A FIELD STUDY OF THE WESTERN RING-TAILED POSSUM, PSEUDOCHEIRUS OCCIDENTALIS (MARSUPIALIA, PETAURIDAE).

by

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The views and opinions expressed in this report are those of the authors and do not necessarily reflect those of the Commonwealth Government, the Minister for the Arts, Sport, The Environment, Tourism and Territories, or the Director of the Australian National Parks and Wildlife Service.

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ABSTRACT

Sixty one sites were surveyed for presence or absence of *Pseudocheirus occidentalis* in southwestern Western Australia. These observations were compared to historical and other records to produce a picture of the nature of the decline of the species this century.

Sixteen sites were investigated in some detail. This enabled a comparison of the relative abundance of *P. occidentalis* with a number of habitat variables, such as both vegetation structure and floristics, foliage nutrient levels, and aspects of habitat disturbance (fire, cutting) and predation. In the sites with either *Agonis flexuosa* or both *A. flexuosa* and *Eucalyptus*, levels of foliage potassium in February alone explained 71% of the variation in relative abundance between sites.

An association dominated by *A. flexuosa* (Locke Estate) and one dominated by *Eucalyptus gomphocephala* (Abba R.) were the focus of closer study. Population estimates for Locke Estate range from 95 to 104, with a density of 2.5 to 4.5 ha^{-1}. Abba R. estimates for the core area of 8 ha ranged from 44 to 51 individuals, with a density of 5.5 to 6.4 ha^{-1}; estimates for an enlarged area of 15 ha that incorporated the core area were 113 to 260 individuals, with a density of 7.5 to 17.3 ha^{-1}.

Telemetry based observations on movement indicated that home range at Abba R. was 0.93 ± 1.17 (0.44 - 3.60) ha and 0.62 ± 0.37 (0.18 - 0.90) ha for males and females, respectively. At Locke Estate fewer data suggest that home ranges are 0.4 - 1.3 ha for males and 0.2 - 0.3 ha for females. Excursions from home range were recorded only for juveniles.

There was no evidence to suggest that the species is territorial. Juveniles take up home ranges adjacent to their natal home ranges or disperse further and traverse home ranges of adults.

The species gave birth throughout the year, but frequency of births differed with site. At Locke Estate, some females bred twice in a calender year; at Abba R. most females bred only once and births were concentrated in late autumn to early winter. There were significantly more female than male pouch young plus dependent young at Locke Estate than at Abba R. Diet at both Abba R. and Locke Estate and at other sites was predominantly leaves of the dominant *Eucalyptus* spp or *A. flexuosa*. Usually 3-4% and rarely up to 19% of the diet was other plants.

Grouping of sites using canonical variate analysis of foliage nutrients facilitated selection of sites for translocation and restocking with *P. occidentalis*.

Recommendations for the conservation and management of the species are provided.

INTRODUCTION

The Western Ringtail Possum (*Pseudocheirus occidentalis*) was first described by Thomas (1888). Later workers included *P. occidentalis* as a subspecies of *P. peregrinus*. McKay (1984) suggested that *P. occidentalis* was a species, but later (McKay 1989) recognised only one species of *Pseudocheirus* in southern Australia.

The only detailed account of aspects of the biology of *P. occidentalis* is by Ellis and Jones (1992)*. Inions (1985) examined the interaction between *P. occidentalis* and their habitat trees and fire in the Perup area, southwestern Australia, and Kinnear and Shields (1975), evaluated the relationship between their metabolic rate and ambient temperature. Most references in the literature relate to distributional information (Baynes 1987, Christensen *et al.*, 1985, How *et al.*, 1987, and Shortridge, 1909) and point to the marked contraction in its distribution since the time of European settlement in 1829. In 1983 *P. occidentalis* was given rare and endangered status by the Western Australian Government.

In April 1990 the Western Australian Museum accepted a two year consultancy from the Australian National Parks and Wildlife Service to:

- Document the extant populations of *P. occidentalis*;
- Assess their habitats in terms of vegetation structure and floristics, and extent of disturbance;
- Estimate population densities of *P. occidentalis*;
- For selected populations, assess habitat structure, reproductive cycles, fecundity, survival, population numbers, age structure, density, movement, social organisation, diet, nutritional quality of food and predator pressure.

This report documents the results of our two year field study on *P. occidentalis* and makes management and conservation recommendations.

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* Prepared as a result of the present ANPWS consultancy (Appendix II)

METHODS

FIELD METHODS

Observations

Most observations were made at night either on foot or from a slow-moving vehicle. At various times a 100 watt spotlight and a 12 volt gel battery and Petzl headtorches with halogen bulbs (4.8 volt) were used to detect the eyeshine of animals. The latter proved the most practical while radio-tracking and searching on foot for possums in dense bush. At these times an additional torch (6 volt halogen) was carried to provide more light for direct observation of animals once they were sighted.

