potential habitat for *I. o. obesulus*. Approximately 108,000 ha, or 24% of the island's total area is managed for conservation by the NPWS. This includes the large areas of wilderness held in Flinders Chase NP (73,662 ha) and Cape Gantheaume CP (21,254 ha). Kangaroo Island therefore contains the majority of bandicoot habitat remaining in South Australia.

2.4 Conclusion

I. o. obesulus has a restricted and patchy distribution in South Australia. Bandicoots may already be extinct on the Eyre Peninsula. In the Mount Lofty Ranges and in the South East they are confined to a few small native vegetation remnants. On Kangaroo Island they are widespread. In the Mount Lofty Ranges and in the South East, habitat has been dramatically reduced and fragmented, dividing these populations into a series of isolated colonies. By contrast, large areas of continuous habitat remain on Kangaroo Island. Future clearance of native vegetation does not pose a threat to *I. o. obesulus* as most areas of remaining habitat are already conserved.

CHAPTER 3

FEEDING ECOLOGY

3.1 Review of Feeding Ecology

3.1.1 Diet

(a) Omnivorousness

While most bandicoots eat a wide range of food types and are considered to be omnivorous, they also display a clear dietary preference for invertebrates (Braithwaite, 1983; Broughton and Dickman, 1991; Collins, 1973; Heinsohn, 1966; Lyne, 1971; Maloney, 1982; Opie, 1980; Quin, 1985, 1988; Watts, 1974). Lobert and Opie (1986) found that the diet of *I. o. obesulus* in southern Victoria consisted of invertebrates (adult beetles, ants, beetle larvae and fly larvae), vascular plants and fungus.

(b) Invertebrates

Opie (1980) found that the dietary bulk of *I. o. obesulus* in southern Victoria consisted of soil dwelling invertebrates, principally root dwelling chafer beetle larvae (Melolonthinae, Scarabaeidae, Coleoptera), with other major food items classified as darkling beetle larvae (Tenebrionidae, Coleoptera), earwigs (Forficulidae, Dermaptera), Bugs (Hemiptera), ant pupae (Formicidae, Hymenoptera) and adult beetles (Scarabaeidae, Coleoptera). Sanders (1952) recorded the remains of slugs (Sigmurethra, Gastropoda), insect larvae (Scarabaeidae and Tenebrionidae, Coleoptera; and two types of Lepidoptera) and adult

Coleopterans in the stomach contents of the Northern Brown Bandicoot (*Isoodon macrourus*). Watts (1974) found remains of Hemiptera, Coleoptera and Lepidoptera in scats of *I. o. nauticus*.

Heinsohn (1966) found that in north western Tasmania the main invertebrate component of the diet of *I. o. affinis* was earthworms (Lumbricidae, Annelida), curl grub larvae (Scarabaeidae, Coleoptera), army worm larvae (Noctuidae, Lepidoptera), corbie larvae (Hepialidae, Lepidoptera), fly larvae (Diptera), bull ants (Formicidae, Hymenoptera) and mole crickets (Gryllotalpidae, Orthoptera).

Quin (1985, 1988) was able to identify an even greater range of invertebrate remains in the scats of *I. o affinis* from south eastern Tasmania. These include: ground beetle larvae (Carabiidae, Coleoptera), click beetle larvae (Elateridae, Coleoptera) , rove beetle larvae (Staphylinidae, Coleoptera), curl grub larvae (Scarabaeidae, Coleoptera); weevil larvae (Curculionidae, Coleoptera); adult rove beetles (Staphylinidae, Coleoptera); adult ground beetles (Carabiidae, Coleoptera); bull ants (Formicidae, Hymenoptera); bees and wasps (Ichneumonidae, Hymenoptera); blowfly larvae (Calliphoridae, Diptera); adult blowflies (Calliphoridae, Diptera); adult army worms (Noctuidae, Lepidoptera); adult corbie (Hepialidae, Lepidoptera); fleas (Siphonaptera, Hemiptera); centipedes (Chilopoda); slater bugs (Isopoda); mites (Acarina); springtails (Collembola); and crickets (Gryllidae, Orthoptera).

(c) Plants

Vascular plants also form an important food source for bandicoots. Harrison (1963) found raspberry fruits, small seeds, root material, leaf or shoot material and fibre (possibly sugar cane) in the stomach contents of *I. macrourus*. Sanders (1952) found that a specimen of *I. macrourus* had mainly parts of the wild passionfruit (*Passiflora foetida*) in its stomach. Watts (1974) detected significant quantities of seeds and plant material of the genus *Mesembryanthemum* in the scats of *I. o. nauticus*. Bandicoots are also known to eat the fleshy fruits of *Cassytha* species (Lauraceae) (Lee and Cockburn, 1985).

Quin (1985) was able to identify the species of many seeds found in the scats of *I. o. affinis* in Tasmania. These include: *Agrostis capillaris*, *Agrostis* species, *Anthoxanthum odoratum*, *Danthonia caespitosa*, *Deyeuxia densa*, *Gnaphalium* species, *Holcus lanatus*, *Hordeum vulgare*, *Hypochoeris radicata*, *Lolium perenae*, *Phalaris minor*, *Plantago* species, *Schoenus apogon*, *Trifolium dubium*, *Trifolium repens*, *Trifolium subterraneum* and *Trifolium* species. Blackberry, clover leaves and nodules, moss (*Lembophyllum divulsum*, *Campylopus* species and *Camptochaete arbuscula*), dicot (*Acacia dealbata* phyllodes), monocot (couch grass, *Cynodon dactylon*; blue tussock grass, *Poa poiformis* and *Poa annua* were also detected by Quin (1985).

(d) Fungi

It appears that fungi are also an important component in the diet of *I. obesulus*. Opie (1980) observed fungus (Family Endonaceae) in an analysis of *I. o. obesulus* scats from southern Victoria. Quin (1985) detected evidence of the underground puffball mushroom of the class Gasteromyceta in scats from south eastern Tasmania, finding spores similar to a *Hymenogaster* spore and spores similar to a *Rhizopogon* type puffball. Zygomycete fungal spores and hyphae of Endotrophic mycorrhizas were also detected by Quin (1985).

(e) Vertebrates

Small vertebrates are also eaten by bandicoots. Sanders (1952) found a small lizard tail (*Leiolopisma* species) in the stomach contents of a specimen of *I. macrourus*. Heinsohn (1966) recorded the remains of a skink (*Leiolopisma* species) and a frog (Hylidae) in the stomach contents of *I. o. affinis* in north west Tasmania. Rayment (1954) stated that bandicoots have been observed to devour small birds and Watts (1974) found small amounts of down feathers in scats of *I. o. nauticus* which probably came from moribund or recently deceased penguin chicks.

(f) Water

Bandicoots will occasionally drink water in captivity but in the wild they seem to obtain sufficient metabolic water from their diets and from dew (Gordon, 1971; Hulbert and Dawson, 1974; Hulbert and Gordon, 1972; Maloney, 1982; Stanbury, 1970; Walker, 1964). On Franklin Island there is no permanent fresh water available to *I. o. nauticus* (Copley *et al.*, 1990) yet bandicoots thrive there.

3.1.2 Feeding Behaviour

Heinsohn (1966) observed one individual *I. o. affinis* digging with its forefeet in wet soil in the wild in north western Tasmania, using its nose as a probe and keeping its eyes closed while digging. Whenever a food item was found the digging stopped while the food was eaten. This particular bandicoot concentrated its digging in one small area and, in 36 minutes, it moved a linear distance of 446 cm, dug 21 holes ranging in diameter from 2.5 cm to 25 cm and depth of 3.8 cm to 7.7 cm. In one three minute period five earthworms were caught and eaten at a rate of one earthworm every 36 seconds (Heinsohn, 1966).

Food is apparently detected in the soil by olfaction (Buchman and Grecian, 1974; Gordon and Hulbert, 1989; Heinsohn, 1966; Jones, 1924; Maloney, 1982; Stodart, 1977; Quin, 1985), aided by the tactile sensations imparted by the vibrissae (Jones, 1924). Quin (1985) investigated the efficiency of *I. o. affinis* as a food gatherer and found that the mean number of diggings per night is extremely low despite the number of findings of prey items being relatively high. Quin (1985) concluded that random digging by *I. o. affinis* appeared to be minimal.

I. obesulus has been observed to employ a rapid scrambling motion of its forefeet when dealing with live prey or unusual objects which are regarded with suspicion (Heinsohn, 1966; Jones, 1924). The bandicoot rolls and kneads its food item until the object is reduced to an almost shapeless mass, then either eats it or rejects it (Heinsohn, 1966; Jones, 1924). Heinsohn (1966) believes that this behaviour may help to account for the inclusion of spiders, scorpions and bullants with stings in bandicoots' diets.

3.1.3 Seasonal Feeding Strategy

It is well recognised that bandicoots exploit different food resources opportunistically, so preferences for particular food items and dietary variations reflect the spatial and temporal availability of various food items (Gordon, 1974; Guiler, 1958; Heinsohn, 1966; Lee and Cockburn, 1985; Maloney, 1982; Quin, 1985, 1988). Lobert (1985) found that the abundance of invertebrates in sandy soil in southern Victoria is strongly influenced by soil moisture and, generally, the abundance of soil fauna is highest in late winter to early summer. However, food availability is reduced in the summer months as invertebrates either die or burrow deeply when the soil dries out (Lee and Cockburn, 1985; Lobert, 1985).

When preferred food types diminish bandicoots may survive on less preferred types. Lobert and Lee (1990) found that during a drought bandicoots ate millipedes, scorpions, centipedes and bullants which are all usually avoided or ignored. Heinsohn (1966) found that in north western Tasmania, earthworms (Lumbricidae: Annelida) were the most important food item in wet months while insects such as army worm (*Persectania ewingii,* Noctuidae, Lepidoptera) and bullants (*Myrmecia forficata,* Formicidae, Hymenoptera), and large quantities of boxthorn berries were found in the stomach contents of *I. o. affinis* in summer months. Maloney (1982) found that ants were the major food items associated with drought in Tasmania.

In Victoria adult ground beetles appear to be a major dietary component for much of the year but, in late summer and early winter, ant pupae and earthworms become temporarily important (Stoddart and Braithwaite, 1979). Opie (1980) found that the root feeding chafer beetle lavae (Melolonthinae, Scarabaeidae, Coleoptera) was most prevalent in the diet of *I. o. obesulus* from winter to autumn while ant pupae (Formicidae, Hymenoptera), adult beetles (Melolonthinae, Scarabaeidae, Coleoptera) and adult bugs (Hemiptera) were dominant in spring and early summer. Subterranean fruiting bodies of hypogeal fungi *Glomulus* and *Endogone* were eaten in winter and spring when the soil was moist (Opie, 1980).

Quin (1988) observed the following seasonal variations in the diet of *I. o. affinis* in southern Tasmania. Araneae, unidentified fungus and clover occurred in a higher incidence of scats in spring than autumn and winter. Coleoptera and Zygomycete fungus occurred in a higher incidence of scats in autumn and winter than in spring. Scats containing Carabidae larvae were more prevalent in winter, whereas scats containing Hepialidae and blackberries were less prevalent in winter and more prevalent in autumn respectively.

3.1.4 Feeding Sites

Guiler (1958) found that *I. o. affinis* feeds in clearly defined areas and that the location of these sites may change from time to time. While some areas appear to be used almost constantly as feeding sites, other large areas are only used at irregular intervals (Guiler, 1958). Heinsohn (1966) found that *Perameles gunnii* normally concentrate their feeding in small areas, although during favourable periods when food is widely abundant, bandicoots can forage almost anywhere (Heinsohn, 1966). In dry seasons however, food supplies are concentrated in localised areas which may be widely separated (Heinsohn, 1966).

3.2 Method of Examining Feeding Ecology

3.2.1 Diet Analysis

I. o. obesulus scats were collected on 15 occasions during the present study (nine scats from the Mount Lofty Ranges and six scats from the South East). These scats were dissected in a 70% ethanol solution to recover invertebrate and plant remains. Invertebrate body parts such as mandibles, heads, legs and elytra were identified by the entomology section of the SAM.

3.2.2 Feeding Sites and Diggings

Lobert (1985) found that dry soil conditions limit bandicoot food availability. Heinsohn (1966) believed that the reason bandicoots have been able to persist in areas of high rainfall while they have vanished or declined drastically in arid and semi-arid regions is strongly linked to the increased food availability associated with higher soil moisture status.

During the present study general observations were made of the distribution, size and frequency of bandicoot diggings encountered in the field. The soil moisture status of each feeding site was indirectly assessed by noting its aspect (recorded as north, north-east, east, south-east, south, south-west, west and north west) and its slope position (recorded as upper, middle, lower valley slopes, or plain surface). Sites which occurred on lower valley slopes or on a plain surface were considered to be moister than those sites which occurred on middle and upper valley slopes, due to downslope drainage. Slopes which faced south were considered to be cooler than those sites which faced north, due to the reduced solar radiation which they received. Therefore, sites which occurred on south facing lower valley slopes were considered to be the coolest and moistest sites, while sites with northern aspects on upper slopes were considered to be the warmest and driest sites. A one tailed χ^2 test was then used to examine the following hypothesis.

H_0: No significant association exists between aspect and slope position in determining the location of bandicoot feeding sites.

H_1: An association exists between aspect and slope position, with significantly more sites found lying on moist land facets than on dry land facets.

3.3 Results and Discussion

3.3.1 Diet

(a) Invertebrates

Table 3.1 shows the invertebrate groups identified from *I. o. obesulus* scats collected during the present study compared to the invertebrate groups identified in the diets of *I. macrourus* by Sandars (1952); *I. o. obesulus* by Opie (1980); *I. o. affinis* by Heinsohn (1966) and Quin (1985, 1988); and, *I. o. nauticus* by Watts (1974). All invertebrate groups recorded during the present study have previously been identified by the above authors. Siphonaptera, Arachnida, Carabiidae (Coleoptera) and Curculionidae (Coeoptera) have each only been recorded once in previous studies. Few larval parts were identified during the present study compared to adult parts which probably reflects their differential digestability, rather than

TABLE 3.1

Invertebrate Groups Eaten by *I. obesulus*

	Present Study				**Previous Studies**			
Previous Authors					**He**	**Op**	**Qu**	**Wa**
Region	**MLR**	**MLR**	**MLR**	**SE**	**Tas**	**Vic**	**Tas**	**SA**
COLEOPTERA Scarabaeidae	⊗L1		⊗A1 ⊗L1	⊗	⊗	⊗	⊗	
Carabiidae		⊗A	⊗A	⊗			⊗	
Curculionidae				⊗A			⊗	
Other Coleopterans	⊗A		⊗A	⊗A				⊗
HEMIPTERA	⊗A2		⊗A2	⊗A			⊗	⊗
HYMENOPTERA	⊗A3		⊗A3	⊗A3 ⊗A4		⊗	⊗	
Myrmicinae		⊗A5	⊗A5 ⊗A6	⊗A5 ⊗A6	⊗	⊗	⊗	
ARACHNIDA		⊗7	⊗8	⊗8		⊗		
SIPHONAPTERA	⊗						⊗	

Notes

MLR = Mount Lofty Ranges
SE = South East

He = Heinsohn (1966) *I. o. affinis*
Op = Opie (1980) *I. o. obesulus*
Qu = Quin (1985, 1988) *I. o. affinis*
Wa = Watts (1974) *I. o. nauticus*

⊗ = Invertebrate group recorded
A = Adult Stage
L = Larval Stage

1 = *Heteronyx Spp*, Melolonthinae, Scarabaeidae
2 = Cydnidae, Hemiptera
3 = Wasp, Hymenoptera
4 = Bee, Hymenoptera
5 = Ant, Hymenoptera
6 = *Monomorium Spp*, Myrmicinae, Hymenoptera
7 = Harvestmen, Opiliones, Arachnida
8 = Spiders, Araneida, Arachnida

their differential availability. Quin (1985) was unable to detect earthworm (Lumbricidae) gizzard rings and chaetae in the scats of captive *I. o. affinis* which had been fed worms. Therefore, soft bodied prey such as earthworms may often be totally digested and are hence absent in bandicoot faeces (Quin, 1985, 1988).

Ants were recorded in *I. o. obesulus* scats from both the South East and the Mount Lofty Ranges. One ant genus (*Monomorium*, Myrmicinae, Hymenoptera) was recorded in both regions. Harvestmen (Opiliones), spiders (Araneida) and bees and wasps (Hymenoptera) were also detected in both regions. These invertebrate groups are generally considered to be less preferred food types of *I. obesulus* (Heinsohn, 1966; Maloney, 1982). Trapping in the South East coincided with drought conditions (with no rain having fallen for approximately five months) and it is possible that preferred food groups were in low abundance there due to low soil moisture content. Major food types identified by previous authors in Victoria and Tasmania, but not recorded in South Australia, include: earthworms (Lumbricidae, Annelida), Diptera, Orthoptera and Lepidoptera.

(b) Plants

The only plant parts identified from *I. o obesulus* scats collected during the present study were *Chrysanthemoides monilifera* seeds found in two scats collected from the Mount Lofty Ranges in October 1988. This exotic plant species produces fleshy fruits from approximately October to January in the Mount Lofty Ranges. These two scats contained five and six *C. monilifera* seeds respectively with each seed measuring three to four mm in diameter. Fragments of *Pteridium esculentum* fronds and moss were also observed on several occasions, but it appeared that they had adhered to the surface of the scats while lying in the bottom of traps.

3.3.2 Distribution of Feeding Sites and Diggings

The relative soil moisture status of all feeding sites encountered during the present study, classified by slope position and aspect, is summarised in Tables 3.2, 3.3 and 3.4.

(a) Mount Lofty Ranges

Diggings in the Mount Lofty Ranges were ususally found clustered in small pockets with very few diggings interspersed between these feeding sites. Diggings ranged in depth from approximately five to 15 cm. No significant association was found to exist between slope position and aspect of Mount Lofty Ranges feeding sites ($\chi 2 = 0.17$; $\alpha = 0.05$; df = 1). This indicates that even relatively dry sites in the Mount Lofty Ranges are moist enough to act as bandicoot feeding sites. However, most of these sites were surveyed during wet seasons and it is not known if they are used in dry seasons.

(b) South East

Diggings in the South East, like those in the Mount Lofty Ranges, were usually found clustered in small pockets with very few diggings lying between clearly defined feeding sites. A significant association was found to exist between slope position and aspect ($\chi 2 = 88.14$, df = 1; $\alpha = 0.05$) with virtually all South East feeding sites located on moist land facets. The

TABLE 3.2
Relative Soil Moisture at Mount Lofty Ranges Feeding Sites

	SLOPE ASPECT	
SLOPE POSITION	Warm	Cool
Dry	5	17
Moist	2	10

$\chi2$= 0.17; (NS); α = 0.05; df = 1

TABLE 3.3
Relative Soil Moisture at South East Feeding Sites

	SLOPE ASPECT	
SLOPE POSITION	Warm	Cool
Dry	3	9
Moist	1	86

$\chi2$ = 88.14; (S); α = 0.05; df = 1

TABLE 3.4
Relative Soil Moisture at Kangaroo Island Feeding Sites

	SLOPE ASPECT	
SLOPE POSITION	Warm	Cool
Dry	20	7
Moist	11	29

$\chi2$ = 14.06; (S); α = 0.05; df = 1

Notes

Slope Position
Dry = Upper and Middle Valley Slopes
Moist = Lower Valley Slopes and Flats

Slope Aspect
Warm = North, North West, North East, East and West Facing Slopes
Cool = South West, South and South East Facing Slopes

S = Significant
NS = Not Significant

topography of the South East study area is less complex than the Mount Lofty Ranges, and a number of the slopes sampled were nearly flat with poorly defined aspects. However, 96% of South East feeding sites had southerly aspects, indicating that bandicoot food availability is greatest at moist sites. Drought conditions were prevailing in the South East during this survey and drier areas may be used as feeding sites in wet seasons.

Large numbers of diggings were found at all trapping sites in the South East and it is apparent that bandicoots feed in much of the native vegetation which remains in the study area. This includes areas along roadside reserves and fire tracks within mature pine plantations. Several anecdotal records obtained from foresters confirm that bandicoot diggings can sometimes be found on plantation fire tracks, several hundred metres from the nearest patch of native vegetation. This may indicate that fire tracks are potential dispersal corridors for *I. o. obesulus* through pine plantations. These fire tracks often support dense ground cover of native species such as *Pteridium esculentum* and *Xanthorrhoea australis*. The relative importance of particular plant species for the provision of bandicoot food items can not be accurately assessed until more is learnt of the plant/invertebrate inter-relations which regulate bandicoot diet. However, diggings were often seen around the bases of *Leptospermum juniperinum, Bossiaea cinerea, Acacia melanoxylon* and *Acacia mearnsii,* suggesting that bandicoots were feeding amongst their root systems.

Diggings in the South East were found to be particularly deep, sometimes exceeding 40 cm in depth. As drought conditions were prevailing in the South East during this survey, soil invertebrates were possibly scarce near the ground surface, forcing bandicoots to dig further for their prey.

Heinsohn (1966) observed one *I. o. affinis* digging in sandy soil , using its forefeet like a dog to produce a hole 31 cm to 51 cm deep, about 13 cm diameter at the top and 8 cm diameter at the bottom. While digging such a deep hole the bandicoot would completely disappear into the hole at times. Heinsohn (1966) found that in areas of scrub where *I. o affinis* is active, the soil is usually pockmarked with holes of various sizes, indicating the relative depths of a range of prey items.

(c) Kangaroo Island

In contrast to the Mount Lofty Ranges and the South East, bandicoot diggings on Kangaroo Island were rarely found in concentrations and usually only one or two diggings were observed at each feeding site. Countless echidna diggings were found at all sites on the island though, and it is likely that they obscured some bandicoot diggings. However, the distribution and density of bandicoot diggings found during this survey suggests that while *I. o. obesulus* is widespread on Kangaroo Island, food items are seldom locally abundant and feeding sites are therefore not well defined compared to the Mount Lofty Ranges and the South East. A significant asssociation was found to exist between slope position and aspect ($\chi 2 = 14.06$, df = 1; $\alpha = 0.05$) with approximately half of all Kangaroo Island feeding sites being located on moist land facets. This indicates that bandicoot food availability on Kangaroo Island is greatest at moist sites.

The sparse distribution of diggings observed on Kangaroo Island during this survey may have been a seasonal variation, and some sites may display dense concentrations of diggings during favourable periods. However, it is also the observation of Kangaroo Island NPWS Officers that bandicoot diggings on the island are usually sparsely distributed

(Dennis and Baxter, personal communication) and not as concentrated as in the Mount Lofty Ranges and the South East. Relatively dry soil conditions, created by the low rainfall received over much of the island, are likely to limit food availability which consequently affects the distribution of bandicoot feeding sites and thus the density of the local bandicoot population.

3.4 Conclusion

In South Australia *I. o. obesulus* eats a wide range of invertebrates, most of which have been previously recorded in the diets of bandicoots in other states. The distribution of diggings observed during the present study indicates that food sources in South Australia are restricted to small pockets, with prey items occurring in lower concentrations between defined feeding sites. Taylor (1992) has recently shown that the distribution of diggings of the Tasmanian Bettong (*Bettongia gaimardi*) closely reflects the clumped distribution of sporocarps of hypogeae fungi, the major dietary component of bettongs. Occurrence of this food source is related to soil moisture and soil fertility status (Taylor, 1992).

The patchy distribution of bandicoot diggings also suggests close ties to soil moisture, and possibly soil fertility. As food sources fluctuate, the location of productive bandicoot feeding sites tends to shift. However, sites with high diversities of prey items may provide a continuous but changing food supply. Other sites with low diversities of food sources may only be used occasionally by bandicoots according to episodic booms. This pattern suggests that only small sections of an area of habitat are capable of supporting high bandicoot densities at any one time.

CHAPTER 4

NESTS AND SHELTER

4.1 Review of Bandicoot Nesting

Isoodon and *Perameles* construct nests out of large bundles of dry sticks, coarse grass, leaves and litter to create moundlike structures which are usually concealed by undergrowth or grass tussocks (Collins, 1973; Lee and Cockburn, 1985; Ride, 1970; Triggs, 1984; Troughton, 1973). In dry or open places nests are usually situated in deep depressions with their tops lying flat and level with the ground surface, but in areas of closed vegetation nests usually lie in shallow depressions with low mounds of litter raised 8 to 30 cm above the ground surface (Gordon and Hulbert, 1989; Troughton, 1973). Gordon (1974) found the nests of *I. macrourus* to be approximately 40 cm long while Stodart (1977) found the nests of the Eastern Long-nosed Bandicoot (*Perameles nasuta*) ranged from 30 to 60 cm long, with males' nests being larger than females' nests.

According to Jones (1924), Ride (1970) and Triggs (1984), the nests of *I. obesulus* lack a permanent hole for entry and exit, and the occupants burrow in and out at any point, closing the temporary holes behind them. However, nests of *P. nasuta* and *I. macrourus* were found by Gordon (1974) and Stodart (1966) to have fixed entry and exit holes, although bandicoots were likely to break out at any point of their nests when disturbed. Gordon (1974), Jones (1924) and Stodart (1966) considered that *Isoodon* nests do not have a definite permanent chamber and that the occupants which they observed simply lay in a hollow in the middle of the collected material. Lobert (1990) found that in Victoria, *I. o. obesulus* nests had an opening at each end, leading to a small dry chamber. When an animal entered or emerged from a nest, Lobert (1990) noticed that the roof and walls of these openings collapsed, leaving the opening inconspicuous and concealing the nest.

Jones (1924) commented that bandicoots are aware of the approach of bad weather, for before heavy rain they add to their nest piles with feverish activity. One *I. obesulus* which Jones (1924) observed in captivity always left its open air nest and retreated to a nest box in advance of bad weather. The two *I. macrourus* nests which Gordon (1974) found during wet weather had a layer of soil scraped over the top, possibly helping to waterproof them. Stodart (1966) also found that the nests of captive *P. nasuta* were sometimes partly covered with soil.

Troughton (1973) considered that, except for the pits dug while feeding, *Isoodon* do not burrow, and when hunted from the nest they seek shelter in deep undergrowth, or in holes in the ground and in hollow logs. *Perameles and Isoodon* are known to make use of rabbit burrows for shelter or nests sites when they are available (Collins, 1973; Heinsohn, 1966; Stodart, 1966, 1977; Troughton, 1973). In south western Western Australia Kirsch (1968) observed *I. o. fusciventer* to construct burrows in sandy soil during very hot weather. Gordon (1974) found that if inadequate nesting materials and sites were supplied to captive *I. macrourus*, they resorted to digging primitive nesting burrows of about 0.3 to 0.5 m deep. However, no bandicoots were known to burrow in the wild during Gordon's (1974) study. Gordon (1974) believed that Kirsch's (1968) observation that burrowing of *I. obesulus* in captivity is a response to hot weather, is not supported by the data for *I. macrourus* which burrowed as a response to a lack of acceptable surface nesting materials and sites.

4.2 Method of Examining Nests

Whenever bandicoot nests were encountered during the present study, general descriptions were made of each nests' construction and dimensions. The plant species which these nests were concealed beneath were recorded. Other nest features, such as a covering of dirt, were also noted.

4.3 Results and Discussion

4.3.1 Mount Lofty Ranges

Only seven nests were located during the Mount Lofty Ranges Trapping Survey. Each of these nests was comprised of a low, round to oval, mound of litter material set in a shallow depression ten to 15 cm deep and measuring between 35 to 45 cm in diameter. The litter used in the construction of these nests was highly variable, with bandicoots obviously taking advantage of locally available plant material. However, the leaves of *Eucalyptus obliqua* and of *Xanthorrhoea semiplana* were found in virtually all nests. Each nest had a layer of dirt scraped over it as described by Gordon (1974) and Stodart (1966), possibly for waterproofing purposes. No entrance or exit holes were visible and no inner chambers were apparent. Four of these nests were hidden under the foliage of *X. semiplana*, one under *Lepidosperma semiteres*, one under *Pteridium esculentum* and one under *Rubus ulmifolius*. The combination of a dirt covering and concealment beneath dense vegetation made these nests extremely difficult to detect and accounts for the low number of nests located in the Mount Lofty Ranges.

Two bandicoots were also observed to make use of vacant rabbit burrows for shelter. These observations were both made during a radio-telemetry exercise conducted during the present study at Scott Creek CP (described in section 7.2.2 of this thesis). In the first instance, a transmitter which had become detached from a bandicoot was recovered from deep within a rabbit burrow. In the second case a bandicoot was observed leaving its nest at the onset of a rainstorm and entering an adjacent rabbit burrow which presumably offered waterproof shelter. This animal moved back to the nest about 30 minutes after the conclusion of the rainstorm. It is interesting to compare this behaviour with Jones' (1924) observation about the weather forecasting behaviour of *I. o. obesulus*.

4.3.2 South East

Approximately 30 bandicoot nests were located during the South East survey and nearly all of these were situated beneath the foliage of *Xanthorrhoea australis*. This is clearly a very important plant species for bandicoot nest sites in the South East. Only mature *Xanthorrhoea australis* which had well developed "skirts" of dead leaves reaching down to the ground were used for nest sites. Fire inevitably destroys these skirts. Therefore, successional stage of vegetation after burning may be closely related to the availability of nest sites in the South East.

All of the nests encountered in the South East had similar dimensions to those nests located in the Mount Lofty Ranges. However, their building material was usually comprised entirely of broken sections of *X. australis* leaves, occasionally interspersed with *Eucalyptus baxteri* leaves. All nests located in the South East were covered by a thin layer of soil. No entrance or exit holes, or inner chambers were observed.

At several patches in the north of the South East study area, where *X. australis* is absent or uncommon (for example Whennans NFR, Byrne's and Paltridge's), extensive runways and tunnels were found undermining *X. semiplana*. These tunnels may provide *I. o. obesulus* with alternative resting sites in areas where *X. australis* does not grow.

4.3.3 Kangaroo Island

No nests were located during the Kangaroo Island trapping survey although suitable nest positions occurred at most sites, beneath species such as *X. semiplana* and *L. semiteres*. It is unclear why nests were not observed on Kangaroo Island. Rabbit burrows are not available on the island for use as alternative nest sites. Ground layer vegetation was sparser on Kangaroo Island than in the Mount Lofty Ranges or in the South East (see section 5.5.2 of this thesis), and was therefore unlikely to obscure nests. A similar amount of time was spent searching for nests on Kangaroo Island as was spent in the South East where 30 nests were found. This suggests that bandicoots on Kangaroo Island either nest away from feeding sites, or are relatively sparsely distributed. The latter case is supported by the sparse distribution of diggings observed on the island.

4.4 Conclusion

In South Australia, *I. o. obesulus* constructs nests similar to those used by bandicoots in other states. All nests located during the present study were well concealed beneath dense vegetation. Each nest was covered with a thin layer of soil, improving camouflage and water proofing qualities. In the Mount Lofty Ranges and in the South East, Rabbit burrows also offer shelter from rain, predators and possibly even fires.

CHAPTER 5

HABITAT

5.1 Habitat Preferences and Requirements

Braithwaite (1983, p 94) observed that

> "the Southern Brown Bandicoot prefers scrubby habitats that are burnt out from time to time. During the early stages of regeneration, after fire, the diversity of growing vegetation supports abundant insect food for bandicoots and constitutes a very favourable habitat".

However, competitive exclusion may restrict individuals to different sub-optimal habitats and, consequently, the area in which a bandicoot is found is not necessarily its preferred habitat (Maloney, 1982; Quin, 1985).

Braithwaite and Gullan (1978) and Stoddart and Braithwaite (1979) found that *I. o. obesulus* in Victoria prefer to inhabit dry regenerating heathland of a young successional stage. Gordon and Hulbert (1989) noted that, while bandicoots may have a preferred habitat, they are sufficiently flexible to make widespread use of alternate habitats. *I. obesulus* has been reported to occur in: thick scrubby places on dry elevations (Troughton, 1973); sclerophyll forests, woodlands and heaths, wherever there is good ground cover (Ride, 1970); wet and dry sclerophyll forests, humid woodlands and heaths (Aitken, 1979); fertile spots where vegetation is abundant (Jones, 1924); open timbered country, overlapping into thick scrub (Guiler, 1958); and areas of high timber and tangled *Lantana camara* interspersed with an occasional cycad (Dixon, 1978). Bandicoots can also exploit alienated areas such as farmland and rubbish tips (Lee and

Cockburn, 1985), pastures and urbanised areas (Heinsohn, 1966; Maloney, 1982).

5.1.1 Ground Layer Density

I. obesulus is recognised to be a secretive animal which inhabits areas of dense ground cover and rarely ventures far from shelter (Heinsohn, 1966; Maloney, 1982; Quin, 1985). *I. obesulus* therefore selects its habitats on the criterion of low dense ground cover to accommodate its secretive nature. Heinsohn (1966) found *I. o. affinis* living in a dense African Boxthorn and Gorse hedgerow system in an area of open paddocks in north western Tasmania. While *I. o. affinis* usually avoid open areas and prefer areas with a taller vegetation cover, Heinsohn (1966) considered that the presence of thorny hedgerows at this site offerred nest sites and refuge from danger. Heinsohn (1966) added that whenever *I. o. affinis* were seen in a paddock, they were invariably just on the edge by cover.

Heinsohn (1966) considered that *I. o. affinis* does not have obligate associations with native vegetation and can adapt to habitat changes produced by humans. Heinsohn (1966) found that *I. o. affinis* was inhabiting urban terrain at the township of Smithton. The availability of lots of cover and many hiding places attributed to the presence of bandicoots at Smithton (Heinsohn, 1966).

In south eastern Tasmania Maloney (1982) trapped *I. o. affinis* predominantly in areas of open forest and shrubland which had good understorey cover, but also in areas of low ground cover, open grassland and pasture, but not in a clearing. Maloney (1982) also recorded *I. o. affinis* in a fire affected area but considered that "substantial ground covering...appeared to be essential before substantial movements into a fire affected area occurred" (p.147).

Quin (1985) also trapped *I. o. affinis* in south eastern Tasmania (in descending order of importance) on open golf course fairways, in regenerating heath, in forest adjoining pasture, in open wet sclerophyll forest, in scrub adjoining pasture and in open pasture, but not in dense wet sclerophyll forest. Whenever Quin (1985, p 127) sighted an *Isoodon* they were "generally adjacent to, or a short distance from dense vegetation e.g. Blackberry clumps when observed in the pasture or when observed on the golf course, only a short distance from dense vegetation".

Gordon (1974) found that *I. macrourus* displays similar habitat requirements to *I. obesulus* and is found in areas with moderately dense plant cover near ground level, such as grass or other herbage growing to 30 cm or more, or low shrubbery (including *Lantana camara*), but this layer must be sufficiently open to permit free movement.

5.1.2 Floristic Composition

While ground layer structure obviously plays a major role in bandicoot habitat selection, the floristic composition of vegetation may also be correlated with the food resources present (Braithwaite and Gullan, 1978). Quin (1985) found that the floristic group most often used by *I. obesulus* possessed the densest cover of Blackberry which offers bandicoots both food and shelter. Quin (1985) also found *Trifolium repens* in this vegetation group and detected seeds and leaves of *Trifolium repens* in *I. o. affinis* scats. Quin (1985) found that low diversity areas of pasture and adjoining heath were avoided by *I. o. affinis*, presumably because these areas could not meet food and shelter requirements.

At Cranbourne in southern Victoria, *I. o. obesulus* has shown a preference for regenerating heathland dominated by *Leptospermum myrsinoides* (Braithwaite and Gullan, 1978; Lobert and Opie 1986; Stoddart and Braithwaite, 1979). Lobert and Opie (1986) found that some primary bandicoot food items (such as adult beetles, ants, beetle larvae, dipteran larvae, fungus and vascular plant materials) were more abundant at preferred sites.

5.2 Role of Fire in Modifying Bandicoot Habitat

I. obesulus is adapted to utilizing sub-optimal habitats in unpredictable environments where adjacent, unoccupied, optimal patches frequently become available for reinvasion (Gordon and Hulbert, 1989; Stoddart and Braithwaite, 1979). In this way *I. obesulus* can take advantage of the benefits of fire. Stoddart and Braithwaite (1979) proposed that young, dispersing bandicoots colonise habitats soon after fire, attracted by the high productivity of regenerating vegetation. Fire massively releases nutrients bound up in mature trees, fallen logs and litter, creating a tremendous surge in plant and animal populations, and increased diversity (Recher *et al.*, 1975). However, as habitats mature, biomass productivity declines and habitat resources are reduced for bandicoots (Braithwaite, 1983). As Gill (1979, p 270) pointed out, the "absence of fire can be just as much a hazard as its presence for some organisms".

5.2.1 Effects of Fire on Vegetation

Specht *et al.* (1958) considered that heath layers in mediterranean climates reach peak biomass between five and 15 years of succession. Jackson (1968) found that in wet temperate Tasmania, heathlands prevail when the land is burnt each 20 years or so, and that fire regeneration provided conditions for rapid increases in animal populations. Opie (in Lee and Cockburn, 1985) found a high abundance of Melolonthine larvae (Scarabaeiidae), a preferred bandicoot prey type, in regenerating heath, and that ten year regeneration habitats showed consistantly higher larvae abundances than 15 year regeneration habitats. Thompson *et al.* (1989) considered that habitats similar to their Kuitpo bandicoot study site in the Mount Lofty Ranges re-established climax vegetation within 10 years of a fire. Braithwaite (1983) suggested that for a particular area to support a stable population of *I. obesulus* parts need to be recently burnt creating a changing mosaic of suitable habitat patches.

Purdie and Slatyer (1976) found that after a fire in south eastern Australia virtually all plant species present before the fire recovered from propagules and all trees and shrubs began regrowth within a few months to a year. Specht *et al.* (1958) recorded peak floristic diversity in heath soon after fire with numbers of plant species then declining with time.

Fire intensity has variable effects on vegetation regeneration though and Cowley *et al.* (1969) found that a summer wildfire at Daylesford, Victoria introduced long lasting effects by eliminating living vegetation and ground litter, and seriously depleting microfauna and small mammals. Prior to this wildfire, low intensity spring fuel reduction burns had only removed the dry surface litter, heaps of bark at the bases of trees, small shrubs and grasses (Cowley *et al.*, 1969). Low intensity fires seldom burn more than 75% of forest communities and leave a mosaic of burnt patches, but high intensity wildfires leave few unburnt refugia (Cowley *et al.*, 1969). Thompson *et al.* (1989) point out that if areas are burnt too often with low intensity fuel reduction burns the vegetation will drastically alter, particularly the understorey structure and floristics (Catling *et al.*, 1982), resulting in a relatively uniform understorey of fast growing, short lived plants (Recher and Rohan-Jones, 1981; Thompson *et al.*, 1989).

5.2.2 Effects of Fire on Invertebrates

Thompson *et al.* (1989) considered that litter abundance and understorey structure influence food, shelter and habitat for bandicoot prey species. A number of studies have reported on the effects of fire on soil and litter invertebrate fauna (Campbell and Tanton, 1981; Cowley *et al.*, 1969; Leonard, 1970, in Newsome *et al.*, 1975; Opie, in Lee and Cockburn, 1985; Springett, 1976), and their findings are quite variable. Cowley *et al.* (1969) found that after a spring fuel reduction burn at Daylesford, Victoria, living litter fauna were still evident. Leonard (1970) observed a decline in the abundance and diversity of litter organisms following a mild fire, but a natural decline was also witnessed a few months later on an adjacent unburnt patch. Springett (1976) investigated the effects of five to seven year cycle low intensity prescribed burning in Karri (*Eucalyptus diversicolor*) and Jarrah (*Eucalyptus marginata*) forests and found that diversity and density of soil fauna are reduced after a fire and do not recover to their preburn values during a normal prescribed burning cycle. Springett (1976) therefore considered that burning on a five to seven year rotation is likely to permanently simplify the litter flora and fauna.

Campbell and Tanton (1981) found that invertebrate populations are dynamic on both burnt and unburnt sites, and may show considerable spatial and temporal variability which masks the effects of subsequent fires, especially if the prefire situation is unknown. Invertebrate communities recover quickly after a fire and reach abundance levels which are comparable to the range of variation found in similar communities which are not burnt (Campbell and Tanton, 1981). Campbell and Tanton (1981) considered that the drastic reductions in invertebrate abundance and diversity which Springett (1976) attributed to fire may be an artefact of low intensity data sampling and extraction. Campbell and Tanton (1981) therefore considered that Springett's (1976) work was cursory and superficial in the light of their own results.

While it appears that the effect of fire on invertebrate communities can not be predicted from the results obtained at another fire, Campbell and Tanton (1981) found that, for their study at least, fire in spring was less detrimental and had less impact on litter fauna than fire in winter. Burning in winter corresponded to a period of minimum activity when a large component of the total invertebrate population is in a resting stage or shows low mobility and is unable to avoid fire. Spring corresponds to a period of maximum activity when many invertebrates are in a reproductive state and the effects of fire on invertebrate population levels are soon overcome (Campbell and Tanton, 1981).

5.2.3 Effects of Fire on Bandicoots

While few studies have been conducted on the effects of fire on bandicoot populations, Newsome *et al.* (1975) stress the variable influence of intensity and duration of fires, and the stage of habitat succession prior to the fire. Newsome *et al.* (1975) attributed a decline in bandicoot numbers (*I. o. obesulus* and *Perameles nasuta*) following a severe fire at Nadgee in south eastern New South Wales to destruction of their nests and cover. Outbreaks of invertebrate populations (Coccinellidae, Noctuidae, Symphata) began six weeks after this fire and Newsome *et al.* (1975) felt that perhaps bandicoot food supply had not diminished too much. Bandicoot diggings were seen soon after the fire and within a year when ground vegetation had regrown densely it appeared that bandicoots had increased in activity if not in abundance (Newsome *et al.*, 1975). However, Fox (1978) found that *I. macrourus* disappeared following a fire in coastal heathland at the Myall Lakes National Park and, after 36 months, was still extinct.

Aitken *et al.* (1986) noted that bandicoots have been found dead after high intensity prescribed burns, whereas individuals have been retrapped after low intensity prescribed burns. At Kuitpo in the Mount Lofty Ranges, Aitken *et al.* (1986) and Thompson *et al.* (1989) found that *I. o. obesulus* persisted on an experimental trapping grid after a low intensity spring prescribed burn in which most of the understorey was removed and, while population numbers were low throughout the study, no effects of the fuel reduction burn were obvious from the data. Bandicoot numbers rose on an adjacent unburnt control trapping grid from zero to between three and five individuals known to be alive and there is an indication that this bandicoot population was increasing just prior to the fuel reduction burn (Thompson *et al.*, 1989). Two animals were recorded moving from the exprimental grid to the control grid where they became residents after the fuel reduction burn (Thompson *et al.*, 1989).

Thompson *et al.* (1989) observed an increase in the abundance of bandicoot diggings on their experimental grid after the fuel reduction burn. Thompson *et al.*(1989) suggested that removal of the understorey layer had either made diggings more visible, or that the fire had forced bandicoots to increase their search effort for limited food. This latter explaination seems plausible as the destruction of understorey food sources and litter food sources would force bandicoots to obtain all of their food from below ground. In February 1983, 16 months after the Kuitpo fuel reduction burn, the Ash Wednesday bushfires burnt both the experimental and control grids, as well as large areas of surrounding country. No bandicoots have been caught in this area since or signs seen of their activity or presence (Thompson *et al.*, 1989).

5.3 Effects of Other Types of Habitat Disturbance

Fire plays an important role in creating these highly productive, regenerating habitats for bandicoots but other types of habitat disturbance may also benefit bandicoots. Opie (in Lee and Cockburn, 1985) found that an experimental clearing of habitat at Cranbourne, Victoria arrested a decline and stimulated the growth of the local bandicoot population. Lee and Cockburn (1985) concluded that *I. obesulus* shows a clear preference for ecotonal or early seral habitats which can provide dense cover in the ground stratum and a diversity of food sources to accommodate the opportunistic omnivore dietary requirements of this species.

5.4 Method of Examining Habitat

The floristic composition and overstorey structure of feeding sites located during the present study were recorded, along with data on the density of ground layer vegetation and successional stage of regeneration from fire. Preference for particular habitats was investigated by comparing bandicoot capture rates in each community to see if any particular habitats supported higher bandicoot abundances than others. The following three hypotheses were then investigated.

1. Certain floristic groups are used more commonly and support higher bandicoot abundances than other habitats. Studies of *I. o. obesulus* in southern Victoria suggest that heathland communities are preferred habitat types (Stodart and Braithwaite, 1979).

2. Certain sites are preferred by bandicoots due to the quality of cover which they provide. Previous studies have suggested that sites with dense ground cover are preferred, but not so dense as to restrict movements (Gordon, 1974).

3. Sites of a particular successional stage are preferred to other sites. Previous studies have suggested that sites in the early stages of fire regeneration will be preferred to mature sites, and to sites which have been very recently burnt (Braithwaite, 1983).

5.4.1 Vegetation Composition

Floristic composition was described at each site by identifying the abundant species present. Some annual species and species which occurred in very low abundances were not necessarily noted on these lists. A total of 167 species were recorded at 200 feeding sites in the three study regions. These data were summarised in a matrix with 167 columns (each column representing one species) and 200 rows (each row representing one site). The presence or absence of each species at each site was recorded as a 1 or a 0.

Each site was assigned to a floristic group by using ALOC, a non-hierarchical clustering strategy contained in the pattern analysis package PATN (Belbin, 1987 a, b & c, 1991). ALOC is based on the allocation of objects (sites) to a set of seed objects which are used as initial group centroids to begin the allocation strategy. The first phase of ALOC checks the association between each site and all seed sites. Any value greater than a user specified threshold forces this site to be added to the seed site (Belbin, 1987 a, b & c). For the present study an allocation radius of 0.65 was used. The second pass of ALOC through the data set allocates each site to its nearest seed site. During this phase the seeds remain fixed and are not altered in any way by the addition of other sites (Belbin, 1987 a, b & c). The third phase then dismisses the seeds of each group and recalculates the group centroids based on the assignment of sites in phase two. From this point on the seeds have no definition and the groups are defined only by their centroids; the arithmetic average of their attributes (Belbin, 1987 a, b & c). The fourth phase of ALOC involves iteration and relocation of sites to groups. Each iteration tests site-to-centroid distances and allocates the site to the nearest group (Belbin, 1987 a, b & c). Each site is then removed from its current group to avoid bias. At this point groups may disintegrate in that their members may be completely reallocated to other groups (Belbin, 1987 a, b & c). This iterative phase continues until one of the following factors comes into play:

1. the maximum number of iterations defined by the user is acheived (ten iterations were used in this analysis);

2. the number of reallocations for any iteration is below a user defined minimum; or,

3. the algorithm detects that any oscillation between groups is occurring (Belbin, 1987 a, b & c).

The measure of association chosen for this clustering procedure is attributed to Czekanowski, which is the presence/absence equivalent of the Bray and Curtis measure of association for continuous data (Belbin, 1991). The Czekanowski formula is:

$D = 1 - 2A/(2A + B + C)$ where

A = number of 1 : 1 matches, and B and C = number of mismatches between sites (Belbin, 1987 a, b & c, 1991).

The GDEF (group definition) module of PATN was then used to define 21 groups which were considered to be appropriate representations of the floristic diversity found at the 200 feeding sites. The GSTA (group statistics) module was used to calculate the frequency occurrence of each species within each of these groups. Histograms depicting the frequency of occurrence of species within groups were then graphed.

The overstorey structure at each site was described by estimating the height and projected foliage cover of the canopy layer. Overstorey formation classes were assigned to sites based on the structural categories presented in Table 5.1. Finally, communities were named according to their dominant species and overstorey structures.

5.4.2 Ground Layer Density

The density of ground layer vegetation (<1 m tall) was recorded at each site by estimating the projected percentage of ground area which was covered by the stems and foliage of all plants. These estimates were made in ten percent increments where: 10% coverage was considered to be a very sparse layer with shelter virtually absent; 50% coverage was considered to be a moderately dense layer but usually not providing continuous cover; and 90% coverage was considered to be a very dense layer, providing continuous cover.

