RE-INTRODUCTION OF THE WOYLIE *BETTONGIA PENICILLATA* TO FOREST AREAS OF THE SOUTH WEST OF WESTERN AUSTRALIA.

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Abstract

Trial reintroductions of the woylie (*Bettongia penicillata*) were carried out in the forests of south-west of Western Australia during the late 1970's and early 1980's. Results suggest that establishment and persistence of viable colonies depend on successful fox (*Vulpes vulpes*) control. The overiding impression from these trials is that the balance between success and failure is delicate. Quite small changes in fox numbers appear to have a disproportionately large effect on woylie numbers.

Detailed monitoring of trials is essential if there is to be any hope of interpreting the reason for success or failure.

Introduction

In 1971 - 1972 in the Perup forest (Fig. 1) Woylies (*Bettongia penicillata*) were sighted frequently on spotlight surveys and capture rates were as high as 25-30 percent. By 1974 Woylie numbers had declined dramatically in the northern section of the Perup forest. Not a single animal was captured over 260 trap nights and a further 400 trap nights in surrounding areas known previously to have contained good populations, produced similar results. The woylie had declined drastically or disappeared over a large portion of its range (Fig. 1).

The decline of the woylie coincided with a general and fairly widespread decline in medium sized forest mammals including the Numbat (*Myrmecobius fasciatus*), the Western Ringtail Possum (*Pseudocheirus occidentalis*) and the Brushtail possum (*Trichosurus vulpecula)* which occurred at

that time Christensen (1980a and 1980b) and Christensen *et al.* (1985) which was attributed to an increase in the numbers of the introduced European red fox (*Vulpes vulpes).*

Woylie populations, although declining at this time, remained reasonably high in the southern section of the Perup forest with a capture rate of 8-9 percent. In 1977 it was decided to attempt to re-introduce the Woylie to the north using animals from 20 km to the south.

Research by Christensen (1980a) had established that Woylies which are released into areas outside their home range do not generally stray far from the point of release. On the basis of this information and after having obtained permission from the then Department of Fisheries and Wildlife, a trial release was carried out to test the feasibility of releasing woylies and following their movements using radio tracking techniques.

A young male woylie was released in mid 1977 and for two weeks its movements were recorded. (see Fig 2). The animal did not travel far from the point of release and appeared to settle down only about 1km from the area which we had chosen for the release site. Radio tracking the animal presented no problems.

The success of this trial release spurred us to attempt the release of further animals, using radio tracking to monitor the movements of selected individuals.

Description of the Study Site

The Perup forest, now scheduled to become a Nature Reserve, is approximately 40,000 ha in area and is located 50 km to the East of Manjimup (Fig 1). The release area in the north of the reserve, Yendicup block, lies between the Perup and the Tone Rivers. Topography is undulating low hills and ridges separated by broad flat valleys. Open jarrah *(Eucalyptus marginata)* and marri (*E. calophylla*) forest dominates on the sandy gravelly loams of the ridges. In the valleys marri predominates on sandier soils but where clay soils are present wandoo (*E. wandoo)* forms open forest and woodland. Flooded gums (*E. rudis)* are often present along drainage lines. The

understorey is predominantly sclerophyllous shrubs with *Bossiaea ornata* and *Hakea lissocarpha* prominent on the ridges. In the valleys *Melaleuca viminea* and *Gastrolbium bilobum* it often forms dense monospecific stands, the former on clay soils and the latter on the more fertile loams.

Methods

The Yendicup study site in the north of the Perup encompasses some 37 km of tracks (Fig 3) comprising an inner and outer ring. The tracks were marked at 100 m intervals to form the basis of a trapping grid; these points also provided mapped locations from which bearings could be taken to accurately locate animals with radio collars.

During October 1977 a total of 52 animals were trapped in the south of the Perup to be released on the study site. Animals were taken `as they came' and the 52 which were relocated were of varying age with approximately equal numbers of each sex. All animals were ear tagged, weighed and measured and six individuals, 3 males and 3 females were fitted with radio transmitters. We used the same equipment and monitored the movements of the animals using the same methods, grid trapping and triangulation for the radio collared animals, as detailed by Christensen (1980a).

Baiting for foxes was introduced in late 1978 when results from radio tracking suggested that foxes were a problem. Six baitings were carried out over the period 1978 to 1981 (Fig 6). A total of 28 stations were baited each with 6 standard `dog baits' (for dingoes) containing 1080 as used by the Agricultural Protection Board of W.A. (APB). All baiting was carried out by APB officers. Twenty eight sand tracks, checked and brushed each week were used to monitor fox activity and the numbers of baits taken was also recorded. A limitation of the sand tracks techniques was that monitoring was only possible during periods when no rain fell. Digging activity was monitored on 6 triplicate plots each 15 x 15m^2 in the manner of Christensen (1980a). Monitoring continued on a monthly basis from December 1977 until December 1980.

In order to have a comparison with which to evaluate the study, a control area was set up in the south of the Perup in Boyicup block. Mark and release trapping was carried out for comparisons of capture rate, breeding, male/female ratio and other population parameters. Fourteen sand tracks were also established to monitor fox activity but no fox baiting was carried out.