The following details were recorded for most *P. occidentalis* sightings: position at first sight (if in tree then tree species and height, possum height and position), approximate possum size and the occurrence of companions. If observable, details of sex, activity and identity were recorded. The date, time, weather and site were also recorded.

Abundance data was collected by counting sightings of possums per hour (while walking) or per kilometre (while driving). At the four study sites for which accurate maps had been prepared (Abba River, Locke Estate, Geographe Bay development site and Emu Point) sightings were mapped.

Sightings of Brushtail Possum (*Trichosurus velpecula*) were also recorded to compare their relative abundance with *P. occidentalis*.

During daylight, information about both species of possum was collected by searching for faecal pellets, dreys and scratch-tracks on trees. The faecal pellets of *P. occidentalis* and *T. vulpecula* are distinctive and their density may reflect the abundance of possums at the site. *P. occidentalis* pellets were collected from the ground at most sites to be used for later dietary analysis; their relative abundance was scored on a scale of 1-5.

Also recorded were the height of dreys, and the height of tree or shrub species in which the drey occurred. Three types of drey were recognised:

- well constructed drey - an approximately spherical construction of flexible twigs "woven" together and currently maintained or occupied;
- "derelict drey" - appears to have been larger previously but show no sign of recent maintenance;
- platform drey - made of fresh (still green) peppermint, *Agonis flexuosa,* twigs and foliage "woven" to form a single platform. These have been observed at Geographe, Locke Estate and Emu Point. Platforms are of flimsy construction and appear unlikely to withstand any more than temporary or casual use. Some appear to have been built on top of old platforms.

All three types of drey were used by *P. occidentalis*. The term derelict drey describes the state of structural decay of a drey, and not its pattern of usage by possums.

At a number of sites, drey occupancy was determined by disturbing the drey (by shaking or poking it) sufficiently to ensure that any occupant departed. Details of any drey occupants were recorded.

Additional observations were obtained from Leschenault Peninsula where possums were released in 1991.

Capture Methods and Handling

Possums were caught opportunistically and in the course of organised hunts. *P. occidentalis* that use hollows for daytime shelter can only be caught at night, while drey-users can also be caught during daylight. In order to catch possums a hook attached to an aluminium pole was used. This pole, constructed by joining together a series of two metre lengths, provided a total reach of 8 metres. The hook was used to dislodge the possum or, more commonly, to break off small branches to which the possum clings. A large butterfly net fitted with a fabric bag was used to catch the possum before it hit the ground. Sometimes the hook was used to shepherd possums to a suitable branch. At least three people were required to successfully catch possums in this way.

Once caught, possums were placed in calico bags and left to settle down before handling. The following details were recorded from each individual: sex, age, external body lengths (ear, head, tail and femur), weight, testis length and width, pouch condition and size of young (head length and/or weight). Individual earmarks were used to identify individuals. Some individuals weighing more than 750 grams had radio collars fitted to their neck.

Telemetry Techniques

Collars consisting of a transmitter, batteries and antennae, were fitted to a number of animals. A small Yagi antennae was used with the receiver to monitor collared animals. Transmitters, receivers and antennae were all obtained from Biotelemetry Services, Magill Road, Adelaide. There was a relatively high rate of failure amongst the 26 collars used, such that monitoring was less extensive than originally intended.

Animals were located by taking successive bearing on their strongest transmission. When no collared possum could be seen, the tree which it occupied could usually be confidently determined. Only in very dense areas where there were a number of trees very close together was it difficult to determine the precise tree. In text a telemetry observation is denoted as a 'LOC'. For observations made during darkness there is often a sighting associated with a LOC.

The positions of collared possums were recorded on a detailed site map derived from 1:2000 aerial photograph. At most sites, positions could be mapped with an accuracy of ± five metres, but at Locke Estate the vegetation characteristics limited accuracy to ± 10 metres.

At Abba River most observational periods were for two to four days each fortnight. During a monitoring period the location of collared animals was determined during daylight to identify "nest" trees and if possible rest sites. Some nest trees known to be occupied during daylight were observed at dusk to determine the time possums emerged from their rest site and sometimes to confirm use of a nest tree by a possum. Most observations were made during the first half of the night. At Abba R. three all night observational periods were carried out to determine if wet, windy or stormy weather discouraged emergence or activity. A number of nights in post-sunset and pre-dawn periods were monitored. No attempt was made to follow an individual through a whole night, because most animals suspend activity somewhat or alter their behaviour when being observed.

SITE DESCRIPTIONS

In this study, the most complete description of a site includes information on possum abundance, habitat structure and disturbance as well as climate and topography.