5.4.3 Stage of Vegetation Succession

When possible the successional stage of each community was determined from fire history records obtained from the South Australian Department of Environment and Planning, from the W&F Department or from interviews with local residents. Fire records have been poorly maintained in the past and in a number of instances it was not possible to determine a site's successional stage. This was particularly true for Kangaroo Island,

TABLE 5.1

Vegetation Formation Classes

	Canopy Cover		
Canopy Height	**60 - 70%**	**30 - 50%**	**10 - 20%**
> 10m	Medium Open Forest	Medium Woodland	Medium Open Woodland
> 5 ≤ 10m	Low Open Forest	Low Woodland	Low Open Woodland
> 2 ≤ 5m	Tall Moderately Open Shrubland	Tall Open Shrubland	Tall Very Open Shrubland
> 1 ≤ 2m	Medium Moderately Open Shrubland	Medium Open Shrubland	Medium Very Open Shrubland
≤1m	Medium Moderately Open Herbland	Medium Open Herbland	Medium Very Open Herbland

<u>Source</u>

Adapted from Specht (1981)

but accurate fire records were available for most sites in the South East (from the W&F Department) and for some sites in the Mount Lofty Ranges (from the Department of Environment and Planning). The successional stages of sites were expressed simply as age in years since last burning. This ignores the variable effects of freqency and intensity of fires on habitat succession but it was considered that a more detailed analysis was not possible due to the incomplete nature of available fire records.

5.4.4 Calculation of Bandicoot Capture Rates

Bandicoot capture rates were calculated for each site so that vegetation composition, ground layer density and successional stage could be related to bandicoot abundance. Capture rates offer a crude measure of bandicoot abundance at a site, assuming that there is a roughly linear relationship between the number of traps set per site and the total number of bandicoots captured (initial captures + recaptures). When trap spacings are kept roughly constant between sites bandicoot capture rates can be expected to vary according to the habitat resources available. In reality this relationship would not be precisely linear as some individuals may exhibit trap shyness while others may habituate to trapping (Gordon, 1971). It should also be noted that this relationship would plateau and cease to be linear at a point where sites became saturated with traps compared to the number of bandicoots present. Nevertheless, for the purpose of the present study it was assumed that sites which returned high capture rates indicated that more favourable habitat conditions prevailed than sites which returned low capture rates.

The present study relied heavily upon borrowed traps, and due to the extended nature of these trapping surveys it was not always possible to set the same number or combination of traps at each site. Each of the four types of traps used varied in their efficiency at capturing bandicoots, so it was necessary to numerically transform the number of trap nights (1 trap night = 1 trap (regardless of trap type) x 1 night) conducted at each site to standard trapping units. Each trap type was found to achieve the following capture rates during the present study:

Large Cage Traps	=	1 bandicoot per	18.25* Trap Nights
Small Cage Traps	=	1 bandicoot per	18.62* Trap Nights
Type B Elliott Traps	=	1 bandicoot per	35.46* Trap Nights
Type A Elliott Traps	=	1 bandicoot per	163.93* Trap Nights

* These figures were calculated using only data collected from successful bandicoot capture sites during successful trapping periods.

Large Cage traps (the most efficient trap type) were therefore selected as a standard trapping unit and, accordingly, Small Cage traps, Type B Elliott traps and Type A Elliott traps were calculated to be only 98%, 51% and 11% as efficient respectively. Trap nights per site were then adjusted at this rate. For example, a site which received 20 Large Cage trap nights, 15 Small Cage trap nights, 35 Type B Elliott trap nights and 90 Type A Elliott trap nights was calculated to receive:

20 trap nights	x	100%	=	20.00	adjusted trap nights
15 trap nights	x	98%	=	14.70	adjusted trap nights
35 trap nights	x	51%	=	17.85	adjusted trap nights
90 trap nights	x	11%	=	9.90	adjusted trap nights
Total			=	**62.45**	**adjusted trap nights**

Bandicoot capture rates were then calculated for each site as the total number of bandicoot captures (initial captures + recaptures) per 100 adjusted trap nights. Further references in this thesis to capture rates should be interpreted as total bandicoot captures per 100 adjusted trap nights.

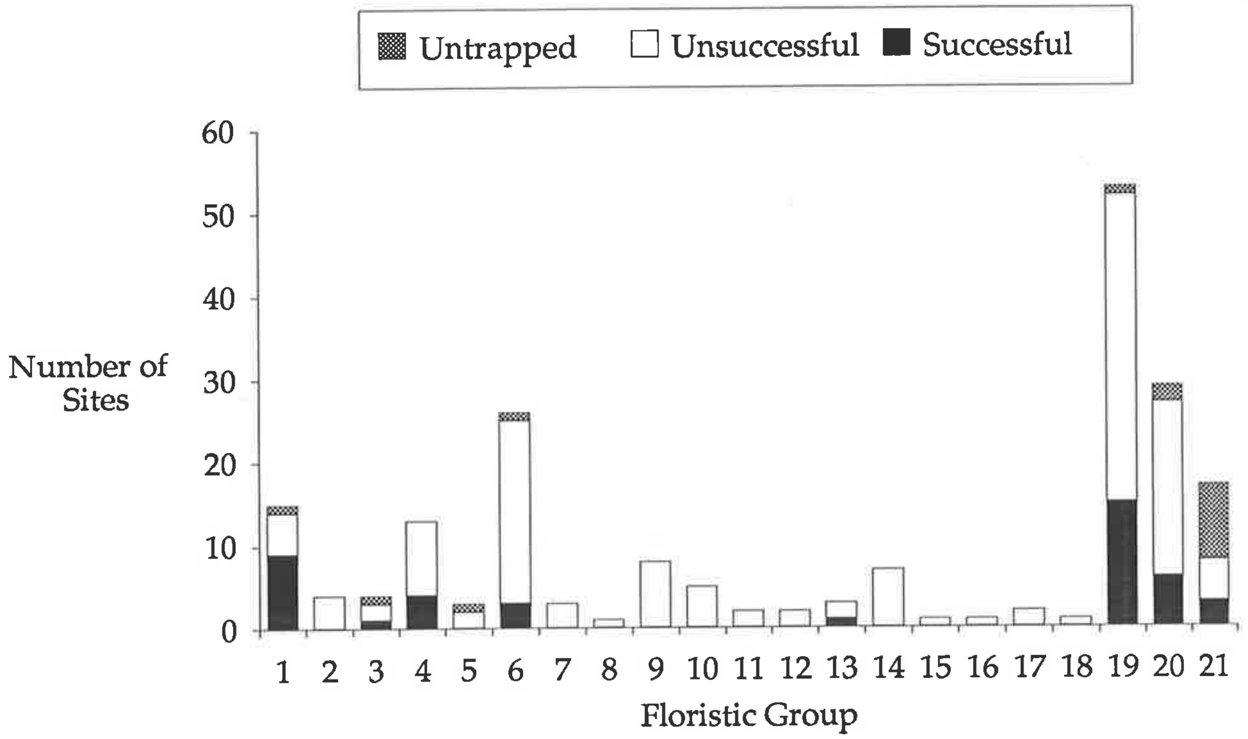
5.5 Results and Discussion

5.5.1 Vegetation Composition

The composition of the 21 floristic groups produced by ALOC is summarised in Appendix 3. Trapping results for each site are shown in Appendix 4. Very little inter-regional overlap of floristic groups occurred in the clustering process, indicating that sites in each region were floristically distinct to the sites in the other two regions. Figure 5.1 shows that more than 50% of sites occurred in groups 19, 20 and 21, with over 25% of all sites occurring in floristic group 19 alone. This community also contained over a third of all successful capture sites. Group 19 sites produced the highest mean capture rate (16.71%), followed by group 20 (12.05%) and group 3 (10.29%) (Figure 5.2). Table 5.2 shows that a significant association exists between capture rates and floristic groups ($\chi^2 = 14.20$; df = 7; $\alpha = 0.05$). Group 19 contained approximately three times as many sites with high capture rates (> 6%) than sites with low capture rates (≤ = 6%). Group 20 contained twice as many sites with high capture rates than sites with low capture rates. Groups 19 and 20 were therefore the most common community types encountered during the present study and they contained the greatest number of sites with high capture rates. This suggests that they are capable of supporting higher bandicoot densities than the other communities sampled.

FIGURE 5.1

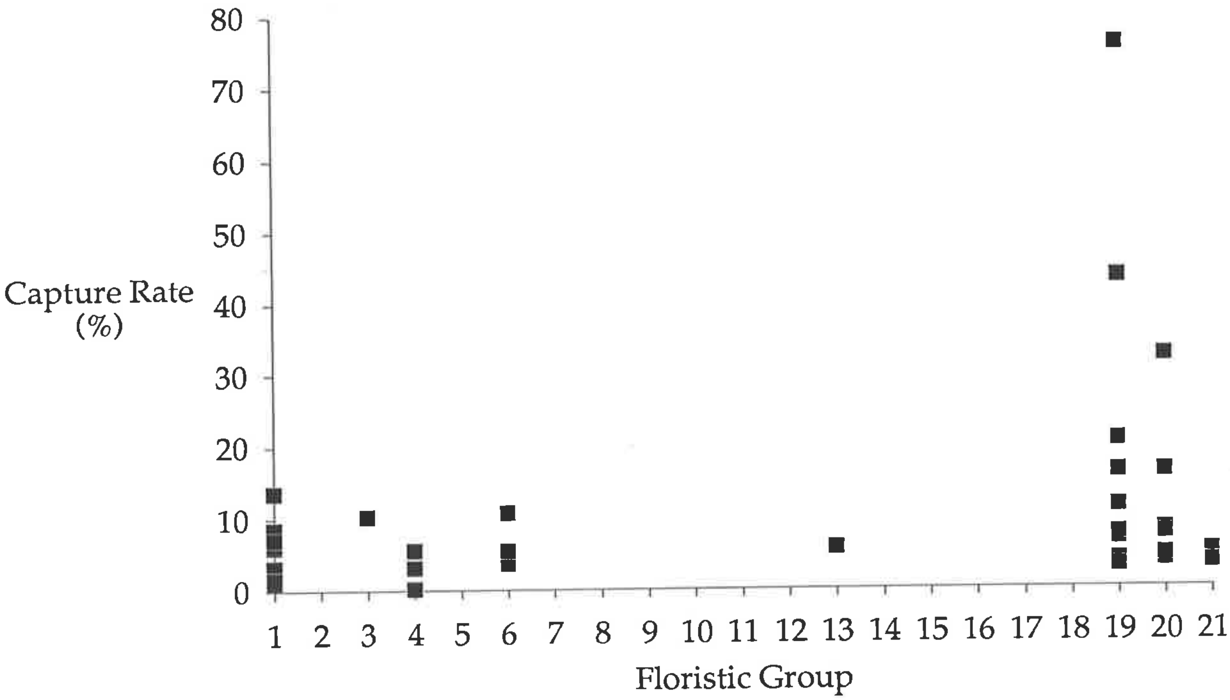
Distribution of Floristic Groups at Feeding Sites



Untrapped
Unsuccessful
Successful
60
50
40
30
20
10
0
Number of Sites
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Floristic Group

FIGURE 5.2

Capture Rates Per Floristic Group



Capture Rate (%)
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Floristic Group

TABLE 5.2
Association Between Floristic Group and Capture Rate

	Floristic Groups							
Capture Rate	**1**	**3**	**4**	**6**	**13**	**19**	**20**	**21**
Low	6	0	4	2	1	4	2	3
High	3	1	0	1	0	11	4	0

$\chi^2 = 14.20$; (S); $\alpha = 0.05$; df = 7

TABLE 5.3
Association Between Floristic Group and Ground Layer Density

	Floristic Groups		
Ground Layer Density	**1 to 4**	**5 to 18**	**19 to 21**
Sparse	11	43	5
Dense	25	22	94

$\chi^2 = 70.46$; (S); $\alpha = 0.05$; df = 2

TABLE 5.4
Association Between Ground Layer Density and Capture Rate

	Ground Layer Density	
Capture Rate	**Medium**	**Sparse & Dense**
Low	6	12
High	17	7

$\chi^2 = 5.84$; (S); $\alpha = 0.05$; df =1

TABLE 5.5
Association Between Successional Age and Capture Rate

	Successional Stage	
Capture Rate	**Young**	**Old**
Low	8	2
High	8	4

$\chi^2 = 0.47$; (NS); $\alpha = 0.05$; df = 1

Notes

Capture Rate (CR)
Low ≤ 6.0%
High > 6.0%
Ground Layer Density (GLD)
Sparse ≤ 50% cover
Medium = 60% & 70 % cover
Dense ≥ 80% cover
Successional Stage (Age)
Young ≤ 7 years
Old > 7 years
(S) = Significant
(NS) = Not Significant

Mount Lofty Ranges Virtually all sites occurred in *Eucalyptus obliqua* open forests, woodlands and tall shrublands (groups 1 to 4). One site (134) occurred in *Eucalyptus cosmophylla* low woodland (Group 5). Shrub and ground layers in these Mount Lofty Ranges communities were dominated by heathland species. *Eucalyptus obliqua, Eucalyptus fasciculosa, Leptospermum juniperinum, Leptospermum myrsinoides, Banksia marginata, Pultenaea daphnoides, Pteridium esculentum, Acrotriche fasciculiflora, Platylobium obtusangulum, Xanthorrhoea semiplana, Lepidosperma semiteres* and *Acacia pycnantha* were each recorded at 50 % or more of all successful bandicoot capture sites. No species was recorded at all bandicoot capture sites. *Lepidosperma semiteres, Pteridium esculentum* and *Xanthorrhoea semiplana* are used to conceal nests and they appear to serve an important shelter function. Several exotic species found in these communities are also utilised by bandicoots. *Chrysanthemoides monilifera* is eaten by *I. o. obesulus* in the Mount Lofty Ranges (Present Study, Chapter 3.3.1); *Holcus lanatus* is eaten by *I. o. affinis* (Quin, 1985); and *Rubus* species are used by bandicoots for food and shelter (Harrison, 1963; Heinsohn, 1966; Quin, 1985).

South East Feeding sites all occurred in *Eucalyptus baxteri* low forests, woodlands and tall shrublands (groups 19 to 21). *Eucalyptus baxteri, Acacia melanoxylon, Leptospermum juniperinum, Pteridium esculentum* and *Xanthorrhoea australis* were each recorded at 50 % or more of all successful bandicoot capture sites in the South East. *Pteridium esculentum* was present and abundant at all capture sites. *Xanthorrhoea australis* is used extensively to conceal nests in the South East. *Pinus radiata* was one of the few exotic species to be recorded in the South East, occurring commonly in shrub and ground layers and as a sub-dominant overstorey species. It was obviously invading these habitat patches from surrounding pine plantations.

Kangaroo Island A far greater range of community diversity was observed on Kangaroo Island. Kangaroo Island community types included: *Eucalyptus obliqua* open forests, woodlands and tall shrublands (groups 1 & 4), *Eucalyptus cosmophylla* low woodlands (group 5), *Eucalyptus baxteri/Hakea rostrata/Banksia marginata* low woodlands and tall shrublands (group 6), *Melaleuca/Allocasuarina* low woodlands and tall shrublands (group 7), *Eucalyptus cneorifolia* tall shrubland (group 8), *Eucalyptus diversifolia* low woodlands and tall shrublands (groups 9 & 14), *Eucalyptus cladocalyx* woodlands (groups 10 & 11), *Banksia marginata/Leptospermum juniperinum* woodland (group 12), *Eucalyptus leucoxylon* low woodlands and tall shrublands (group 13), *Acacia longifolia/Leucopogon parviflorus* coastal shrubland (Group 15), *Eucalyptus oleosa/Eucalyptus rugosa* tall shrubland (group 16), *Eucalyptus lansdowneana* low woodlands (group 17) and *Gahnia duesta* herbland (group 18). Only four successful capture sites were recorded in two of these floristic groups (groups 6 & 13).

Kangaroo Island habitat types not represented on the mainland included: mallee communities (groups 8, 9, 14 and 16), a coastal shrubland community (group 15) and a Sedge/Herbland community (group 18). However, even in these atypical communities most shrub and ground layers were composed of heathland species. *Eucalyptus baxteri, Eucalyptus diversifolia, Adenanthos terminalis, Acacia myrtifolia, Daviesia aspera, Hakea rostrata, Banksia marginata, Allocasuarina striata, Xanthorrhoea semiplana, Isopogon ceratophyllus, Petrophile multisecta, Pultenaea* *viscidula* and *Lepidosperma semiteres* were each recorded at 50 % or more of the Kangaroo Island capture sites.

5.5.2 Ground Layer Density

Figure 5.3 shows that diggings were found in habitats with ground layers as sparse as 10% and as dense as 90%, with a mean ground layer density (GLD) of 63.3%. It appears that bandicoots on Kangaroo Island utilise sparser ground layers than bandicoots on the mainland. Sites on Kangaroo Island had a mean GLD of 49.1%, while Mount Lofty Ranges and South East sites had a mean GLD of 64.4% and 71.9% respectively. Table 5.3 shows that a significant association exists between GLD and floristic groups ($\chi^2 = 70.46$; df = 2; $\alpha = 0.05$). South East floristic groups (19 to 21) had approximately 19 times as many sites with dense ground layers than with sparse ground layers. Mount Lofty Ranges floristic groups (1 to 4) had approximately twice as many sites with dense ground layers than with sparse ground layers. Kanagaroo Island floristic groups (5 to 18) had approximately half as many sites with dense ground layers than with sparse ground layers.

Gordon (1974) found that *I. macrourus* prefers areas of dense ground cover but not so dense as to restrict movement. This implies that an optimum value of GLD exists, and this should be reflected in population density and therefore capture rates. Figure 5.4 shows a scatterplot of capture rates by GLD class for all successful capture sites. The highest mean capture rates were obtained at sites with 60% and 70% GLD (mean capture rate for sites with 60% GLD = 10.89% and 70% GLD = 16.81%), while sites with denser and sparser GLDs produced lower mean capture rates (mean capture rate for sites with 50% GLD = 9.13%, 80% GLD = 9.98

FIGURE 5.3

Distribution of Ground Layer Density Classes at Feeding Sites

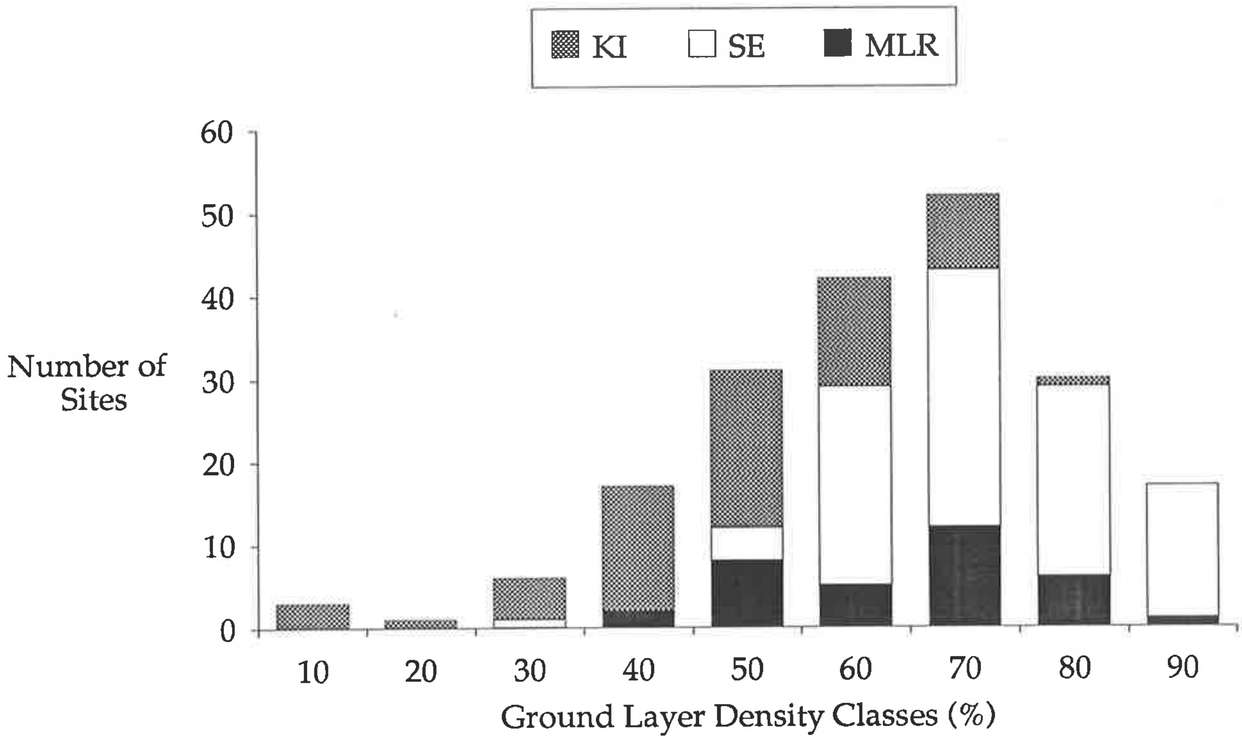
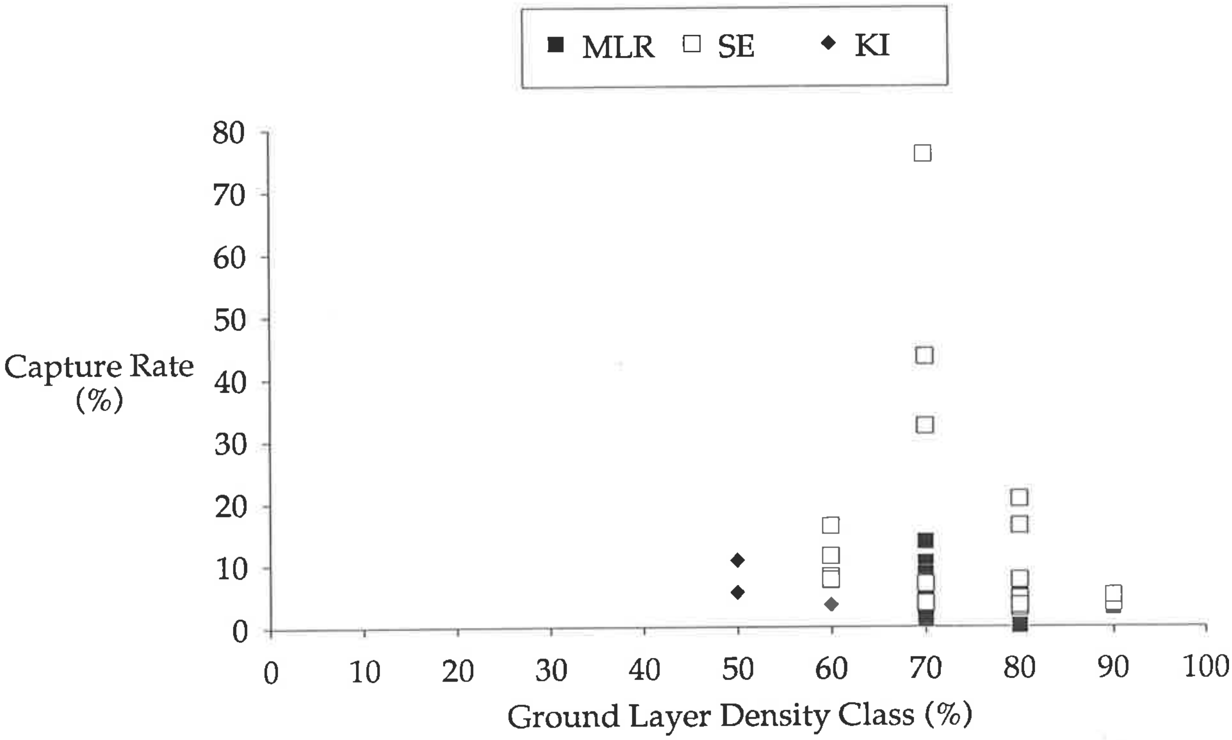

KI
SE
MLR
60
50
40
30
20
10
0
Number of Sites
10
20
30
40
50
60
70
80
90
Ground Layer Density Classes (%)

FIGURE 5.4

Capture Rates Per Ground Layer Density Class



MLR
SE
KI
Capture Rate (%)
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Ground Layer Density Class (%)

and 90% GLD = 4.35%). Table 5.4 shows that there is a significant association between GLD and capture rate ($\chi^2 = 22.51$; df = 1; $\alpha = 0.05$). Habitats with 60% and 70% GLD produced more sites with high capture rates than low capture rates, and habitats with 50%, 80% and 90% GLD produced more sites with low capture rates than high capture rates. No captures were made at sites with less than 50% GLD. This supports Gordon's (1974) observation that *Isoodon* prefer areas of dense ground cover, but not too dense.

Diggings were observed at sites with less than 50% GLD, demonstrating that bandicoots will sometimes feed at relatively sparse sites. On Kangaroo Island bandicoots may occasionally be seen in open areas, such as on sparsely covered roadside corridors, dominated by *Allocasuarina* species (Baxter, personal communication). However, it appears that suitable habitat must also offer nearby dense ground cover to satisfy this species' shelter requirements. During the present study bandicoots were sighted in the open by the author on only four occasions, and they were never more than two metres away from dense ground cover. Additionally, when trapped animals were released on an open track they always ran straight for cover.

Since the introduction of cats and foxes to the Mount Lofty Ranges and the South East, and cats to Kangaroo Island, dense understorey cover may be essential for bandicoot survival. It is not clear why bandicoots sometimes use sparse understories on Kangaroo Island. It is possible that the absence of foxes allows bandicoots to forage in open areas. However, the feral cat population on Kangaroo Island appears to be flourishing in the absence of foxes. The Kangaroo Island cat capture rate recorded during the present study was approximately 3.5 times as great as the Mount Lofty Ranges cat capture rate (0.31 cats per 100 cage trap nights on Kangaroo Island versus 0.09 cats per 100 cage trap nights in the Mount Lofty Ranges). No cats were caught in the South East. On one occasion feral kittens were observed eating a wallaby carcass on a Kangaroo Island roadside. Vast quantities of Possum, Kangaroo and Wallaby roadkill carrion always litter the island's roadsides and it is likely that this facilitates a high feline survival rate.

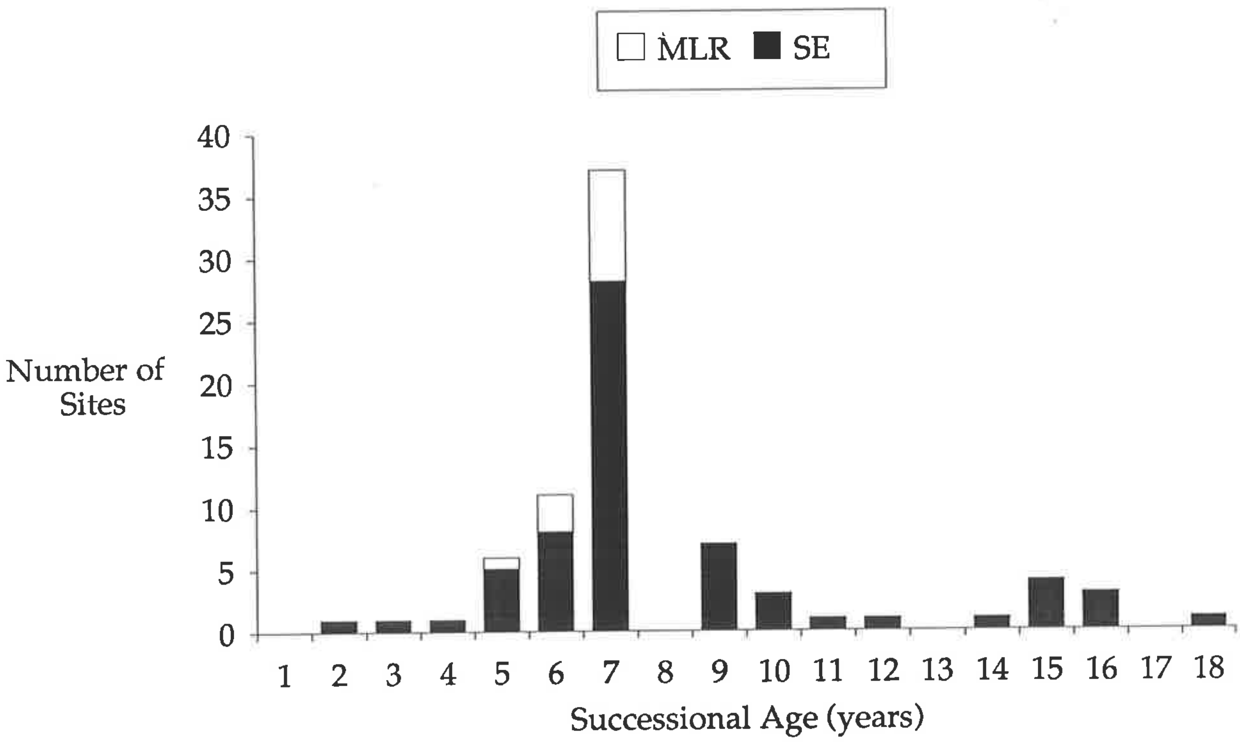
5.5.3 Successional Age

Figure 5.5 shows the distribution of successional ages of feeding sites in the South East and Mount Lofty Ranges, measured in years since last burning. This sample only includes those sites for which accurate fire records were available (N = 22 capture sites, 54 unsuccessful trapping sites and 2 untrapped sites). Successional ages of Kangaroo Island sites could not be accurately determined from available records.

Sites in this sample were aged between two and 18 years (mean = 7.95 years) since last burning, but it appears that some other feeding sites were much older than this. For example, it is probably more than 30 years since sites 282 to 290 last burnt (Aslin, personal communication). Likewise, some feeding sites within NFRs have no records of fires in the last 20 years (W&F Dept fire records). While these sites of undetermined age have been excluded from further analysis, it is important to note that sites older than 18 years are utilised by *I. o. obesulus*. Also, young sites such as the Millicent Golf Course (site 297) may be recolonised very soon after burning. Bandicoots and their diggings were observed by the golf course managers along the fairway roughs within eight to ten months of this site

FIGURE 5.5

Distribution of Successional Ages at Feeding Sites


MLR
SE
Number of Sites
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Successional Age (years)

burning in the severe Ash Wednesday bushfire of February, 1983. This fire was followed by a particularly wet winter which resulted in dense regrowth of *P. esculentum* in the ground layer (Millicent Golf Course Management, personal communication).

Figure 5.6 compares capture rates to the successional ages of feeding sites. Five and six year old vegetation returned the highest mean capture rates of all age classes (13.8% and 12.5% capture rates respectively), and the site with the highest capture rate (site 289; capture rate = 75.76%) occurred in seven year old vegetation. However, Table 5.5 shows that vegetation which was burnt more than seven years ago produced similar proportions of sites with high and low capture rates to vegetation which was burnt during the last seven years ($\chi^2 = 0.47$; df = 1; $\alpha = 0.05$).

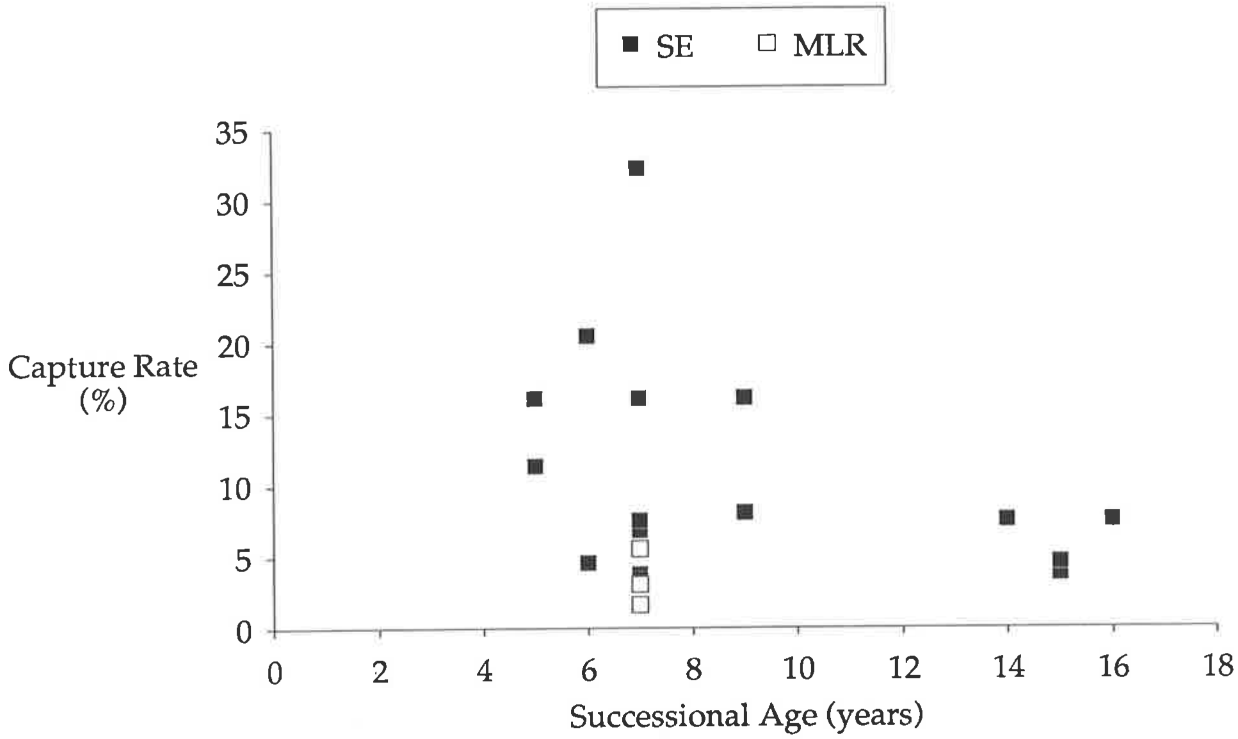
5.6 Conclusion

Guiler (1958) found that *I. o. affinis* rarely forage when moving between feeding sites and therefore diggings do not appear in these areas. Sites described during the present study represent feeding sites, so habitat types used for other activities such as migration and nesting, were not necessarily sampled. However, by examining 200 feeding sites, the following observations have been made.

1. Bandicoots in South Australia utilise a wide range of habitats. The stringybark species *Eucalyptus obliqua* and *Eucalyptus baxteri* dominate overstories in most of these communities. A range of heathland species typically comprise the shrub and ground layers. Only a small number of the floristic communities identified during the present study were used

FIGURE 5.6

Capture Rates Per Successional Age



SE
MLR
Capture Rate (%)
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
Successional Age (years)

extensively by bandicoots. The two communities which were most commonly used (groups 19 and 20) also appeared to support higher bandicoot abundances than other habitats.

2. Areas of both sparse and dense ground cover are used. However, habitats with 60% and 70% GLD produced more sites with high capture rates than sparser or denser ground habitats. No captures were made at sites with less than 50% GLD.

3. Bandicoots on Kangaroo Island appear to be using sparser ground layers than those on the mainland. This may be due to the absence of foxes on the island.

4. Feeding sites in the Mount Lofty Ranges and in the South East occur most commonly in vegetation which has been burnt between two and 18 years ago. However, habitats older than 18 years and younger than two years are also used.

5. No association was found to exist between the successional ages of sites and the capture rates which they produced. Therefore, old sites are equally likely to produce high capture rates as young sites.

Some of the habitat types identified during the present study have not been described by previous studies of bandicoot habitat selection. Historical occurrence records show that *I. o. obesulus* once utilised mallee communities on the South Australian mainland (at Rudall on the Eyre Peninsula and at Lake George in the South East). Survey results of the present study show that bandicoots still occur in mallee communities with sparse heath understories on Kangaroo Island. The absence of foxes on the island may account for the continued use of this habitat type. Unfortunately, mallee communities on the mainland may no longer be able to provide bandicoots with adequate shelter from foxes. The use of coastal habitats on Kangaroo Island is also interesting as it suggests that bandicoots may have occurred in coastal areas on the mainland prior to the introduction of foxes. This is supported by the sub-fossil remains of *I. o. obesulus* recently collected from the coastal environment at Innes National Park on the southern tip of Yorke Peninsula. The implications of these findings are that *I. o. obesulus* may have once had a wider geographical range on the South Australian mainland than has been previously recognised.

Braithwaite and Gullan (1978) described the distribution of *I. obesulus* as enigmatic, with bandicoots often being rare or absent in apparently suitable habitats. Bandicoots select habitats according to the food and shelter resources which they offer. The relationship between plant communities and the availability of food resources was not investigated during the present study, but the structural role which certain plant species play within these habitats is now clear. For example, *Xanthorrhoea* species are commonly used to conceal nests. However, as Braithwaite and Gullan (1978) observed, until further knowledge of the specific plant/invertebrate relationships which regulate bandicoot diet is acquired the occurrence of *I. obesulus* will remain a puzzle.

CHAPTER 6

REPRODUCTIVE ECOLOGY AND LIFE HISTORY

6.1 Review of Reproductive Ecology and Life History

6.1.1 Breeding Season

Seasonality of breeding in *Isoodon* varies considerably between geographic regions, with seasonal breeding occurring in response to aspects of environmental seasonality (Friend, 1990; Lobert and Lee, 1990). Gordon (1971) found that in northern New South Wales *I. macrourus* breed between August and March in direct response to food availability. In southern Queensland, where food supply is less seasonal than further south, *I. macrourus* breeds throughout the year (Gordon, 1966; Gordon, 1974; Hall, 1983; Mackerras and Smith, 1960). In the Northern Territory *I. macrourus* breeds seasonally between August and April with a peak in spring in tropical open forests which receive highly seasonal and erratic rainfall (Friend, 1990).

I. obesulus shows a similar range of breeding seasonality across southern Australia. In south western Western Australia *I. o. fusciventer* breeds continuously (Heinsohn, 1986) with most young produced between July and September (Thomas, 1990). In South Australia *I. o. nauticus* carry pouch young throughout the year with a breeding peak in spring and lower rates in summer (Copley *et al.*, 1990). Thompson *et al.* (1989) recorded female *I. o. obesulus* carrying pouch young from July to December in the Mount Lofty Ranges. In Tasmania female *I. o. affinis* have been recorded lactating between August and February, with an apparent peak in breeding activity between September and January (Heinsohn, 1966). Heinsohn (1966) considered that the timing and length of this breeding season coincided with the time of maximum annual food abundance and was thus indirectly related to rainfall and temperature.

Lobert and Lee (1990) recorded marked seasonal fluctuations of scrotum length in *I. o. obesulus*, reaching a maximum size in the middle of the breeding season and declining again to a minimum between January and April. However, it seems unlikely that male bandicoots provide the stimulus for females to begin breeding as Gemmell (1990) observed oestrus cycles in female *I. macrourus* housed separately from males.

In western Victoria *I. o. obesulus* is known to breed both seasonally and non-seasonally. In the Grampians *I. o. obesulus* breeds all year in the Victoria Valley, whereas at altitude on Mount William (1167m) they breed seasonally (Lobert and Lee, 1990). In southern Victoria at Cranbourne *I. o. obesulus* breed between July and December (Lobert and Lee, 1990; Stoddart and Braithwaite, 1979). Onset and cessation of breeding at Cranbourne is highly predictable, with females entering oestrus synchronously so that breeding coincides with the maximum annual abundance levels of major soil food items (Lobert and Lee, 1990; Stoddart and Braithwaite, 1979). Lobert and Lee (1990) also found that the timing of breeding at Cranbourne is not modified by the seral stage of heath occupied by *I. o. obesulus* or by marked annual variations in food abundance or rainfall. Captive enclosure studies of *I. macrourus* and *P. nasuta* have shown that periods of no breeding occur, even when food supply is constant throughout the year (Close, 1977; Gemmell, 1982). Drought and declining food supply have been linked strongly to the cessation of breeding (Close, 1977; Heinsohn, 1966; Stoddart and

Braithwaite, 1979) and it appears that food availability may influence the length of the breeding season of *Isoodon* (Gordon, 1971; Lobert and Lee, 1990). However, the factors which initiate breeding are still poorly understood.

Stoddart and Braithwaite (1979) felt that the highly predictable breeding season seen at Cranbourne suggested the operation of a predictable environmental factor such as photoperiod. Barnes and Gemmell (1984) subsequently examined the relationship between the environmental variables of rainfall, daylength and temperature, and the breeding activity of *P. gunnii* in Tasmania, *I. o. obesulus* in Victoria and *I. macrourus* in New South Wales and Queensland. Strong correlations were found between the proportion of lactating females in these populations and the rates of change of minimum temperatures, with some associations to rainfall and daylength (Barnes and Gemmell, 1984).

There are indications that breeding is not triggered by any single environmental factor such as daylength, rainfall or minimum temperature (Gemmell, 1990). In seasonal environments though, variations in these factors will result in food resources being abundant in some seasons and scarce in others, and bandicoots can be expected to breed seasonally.

6.1.2 Oestrus and Mating

Bandicoots are polyoestrus (Lyne, 1971) and females appear to be able to breed whenever conditions are favourable. Hughes (1962) examined vaginal smears of *P. nasuta* and found that the interval separating peaks of vaginal cornification averaged 26 days (range 17 - 34 days). Stodart

(1977) managed to induce oestrus in *P. nasuta* with injections of pregnant mare serum and human chorionic gonadotrophin and found that successive nights of attraction to males were then 28, 13, 14 and 15 days apart, with the subject becoming pregnant on the last occasion.

Lyne (1976) examined the oestrus cycle of *I. macrourus* and *P. nasuta* and found that the time between oestrus for 15 animals ranged from nine to 34 days, with an average of 20 days between successive cycles. Gemmell (1988) calculated the mean oestrus cycle length of ten *I. macrourus* to be 22.1 days with a range of 14 to 30 days. Lyne (1976) was unable to obtain any information on the timing of ovulation in bandicoots but pointed out that in other marsupials ovulation occurs one to several days after oestrus and pregnancy does not interupt the oestrus cycle. Gemmell (1988) found that when lactating *I. macrourus* had 30 day old pouch young removed, ovulation occurred 5.5 days after removal of the young.

Ovulation in bandicoots coincides with the time of maximum male attraction. Stodart (1966, 1977) found that sexual activity in *P. nasuta* is restricted to a few nights close to oestrus and reaches a peak on one night only. Stodart (1977) observed mating at night only and it involved an initial period of persistant close following of the female by the male for several hours. Mating then occurred several times in quick succession, with intromission lasting from two to four seconds. Mating in bandicoots appears to be promiscuous or polygamous (Lee and Cockburn, 1985).

6.1.3 Gestation and Placenta

The gestation periods of bandicoots are considerably shorter than the length of their oestrus cycles (Hughes, 1962; Lyne, 1976). In fact, both *I.*

macrourus and *P. nasuta* have a gestation period of only 12.5 days which is the shortest recorded gestation for any mammal (Hughes, 1962; Lyne, 1974; Stodart, 1966). Stoddart and Braithwaite (1979) considered that the gestation period of *I. o. obesulus* is likely to be the same as *I. macrourus* and is probably common to all bandicoots (Quin, 1985). Lobert and Lee (1990) recorded the gestation period of *I. o. obesulus* at Cranbourne, Victoria to be to be less than 15 days and similar to the 12.5 day gestation recorded for *I. macrourus* and *P. nasuta*.

Bandicoots are the only marsupials which possess functional chorio-allantoic placentas in addition to transient yolk-sac placentas and implantation is similar to that found in eutherian mammals (Gordon and Hulbert, 1989;Hughes, 1962;Quin, 1985; Walker, 1964). Towards the end of gestation the chorio-allantoic placenta supercedes the yolk-sac as the major extraembrionic organ for respiration and metabolic exchange (Hughes, 1984). This configuration has evolved independantly of the placenta found in the eutherian mammals and it apparently enables the rapid rate of embrionic development and short gestation periods seen in bandicoots (Gordon and Hulbert, 1989).

6.1.4 Parturition and Attachment

Available evidence suggests that while bandicoots mate at night when activity is at its greatest, they give birth in the nest during the day when activity is at a minimum (Lyne, 1974). Female *I. macrourus* have been seen to give birth while lying on their side with one leg raised, licking their urogenital region (Lyne, 1974). Parturition occurs with the young attached to an allantoic stalk which is united with the uterus. These stalks appear to act as saftey lines, anchoring the young to the mother in case they become dislodged during their journey to the pouch (Lyne, 1974). Newborn bandicoots use deciduous claws on the three central digits of each manus to pull themselves forward from the birth canal to the pouch. *I. macrourus* young are able to leave the maternal passages and reach the pouch unaided, even after the death of the mother (Mackerras and Smith, 1960).

The mother's pouch opens posteriorly to ensure a short journey for the young at birth, to limit the entry of dirt and debris to the pouch and to prevent it from becoming snagged as pouch gravid females move through undergrowth (Collins, 1973; Jones, 1924; Maloney, 1982). When the young reach the pouch they attach themselves firmly to one of eight teats which are arranged in two semicircles (Jones, 1924; Lyne, 1974). When newborn bandicoots first reach the pouch the teats are very small, firm and pointed, and the infants draw the tip of a teat into their mouths by suction using their well developed tongues (Mackerras and Smith, 1960). During the course of lactation the teats enlarge and elongate considerably. However, no permanent union forms between the mouth and the teat, and pouch young can be removed without damage at any stage by gentle traction (Mackerras and Smith, 1960). Reattachment to the teat is unreliable though, especially with very small pouch young. Stodart (1977) recorded the time taken for the birth of a litter of three *P. nasuta*, their passage to the pouch and attachment to teats as being less than ten minutes.

6.1.5 Litter Size

Isoodon and *Perameles* usually give birth to between one and four pouch young (Copley *et al.*, 1990; Friend, 1990; Heinsohn, 1966; Lobert and Lee, 1990; Seebeck, 1979; Stodart, 1966; Stoddart and Braithwaite, 1979; Watts, 1974), although up to seven *I. macrourus* have been recorded in one litter (Gordon, 1974; Mackerras and Smith, 1960). Survival of newborn bandicoots is low and as the size of the babies increases, the size of the litter usually decreases (Gemmell, 1982; Gemmell *et al.*, 1984; Mackerras and Smith, 1960).

Stodart (1966, 1977) found that approximately half of the pouch young born to *P. nasuta* in captivity survived to weaning. Stoddart and Braithwaite (1979) found that the expulsion of *I. o. obesulus* pouch young in the wild is a natural occurrence, with young being most vulnerable during the middle stages of pouch life. Captive female bandicoots are highly prone to destroy and eat their young (Jones, 1924; Lyne, 1964, 1971; Mackerras and Smith, 1960) and the risk of expulsion increases with handling of pouch gravid females (Stodart, 1966). Copley *et al.* (1990) found that on Franklin Island 22% of pouch young were lost from 31% of *I. o. nauticus* litters, although at least one, two or three young survived to weaning in most litters. Heinsohn (1966) found that in Tasmania 61% of *P. gunnii* pouch young survived to weaning.

Decreases in bandicoot litter size during lactation have been attributed to both food shortages and crowding in the pouch (Gemmell *et al.*, 1984; Heinsohn, 1966). Gordon (1971) and Gemmell (1982) suggested that litter size may decrease during lactation if the mother is unable to meet the nutritional requirements of the pouch young.

There is some suggestion that litter size may be influenced by the size of previous litters which have been recently weaned (Lee and Cockburn, 1985). Heinsohn (1966), Collins (1973) and Lyne (1974) argued that bandicoot neonates are too small to attach to recently suckled teats and, accordingly, the number of young suckled in two successive litters should not exceed eight, the total number of nipples available. However, Lobert and Lee (1990) observed that, in some instances, newborn bandicoots may attach to enlarged nipples.

Stoddart and Braithwaite (1979) and Hall (1983) found an apparent positive relationship between the size of litters and maternal body weight of *I. o. obesulus* and *I. macrourus*, with the largest and oldest females producing the largest litters. Stoddart and Braithwaite (1979) also found some indication that litters of *I. o. obesulus* produced late in a breeding season are larger than those produced early. Gordon (1971, 1974) found that *I. macrourus* litters born early in a season averaged from 2.6 to 2.9 pouch young; mid-season litters averaged from 3.6 to 3.8 pouch young; and late litters ranged from 2.1 to 2.6 pouch young. Friend (1990) found that mean litter sizes of *I. macrourus* in the Northern Territory were significantly larger in the January to March period than in September to December (3.5 versus 2.4). Heinsohn (1966) observed that, within a season, the second and third litters produced by *P. gunnii* in Tasmania are larger than the first and fourth. However, Copley *et al.* (1990), Friend (1990), Gemmell *et al.* (1984), Gordon (1971) and Lobert and Lee (1990) could not demonstrate that heavier or older female *I. o. nauticus, I. o. obesulus* and *I. macrourus* produced larger or more litters in a breeding season. Hall (1983) was unable to find a strong relationship between litter size and time of production.