Results

The radio collared animals were closely monitored over the period 4/10/77 to 28/11/77, by the latter date only two animals (one male and one female) were still alive. The male continued to be caught in the area until March 1979. Of the remaining animals the two females were taken by foxes within 6 weeks of release (their collars were recovered) and the two males disappeared without a trace within a month. An aircraft fitted with receiving equipment was used to search for them but no trace could be found. Experience from previous studies suggests the animals would have been located had the transmitters been working. Since it is unlikely that the transmitters would fail within such a short period, predation by foxes with damage to the transmitters was therefore suspected.

Later the transmitter from one of the animals was located in a foxes den on the edge of farmland about 3 km from the release point. Along with the transmitter were the remains of at least three other woylies. One animal whose ear tag was recovered was definitely identified as a release animal. The remains of four sub-adult Tammar (*Macropus eugenii)* wallabies, three common brushtail possums (*Trichosurus vulpecula*) and a young Western Grey Kangaroo (*Macropus fuliginosus*) were also found there.

Radio tracking showed that four of the woylies remained within 1.5 km of the release site and two travelled up to 2.5 km from the site (Fig 4). These results confirm earlier work (Christensen 1980a) which suggested that released animals do not travel far from the point of release.

The results of trapping in Yendicup block showed an initial low percentage capture in 1977/78 increasing steadily to 12-14 percent over 1981 - 1984 with a further increase to 46 percent by 1992. In the southern control area, Boyicup block, there was also a steady increase in the percentage captures from 1979 onwards which level off by 1982 at approximately 50-55% (Table 1). Capture rates in both areas have remained steady to 1992.

Sex ratio of adults favours males, though this is not significant, compares to the population studied by Christensen (1980a). Breeding was normal throughout the period of the study averaging 78% of females with joeys in the pouch. Pouch mortality was judged to be between 12.9 - 20.5 percent (Table 2) which compares favourably with the population in the south where Christensen (1980a) recorded figures of 8.8 - 18.5 percent. Pouch mortality of this order appears to be normal for macropods, in their book Kangaroos Frith and Calaby (1969) report 16% pouch mortality in the Red Kangaroo (*Megaleia rufa*).

Examination of `resident', animals captured four or more times, revealed that initially animals were confined to a relatively small central area in the vicinity of the site where the original animals were released. Within 18 months, as the population increased the animals spread quite rapidly to the outer circle of the trapping grid and beyond (Fig 5). Mean home range area, calculated at 33 ha (n=10) is not significantly different from 42 ha estimated by Christensen (1980a) and 45 ha, Sampson (1971).

Digging activity recorded on a monthly basis on the paired plots is shown in fig 7. Sites 1 and 2 on Bandicoot and South Roads consistently had a higher number of diggings than the other plots, because of the presence of the Southern Brown Bandicoot (*Isoodon obeselus)* in the area. This needs to be taken into consideration when interpreting the results.

The pattern of digging activity in the plots confirms the pattern of expansion of the release population which was indicated by the trapping results. Thus during the early part of the study (1977 to mid 1979) diggings were more frequent on the plots in the vicinity of the release area, Bandicoot, South and Spencer Roads (fig 3). As the Woylies spread out and increased their range from mid 1979 to December 1980, diggings increased on the plots on Balbanup Road on the outer perimeter of the study area.

Observation of baits revealed that 50% of the baits were taken within 8 days of being laid, with a further 15-25 percent within the next two weeks and the remainder after 3 weeks or more. The

baits which were used became effective for a maximum of eight days only in the field[1] which means that a large proportion of the baits were ineffective . The results of the sand track counts of fox activity also suggest that the baiting used was not effective in reducing fox numbers (Fig. 6). Later work has shown that track counts are not a reliable indicator of fox abundance[2] nevertheless any substantial change in numbers should have been evident had it occurred. There does appear to have been a reduction of activity in the period immediately following baiting (see fig 6). It is interesting to note that fox activity in Boyicup was consistently lower than in Yendicup block this may account for the higher populations of woylies in the former area (Fig. 5).

Two further releases of the woylie were undertaken in different areas of the South west forests in 1983. In neither case was detailed monitoring carried out. The first of these releases was in an area of forest very similar to Yendicup some 80 - 100 km to the north, at Batalling to the east of the town of Collie. A total of 56 animals were released in this area. Following release trap success was 3 - 5%. during the first two years, trapping was then discontinued. Trapping in 1990 and 1991 suggested that the colony must have continued to persist through to the 1980's in very low numbers (Table 3). It was then decided to try reducing fox numbers to see if this would allow the population to increase. More effective meat baits (see Kinnear *et al.* 1988) were used and the population responded almost immediately (see Table 3).

A further trial release of 67 woylies, 30 in March and 37 in September 1983 was carried out at St Johns Brook to the west of the town of Nannup (see Map 1). This area was known to have had woylie populations in 1919[3] . Following the initial recapture of two animals a few weeks after the first release no further woylies have been captured in the area. No further trapping has been carried out in the area since 1984. It appears that this trial release was unsuccessful. No fox baiting was carried out in this area.

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1 APB Pers. Comm.
2 Dr D. Algar Pers. Comm.
3 D. Perry Pers. Comm.