All data collected falls into one of the six following groups:

(1) *Site Description:* A brief site description of location, vegetation type and topography.

(2) *Possum Species and Abundance:* Because *P. occidentalis* will not enter traps we assessed their abundance from sightings and observations. Potential indicators of their abundance were numbers of possums sighted per unit night survey; counts of dreys per hour of survey time; proportion of dreys occupied; relative abundance of faecal pellets on ground.

Where possums were located, additional information was collected on location of both dreys and possums. Those areas where detailed mapping of possum sightings was possible provide the best data for determining densities of possums. They also provide an opportunity to evaluate techniques of deriving relative abundance estimates from survey data.

(3) *Vegetation Description*: Vegetation structure was described by estimating the height range and percentage canopy cover of dominant vegetation strata in a circular area of 20 m radius. Vegetation floristics included assessment of the relative abundance of the tree species and of common (>10% cover) or prominent understorey species.

(4) *Trees:* Trees occupy the upper two vegetation strata. The following variables were recorded from twenty trees representative of a site: tree species (dead or alive), diameter at breast (DBH), lower foliage height, upper foliage height, maximum height, number of connections (number of trees contacting the subject tree at height greater than 2 m), number of hollows above 1 m (number of visible hollows plus the number estimated by counting dead limbs with broken terminal ends and diameter > 20 cm), height of burn scars on trees, and the species and maximum height of any climbing plants growing on the tree.

(5) *Nutritional Quality:* Foliage nutrient analysis provides information about the nutritional quality of leaves from different study areas or in different seasons. Samples of Peppermint (*A. flexuosa*) leaves were collected at sites occupied by *P. occidentalis* in the Busselton area and at Emu Point, and from sites without *P. occidentalis* at Yalgorup NP, Leschenault Peninsula and Wilsons Inlet. Samples of Jarrah, *Eucalyptus marginata,* and Marri, *E. calophylla*, leaves were collected at Perup. Some additional samples were collected to determine nutrient levels in less common species in the Busselton area. Most samples were collected in summer or winter, but some from other seasons were collected at Locke estate and Abba River.

Leaves were collected from taller trees by using the possum hook to pull down small upper branches. The outer foliage was stripped from the main stem and stored in labelled paper bags which were kept in a fridge before drying and storage. All samples were collected from the central, upper one-third of a tree's canopy.

Samples were chemically analysed by Lin Wong at the Western Australian Department of Conservation and Land Management (CALM) laboratories, Como, using techniques described in McKenzie and Wallace (1954), Kitson and Melon (1944), David (1959) and Piper (1942) to determine the amounts of nitrogen (N), phosphorous (P), potassium (K) and calcium (Ca) in leaves.

Principal component and canonical variate analyses were performed using the SPSSX package (SPSSX Inc. 1988) and a subset of the results to investigate trends in variation. Details of samples collected and analyses are listed with Site Descriptions.

(6) *Comments*: A series of unrelated site descriptions which include information available about a site such as its disturbance history, current land use, predator abundance and other information.

Site vegetation description and the site comments are provided in Appendix I.