Copley *et al.* (1990) found that the mean litter size of *I. o. nauticus* reflects seasonal conditions, so that litters are larger in spring following good rains when food and cover are abundant (mean spring litter size = 2.4) and smaller in summer during relatively dry periods when conditions deteriorate (mean winter litter size = 1.6). Similarly, Gordon (1966) noted small litter sizes in *I. macrourus* in periods of least breeding. This suggests that the production of small litters is a response to suboptimal breeding conditions. Gordon (1971) found that survival rates were greatest for litters born early in the breeding season as they were weaned when food was most abundant. Also, Heinsohn (1966) attributed the birth of small litters of *P. gunnii* late in the Tasmanian breeding season to diminishing food resources.

Lobert and Lee (1990) considered that variations in mean annual reproductive output of *I. o. obesulus* in Victoria are related to changes in food abundance. Between year fertility varies considerably at Cranbourne. If food abundance is high, females produce large litters and a number of litters per season, but if food abundance is low, litter size and number of litters produced appears to decrease (Lobert and Lee, 1990).

Lobert and Lee (1990) noted that there are problems in comparing litter sizes from different studies as the stage of pouch life at which litter size is calculated is rarely reported. Lobert and Lee (1990) warned that differences in litter size, maternal body weight and stage of breeding season, as observed by Stoddart and Braithwaite (1979), are often only slight and comparisons between litter sizes should be made cautiously . Counts of enlarged nipples after the birth of a litter may not accurately indicate the size of the previous litter because newborn bandicoots may, in some instances, attach to already enlarged nipples and, also, when close to or at weaning, young can suckle from more than one nipple (Lobert and Lee, 1990).

6.1.6 Pouch Life and Development

When newborn *I. o. affinis* reach the pouch, they weigh approximately 0.35 g and have a crown-rump length of about 15 mm (Heinsohn, 1966). At three to four days their eyes begin to be visible and their mouths are circular. At the end of the first week of pouch life sex can be distinguished as the pouch depression and the scrotum become evident. The mouth is still a round aperture at one week but the outline of the lips begins to show (Heinsohn, 1966). At 13 days, the lips are clearly visible and fused laterally; mystacial, supraorbital and genal vibrissae have errupted and small amounts of pigmentation can be seen on the snout. Eyes are still closed at 17 days but their outlines begin to show. By 27 days a distinct outline between the upper and lower lids is apparent. The pouch young at this stage are still naked and their lips are still fused (Heinsohn, 1966). The exact time when lips separate laterally was not assertained by Heinsohn (1966) but he did note that it occurs between 27 and 45 days, in which time the eyes also open. Hall (1983, 1990) found that the lips of pouch young begin separating at 37 days and eyes open at about 45 days. Mackerras and Smith (1960) found that the lips of *I. macrourus* were fully separated by the seventh week of pouch life. At seven weeks, both *I. o. affinis* and *I. macrourus* are completely covered with stiff short fur (Heinsohn, 1966; Mackerras and Smith, 1960). At 50 days, *I. macrourus* have detached from the original teat and may begin teat swapping (Hall, 1990).

Heinsohn (1966) estimated that *I. o. affinis* leave the pouch at 45 to 47 days. A captive litter which Heinsohn (1966) hand reared were weaned completely at seven weeks using soft and liquid foods. However, at 60 days these young bandicoots had difficulty eating Lepidoptera larvae and it is possible that they were weaned too young (Heinsohn, 1966). Mackerras and Smith (1960) found that *I. macrourus* leave the pouch voluntarily at the end of the seventh week and under natural conditions they are dependant on the mother for another week or two. Gordon (1974) found that the pouch life of *I. macrourus* lasts for 50 ± 7 days but in the wild the period of following the mother (young at foot) is either brief or non-existent. Hall (1990) found that young *I. macrourus* leave the pouch at 52 days but are not fully weaned for about another week. At Innisfail in northern Queensland Mackerras and Smith (1960) observed one *I. macrourus* following its mother while weighing 108 g, and another individual on its own at 107 g. In the laboratory *I. macrourus* were found to wean in their eighth week, weighing between 138 and 212.5 g (Mackerras and Smith, 1960). Lobert and Lee (1990) found that *I. o. obesulus* wean after two months of pouch life at body weights between 105 and 140 g. Juvenile *I. o. obesulus* then become trappable at mean body weights of 226 g for males and 229 g for females (Lobert and Lee, 1990).

Lyne (1971) found that young *P. nasuta* leave the pouch at 65 to 70 days and wean at about 75 days. Stodart (1966, 1977) found that, in captivity, *P. nasuta* pouch young are carried for 50 to 54 days, by which time the pouch bulged and the mother was forced to move more slowly than usual. Thereafter, pouch young remained in the nest at night until 62 to 63 days when they began foraging with their mother, gleaning food from her diggings and digging for themselves (Stodart, 1966, 1977).

P. gunnii in Tasmania leave the pouch at 58 to 59 days and cease suckling at 59 to 61 days but continue to follow their mother until 71 to 73 days (Heinsohn, 1966). Seebeck (1979) found that *P. gunnii* in Victoria wean within a similar time range of 59 to 61 days.

6.1.7 Lactation and Return to Oestrus

Suckling supresses oestrus in bandicoots only until the terminal period of pouch life when a lactation oestrus occurs and females may be fertilised again. This allows existing litters to be replaced by new litters at the time of their weaning (Close, 1977; Gordon, 1971, 1974, 1984; Lyne, 1964; Stodart, 1977) and, during an extended breeding season, litters can be replaced continuously (Gordon and Hulbert, 1989; Stoddart and Braithwaite, 1979).

Bandicoots are unique among marsupials as the corpus luteum of pregnancy persists beyond parturition and during lactation (Gemmell, 1979, 1981). The concentrations of progesterone in the plasma of lactating female *I. macrourus* correlate with the presence of granules in the luteal cells that are thought to contain progesterone and relaxin (Gemmell, 1979). Early in lactation the corpus luteum is thought to inhibit ovulation by secreting progesterone (Gemmell, 1981). Progesterone concentration in the plasma increases to a plateau which is maintained into early lactation. The corpus luteum then ceases to excrete in the middle stages of lactation although morphological change is slight until the end of lactation (Gemmell, 1981; Hollis and Lyne, 1980; Lyne and Hollis, 1979). Hughes (1962) found that the corpus luteum starts to degenerate when the young have suckled for about 45 days. Birth in *I. macrourus* has been correlated with increased levels of prostaglandins (Gemmell *et al.*, 1980).

Lactation in *I. o. obesulus* and in *I. macrourus* lasts for about 60 days (Lobert and Lee, 1990; Merchant, 1990; Stoddart and Braithwaite, 1979), which is possibly the shortest lactation period of all mammal species irrespective of size. Stodart (1966, 1977) recorded that for five female *P. nasuta* the interval between successive periods of oestrus, when young which were conceived at the first oestrus were successfully reared to weaning, was 62 to 63 days. The females mated when the young were 49 to 50 days old and still in the pouch. These young suckled for another 12 or 13 days and appeared to be weaned when the next litter was born (Stodart, 1966, 1977).

Merchant (1990) has shown that milk compositon of *I. macrourus* changes during lactation, so that by 55 days of lactation when the young are only a few days from independence, milk solids have increased from an initial eight to ten percent, to more than 40 percent. Carbohydrate concentrations are initially high at about 45 percent of the solids fraction but decrease during lactation to about seven percent. Lipid concentrations increase from about 35 percent at 30 days of lactation to about 60 percent by 56 days of lactation. Protein concentrations decline from about 35 percent at 30 days to about 20 percent at 55 days of lactation (Merchant, 1990). This composition then rapidly changes back again at the end of lactation to support the next litter about to be born (Merchant, 1990).

Stodart (1977) and Close (1977) both observed recurrence of breeding in *P. nasuta* when pouch young were prematurely removed and lactation was interrupted. Close (1977) found that if litters less than six days old were removed, females came into oestrus and were fertilised 17 to 26 days later. However, if pouch young older than ten days were removed, females came into oestrus in only five to ten days. Stodart (1977) found that when pouch young were removed at 28 to 31 days, female *P. nasuta* became attractive to males six to seven days later; 11 to 15 days earlier than if lactation lasted the full period.

6.1.8 Sexual Maturity

Bandicoots can breed in their first year of life (Mackerras and Smith, 1960) although the age at which juveniles become sexually mature shows variation between sex, species and geographic location. Heinsohn (1966) found that female *P. gunnii* in Tasmania were usually mature at three months, and in one case at two and a half months, while males became reproductive at four to six months. Lyne (1964) found that *P. nasuta* reaches sexual maturity at about four months for females and five months for males.

Mackerras and Smith (1960) trapped some very small pouch gravid female *I. macrourus* in south eastern Queensland which were approximately the same weight as six month old laboratory reared animals. Gordon (1971) found that in northern New South Wales female *I. macrourus* may breed first at ages ranging from 96 to 200 days. Gordon (1971) also observed that in three male *I. macrourus*, sperm production had commenced at the approximate ages of 200, 200 and 300 days respectively, which enabled them to breed in the season of their birth.

Heinsohn (1966) examined four young female *I. o. affinis* in north western Tasmania and found that one was lactating at four to five months of age while the other three had pouch young at between four and eight months. Male *I. o. affinis* may become sexually mature by six months of age and one five month old individual which Heinsohn (1966) examined had spermatazoa present. However, Lobert and Lee (1990) found that, at Cranbourne in southern Victoria, female *I. o. obesulus* must be a minimum of seven months old before breeding. Therefore, females at Cranbourne reach reproductive maturity in the breeding season following their birth (Lobert and Lee, 1990). Lobert and Lee (1990) noted that the eight month breeding season in Tasmania easily allows young bandicoots to develop to sexual maturity and breed within the same season, while southern Victoria's six month breeding season is generally too short for individuals to reach sexual maturity in the year of their birth. Copley *et al.* (1990) observed that female *I. o. nauticus* reach sexual maturity at body weights of about 350 g to 450 g and males probably become reproductive at 450 g to 500 g.

6.1.9 Adult Growth

Heinsohn (1966) found that *I. o. affinis* continue a general increase in weight with age after weaning which continues to about 18 months of age. While growth rates for both sexes are initially equal, males become heavier than females after six months (Heinsohn, 1966). Male *I. o. affinis* weigh about 800 g at 12 months and about 1300 g at 18 months while females plateau at a maximum weight of about 800 g at 12 months of age (Heinsohn, 1966).

In Victoria, *I. o. obesulus* grow slower and weigh less as adults than *I. o. affinis* (Lobert and Lee, 1990). The heaviest male and female recorded by Lobert and Lee (1990) weighed 1150 g and 730 g respectively while the heaviest male and female caught by Heinsohn (1966) weighed 1602 g and 1104 g respectively. In Victoria sexual dimorphism becomes apparent later than in Tasmania, with males weighing more than females by three months prior to their first breeding season (Lobert and Lee, 1990). Lobert and Lee (1990) found that for males at Cranbourne there was little or no overlap in the weight classes between successive seasons' cohorts and the oldest animals were predictably the heaviest. Yet, by 12 to 18 months of age, females born in 1981 at Cranbourne had similar body weights to females born in 1980 (Lobert and Lee, 1990). Female body weights at Cranbourne assymptote at about 600 g at 18 to 24 months of age, whereas males apparently grow throughout life (Lobert and Lee, 1990).

Mackerras and Smith (1960) found that, after weaning, captive *I. macrourus* made their most rapid weight gains between the ninth and sixteenth weeks of life, with males gaining up to ten g daily and females gaining four g to five g daily. After six months the growth of these animals slowed down and was even static in some weeks. At six months males weighed between 900 g and 1000 g and females weighed up to 720 g (Mackerras and Smith, 1960). At one year of age males weighed up to 1480 g and females weighed up to 1120 g (Mackerras and Smith, 1960).

Gordon (1971) found that *I. macrourus* in northern New South Wales showed growth rates which reflected seasonal influences, with high rates of weight increase being recorded in winter to early spring followed by relatively stable weights through spring and summer. This growth pattern suggested that size increase was influenced by a seasonal growth rhythm. Gordon and Hulbert (1989) suggested that this was the mechanism that prepared the animals for the coming breeding season. Lobert and Lee (1990) found no indication of seasonal changes in the body weight of either sex of *I. o. obesulus*. Heinsohn (1966) found that individual *I. o. affinis* occasionally lost weight between successive captures and that the direction of the weight change depended on the prevailing food conditions. Heinsohn (1966, p 61) felt that "because of the close interdependance of body weight with environmental conditions, body weight is not a good criterion to use [for age estimation] except in perhaps a very general way".

6.1.10 Longevity

Stodart (1977) considered that the few bandicoots which do survive to maturity have a life expectancy of two and a half to three years. Gordon (1971) found that all young *I. macrourus* born during the first breeding season of his study were dead by 1070 days and all born in the second breeding season were dead by 855 days of age. Gemmell (1990) reported the mean lifespan of captive male *I. macrourus* to be 23.3 months and females to be 18.9 months. Heinsohn (1966) observed that in Tasmania *I. o. affinis* live over two years in the wild. Lobert and Lee (1990) found that in Victoria no *I. o. obesulus* survived into their fourth non-breeding season; that is, the maximum known longevity for both males and females was three and a half years.

6.1.11 Reproductive Potential

Heinsohn (1966, p 75) defines reproductive potential as "mean litter size times mean number of litters per breeding season". Gordon and Hulbert (1989) point out that under favourable conditions bandicoots can obtain a high reproductive output because of their short gestation period, their rapid development to maturity and their ability to produce litters in rapid succession, investing a minimum of maternal care.

Seebeck (1979) found that for female *P. gunnii* having successive litters, the mean separation between births was 65 days. In this study four female *P. gunnii* produced 35 pouch young, out of 19 litters, over a period of 16 months (mean litter size = 1.8, range = one to three) (Seebeck, 1979). Gemmell (1982) considered that captive populations of *I. macrourus* can treble every two years. Mackerras and Smith (1960) observed one captive female *I. macrourus* to produce eight litters in 17 months, totalling at least 32 young. Wild populations of *I. macrourus* also have a high reproductive potential. Gordon (1974) saw one female *I. macrourus* produce six litters in 13 months, averaging one litter every 56 days. The mean overall litter size in this study was 3.38 (Gordon, 1974). Despite this very high reproductive potential, recruitment rates are low in the wild, and *I. macrourus* populations are usually either static or they decline (Gemmell, 1990).

Stoddart and Braithwaite (1979) found that for female *I. o. obesulus* present on the Cranbourne study grid for an entire breeding season, the mean litter size was 3.17 and the mean number of litters per female was 2.61. Therefore the mean number of young produced annually per female during this study was 8.27. Lobert and Lee (1990) calculated that female *I. o. obesulus* which survived into their third breeding season at Cranbourne could produce between 12 and 35 young in a lifetime.

In Tasmania, female *I. o. affinis* produce three to four litters annually with a mean litter size of 2.80 young (Heinsohn, 1966). This suggests that an average of approximately ten young are produced annually by each female in Tasmania. On Franklin Island, Copley *et al.* (1990) found that *I. o. nauticus* produce mean litter sizes of only 2.06 young. However, Copley *et al.* (1990) considered that small litter sizes on Franklin Island may be compensated for by the ability to produce at least four and possibly five litters throughout the year, resulting in eight to ten young annually. These estimates of reproductive potential indicate that *I. o. obesulus* and other bandicoots are among the most highly fecund and fertile of all marsupials (Cockburn, 1990; Lobert and Lee, 1990).

6.1.12 Reproductive Strategy

In contrast to many other marsupials, bandicoots have undergone selection for high fecundity and rapid maturity (Lee and Cockburn, 1985). In fact, bandicoots display the most rapid growth and development of all marsupials (Gordon and Hulbert, 1989; Hall, 1983; Lee and Cockburn, 1985; Lyne, 1964; Mackerras and Smith, 1960).

Braithwaite and Stoddart (1979) postulated that female *I. o. obesulus* at Cranbourne display a temporally dynamic reproductive strategy which changes with age and body weight, and that variations observed in reproductive output are an adaptive response to prevailing population characteristics. They argued that this dynamic strategy oscillates around a continuum similar to the semelparity-iteroparity (production of one litter or many litters during the lifespan) gradient, although shifts in bandicoots' reproductive tactics occur at the iteroparity end of the scale and not at the semelparity end (Stoddart and Braithwaite, 1979). Schaffer (1974) noted that iteroparity is likely to evolve in situations of high or variable juvenile mortality (as found in wild *I. obesulus* populations), while semelparity evolves in response to low juvenile mortality and high adult mortality.

Lobert and Lee (1990) suggest that Stoddart and Braithwaite's (1979) conclusions need cautious interpretation as they are based primarily on small changes in litter size. Unlike Stoddart and Braithwaite (1979), Lobert and Lee (1990) found no indication that young females breed earlier in a season than old females; that litters produced late in a breeding season tended to be larger than litters produced early; or that there was a positive relationship between mean litter size and female body weight.

However, Lobert and Lee (1990) acknowledged that the strategy of producing small litters of rapidly growing young at frequent intervals and forcing these young to disperse suited a species living in a habitat in which unoccupied patches are frequently available, such as the heathlands of south eastern Australia (Lee and Cockburn, 1985; Stoddart and Braithwaite, 1979).

Lee and Cockburn (1985) concluded that the variation in life history tactics of bandicoots is primarily faculative and is manifested through changes in the length of the breeding season and the production of dispersive offspring. Lobert and Lee (1990) pointed out that the breeding season at Cranbourne is highly predictable and that the life history traits of *I. o. obesulus* are characterised by variation in the annual reproductive output of females.

Friend (1990) suggested that the variation in reproductive rates seen in *I. macrourus* is a response to environmental conditions, with increased breeding in the more highly seasonal areas which have short favourable periods. In less seasonal situations with longer breeding seasons, incidence of breeding seems to be lower or more variable whereas it is maximised in the highly seasonal situations to take advantage of the shorter breeding season (Friend, 1990).

6.2 Method of Examining Reproductive Ecology

6.2.1 Field Observations and Measurements

Field observations recorded during the present study provided information on litter size, breeding season, oestrus and mating, duration of pouch life, age of sexual maturity, adult growth and longevity. Each independant bandicoot captured during the present study was sexed, weighed and measured for head and pes length. Females were examined for the presence of pouch young or enlarged nipples. Litters of pouch young were sexed but not weighed. Before being released each independant bandicoot was marked on the ear with an indelible texta so that individuals could be recognised if recaptured. These texta marks remained visible for up to a week. When sites were trapped over longer periods, individuals were assigned with identification numbers which were encoded in the margins of their ears by piercing small holes with a hole punch device (Figure 6.1).

Reproductive data were also obtained by examining the SAM *I. o. obesulus* specimen collection and unpublished data collected by the FNS Mammal Club at Kuitpo in the Mount Lofty Ranges in the early 1980s. These two data sources provided additional information on litter size, breeding season, oestrus and mating, duration of pouch life, age of sexual maturity, adult growth and longevity. Finally, reproductive potential was assessed by combining information on litter size and number of litters produced per year.

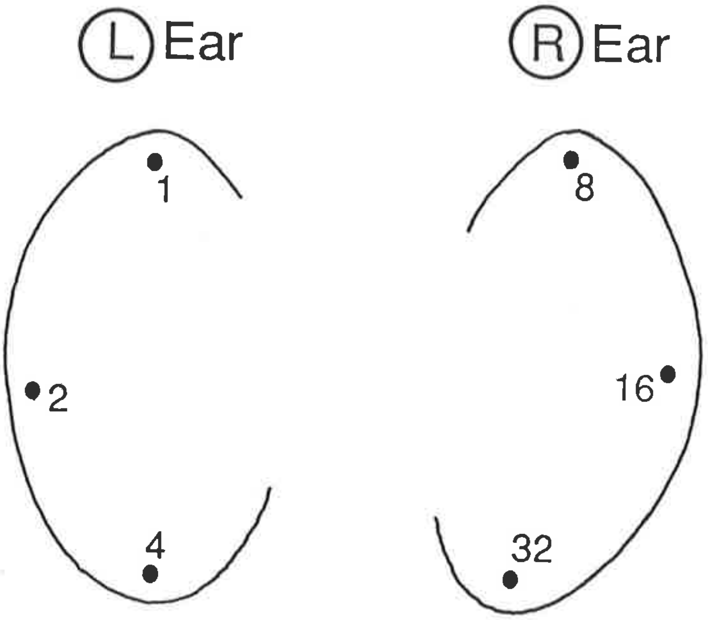
FIGURE 6.1

Ear-Mark Identification System

Notes

Combinations of these hole positions allow up to 63 individuals of each sex to be marked.

For example: 1 + 8 = 9
32 + 16 + 8 + 4 + 2 + 1 = 63



•8 = Ear Hole Punch Positions and Corresponding Numerical Codes

6.2.2 Age Estimation of Pouch Young

The ages of pouch young which were examined in the field and the SAM specimen collection were estimated from their stages of morphological development, as described in section 6.1.6 of this thesis. It was not possible to estimate the ages of pouch young observed by the FNS Mammal Club as the stages of development of these litters were not recorded.

6.2.3 Age Estimation of Independant Juveniles

Growth curves based on the body weights of juvenile *I. obesulus* of known ages were graphed so that the ages of young independant wild caught bandicoots, weighing ≤ 500 g, could be estimated. These growth curves were calculated by combining body weight data for *I. o. affinis* (compiled by Heinsohn, 1966) and *I. o. obesulus* (compiled by Lobert and Lee, 1990), with additional data collected by the author while hand rearing a male *I. o. obesulus* pouch young which was orphaned during the Mount Lofty Ranges trapping survey. The initial age of this individual was estimated by the author to be six weeks based on its weight and stage of morphological development. When collected, it weighed 38 g, its eyes were open, its lips had separated and black guard hairs were begining to erupt through a soft coat of golden coloured hair.

6.2.4 Adult Growth Patterns

The growth patterns of individuals that were repeatedly caught over periods of three months or more were examined by plotting their body weight increases against time from their initial captures. A number of inividuals from the FNS Mammal Club's Kuitpo study were also included in this sample. Some of these animals weighed < 500 g at their initial captures, allowing their weights to be plotted against estimated age.

6.3 Results and Discussion

6.3.1 Juvenile Growth Curves

Growth curves used for age estimations of young animals weighing < 500 g are shown in Figure 6.2. It appears that growth rates for both sexes are initially similar, and sexual dimorphism is not apparent for at least six months.

6.3.2 Breeding Season

Table 6.1 and Table 6.2 summarise the breeding records for *I. o. obesulus* in South Australia obtained from field observations collected during the present study, unpublished data from the FNS Mammal Club's Kuitpo study and from examination of the SAM specimen collection.

Table 6.1 shows that 23 litters of *I. o. obesulus* pouch young have been recorded in the Mount Lofty Ranges. None of these litters were recorded between the months of February and May. Breeding in the Mount Lofty Ranges therefore seems to be seasonally biased towards the latter half of the year. However, a number of juveniles recorded from the Mount Lofty Ranges were apparently born outside of this breeding season (Table 6.2). The ages of these unseasonally small bandicoots were estimated from Figure 6.2. These results indicate that while the majority of breeding

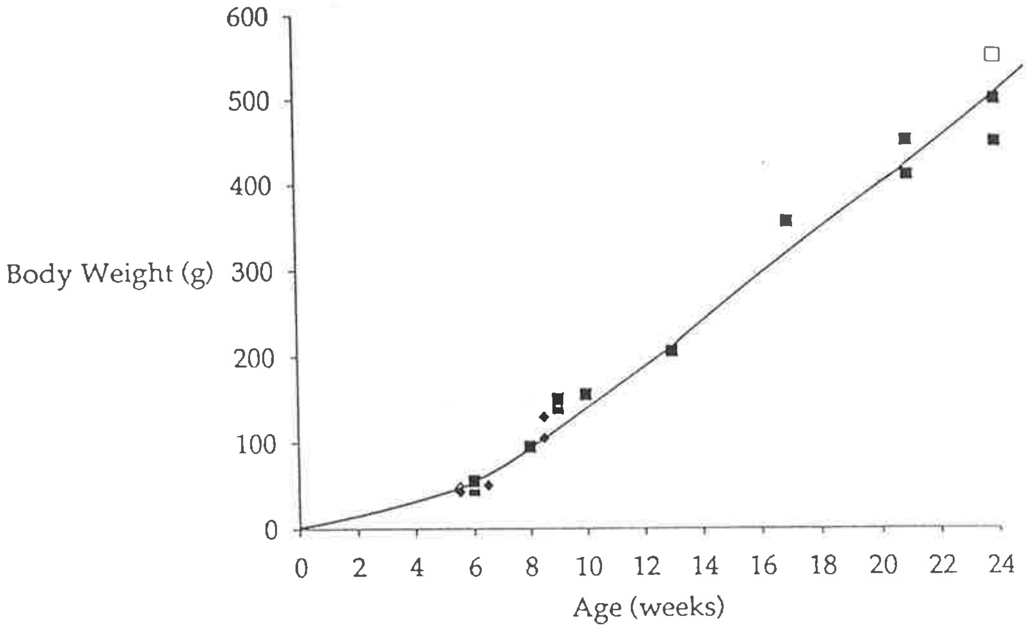
FIGURE 6.2

Juvenile Growth Curves for *I. o. obesulus*

<u>Source</u>

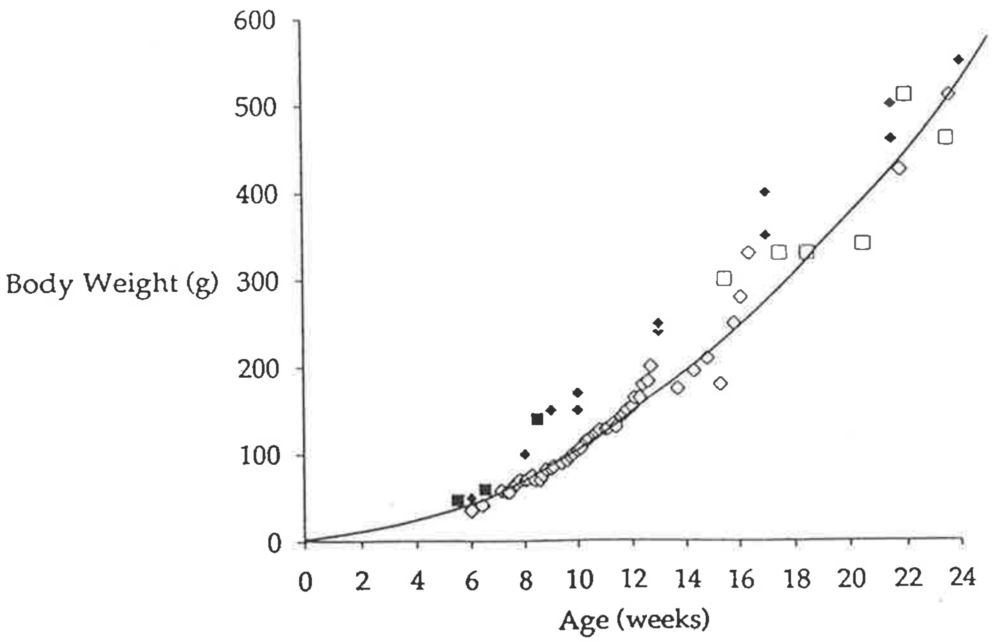
Compiled from data published by Heinsohn (1966) and Lobert and Lee (1990), and data collected during the present study by the author while hand rearing a male *I. o. obesulus.*

Female



- ■ Heinsohn (1966): 2 Captive *I. o. affinis*
- □ Heinsohn (1966): 1 Wild *I. o. affinis*
- ♦ Lobert & Lee (1990): 2 Captive *I. o. obesulus*

Male



- ■ Heinsohn (1966): 2 Captive *I. o. affinis*
- □ Heinsohn (1966): 4 Wild *I. o. affinis*
- ♦ Lobert & Lee (1990): 1 Captive *I. o. obesulus*
- ◇ Present Study: 1 Captive *I. o. obesulus*

TABLE 6.1

Records of Litters of Pouch Young of *I. o. obesulus* in South Australia

Region	Source	Litter Size	Maternal Weight (g)	Sex Ratio	Date Recorded	Age (Weeks)	Estimated Birth
MLR	PRES	3	550	2:1	22/ 7/1987	1	15/7/1987
		1	470	1:0	5/10/1987	6	24/8/1987
		2	470	1:1	6/10/1987	1	30/9/1987
		2	550	1:1	2/6/1988	2	19/5/1988
		3	660	1:2	21/8/1988	4	23/7/1988
		1	500	0:1	27/8/1988	6	16/7/1988
	FNS	5	480	?	27/7/1980	?	?
		4	?	?	24/8/1980	?	?
		4	590	?	25/10/1980	?	?
		2	685	?	26/7/1981	?	?
		2	430	?	23/8/1981	?	?
		3	620	?	23/8/1981	?	?
		3	600	?	21/9/1981	?	?
		3	560	?	18/10/1981	?	?
		3	575	?	21/11/1981	?	?
		4	730	?	27/7/1982	?	?
		2	560	?	22/8/1982	?	?
		5	670	?	26/9/1982	?	?
		4	585	?	23/10/1982	?	?
		5	785	?	21/11/1982	?	?
	SAM	3	?	1:2	Aug 1895	6	Jul 1895
		3	?	1:2	Jan 1902	5	Dec 1902
		4	?	4:0	Dec 1959	6	Nov 1959
SE	-----	--	----	----	------------	--	-----------
KI	-----	--	----	----	------------	--	-----------

Notes

MLR = Mount Lofty Ranges
SE = South East
KI = Kangaroo Island
PRES = Field observations recorded during the present study.
FNS = Unpublished records supplied by FNS Mammal Club from Kuitpo and Kyeema.
SAM = Records obtained from examination of the SAM *I. o. obesulus* specimen collection.
Mat Wt (g) = Maternal body weight in grams (including weight of pouch young).
Sex Ratio = The ratio of male to female pouch young.
Date = The date of capture or collection.
Age Wks = The estimated age of pouch young in weeks, based on their stage of morphological development.
Estimated Birth = The estimated date of birth of each litter.

TABLE 6.2

Estimated Ages and Dates of Birth of Juvenile *I. o. obesulus* Recorded in South Australia

Region	Source	Weight (g)	Sex	Date	Age (Weeks)	Estimated Birth
MLR	PRES	390	Male	8/7/1987	20	18/2/1987
		330	Female	9/7/1987	18	5/3/1987
		220	Female	26/5/1988	13	24/2/1988
		370	Female	3/6/1988	19	21/1/1988
		270	Female	21/8/1988	15	8/5/1988
		400	Male	24/8/1988	20	6/4/1988
	FNS	330	Male	26/1/1981	18	22/9/1980
		400	Female	27/7/1981	20	8/3/1981
		108	Female	23/10/1982	9	21/8/1982
		320	Female	19/12/1982	17	22/8/1982
		390	Female	2/1/1983	20	5/9/1982
		107	Female	23/1/1983	9	21/11/1982
	SAM	240	Female	14/9/1988	14	8/6/1988
		150	Male	Dec 1987	10	Oct 1987
SE	PRES	280	Male	6/4/1990	16	15/12/1989
		280	Female	16/4/1990	16	25/12/1989
		310	Female	1/5/1990	17	2/1/1990
	FNS	---	------	----------	--	----------
	SAM	---	------	----------	--	----------
KI	PRES	92	Female	18/6/1990	8	23/4/1990
	FNS	---	------	----------	--	----------
	SAM	---	------	----------	--	----------

<u>Notes</u>

MLR = Mount Lofty Ranges
SE = South East
KI = Kangaroo Island
PRES = Field observations recorded during the present study.
FNS = Unpublished records supplied by FNS Mammal Club from Kuitpo and Kyeema.
SAM = Records obtained from examination of the SAM *I. o. obesulus* specimen collection.
Wt (g) = Body weight in grams.
Date = Date of capture or collection.
Age Wks = The estimated age of juveniles in weeks, based on their body weights.
Estimated Birth = The estimated date of birth of each juvenile.

activity occurs between June and December, breeding may occur in all months of the year.

Very little information is available on the timing of breeding in the South East and on Kangaroo Island. No records of pouch young could be obtained from either of these regions. Three juveniles caught during the South East trapping survey had estimated births in mid December, 1989 to early January 1990 (Table 6.2). One very small female caught on Kangaroo Island weighed only 92 g and was estimated to be born at the end of April.

Other limited evidence for an extended breeding season was obtained by examining females for elongated teats as an indication of recent attachment. Two females caught in the Mount Lofty Ranges in April 1988 had enlarged teats. While no females were recorded carrying pouch young in the South East in late April and early May 1990, five out of the 20 individuals examined had elongated teats. However, the time for which teats remain elongated after the weaning of a litter is not clear, and these observations may indicate breeding late in 1989 rather than breeding in January, February or March of 1990.

6.3.3 Litter Size

Only six litters of pouch young were observed during the present study (all recorded from the Mount Lofty Ranges), ranging in size from one to three pouch young (mean litter size = 2.00 ± 0.4 Standard Error of the Mean (SE)). Larger litters have previously been recorded in the Mount Lofty Ranges at Kuitpo where the mean litter size of 14 litters was 3.50 ± 0.3 SE (FNS Mammal Club, unpublished data). Three litters of *I. o. obesulus* from the Mount Lofty Ranges are also held in the SAM specimen collection. These litters range in size from three to four, with a mean size of 3.04 ± 0.6 SE. Therefore, for 23 litters recorded from the Mount Lofty Ranges, sizes ranged from one to five, with a mean size of 3.08 ± 0.2 SE. Comparisons to other *I. obesulus* populations are shown in Table 6.3.

Figures 6.3 and 6.4 show that no significant relationship was found to exist between maternal body weight and litter size ($r = -0.228$, $\alpha = 0.05$, $N = 19$), or between time of production of litters and litter size ($r = 0.214$, $\alpha = 0.05$, $N = 23$). This does not support Stoddart and Braithwaite's (1979) observation that litters born late in a breeding season are larger than those prouced early in a season, or that a positive correlation exists between litter size and maternal body weight. Lobert and Lee (1990) were also unable to confirm Stoddart and Braithwaite's (1979) findings. The different results between Stoddart and Braithwaite (1979), Lobert and Lee (1990) and the present study may be attributed to both small sample sizes and variable methods of data collection. Lobert and Lee (1990) recorded maternal body weights prior to the birth of a litter. The present study included the weights of *in situ* litters (ranging in age from newly born to nearly independant pouch young) with the measure of maternal body weight. Stoddart and Braithwaite (1979) did not state the stage of lactation at which the maternal body weights were measured.

6.3.4 Litter Sex Ratio

Six male and six female pouch young were recorded during the Mount Lofty Ranges trapping survey (Table 6.1). The SAM's *I. o. obesulus* collection contains six male and four female pouch young from the Mount Lofty Ranges. Sex ratios of litters observed by the FNS Mammal

TABLE 6.3

Mean Litter Sizes of *I. obesulus*

	I.o.obesulus **Mount Lofty Ranges (Present Study)**	***I.o.nauticus*** **Franklin Island (Copley *et al.*, 1990)**	***I.o.obesulus*** **Cranbourne Victoria (Stoddart & Braithwaite, 1979)**	***I. o. obesulus*** **Cranbourne Victoria (Lobert& Lee, 1990)**	***I. o. affinis*** **Smithton Tasmania (Heinsohn, 1966)**
Mean	3.08	2.06	3.04	2.35	2.80
SE	±0.2	±0.1	±0.2	±0.2	±0.3
N	23	81	56	17	15
Range	1 - 5	1 - 4	1 - 6	1 - 3	1 - 4

Notes

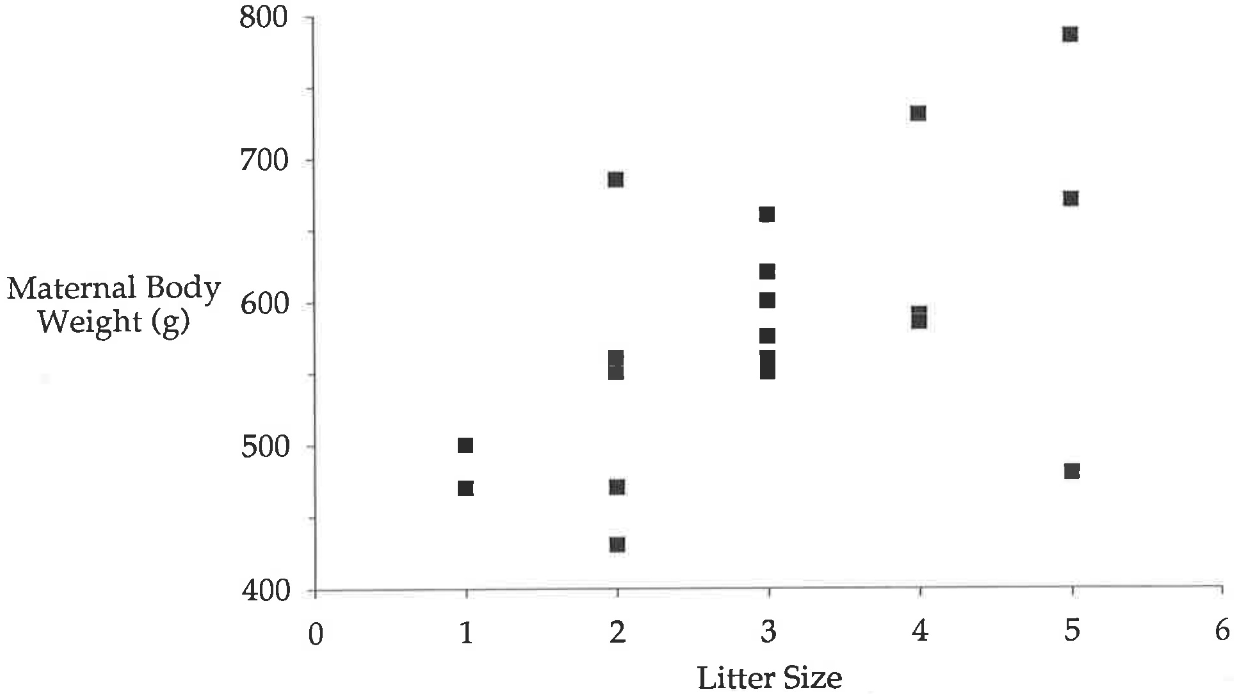
Mean = Mean Litter Size of Sample
SE = Standard Error of the Mean
N = Number of Litters in Sample
Range = Range of Litter Sizes in Sample

FIGURE 6.3

Relationship Between Litter Size and Maternal Body Weight

<u>Notes</u>

r = - 0.228 (NS), $\alpha = 0.05$, N = 19



800
700
600
500
400
Maternal Body Weight (g)
0
1
2
3
4
5
6
Litter Size

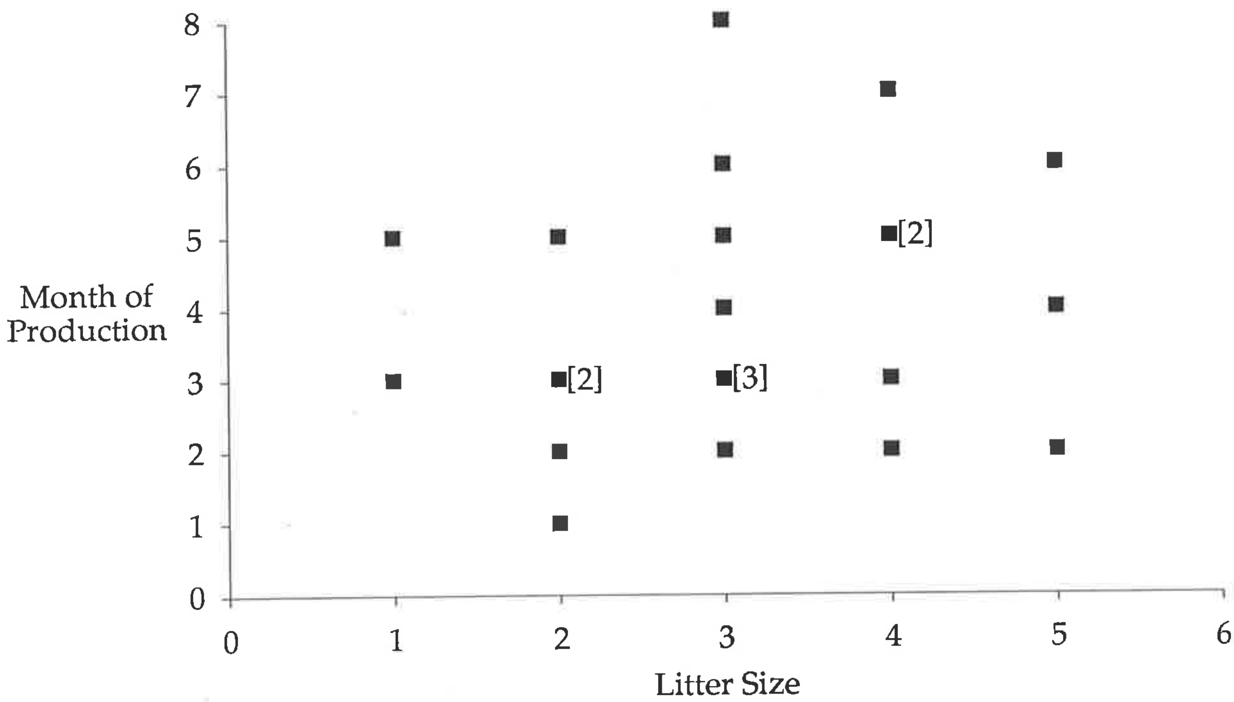
FIGURE 6.4

Relationship Between Litter Size and Time of Production

Notes

$r = 0.214$ (NS), $\alpha = 0.05$, $N = 23$

Month of Production = Months after the start of the breeding season in May.
Numbers in brackets indicate where two or three data points coincide.


Month of Production
Litter Size
[2]
[2]
[3]
[2]

Club were not recorded (Table 6.1). Although this is a very small sample size, it does indicate that approximately equal proportions of males and females are conceived in the Mount Lofty Ranges. No data were available for litter sex ratios in the South East or on Kangaroo Island.

6.3.5 Weaning Age

The smallest independant *I. o. obesulus* captured during the present study weighed 92 g. The age of this individual was estimated to be only eight weeks (Table 6.2). Two small independant juveniles were also recorded by the FNS Mammal Club at Kuitpo, weighing only 107 g and 108 g, with estimated ages of nine weeks. All of these exceptionally small individuals were females.

Although these three juveniles had clearly left their mothers' pouches, it is not certain if they were completely independant and weaned. In 1987, the SAM obtained a male juvenile *I. o. obesulus* specimen from Myponga Tiers in the Mount Lofty Ranges. This individual weighed 150 g after preservation in spirit, and it was estimated by the author to be approximately ten weeks old. The collector of this specimen was subequently interviewed by the author and it was revealed that this juvenile was flushed from a nest, along with three or four other similar sized bandicoots, and it was killed by a terrier. This suggests that young *I. o. obesulus* in the Mount Lofty Ranges sometimes continue to associate with their siblings, and they may possibly maintain a degree of dependancy on their mothers for up to ten weeks of life.

6.3.6 Sexual Maturity

The two lightest females with pouch young recorded during the present study weighed 470 g each. The lightest female with pouch young recorded by the FNS Mammal Club weighed 430 g. This indicates that females in the Mount Lofty Ranges can reach sexual maturity by the time they are approximately five or six months old. Therefore, only those females which are born early in a breeding season can be expected to breed in the year of their birth. No data are availble for male sexual maturity.

6.3.7 Oestrus and Mating

Female bandicoots can enter oestrus while still lactating, and the birth of one litter may be closely followed by the birth of another (Stoddart and Braithwaite, 1979). Evidence of this was seen at Scott Creek CP in October, 1987 when female 28 (470 g) was apparently mated while still carrying a single male pouch young, estimated to be approximately six weeks old and two weeks away from weaning. Bandicoots are pugnacious and usually avoid each other but on three consecutive nights a male bandicoot was caught in the same trap as female 28 (male 12 (1110 g) on the first two nights and male 8 (990g) on the third night). Mating at this time would have resulted in the birth of the next litter when the present pouch young was due to be weaned. Gordon (1974) recorded similar mating behaviour in *I. macrourus* which resulted in the birth of a litter after 12 days.

This observation indicates that females are attractive to males for at least three consecutive nights around oestrus. It also indicates that mating behaviour in *I. o. obesulus* is promiscuous. It is interesting to note that the two males caught with female 28 were the heaviest individuals known to be alive on this trapping grid, and it is possible that they were exerting a selective advantage over two lighter males also present on the grid (Male 5 (650g) and male 11 (840g)).

6.3.8 Adult Growth

Figures 6.5 and 6.6 show the body weight increases for individuals trapped over three or more successive months in the Mount Lofty Ranges. Individuals included in Figure 6.5 weighed ≤ 500 g at their first captures, allowing their ages to be estimated fom Figure 6.2. After six months of age, growth rates for both sexes slow considerably, with female body weights reaching about 550 g to 700 g by eighteen months and male body weights reaching about 700 g to 800 g by eighteen months (Figure 6.5). Figure 6.6 shows that further weight gains by females are only gradual, while mature males can make substantial weight gains throughout their lives.

Table 6.4 compares the mean body weights, head lengths and pes lengths of all adult bandicoots (> 400 g) caught during the present study and the FNS Mammal Club's Kuitpo study, with data for other populations of *I. obesulus*.