Discussion

The results of the Yendicup re-introduction trials clearly demonstrate that it is possible to re-introduce the woylie to areas where it was formerly present and that fox predation is a major factor limiting woylie distribution in south west forests. After an initial slow start the population in Yendicup increased rapidly and animals spread out from the release site in every direction occupying all suitable habitat. Further trapping in the area suggests that the population is quite patchy, high populations occurring in optimum habitat with lower populations in sub-optimum habitat.

The method of direct transfer and release which was employed was successful. This negates the need for expensive enclosures for acclimatization and supplementary feeding. However this technique may not always work, for example in instances where animals come from further afield. Mature animals seem to be more successful `immigrants' than sub-adults, although no quantative data are available to support this. The tendency for the released animals to clump together in the vicinity of the release area made monitoring very much simpler than if they had scattered in all directions. We suspect that the use of a `pilot' animal in the first instance to pick the release area may have assisted in this regard. The pilot animal actually moved from its original release site which we selected for it, to a new area only 1 km away, where it finally settled. This area which was chosen by the pilot animal was the area in which we released the 52 `immigrants'.

Monitoring digging activity was a successful, indirect method of monitoring the spread of the colony. This technique could well be employed with more perhaps smaller plots, to record more accurately the spread of a colony of released animals.

No conclusive data on fox control were obtained from the Yendicup trial. The use of standard `dog baits' has since been demonstrated not to be a good method of fox control. The use of tracks for monitoring fox numbers has since also been demonstrated to be of limited value[3] .

[3] Dr. D. Algar Pers. Comm.

The trial at Batalling, though not as immediately successful, appears to be producing results following better fox control measures. The St Johns Brook trial was not successful.

The question remains why was the Yendicup release successful in the absence of successful fox control? The close monitoring in the Yendicup trial together with the extensive information base available on the Perup woylies (Christensen 1980a) makes it possible to speculate on this question. The Yendicup trial happened to coincide with what appears to have been a general and widespread decline in the fox populations of the south west. Following a massive increase in foxes in 1973/74 there was a period up until about 1978 when fox populations, as evidenced by road kills (pers. obs.) remained very high. From 1979 onwards fox numbers appeared to decline to a lower level, which co-incided with a general increase in woylies as well as other species like the Brushtail possum (*Trichosaurus vulpecula*) and Western Ringtail (*Pseudocheirus occidentalis*) in the Perup Forest.

The recorded increase in capture of woylies in both Yendicup and the Boyicup control from 1979/80 are consistent with this hypothesis. The hypothesis also explains the observed fluctuations in distribution and numbers of the woylies in recent times. Thus, when predation pressure was high in 1973-1979 the woylies contracted to more optimum sites with the most effective ground cover which are in the south Perup. After 1979 when predation pressure appears to have relaxed a little the woylie once again increased in numbers and expanded its population to the sub-optimum location in the north Perup. Had the re-introduction not taken place woylies from the south might have re-colonized the north, unaided.

Populations in the optimum habitat in the south Perup remain higher than those in the sub-optimum habitat of the north Perup (Table 1). This interpretation, based on perceived changes in fox numbers over the last 20 years, is further supported by the results of the Batalling trial where woylie numbers are increasing following fox control. Kinnear *et al.* (1988) have since

experimentally demonstrated the link between the numbers of certain species of medium sized native animals and fox numbers.

The results of these three re-introduction trials when taken together suggest that very small fluctuations in fox numbers may have a large effect on populations of the woylie. This has important implications for the long term survival of the woylie and perhaps other species. It may be feasible for example to establish and maintain populations of the woylie in certain areas with minimal fox control. Lastly these trials demonstrate clearly the importance of very close monitoring of any re-introduction trials, a point also made strongly in recent reviews of re-introductions by Price (1989) and Short *et al.* (1992). It was not possible to interpret the failed St John Brook trial due to the lack of detailed monitoring. In the case of the Batalling trial where some monitoring took place it was possible to infer the reason for the initial failure of the colony to expand.

Acknowledgements

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Subscripts for Tables and Figures.

Tables 1. Woylie Captures in the study area before, during and after the study.

2. Survival of Pouch Young - calculated from data obtained from captures of woylies in Yendicup.

3. Woylie Captures - Batalling near Collie

Figures 1. Woylie distribution in forest areas east of Manjimup.

2. Detailed movements of Woylie fitted with radio transmitter.

3. Study site in Yendicup.

4. Recorded movements of four Woylies released at the same location.

5. Range expansion of 52 Woylies released in Yendicup Block during September and October 1977.

6. Summary of numbers of fox prints counted on sand tracks.

7. Monthly digging activity on six triplicated 15 x 15 m plots.

Table 1 **Woylie Captures in the study area before, during and after the study.**

a. Yendicup Block

Year	Captures	%
9/77 - 9/78	43	1.5
11/78 - 9/79	60	2.6
11/79 - 9/80	118	5.12
11/80 - 9/81	147	6.29
11/81 - 9/82	259	11.73
1983	69	14.2
1984	44	12.0
1990	68	34.0
1991	160	44.7
1992	46	46.0