SITE NUMBERS

S1: AVON RIVER, BEVERLEY (Beverley:32°06"S,116°55"E)
S2: TUTTANING NATURE RESERVE *c.* 20 k E Pingelly, (Tuttaning NR:32°33"S,117°20"E)
S3: BOYAGIN NATURE RESERVE (Boyagin NR, 32°28'S, 116°54'E)
S4: HASSEL'S FARM *c.*12 k ESE Pingelly (Pingelly: 32°35"S, 117°08"E)
S5: MELROS *c.* 15 k SW Mandurah (Melros: 32°38"S,115°37"E)
S6: YALGORUP NP Tims Thicket Rd, behind coastal dunes (Yalgorup NP, N Coast: 32°39"S, 115°37"E)
S7: YALGORUP NP Tims Thicket Rd, NE boundary (Yalgorup NP, N Boundary: 32°39"S, 115°38"E)
S8: YALGORUP NP White Hill Rd (Yalgorup NP, White Hill Rd: 32°41"S,115°37"E)
S9: YALGORUP NP, MARTINS TANK **YMT** (Martins Tank: 32°50"S, 115°40"E)
S10: YALGORUP NP, LAKE HAYWOOD (Lake Haywood :32°53"S, 115°41"E)
S11: LESCHENAULT PENINSULA **LP** N of Bunbury (Leschenault Pen: 33°14"S, 115°41"E)
Also LP North (**LPN**), LP Central, (**LPC**), LP Belvedere, (**LPB**), LP South, (**LPS**)
S12: COLLIE RIVER below Wellington Dam (Collie R.: 33°24"S, 115°58"E)
S13: PEPPERMINT GROVE BEACH *c.* 5 k NW Capel (Peppermint Grove Beach: 33°31"S, 115°31"E)
S14: LUDLOW SWAMP *c.* 5 k NNE Ludlow Settlement (Ludlow Swamp: 33°35"S, 115°30"E)
S15: LUDLOW SETTLEMENT (Ludlow Settlement: 33°36"S, 115°29"E)
S16: LUDLOW ABBA RIVER **AB** *c.*10 k SW Ludlow Settlement (Abba: 33°38"S, 115°26"E)
S17: RUABON *c.*10k SE Ludlow settlement (Ruabon: 33°39"S, 115°41"E)
S18: FORREST BEACH *c.* 6 k NNW Ludlow settlement (Forrest Beach: 33°36"S, 115°26"E)
S19: GEOGRAPHE BAY DEVELOPMENT SITE **GBDS** *c.* 5 k NW Busselton town centre (GBDS: 33°38"S, 115°24"E)
S20: BUSSELTON Townsite (Busselton: 33°39"S, 115°20"E)
S21: LOCKE ESTATE **LO** *c.* 10 k W of Busselton (Locke: 33°39"S, 115°14"E)
S22: YALLINGUP RIDGE **YR** nr Yallingup Cave entrance (Yallingup Ridge: 33°38"S, 115°02"E)
S23: LEUWIN NARURALISTE NP, ELLENSBROOK (Ellensbrook: 33°55"S, 115°01"E)
S24: BORANUP NP *c.* 10 k NNW Karridale (Boranup: 34°11"S, 116°56"E) R03
S25: EAST AUGUSTA **EA** east side Hardy Inlet (East Augusta: 34°19"S, 115°10"E)
S26: SCOTT RIVER NP *c.* 8 k ENE Augusta (Scott R.: 34°17"S, 115°16"E) R36
S27: BLACKWOOD RIVER, SUES BRIDGE (Sues Bridge: 34°04"S, 115°23"E)
S28: BLACKWOOD RIVER, SCHRODERS POOL (Schroders Pool: 34°05"S, 115°17"E)
S29: BLACKWOOD RIVER, ALEXANDER BRIDGE (Alexander Bridge: 34°10"S, 115°11"E)
S30: GARDNER RIVER, NORTHCLIFFE (Gardner R.: 34°39"S, 116°07"E)
S31: PERUP YENDICUP **PY** *c.* 12 k NW Tonebridge (Yendicup: 34°10"S, 116°35"E)
S32: PERUP MORDALUP **PM** c. 5 k SSW Tonebridge (Mordalup: 34°16"S, 116°40"E)
S33: MT SHADFORTH *c.* 10k WSW Denmark (Mt Shadforth: 34°58"S, 117°17"E)
S34: DENMARK undeveloped land in town (Denmark: 34°58"S, 117°22"E)
S35: WILSONS INLET WEST (Wilsons Inlet: 35°01"S, 117°19"E)
S36: WILSONS INLET EAST **WI** (Wilsons Inlet (E): 35°01"S, 117°26"E)
S37: LOWLANDS ROAD (Lowlands Rd: 35°04"S, 117°31"E)
S38: WEST CAPE HOWE NP *c.* 5 k W Torbay Hill (West Cape Howe NP: 35°01"S, 117°35"E)
S39: WEST CAPE HOWE NP, TORBAY HILL (West Cape Howe NP (W): 35°04"S, 117°37"E)
S40: COSY CORNER *c.* 5k ENE Torbay Hill (Cosy Corner: 35°04"S, 117°39"E)
S41: ELLEKER *c.* 15 k W Albany (Elleker: 34°59"S, 117°44"E)
S42: KING RIVER between King River townsite and Oyster Harbour (King R.: 34°56"S, 117°56"E)
S43: KALGAN RIVER, LOWER KALGAN (Lower Kalgan: 34°56"S, 117°59"E)
S44: EMU POINT **EP** Albany (Emu Point: 35°00"S, 117°56"E)
Also EP Park, (**EPP**), EP Ridge, (**EPR**), EP Chalet, (**EPC**), EP Bowls, (**EPB**)(Fig 4)