6.3.9 Longevity

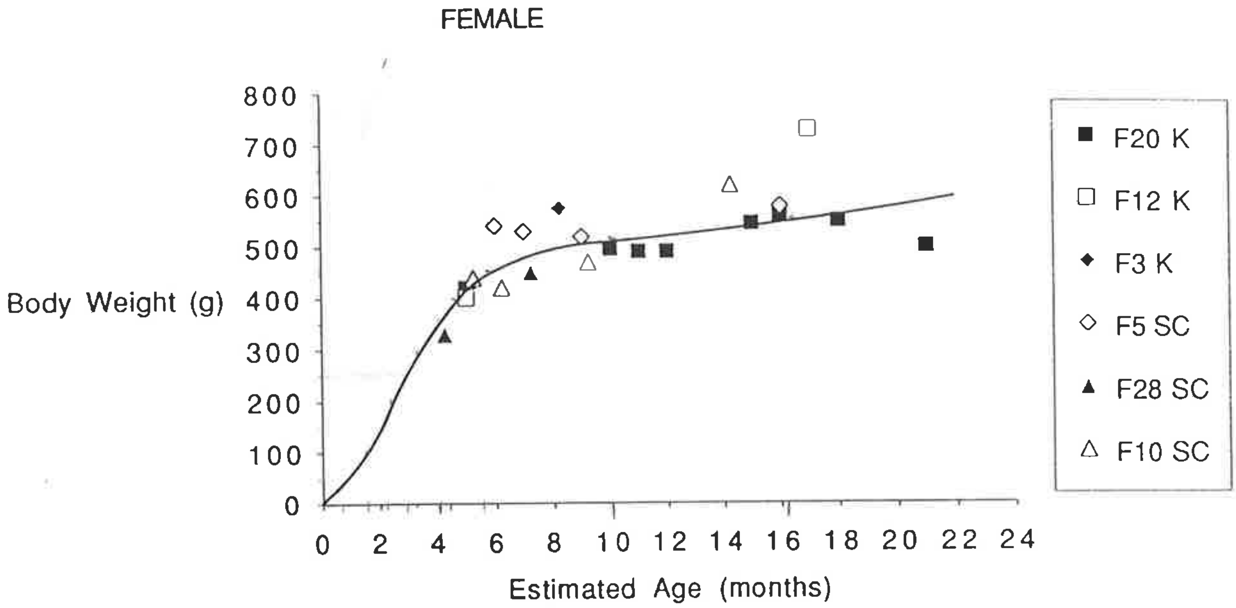
The heaviest male recorded in South Australia weighed 2400 g (Male 8 Kuitpo, Figure 6.6). Growth rates for other individuals presented in Figures 6.5 and 6.6 suggest that this inividual was at least three years old. The heaviest female recorded in South Australia weighed 870 g (Female 17 Kuitpo, Figure 6.6). It was estimated that this individual was

FIGURE 6.5

Body Weight Increases of Individuals Weighing ≤ 500g at Their Initial Capture

Notes

M = Male
F = Female
SC = Scott Creek CP
K = Kuitpo NFR


FEMALE
Body Weight (g)
0
100
200
300
400
500
600
700
800
0 2 4 6 8 10 12 14 16 18 20 22 24
Estimated Age (months)
F20 K
F12 K
F3 K
F5 SC
F28 SC
F10 SC

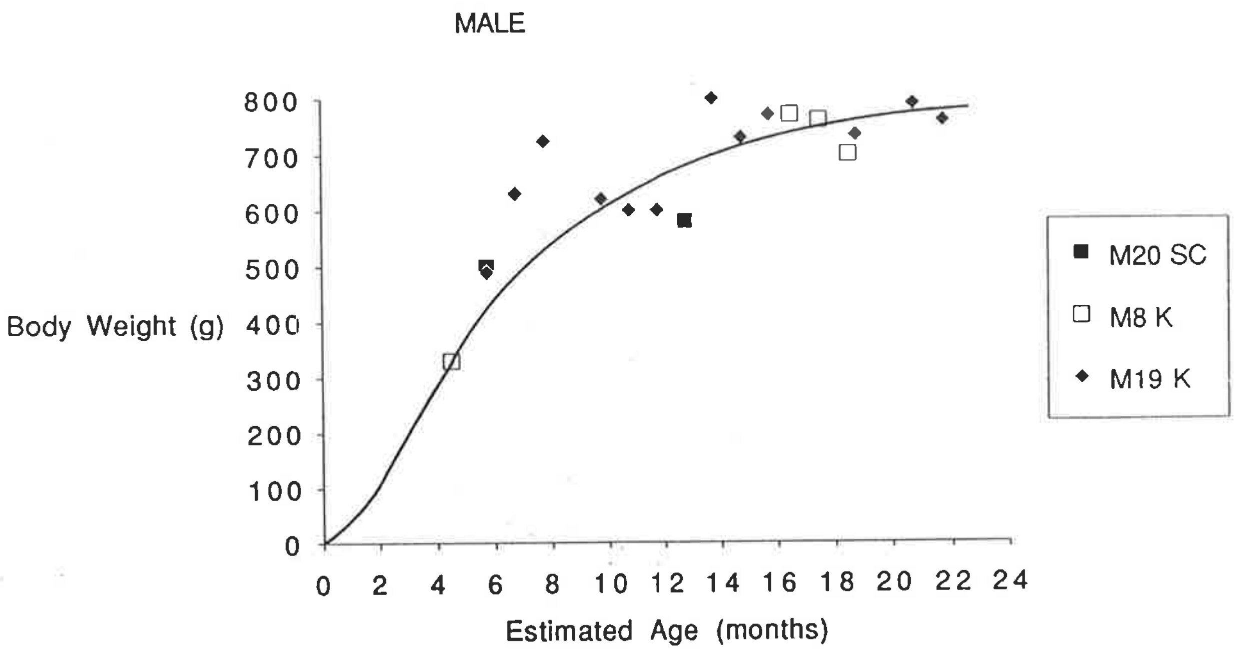
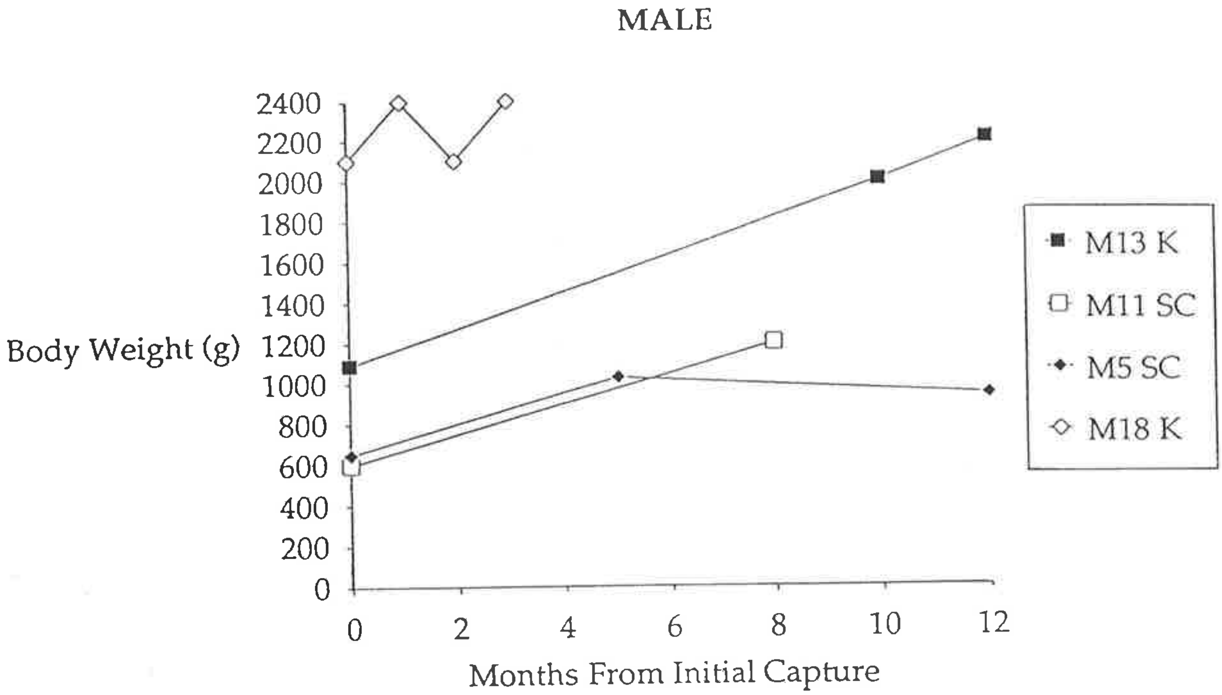

MALE
Body Weight (g)
0
100
200
300
400
500
600
700
800
0 2 4 6 8 10 12 14 16 18 20 22 24
Estimated Age (months)
M20 SC
M8 K
M19 K

FIGURE 6.6

Body Weight Increases of Individuals Weighing > 500 g at Their Initial Capture

Notes

M = Male
F = Female
SC = Scott Creek CP
K = Kuitpo NFR


MALE
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Body Weight (g)
0
2
4
6
8
10
12
Months From Initial Capture
M13 K
M11 SC
M5 SC
M18 K

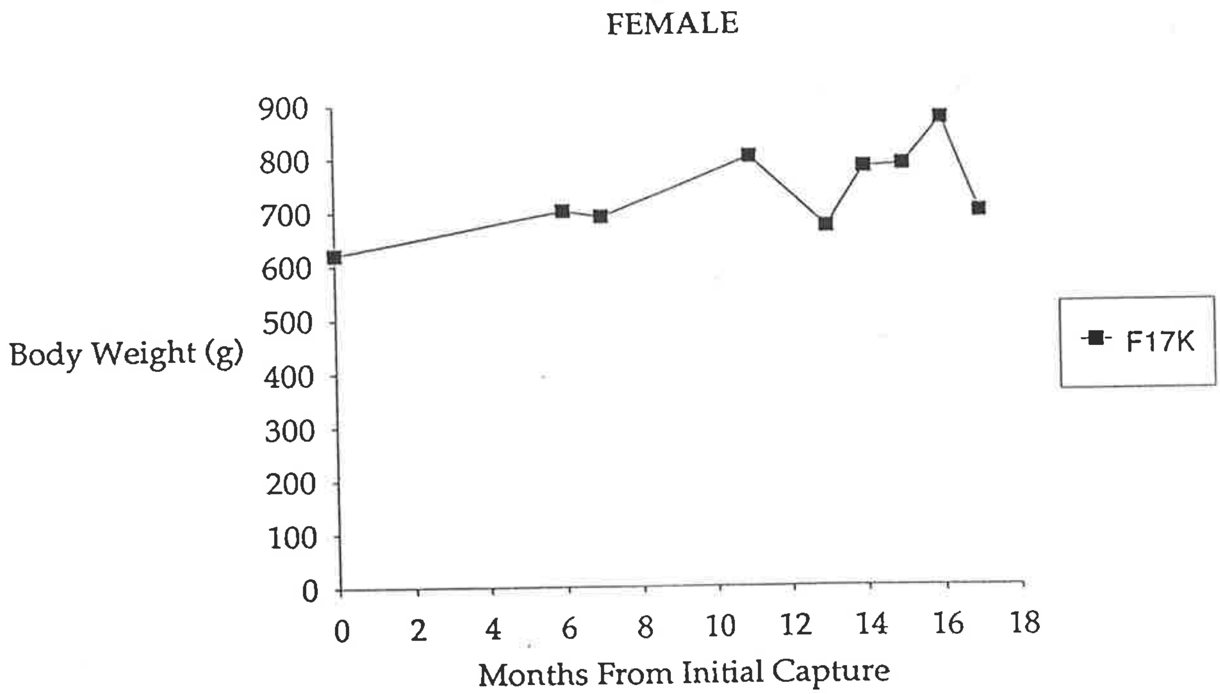

FEMALE
900
800
700
600
500
400
300
200
100
0
Body Weight (g)
0
2
4
6
8
10
12
14
16
18
Months From Initial Capture
F17K

TABLE 6.4

I. obesulus Body Dimensions

		Body Weight (g)		Head Length (mm)		Pes Length (mm)	
		Males	Females	Males	Females	Males	Females
Mt Lofty Ranges Present Study & FNS Kuitpo Study (*I. o. obesulus*)	**Mean** **SE** **N**	927.7 ±55.9 70	578.3 ±6.9 45	77.6 ±2.2 39	70.9 ±1.0 17	54.2 ±0.5 39	48.9 ±0.8 17
South East Present Study (*I. o. obesulus*)	**Mean** **SE** **N**	645 ±80.9 6	594.4 ±0.2 18	77.5 ±2.7 6	78.2 ±1.4 18	47.7 ±7.8 6	53.9 ±0.6 18
Kangaroo Island Present Study (*I. o. obesulus*)	**Mean** **SE** **N**	849 ±190.9 2		77 ±2.1 2		58 ±1.4 2	
Franklin Island Copley *et al*., 1990 (*I. o. nauticus*)	**Mean** **SE** **N**	595.3 ±6.3 189	527.8 ±6.1 143	72.3 ±0.04 94	64.4 ±0.03 94	52.6 ±0.02 92	49.2 ±0.02 95
Cranbourne, Vic Stoddart & Braithwaite, 1979 (*I. o. obesulus*)	**Mean** **SE** **N**	614.2 ±30.2 31	476.1 ±18.0 36				
Smithton, Tas Heinsohn, 1966 (*I. o. affinis*)	**Mean** **SE** **N**	1,031.2 ±41.7 8	614.5 ±33.0 5	89.6 ±0.6 8	83.7 ±0.6 5	60.1 ±0.4 8	53.9 ±0.7 5

<u>Notes</u>

SE = Standard Error of the Mean
N = Number of Individuals in Sample

approximately 12 months old at its initial capture and was therefore two and a half years old at its final capture. Lobert and Lee (1990) found that the maximum known longevity for both sexes of *I. o. obesulus* in the wild was three and a half years. However, *I. o. obesulus* can apparently survive for longer periods in captivity. SAM *I. o. obesulus* specimen 07948 was reportedly maintained in captivity for five years before its death (Appendices 1.2 and 2.3).

6.3.10 Reproductive Potential

Although females are capable of producing litters at intervals of only two months, it is most likely that in the Mount Lofty Ranges two or three litters are born in the peak breeding season of winter and spring while another one or two litters may be possible in summer and autumn. Therefore, the reproductive potential of *I. o. obesulus* in the Mount Lofty Ranges is two to five litters per year with a mean litter size of 3.08. Each female may then produce six to 15 pouch young per year. This is probably a maximum level though and it may not be achieved in poor years. Also, the mean litter size at weaning is likely to be smaller than 3.08, as the calculation of this figure includes some litters of very small pouch young. Reproductive output is therefore likely to be lower than this potential value.

6.4 Conclusion

In South Australia *I. o. obesulus* can achieve a high reproductive potential, by reaching sexual maturity at a young age and producing successive litters throughout the year. However, actual reproductive output can be expected to reflect prevailing environmental conditions, with output varying in response to factors such as increased food availability. Most births are recorded in winter and spring when soils are moist and invertebrate abundances may be high. This reproductive strategy of producing litters of rapidly maturing pouch young during favourable seasons then serves to optimise the survival of offspring when they become independent.

CHAPTER 7

POPULATION ECOLOGY

7.1 Review of Population Ecology

7.1.1 Survival, Recruitment and Mortality

Despite the high fecundity of bandicoots, weaning is followed by rapid dispersal and high mortality rates of juveniles, resulting in low levels of recruitment to adult populations (Cockburn, 1990; Lee and Cockburn, 1985). Stoddart and Braithwaite (1979) found that a significant proportion of juvenile *I. o. obesulus* which entered the trappable population at Cranbourne were never recorded again. Lobert and Lee (1990) noticed that disappearance rates for both sexes of *I. o. obesulus* at Cranbourne were highest prior to the commencement of the first breeding season of life. This suggests that young animals have considerable trouble becoming permanently established on a home range (Stoddart and Braithwaite, 1979).

On West Franklin Island, Copley *et al.* (1990) recorded 167 *I. o. nauticus* pouch young in six trapping periods which spanned 13 months, but in that time only 45 independant juveniles were caught. This indicated a loss of 73% of all offspring and, as about 22% of pouch young were lost before weaning, a minimum of 50% were lost between leaving the pouch and becoming adults (Copley *et al.*, 1990). Copley *et al.* (1990) observed that most of the new animals entering their study sites on West Franklin Island were recently independant juveniles. Recruitment to the *I. o. nauticus* population occurred throughout the year at a relatively low level of about 5% per month, but it was matched by a similar migration and mortality rate, resulting in a situation of demographic stability (Copley *et al.*, 1990).

At Cranbourne, Stoddart and Braithwaite (1979) found that recruitment of young *I. o. obesulus* into the trappable population varied between 11.9% and 17.5% with approximately seven eighths of the production being lost from the study area. High levels of juvenile dispersal were indicated as 80% of recruitment onto the grid came from litters produced outside the grid (Stoddart and Braithwaite, 1979).

Low survival and recruitment rates of wild populations of *I. macrourus* and *P. gunnii* have also been reported. Gordon (1974) found that of 26 young *I. macrourus* known to survive pouch life, only three reached sexual maturity within the study area. Heinsohn (1966) recaptured only one juvenile *P. gunnii* after marking a sample of 44 young juveniles and large pouch young in one breeding season. Survival rates of captive bandicoots can also be low. Gemmell (1990) reported that of 76 female *I. macrourus* which grew to an initial weight of 600 g, only 32 survived to give birth to a litter.

Gordon (1971) noticed that an island population of *I. macrourus* in northern New South Wales showed regular annual peaks in population size due to the influx of new young. However, these peaks were absent from a mainland population as most young were able to disperse from the area before becoming trappable (Gordon, 1971).

Copley *et al.* (1990) also encountered annual recruitment fluctuations of *I. o. nauticus* on West Franklin Island. Few new adults were observed to enter the *I. o. nauticus* population in May and June but in October, January and February almost half of the animals trapped, including juveniles and adults, were unmarked (Copley *et al.*, 1990). Friend (1990) observed two annual peaks in an *I. macrourus* population in the Northern Territory, with the first in February due to the recruitment of juveniles and the second in September and October due to an increase in the number of males in the early part of the breeding season. However, annual fluctuations in population size were not observed by Stoddart and Braithwaite (1979) or Heinsohn (1966) for *I. o. obesulus* in Victoria and *I. o. affinis* in Tasmania, or by Heinsohn (1966) for *P. gunnii* in Tasmania.

Once juveniles leave the pouch, they become particularly vulnerable to predation. In Tasmania, bandicoots are mostly preyed upon by Cats (*Felis catus)* but many deaths are also accounted for by Dogs (*Canis familiaris*), Tiger Cats (*Dasyurus maculatus*), Tasmanian Devils (*Sarcophilus harrisii*), Masked Owls (*Tyto novaehollandiae*), Tiger Snakes (*Notechis ater humphreysi*) and Copperhead Snakes (*Austrelaps superbus*) (Heinsohn, 1966). Deaths through road kills, Rabbit traps and disease also accounted for many bandicoot deaths during Heinsohn's (1966) study. On West Franklin Island *I. o. nauticus* are preyed upon by Tiger Snakes (*Notechis ater niger*) and Barn Owls (*Tyto alba*) (Copley *et al.*, 1990). In southern Victoria Dogs (*Canis familiaris*), Foxes (*Vulpes vulpes*) and diurnal birds of prey have been observed to eat *I. o. obesulus*, and Cats (*Felis catus*), Tiger Snakes (*Notechis scutatus*) and Owls are also considered to be potential bandicoot predators (Lobert, 1990; Stoddart and Braithwaite, 1979). Seebeck (1979) pointed out that the first appearance of Foxes near Hamilton in 1906 to 1914 was associated with the decline of *P. gunnii*. Dogs, Cats, raptorial birds, snakes, Rabbit traps and automobiles also cause the deaths of many *P. gunnii* in Victoria (Seebeck, 1979). Gordon (1971) listed Tree Goannas (*Varanus varius*), Carpet Snakes (*Morelia spilotes*) and some species of owls as predators of *I. macrourus* in northern New South Wales.

7.1.2 Sex Ratios

Lyne (1964, 1971) found that bandicoots conceive approximately equal sex ratios; that approximately equal numbers of male and female pouch young are reared; and that adults of both sexes are usually trapped in similar proportions. However, Hall (1983) found that the sex ratio of *I. macrourus* pouch young favoured males by 1.0 : 0.8. Heinsohn (1966) found that 54% of *I. o. affinis* pouch young less than 24 days old were male. Furthermore, of 27 reproductively mature *I. o. affinis* which were live trapped by Heinsohn (1966), 66.7% were male. Yet Heinsohn (1966) felt that this was not an accurate tertiary sex ratio as only 58.3% of mature *I. o. affinis* collected in shooting surveys were male. Nevertheless Heinsohn (1966) considered that there was an increase in the proportion of males to females of about 4.5% between birth and sexual maturity .

Unlike Hall (1983) and Heinsohn (1966), Copley *et al.* (1990) found that the sex ratio of *I. o. nauticus* pouch young favoured females by 1.00 : 1.41. While this bias in favour of females was also evident in capture data for subadult *I. o. nauticus* , the sex ratio of adult animals favoured males slightly (Copley *et al.*, 1990).

The apparent predominance of males in wild populations of *I. obesulus* indicates either differential behaviour such as female trap shyness or differential mortality, with survival and longevity favouring males (Copley *et al.*, 1990; Guiler, 1958; Heinsohn,1966). Lobert and Lee (1990) found that survival rates for males at Cranbourne was slightly higher than for females. Stoddart and Braithwaite (1979) suggested that older and larger males dominate the use of optimal habitats at Cranbourne. This then forces females to occupy sub-optimal habitats which may result in lower survival rates.

7.1.3 Population Turnover

Watts (1974) considered that the population structure of *I. o. nauticus* on West Franklin Island indicated two age groups which consisted of sub-adults and one year old adults, with possibly a few older animals. Stoddart and Braithwaite (1979) found that male generations of *I. o. obesulus* at Cranbourne turn over synchronously in three year cycles. Stoddart and Braithwaite (1979) suggested that this is because young bandicoots disperse to and colonise vacant, high quality habitat soon after its creation . At the end of three years the cohort of aging males which dominated this habitat dies, causing a synchronous turnover of generations as young individuals replace the old (Stoddart and Braithwaite, 1979).

7.1.4 Social Behaviour

I. obesulus is strongly aggressive, pugnacious and solitary living (Collins, 1973; Gordon, 1974; Heinsohn, 1966; Jones, 1924; Lee and Cockburn, 1985; Mackerras and Smith, 1960; Ride, 1970; Stodart, 1966, 1977; Stoddart and Braithwaite, 1979; Quin, 1985). Studies of captive bandicoots have shown that when two animals are housed together one is clearly dominant (Heinsohn, 1966; Stodart, 1977). Dominance in bandicoots is directly related to body weight and it is established by chases or fights (Gordon and Hulbert, 1989).

Captive bandicoots are highly prone to fighting which often results in animals being seriously injured or killed (Jones, 1924). In a fight an aggressor will persistently follow its victim until it tires. When making an assault the aggresssor jumps over the victim and strikes it with the claws of its hind feet. These strokes remove hair and cause scratches on the victim's back (Jones, 1924). As the victim tires, the aggressor attacks with a rapid scrambling motion of its fore feet, similar to the kneading action observed in bandicoot feeding behaviour (Jones, 1924). In the wild, subordinate animals may flee from an attacker but in captivity this option is usually impossible. Therefore, more serious injuries are likely to be recorded in captive studies than would occur under natural conditions.

Seebeck (1979) found that it was impractical to house more than one pair of *P. gunnii* or *P. nasuta* together in captivity. Mackerras and Smith (1960) and Collins (1973) found that when housing pairs of bandicoots together it was essential to choose animals which were approximately the same size, otherwise the smaller one was maimed or killed. Stodart (1966) found that two male *P. nasuta* could only be successfully housed together in large enclosures. Lyne (1971) found that several female *P. nasuta* could be housed with one male without serious fighting resulting.

Stodart (1966) found that male/male interactions were antagonistic amongst captive *P. nasuta* but females usually ignored other females. Stodart (1977) found that interactions between male and female *P. nasuta* in captivity were usually absent but when the two sexes met, the female usually avoided the male. Heinsohn (1966) found that when a male and a female *I. o. affinis* were housed together, the male spent a considerable time harassing the female.

Male bandicoots are strongly attracted to females for a few nights before the onset of oestrus and they have been observed to closely follow the movements of females in oestrus (Stodart, 1966). Stodart (1966) found that when a female *P. nasuta* in oestrus was placed with two males, the larger dominant male followed her while the subordinate male appeared not to be interested and kept out of the way.

In captivity two female *P. nasuta* or one male and one female *P. nasuta* may occasionally nest together (Stodart, 1977). Gordon (1974) found that wild adult *I. macrourus* always nested alone in the daytime and moved about independently at night. Gordon (1974) recorded only one association between adult *I. macrourus* in the wild. In this instance, a male and a female were probably engaging in mating behaviour as the female gave birth 12 days later (Gordon, 1974). Similarly, Heinsohn (1966) observed adult *I. o. affinis* together on only one occasion, with one animal closely following the other, apparently as part of mating behaviour.

7.1.5 Home Range

Male bandicoots occupy larger home ranges and are more mobile than females (Table 7.1) (Copley *et al.*, 1990; Gordon, 1974; Heinsohn, 1966, 1986; Lee and Cockburn, 1985; Ride, 1970; Stoddart and Braithwaite, 1979). Copley *et al.* (1990) found that the maximum home range diameters of male *I. o. nauticus* were 200 m to 220 m compared with 157 m to 168 m for females. Gordon (1974) found that range diameters of *I. macrourus* were

TABLE 7.1

Bandicoot Home Range Areas

Author	Species	Region	Male Home Range (ha): Mean & (SE)	Female Home Range (ha): Mean & (SE)	Method
Lobert (1990)	*I. o. obesulus*	S Vic	1.6 (0.4)	1.1 (0)	Telemetry
Lobert (1990)	*I. o. obesulus*	S Vic	0.9 (0.1)	1.1 (0)	Trapping
McKenzie (1967)	*I. o. obesulus*	S Vic	2.2 (?)	2.2 (?)	Not Stated
Sampson (1971)	*I. o. fusciventer*	SW WA	19.9 (?)	1.8 (?)	Not Stated
Buchman (unpubl)	*I. o. affinis*	SE Tas	0.5 (?)	0.4 (?)	Not Stated
Buchman (unpubl)	*P. gunnii*	SE Tas	0.4 (?)	0.3 (?)	Not Stated
Heinsohn (1966)	*I. o. affinis*	NW Tas	5.3 (0.5)	2.3 (0)	Trapping
Heinsohn (1966)	*P gunnii*	NW Tas	12.4 (2.3)	2.6 (0.6)	Trapping
Maloney (1982)	*I. o. affinis*	SE Tas	1.2 (0.4)	0.6 (0.1)	Trapping
Maloney (1982)	*P. gunnii*	SE Tas	0.6 (0.2)	--	Trapping
Copley *et al.* (1990)	*I. o. nauticus*	Franklin Isl	2.2 (0.2)	1.6 (0.2)	Trapping
Gordon (1974)	*I. macrourus*	SE Qld	2.8 (0.7)	1.9 (0.5)	Telemetry

Notes

SE = Standard Error of the Mean

Sources

Maloney (1982): Calculated from Table 5.2.1, in Maloney, 1982, P 140.
Heinsohn (1966): Calculated from Tables 15, 16 & 17, in Heinsohn, 1966, Pp 79, 80 & 84.
Sampson (1971): Obtained from Table 5.2.2, in Maloney, 1982, P 140.
Buchman (Unpubl): Obtained from Table 5.2.2, in Maloney, 1982, P 140.
Copley *et al.*.(1990): Obtained from Table 4, in Copley *et al.*, 1990, P 351. (*Individuals captured more than ten times only).
McKenzie (1967): Obtained from Lobert, 1990.
Lobert (1990): Calculated from Table 2, in Lobert, 1990, P 322.
Gordon (1974): Calculated from Table 5, in Gordon, 1974, P 415.

greater than 150 m for males and less than 150 m for females. Gordon (1974) considered that the larger home ranges of males were due partly to their greater body weight, as large animals required more space than small ones. However, Maloney (1982) found no significant correlation between home range area and weight of individual *I. o. affinis*. Heinsohn (1966) found no indication that home range area is affected by age in either sex of *P. gunnii.*

Heinsohn (1966) found that *I. o. affinis* used smaller home ranges than *P. gunnii*. Stodart (1977) thought that this may be due to the preference of *Perameles* for more open habitats than those used by *Isoodon*. The home range areas of *I. o. affinis* and *P. gunnii* in south eastern Tasmania were found by Buchman (in Maloney, 1982) and Maloney (1982) to be considerably smaller than those of Heinsohn's (1966) north western Tasmania study. Maloney (1982) felt that this difference may have been due to the more open habitat at Heinsohn's (1966) study site, enabling less restricted movements. This was also supported by the larger linear distances moved between successive captures recorded by Heinsohn (1966) compared to Maloney (1982). Maloney (1982) also found that individual males and females had home ranges of similar sizes but considered that the home range patterns of this population were being influenced by the encroachment of human settlement on three sides of the study site.

I. o. nauticus on West Franklin Island and *I. macrourus* in south east Queensland have been oberved to occupy small home ranges (Table 7.1) (Copley *et al.*, 1990; Gordon, 1974). By contrast Sampson (in Maloney, 1982) found the mean home range area of *I. o. fusciventer* in south west Western Australia to be especially large, particularly for males. Sampson (in Maloney, 1982) attributed these exceptionally large male home ranges to the arid Western Australian conditions, causing individuals to forage over greater distances for food. Lobert (1990) demonstrated that the different methods employed by the above authors for measuring and calculating home range area influenced the variability of their findings. Lobert (1990) found that trap-determined home range estimates were likely to underestimate the home range areas determined by radio tracking. Large variability also typically exists in the home ranges of individual bandicoots, so that some animals occupy very large areas and other animals occupy very small areas (Lobert, 1990).

The degree of overlap in inividuals' home ranges was also found to vary considerably between each of these studies. Heinsohn (1966) found that *I. o. affinis* were widely dispersed over the study area with very little overlap in home ranges. By contrast the home ranges of *P. gunnii* overlapped extensively at the same site, and some males' home ranges not only encompassed several females' home ranges but also overlapped with other males' home ranges (Heinsohn, 1966). In south eastern Tasmania Maloney (1982) found that overlap was extensive in the ranges of individual *I. o. affinis* but no overlap occured in the home ranges of *P. gunnii* conspecifics. Maloney (1982) found that home ranges of *Perameles* and *Isoodon* overlapped though.

Lobert (1990) found that home ranges of *I. o. obesulus* at Cranboune displayed a high degree of overlap both within and between sexes. Copley *et al.* (1990) found that onWest Franklin Island*I. o. nauticus* home ranges partially overlapped between animals of the same sex and completely overlapped between animals of different sex. In south western Western Australia Heinsohn (1986) found that female *I. o. fusciventer* had small non-overlapping home ranges which were restricted by a distinct preference for specific types of vegetation while males occupied very large home ranges and utilised all plant associations.

Gordon (1974) found that the home ranges of radio-tracked *I. macrourus* overlapped 30% to 100% in female/female and male/female combinations. Two males being tracked together showed a range overlap of about 33%. Gordon (1974) pointed out that in this study other untracked animals were also often present and overlap of home ranges may have been total.

Gordon (1974) found that both sexes of *I. macrourus* usually maintain discrete core areas within their home ranges. These core areas are regions which are subject to more intensive use, such as feeding sites and nest sites (Maloney, 1982). In small home ranges these core areas may not be evident but in larger home ranges, two or more core areas may be present (Gordon, 1974). Gordon (1974) found that core areas are not necessarily located in the centre of home ranges but are sited according to social pressures, and that socially subordinate individuals may not be able to maintain exclusive use of their core areas.

Copley *et al.* (1990) considered that, although the home ranges of *I. o. nauticus* overlapped extensively, individual animals may be able to occupy totally discrete home ranges through temporal separation of activity or perhaps by some defence of the areas around nest sites. However, Watts (1974) found no indication that individual *I. o. nauticus* held territories from which others were excluded. Heinsohn (1966) and Maloney (1982) felt that considering its territorial behaviour in captivity *I. o. affinis* is probably strongly territorial in the wild. To support this, Heinsohn (1966) also observed one large wild *I. o. affinis* defending its territory when three hand reared juvenile *I. o. affinis* were released into its established home range. Lobert (1990) pointed out that the studies which considered *I. obesulus* to be territorial, such as Heinsohn (1966) and McKenzie (in Lobert, 1990) were generally conducted at low population densities where home ranges did not overlap significantly.

Gordon (1974) found that male *I. macrourus* performed a patrolling behaviour in which they traversed rapidly around most of their range at some time of the night, while most of their night's activity was spent in a relatively small section of their home range. Female *I. macrourus* apparently did not display this behaviour and Gordon (1974) believed that range patrolling was responsible for the larger home range areas of males. Gordon (1974) considered that range patrolling may serve to familiarise the animal with its range and to aid in the detection of intruding animals. However, Gordon (1974) considered that patrolling movements were probably too infrequent to keep intruders out. Gordon (1974) pointed out that males which move over large home ranges also have a selective advantage in being able to mate with a greater number of females.

Home ranges of bandicoots are plastic and dynamic, changing in size under the influence of pressures such as food abundance and population densities (Maloney, 1982). Gordon (1974) found that fidelity to a particular locality did not prevent a slow drift in the position of core areas of *I. macrourus* from one side of the home range to another over a period of four to six months. Maloney (1982) concluded that if bandicoots do possess territories, then they are in the form of spatio-temporal systems, based on passive avoidance of other bandicoots and reinforced by experience and learning. Animals may therefore only defend the area where they happen to be at any given time (Maloney, 1982). Day *et al.* (1974) suggested that faeces may be used by *I. macrourus* as territorial markers. Day *et al.* (1974) found that defaecation by *I. macrourus* increased with increased exposure to novel environments and when faeces and urine were placed in an open field, other bandicoots approached them and then backed away.

Nests and feeding sites apparently act as nuclei of core areas. Gordon (1974) found that in the wild *I. macrourus* positioned their nests anywhere from the centre of their home ranges to the extreme margins, away from regions of current activity. Usually their nests were positioned in relation to their patterns of movement (Gordon, 1974). Animals with large home ranges and two separate regions of activity usually had a nest site in each region, and at the end of a night's activity they occupied the nest site in the region last used (Gordon, 1974). Heinsohn (1966) and Maloney (1982) found that both *I. o. affinis* and *P. gunnii* located their nests in densely vegetated areas and then moved into different habitats to forage at night.

Gordon (1974) found that *I. macrourus* had a high rate of nest changing and if disturbed from a nest, moved straight to an alternative nest. Seebeck (1979) found that when *P. gunnii* were taken from the wild and placed in captivity each animal initially made one or two nests but only occupied these for a week or two before deserting them. Stodart (1966) found that captive *P. nasuta* could usually be found in the same nest but if animals were caught too often they would tend to move to another nest.

7.1.6 Movement Patterns

Watts (1974) found that *I. o. nauticus* moved an average distance of 68 m between successive captures and therefore considered this species to be highly mobile. In Tasmania, Heinsohn (1966) found that the mean linear distance travelled by *I. o. affinis* between successive 24 hour observations was 259 m (maximum = 632 m) for males and 134 m (maximum = 473 m) for females. Heinsohn (1966) observed a young male *I. o. affinis* to move 359 m in one day along a tea-tree hedgerow surrounded by open paddocks.

In some instances mobility appears to change seasonally. Copley *et al.* (1990) found a consistent seasonal trend in the mean range lengths of *I. o. nauticus*, with the greatest movement being recorded in December, declining to a minimum in June and followed by a sharp increase in October. Copley *et al.* (1990) suggested that increased mobility of *I. o. nauticus* in summer may be caused by the arrival of vast numbers of shearwaters to Franklin Island, or it may reflect a need to increase foraging range during dry periods when food resources are more widely dispersed.

Gordon (1974) found that when *I. macrourus* forage, they progress slowly onward in an undirected fashion with little evidence of rigid patterns such as the use of fixed runways or orientation around fixed goals. Movements of *I. macrourus* only follow definite runways where ground layer vegetation is very dense but in less dense vegetation and open areas, no visible paths develop (Gordon, 1974). Guiler (1958) found that *I. o. affinis* used well defined trails when travelling between nest sites and feeding areas. As Guiler (1958) made very few captures on these trails compared to captures at feeding sites, he concluded that *I. o. affinis* was not interested in foraging for food while in transit on runways. Gordon

(1974) found that *I. macrourus* never stayed long in one spot, except at rest sites and they would often return to feeding sites visited earlier in the night.

7.1.7 Transiency and Residency

Gordon and Hulbert (1989) noted that studies of bandicoot populations often report high rates of transiency and Thomas (1990) suggested that when suitable habitat is limited the ratio of transient to resident individuals increases in a population. This is not entirely supported by Guiler (1958) who made very few recaptures of *I. o. affinis* in a low density population, or by Copley *et al.* (1990) who recorded high recapture rates in the relatively dense *I. o. nauticus* population.

Transiency in bandicoots is driven by the need to find new, productive habitats, while avoiding competition from larger, dominant individuals. Heinsohn (1966) documented the complete shift of home ranges of three young *P. gunnii* which had probably been forced to make the move by older bandicoots. Two of these individuals shifted to an area which had been burnt the preceding autumn and their movements may have represented the utilization of an area that had just been opened up to exploitation by *P. gunnii* (Heinsohn, 1966).

Gordon (1974) found that of 20 *I. macrourus* trapped on a study site, ten were resident for between two and 18 months, while ten were transient and were only trapped once. This indicated that about half of the animals on this study site did not have a permanent home range. Eight of these ten transient animals were male and two were female (Gordon, 1974). Stoddart and Braithwaite (1979) found that male *I. o. obesulus* remained on a trapping grid for a shorter duration than females (male = 5.78 months; female = 8.89 months), indicating a male bias in transiency rates. Lobert and Lee (1990) found that both sexes of *I. o. obesulus* remained in the trap record for similar periods of time, with mean values of 192.7 days for males and 171.4 days for females. Despite the apparently short stays which many bandicoots make at particular sites, Stoddart and Braithwaite (1979) found that 12.4% of all *I. o. obesulus* caught appeared in the trapped sample for at least 12 months and one animal which was an adult when first trapped persisted on the trapping grid at Cranbourne for 32 months. Therefore, while significant proportions of these bandicoot populations were transients, some animals became established on semi-permanent home ranges.

Maloney (1982) pointed out that, in general, the poorer the energy yield of a habitat, the larger the size of the home range to compensate for the former. The flexible, free ranging movements displayed by bandicoots are apparently an adaptation to finding food that is scattered about in small quantities rather than in a large concentration in one spot (Gordon, 1974).

7.1.8 Population Density

In north western Tasmania, Heinsohn (1966) found *I. o. affinis* at a density of three to eight individuals per 40 ha. Watts (1974) found that on Franklin Island, where the home ranges of *I. o. nauticus* overlap extensively, densities reached as high as eight and 11 bandicoots per ha. Watts (1974) also considered that the general lack of male aggression seen on Franklin Island (where animals usually ignored each other completely) suggested that social organisation in this population was based on peck order rather than on territorial behaviour which Heinsohn

(1966) proposed was operating in Tasmania. Gordon (1974) suggested that Heinsohn's (1966) *I. o. affinis* population occured below normally attainable densities, for some unknown reason, and therefore non-overlapping home ranges resulted.

Maloney (1982) considered that variability of population estimates between studies can presumably be attributed to differences in climate, abundance of food and vegetation. Maloney (1982) demonstrated that two sites in the Hobart region which were separated by about ten km displayed considerably different population densities of *I. o. affinis*. In 12 years the population density at one of these sites declined from 21 bandicoots per 20 ha to four bandicoots per 20 ha Maloney (1982). In that time the area had been subjected to several bushfires. Urban encroachment had also isolated this patch to some degree and increased predation rates were experienced from Dogs and Cats (Maloney, 1982). Guiler (1958) warned that changes which may occur to bandicoot populations make any population density estimates unreliable over a long period and recommended that only short term trapping should be used for population estimates.

Gordon and Hulbert (1989) considered that where bandicoot population dynamics have been studied, numbers have ranged from being relativly stable to quite stable. However, Friend (1990) documented a drastic decline of a population of *I. macrourus* in the Northern Territory with densities falling from 0.7 animals per ha in February 1981 to 0.05 animals per ha in January 1983. Heinsohn (1966) observed a similar decline in a *P. gunnii* population from 59 animals per 40 ha in March 1961 to 18 animals per 40 ha in April 1962. Copley *et al.* (1990) found that in 1984 bandicoot densities on Franklin Island were only 1.3 to 1.4 animals per ha in contrast to Watts' (1974) estimate of the 1970 population density of 8 to 11 animals per ha. Despite some evidence that bandicoot numbers on Franklin Island may fluctuate seasonally (with high densities in autumn dropping off slightly in winter and spring to a low in summer), Copley *et al.* (1990) described the overall pattern as one of numerical stability.

Stoddart and Braithwaite (1979) found no marked changes in the density of *I. o. obesulus* with time at Cranbourne, Victoria. Even the cull of eight animals from the Cranbourne trapping grid in 1976 caused only a temporary reduction in numbers and within four months normal population levels were regained (Stoddart and Braithwaite, 1979). *I. obesulus* populations have the capacity to increase in both size and density in a short period of time (Thomas, 1990) and by the 1982 breeding season the bandicoot density at Cranbourne had reached its highest recorded level of 5.0 animals per ha on the study grid (Lobert and Lee, 1990). Lobert and Lee (1990) pointed out that while the abundance of soil invertebrates was relatively high at this time, the bandicoot population increase could have resulted in a decrease in the amount of food available to individual bandicoots during 1982 because of the increased competition for food resources. This may have then contributed to a bandicoot population crash witnessed in mid to late 1983 when only 1.0 bandicoot was found per ha on this study grid (Lobert and Lee, 1990). Lobert and Lee (1990) considered that the inclusion of usually ignored food items such as millipedes, scorpions, centipedes and bullants in the diet of *I. o. obesulus* at Cranbourne, combined with a drought which lasted from mid 1982 to early 1983, indicated a shortage of food at this time. Lobert and Lee (1990) also considered that between year decreases in the reproductive output of *I. o. obesulus* may be caused by decreases in the abundance of food resources.

Food availability may not be the only mechanism which regulates bandicoot numbers. Thomas (1990) proposed that stress induced in *I. o. fusciventer* by high population densities may be sufficient to induce intrinsic population regulation mechanisms. Gordon (1974) suggested that *I. macrourus* may modify its behaviour to spend less time active and thus avoid conspecifics at higher densities.

7.2 Method of Examining Population Ecology

7.2.1 Capture / Recapture Trapping

Three permanent trapping grids were established at Scott Creek CP in the Mount Lofty Ranges so that a sample of the local bandicoot population could be monitored between May, 1987 and October, 1988 (Figure 7.1). Bandicoots trapped on these grids were ear-marked (Figure 6.1) and the trap station of each capture was recorded. Trapping over successive seasons then provided information on individuals' movements and changes in the population structure on each grid. Additional unpublished population data for two other Mount Lofty Ranges trapping grids (Kuitpo and Kyeema Grids) were made available by courtesy of the FNS Mammal Club (Figure 7.2).

7.2.2 Radio-Telemetry

In October, 1988 a two week radio-telemetry exercise was conducted on grid 2 at Scott Creek CP to obtain further information on bandicoots' movements. During this period four adult males were each fitted with a lace-up canvas harness holding a *"BIOTRACK SR-1"* radio transmitter (150.7 to 151.0 MHz) (Figure 7.3). Unfortunately, no females were caught

FIGURE 7.1

Scott Creek Permanent Trapping Grids

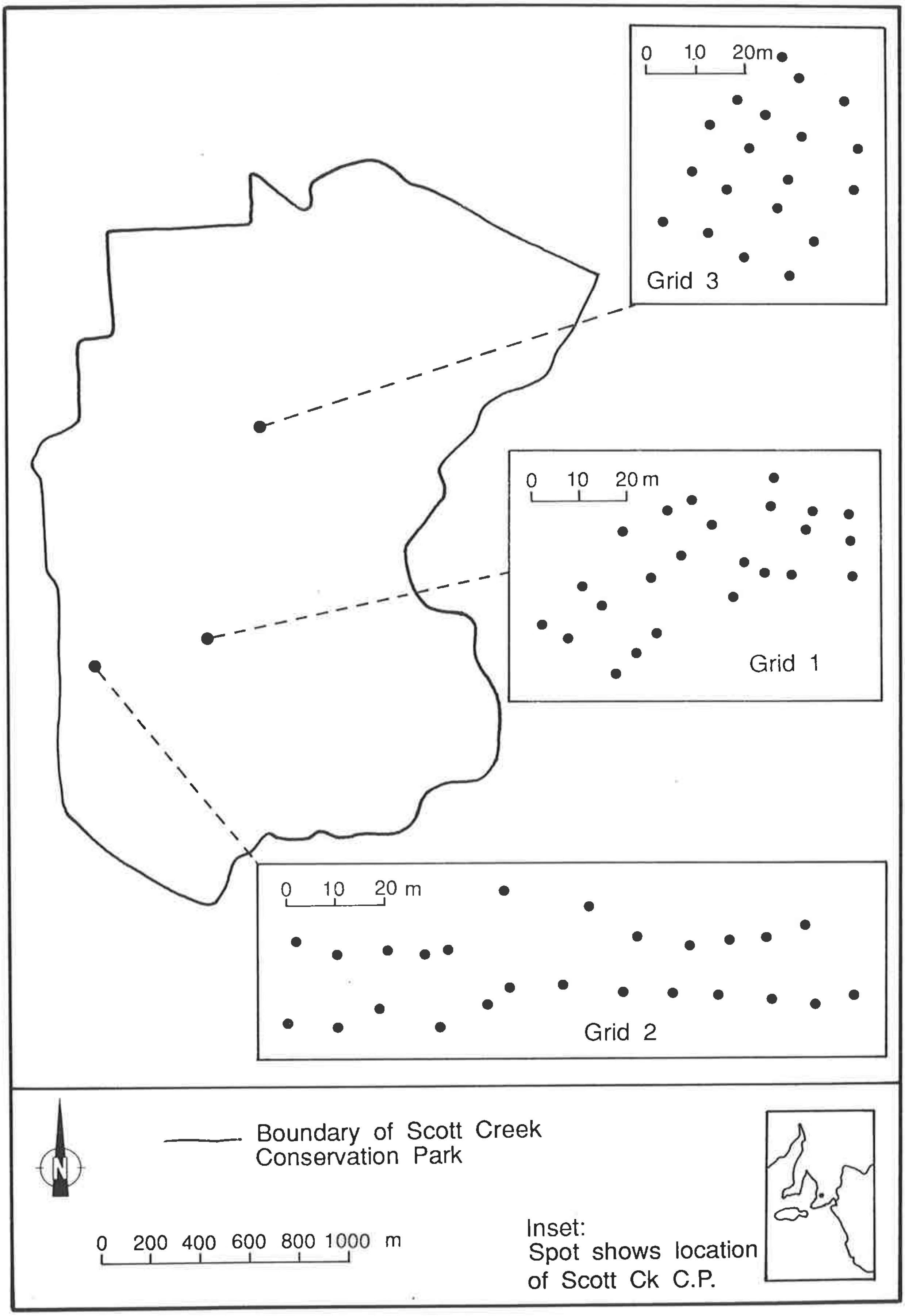

0 10 20m
Grid 3
0 10 20 m
Grid 1
0 10 20 m
Grid 2
N
Boundary of Scott Creek Conservation Park
0 200 400 600 800 1000 m
Inset:
Spot shows location of Scott Ck C.P.

FIGURE 7.2

Kuitpo and Kyeema Permanent Trapping Grids

Notes

Inset shows the location of Kuitpo and Kyeema.
Squares = Trapping Stations.
Dark Stipple = Pine Forest.
Light Stipple = Native Forest.
Fire access roads are not shaded.

Source

Thompson *et al.* (1989)

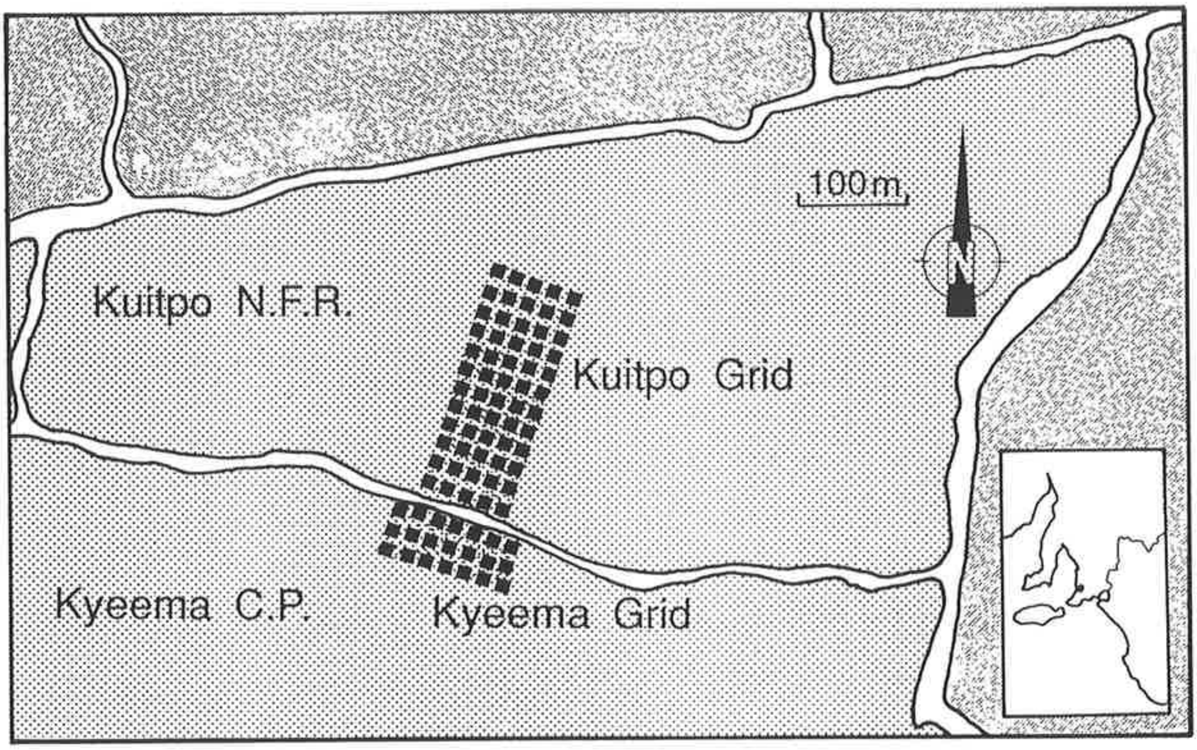

100m
N
Kuitpo N.F.R.
Kuitpo Grid
Kyeema C.P.
Kyeema Grid

FIGURE 7.3

Radio Transmitter Harness

during this exercise, limiting the telemetry sample to males only. It was found that the four bandicoots which were tracked could each be approached closely, allowing their positions to be recorded to the nearest ten metres by using a single portable directional antenna. The coordinates of each radio location were recorded from a grid overlay placed on an aerial photograph of Scott Creek CP.