b. Boyicup Block

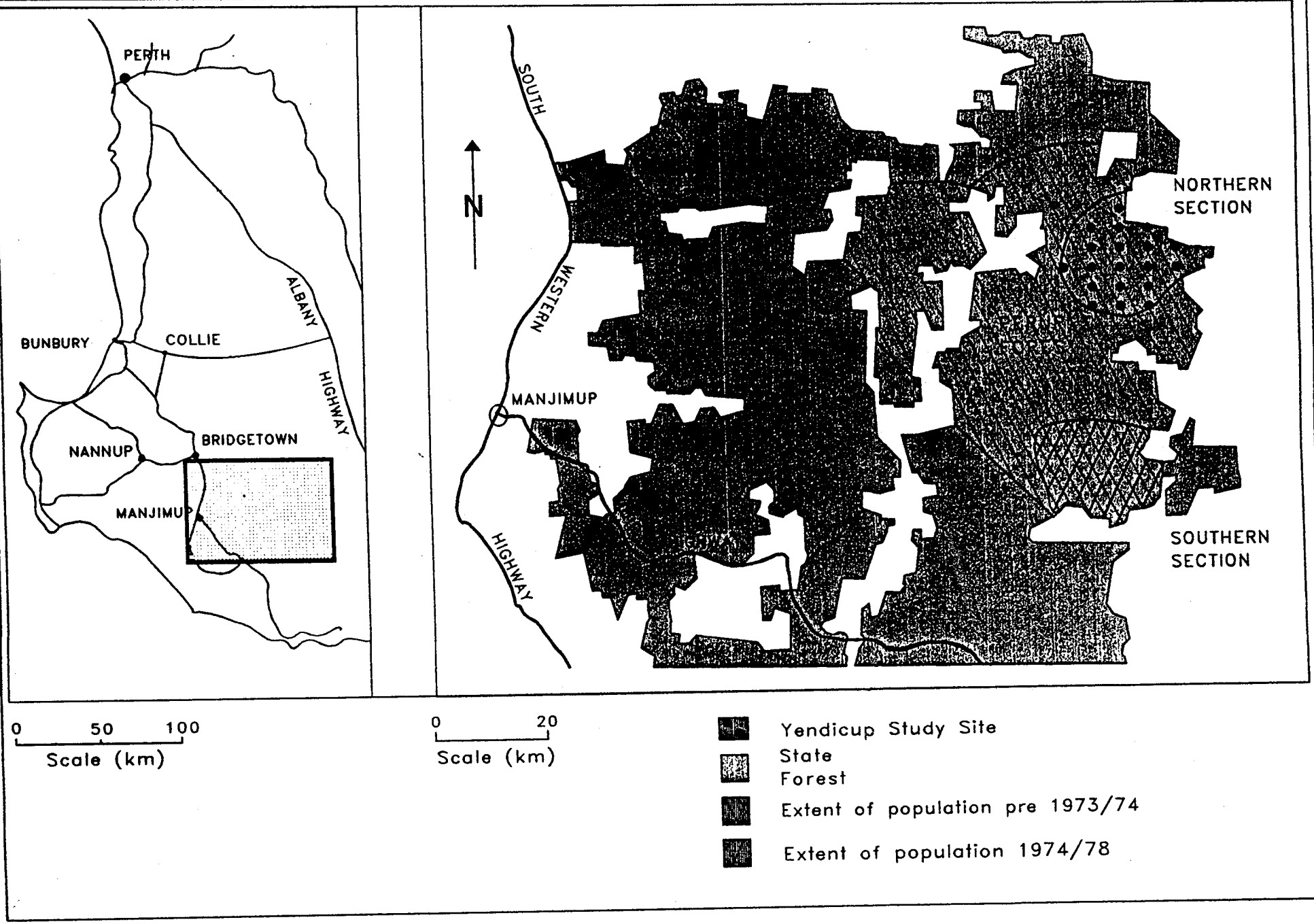
Year	Captures	%
1976	33	7.2
1977	37	8.1
1978	96	8.4
1979	146	16.0
1980	270	26.0
1981	507	29.9
1982	111	52.8
1983	141	47.2
1984	161	51.4
1985	158	48.7
1986	71	65.7
1988	21	77.8