S45: MT MELVILLE Albany townsite(Mt Melville: 35°01"S, 117°52"E)
S46: MT CLARENCE Albany townsite(Mt Clarence: 35°01"S, 117°54"E)
S47: LAKE SEPPINGS Albany townsite(L.Seppings: 35°01"S, 117°55"E)
S48: MIDDLETON BEACH Albany townsite (Middleton Beach: 35°01"S, 117°55"E)
S49: PORONGORUP NP (Porongorup NP: 34°40"S, 117°53"E)
S50: STIRLING RANGE NP 7 K OUT (Stirling Ra. 7 km out: 34°23"S, 117°53"E)
S51: STIRLING RANGE NP WHITE GUM FLAT (Stirling Ra. WGF: 34°24"S, 117°54"E)
S52: STIRLING RANGE NP MAGOG (Stirling Ra. Magog: 34°24"S, 117°55"E)
S53: STIRLING RANGE NP TALYABERLUP (Stirling Ra. Talyaberlup: 34°25"S, 117°57"E)
S54: KALGAN RIVER, KAMBELLUP (Kambellup: 34°35"S, 117°59"E)
S55: TWO PEOPLES BAY AREA Goodga River to **TPB** (TPB Area)
S56: TWO PEOPLES BAY NORTH LAKE (TPB, N Lake: 34°58"S, 118°08"E)
S57: TWO PEOPLES BAY OFFICE (TPB, Office: 34°58"S, 118°10"E)
S58: TWO PEOPLES BAY TICK FLAT GULLY (TPB, TFGully: 34°59"S, 118°11"E)
S59: TWO PEOPLES BAY LOWER FIREBREAK GULLY (TPB, LFGully: 34°59"S, 118°11"E)
S60: TWO PEOPLES BAY UPPER FIRE BREAK GULLY (TPB, UFGully: 34°59"S, 118°11"E)
S61: TWO PEOPLES BAY ROBINSONS GULLY (TPB, Robinsons: 34°59"S, 118°12"E)

DIETARY STUDIES

We used the techniques described by Storr (1961) to prepare slides of stained fragments of plant epidermis in *P. occidentalis* faeces. Reference leaf epidermis from a variety of potential food plants was prepared using the same procedure; this was used to identify the source of epidermal fragments in the faeces. One hundred fragments per slide (one faecal pellet per slide) were counted and assigned to one of five abundance classes on the basis of relative surface area (SA). The relative abundance of fragments was quantified in two ways: the percentage of fragments assigned to each epidermal type (number of fragments matching species A/100 fragments), and the surface area of all fragments of species A/total surface area for the hundred counted fragments.

Additional data was obtained from sightings of *P. occidentalis* in the foliage of different plant species.

RESULTS

DISTRIBUTION

Information about the species decline during this century was obtained by comparing their extant distribution documented on this study with previous and historical accounts.

Present Distribution

The distribution of *P. occidentalis* as determined between 1990 and 1992 in shown in Figure 1. The species has a patchy distribution in the forests and woodlands of southwestern Western Australia between the Collie R. near Bunbury and Two Peoples Bay near Albany. It is not known east of the Darling Range, but further south it occurs inland in the Warren River catchment area (Perup). It is relatively abundant on the coastal plain between Capel and Dunsborough, and in the Perup Fauna Priority Area.

Past Distribution

The previously known distribution of *P. occidentalis* assessed from reliable sources are shown in Figure 2. The caption to this figure lists the date and nature of each record.

Records not shown on Figure 2 are those of Baynes (1987) who recorded bones from this species from caves near Madura and Balladonia which were associated with material radio-carbon dated at 390 ± 210 years ago. Further Archer (1974) records the species of bones from the Orchestra Skull cave, near Wanneroo.

Our studies suggest that late last century the species probably occurred in suitable habitat on all river systems from the Swan River to the Kalgan River, and perhaps further to the east as far as the Pallingup River.

The Decline in Range of P. occidentalis

Comparison between our data and older records (Figures 1–2) shows that inland populations have declined more than coastal ones, and northern populations have declined more than southern ones.

Shortridge (1909) first commented that *P. occidentalis* was "apparently disappearing in may areas". How *et al.* (1987) noted its decline in some southwestern coastal areas. Such comments suggest that for most of the last century the distribution and/or abundance of this species appears to have been in decline. Prior to 1950 capture of *P. occidentalis* (and *T. vulpecula*) in southwestern Western Australia for their skins was widespread and common.

The species decline in the Pingelly–Dryandra area has been relatively recent, the last specimen collected was from Tuttaning Nature Reserve in 1962 (WAM registration number M5139). Sightings have been reported from the area as recently as 1991, but no sign of it was found in the course of this study.

The disappearance of *P. occidentalis* from the northern and inland parts of the range contrasts with its persistence in the Albany area. Records suggest that Two Peoples Bay has been the most easterly population for at least the last century. Comparison of our Two Peoples Bay survey results (see Abundance section) with records in Ellis and Jones (1992) suggests that population numbers at Two Peoples Bay have changed little since the early 1970's. Our

surveys showed no sign of the species at West Cape Howe National Park, but Professor A. Main (pers. comm.) reports that the species was commonly observed in the area during the early 1970's. He also reported an apparent increase in this species in regenerating Karri forest after an extensive fire in the mid 1970's. In the Elleker district (*c.* 15 km W Albany), Mr Allan Taylor an intermittent local resident since the 1920's, reported (pers. comm.) that the species became relatively rare during the mid 1930's. He also reported that his more recent sightings suggested that the species abundance in this district has remained relatively constant since the 1940's.