7.3 Results and Discussion

7.3.1 Survival and Recruitment

During the Mount Lofty Ranges trapping survey, 12 pouch young were observed but only six independant juveniles (≤ 400 g) were caught. This indicates a loss of approximately 50% of offspring from pouch life to adulthood. The FNS Mammal Club recorded a total of 49 pouch young on the Kuitpo and Kyeema trapping grids, but in the same time only five independant juveniles were caught, indicating a loss of approximately 90% of offspring. No data were available for survival and recruitment rates in the South East or on Kangaroo Island.

7.3.2 Juvenile and Adult Sex Ratios

Captures of juveniles (weighing ≤ 400 g) were dominated by females. Two juvenile males were caught during the Mount Lofty Ranges trapping survey compared to four females; one juvenile male and two females were caught during the South East trapping survey; and one juvenile female was caught during the Kangaroo Island trapping survey. The FNS Mammal Club recorded one juvenile male compared to four juvenile females. Overall then, four juvenile males have been recorded in South Australia compared to 11 juvenile females. While juvenile sex ratios suggest that a differential survival rate exists which favours females, this bias was not reflected in adult sex ratios. Twenty seven adult males were captured compared to ten females during the Mount Lofty Ranges trapping survey; six adult males and eighteen females were caught during the South East trapping survey; and two adult males were caught during the Kangaroo Island trapping survey. The FNS Mammal Club recorded seven adult males compared to nine females. Overall then, 42 adult males have been recorded in South Australia compared to 37 adult females.

Apparently the sex ratios of adult *I. o. obesulus* varies considerably between different sites. The population structure recorded during each trapping period on Scott Creek Grids 1, 2 and 3, and on the Kuitpo and Kyeema Grids is shown in Tables 7.2 to 7.6. Each of these five sites was used almost exclusively by either males or females, but not by both sexes. Scott Creek Grids 1 and 2, and the Kyeema Grid were used predominantly by males. Scott Creek Grid 3 and the Kuitpo Grid were used predominantly by females. It is possible that males on Grids 1 and 2 and on the Kyeema grid competed for food and shelter at the exclusion of females. Stoddart and Braithwaite (1979) believed that very few females were caught at Cranbourne in areas of regenerating heathland as the presence of males excluded the entry of females into this vegetation type. During the present study there was no indication that either sex was more trap-shy than the other. Each female marked and released on these five grids was captured an average of 3.71 times compared to 3.24 captures for males.

TABLE 7.2

Population Changes on Scott Creek Grid 1

GRID 1					
May 87	**Jun 87**	**Jul 87**	**Oct 87**	**Mar 88**	**Oct 88**
M1 (1150)	M1 (1120)	M2 (930)	M9 (730)	F10 (620)	M36 (540)
M2 (900)	M2 (930)	M3 (400)	M13 (520)		
M3 (480)	M3 (480)	M13 (390)	M17 (950)		
M4 (1030)	F10 (440)	M17 (930)	M32 (600)		
			F10 (470)		

TABLE 7. 3

Population Changes on Scott Creek Grid 2

GRID 2				
Jul 87	**Sep 87**	**Oct 87**	**Mar 88**	**Oct 88**
M19 (1210)	F28 (330)	M5 (650)	M5 (1030)	M5 (940)
M11 (610)		M19 (1120)	M10 (850)	M10 (900)
M16 (1000)		F28 (470)	M11 (1200)	M20 (600)
		M8 (990)	M20 (500)	MY (550)
			MX (540)	M33 (680)

TABLE 7.4

Population Changes on Scott Creek Grid 3

GRID 3			
May 87	**Jun 87**	**Jul 87**	**Mar 88**
M6 (970)	F5 (540)	M18 (630)	F5 (580)
F5 (540)	F9 (510)	F5 (520)	
		F9 (550)	

<u>Notes</u>

M = Male
F = Female
(650) = Individual's body weight in grams
MX and MY (Grid 2) were not given a permanent identification mark

TABLE 7.5

Population Changes on Kuitpo Grid

KUITPO						
Jul 80	**Jan 81**	**Mar 81**	**Jul 81**	**Aug 81**	**Sep 81**	**Feb 82**
F1 (480)	M8 (330)	M9 (1040)	M13 (1090)	F3 (430)	F20 (420)	F17 (700)
			F12 (400)	F17 (620)		
			F14 (685)			
Mar 82	**Jul 82**	**Sep 82**	**Oct 82**	**Nov 82**	**Dec 82**	**Jan 83**
F17 (700)	M26 (580)	F17 (670)	F17 (780)	F17 (785)	M30 (720)	M30 (720)
	F12 (730)				F17 (870)	F17 (695)
	F17 (800)					F31 (107)

TABLE 7. 6

Population Changes on Kyeema Grid

KYEEMA							
Sep 81	**Oct 81**	**Nov 81**	**Jan 82**	**Feb 82**	**Mar 82**	**Apr 82**	**May 82**
M18 (610)	M19 (630)	M19 (725)	M8 (770)	M8 (760)	M8 (700)	F20 (490)	M13 (2000)
M19 (490)	F4 (560)	F3 (575)	M19 (620)	M19 (600)	M19 (600)		M19 (800)
F24 (600)			F25 (510)	F20 (510)	F20 (490)		
Jun 82	**Jul 82**	**Aug 82**	**Sep 82**	**Oct 82**	**Nov 82**	**Dec 82**	**Jan 83**
M19 (730)	M13 (2200)	M18 (2400)	M18 (2100)	M18 (2400)	M18 (1875)	M19 (790)	M19 (760)
	M18 (2100)	F20 (560)		M19 (735)			F20 (500)
	M19 (790)			F20 (585)			F29 (400)
	M27 (570)			F28 (108)			
	F20 (550)						

<u>Notes</u>

M = Male
F = Female
(650) = Individual's body weight in grams

7.3.3 Population Dynamics on Trapping Grids

Scott Creek Grid 1

During 1987, ten individuals were trapped on this grid. However, only two individuals were caught on Grid 1 in 1988 (Table 7.2). Lobert and Lee (1990) believed that a similar decline in bandicoot numbers at Cranbourne in 1983 was related to a reduction in food abundance. The decline in bandicoot numbers seen on Grid 1 may also have been due to increased competition for food amongst bandicoots, coinciding with the desiccation of top-soil during the summer of 1987/1988.

Scott Creek Grid 2

Turnover of mature males and recruitment of juvenile males helped to maintain relatively stable bandicoot numbers on Grid 2 from October, 1987 (Table 7.3). In 1987, mature males 8, 16 and 19 disappeared, allowing males 5, 10 and 11 to then become established on this grid. Since the completion of the present study, this site has been used for a study of bandicoot diet (Herbert, personal communication), and apparently bandicoot numbers on Grid 2 were still high in late 1991.

Scott Creek Grid 3

Female 5 was caught on Grid 3 on all trapping periods. A second female (female 9) was caught in June and July, 1987 (Table 7.4). Two males were also recorded here but, as they were only trapped once each, it can be assumed that they were either transient or that they only occasionally moved onto this grid, perhaps to mate with females 5 and 9.

Kuitpo Grid

Bandicoot numbers remained relatively constant on the Kuitpo Grid thoughout the FNS Mammal Club's study despite an experimental fuel reduction burn conducted prior to the September 1981 survey period (Table 7.5). However, following the severe Ash Wednesday bushfires of February, 1983 no more bandicoots were caught on this grid (Thompson *et al.*, 1989).

Kyeema Grid

No bandicoots were caught on the Kyeema Grid until the experimental fuel reduction burn was conducted on the adjacent Kuitpo Grid. Following this, bandicoot numbers on the Kyeema Grid remained between one and five individuals per survey period until the Ash Wednesday bushfire apparently caused the local extinction of *I. o. obesulus* from this area (Table 7.6). Four individuals (Males 8 and 13; Females 3 and 20) were recorded to move from the Kuitpo Grid to the adjacent unburnt Kyeema Grid following the fuel reduction burn (Tables 7.5 and 7.6).

7.3.4 Transiency and Residency

High rates of transiency were recorded on each of these five grids with new unmarked adult individuals (> 400g) appearing during virtually all trapping periods. However, this did not lead to any large changes in population numbers on these grids as the arrival of new animals was balanced by the disappearance of previously marked animals at similar rates.

Tables 7.7 and 7.8 summarise the duration of residency of bandicoots on the five grids for individuals caught two or more times. The average duration of residency was 173.34 days (157.11 days and 199.91 days for males and females respectively) (Table 7.7). The maximum duration of residency recorded on these grids was 519 days for females (Female 17 on the Kuitpo grid) and 427 days for males (Male 18 on the Kyeema grid). Table 7.8 shows that a large percentage of individuals appeared on these grids for only a short time (< 3 months). However, approximately one fifth of all individuals remained on the trapping grids for twelve months or more. Therefore, while a large proportion of individuals were transients, some individuals were able to establish themselves semi-permanently.

7.3.5 Home Range and Movements

The home range boundaries of the four males radiotracked across Grid 2 are shown in Figure 7.4. These boundaries were defined by simply delimiting the maximum extent of each individual's recorded movements during the telemetry period. Males 5, 10 and 20 had previously been trapped on Grid 2 but Male 33 had never been caught before. It appears from this small sample that a relationship may exist between these animals' home range areas, their body weights and the duration of their presence on the grid, with home range area increasing with an individual's size and its duration of residency (Table 7.9). Stoddart and Braithwaite (1979) observed that heavy males were more mobile than lighter males and females as they moved further between successive captures. Maloney (1982) noted that the poorer the energy yield of a habitat, the greater the home range area utilised by individuals. Large animals with high energy requirements must eat more than small

TABLE 7.7

Duration of Residency of *I. o. obesulus* on Mount Lofty Ranges Grids

	BOTH SEXES	MALE	FEMALE
GRID 1			
N	8	7	1
MEAN	70.38	41.29	274.00
SE	±29.58	±13.26	±0
GRID 2			
N	7	6	1
MEAN	127.14	133.00	92.00
SE	±36.19	±41.75	±0
GRID 3			
N	2	0	2
MEAN	165.00		165.00
SE	±90.51		±90.51
KUITPO/KYEEMA			
N	12	5	7
MEAN	239.42	274.00	214.71
SE	±57.22	±72.44	±82.08
ALL GRIDS			
N	29	18	11
MEAN	173.34	157.11	199.91
SE	±30.67	±34.89	±56.33

Notes

Duration of residency on these grids is expressed in days between each individuals' first and last capture.

SE = Standard Error of the Mean.
N = Number of individuals in each sample.

Grid 1 = Scott Creek Grid 1
Grid 2 = Scott Creek Grid 2
Grid 3 = Scott Creek Grid 3

Kuitpo and Kyeema Grids are combined as one sample because two males and two females moved from the Kuitpo Grid to the Kyeema Grid.

TABLE 7. 8

Transiency Rates of *I. o. obesulus* in the Mount Lofty Ranges

	Male	Female	Both Sexes
< 3 Months	53.9%	62.5%	60.5%
3 to 6 Months	11.1%	6.3%	9.3%
6 to 9 Months	7.4%	0%	4.7%
9 to 12 Months	3.7%	12.5%	7.0%
> 12 Months	18.5%	18.8%	18.6%

Notes

These percentages represent the proportion of individuals disappearing from trapping grids (Scott Creek Grids 1, 2 & 3; Kuitpo Grid & Kyeema Grid) at three monthly intervals from the time of their initial captures.

FIGURE 7.4

Home Range Boundaries of Individuals Radio-Tracked at Scott Creek CP

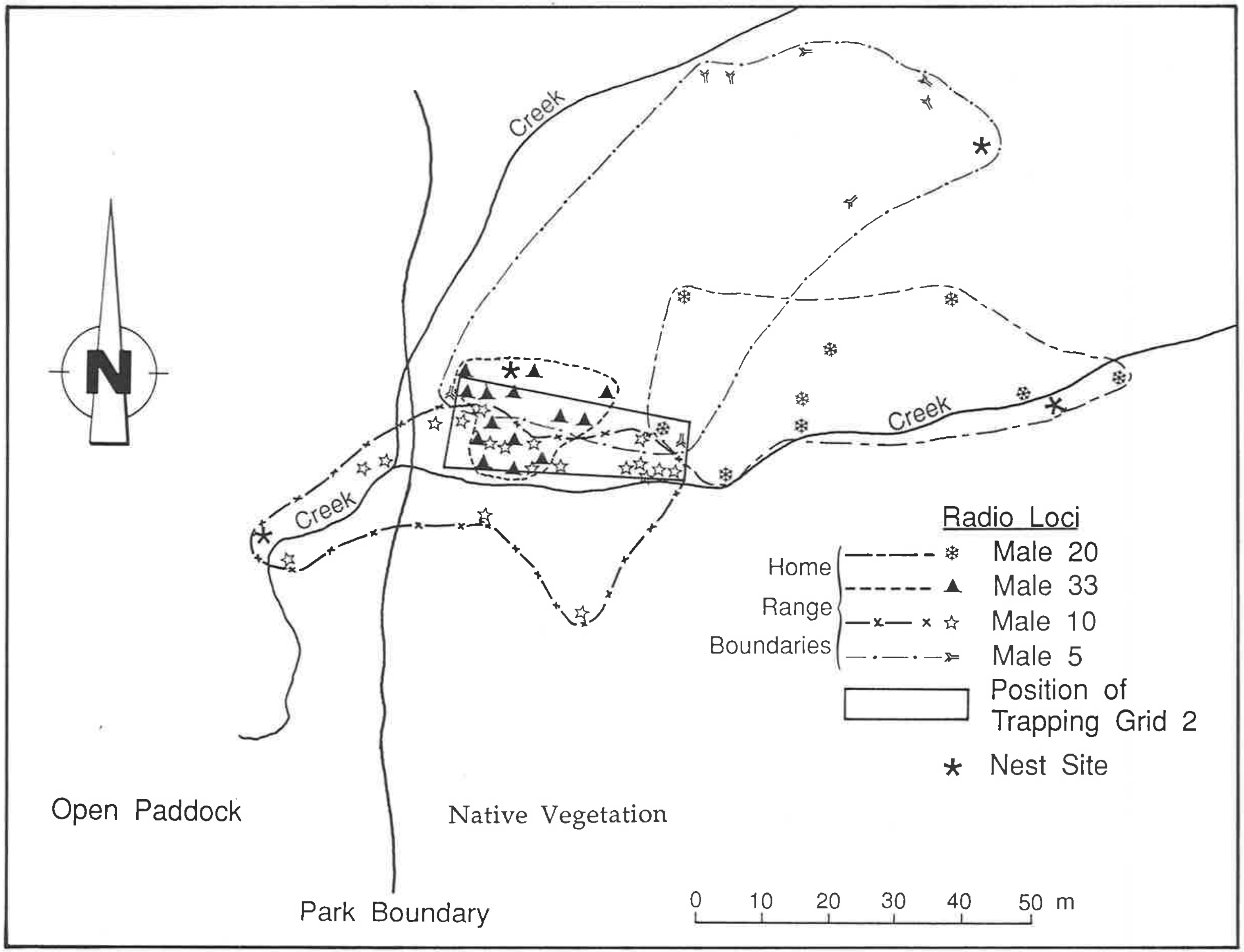

N
Creek
Creek
Creek
Radio Loci
Home Range Boundaries
Male 20
Male 33
Male 10
Male 5
Position of Trapping Grid 2
Nest Site
Open Paddock
Native Vegetation
Park Boundary
0 10 20 30 40 50 m

TABLE 7.9

Home Range Area, Body Weight and Duration of Residency of Radio-Tracked Individuals on Scott Creek Grid 2

	Months Since Initial Capture	Body Weight (g) During Telemetry Exercise	Home Range Area (m^2)
Male 5	12	1030	57,000
Male 10	7	940	31,000
Male 20	7	600	27,000
Male 33	0	680	4,500

Notes

Home Range Areas were calculated from polygons connecting the outermost radio-loci of each individual's movements.

individuals, so they move further and compete more vigorously for feeding sites.

During the telemetry exercise there was very little overlap in the home ranges of Males 5, 10 and 20, except on the trapping grid itself where their movements often converged (Figure 7.4). Male 33's home range was entirely overlapped by the movements of Males 5 and 10 but it was never entered by Male 20. In this situation, bandicoots of similar size appeared to be avoiding each other while large individuals frequently entered the home ranges of smaller individuals.

Only one nest was used by each of these bandicoots while they were being radio-tracked. Males 5 and 33 were also known to shelter in vacant Rabbit burrows. One afternoon, at the onset of a light rainstorm, Male 33 was seen to leave his nest and enter a nearby Rabbit burrow, only to reverse the move 45 minutes later when the rain stopped. Jones (1924) commented on this species' remarkable ability to predict the approach of inclement weather. Rabbit burrows may be used extensively by *I. o. obesulus* in the Mount Lofty Ranges and the South East. Male 5's radio transmitter became detached and was eventually recovered from a Rabbit burrow. Two other transmitters which were lost during this exercise also probably became detached underground, as their signals completely vanished. Besides providing alternative nesting sites and shelter from rain, Rabbit burrows may provide an important refuge against predator attack and even fire.

These bandicoots' nest sites tended to be located on the extremities of their home ranges (Figure 7.4). For the entire telemetry period male 10 nested in a blackberry choked creekline which runs through an open paddock adjacent to the park's western boundary. Each night this animal would move back along the creekline into the park to forage, apparently using the blackberries as a sheltering corridor. This animal also made one foray to the ridge south of the creek immediately after being fitted with a transmitter. This was not typical of male 10's usual pattern of movement so he may have suffered some disorientation after being released. When Male 20 was released he also showed signs of disorientation by moving 150 m to the north before turning east to his nest. For the next five days Male 20 moved only along the blackberry infested creekline, occasionally reaching the trapping grid. He then vacated his nest and his radio signal was lost. Male 33 nested on the trapping grid itself and rarely ventured beyond the immediate vicinity of this nest. After 12 days this bandicoot dropped his transmitter and vacated his nest.

While Males 10, 20 and 33 nested on the lower valley slopes of MacKreath Creek, male 5 nested on an upper valley slope, north west of Grid 2. This bandicoot moved up to 450 m from his nest to the trapping grid and also made regular forays into the valley immediately north of MacKreath Creek, visiting a second feeding site. Male 5 vacated his nest after 10 days and his transmitter signal was lost.

Unfortunately, no female bandicoots were trapped during the telemetry exercise so no data are available on females' home ranges. However, trapping results from Scott Creek and Kuitpo/Kyeema showed that, with the exception of Grid 1 at Scott Creek, the distance moved between successive captures was similar for males and females (Table 7.10).

TABLE 7.10

Distance Moved Between Successive Captures on Mount Lofty Ranges Trapping Grids

	MALE	FEMALE	BOTH SEXES
GRID 1			
N	13	5	18
MEAN	23.69	13.4	20.83
SE	±3.67	±1.19	±2.88
GRID 2			
N	27	4	31
MEAN	40.52	40.75	40.55
SE	±5.19	±6.96	±4.61
GRID 3			
N	0	10	10
MEAN		16.3	16.3
SE		±2.84	±2.84
KUITPO/KYEEMA			
N	24	26	50
MEAN	46.83	40.89	43.74
SE	±6.38	±7.93	±5.15
ALL GRIDS			
N	64	45	109
MEAN	38.91	32.36	37.18
SE	±3.54	±5.00	±2.99

Notes

Distance between successive captures is expressed in metres.

SE = Standard Error of the Mean.
N = Number of individuals in each sample.

Grid 1 = Scott Creek Grid 1
Grid 2 = Scott Creek Grid 2
Grid 3 = Scott Creek Grid 3

Kuitpo and Kyeema Grids are combined as one sample because two males and two females moved from the Kuitpo Grid to the Kyeema Grid.

7.3.6 Dispersal Capacity

Bandicoots are highly mobile and they have no problem recolonising sites from several kilometres away (Gordon, personal communication). At Scott Creek, Male 20 was known to move up to 100 m in one hour. However, during the present study no bandicoots were seen further than two metres away from dense ground cover and it appears that expanses of open terrain may represent dispersal barriers.

I. obesulus is known to utilise vegetation corridors for dispersal. Heinsohn (1966) observed a young male *I. o. affinis* moving 360 m along a teatree hedgerow which separated two fields. During the present study a juvenile female was repeatedly trapped over two weeks in a strip of native roadside vegetation at Deep Creek CP (Female A; Site 131). A juvenile *I. o. obesulus* lodged in the SAM specimen collection (Reg No 14472) was found at Myponga Tiers in a millet paddock which lay approximately 350 m from a patch of native vegetation which supports a bandicoot colony. This patch joins the millet paddock by a blackberry infested creekline. Radio-telemetry results from Scott Creek have confirmed bandicoots' movements are often directed along blackberry infested drainage channels.

Despite the high mobility of *I. o. obesulus*, the presence of continuous corridors of dense ground cover appears necessary for dispersal across open country. Corridors used by *I. o. obesulus* in the Mount Lofty Ranges were found to be dominated by either native or exotic species, and it appears that structural density of the vegetation cover is of greater significance than floristic composition in determining bandicoots' movements.

7.4 Conclusion

The population ecology of *I. o. obesulus* appears to be suited to survival in unpredictable, changing habitats such as the woodlands and heathlands of South Australia. Disappearance of both adults and juveniles from trapping records can be accounted for by high rates of mortality and transience. Under favourable conditions, certain competitive individuals may become semi-permanently established on a home range but, according to factors such as food availability and social pressures, large proportions of bandicoot populations remain transient. When areas of favourable habitat are limited, dominant individuals compete for and occupy optimal sites while sub-dominant individuals must remain mobile as they search for unoccupied, productive sites. In some instances, dominant males use particularly productive sites at the exclusion of females. This results in the production of young away from areas already occupied by dominant males, thus improving the chances of juveniles surviving to become established in new unoccupied habitats.

CHAPTER 8

CONSERVATION OF *I. o. obesulus* IN SOUTH AUSTRALIA

8.1 Introduction

Considering the extensive habitat destruction that has occurred since European settlement, and the introduction of feral predators, it is remarkable that this small, ground nesting marsupial has been able to survive in South Australia. In the past no direct effort has been made to conserve *I. o. obesulus*. However, by examining its distribution and ecology, the present study has now made it possible to assess this species' conservation status and conservation requirements. In addition, a number of specific threats to the survival of *I. o. obesulus* have been identified. These are summarised in Table 8.1, along with some recommendations for conservation strategies which may be adopted in the future.

8.2 Mount Lofty Ranges

Most areas of *I. o. obesulus* habitat in the Mount Lofty Ranges are already managed for conservation, although this does not necessarily guarantee this species' survival. Native vegetation in this region has been so severely reduced that it now only occurs in small, remnant patches. This fragmentation has isolated the *I. o. obesulus* population into a series of disjunct colonies which have little chance of interbreeding. However, fragmentation may have also enhanced bandicoot habitats by creating many new areas of edge and early seral vegetation.

TABLE 8.1

Conservation Status of *I. o. obesulus* in South Australia

	MOUNT LOFTY RANGES	SOUTH EAST	KANGAROO ISLAND
HABITAT STATUS	Mostly managed for conservation by the NPWS.	Mostly managed by W&F Dept. Possible clearance of failed pines with native understorey. Virtually none managed by NPWS.	Large areas managed by NPWS. Possibly some limited future clearance of degraded, privately owned vegetation.
POPULATION CHARACTERISTICS	Fragmentation and genetic isolation of population into disjunct, non-interbreeding colonies.	Possible fragmetation and genetic isolation of population into disjunct, non-interbreeding colonies.	Low density but widely distributed population.
FIRE	Lack of patchy burns; habitat patches may be severely burnt by wildfires, leading to local extinctions.	FRBs conducted on short rotation at virtually all patches. Also the threat of extensive wildfires.	Large scale wildfires prevalent but not perceived to be a significant threat.
FERAL PREDATORS	Cats and Foxes.	Cats and Foxes.	Cats but no Foxes.
MANAGEMENT CONFLICTS	Rabbit warren ripping and Blackberry clearance.	Possible adverse effects of FRB.	None identified.
RECOMMENDATIONS	Periodic surveys for diggings. Reintroductions to isolated patches. Cease ripping and fumigation at known bandicoot "hotspots".	Periodic surveys for diggings. Assessment of the effects of FRBs. Determine if migration occurs through corridors in pine plantations.	Periodic surveys of bandicoot occurrence by collection of anecdotal records.

Notes
NPWS = National Parks and Wildlife Service.
CP = Conservation Park.
NP = National Park.
NFR = Native Forest Reserve.
W&F Dept = Woods and Forests Department.
FRB = Fuel Reduction Burn.

Fire presents a significant threat to isolated bandicoot colonies, yet it also helps to maintain a mosaic of regenerating vegetation. If a habitat patch is to support a stable population of *I. o. obesulus* it should offer a range of regenerating communities to satisfy this species' opportunistic ecology. The strategy of invading recently disturbed communities relies on the presence of undisturbed refuges, so that bandicoots can rapidly disperse to and recolonise regenerating sites when vegetation cover and food supplies reach adequate levels. However, instead of a fire regime which includes many small burns, bushfires now tend to entirely decimate isolated habitat patches, and severe fires may lead to the local extinction of all bandicoots within a patch. This has apparently occurred at Kuitpo NFR and Kyeema CP in the Mount Lofty Ranges. So, while fires create new areas of habitat, they also pose one of the greatest threats to isolated colonies of *I. o. obesulus*.

Bandicoots have been able to survive in the Mount Lofty Ranges by adapting to changes brought about by European settlement. Exotic species such as *Chrysanthemoides monilifera* have been incorporated into their diet. Rabbit burrows and thickets of Blackberries, Broom and Gorse are used for shelter and for dispersal corridors. Ironically, Blackberries and Rabbit burrows have probably contributed greatly to the survival of *I. o. obesulus* in the Mount Lofty Ranges, by offering shelter from predators. In direct conflict with this, some land managers, such as the NPWS and the E&WS (Engineering and Water Supply Department), rip and fumigate Rabbit warrens, and poison Blackberry thickets.

8.3 South East

Remnant habitat patches in the South East are generally separated by mature pine plantations, rather than cleared, open land as found in the Mount Lofty Ranges. Anecdotal evidence collected during the present study suggests that bandicoots are able to move along fire breaks in these plantations to reach adjacent native vegetation patches. This suggestion is further supported by the presence of bandicoots in virtually every patch of native vegetation surveyed in the South East study region. However, more information needs to be gathered on the dispersal capabilities of *I. o. obesulus* before definite conclusions can be drawn about the value of these dispersal corridors. This data would best be collected by the use of radio telemetry. These results could then help with future decision making for South East habitat management. For instance, maintenance and enhancement of dispersal corridors might be one possible conservation strategy.

In the South East, NFRs are secure from further clearance. However, some areas of failing pine plantation which contain dense understories of native species are used by bandicoots. These areas are not necessarily designated as NFRs, and they may be cleared in the future for replanting with pines. One such area (Diagonal Road, Site 299) is currently being considered by the W&F Department for clearing and replanting with pines. The very restricted availability of *I. o. obesulus* habitat in the South East means that the conservation value of mixed communities of exotic and native species needs to be assessed carefully.

The practice of conducting short rotation fuel reduction burns (FRBs) of NFRs needs to be assessed. At present it is not known if FRBs have a positive or a negative effect on bandicoots. Short rotation prescribed burning may affect bandicoot habitat by altering floristic composition. FRBs are usually set in spring and this may simplify the floristic composition of plant communities by selecting against those species which reproduce in this season. This may eventually be reflected in changes to the invertebrate populations upon which bandicoots prey. Alternatively, prescribed burning may benefit bandicoots by increasing the densities of regenerating ground layer vegetation and by creating a mosaic of successional communities which bandicoots can exploit at appropriate stages.

The present study considers that an evaluation of the effects of prescribed burning on *I. o. obesulus* in the South East is essential as virtually all areas of bandicoot habitat in this region are subject to this imposed fire regime. In particular, the practice of burning sites at which bandicoots occur needs to be reviewed, and instead a strategy of using fire to enhance those habitats which surround bandicoot colonies should be considered.

8.4 Kangaroo Island

On Kangaroo Island the threats to *I. o. obesulus* are not as great as those on the mainland. Large expanses of habitat are conserved and foxes have never been introduced. Apart from developing control measures for feral Cats, there is little that can be done to actively conserve bandicoots. Fragmentation of bandicoot habitat on Kangaroo Island is not particularly severe and so the effects of isolation are not as great as for the two mainland populations. Fires sometimes burn large parts of Kangaroo Island, but the extensive native vegetation remaining there ensures that many source areas for recolonisation remain.

8.5 Conclusion

While seven other bandicoot species have disappeared from South Australia this century, *I. o. obesulus* has been able to survive the changes brought about by European settlement. The present study has contributed to the understanding of this species' distribution, ecology and conservation status in the Mount Lofty Ranges, in the South East and on Kangaroo Island. However, the status of *I. o. obesulus* on the Eyre Peninsula remains unknown, and consequently the present study regards this population as the most threatened in the state. Eyre Peninsula was not surveyed during the present study but it is recommended that a future study should be conducted of this region to determine the current status of *I. o. obesulus*.

Until now, baseline occurrence data has not been available for *I. o. obesulus* in South Australia. In the future it will be possible to assess changes in the distribution of this species by updating the *I. o. obesulus* occurrence database established during the present study. As well as compiling new bandicoot occurrence records collected by organisations such as the SAM, it is recommended that those colonies which were located in the Mount Lofty Ranges and the South East during the present study should be periodically surveyed for the presence of fresh diggings, to determine if bandicoots are still present. Direct monitoring of the Kangaroo Island population is not feasible though, given the extensive areas of habitat remaining in this region. However, anecdotal evidence of bandicoot occurrence was readily obtained during the present study, and this offers the most feasible method of future population monitoring on Kangaroo Island. It is recommended that this database should be maintained by either the SAM or the NPWS. Land managers such as the

W&F Departmant and the NPWS could then be be made aware of changes in the location of bandicoot colonies, and practices such as FRBs, Blackberry clearance and Rabbit warren ripping can be planned so that they do not conflict with bandicoots.

While bandicoots still remain in most patches of habitat in the South East and on Kangaroo Island, a reintroduction programme could be considered for the Mount Lofty Ranges, with the aim of restocking isolated patches from which bandicoots have disappeared. Introduced animals could either be translocated from nearby extant wild colonies or taken from captive breeding colonies. One captive colony of *I. o. obesulus* was established at Wurrawong Sanctuary in the Mount Lofty Ranges during the present study. The four founding animals of this colony (two males and two females) were collected by the author from Scott Creek CP in March 1988. This colony has now increased in size to approximately 200 individuals (Wurrrawong Sanctuary, personal communication).

With a clearer understanding of the distribution, ecology and status of *I. o. obesulus* it should be possible to protect one of South Australia's most unique marsupials. *I. o. obesulus* has been able to survive until now without any conservation intervention. However, careful planning may become necessary for the long term survival of this species, especially in those areas where habitat has been severely reduced and human pressures are greatest felt.

APPENDICES

APPENDIX 1

I. o. obesulus Occurrence Records

Notes

Map Sheets = SA Lands Department 1:50,000 series.

Reg No = SAM Registration Number.

APPENDIX 1.1

Eyre Peninsula *I. o. obesulus* Occurrence Records

1.1.1 Anecdotal Records

(a) Letter fom S. Jericho to C. Watts

Dr C.H.S. Watts	Mr S.G. Jericho
South Australian Museum	
North Terrace, Adelaide, SA 5000	25/1/86

Dear Sir,

I am writing this letter in relation to your contribution in the book *Natural History of Eyre Peninsula*. The chapter in question is entitled *Terrestrial Mammals*.

On page 145 in Table 4 the southern Brown Bandicoot is shown as being extinct with no modern records. In the late 1960's (probably 1968 or 1969) there was one caught on my farm, sec. 47 Hd. of Rudall, by Dr Wittwer of Cleve and I believe it was sent to the Museum on its death.

The story goes as follows: some time after seeding and the crop up and growing I noticed tracks which I associated with a rat kangaroo. Obviously it was living in the entrance of a rabbit hole and a path went from this hole over a netting fence which was slightly bent down. The scratchings were unlike those of a rabbit and I mentioned this to Dr Wittwer who brought out his 'wild-life' traps and caught it in a very short time. I saw the animal and agreed it was a bandicoot. It was taken to the Cleve Fauna Park and I believe it died there.

I had been on this property for 25 years as owner and 10 years working for my father and had never seen any indications similar before.

A little private research and a chance statement brought me to the place where a colony had obviously lived since the early settlement of the Hd. of Rudall in 1912. The chance statement came from people who had reason to travel past a certain place about dusk on a Sunday evening. They told me they sometimes saw a rat kangaroo hopping along the side of the road at a place called Karkarrook. This was a railway siding with no dwellings and only a wheat shed and stacks of wheat outside. It is on the Kimba line between Rudall and Kielpa. This led me to interview the agent for this site and he also said he saw rat kangaroos when shifting dunnage etc. Adjoining this siding was a very sandy farm which was not cleared to any extent until the 1960s. Bulk handling of grain came in about 1966 and the siding ceased to be a receival place for wheat, the shed and dunnage was sold and removed. All this coincides with the arrival of the animal on my farm which is connected by corridors of scrub.

After this one was caught I noticed the same tracks and scratchings in several places on the farm but did not see or find where they may be living. This only lasted a short time and I have noticed no signs since so I assume that the colony has become extinct unless they were able to recolonise somewhere else. I do not expect to see any more bandicoots on my farm now. However it is a study of suitable habitat plus a reliable food source for any species to survive.

I have lived all my life on Eyre Peninsula and have certainly seen great changes during my memory of over 60 years. The interesting thing is that the present generation seem to think it was always as it is today.

Yours sincerely,

S.G. Jericho

(b) Letter from C. Kemper to I. Wittwer

Dr I. Wittwer

Dr C.M. Kemper
South Australian Musem
31/3/1987

Dear Dr Wittwer,

I have been writing a paper on the Status of Bandicoots in South Australia and have come across a record of *Isoodon obesulus* from Sun Flat, Eyre Peninsula. As there are two such localities on the Peninsula, could you please tell me from which one the animal was located? Are there any other details of the record (eg habitat, conditions of capture, etc.) which would be useful?

I notice in correspondence to Peter that you refer to an animal from Kielpa as well. Do you know the fate of this specimen?

I have enclosed a map of the distribution of this species in South Australia, for your interest.

Yours sincerely,

Dr Catherine Kemper
(Curator of Mammals)

(c) Letter from I. Wittwer to C. Kemper

Dr C. Kemper
Curator of Mammals
SA Museum
Nth Terrace
Adelaide

5/4/1987

Dear Dr Kemper,

Thank you for your inquiry re the Eyre Peninsula *Isoodon obesulus.*

Regrettably, in preparation for retirement, I consigned much correspondence to the everlasting bonfire recently, and thus answer your query from memory. This function is rusty to say the least.

On the enclosed map I have marked

1: Rudall
2: Kielpa
3: Property of S.G. Jericho
4: Gum Flat

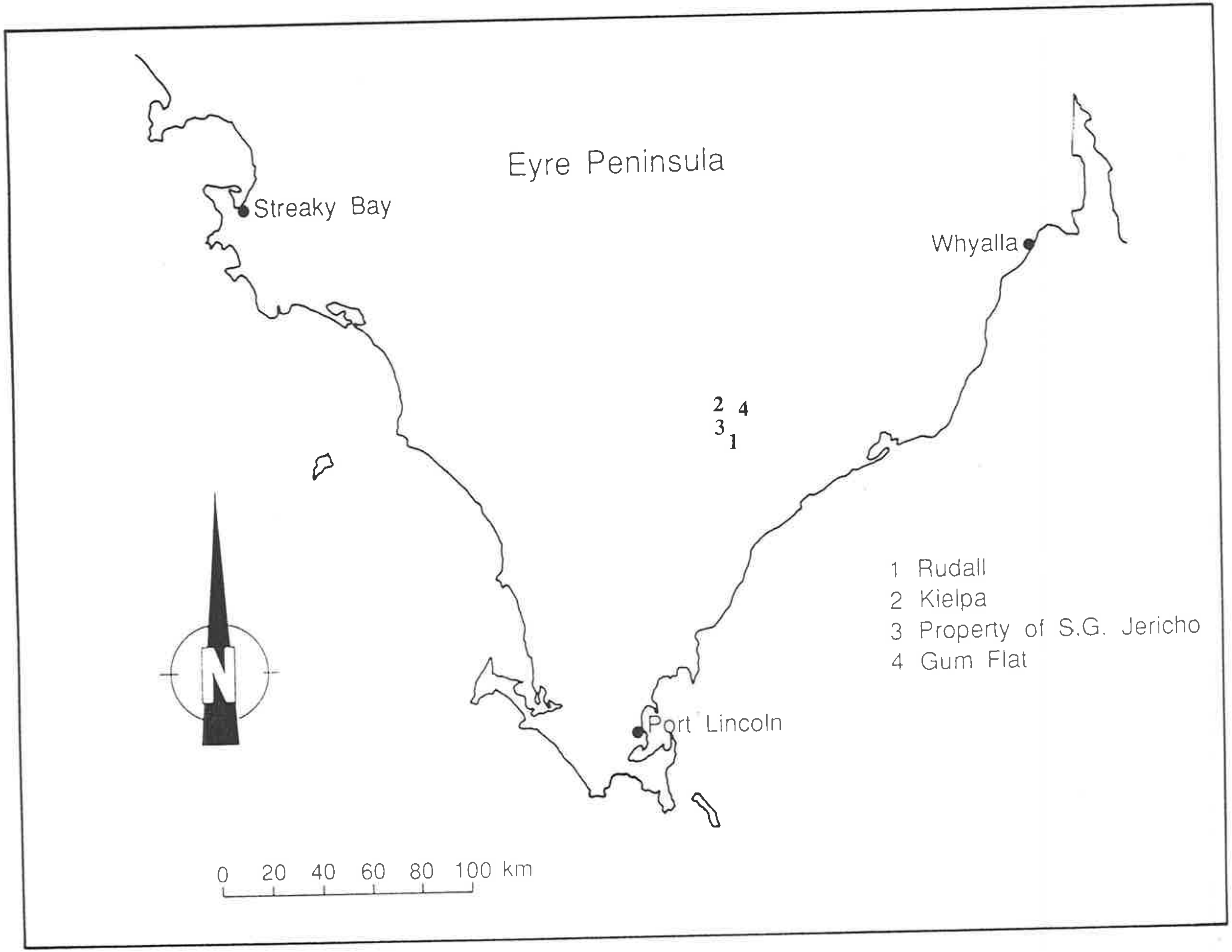
You will notice that these locations are contiguous. Kielpa is 8 km north of Rudall, the property is about halfway in between and the Gum Flat referred to is about 8 km east of Kielpa.

The animal I had in captivity for some five years was taken on the property of S.G. Jericho. We did not know for what we were looking, but noted odd diggings in the sandhill country on the property. Mr Jericho years ago fenced his sandhills so that neither rabbits or sheep have disturbed the native vegetation for some thirty years. I used a net baited with peanut butter and honey, as I recall...or maybe apple was used as well.

I do not recall a separate record for Kielpa, but I have already commented on my memory.

Some three years after I aquired the live specimen, I found a roadkill at Gum Flat. This is an attractive area of some fifty hectares with large eucalypts. Most is private property and heavily grazed, but quite a few hectares, maybe seven-ten are roadside reserve and well covered with low vegetation in between the eucalypts.

In 1983 while guiding a friend of mine from Queensland around the district for the purpose of shooting foxes, I twice sighted a bandicoot in the above area. My friend has a property at Crow's Nest, Queensland, and this area is riddled with bandicoots. He sighted the specimens at the same time as I did and immediately identified them as short-nosed bandicoots. I consider Gum Flat is the Mecca for the Rudall-Kielpa specimens.


Eyre Peninsula
Streaky Bay
Whyalla
Port Lincoln
2 4
3 1
1 Rudall
2 Kielpa
3 Property of S.G. Jericho
4 Gum Flat
N
0 20 40 60 80 100 km

In the winters of 1980-5 I spent an average of forty nights annually guiding my friend around the Eyre Peninsula for his fox shooting enterprise. We covered about 10,000 km on roadsides and private property in this time, spending an average of six hours per night working the spotlight. In this time I believe we saw more of the mammalian nocturnal life than most people today would see in a life-time on Eyre Peninsula. The sightings mentioned are the only ones of bandicoots in this time.

Sincerely,

Ivan Wittwer

1.1.2 SAM Specimen Collection Records

SAM Specimen Reg No	Year Collected (or Reg*)	Nearest Named Place	Latitude	Longitude
07948	1968	Rudall	33.39.00 S	136.15.00 E

(Note: *I. o. obesulus* found in rabbit burrow on property of Mr S. Jericho.)

08993	1971	Rudall	33.35.00 S	136.22.00 E

(Note: Rudall = "Gum Flat".)

APPENDIX 1.2

Mount Lofty Ranges *I. o. obesulus* Occurrence Records

1.2.1 Anecdotal Records

Patch Name	Date	Map Sheet	Grid Reference
Second Valley NFR	**1981**	**Torrens Vale**	**541-628**

(Source: Mr T. Keynes (c/- Roseworthy Agricultural College). *I. o. obesulus* trapped by Roseworthy College students.)

Mount Lofty	**1988**	**Adelaide**	**910-258**

(Source: Mr M. Young (c/- Botanical Gardens). *I. o. obesulus* seen by gardeners.)

Upper Sturt	**1986 - 1988**	**Noarlunga**	**873-213**

(Source: Dr. A. Robinson (c/- NPWS). *I. o. obesulus* occasionally seen at Upper Sturt residence.)

Loftia RP	**1987 - 1988**	**Noarlunga**	**913-210**

(Source: Mr I. Furgusson (Scott Creek Road resident). *I. o. obesulus* occasionally found dead on Scott Creek Road.)

Cox Scrub CP	**1989**	**Willunga**	**953-877**

(Source: Mr J. Reid (c/- Roxby Downs). *I. o. obesulus* seen foraging near dam.)

Deep Creek CP **1987 - 1988** **Cape Jervis** **495-552**
(Source: Mr P. Seger (NPWS). *I. o. obesulus* occasionally seen on Black Bullock Track.)

Cleland CP **1983** **Adelaide** **892-276**
(Source: Mr P. Copley (NPWS). *I. o. obesulus* known to occur in Wilson's Bog until Ash Wednesday, 1983.)

Cleland CP **1990** **Adelaide** **904-262**
(Source: "Friends of Cleland" members saw a single *I. o. obesulus* on two occasions while clearing weeds.)

Myponga CP **1987** **Yankalilla** **675-735**
(Source: Mr P. Copley (NPWS). Fresh *I. o. obesulus* diggings seen on Waterfall Track.)

Uraidla **1983** **Adelaide** **943-276**
(Source: Mr R. Hensell (c/- Richardson Road.,Uraidla). *I. o. obesulus* observed on Uraidla property until Ash Wednesday, 1983. Have not been seen since.)

Crafers West **1960's** **Noarlunga** **897-233**
(Source: Mr D. Barrington (Dept of Environment & Planning). *I. o. obesulus* abundant on Sheoak Road until the late 1960's when *Rubus ulmifolius* thickets were cleared and bandicoots apparently vanished.)

Bridgewater Park **1960's** **Onkaparinga** **950-250**
(Source: Mr D. Barrington (Dept of Environment & Planning). *I. o. obesulus* known to occur here until the early 1970's.)

Hale CP **1960's** **Barossa** **084-597**
(Source: Mr T. Dennis (NPWS).)

Wotton Scrub CP **1970's** **Onkaparinga** **972-262**
(Source: Dr. W. Breed (c/- University of Adelaide).)

Kenneth Stirling CP **1980** **Onkaparinga** **983-299**
(Source: Mr W. Propert (c/- Deviation Road, Forest Range). *I. o. obesulus* and their diggings regularly seen during the late 1970's.)

Ashton **1970** **Adelaide** **937-307**
(Source: Mr C. Hutchinson (c/- Ashton). *I. o. obesulus* nests and diggings regularly seen until the early 1970's.)

1.2.2 FNS Mammal Club Trapping Survey Records

Patch Name	Date	Map Sheet	Grid Reference
Horsnell Gully CP	**December, 1967**	**Adelaide**	**900-315**
(Note: Traces of *I. o. obesulus* seen.)			
Bridgewater	**July, 1968**	**Onkaparinga**	**960-247**
(Note: This is the same specimen as SAM m12560.)			
Kuitpo NFR	**January, 1968**	**Willunga**	**918-936**
(Note: *I. o. obesulus* seen.)			
McHarg Creek	**January, 1969**	**Willunga**	**930-943**
(Note: Traces of *I. o. obesulus* seen.)			

Kuitpo NFR	**January, 1969**	**Willunga**	**918-936**

(Note: *I. o. obesulus* seen.)

Kuitpo NFR	**January, 1969**	**Willunga**	**918-936**

(Note: *I. o. obesulus* trapped.)

Mt Magnificent CP	**July, 1969**	**Willunga**	**893-904**

(Note: *I. o. obesulus* trapped.)

Kyeema CP	**March, 1970**	**Willunga**	**895-950**

(Note: Traces of *I. o. obesulus* seen.)

Kyeema CP	**September, 1970**	**Willunga**	**895-950**

(Note: *I. o. obesulus* trapped.)

Deep Creek CP	**January, 1972**	**Cape Jervis**	**480-513**

(Note: Traces of *I. o. obesulus* seen. FNS Mammal Club also recorded *I. o. obesulus* from this area four weeks previously.)

Kenneth Stirling CP	**September, 1973**	**Onkaparinga**	**984-310**

(Note: *I. o. obesulus* trapped. This site is referred to as Filsell Hill by FNS Mammal Club.)

Springmount CP	**February, 1968**	**Willunga**	**755-745**

(Note: *I. o. obesulus* reported from here previously.)

Warren CP	**May, 1969**	**Barossa**	**093-543**

(Note: Traces of *I. o. obesulus* seen.)

Kyeema CP	**September, 1969**	**Willunga**	**895-950**

(Note: Traces of *I. o. obesulus* seen.)

Cleland CP	**June, 1970**	**Adelaide**	**900-282**

(Note: Traces of *I. o. obesulus* seen.)

Kuitpo NFR	**July, 1980 to January, 1983**	**Willunga**	**893-955**
Kyeema CP	**July, 1980 to January, 1983**	**Willunga**	**895-950**

(Note: 30 individual *I. o. obesulus* captured, marked and released on Kuitpo NFR and Kyeema CP study grids.)

Scott Creek CP	**September, 1985**	**Noarlunga**	**897-135**

(Note: *I. o. obesulus* trapped.)

Belair RP	**October, 1988**	**Noarlunga**	**878-218**

(Note: *I. o. obesulus* trapped. Female with pouch young. Same specimen as SAM 14598.)

1.2.3 SAM Specimen Collection Records

SAM Specimen Reg No	Year Collected (*or Reg)	Nearest Named Place	Map Sheet	Grid Reference
00777	*1918	Crafers	Adelaide	901-245
01601	1898	Mount Lofty	Adelaide	916-264
01602	1898	Mount Lofty	Adelaide	916-264
01603	1890	Mount Lofty	Adelaide	916-264
01604	1892	Norton Summit	Adelaide	929-338

02502	1928*	Glenelg	Adelaide	747-279

(Note: From an old collection. Found in a rabbit burrow.)

02578	1929*	Mylor	Echunga	963-191
02665	1929	Mylor	Echunga	963-191
03006	1931	Cudlee Creek	Onkaparinga	004-432
03011	1931	Athelstone	Adelaide	898-393
03950	1902	Aldgate	Noarlunga	932-227

(Note: Male pouch young collected in January. Sibling of 03951 and 03953.)

03951	1902	Aldgate	Noarlunga	932-227

(Note: Female pouch young collected in January. Sibling of 03950 and 03953.)

03953	1902	Aldgate	Noarlunga	932-227

(Note: Female pouch young collected in January. Sibling of 03950 and 03951.)

03991	1895	Pewsey Vale	Barossa	151-676

(Note: Female pouch young collected in August. Sibling of 03992 and 03993.)

03992	1895	Pewsey Vale	Barossa	151-676

(Note: Female pouch young collected in August. Sibling of 03991 and 03993.)

03993	1895	Pewsey Vale	Barossa	151-676

(Note: Male pouch young collected in August. Sibling of 03991 and 03992.)