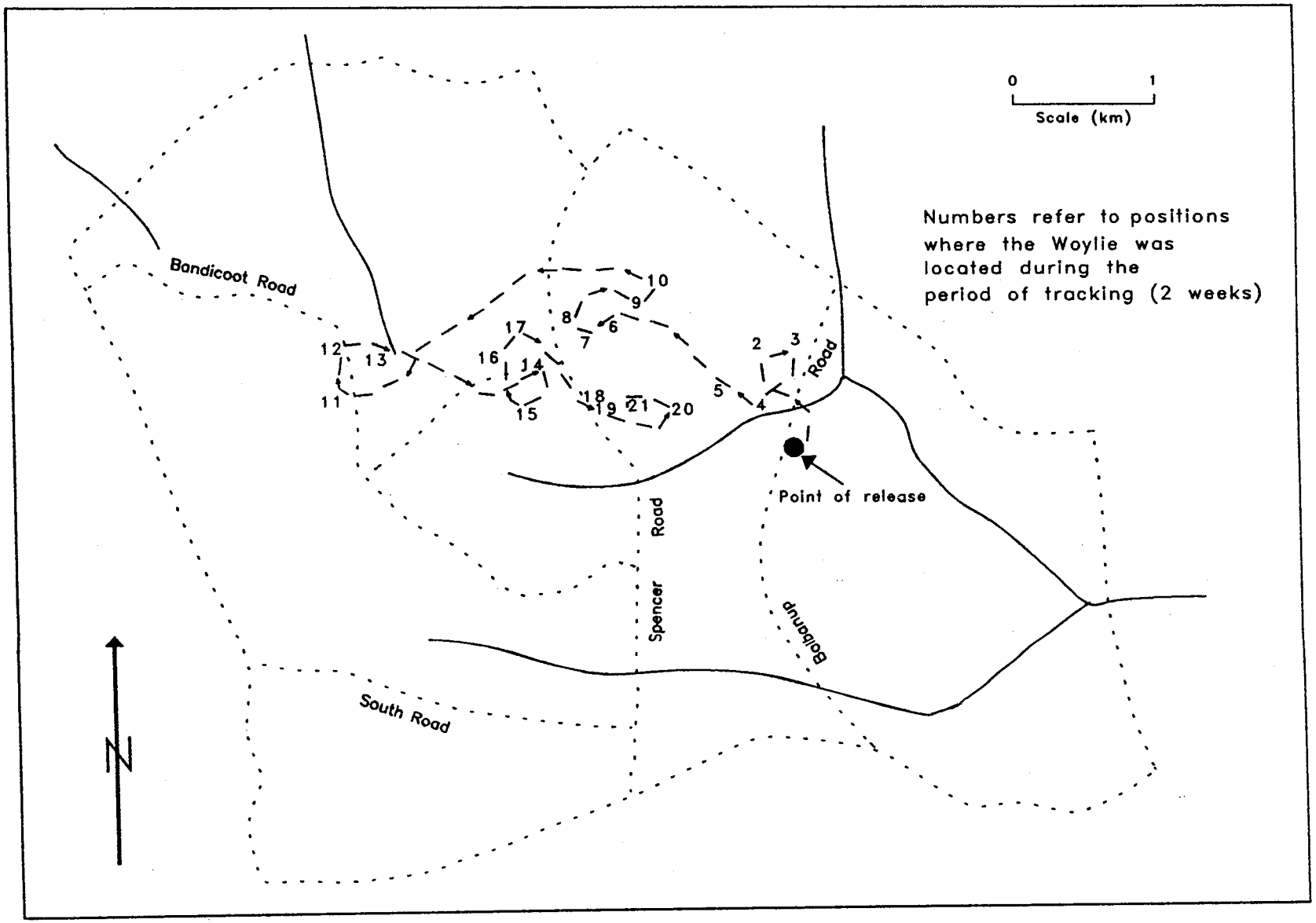
Table 2 **Survival of Pouch Young - calculated from data obtained from captures of Woylies in Yendicup.**

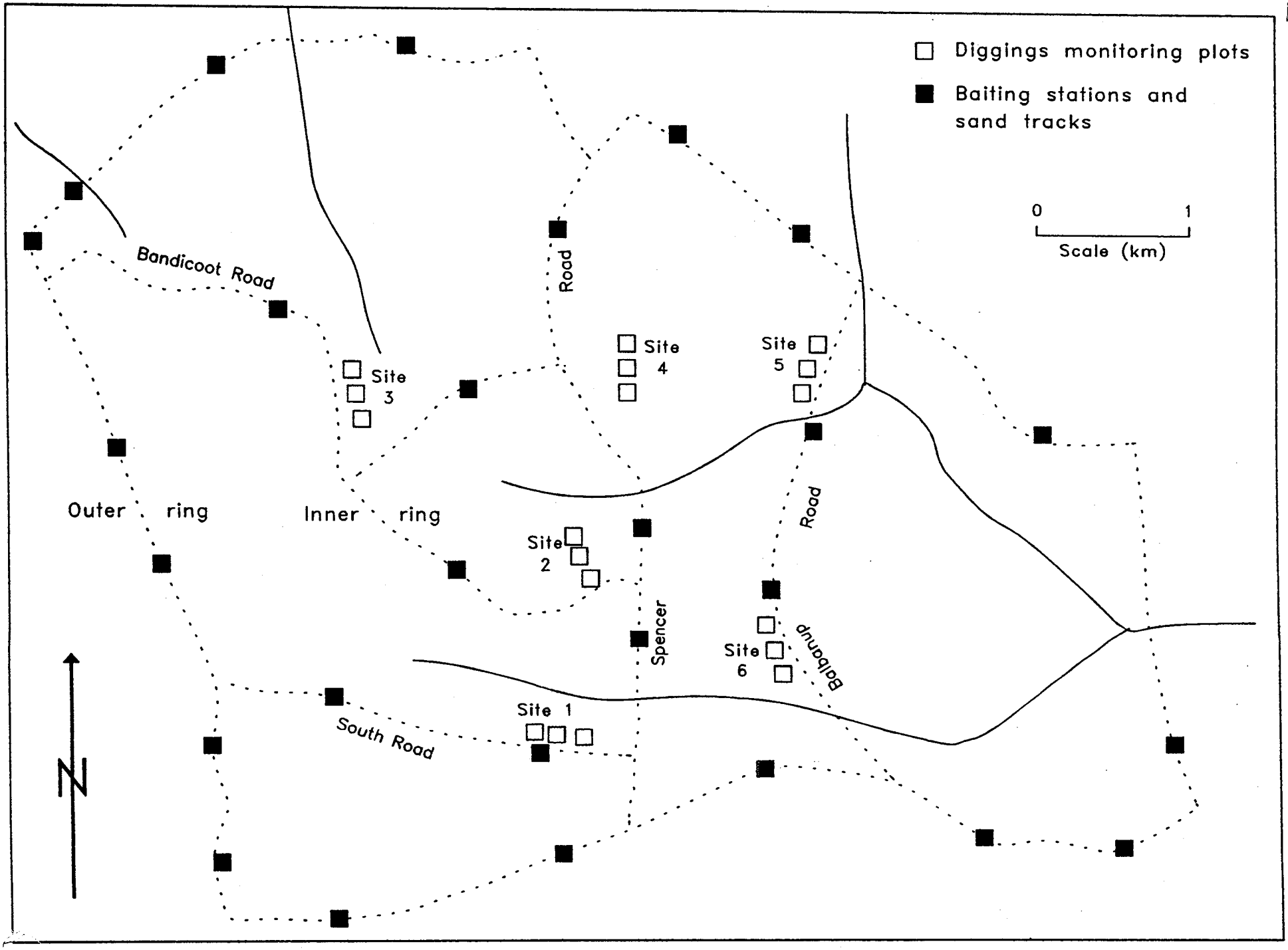
	Known Survivals	Probable Survival	Unknown Fate	Mortalities
Number of Joeys	20	46	48	17
Percentage of Total	15.3	35.1	36.6	12.9
Percentage of total minus animals of unknown fate	24.0	55.4		20.5