The occurrence of *P. occidentalis* in the extensive hardwood forests of the South West is patchy (Christensen *et al.* 1985). It is present and relatively abundant in the Perup area, where several other rare mammals also occur. In contrast, Mr George Gardener, a Northcliffe resident, reports (pers. comm.) that is has declined in the Northcliffe area, and he has not seen it since about 1975.

ABUNDANCE

Abundance of *P. occidentalis* and *T. vulpecula* was assessed using the:- number of possums seen per unit night survey period; number of dreys seen per unit day survey period; proportion of dreys occupied; and relative abundance of faecal pellets. Abundance of *T. vulpecula* was also assessed because it may be a potential indicator of habitat or site quality for *P. occidentalis*. However, assessment of abundance of *P. occidentalis* and *T. vulpecula* were not strictly comparable. This was because whereas *P. occidentalis* were rarely sighted on the ground, *T. vulpecula* was. Because we concentrated on looking in trees, we probably underestimated the abundance of *T. vulpecula.*

The results (Table 1) showed clearly that *T. vulpecula* did not occur in *A. flexuosa* woodland and forest sites that supported *P. occidentalis*. A single exception was the single *T. vulpecula* that took up residence at the Forrest Beach site in 1991. This individual was sighted three times, always alone. It is possible that this animal was released at the site by someone who had trapped it as a 'problem possum'.

Another contrast between results for the two species shows in the number of possums sighted together in a single tree, or adjacent trees. *P. occidentalis* were seen in twos, and occasionally threes, more frequently (average per subject tree and immediately adjacent tree of 1.49 from 65 sightings) than *T. vulpecula* (1.21 from 45 sightings). Many of the 'pairs' of *P. occidentalis* sighted were of females and larger young, but it was not always possible to accurately judge their age or sex.

Faecal Pellet Frequency

Quantitative determination of frequency of occurrence of faecal pellets was impractical because of variation in ground cover at different sites and at the same sites in different seasons. Hence observations on abundance were given a subjective ranking (Table 2).

Drey Abundance

Dreys were not recorded for *P. occidentalis* at Perup, and were rarely seen at Abba R. Hollows were far less frequent in *A. flexuosa* associations than in Tuart (*Eucalyptus gomphocephala*) or Jarrah-Marri (*E. marginata* and *E. calophylla)* woodlands. All dreys occur in areas with *A. flexuosa* (see Rest Sites for details).

At Two Peoples Bay, dreys were more abundant than at most other sites (Table 3). However, the occupancy rate of dreys at Two Peoples Bay was low - one occupied drey out of sixteen checked (6%). At all other sites it was 20-50%.

Site mapping

The location of dreys was mapped at Geographe Bay, Emu Point and Locke Estate (Figures 3-5). The number of dreys associated with groups of sightings and dreys shown on the maps is to facilitate discussion of these groups.

At all sites the *P. occidentalis* that were sighted were not evenly distributed but were usually within one hundred metres of mapped dreys. Geographe Bay and Locke Estate had more dreys and platforms, and both of these were more evenly distributed that at Emu Point. The pattern of sightings at these former two sites differs considerably from other sites such as those at Forrest Beach and Abba R. where sightings, while still clumped to some degree, were much more evenly distributed.

Because the vegetation at Emu Point and Geographe Bay appears similar to that at the Forrest Beach and Abba R. sites, this pattern of dispersion in the former areas could be interpreted as suggesting that at Emu Point and Geographe Bay, populations of *P. occidentalis* were well below the carrying capacity of the habitat for this species.

The total population at Emu Point and Geographe Bay, estimated from the minimum number of *P. occidentalis* that would account for all sightings, was 7 and 13 individuals, respectively (included two and three dependant young, respectively).

At Geographe Bay B. Jones (unpublished data) judged that of the total area of 50 ha (Figure 3), 22 ha was suitable habitat for *P. occidentalis*. Using these two areas the density of *P. occidentalis* was calculated at between 0.26 and 0.59 individuals ha^{-1}.

At Emu Point, the estimation of the area of suitable habitat for *P. occidentalis* is limited by the extensive disturbance associated with urban development. Also they are known to live in gardens in the Busselton area, but information from residents at Emu Point suggests that this is much rarer at Emu Point. Using the total area shown in Figure 4 of 85 ha the density is calculated at 0.08 individuals/ha. The area enclosed by the most distant dreys or sightings is *c.* 20 ha; using this area the density is 0.35 individuals ha^{-1}.