04567	1934	Clarendon	Noarlunga	845-114
04609	1939	Aldgate	Noarlunga	932-227
04702	1936*	Encounter Bay	Encounter	959-691
04928	1939	Montacute	Adelaide	898-375
05230	1893	Norton Summit	Adelaide	929-338
05283	1945*	Crafers	Adelaide	901-245
05620	1946*	Hope Forest	Willunga	833-929
06054	1956	Belair R.P.	Noarlunga	855-225
06096	1957	Cherry Gdns	Noarlunga	856-171
06271	1959	Yundi	Willunga	848-893

(Note: Adult female with four pouch young. Collected December 23, 1959.)

06290	1960	Mount Crawford	Barossa	138-583
06292	1960	Back Valley	Encounter	764-650
06323	1960	Mount Crawford	Barossa	138-583
06816	1966	Cherry Gardens	Noarlunga	856-171
07251	1968	Crafers	Adelaide	901-245
07254	1965	Belair	Adelaide	833-248
07255	1965	Waitpinga	Encounter	766-576
08639	1969	Carey Gully	Onkaparinga	976-284
08640	1969	Carey Gully	Onkaparinga	976-284
08641	1969	Carey Gully	Onkaparinga	976-284
08642	1969	Carey Gully	Onkaparinga	976-284
08643	1969	Carey Gully	Onkaparinga	976-284
08992	1967	Brownhill Ck.	Adelaide	825-262

09478	**1975**	**Carey Gully**	**Onkaparinga**	**976-284**
10163	**1973**	**Carey Gully**	**Onkaparinga**	**976-284**
11011	**1981**	**Kuitpo**	**Willunga**	**890-955**

(Note: Juvenile collected April 4, 1981.)

11014	**1981**	**Kuitpo**	**Willunga**	**890-955**

(Note: Juvenile collected July 27, 1981.)

11015	**1981**	**Kuitpo**	**Willunga**	**890-955**

(Note: Juvenile collected July 27, 1981.)

12560	**1968**	**Bridgewater**	**Onkaparinga**	**960-247**

(Note: Same specimen as FNS Mammal Club, 1968.)

14472	**1987**	**Myponga Tiers**	**Willunga**	**755-773**

(Note: SAM records list Springmount CP as the nearest named place to this site. This specimen was a juvenile male, collected from a millet paddock (December, 1987) 300-400 m from a patch of native vegetation. It was flushed from a nest, along with approximately three siblings, and killed by a Fox Terrier.)

12217	**1980**	**Uraidla**	**Onkaparinga**	**945-300**
12757	**1985**	**Ironbank**	**Noarlunga**	**878-214**

(Note: Cat kill.)

12804	**1983**	**Upper Sturt**	**Noarlunga**	**900-225**

(Note: Cat kill.)

12999	**1986**	**Waitpinga**	**Torrens Vale**	**733-547**

(Note: Habitat = light mallee with open fields surrounding. Generally sandy soil. This site is also referred to as Newland Head CP in this thesis.)

13010	**1983**	**Scott Creek**	**Noarlunga**	**890-148**

(Note: Habitat = creek bed with dense *Rubus ulmifolius* cover. Open *Eucalyptus obliqua* Forest with heath understorey.)

13473	**1981**	**Upper Sturt**	**Noarlunga**	**878-227**

(Note: .22 bullet found in bones.)

14598	**1988**	**Belair RP**	**Noarlunga**	**878-218**

(Note: Habitat = Dead *Rubus ulmifolius* in weed infested paddock surrounding house. Age = Subadult. Nearest named place = Melville House.)

The following specimens were collected during the present study as part of a joint trapping exercise with the FNS Mammal Club, and were donated to the SAM.

14593	**1988**	**Upper Sturt**	**Noarlunga**	**875-213**

(Note: Open *Eucalyptus obliqua* Forest with understorey of *Rubus ulmifolius, Cytissus proliferus, Ulex europaeus* and grass species.)

14594	**1988**	**Upper Sturt**	**Noarlunga**	**875-213**
14595	**1988**	**Upper Sturt**	**Noarlunga**	**875-213**

(Note: Female pouch young.)

14596	**1988**	**Upper Sturt**	**Noarlunga**	**875-213**

(Note: Male pouch young.)

14597	**1988**	**Upper Sturt**	**Noarlunga**	**875-213**

(Note: Female pouch young. Sibling of 014596.)

APPENDIX 1.3

South East *I. o. obesulus* Occurrence Records

1.3.1 Anecdotal Records

Patch Name	Date	Map Sheet	Grid Reference
Benara	**1971**	**Schank**	**695-120**

(Source: Mr F. Aslin (c/- Mt. Gambier). *I. o. obesulus* killed by a slasher in the paddock of Mr P. Siggers. Dense *Pteridium esculentum* with no overstorey.)

Aslin's	**1970**	**Nangwarry**	**790-273**

(Source: Mr F. Aslin (c/- Mt. Gambier). *I. o. obesulus* pes collected from Grundy Lane property.)

Kalangadoo Road	**1987**	**Kalangadoo**	**683-330**

(Source: Mrs. D. Bennier (c/- Kalangadoo). *I. o. obesulus* run over on the Kalangadoo to Glencoe Road.)

Lake Leake	**1980's**	**Kalangadoo**	**633-361**

(Source: Roy (Forrester, Mt Burr). *I. o. obesulus* seen while spotlighting.)

Cottage Garden Swamp	**1989**	**Penola**	**965-505**

(Source: Mr G. Vincent (NPWS). *I. o. obesulus* reported by member of the public.)

Telford CP	**1970**	**Nangwarry**	**808-275**

(Source: Mr F. Aslin (c/- Mt. Gambier). *I. o. obesulus* trapped in a rabbit trap.)

Millicent Golf Course	**1970's**	**Millicent**	**507-417**

(Source: Mr M. Bleeby (W&F Dept, Mt Burr). *I. o. obesulus* found living in mature *Pinus radiata* plantation, approximately 300 m east of the golf course.)

Glencoe Hill NFR	**1985**	**Kalangadoo**	**561-295**

(Source: Roy ? (Forester, Mt Burr). *I. o. obesulus* diggings seen on fire track in mature *Pinus radiata* plantation, approximately 300 m from Glencoe Hill. Understorey of *Pteridium esculentum* and *Xanthorrhoea australis*.)

Millicent Golf Course	**1983**	**Millicent**	**520-415**

(Source: Roy ? (Forester, Mt Burr). *I. o. obesulus* regularly seen on edges of fairways until Ash Wednesday, 1983.)

Millicent Golf Course	**1990**	**Millicent**	**520-415**

(Source: Millicent Golf Course Staff. *I. o. obesulus* seen to reappear 12 to 18 months after Ash Wednesday, 1983 following heavy winter rains and dense regrowth of *Pteridium esculentum*.)

1.3.2 Bellchambers' Mammal Survey Records (Includes Bellchamber's own capture records plus other recent records of *I. o. obesulus* obtained by Bellchambers.)

Patch Name	Date	Map Sheet	Grid Reference
Millicent Golf Course	1982	Millicent	520-415
Marshes NFR	1982	Kalangadoo	590-365
Yeate's Scrub NFR	1982	Nangwarry	927-410
Hackett Hill NFR	1982	Kalangadoo	695-305
Whennan's NFR	1982	Kalangadoo	565-428
Gran Gran Swamp	1982	Millicent	540-447
Long's NFR	1982	Kalangadoo	615-277
Mount Lyon NFR	1982	Kalangadoo	645-345
Honan Scrub NFR	1982	Kalangadoo	670-240
Grundy Lane NFR	1979	Kalangadoo	780-265
(Note: Same as SAM specimen 010285.)			
Telford CP	1980	Nangwarry	808-275
Diagonal Road	1979	Kalangadoo	690-250
Mt Gambier Forest	1982	Schank	675-200
Mt Burr Mill Drop	1982	Millicent	553-435

1.3.3 CEP Survey Team Records

Patch Name	Date	Map Sheet	Grid Reference
Gower CP	1984	Kalangadoo	574-257
(Note: Same as SAM specimen 11943.)			
Long's NFR	1985	Kalangadoo	618-276
Woolwash NFR	1984	Kalangadoo	632-264
Marshes NFR	1985	Kalangadoo	596-369
Grundy Lane NFR	1985	Kalangadoo	767-268
Wandilo Scrub NFR	1985	Kalangadoo	715-284
Honan Scrub NFR	1984	Kalangadoo	665-240
(Note: Same as SAM specimens 11592, 11593 and 12932.)			
Mount Lyon NFR	1985	Kalangadoo	645-348
Diagonal Rd NFR	1984	Kalangadoo	690-250

1.3.4 SAM Specimen Collection Records

SAM Specimen Reg No	Year Collected (*or Reg)	Nearest Named Place	Map Sheet	Grid Reference
02326	*1927	Mt Gambier	Gambier	810-126

03259	**1932**	**Mt Gambier**	**Gambier**	**810-126**
05119	**1944**	**Kalangadoo**	**Kalangadoo**	**735-422**
05122	**1944**	**Kalangadoo**	**Kalangadoo**	**735-422**
05128	**1944**	**Kalangadoo**	**Kalangadoo**	**735-422**
05131	**1944**	**Mount Burr**	**Millicent**	**543-384**
05132	**1944**	**Mount Burr**	**Millicent**	**543-384**
02924	**1930**	**Glenelg River**	**Gambier**	**965-935**
06800	**1965**	**Rocky Camp**	**Millicent**	**455-402**
07268	**1965**	**Lake George**	**Beachport**	**006-640**
08644	**1970**	**Mt Gambier**	**Gambier**	**810-126**

(Note: This specimen was not collected from Mount Gambier. It either came from Grundy Lane or Benara (Mr F. Aslin, personal communication).)

10284	**1979**	**Hachett Hill NFR**	**Kalangadoo**	**706-311**
10285	**1979**	**Grundy Lane NFR**	**Kalangadoo**	**780-265**

(Note: Juvenile male trapped October, 30. Same specimen as Bellchambers, 1979.)

11935	**1981**	**Borderlands**	**Gambier**	**958-188**

(Note: Habitat = Eucalyptus baxteri, *Eucalyptus viminalis* and *Pteridium esculentum*. Collected during clearing operations.)

11943	**1984**	**Gower CP**	**Kalangadoo**	**574-257**

(Note: Habitat = Medium *Eucalyptus baxteri* Woodland with a Medium Open Shrub layer. Dense *Xanthorrhoea australis* and *Pteridium esculentum*. Same specimen as CEP Survey Team, 1984.)

11951	**1984**	**Diagonal Rd NFR**	**Kalangadoo**	**706-256**

(Note: Juvenile female trapped October, 16. Habitat = Medium Open Failed *Pinus radiata* Plantation with *Eucalyptus* species and a Tall Closed Shrub layer. Same specimen as CEP Survey Team, 1984.)

11952	**1984**	**Honan Scrub NFR**	**Kalangadoo**	**657-244**

(Note: Juvenile male trapped November, 9. Habitat = Medium Open *Eucalyptus baxteri* Woodland with a Medium Open Shrub layer. Tall *Pteridium esculentum* understorey and deep litter layer. Same specimen as CEP Survey Team, 1984.)

11953	**1984**	**Honan Scrub NFR**	**Kalangadoo**	**657-244**

(Note: Juvenile female trapped November, 25. Same specimen as CEP Survey Team, 1984.)

12932	**1984**	**Honan Scrub NFR**	**Kalangadoo**	**662-237**

(Note: Same specimen as CEP Survey Team, 1984.)

12857	**1984**	**Penola HQ NFR**	**Penola**	**867-524**

APPENDIX 1.4

Kangaroo Island *I. o. obesulus* Occurrence Records

1.4.1 Anecdotal Records

Patch Name	Date	Map Sheet	Grid Reference
Cape Cassini	**1985 and 1986**	**Cassini**	**103-572**

(Source: Mr R. Tuesner (c/- Cape Cassini Road). Three *I. o. obesulus* seen crossing Cape Cassini Road while spotlighting. Each sighting was approximately six months apart and no sightings have been made since.)

Maylands	**1970's**	**Stokes Bay**	**980-472**

(Source: Mr B. Kelly (c/- Parndana). *I. o. obesulus* occasionally seen on property until about ten years ago.)

Pratts Road	**1970's**	**Stokes Bay**	**990-500**

(Source: Mr R. Stanton (c/- Pratts Road). *I. o. obesulus* seen almost daily in the 1960's and 1970's while clearing section 58 Hundred of Duncan. None sighted since before 1980.)

Amen Corner	**1985**	**Stokes Bay**	**010-490**

(Source: Mr R. Stanton (c/- Pratts Road). Numerous *I. o obesulus* seen crossing Bark Hut Road.)

Parndana CP	**1988**	**Cassini**	**112-417**

(Source: Mr T. Dennis (NPWS). *I. o. obesulus* diggings seen in northern gullies. Only occasional diggings with no apparent concentrations.)

Wedgewood Road	**1987**	**Stokes Bay**	**026-327**

(Source: Ms. D. Papenfuss (NPWS). *I. o. obesulus* seen crossing road.)

Hickmans Road	**1989**	**Vivonne**	**029-310**

(Source: Mrs. J. Rees (c/- Vivonne Bay). *I. o. obesulus* seen crossing road.)

Riccorang	**1980's**	**Stokes Bay**	**940-360**

(Source: Mr P. Davis (c/- Brookland Park). *I. o. obesulus* regularly seen on highway with the most recent sightings made around sections 71 and 72, Hundred of Duncan.)

Bourkel	**1980's**	**Stokes Bay**	**900-355**

(Source: Mr C. Baxter (NPWS). *I. o. obesulus* regularly seen on Playford Highway, particularly around the Harriet Road junction. Often seen in degraded roadside vegetation.)

Ritchie	**1986**	**Grainger**	**725-305**

(Source: Mr T. Dennis (NPWS). *I. o. obesulus* seen fleeing from a bushfire.)

West End Junction	**1990**	**Snug Cove**	**714-380**

(Source: Mr B. Furner (NPWS). *I. o. obesulus* seen on the corner of Playford and West End Highways.)

Ravine Crossing	**1985**	**Borda**	**524-405**

(Source: Mr T. Dennis (NPWS). *I. o. obesulus* seen on the Playford Highway at the point where the ravine crosses.)

Ravine Gravel Pits **1990** **Borda** **470-421**
(Source: NPWS. *I. o. obesulus* diggings often seen around gravel pits at the corner of the Playford Highway and the Ravine to Rocky River track.)
Flinders Chase Gates **1987** **Grainger** **585-204**
(Source: Mr G. Rees (c/- Vivonne Bay). *I. o. obesulus* seen foraging in broad daylight on the Flinders Chase entrance road.)
Flinders Chase Gates **1990** **Grainger** **604-197**
(Source: Mr C. Baxter (NPWS). *I. o. obesulus* seen on track running south of Flinders Chase entrance gates. Appeared to be digging amongst ant nests.)
Tandanya **1980's** **Grainger** **620-192**
(Source: Mr C. Baxter (NPWS). *I. o. obesulus* regularly seen between Tandanya Kitchen and Flinders Chase entrance gates.)
Tandanya **1980's** **Grainger** **620-192**
(Source: Mr R. Beckwith (c/- Section 9, Hundred of McDonald). *I. o. obesulus* regularly seen between Tandanya Kitchen and Flinders Chase entrance gates.)
Greenslopes **1980's** **Grainger** **655-174**
(Source: Mr C. Baxter (NPWS). *I. o. obesulus* seen on South Coast Road.)
Grainger Lagoon **1990** **Grainger** **703-246**
(Source: Mr P. Davis (c/- Brookland Park). *I. o. obesulus* seen on edge of paddock adjacent to scrub.)
Gradi Downs **1990** **Vivonne** **830-159**
(Source: Mr P. Davis (c/- Brookland Park). *I. o. obesulus* seen on road.)
Mount Taylor CP **1990** **Vivonne** **846-220**
(Source: Mr R. Tuesner (c/- Cape Cassini). *I. o. obesulus* seen on Mount Taylor Road, adjacent to Mount Taylor CP.)
Mount Taylor CP **1980's** **Vivonne** **846-230**
(Source: Mr P. Davis (c/- Brookland Park). *I. o. obesulus* occasionally seen on Mount Taylor Road. A colony of bandicoots is rumoured to occur in Section 92, Hundred of Newland.)
Vivonne Bay **1980 to 1990** **Vivonne** **964-168**
(Source: Mr G. Rees (c/- Vivonne Bay). *I. o. obesulus* regularly seen around the Vivonne Bay Outdoor Education Centre in mallee vegetation regenerating from clearance in the mid 1970s.)
Little Sahara **1990** **Vivonne** **011-180**
(Source: Mr G. Rees (c/- Vivonne Bay). *I. o. obesulus* seen several times on the western side of the Little Sahara.)
Kiawarra **19??** **Seddon** **083-227**
(Source: Mr A. Lashmar (c/- Penneshaw). This record documents the sighting of *I. o. obesulus* on the South Coast Road. Year unknown.)
Cape Gantheaume CP **1990** **Seddon** **214-051**
(Source: Mr T. Dennis and Mr C. Baxter (NPWS). Lower mandibles of *I. o. obesulus* collected from the tip of Cape Gantheaume.)
Pennington Bay **1950** **Destrees** **478-299**
(Source: Mr A. Lashmar (c/- Penneshaw). *I. o. obesulus* seen on the Mount Thisby Road.)

Felt Hat Corner	**1975**	**Penneshaw**	**550-340**

(Source: Mr G. Trethewey (c/- Penneshaw). *I. o. obesulus* sighted in daylight on roadside. Sparse mallee.)

Rocky Point	**1977**	**Penneshaw**	**570-343**

(Source: Mr A. Lashmar (c/- Penneshaw). *I. o. obesulus* seen just east of Rocky Point.)

NSEW Corner	**1970**	**Penneshaw**	**630-330**

(Source: Mr G. Trethewey (c/- Penneshaw). *I. o. obesulus* seen on intersection of North South and East West Roads.)

Pigs Head Corner	**1975**	**Penneshaw**	**670-309**

(Source: Mr G. Trethewey (c/- Penneshaw). *I. o. obesulus* seen on roadside.)

Willson River	**1985**	**Penneshaw**	**670-308**

(Source: Mrs. K. Willson (c/- Queens Highway). *I. o. obesulus* seen on roadside.)

Black Point Road	**1990**	**Penneshaw**	**673-304**

(Source: Mrs. B. Overton (c/- Kingscote). *I. o. obesulus* seen running across fire track.)

Buick's	**1980**	**Willoughby**	**320-370**

(Source: Mr G. Trethewey (c/- Penneshaw). *I. o. obesulus* seen in a paddock, Section 82, Hundred of Dudley.)

Lashmar's	**1976 to 1982**	**Willoughby**	**335-365**

(Source: Mr A. Lashmar (c/- Penneshaw). Three *I. o. obesulus* seen on roadside.)

1.4.2 FNS Mammal Club Trapping Survey Records

Patch Name	Date	Map Sheet	Grid Reference
Brookland Park	**1974**	**Grainger**	**680-263**

(Note: Diggings only sighted.)

1.4.3 SAM Specimen Collection Records

SAM Specimen Reg No	Year Collected (*or Reg)	Nearest Named Place	Map Sheet	Grid Reference
05833	***1950**	**Kangaroo Island**	**Cassini**	**107-320**
06032	**1955**	**Kangaroo Island**	**Cassini**	**107-320**
06194	**1958**	**Kangaroo Island**	**Cassini**	**107-320**
06201	**1959**	**Parndana**	**Cassini**	**048-377**
07264	**1965**	**Kingscote**	**Kingscote**	**383-516**
07265	**1965**	**Vivonne Bay**	**Vivonne**	**999-156**
07950	**1969**	**Bark Hut**	**Cassini**	**139-412**

(Note: This site is referred to as Kingscote Aerodrome in SAM records.)

08503	**1970**	**Calana**	**Cassini**	**097-506**
09022	**1973**	**Kangaroo Island**	**Cassini**	**107-320**
09216	**1973**	**Parndana**	**Cassini**	**048-377**
09479	**1974**	**Karatta**	**Grainger**	**743-162**
10139	**1975**	**McHughs Road**	**Vivonne**	**986-323**

(Note: This site is referred to as Parndana in SAM records.)

10991	**1979**	**Moffat's Bridge**	**Penneshaw**	**683-360**

(Note: This site is referred to as Coranda in SAM records.)

07252	**1967**	**Parndana**	**Cassini**	**048-377**
12277	**1985**	**Kaiwarra**	**Seddon**	**085-235**
12998	**1983**	**Colmans Road**	**Snug Cove**	**716-420**

(Note: This site is referred to as Gosse in SAM records.)

13244	**1986**	**Birchmore Lagoon**	**Cassini**	**244-372**

(Note: This site is referred to as Parndana in SAM records.)

13960	**1987**	**Kingscote**	**Kingscote**	**383-517**

(Note: Collection date questionable.)

13961	**1987**	**Eleanor Downs**	**Vivonne**	**030-229**
13962	**1987**	**Karatta**	**Grainger**	**728-162**

(Note: Habitat = Low Mallee and Banksia.)

14060	**1987**	**West End Junction**	**Snug Cove**	**715-381**

(Note: This site is referred to as Parndana in SAM records. Habitat = Eucalyptus baxteri, Eucalyptus remota, *Banksia ornata* and *Xanthorrhoea semiplana*. Low Open Shrubland.)

14424	**1987**	**West End Junction**	**Snug Cove**	**740-383**

(Note: This Site is referred to as Binnowie in SAM records. Age = Subadult. Male. Collected August, 5.)

15365	**1989**	**Karatta Park**	**Vivonne**	**810-162**

(Note: Age = Juvenile. Male. Collected August. Cat Kill.)

16156	**1990**	**Cape Willoughby**	**Willoughby**	**380-285**

(Note: Specimen collected during NPWS vertebrate survey.)

APPENDIX 2

Location of Bandicoot Feeding Sites

Notes

Map Sheets = SA Lands Department 1:50,000 series.

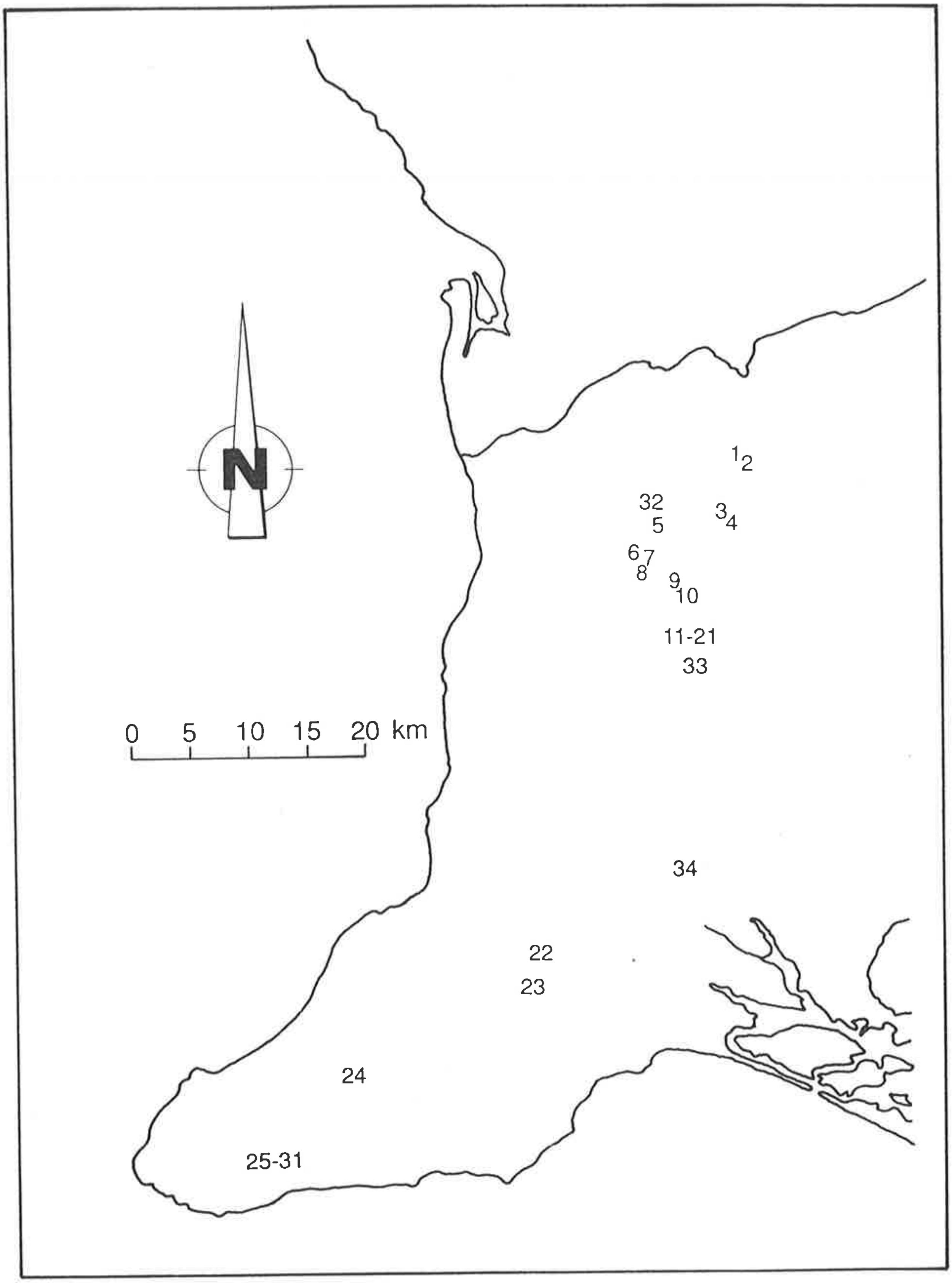
Mount Lofty Ranges site numbers have the prefix 1.
South East site numbers have the prefix 2.
Kangaroo Island site numbers have the prefix 3.

CP = Conservation Park
NP = National Park
RP = Recreation Park
NFR = Native Forest Reserve

APPENDIX 2.1

Mount Lofty Ranges Feeding Sites

Site No	Patch Name	Map Sheet	Grid Reference
(Trapping Sites)			
101	Kenneth Stirling CP	Onkaparinga	983-299
102	Kenneth Stirling CP	Onkaparinga	983-293
103	Wotton Scrub CP	Onkaparinga	972-262
104	Wotton Scrub CP	Onkaparinga	968-258
105	Cleland CP	Adelaide	901-284
106	Upper Sturt	Noarlunga	874-213
107	Upper Sturt	Noarlunga	875-213
108	Upper Sturt	Noarlunga	873-208
109	Loftia RP	Noarlunga	903-211
110	Loftia RP	Noarlunga	904-211
111	Scott Creek CP	Noarlunga	894-154
112	Scott Creek CP	Noarlunga	894-151
113	Scott Creek CP	Noarlunga	890-149
114	Scott Creek CP	Noarlunga	888-142
115	Scott Creek CP	Noarlunga	888-141
116	Scott Creek CP	Noarlunga	889-142
117	Scott Creek CP	Noarlunga	889-141
118	Scott Creek CP	Noarlunga	890-143
119	Scott Creek CP	Noarlunga	891-143
120	Scott Creek CP	Noarlunga	892-143
121	Scott Creek CP	Noarlunga	899-136
122	Myponga Tiers	Willunga	751-772
123	Springmount CP	Willunga	757-731
(Note: This site is actually called Mount Alma but this patch is continuous with the Springmount CP patch.)			
124	Second Valley NFR	Torrens Vale	541-628
125	Deep Creek CP	Cape Jervis	501-571
126	Deep Creek CP	Cape Jervis	492-549
127	Deep Creek CP	Cape Jervis	485-520
128	Deep Creek CP	Torrens Vale	518-535
129	Deep Creek CP	Torrens Vale	533-563
130	Deep Creek CP	Torrens Vale	531-567
131	Deep Creek CP	Torrens Vale	526-574
(The following three sites displayed bandicoot diggings but were not trapped.)			
132	Horsnell Gully CP	Adelaide	898-310
133	Mount Bold	Noarlunga	906-145
134	Cox Scrub CP	Willunga	952-876


N
0 5 10 15 20 km
1
2
32
3
4
5
6
7
8
9
10
11-21
33
34
22
23
24
25-31

APPENDIX 2.2

South East Feeding Sites

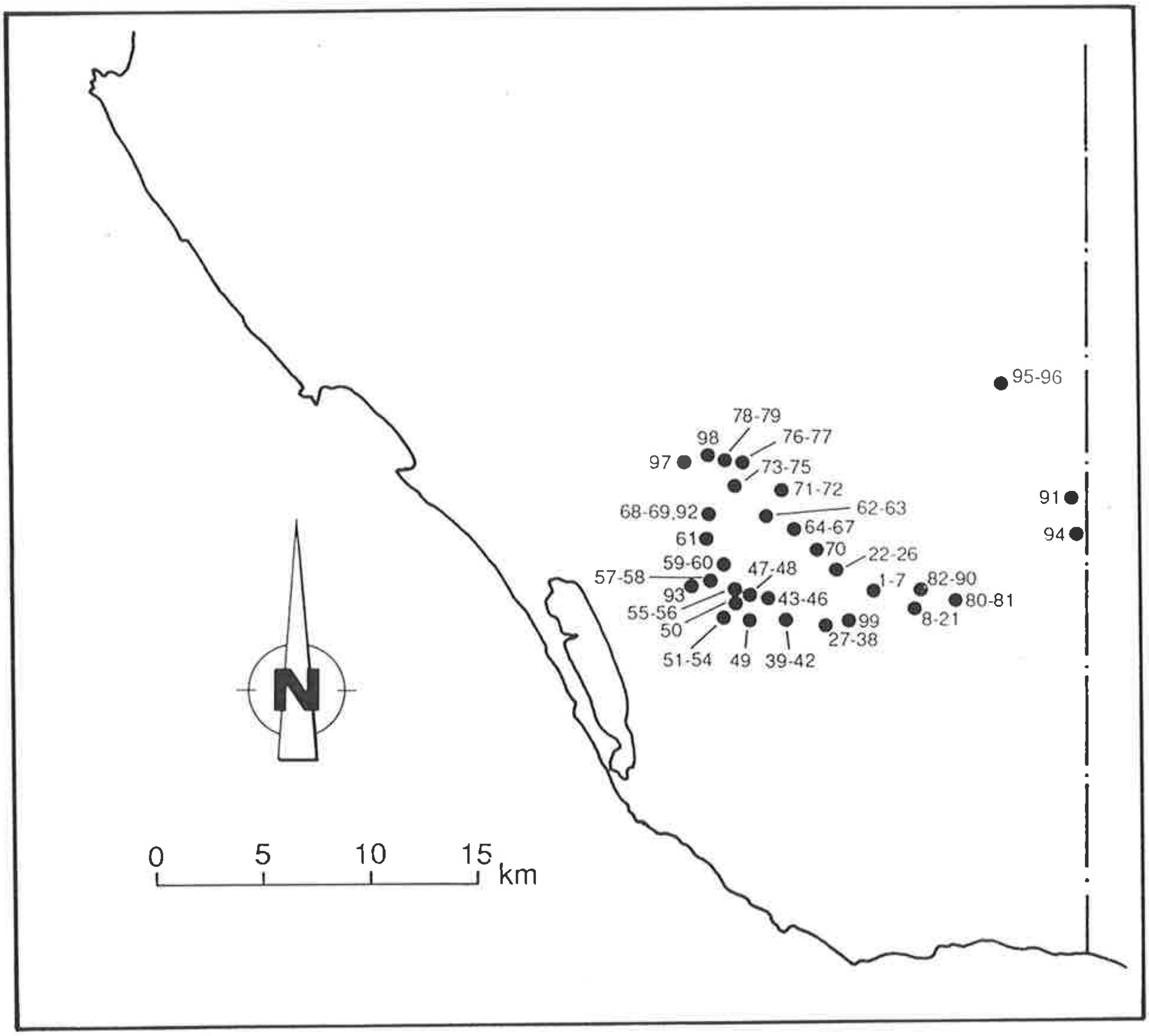
Site No	Patch Name	Map Sheet	Grid Reference
(Trapping Sites)			
201	Wandilo Scrub NFR	Kalangadoo	747-259
202	Wandilo Scrub NFR	Kalangadoo	738-263
203	Wandilo Scrub NFR	Kalangadoo	736-263
204	Wandilo Scrub NFR	Kalangadoo	718-280
205	Wandilo Scrub NFR	Kalangadoo	716-283
206	Wandilo Scrub NFR	Kalangadoo	716-284
207	Wandilo Scrub NFR	Kalangadoo	717-285
208	Grundy Lane NFR	Kalangadoo	764-269
209	Grundy Lane NFR	Kalangadoo	763-268
210	Grundy Lane NFR	Kalangadoo	767-267
211	Grundy Lane NFR	Kalangadoo	769-266
212	Grundy Lane NFR	Kalangadoo	775-264
213	Grundy Lane NFR	Kalangadoo	777-264
214	Grundy Lane NFR	Nangwarry	783-264
215	Grundy Lane NFR	Nangwarry	784-264
216	Grundy Lane NFR	Nangwarry	790-266
217	Grundy Lane NFR	Nangwarry	792-266
218	Grundy Lane NFR	Nangwarry	792-265
219	Grundy Lane NFR	Nangwarry	790-265
220	Grundy Lane NFR	Nangwarry	795-266
221	Grundys Lane NFR	Nangwarry	794-265
222	Hackett Hill NFR	Kalangadoo	703-313
223	Hackett Hill NFR	Kalangadoo	703-312
224	Hackett Hill NFR	Kalangadoo	701-305
225	Hackett Hill NFR	Kalangadoo	697-299
226	Hackett Hill NFR	Kalangadoo	698-298
227	Honan Scrub NFR	Kalangadoo	676-247
228	Honan Scrub NFR	Kalangadoo	676-248
229	Honan Scrub NFR	Kalangadoo	674-248
230	Honan Scrub NFR	Kalangadoo	664-247
231	Honan Scrub NFR	Kalangadoo	665-244
232	Honan Scrub NFR	Kalangadoo	666-238
233	Honan Scrub NFR	Kalangadoo	667-234
234	Honan Scrub NFR	Kalangadoo	666-233
235	Honan Scrub NFR	Kalangadoo	661-236
236	Honan Scrub NFR	Kalangadoo	661-237
237	Honan Scrub NFR	Kalangadoo	657-244
238	Honan Scrub NFR	Kalangadoo	656-247
239	Woolwash NFR	Kalangadoo	634-245
240	Woolwash NFR	Kalangadoo	637-248
241	Woolwash NFR	Kalangadoo	638-251

242	Woolwash NFR	Kalangadoo	632-264
243	Long's NFR	Kalangadoo	623-275
244	Long's NFR	Kalangadoo	621-277
245	Long's NFR	Kalangadoo	618-278
246	Long's NFR	Kalangadoo	616-280
247	North Windy Hill NFR	Kalangadoo	591-276
248	North Windy Hill NFR	Kalangadoo	594-275
249	The Bluff NFR	Kalangadoo	605-248
250	South Windy Hill NFR	Kalangadoo	574-267
251	Gower CP	Kalangadoo	577-258
252	Gower CP	Kalangadoo	575-259
253	Gower CP	Kalangadoo	572-258
254	Gower CP	Kalangadoo	569-259
255	Mount Watch NFR	Kalangadoo	577-285
256	Mount Watch NFR	Kalangadoo	579-285
257	Glencoe Hill NFR	Kalangadoo	570-295
258	Glencoe Hill NFR	Kalangadoo	567-295
259	Native Wells NFR	Kalangadoo	575-307
260	Native Wells NFR	Kalangadoo	572-314
261	Frill West NFR	Kalangadoo	565-336
262	Marshes NFR	Kalangadoo	584-369
263	Marshes NFR	Kalangadoo	584-370
264	Mount Lyon NFR	Kalangadoo	645-350
265	Mount Lyon NFR	Kalangadoo	645-347
266	Mount Lyon NFR	Kalangadoo	646-345
267	Mount Lyon NFR	Kalangadoo	645-345
268	Burr Slopes NFR	Kalangadoo	558-366
269	Burr Slopes NFR	Millicent	553-366
270	Kalangadoo Road	Kalangadoo	683-330
271	Brooksby Road	Kalangadoo	627-392
272	Brooksby Road	Kalangadoo	628-389
273	East McRostie's NFR	Kalangadoo	591-413
274	West McRostie's NFR	Kalangadoo	580-408
275	West McRostie's NFR	Kalangadoo	577-406
276	Mount McIntyre NFR	Kalangadoo	578-416
277	Mount McIntyre NFR	Kalangadoo	580-417
278	Whennan's NFR	Kalangadoo	562-430
279	Whennan's NFR	Kalangadoo	565-429
280	Telford CP	Nangwarry	806-267
281	Telford CP	Nangwarry	810-267
282	Aslin's	Nangwarry	793-273
283	Aslin's	Nangwarry	792-272
284	Aslin's	Nangwarry	791-272
285	Aslin's	Nangwarry	790-273
286	Aslin's	Nangwarry	791-273
287	Aslin's	Nangwarry	792-273
288	Aslin's	Nangwarry	789-279
289	Aslin's	Nangwarry	787-273
290	Aslin's	Nangwarry	787-274

291	Byrne's	Nangwarry	940-399

(The following eight sites displayed bandicoot diggings but were not trapped.)

292	Burr Slopes NFR	Millicent	541-363
293	Glencoe Hill NFR	Millicent	558-292
294	Turkey Heath	Nangwarry	937-370
295	Penola HQ NFR	Penola	884-533
296	Penola HQ NFR	Penola	886-534
297	Millicent Golf Course	Millicent	520-415
298	Mount Burr Mill Drop NFR	Millicent	553-437
299	Diagonal Road NFR	Kalangadoo	695-245



95-96
78-79
98
76-77
97
73-75
71-72
91
68-69,92
62-63
64-67
94
61
70
22-26
59-60
47-48
57-58
1-7
82-90
93
43-46
80-81
55-56
8-21
99
50
27-38
51-54
49
39-42
N
0
5
10
15
km

APPENDIX 2.3

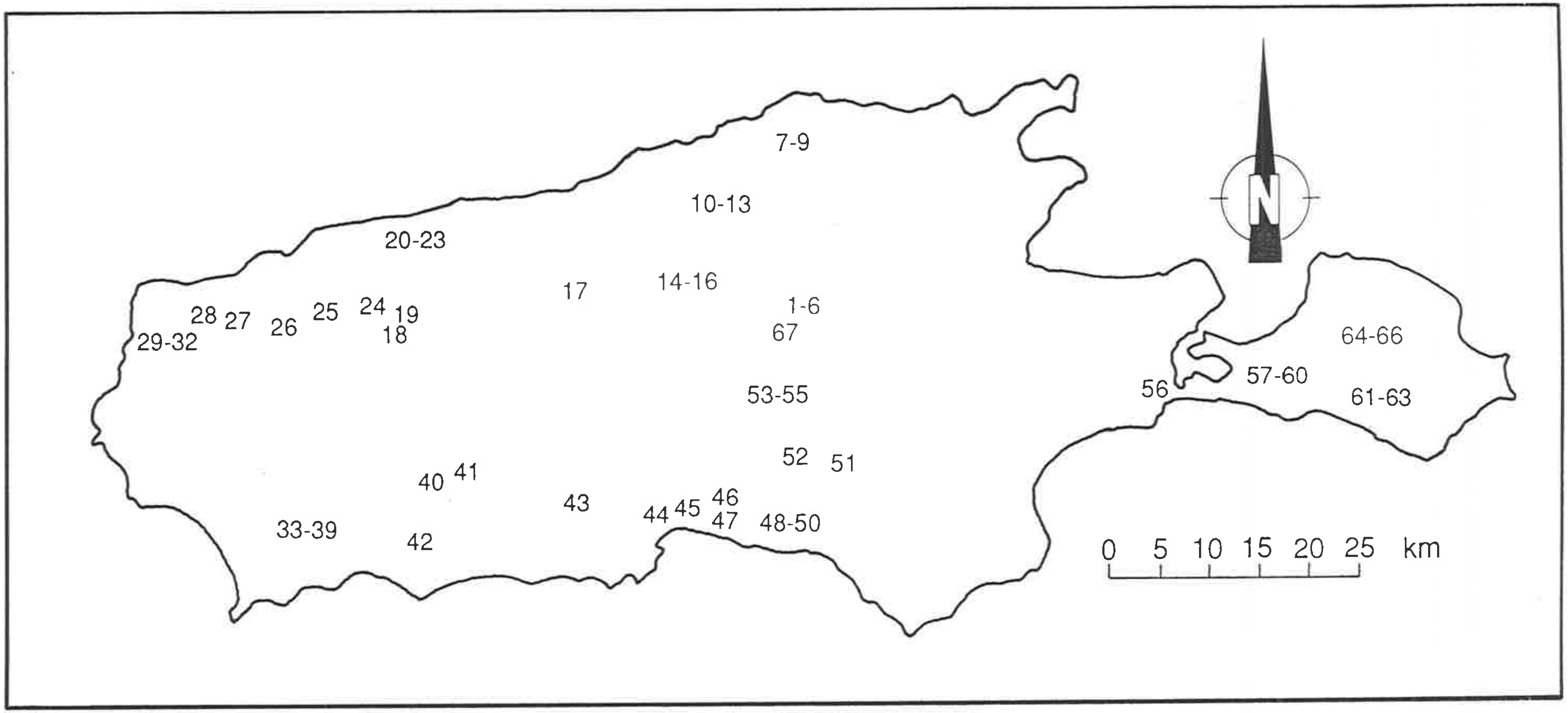
KANGAROO ISLAND

Site No	Patch Name	Map Sheet	Grid Reference
(Trapping Sites)			
301	Parndana CP	Cassini	112-417
302	Parndana CP	Cassini	111-418
303	Parndana CP	Cassini	105-409
304	Parndana CP	Cassini	103-409
305	Parndana CP	Cassisi	009-409
306	Parndana CP	Cassini	097-408
307	Cape Cassini	Cassini	103-572
308	Cape Cassini	Cassini	107-564
309	Cape Cassini	Cassini	106-573
310	Latham CP	Stokes Bay	027-513
311	Latham CP	Cassini	042-514
312	Latham CP	Stokes Bay	034-530
313	Latham CP	Stokes Bay	008-525
314	Kelly's	Stokes Bay	963-492
315	Kelly's	Stokes Bay	963-495
316	Kelly's	Stokes Bay	973-472
317	Middle River	Stokes Bay	901-434
318	Northern Flinders Chase NP	Snug Cove	701-361
319	Northern Flinders Chase NP	Snug Cove	708-373
320	Western River CP	SnugCove	739-464
321	Western River CP	Snug Cove	728-463
322	Western River CP	Snug Cove	729-467
323	Western River CP	Snug Cove	726-468
324	Northern Flinders Chase NP	Snug Cove	683-383
325	Northern Flinders Chase NP	Snug Cove	642-374
326	Northern Flinders Chase NP	Snug Cove	598-359
327	Northern Flinders Chase NP	Borda	529-402
328	Northern Flinders Chase NP	Borda	523-405
329	Northern Flinders Chase NP	Borda	473-401
330	Northern Flinders Chase NP	Borda	453-378
331	Northern Flinders Chase NP	Borda	455-379
332	Northern Flinders Chase NP	Borda	456-376
333	Southern Flinders Chase NP	Vennachar	574-202
334	Southern Flinders Chase NP	Grainger	603-202
335	Southern Flinders Chase NP	Grainger	606-198
336	Southern Flinders Chase NP	Grainger	604-199
337	Southern Flinders Chase NP	Grainger	604-198
338	Southern Flinders Chase NP	Grainger	604-197
339	Southern Flinders Chase NP	Grainger	604-202
340	Davis's	Grainger	704-244
341	Southern Flinders Chase NP	Grainger	722-249

342	Kelly Hill Caves CP	Grainger	680-156
343	Mount Taylor CP	Vivonne	847-219
344	Rees's	Vivonne	968-169
345	Rees's	Vivonne	963-167
346	Eleanor River	Vivonne	005-187
347	Eleanor River	Vivonne	004-193
348	Little Sahara	Vivonne	021-197
349	Little Sahara	Vivonne	021-198
350	Little Sahara	Seddon	030-179
351	Gregor Road	Seddon	085-237
352	Hickman Road	Seddon	038-216
353	Seddon CP	Seddon	050-322
354	Seddon CP	Seddon	056-322
355	Seddon CP	Seddon	034-318
356	Pennington Bay	D'estrees	476-291
357	Dudley CP	Penneshaw	582-326
358	Dudley CP	Penneshaw	583-332
359	Dudley CP	Penneshaw	601-353
360	Dudley CP	Penneshaw	600-344
361	Black Point Road	Penneshaw	679-289
362	Black Point Road	Penneshaw	683-281
363	Black Point Road	Penneshaw	675-301
364	Moffat Road	Penneshaw	681-359
365	Moffat Road	Penneshaw	682-358
366	Moffat Road	Penneshaw	679-359

(The following site displayed bandicoot diggings but was not trapped.)