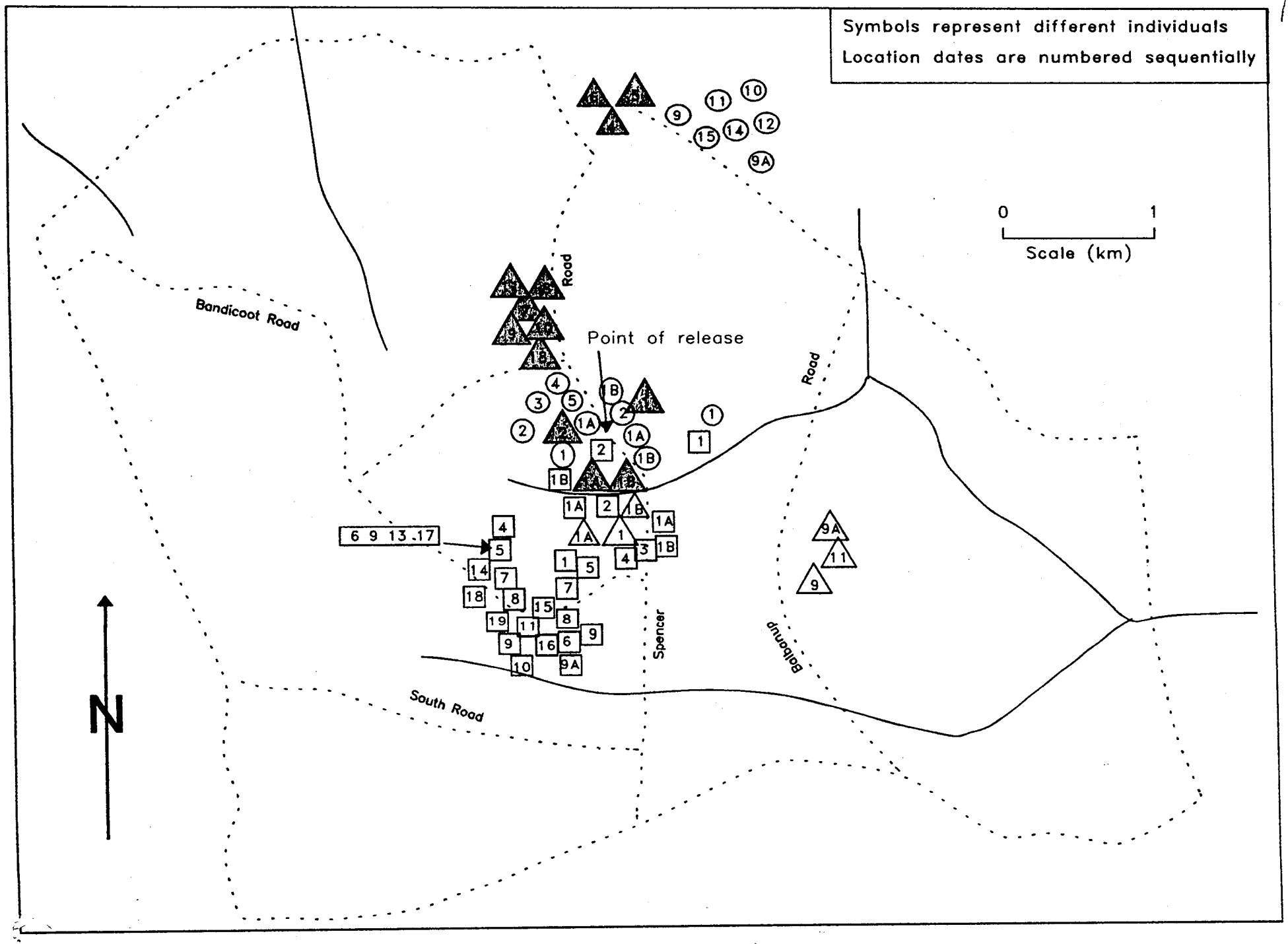
Table 3 **Woylie Captures - Batalling near Collie**