Abundance summary

The five preliminary survey methods for estimating abundance (dreys hr^{-1}; faecal pellet abundance rank; headtorching hr^{-1}; vehicle spotlighting km^{-1} and walk spotlighting hr^{-1}) were compared for concordance using Spearmans Rank correlation coefficient on all pairwise groupings of these methods (data from Tables 1 & 2). Because not all sites were surveyed using the same methods these pairwise correlations were often on different subsets of the sites surveyed. None of these pairwise combinations was significantly correlated. The lowest probably was $0.1<P<0.05$ ($t_8 = 2.86$) for the correlation between faecal pellet abundance rank and walk spotlighting/km. Because the accuracy of survey methods used to determine *P. occidentalis* abundance depends on the site and visibility of possums it was not possible to select one of these preliminary survey methods as superior to the others. Consequently we were unable to assess relative abundance of *P. occidentalis* on these sites using these preliminary methods.

While the preliminary survey methods do not allow an evaluation of relative abundance of possums on all sites visited we were able to rank (0-6) their abundance on a restricted set of sites that were visited periodically throughout the two year study period (see Table 14).

POPULATION DEMOGRAPHY

The data presented here are for two populations studied relatively intensively at Abba R. and Locke Estate and for less intensive studies of *P. occidentalis* at Forrest Beach, Geographe Bay, Busselton area and Perup. Information from the Busselton townsite population is not treated in detail as most animals were kept in captivity for extended periods. A total of 211 captures of 159 *P. occidentalis* were recorded for these six areas. Some data on growth and development were obtained from a recently translocated population on the Leschenault Peninsula using animals from the Busselton townsite population (BAJ, unpublished).

Growth and Development

The smallest pouch young observed in this study had headlengths of 7.0, 7.0 and 8.0 mm. They were newborn and appeared to be recently attached to the teat.

Infrequent recaptures were made of females with pouch young, consequently few data were available on growth rates of the 25 young measured in the pouch. Two females had pouch young (mid term) that were remeasured. The headlength of a 32.0 mm pouch young from Abba R. grew 11 mm in 25 days; the headlength of a 7.0 mm pouch young from Leschenault Peninsula grew 22.2 mm in 54 days. The mean growth rate for these measures is 0.417 ± 0.008 mm day^{-1}.

Young were aged using the equation A = HL − 7.0 mm/0.417 (A: age in days, HL: headlength in mm).

Eyes opened between 65 and 75 days, by which time the young were fully furred. The youngest individuals seen outside the pouch had headlengths of 50 mm and 50.2 mm and were aged *c.* 104 days.

Examination of females and associated young suggests that lactation continues until the young weigh around 550 g and have a headlength of between 60 and 65 mm. While no individual pouch young were followed through to weaning, age at weaning was between 160 and 190 days for both the Abba R. and Locke Estate sites.

Females attain maturity at about 9–10 months of age. For example, ♀ 13 was still suckling as a dependant young on 15 December (weight 430 g, headlength 55 mm); by 19 June she had a newly born pouch young (weight 940 g, headlength 70 mm). All females weighing less than 850 g had undeveloped pouches (a mere fold of skin) and were nulliparous. Five females weighing more than 850 also had undeveloped pouches. Two of these were raised in captivity; three were from Locke Estate during summer when reproductive activity was reduced.

Males weighing between 830–900 g had adult testis dimension of >15 x 15 mm. External measurements for adult *P. occidentalis* are presented in Table 4.

One of these Busselton populations (Abba R.) was selected for a capture–mark–release (CMR) programme, but with a prime focus on telemetry studies. A second population (Locke Estate) was selected for a more intensive CMR programme to obtain more demographic data.

Age Structure and Sex Ratio

Four *P. occidentalis* age categories were recognised:

(1) *Pouch young:* always less than 130 g, located in the pouch.
(2) *Dependent young:* less than 550 g, always associated with lactating females.

(3) *Juveniles*: less than 850 g, females had undeveloped pouches, males had testis dimensions less than 15 x 15 mm.
(4) *Adults*: reproductively mature, weighed more than 850 g.

The sex ratio is close to parity in all age categories for the Abba R. population, but females outnumber males by around 2:1 in the young (both pouch young and dependent young), juveniles and adults at Locke Estate. Only the adults at Locke Estate (X^2_1= 8.40 P<0.01) are significantly different from parity. The high proportion of unsexed pouch young results from our extreme caution in examining the pouch early in the study (Table 5).

Population Size and Density

As discussed earlier the relative abundance of *P. occidentalis* varied over its range and in the Busselton area localised high density populations occurred.