367	Parndana CP	Cassini	095-402


7-9
10-13
20-23
17
14-16
1-6
67
28
27
26
25
24
19
18
29-32
53-55
52
51
40
41
43
44
45
46
47
48-50
33-39
42
56
57-60
64-66
61-63
N
0 5 10 15 20 25 km

APPENDIX 3

Floristic Groups at Bandicoot Feeding Sites

APPENDIX 3.1

Distribution of Sites and Overstorey Formations Per Floristic Group

Group 1
Eucalyptus obliqua Open Forests & Woodlands
15 Members
Medium Open Forest: 104, 114
Medium Woodland: 101, 105, 115, 116, 118, 119, 120, 122, 123, 341
Low Woodland: 102, 133
Low Open Woodland: 117

Group 2
Eucalyptus obliqua Open Forests and Woodlands
4 Members
Medium Open Forest: 128
Low Open Woodland: 103, 126, 130

Group 3
Eucalyptus obliqua Open Forests and Woodlands
4 Members
Medium Open Forest: 107, 108, 132
Medium Woodland: 106

Group 4
Eucalyptus obliqua Woodlands and Tall Shrublands
13 Members
Medium Woodland: 109, 125
Low Woodland: 112, 124, 113, 327, 333
Low Open Woodland: 110, 111, 121
Tall Open Shrubland: 127, 129, 131

Group 5
Eucalyptus cosmophylla Low Woodlands
3 Members
Low Woodland: 134
Low Open Woodland: 317, 354

Group 6
Hakea rostrata/*Banksia marginata*/*Eucalyptus baxteri* Low Open Woodlands and Tall Shrublands
26 Members
Low Open Woodland: 309, 311, 313, 314, 315, 316, 318, 320, 321, 322, 334, 335, 337, 338, 367
Tall Open Shrubland: 302, 319, 336, 340
Tall Very Open Shrubland: 324, 325, 326, 339, 353, 355, 343

Group 7
Melaluca uncinata/Melaleuca gibbosa Shrublands
3 Members
Low Open Woodland: 310
Tall Very Open Shrubland: 307, 312

Group 8
Eucalyptus cneorifolia Shrublands
1 Member
Tall Very Open Shrubland: 365

Group 9
Eucalyptus diversifolia Woodlands and Tall Shrublands
8 Members
Low Open Woodland: 332, 351, 352
Tall moderately Open Shrubland: 330, 347
Tall Very Open Shrubland: 331, 344, 345

Group 10
Eucalyptus cladocalyx Medium Woodlands
5 Members
Medium Woodland: 301, 303, 304, 306, 328

Group 11
Eucalyptus cladocalyx Medium Woodlands
2 Members
Medium Woodland: 323, 329

Group 12
Banksia marginata/Leptospermum juniperinum Low Woodlands
2 Members
Medium Woodland: 305
Low Open Woodland: 308

Group 13
Eucalyptus leucoxylon Woodlands and Tall Shrublands
3 Members
Low Open Woodland: 342, 366
Tall Very Open Shrubland: 364

Group 14
Eucalyptus diversifolia Woodlands and Tall Shrublands
7 Members
Low Open Woodland: 346, 357, 358, 359, 363
Tall Moderately Open Shrubland: 360
Tall Very Open Shrubland: 361

Group 15
Acacia longifolia/Leucopogon parviflorus Shrubland
1 Member
Medium Very Open Shrubland: 356

Group 16
Eucalyptus oleosa/Eucalyptus rugosa Shrublands
1 Member
Tall Very Open Shrubland: 362

Group 17
Eucalyptus lansdowneana Low Open Woodlands
2 Members
Low Open Woodland: 348, 349

Group 18
Gahnia duesta Herbland
1 Member
Medium Open Herbland: 350

Group 19
Eucalyptus baxteri Low Forests and Woodlands
53 Members
Low Open Forest: 209, 211, 212, 224, 237, 238, 242, 245, 247, 249,, 251, 252, 253, 282, 283, 285, 292
Low Woodland: 201, 210, 213, 214, 215, 216, 217, 218, 219, 220, 221, 225, 226, 229, 231, 232, 239, 243, 244, 259, 260, 262, 280, 281, 284, 286, 288
Low Open Woodland: 208, 222, 223, 270, 271, 272, 290
tall Very Open Shrubland: 287, 289

Group 20
Eucalyptus baxteri Low Forests and Woodlands
29 Members
Low Open Forest: 227, 248, 254, 293
Low Woodland: 202, 203, 204, 205, 206, 207, 228, 230, 233, 234, 235, 240, 241, 257, 258, 261, 263, 264, 266, 269, 299
Low Open Woodland: 236, 246, 265, 267

Group 21
Eucalyptus baxteri Low Forests and Woodlands
17 Members
Low Open Forest: 250, 255, 294, 297
Low Woodland: 256, 268, 278, 291, 295, 296, 298
Low Open Woodland: 273, 274, 275, 276, 277, 279

APPENDIX 3.2

Species Name Abbreviations

Species Name	Abbreviation
Acacia acinacea	*Aca.aci*
Acacia leiophylla	*Aca.lei*
Acacia ligulata	*Aca.lig*
Acacia longifolia	*Aca.lon*
Acacia mearnsii	*Aca.mea*
Acacia melanoxylon	*Aca.mel*
Acacia myrtifolia	*Aca.myr*
Acacia oxycedrus	*Aca.oxy*
Acaica paradoxa	*Aca.par*
Acacia pycnantha	*Aca.pyc*
Acaica retinodes	*Aca.ret*
Acacia spinescens	*Aca.spi*
Acacia verticillata	*Aca.ver*
Acaena novae-zelandiae	*Aca.nov*
Acrotriche cordata	*Acr.cor*
Acrotriche depressa	*Acr.dep*
Acrotriche fasciculiflora	*Acr.fas*
Acrotriche patula	*Acr.pat*
Acrotriche serrulata	*Acr.ser*
Adenanthos macropodiana	*Ade.mac*
Adenanthos terminalis	*Ade.ter*
Adiantum aethiopicum	*Adi.aet*
Albizia lophantha	*Alb.lop*
Allocasuarina muelleriana	*All.mue*
Allocasuarina striata	*All.str*
Astroloma conostephioides	*Ast.con*
Astroloma humifusum	*Ast.hum*
Baeckia ericaea	*Bae.eri*
Banksia marginata	*Ban.mar*
Banksia ornata	*Ban.orn*
Bertya rotundifolia	*Ber.rot*
Beyeria lechenaultii	*Bey.lec*
Billardiera bignoniacea	*Bil.big*
Blechnum minus	*Ble.min*
Bossiaea cinerea	*Bos.cin*
Bursaria spinosa	*Bur.spi*
Caesia vittata	*Cae.vit*
Callistemon rugulosus	*Cal.rug*
Calytrix glagerrima	*Cal.gla*
Calytrix tetragona	*Cal.tet*
Carex appressa	*Car.app*

Carpobrotus rossii	*Car.ros*
Cassytha melantha	*Cas.mel*
Cassytha species	*Cas.spp*
Caustis pentandra	*Cau.pen*
Choretrum glomeratum	*Cho.glo*
Chrysanthemoides monilifera	*Chr.mon*
Correa decumbens	*Cor.dec*
Correa reflexa	*Cor.ref*
Cryptandra waterhousii	*Cry.wat*
Cytisus proliferus	*Cyt.pro*
Daviesia asperula	*Dav.asp*
Daviesia brevifolia	*Dav.bre*
Daviesia genistifolia	*Dav.gen*
Daviesia ulicifolia	*Dav.uli*
Dianella revoluta	*Dia.rev*
Dodonaea viscosa	*Dod.vis*
Epacris impressa	*Epa.imp*
Eucalyptus baxteri	*Euc.bax*
Eucalyptus camaldulensis	*Euc.cam*
Eucalyptus cladocalyx	*Euc.cla*
Eucalyptus cneorifolia	*Euc.cne*
Eucalyptus cosmophylla	*Euc.cos*
Eucalyptus diversifolia	*Euc.div*
Eucalyptus fasciculosa	*Euc.fas*
Eucalyptus incrassata	*Euc.inc*
Eucalyptus lansdowneana	*Euc.lan*
Eucalyptus leucoxylon	*Euc.leu*
Eucalyptus obliqua	*Euc.obl*
Eucalyptus oleosa	*Euc.ole*
Eucalyptus ovata	*Euc.ova*
Eucalyptus pauciflora	*Euc.pau*
Eucalyptus remota	*Euc.rem*
Eucalyptus rubida	*Euc.rub*
Eucalyptus rugosa	*Euc.rug*
Eucalyptus viminalis	*Euc.vim*
Exocarpus cupressiformis	*Exo.cup*
Gahnia duesta	*Gah.due*
Gahnia sieberiana	*Gah.sie*
Gahnia trifida	*Gah.tri*
Gonocarpus tetragynus	*Gon.tet*
Goodenia ovata	*Goo.ova*
Goodenia varia	*Goo.var*
Grevillea ilicifolia	*Gre.ili*
Grevillea lavandulacea	*Gre.lav*
Grevillea parviflora	*Gre.par*
Hakea carinata	*Hak.car*

Hakea muelleriana	*Hak.mue*
Hakea rostrata	*Hak.ros*
Hakea vittata	*Hak.vit*
Hibbertia aspera	*Hib.asp*
Hibbertia empetrifolia	*Hib.emp*
Hibbertia exutiacies	*Hib.exu*
Hibbertia riparia	*Hib.rip*
Holcus lanatus	*Hol.lan*
Isolepis nodosa	*Iso.nod*
Isopogon ceratophyllus	*Iso.cer*
Ixodia achillaeoides	*Ixo.ach*
Juncus pallidus	*Jun.pal*
Kunzea pomifera	*Kun.pom*
Lasiopetalum baueri	*Las.bau*
Lasiopetalum schulzenii	*Las.sch*
Lepidosperma carphoides	*Lep.car*
Lepidosperma gladiatum	*Lep.gla*
Lepidosperma longitudinale	*Lep.lon*
Lepidosperma semiteres	*Lep.sem*
Lepidosperma viscidum	*Lep.vis*
Leptocarpus tenax	*Lep.ten*
Leptospermum juniperinum	*Lep.jun*
Leptospermum myrsinoides	*Lep.myr*
Leptospermum pubescens	*Lep.pub*
Leucopogon concurvus	*Leu.con*
Leucopogon ericoides	*Leu.eri*
Leucopogon parviflorus	*Leu.par*
Leucopogon rufus	*Leu.ruf*
Logania ovata	*Log.ova*
Melaleuca brevifolia	*Mel.bre*
Melaleuca decussata	*Mel.dec*
Melaleuca gibbosa	*Mel.gib*
Melaleuca lanceolata	*Mel.lan*
Melaluca squarrosa	*Mel.squ*
Melaleuca uncinata	*Mel.unc*
Microcybe pauciflora	*Mic.pau*
Microlaena stipoides	*Mic.sti*
Myrsiphyllum asparagoides	*Myr.asp*
Olearia axillaris	*Ole.axi*
Olearia ramulosa	*Ole.ram*
Olearia rudis	*Ole.rud*
Olearia tubuliflora	*Ole.tub*
Oxalis corniculata	*Oxa.cor*
Petrophile multisecta	*Pet.mul*
Phyllota pleurandroides	*Phy.ple*
Pimelia linifolia	*Pim.lin*

Pimelia stricta	*Pim.str*
Pinus radiata	*Pin.rad*
Platylobium obtusangulum	*Pla.obt*
Poa species	*Poa.spp*
Pomaderris oraria	*Pom.ora*
Prostanthera aspalathoides	*Pro.asp*
Prostanthera spinosa	*Pro.spi*
Pteridium esculentum	*Pte.esc*
Pultenaea daphnoides	*Pul.dap*
Pultenaea involucrata	*Pul.inv*
Pultenaea trinervis	*Pul.tri*
Pultenaea viscidula	*Pul.vis*
Rubus parvifolius	*Rub.par*
Rubus ulmifolius	*Rub.ulm*
Schoenus apogon	*Sch.apo*
Senecio odoratus	*Sen.odo*
Senecio species	*Sen.spp*
Solanum nigrum	*Sol.nig*
Sollya heterophylla	*Sol.het*
Sprengelia incarnata	*Spr.inc*
Spyridium halmaturinum	*Spy.hal*
Spyridium parvifolium	*Spy.par*
Spyridium species	*Spy.spp*
Spyridium thymifolium	*Spy.thy*
Spyridium vexilliferum	*Spy.vex*
Stipa muelleri	*Sti.mue*
Stipa species	*Sti.spp*
Tetratheca pilosa	*Tet.pil*
Thomasia petalocalyx	*Tho.pet*
Thryptomene ericaea	*Thr.eri*
Ulex europaeus	*Ule.eur*
Xanthorrhoea australis	*Xan.aus*
Xanthorrhoea semiplana	*Xan.sem*

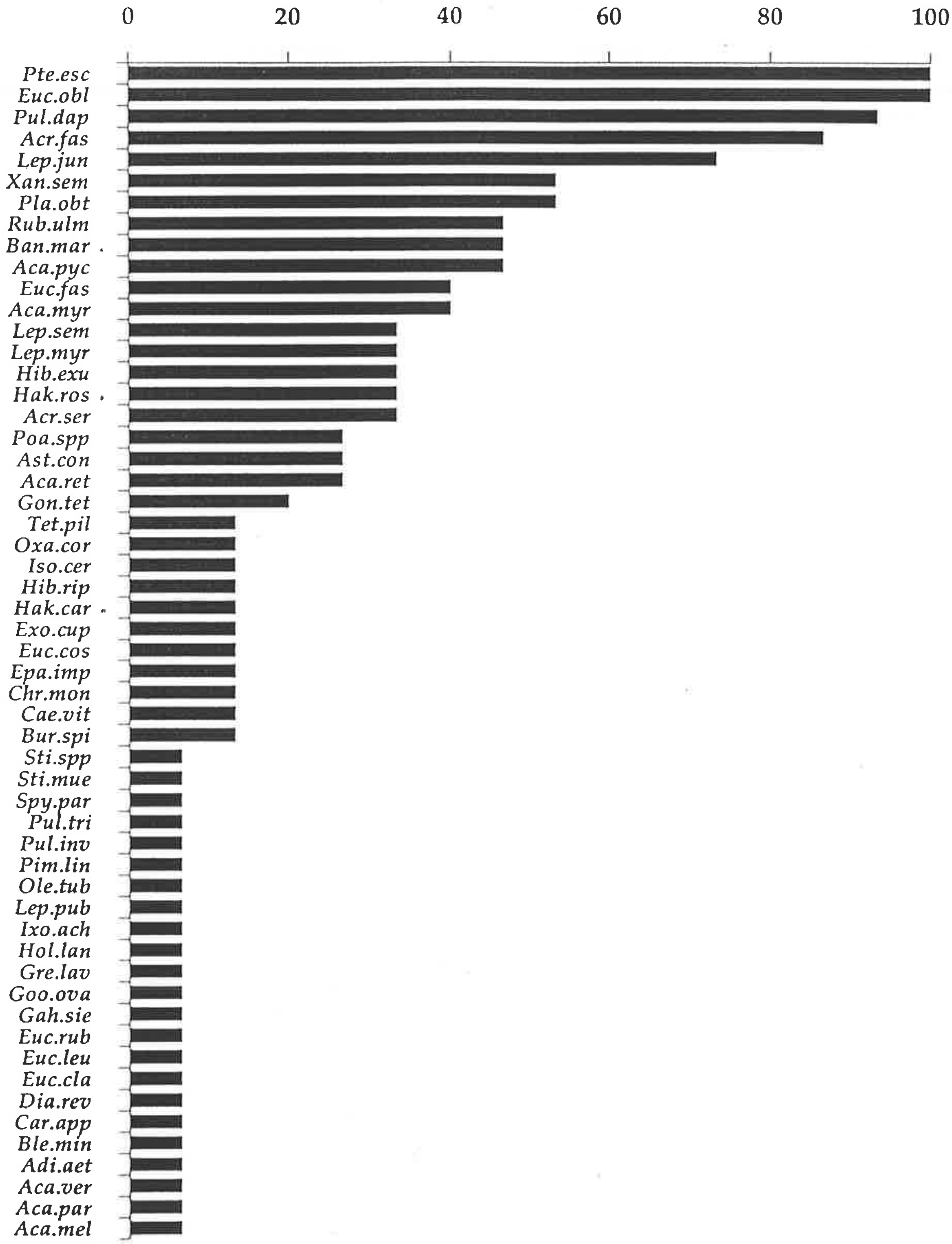
APPENDIX 3.3

Floristic Group Histograms

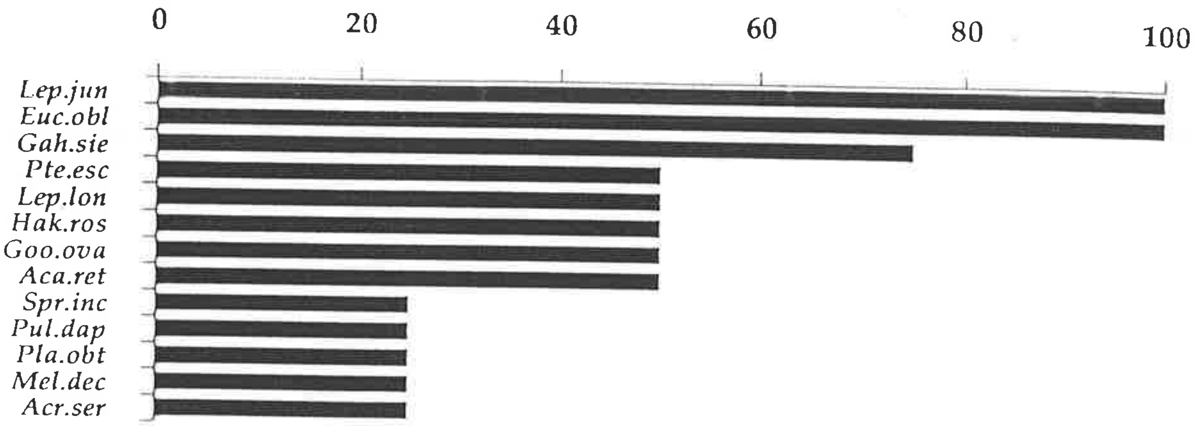
Note

These histograms show the percentage of sites which plant species occurred at within each floristic group.

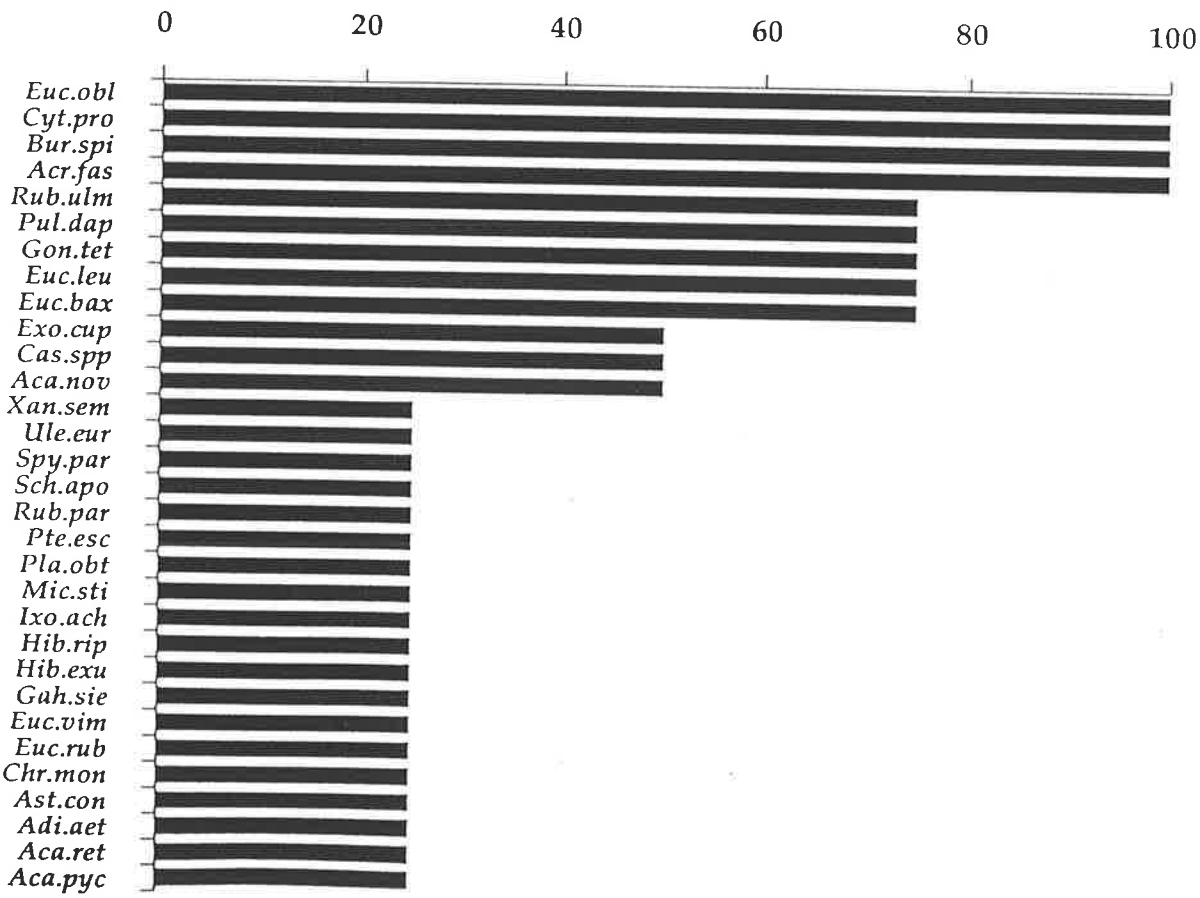
<u>Group 1</u>: *Eucalyptus obliqua* Open Forests & Woodlands



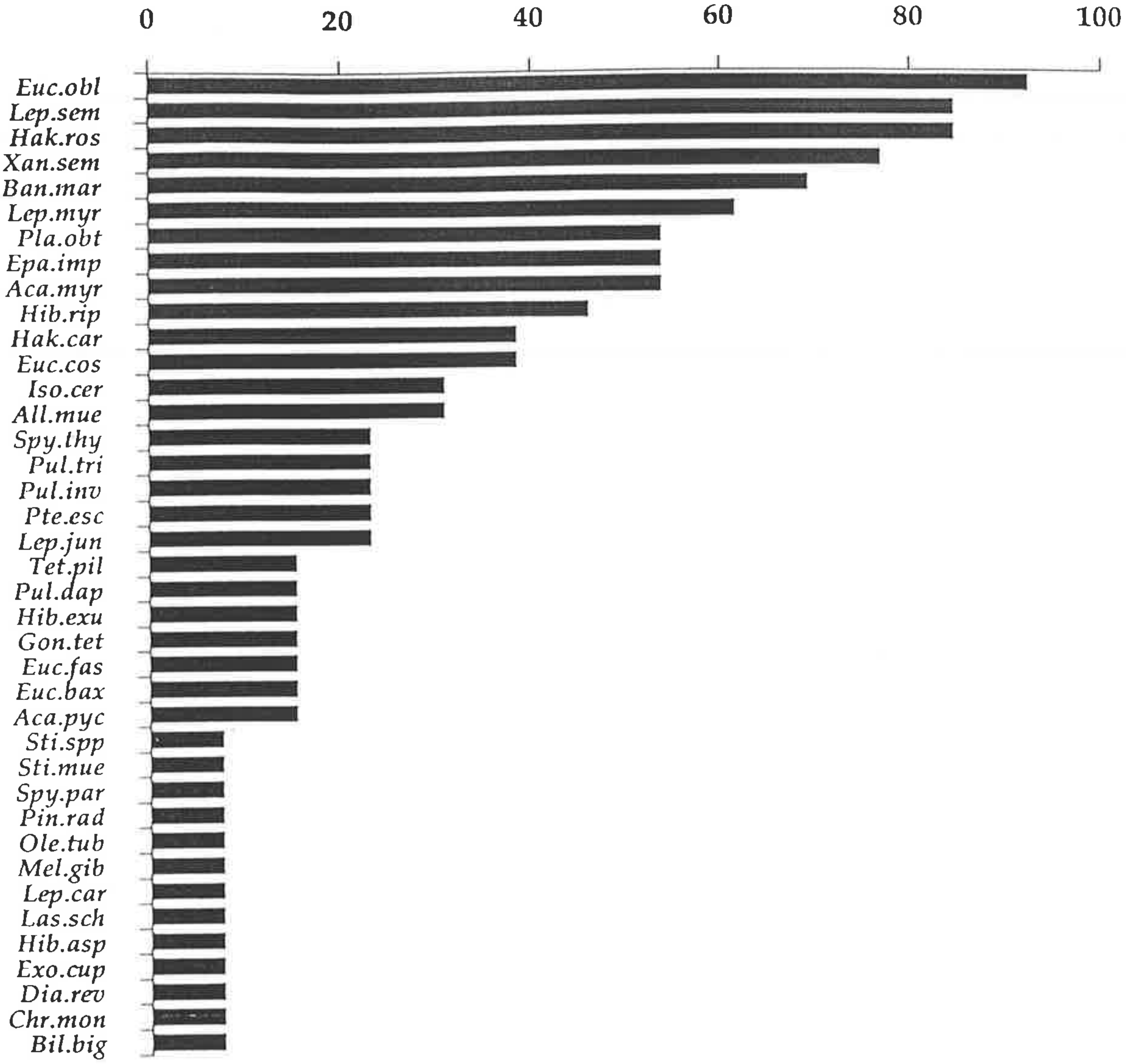
Group 2: *Eucalyptus obliqua* Open Forests & Woodlands



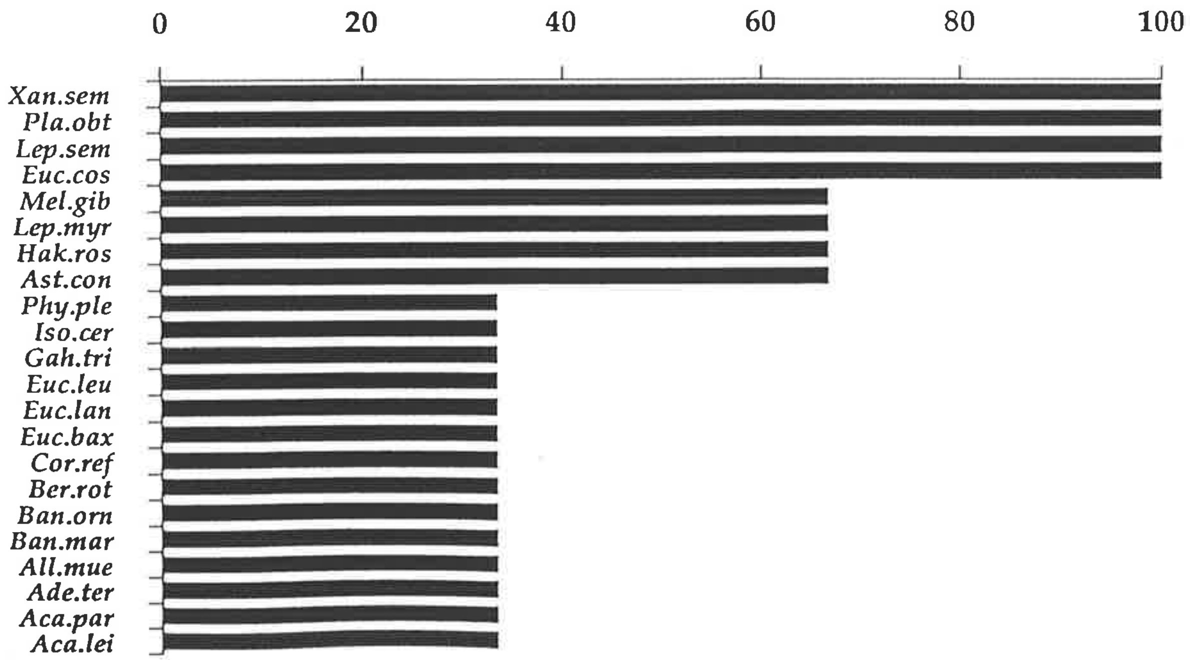
Group 3: *Eucalyptus obliqua* Open Forests & Woodlands



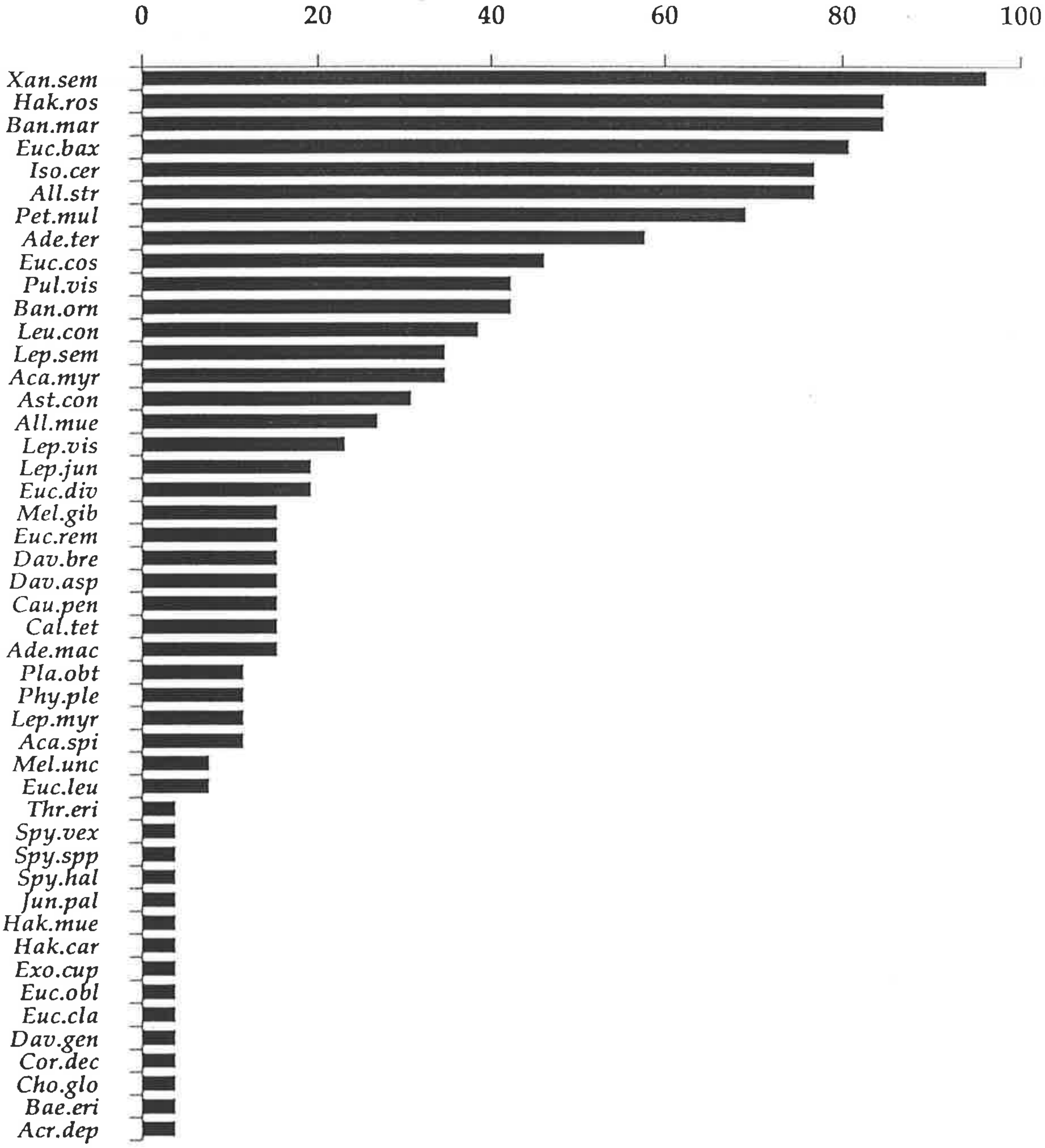
Group 4: *Eucalyptus obliqua* Woodlands & Tall Shrublands



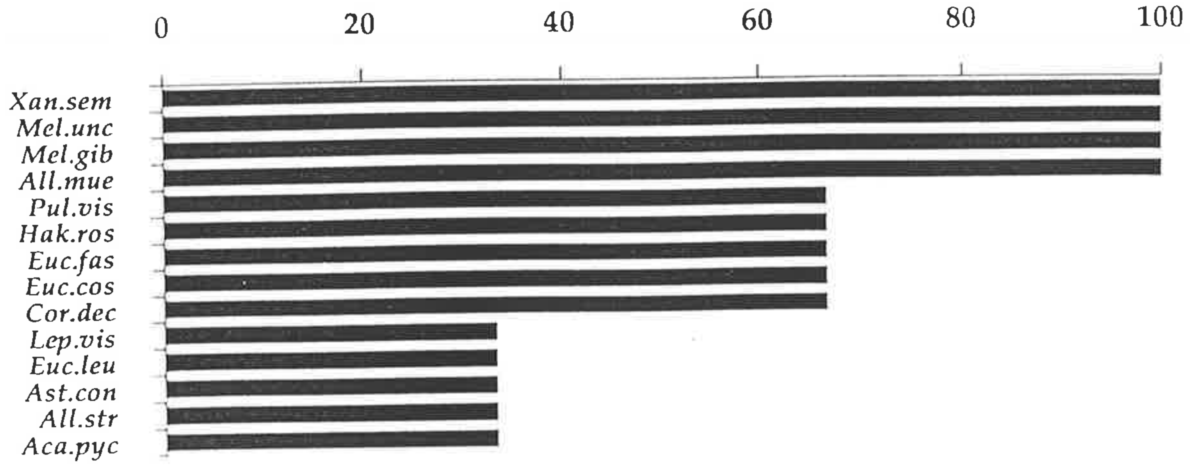
Group 5: *Eucalyptus cosmophylla* Low Woodlands



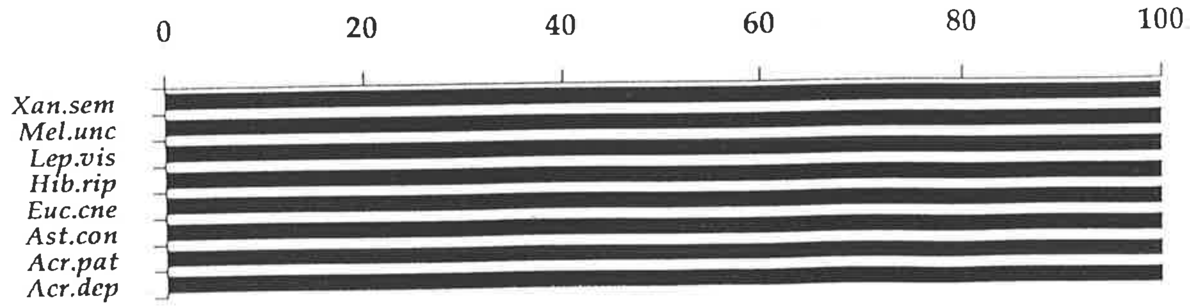
<u>Group 6</u>: *Hakea rostrata/Banksia marginata/Eucalyptus baxteri* Low Woodlands & Tall Shrublands



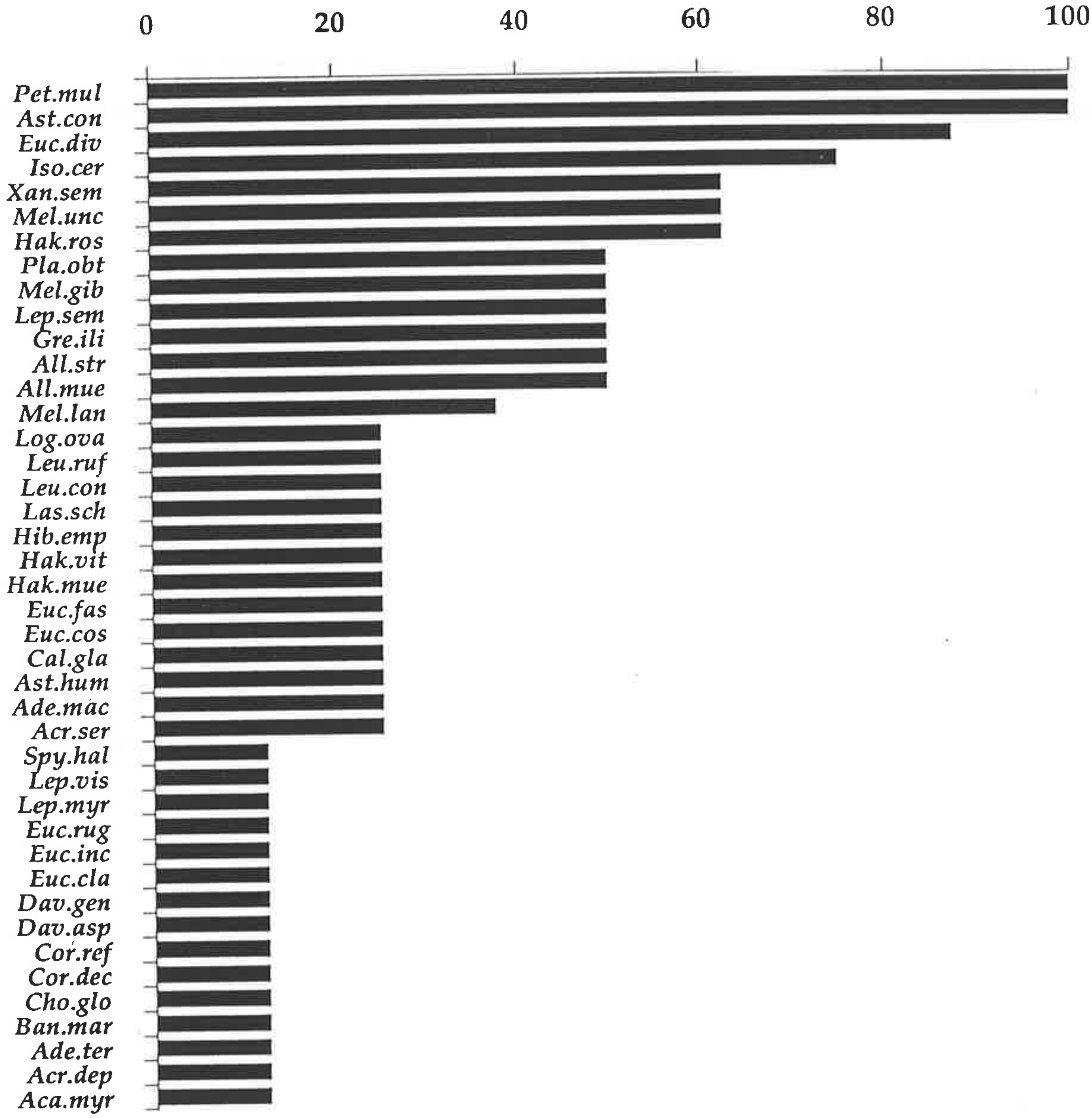
Group 7: *Melaleuca uncinata/Melaleuca gibbosa* Shrublands



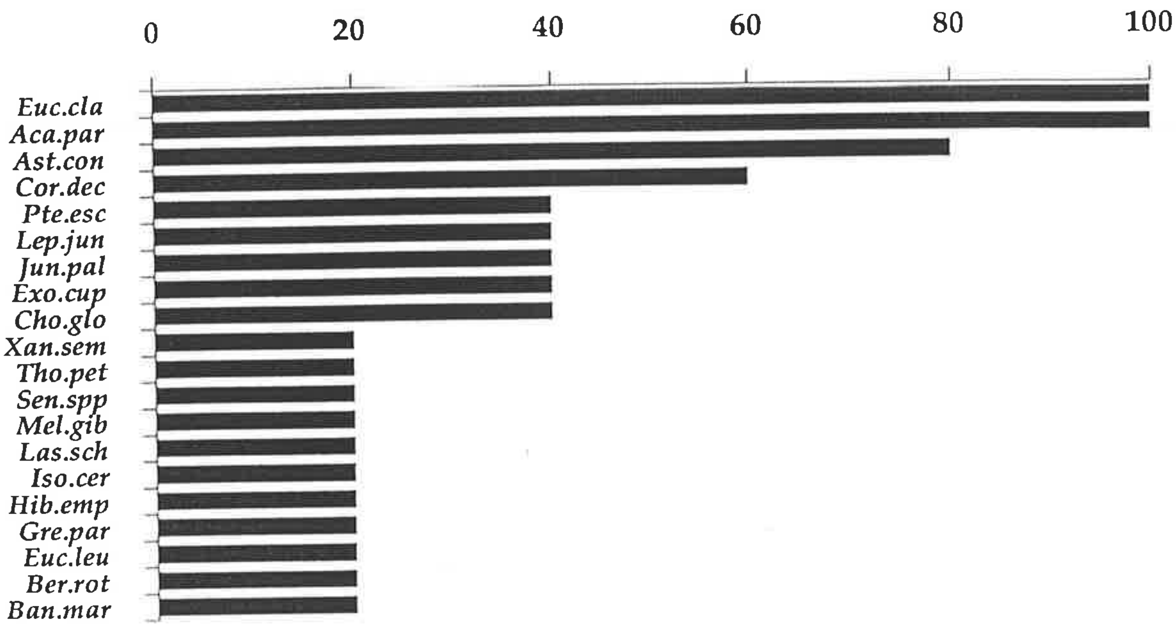
Group 8: *Eucalyptus cneorifolia* Shrublands



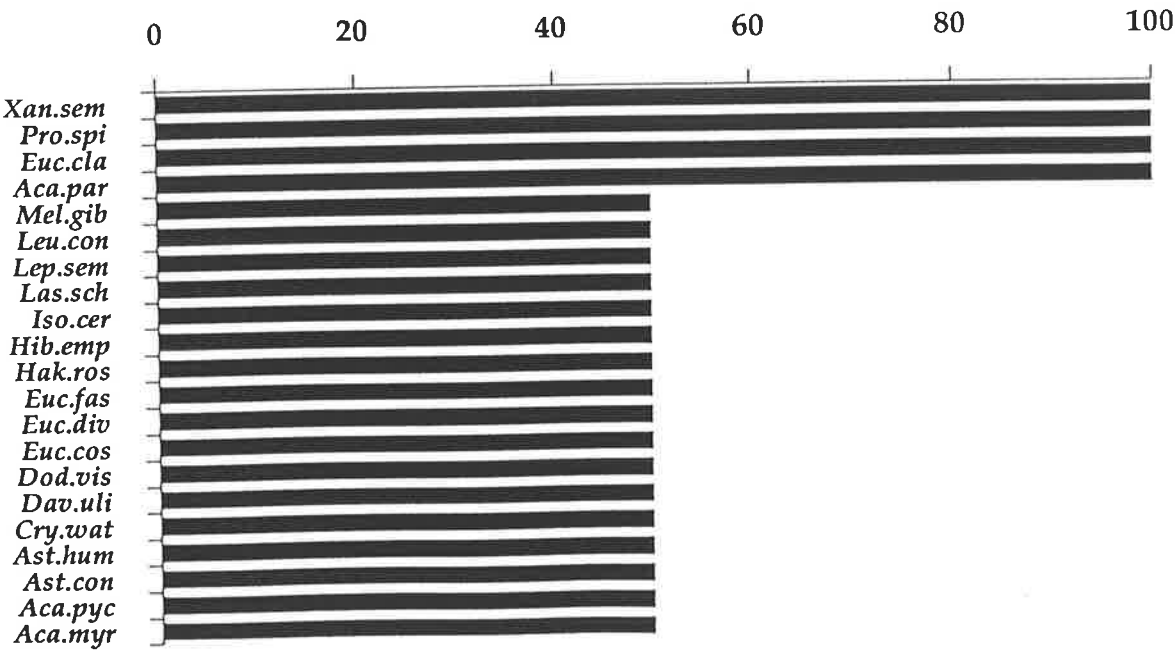
Group 9: *Eucalyptus diversifolia* Woodlands & Tall Shrublands



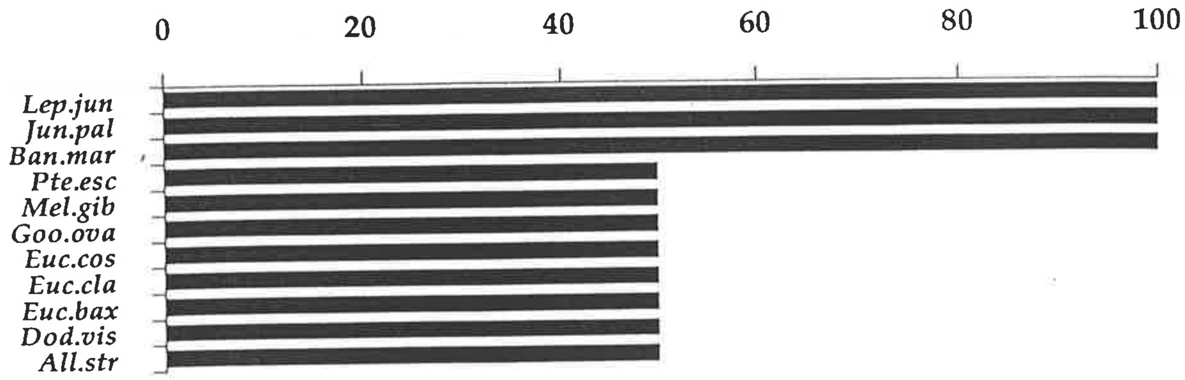
Group 10: *Eucalyptus cladocalyx* Medium Woodlands



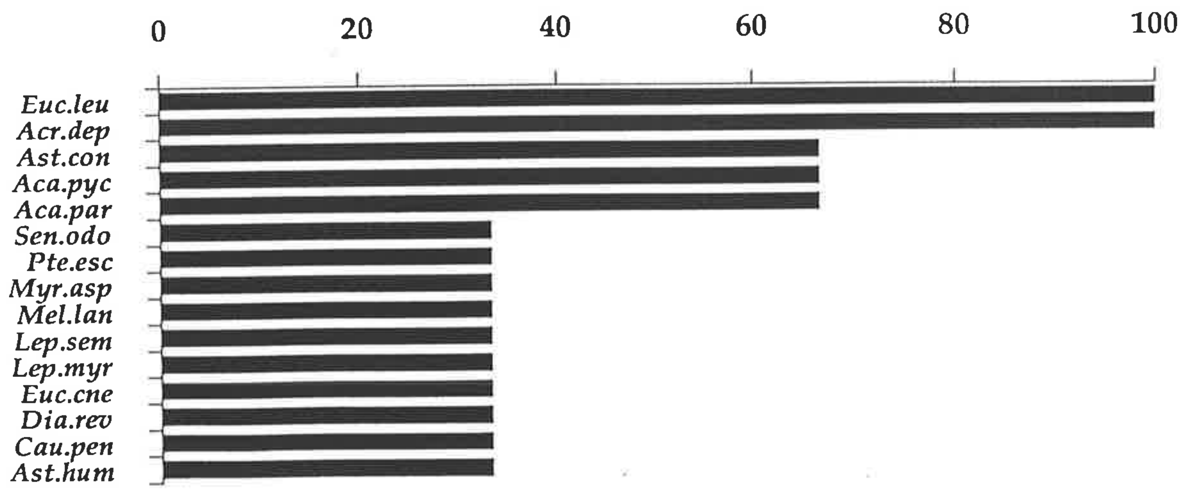
Group 11: *Eucalyptus cladocalyx* Medium Woodlands



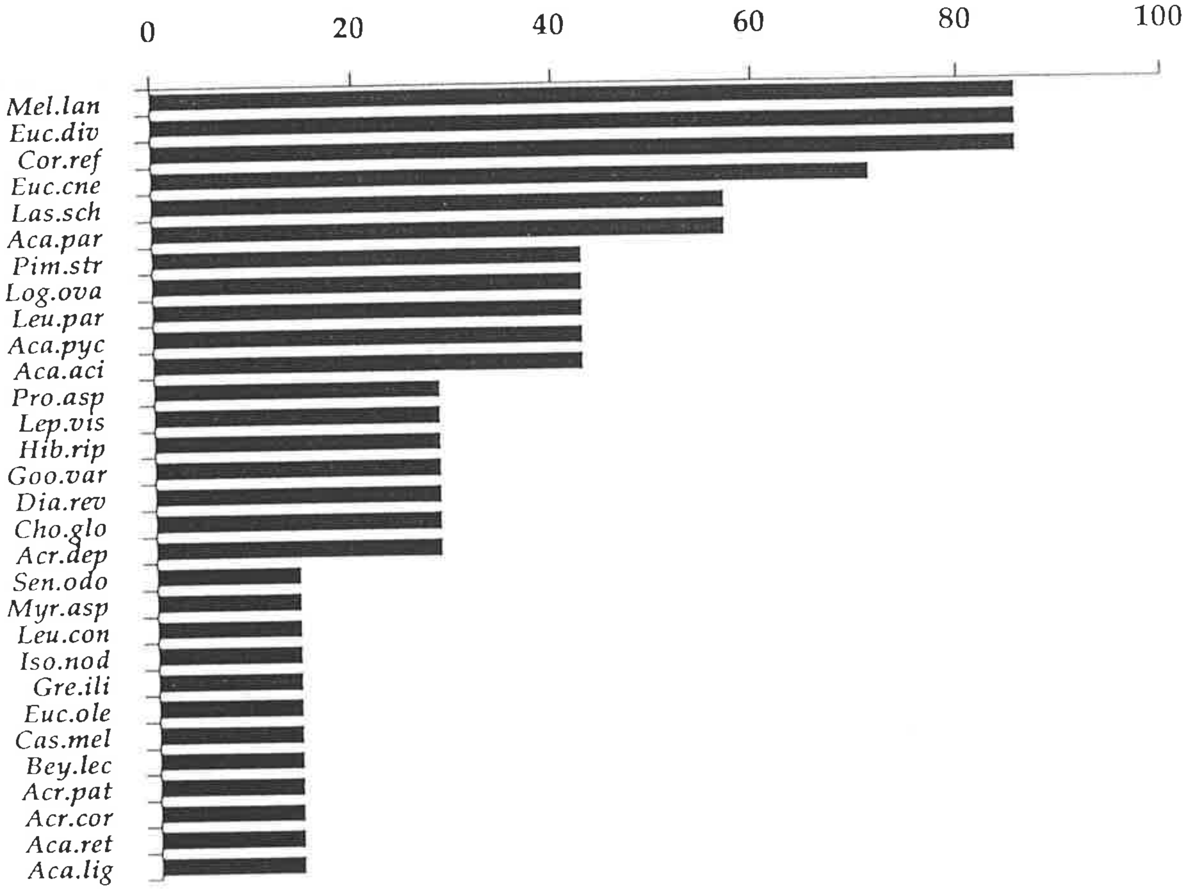
Group 12: *Banksia marginata/Leptospermum juniperinum* Low Woodlands



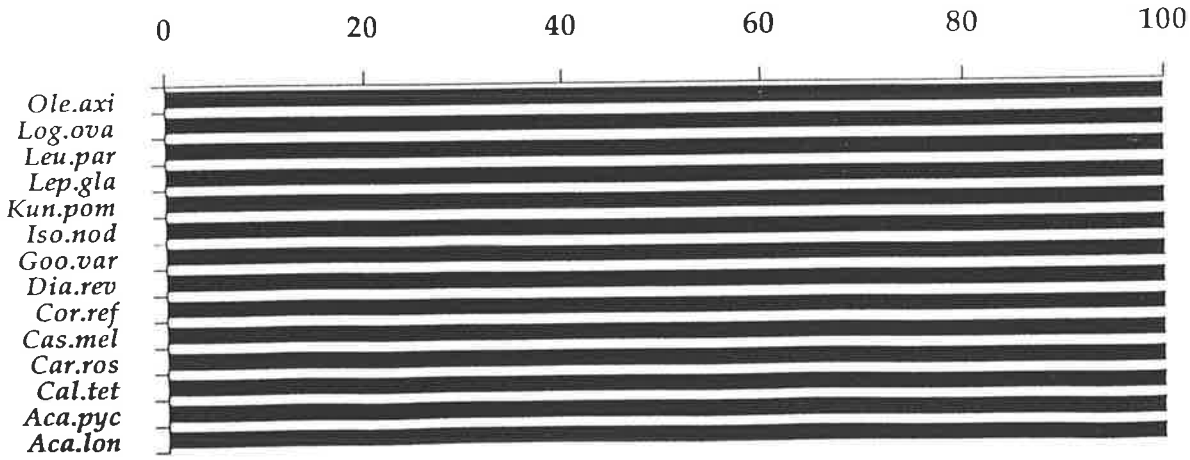
Group 13: *Eucalyptus leucoxylon* Woodlands & Tall Shrublands