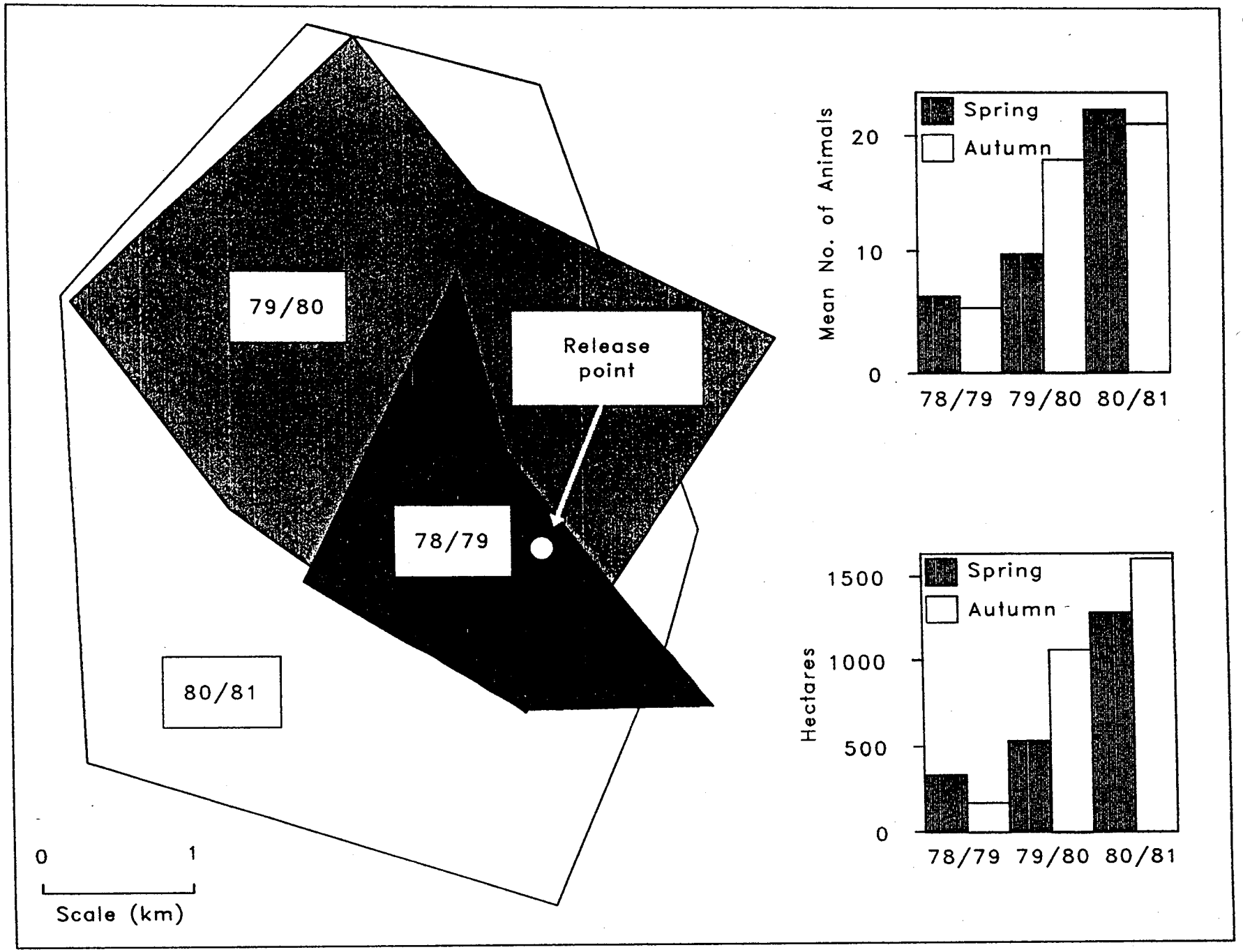
Year and Month	Captures	%
12/90	2	0.70
3/91	3	1.50
7/91	8	2.80
11/91	23	7.19
2/92	15	9.38
5/92	8	8.08