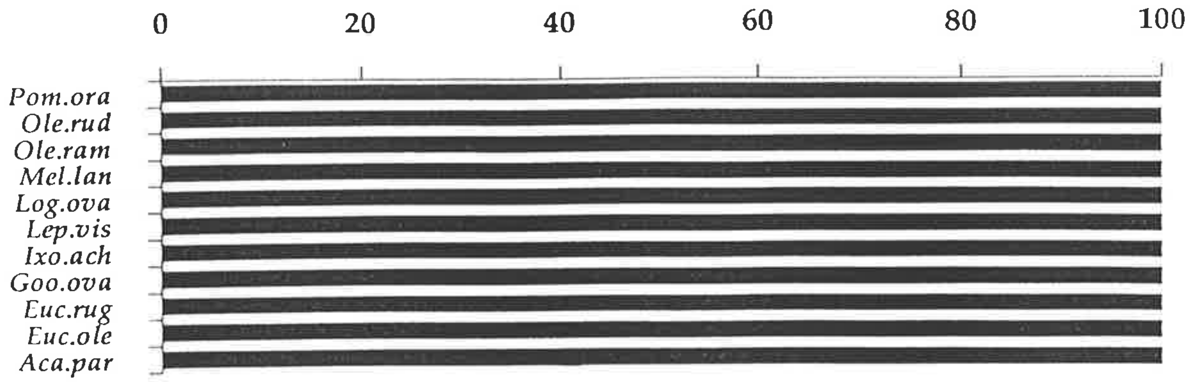
Group 14: *Eucalyptus diversifolia* Woodlands & Tall Shrublands



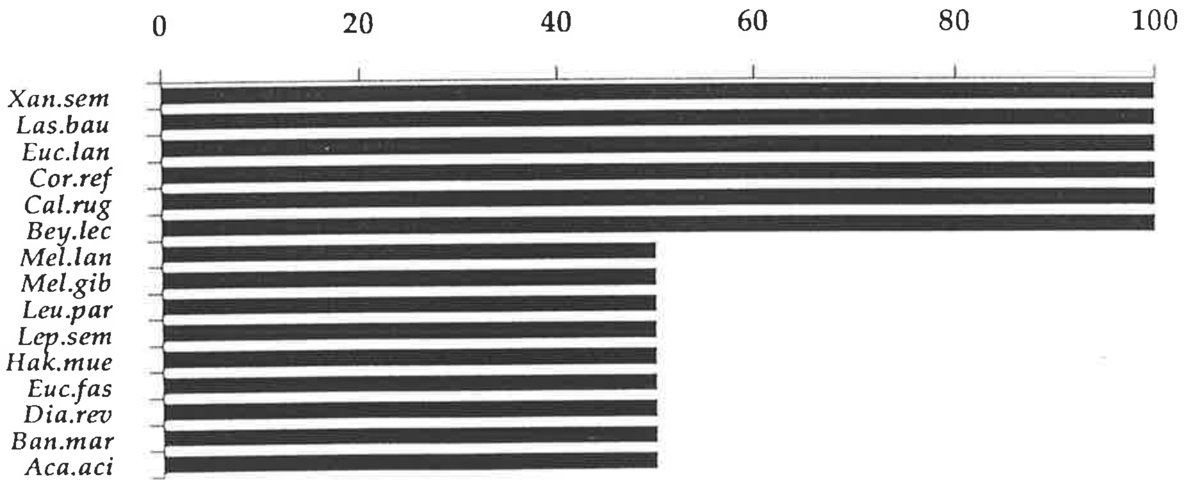
Group 15: *Acacia longifolia/Leucopogon parviflorus* Shrublands



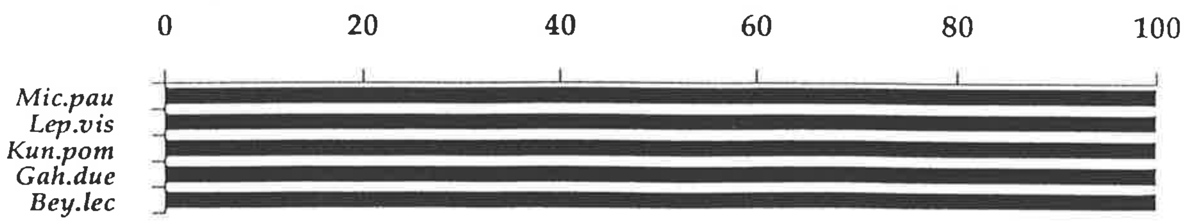
Group 16: *Eucalyptus oleosa/Eucalyptus rugosa* Shrublands



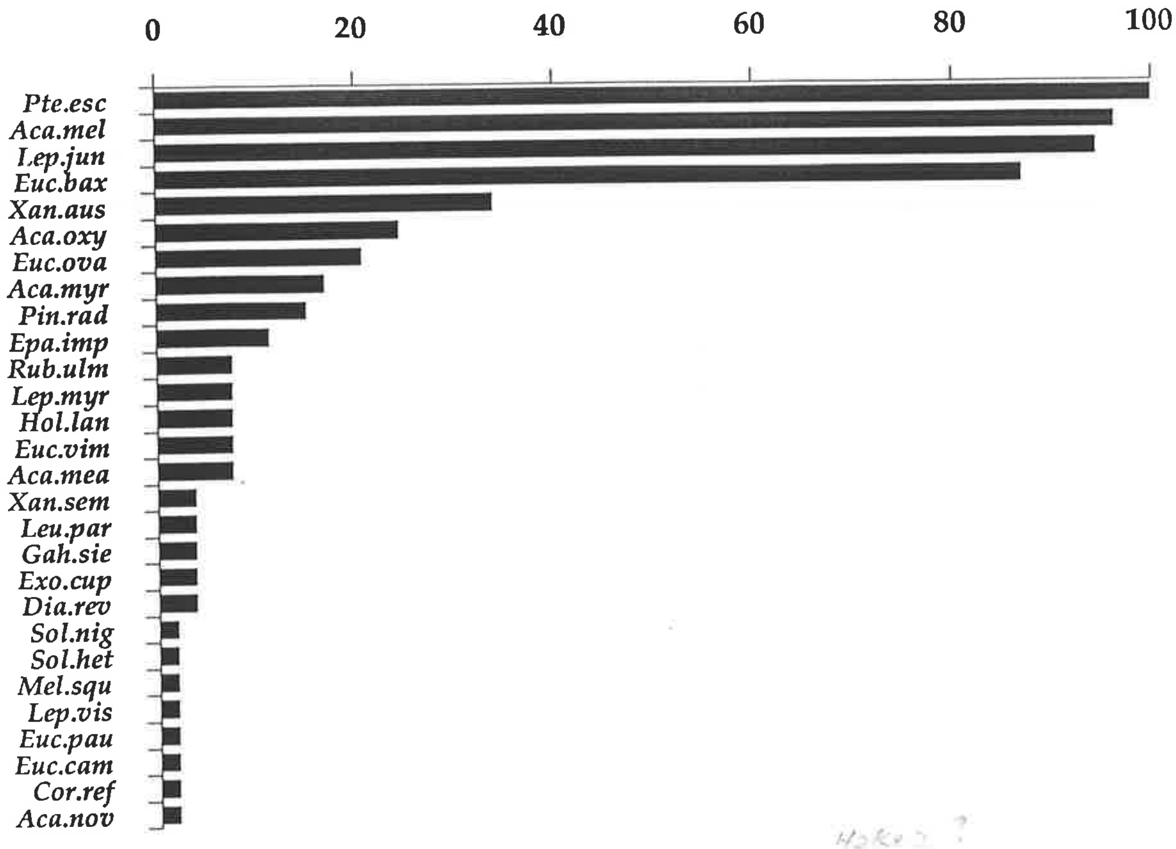
Group 17: *Eucalyptus lansdowneana* Low Open Woodlands



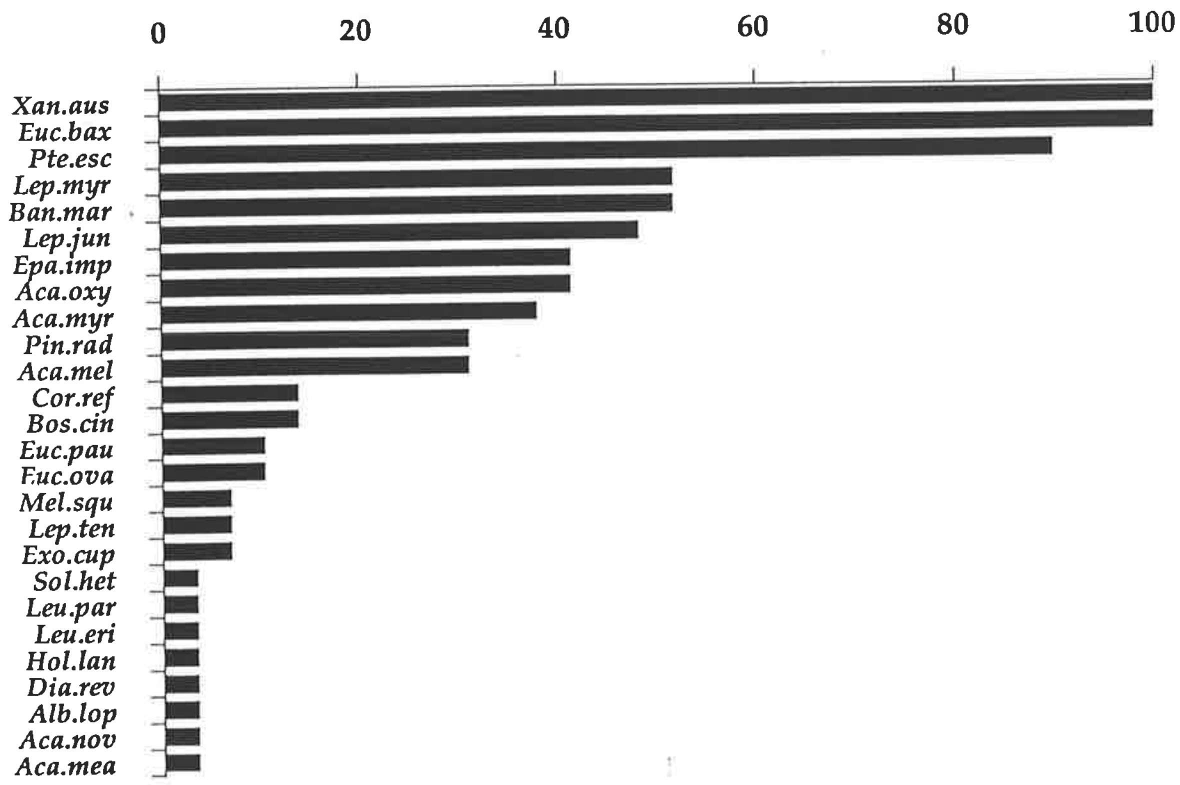
Group 18: *Gahnia duesta* Herblands



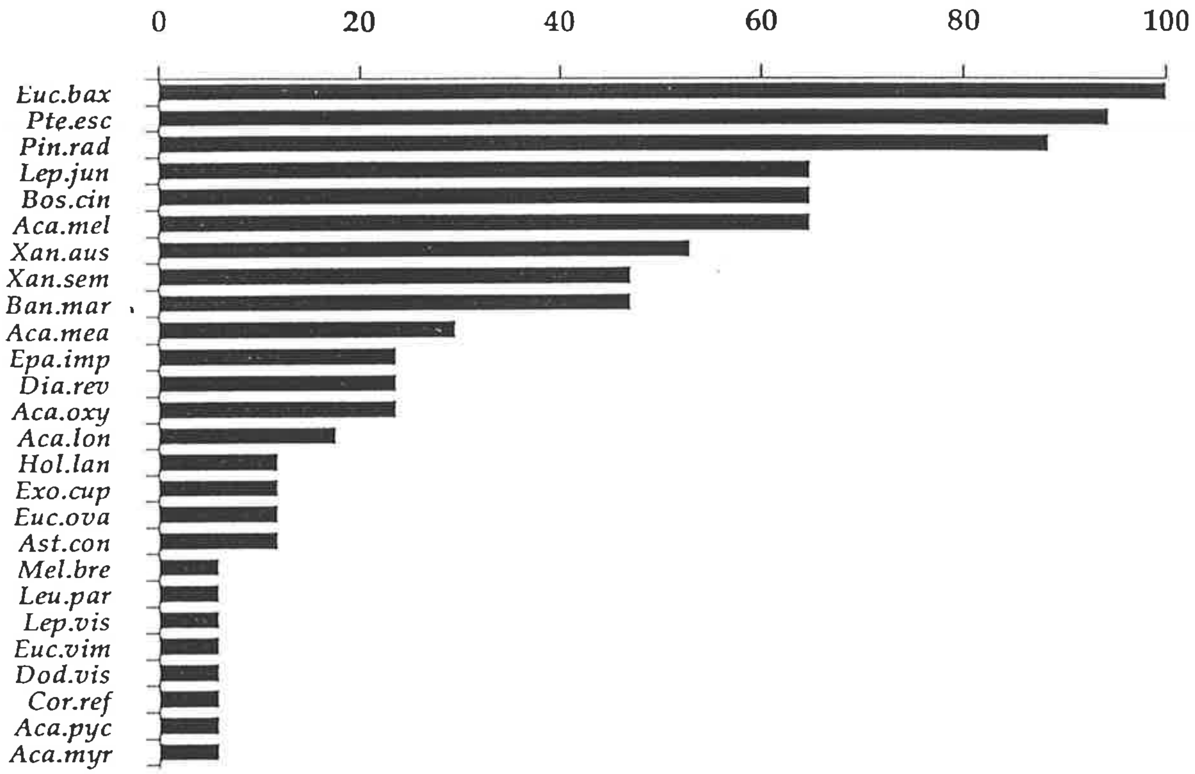
Group 19: *Eucalyptus baxteri* Low Forests & Woodlands



Group 20: *Eucalyptus baxteri* Low Forests & Woodlands



Group 21: *Eucalyptus baxteri* Low Forests & Woodlands



APPENDIX 4

Trapping Survey Results

Notes

T = Total
ADJ = Adjusted
TN = Trap Nights
Unadj = Unadjusted
LC = Large Cage Trap
SC = Small Cage Trap
CR = Capture Rate (%)
LE = Large (Type B) Elliott Trap
SE = Small (Type A) Elliott Trap
Cap = Total Captures (Initial Captures + Recaptures)

MLR = Mount Lofty Ranges
SE = South East
KI = Kangaroo Island

Mount Lofty Ranges site numbers have the prefix 1.
South East site numbers have the prefix 2.
Kangaroo Island site numbers have the prefix 3.

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
101	80					80	40.80					160	120.80			
102	64		56	54.88		120	61.20					240	180.08			
103	40					40	20.40					80	60.40			
104	100	3	56	54.88		196	99.96					352	254.84	3	0.85	**1.18**
105	104		56	54.88		130	66.30		120	13.20		410	238.38			
106	105					105	53.55		210	23.10		420	181.65			
107			133	130.34	13				140	15.40	2	273	145.74	15	5.49	**10.29**
108	91					84	42.84		175	19.25		350	153.09			
109	50		22	21.56		75	38.25					147	109.81			
110	57		21	20.58		75	38.25					153	115.83			
111	32			0.00		10	5.10		64	7.04		106	44.14			
112	391	12	15	14.70	1				408	44.88	1	814	450.58	14	1.72	**3.11**
113	38											38	38.00			
114	90	8	8	7.84	2	10	5.10		134	14.74		242	117.68	10	4.13	**8.50**
115	90	12	8	7.84	1	10	5.10	3	134	14.74		242	117.68	16	6.61	**13.60**
116	90	4	8	7.84	1	10	5.10	2	134	14.74	1	242	117.68	8	3.31	**6.80**
117	103	6	8	7.84		9	4.59		155	17.05	2	275	132.48	8	2.91	**6.04**
118	115	11	27	26.46		67	34.17		131	14.41	1	340	190.04	12	3.53	**6.31**
119	114	5	26	25.48	1	66	33.66		132	14.52		338	187.66	6	1.78	**3.20**
120	115	8	27	26.46	2				131	14.41	1	273	155.87	11	4.03	**7.06**
121	106								100	11.00		206	117.00			
122	28	1	28	27.44					56	6.16		112	61.60	1	0.89	**1.62**
123	145											145	145.00			
124	453	1	56	54.88		200	102.00		424	46.64		1133	656.52	1	0.09	**0.15**
125						20	10.20					20	10.20			

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
126			42	41.16		62	31.62		36	3.96		140	76.74			
127			42	41.16								42	41.16			
128						20	10.20					20	10.20			
129	42	2				30	15.30		72	7.92		144	65.22	2	1.39	3.07
130	56		28	27.44		64	32.64		28	3.08		176	119.16			
131	24	2				84	42.84	2	48	5.28		156	72.12	4	2.56	5.55
132	0	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00			
133	0	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00			
134	0	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00			
MLR	**2723**	**75**	**667**	**653.66**	**21**	**1567**	**799.17**	**7**	**2832**	**311.52**	**8**	**7789**	**4487.35**	**111**	**1.43**	**2.47**

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
201	24	1							24	2.64		48	26.64	1	2.08	3.75
202									32	3.52		32	3.52	0		
203						20	10.20	2	20	2.20	2	40	12.40	4	10.00	32.26
204	6		6	5.88					12	1.32		24	13.20	0		
205	6		6	5.88					12	1.32		24	13.20	0		
206	12		12	11.76					24	2.64		48	26.40	0		
207						20	10.20		20	2.20		40	12.40	0		
208						10	5.10	1	10	1.10		20	6.20	1	5.00	16.13
209						10	5.10	1	10	1.10		20	6.20	1	5.00	16.13
210	4		4	3.92					8	0.88		16	8.80	0		
211	4		4	3.92					8	0.88		16	8.80	0		
212						10	5.10		10	1.10		20	6.20	0		
213						10	5.10		10	1.10		20	6.20	0		
214	4	1	4	3.92					8	0.88		16	8.80	1	6.25	11.36

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
215	4		4	3.92					8	0.88		16	8.80	0		
216	2		2	1.96					4	0.44		8	4.40	0		
217	2		2	1.96					4	0.44		8	4.40	0		
218	2		2	1.96					4	0.44		8	4.40	0		
219	2		2	1.96					4	0.44		8	4.40	0		
220	12								24	2.64		36	14.64	0		
221	12								24	2.64	1	36	14.64	1	2.78	6.83
222						10	5.10	1	10	1.10		20	6.20	1	5.00	16.13
223	6		6	5.88					12	1.32		24	13.20	0		
224	6		6	5.88					24	2.64		36	14.52	0		
225						10	5.10		10	1.10		20	6.20	0		
226	12	1							12	1.32		24	13.32	1	4.17	7.51
227	8								8	0.88		16	8.88	0		
228	16								16	1.76		32	17.76	0		
229	12	1	12	11.76					24	2.64		48	26.40	1	2.08	3.79
230	12		12	11.76					24	2.64		48	26.40	0		
231						20	10.20		20	2.20		40	12.40	0		
232	8		12	11.76					36	3.96		56	23.72	0		
233						20	10.20		28	3.08		48	13.28	0		
234	8								16	1.76		24	9.76	0		
235						10	5.10		10	1.10		20	6.20	0		
236						10	5.10		10	1.10		20	6.20	0		
237	4								4	0.44		8	4.44	0		
238	4	1							8	0.88		12	4.88	1	8.33	20.49
239	12	1							12	1.32		24	13.32	1	4.17	7.51

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
240	12								24	2.64		36	14.64	0		
241			12	11.76					12	1.32		24	13.08	0		
242						20	10.20		20	2.20		40	12.40	0		
243	12								24	2.64		36	14.64	0		
244	12								12	1.32		24	13.32	0		
245			12	11.76					12	1.32		24	13.08	0		
246						20	10.20	1	20	2.20		40	12.40	1	2.50	8.06
247	12		12	11.76					24	2.64		48	26.40	0		
248						20	10.20	1	20	2.20	1	40	12.40	2	5.00	16.13
249	9		9	8.82					36	3.96		54	21.78	0		
250	9	1	9	8.82					36	3.96		54	21.78	1	1.85	4.59
251	18								18	1.98		36	19.98	0		
252	9		9	8.82					18	1.98		36	19.80	0		
253	18								18	1.98		36	19.98	0		
254						30	15.30		42	4.62		72	19.92	0		
255	9		9	8.82	1				18	1.98		36	19.80	1	2.78	5.05
256						30	15.30		30	3.30		60	18.60	0		
257	18								36	3.96		54	21.96	0		
258						30	15.30		30	3.30		60	18.60	0		
259	15		15	14.70	1				30	3.30		60	33.00	1	1.67	3.03
260	12		12	11.76					48	5.28		72	29.04	0		
261	12	1							12	1.32		24	13.32	1	4.17	7.51
262	9	1	3	2.94					12	1.32		24	13.26	1	4.17	7.54
263						10	5.10		10	1.10		20	6.20	0		
264	12	1	12	11.76					24	2.64		48	26.40	1	2.08	3.79

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
265						30	15.30		30	3.30		60	18.60	0		
266	18								36	3.96		54	21.96	0		
267	18								36	3.96	1	54	21.96	1	1.85	4.55
268	12		12	11.76					24	2.64		48	26.40	0		
269	12		12	11.76					24	2.64		48	26.40	0		
270						30	15.30		30	3.30		60	18.60	0		
271	4	1	4	3.92					8	0.88		16	8.80	1	6.25	11.36
272						10	5.10		10	1.10		20	6.20	0		
273	24								48	5.28		72	29.28	0		
274						40	20.40		40	4.40		80	24.80	0		
275	16		16	15.68					32	3.52		64	35.20	0		
276	16		16	15.68					32	3.52		64	35.20	0		
277	24	1							48	5.28		72	29.28	1	1.39	3.42
278	12		12	11.76					24	2.64		48	26.40	0		
279						30	15.30		30	3.30		60	18.60	0		
280	14		10	9.80					24	2.64		48	26.44	0		
281						20	10.20		20	2.20		40	12.40	0		
282	4								4	0.44		8	4.44	0		
283	4								4	0.44		8	4.44	0		
284	4								4	0.44		8	4.44	0		
285	4	1				4	2.04	2	8	0.88		16	6.92	3	18.75	43.35
286						16	8.16		16	1.76		32	9.92	0		
287	4								4	0.44		8	4.44	0		
288	8		8	7.84					16	1.76		32	17.60	0		
289									12	1.32	1	12	1.32	1	8.33	75.76

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
290	6		6	5.88					12	1.32		24	13.20	0		
291									9	0.99		9	0.99			
292																
293																
294																
295																
296																
297																
298																
299																
SE	606	13	306	299.88	2	500	255.00	9	1735	190.85	6	3147	1351.73	30	0.95	2.22

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
301						10	5.10		10	1.10		20	6.20	0		
302						10	5.10		10	1.10		20	6.20	0		
303	8		4	3.92					12	1.32		24	13.24	0		
304	4								4	0.44		8	4.44	0		
305	2		2	1.96					4	0.44		8	4.40	0		
306	6		6	5.88					24	2.64		36	14.52	0		
307	6								6	0.66		12	6.66	0		
308	2		2	1.96					4	0.44		8	4.40	0		
309	2		2	1.96					4	0.44		8	4.40	0		
310	8		8	7.84					16	1.76		32	17.60	0		
311	6		4	3.92					10	1.10		20	11.02	0		
312	4		4	3.92					8	0.88		16	8.80	0		
313						10	5.10		10	1.10		20	6.20	0		

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
314	16								32	3.52		48	19.52	0		
315						20	10.20		20	2.20		40	12.40	0		
316	8		8	7.84					32	3.52		48	19.36	0		
317						10	5.10		10	1.10		20	6.20	0		
318						20	10.20		20	2.20		40	12.40	0		
319	8		8	7.84					16	1.76		32	17.60	0		
320	16								16	1.76		32	17.76	0		
321	8		8	7.84					32	3.52		48	19.36	0		
322						20	10.20		20	2.20		40	12.40	0		
323	8		8	7.84					32	3.52		48	19.36	0		
324	12		12	11.76					24	2.64		48	26.40	0		
325	24								24	2.64		48	26.64	0		
326	4		4	3.92					16	1.76		24	9.68	0		
327						10	5.10		10	1.10		20	6.20	0		
328						10	5.10		10	1.10		20	6.20	0		
329	12		12	11.76					48	5.28		72	29.04	0		
330	8		8	7.84					32	3.52		48	19.36	0		
331						20	10.20		20	2.20		40	12.40	0		
332						20	10.20		20	2.20		40	12.40	0		
333	8		8	7.84					32	3.52		48	19.36	0		
334						40	20.40		40	4.40		80	24.80	0		
335	12		12	11.76					24	2.64		48	26.40	0		
336	24								32	3.52	1	56	27.52	1	1.79	3.63
337						30	15.30	2	30	3.30		60	18.60	2	3.33	10.75
338	16	1	16	15.68	1				48	5.28		80	36.96	2	2.50	5.41

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
339	8		8	7.84					32	3.52		48	19.36	0		
340	8		8	7.84					32	3.52		48	19.36	0		
341						20	10.20		20	2.20		40	12.40	0		
342	16	1							16	1.76		32	17.76	1	3.13	5.63
343	8		8	7.84					32	3.52		48	19.36	0		
344						20	10.20		20	2.20		40	12.40	0		
345	12		12	11.76					24	2.64		48	26.40	0		
346	16									0.00		16	16.00	0		
347						20	10.20			0.00		20	10.20	0		
348	12		12	11.76						0.00		24	23.76	0		
349									60	6.60		60	6.60	0		
350									30	3.30		30	3.30	0		
351	8		8	7.84					32	3.52		48	19.36	0		
352						20	10.20		20	2.20		40	12.40	0		
353	8								8	0.88		16	8.88	0		
354	4		4	3.92					8	0.88		16	8.80	0		
355						10	5.10		7	0.77		17	5.87	0		
356						40	20.40		100	11.00		140	31.40	0		
357	8		8	7.84					16	1.76		32	17.60	0		
358	16											16	16.00	0		
359	8		8	7.84					16	1.76		32	17.60	0		
360	8		8	7.84								16	15.84	0		
361	16								16	1.76		32	17.76	0		
362	8		8	7.84					16	1.76		32	17.60	0		
363						10	5.10		10	1.10		20	6.20	0		

Site No	LC TN	LC Cap	SC TN	SC ADJ TN	SC Cap	LE TN	LE ADJ TN	LE Cap	SE TN	SE ADJ TN	SE Cap	T TN UNADJ	T TN ADJ	T Cap	CR UNADJ	CR ADJ
364	4		4	3.92					16	1.76		24	9.68	0		
365	4		4	3.92					16	1.76		24	9.68	0		
366						10	5.10		10	1.10		20	6.20	0		
367	0		0			0			0			0				
KI	**404**	**2**	**236**	**231.28**	**1**	**380**	**193.80**	**2**	**1319**	**145.09**	**1**	**2339**	**974.17**	**6**	**0.26**	**0.62**
Total	**3733**	**90**	**1209**	**1184.82**	**24**	**2447**	**1247.97**	**18**	**5886**	**647.46**	**15**	**13275**	**6813.25**	**147**	**0.01**	**0.02**

BIBLIOGRAPHY

Aitken, P.F. (1979). The status of endangered Australian wombats, bandicoots and the marsupial mole. In *The Status of Endangered Australian Wildlife.* ed. M.J. Tyler. Pp 61 - 65. Royal Zoological Society of South Australia.

Aitken, P.F. (1983). Mammals. In *Natural History of the South East.* eds. M.J. Tyler, C.R. Twidale, J.K. Ling & J.W. Holmes. Pp 127 - 33. Royal Society of South Australia, Adelaide.

Aitken, P.F., K. Bellchambers, P. Christensen, B. Gepp, M. Thompson, and J. Suiker (1986). Observations on the effect of prescribed burning and wildfires on the southern brown bandicoot, *Isoodon obesulus.* Abstract. In *Bulletin of the Australian Mammal Society.* 9(1), P 21.

Armstrong, S.M., M.J. Chesworth, R. Willig, G.J. Coleman and V.M. Cassone (1990). Unusual circadian activity rhythms in captive bandicoots *Isoodon obesulus* and *Isoodon macrourus.* In *Bandicots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 271 - 83. Surrey Beatty & Sons, Sydney.

Barnes, A. and R.T. Gemmell (1984). Correlations between breeding activity in the marsupial bandicoots and some environmental variables. *Australian Journal of Zoology,* 32, Pp 219 - 226.

Belbin, L. (1987a). *PATN, Pattern Analysis Package, Reference Manual.* CSIRO Division of Wildlife and Rangelands Research, Canberra.

Belbin, L. (1987b). *PATN, Pattern Analysis Package, Command Manual.* CSIRO Division of Wildlife and Rangelands Research, Canberra.

Belbin, L. (1987c). *PATN, Pattern Analysis Package, Users Guide.* CSIRO Division of Wildlife and Rangelands Research, Canberra.

Belbin, L. (1991). The analysis of pattern in bio-survey data. In *Nature Conservation: Cost Effective Biological Surveys and Data Analysis.* eds. C.R. Margules & M.P. Austin. CSIRO, Australia.

Braithwaite, R.W. (1983). Southern brown bandicoot. In *The Australian Museum Complete Book of Australian Mammals.* ed. R. Strahan. Pp 94 - 95. Angus & Robertson Publishers, Australia.

Braithwaite, R.W. and P.K. Gullan (1978). Habitat selection by small mammals in a Victorian heathland. *Australian Journal of Ecology,* 3, Pp 109 - 27.

Braithwaite, R.W. and A.K. Lee (in press). A mammalian example of semelparity. *American Naturalist,* Cited in Stoddart and Braithwaite (1979). *Journal of Animal Ecology,* 48, Pp 165 - 79.

Broughton, S.K. and C.R. Dickman (1991). The effect of supplementary food on home range of the southern brown bandicoot, *Isoodon obesulus* (Marsupialia: Peramelidae). *Australian Journal of Ecology,* 16, Pp 71 - 78.

Buchman, O.K.L. and E.A. Grecian (1974). Discrimination reversal learning in the marsupial *Isoodon obesulus* (Marsupialia, Peramelidae). *Animal Behaviour,* 22, Pp 975 - 81.

Campbell, A.J. and M.T. Tanton (1981). Effects of fire on the invertebrate fauna of soil & litter of a eucalypt forest. In *Fire and the Australian Biota.* eds. A.M. Gill, R.H. Groves & I.R. Noble. Pp 214 - 41. Australian Academy of Science, Canberra.

Catling, P.C. and A.E. Newsome (1981). Responses of the Australian vertebrate fauna to fire: an evolutionary approach. In *Fire and the Australian Biota.* eds. A.M. Gill, R.H. Groves & I.R. Noble. Pp 273 - 310. Australian Academy of Science, Canberra.

Catling, P.C., A.E. Newsome and G. Dudzinski (1982). Small mammal habitat components & fire in south eastern Australia. *Proceedings of the Symposium on the Dynamics & Management of Meditteranean-Type Ecosystems.* U.S. Department of Agriculture, Foresty Service Technichal Report PSW - 58, Pp 199 - 206.

Close, R.L. (1977). Recurrence of breeding after cessation of suckling in the marsupial *Perameles nasuta. Australian Journal of Zoology,* 25 (4), Pp 641 - 645.

Close, R.L., J.D. Murray and D.A. Briscoe (1990). Electophoretic & chromosome surveys of the taxa of the short-nosed bandicoots within the genus *Isoodon*. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 19 - 27. Surrey Beatty & Sons, Sydney.

Cockburn, A. (1990). Life history of the bandicoots: developmental rigidity and phenotypic plasticity. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 285 - 92. Surrey Beatty & Sons, Sydney.

Collins, L.R. (1973). *Monotremes and Marsupials: A Reference for Zoological Institutions.* Smithsonian Institute, Washington, Publication 4888, Pp 147 - 68.

Copley, P.B., V.T. Read, A.C. Robinson and C.H.S. Watts (1990). Preliminary study of the Nuyts Archipelago bandicoot, *Isoodon obesulus nauticus* on Franklin Island, South Australia. In *Bandicoots and Bilbies.* ed. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 345 - 56. Surrey Beatty & Sons, Sydney.

Cowley, R.D., A. Heislers and E.H.M Ealey **(1969).** Effects of fire on wildlife. *Victoria's Resources,* 11, Pp 18 - 22.

Day, B., R. Kirkby and H. Stenhouse (1974). The behaviour of marsupials III. The short-nosed bandicoot, *Isoodon macrourus* (Peramelidae), in the open field.*Australian Mammalogy,*1, Pp 255 - 59.

Dendy, T. (1985). South Australian Heritage Agreement Scheme and clearance controls. *South Australian Geographer,* 1, Pp 16 - 26.

Dixon, J. (1978). Long-nosed bandicoots elude searchers. *Forest and Timber,* 14 (2), Pp 13 - 17.

Fox, B.J. (1978). Temporal changes in a small mammal community on coastal heath regenerating after fire. *Bulletin of the Australian Ecological Society,* 8, Pp 12 - 13.

Look up Sci. Journal
Bandicoots and Bilbies

Friend, G.R. (1990). Breeding and population dynamics of *Isoodon macrourus* (Marsupialia: Peramelidae): studies from the wet-dry tropics of northern Australia. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 357 - 65. Surrey Beatty & Sons, Sydney.

Gemmell, R.T. (1979). The fine structure of luteal cells in relation to the concentration of progesterone in the plasma of the lactating bandicoot, *Isoodon macrourus* (Marsupialia: Peramelidae). *Australian Journal of Zoology,* 27, Pp 501 -10.

Gemmell, R.T. (1981). The role of the corpus luteum of lactation in the bandicoot *Isoodon macrourus* (Marsupialia: Peramelidae). *General & Comparative Endocrinology,* 44, Pp13 - 19.

Gemmell, R.T. (1982). Breeding bandicoots in Brisbane (*Isoodon macrourus;* Marsupialia: Peramelidae). *Australian Mammalogy,* 5, Pp 187 - 93.

Gemmell, R.T. (1988). The oestrus length of the bandicoot *Isoodon macrourus. Australian Wildlife Research,* 15, Pp 633 - 5.

Gemmell, R.T. (1990). The initiation of the breeding season of the northern brown bandicoot *Isoodon macrourus* in captivity. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 205 - 12. Surrey Beatty & Sons, Sydney.

Gemmell, R.T., G. Jenkin and G.D. Thornburn (1980). Plasma concentrations of progestrone and 13, 14-dihydro-15 kepto-prostaglandin F2 at parturition in the bandicoot, *Isoodon macrourus. Journal of Reproduction & Fertility,* 60, Pp 253 - 56.

Gemmell, R.T., M.T. Walker, G. Johnston and G. Cephon (1984). The number of young present in sequential litters of the marsupial bandicoot, *Isoodon macrourus,* in captivity. *Australian Journal of Zoology,* 32, Pp 623 - 29.

Gill, A.M. (1979). Bushfires as a hazard to organisms. In *Natural Hazards in Australia,* eds. R.L. Heathcote & B.G. Thom. Pp 270 - 74. Australian Academy of Science, Canberra.

Gordon, G. (1966). *A Study of Movements of the Short Nosed Bandicoot, Isoodon macrourus (Gould).* Honours Thesis, University of Queensland.

Gordon, G. (1971). *A Study of Island Populations of the Short-Nosed Bandicoot Isoodon macrourus* Gould. PhD Thesis, University of New South Wales.

Gordon, G. (1974). Movements and activity of the short-nosed bandicoot *Isoodon macrourus* Gould (Marsupialia). *Mammalia,* 38, Pp 405 - 431.

Gordon, G. (1984). Bandicoots and Bilbies. In *The Encyclopaedia of Mammals.* ed D. Macdonald. Pp 846 - 849. Vol 2. Allen & Unwin, London.

Gordon, G. and A.J. Hulbert (1989). Peramelidae. In *Fauna of Australia.* eds. D.W. Walton & B.J. Richardson. Pp 603 - 24. Vol 1B. Australian Government Publishing Service, Canberra.

Guiler, E.R. (1958). Observations on a population of small marsupials in Tasmania. *Journal of Mammalogy,* 39 (1), Pp 44 - 58.

Hall, L.S. (1983). Observations on body weights and breeding of the northern brown bandicoot, *Isoodon macrourus,* trapped in south-east Queensland. *Australian Wildlife Research,* 10 (3), Pp 467 - 76.

Hall, L.S. (1990). Growth and a description of the development of external features of pouch young of captive *Isoodon macrourus.* In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 67 - 72. Surrey Beatty & Sons, Sydney.

Harrison, J.L. (1962). Mammals of Innisfail. I. Species and distribution. *Australian Journal of Zoology,* 10, Pp 45 - 83.

Harrison, J.L. (1963). The food of some Innisfail mammals. *Proceedings of the Royal Society of Queensland,* 73, Pp 37 - 43.

Heinsohn, G.E. (1966). Ecology and reproduction of the Tasmanian Bandicoots (*Perameles gunni* and *Isoodon obesulus*). *University of California Publications in Zoology,* 80, Pp 1 - 107.

Heinsohn, G.E. (1986). The ecology of the southern brown bandicoot (*Isoodon obesulus*) in Western Australia. Abstract. In *Bulletin of the Australian Mammal Society.* 9(1), P 21.

Hollis, D.E. and A.G. Lyne (1980). Ultrastructure of luteal cells in fully formed regressing corpora lutea during pregnancy and lactation in the marsupials *Isoodon macrourus* and *Perameles nasuta. Australian Journal of Zoology,* 28, Pp 195 - 211.

Hughes, R.L. (1962). Role of the corpus luteum in marsupial reproduction. *Nature (London),* 194, Pp 890 - 1.

Hughes, R.L. (1984). Structural adaptations of the eggs of the foetal membranes of monotremes and marsupials for respiration and metabolic exchange. In *Respiration and Metabolism of Embryonic Vertebrates.* ed. R.S. Seymour. Dordrecht, Junk.

Hulbert, A.J. and G. Gordon (1972). Water metabolism of the bandicoot *Isoodon macrourus* Gould in the wild. *Comparative Biochemistry and Physiology,* 41A, Pp 27 - 34.

Hulbert, A.J. and T.J. Dawson (1974). Water metabolism in perameloid marsupials from different environments. *Comparative Biochemistry and Physiology,* 47A, Pp 617 - 33.

Jackson,W.D. (1968). Fire, air, water and earth - an elemental ecology of Tasmania. *Proceedings of the Ecological Society of Australia,* 3, Pp 9 - 16.

Jones, F.W. (1924). *The Mammals of South Australia.* Part 2. A.B. James, Government Printer, Adelaide.

Kemper, C.M. (1990). Status of bandicoots in South Australia. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 67 - 72. Surrey Beatty & Sons, Sydney.

Kirsch, J.A.W. (1968). Burrowing by the Quenda, *Isoodon obesulus. The Western Australian Naturalist,* 10 (8), Pp 178 - 80.

Krefft, G. (1865). *On the Vertebrata of the Lower Murray and Darling; Their Habits, Economy and Geographical Distribution.* Pp 1 - 33. Reading & Wellbank Printers, Sydney.

Laut, P., P. C. Heyligers, G. Keig, E. Loffler, C. Margules and R.M. Scott (1977). *Environments of South Australia: Province Reports 1 and 3.* CSIRO Division of Land Research, Canberra.

Lee, A.K. and A. Cockburn (1985). *Evolutionary Ecology of Marsupials.* Oxford University Press, Cambridge.

Leonard, B. (1970). Effects of control burning on the ecology of small mammal populations. *Symposium on Fire Ecology,* Forestry Commission of Victoria. No 2. Pp 1 - 14.

Lobert, B. (1985). *The Ecology of the Southern Brown Bandicoot in South-Eastern Australian Heathland.* MSc Thesis, Zoology Department, Monash University.

Lobert, B. (1990). Home range and activity period of the southern brown bandicoot (*Isoodon obesulus*) in a Victorian heathland. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 319 - 25. Surrey Beatty & Sons, Sydney.

Lobert, B. and A. Opie (1986). Habitat preference by *Isoodon obesulus* in heathland at Cranbourne, Victoria. Abstract. In *Bulletin of the Australian Mammal Society,* 9 (1), P 24.

Lobert, B. and A.K. Lee (1990). Reproduction and life-history of *Isoodon obesulus* in Victorian Heathland. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L.Wallis & C.M. Kemper. Pp 311 - 18. Surrey Beatty & Sons, Sydney.

Lyne, A.G. (1964). Observations on the breeding and growth of the marsupial *Perameles nasuta* Geoffroy, with notes on other bandicoots. *Australian Journal of Zoology.* 12, Pp 322 - 339.

Lyne, A.G. (1971). Bandicoots in captivity. *International Zoo Yearbook,* 11, Pp 41 - 3.

Lyne, A.G. (1974). Gestation period and birth in the marsupial *Isoodon macrourus. Australian Journal of Zoology,* 22, Pp 303 - 9.

Lyne, A.G. (1976). Observations on oestrus and the oestrus cycle in the marsupials *Isoodon macrourus* and *Perameles nasuta. Australian Journal of Zoology,* 24, Pp 513 - 21.

Lyne, A.G. (1981). Activity rhythms in the marsupials *Isoodon macrourus* and *Perameles nasuta* in captivity. *Australian Journal of Zoology,* 29 (6), Pp 821 - 38.

Lyne, A.G. and D.E. Hollis (1979). Observations on the corpus luteum during pregnancy and lactation in the marsupials *Isoodon macrourus* and *Perameles nasuta. Australian Journal of Zoology,* 27, Pp 881 - 99.

Lyne, A.G. and P.A. Mort (1981). A comparison of skull morphology in the marsupial bandicoot genus *Isoodon*: its taxonomic implications and notes on a new species *Isoodon arnhemensis. Australian Mammalogy,* 4, Pp 107 - 33.

Mackerras, M.J. and R.H. Smith (1960). Breeding the short-nosed marsupial bandicoot *Isoodon macrourus* (Gould), in captivity. *Australian Journal of Zoology,* 8 (3), Pp 371 - 82.

Malony, D.J. (1982). *A Comparison of the Behaviour and Ecology of the Tasmanian Bandicoots, Perameles gunnii (Gray 1838) and Isoodon obesulus (Shaw and Nodder 1797).* B.Sc.(Hons.) Thesis, Zoology Department, University of Tasmania.

Merchant, J.C. (1990). Aspects of lactation in the northern brown bandicoot, *Isoodon macrourus.* In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 219 - 28. Surrey Beatty & Sons, Sydney.

Meritt, D.A. Jnr. (1970). Observations on the short-nosed bandicoot *Thylacis macrourus macrourus* at Lincoln Park Zoo, Chicago. *International Zoo Yearbook,* 10, Pp 130 - 31.

Murphy, G I. (1968). Pattern in life history and the environment. *American Naturalist.* 102, Pp 391 - 403.

Newsome, A.E., J. McIlroy and P. Catling (1975). The effects of an extensive wildfire on populations of twenty ground vertebrates in south-east Australia. *Proceedings of the Ecological Society of Australia,* 9, Pp 107 - 23.

Opie, A.M. (1980). Habitat selection and the diet of *Isoodon obesulus*. *Australian Mammal Society Bulletin,* 6, P 56.

Opie, A., P. Gullan and I. Mansergh (1990). Prediction of the geographic range and habitat preference of *Isoodon obesulus* and *Perameles nasuta* in Gippsland. In *Bandicoots and Bilbies.* eds. J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 327 - 34. Surrey Beatty & Sons, Sydney.

Purdie, R.W. and R.O. Slatyer (1976). Vegetation succession after fire in sclerophyll woodland in south eastern Australia. *Australian Journal of Ecology,* 1, Pp 223 - 36.

Quin, D.G. (1985). *Aspects of the Feeding Ecology of the Bandicoots Perameles gunnii (Gray 1838) and Isoodon obesulus (Shaw and Nodder 1797) (Marsupialia: Peramelidae) in Southern Tasmania.* BSc(Hons) Thesis, Zoology Department, University of Tasmania.

Quin, D.G. (1988). Observations on the diet of the southern brown bandicoot, *Isoodon obesulus* (Marsupialia: Peramelidae), in southern Tasmania. *Australian Mammalogy,* 11, Pp 15 - 25.

Rayment, T. (1954). Australia's bandicoots. *Victorian Naturalist* , 70, Pp 194 - 96.

Recher, H.F., D. Lunney and H. Posamentier (1975). Effects of wildfire on small mammals at Nadgee Nature Reserve, N.S.W. *Third Fire Ecology Symposium Papers,* Forests Commission of Victoria, Melbourne. Pp 30 - 6.

Recher, H.F. and W. Rohan-Jones (1981). Forests and wildlife management: conflict or challange? *Living Earth,* June, Pp 11 - 14.

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

Rothchild, I. (1981). The regulation of the mammalian corpus luteum. *Recent Progress in Hormone Research,* 37, Pp 183 - 283.

Sandars, D.F. (1952). Bandicoot food. *Proceedings of the Royal Society of Queensland,* 62, P 33.

Schaffer, W.M. (1974). Selection for optimal life histories: The effect of age structure. *Ecology,* 55, Pp 291 - 303.

Seebeck, J.H. (1979). Status of the barred bandicoot (*Perameles gunnii*) in Victoria: with a note on husbandry of a captive colony. *Australian Wildlife Research,* 6 (3), Pp 255 - 64.

Seebeck, J.H., P.R Brown, R.L. Wallis and C.M. Kemper (1990). *Bandicoots and Bilbies.* Surrey Beatty and Sons, Sydney.

Specht, R.L., P. Rayson and M.E. Jackman (1958). Dark island heath (ninety-mile plain, South Australia). VI. Pyric succession: changes in composition, coverage, dry weight and mineral nutrient status. *Australian Journal of Botany,* 6, Pp 59 - 88.

Specht, R.L. (1981). Foliage projective cover and standing biomass. In *Vegetation Classification in Australia.* eds. A.N. Gillieson & D.J. Anderson. Pp 10 - 21. CSIRO & ANU Press, Canberra.

Springett, J.A. (1976). The effects of prescribed burning on the soil fauna and on litter decomposition in Western Australian forests. *Australian Journal of Ecology,* 1, Pp 77 - 82.

Stanbury, P. (1970). *Looking at Mammals.* Oxford University Press, London.

Stodart, E. (1966). Management and behaviour of breeding groups of the marsupial *Perameles nasuta* Geoffroy in captivity. *Australian Journal of Zoology,* 14, Pp 611 - 23.

Stodart, E. (1977). Breeding and behaviour of Australian bandicoots. In*The Biology of Marsupials.* eds. B. Stonehouse & D. Gilmore. MacMillan, London. Pp 179 - 92.

Stoddart, M.D. and R.W. Braithwaite (1979). A strategy for utilisation of regenerating heathland habitat by the brown bandicoot (*Isoodon obesulus;* Marsupialia, Peramelidae). *Journal of Animal Ecology;* 48, Pp 165 - 79.

Taylor, R.J. (1992). Distribution and abundance of fungal sporocarps and diggings of the Tasmanian bettong, *Bettongia gaimardi*. *Australian Journal of Ecology*, 17, Pp 155 - 60.

Thomas, L. N. (1990). Stress and population regulation in *Isoodon obesulus* (Shaw and Nodder). In *Bandicoots and Bilbies*. eds J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper. Pp 335 - 43. Surrey Beatty & Sons, Sydney.

Thompson, M.B., G. Medlin, R. Hutchinson and N. West (1989). Short term effects of fuel reduction burning on populations of small terrestrial mammals. *Australian Wildlife Research*, 16, Pp 117 - 29.

Triggs, B. (1984). *Mammal Tracks and Signs: A Field Guide for South-Eastern Australia*. Oxford University Press, Melbourne.

Troughton, E. Le G. (1973). *Furred Animals of Australia*. Angus & Robertson, Sydney.

Walker, E.P. (1964). *Mammals of the World*. The Johns Hopkins Press, Baltimore.

Watts, C.H.S. (1974). The Nuyts Islands bandicoot (*Isoodon obesulus nauticus*). *South Australian Naturalist*, 49 (2), Pp 20 - 4.