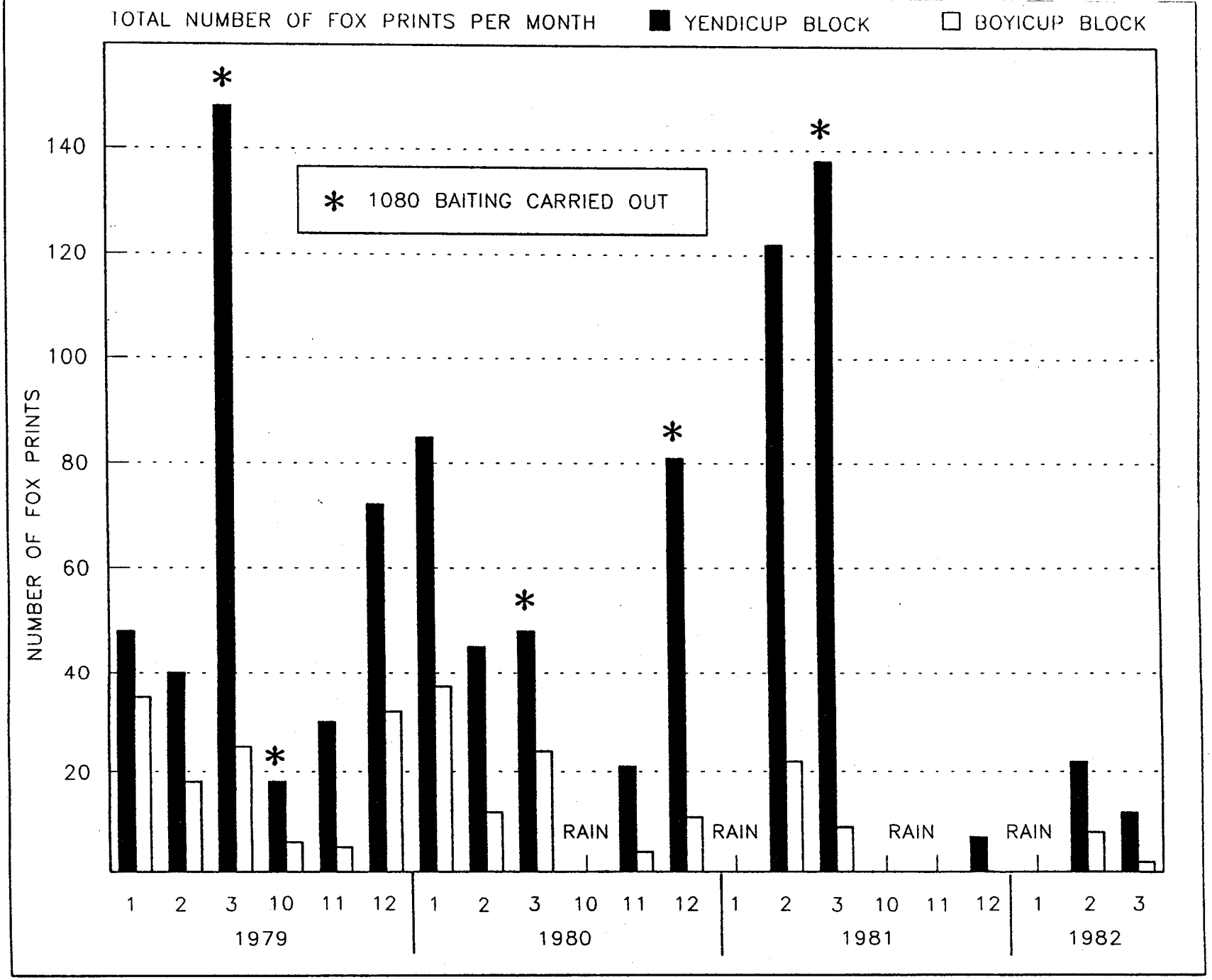

PERTH
BUNBURY
COLLIE
ALBANY
HIGHWAY
NANNUP
BRIDGETOWN
MANJIMUP
SOUTH
WESTERN
HIGHWAY
N
NORTHERN
SECTION
SOUTHERN
SECTION
0 50 100
Scale (km)
0 20
Scale (km)
Yendicup Study Site
State
Forest
Extent of population pre 1973/74
Extent of population 1974/78


0
1
Scale (km)
Numbers refer to positions where the Woylie was located during the period of tracking (2 weeks)
Bandicoot Road
Point of release
Spencer Road
Boliboonup Road
South Road
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21


Diggings monitoring plots
Baiting stations and sand tracks
0
1
Scale (km)
Bandicoot Road
Road
Site 3
Site 4
Site 5
Outer ring
Inner ring
Site 2
Road
Spencer
Site 6
Balbanup
Site 1
South Road
N


Symbols represent different individuals
Location dates are numbered sequentially
0
1
Scale (km)
Point of release
Bandicoot Road
Road
Road
Spencer
Bolbonup
South Road
N
6 9 13 17


79/80
Release point
78/79
80/81
0
1
Scale (km)
Mean No. of Animals
20
10
0
Spring
Autumn
78/79 79/80 80/81
Hectares
1500
1000
500
0
Spring
Autumn
78/79 79/80 80/81


TOTAL NUMBER OF FOX PRINTS PER MONTH
YENDICUP BLOCK
BOYICUP BLOCK
NUMBER OF FOX PRINTS
140
120
100
80
60
40
20
* 1080 BAITING CARRIED OUT
RAIN
RAIN
RAIN
RAIN
1 2 3 10 11 12 1 2 3 10 11 12 1 2 3 10 11 12 1 2 3
1979
1980
1981
1982