The Abba R. population density estimated using the Petersen Index, for the periods Jan–Mar 1991, June–Aug 1991, Nov–Dec 1991 and Jan–Feb 1992 was 44, 51, 260 and 113 individuals, respectively. The small sample size ($\overline{x}$ = 10) in each of these periods, and the low proportion of marked individuals recaptured, contributed in large part to the variation in these estimates. The first two estimates were based on CMR in the area of the central part of the telemetry study area (8 ha). The latter two estimates were from an expanded area (ca 15 ha) as we increased the number of individuals handled and examined.

At Locke Estate, population estimates were obtained for the months of December 1991 and January and February 1992. These were 96, 95 and 104 individuals, respectively. Larger samples were obtained ($\overline{x}$ = 21) than at Abba R. and a slightly higher recapture rate of marked individuals was achieved. Locke Estate comprised 40 ha of *A. flexuosa* woodland. On the western half of this woodland (*c.* 20 ha) we located few dreys and only two *P. occidentalis* (see Rest Sites); almost 90 individuals occupied the 20 ha on the eastern side of the reserve. This density of 4.5 ha^{-1} is more than doubled if only the south-eastern section is considered where the population was concentrated.

Reproduction

Nothing is known of the length of the gestation period or oestrous cycle in *P. occidentalis*, and information on breeding has only recently been collated by Ellis and Jones (1992) for captive held individuals.

Our data from examining the pouches of 67 adult females suggests that some reproductive activity occurs year-round in *P. occidentalis*, but that a trough in activity may occur during summer. Estimated age of pouch young from the above headlength growth equation and of juveniles and dependent young from the bodyweight equation of Ellis and Jones (1992) gives the season of births of *P. occidentalis* presented in Figure 6.

Observational data from females carrying transmitters provides better evidence on reproductive pattern in the Abba River population. From these data it appears that only a few females have visibly distended pouches and carry large pouch young between January and June (Table 6). Two Abba R. females have been associated with young twice since commencement of telemetry studies in October 1990. Both raised a single young over spring and summer (1990–91), and this was repeated during spring and summer (1991–2). These observations suggest that at Abba R. breeding is seasonal, with most births occurring during late autumn/mid-winter (Figure 6).

At Locke Estate the period of births appears more extensive (Figure 6). One Locke Estate female, collared in late August 1991, had two pouch young (100, 105 g) almost ready to emerge. Only one young was subsequently sighted with this female, and this was caught in December 1991 (weighing 750 g) about 400 m from the natal home range. The mother was sighted again in mid January 1992 with a full pouch; in late March the young's weight was estimated to be 400–500 g. These observations indicate that at Locke Estate some females give birth twice within a 12 month period.

A single pouch young was usual, although three of the eighteen females (16.7%) with pouch young at Lock Estate were carrying twins. None of the six females at Abba R. carried twins and none were observed amongst the radio-collared females observed over the eighteen month period, although once a pair of similar sized dependent young were seen with an adult at Abba R. Females associated with twins [1242 ± 34(3) g] were significantly heavier [t_{78} = 4.97; P< 0.001] than other reproductively active females [1062 ± 12.5 (77)].

Taken together these results imply that breeding patterns differ between Locke Estate and Abba R., particularly with respect to the frequency of the birth of twins, the seasonality of births, and perhaps the number of births per annum.

Survival

The capture-mark-release program involved too few individuals and, in the case of Locke Estate, occurred over too brief a period to permit accurate determination of survival rates.

There was no evidence of mortality in pouch young or recently dependent young, with all recaptured females lactating for an appropriate interval after young should have emerged from the pouch.

Survival is probably lowest amongst recently independent juveniles as they disperse from the natal range. Some evidence for this is the recovery of two juveniles that were roadkills in the Tuart forest near Ludlow. Two adult females died during handling or within 24 hours of release; one was in exceptionally poor condition (830 g), the other was lactating and weighed 930 g; both had extremely worn teeth.

Condition

Concentration on capture-mark-release of the populations occurred between November 1991 and early February 1992. The limited information available during this period suggests that males retain weight over the summer, but that females loose weight once weaning has commenced. All three females that were first examined whilst lactating had lost weight by the time of recapture one month or so later. Two adult males had gained weight over a similar period.

TELEMETRY STUDIES

Telemetry studies concentrated on *P. occidentalis* at the Abba R., Locke Estate and Yendicup. Most observations on behaviour were collected at Abba R. where viewing conditions during darkness were relatively good. Reference is made to some observations from Leschenault Peninsula.

Animals were first collared at Abba R. in late November 1990. A total of 13 males and 10 females were collared. A total of *c.* 1600 observations have been recorded in the 20 ha core of the study area. Movements of individuals were represented by 20 to 75 LOCs (see Methods).

At Locke Estate two male and a female were collared in August 1991. Between 15–18 LOCs were recorded for these individuals over eight months; another female had 14 LOCs over a four month period.

Home Range

Figure 7 shows the LOCs from the telemetry study at Abba R. between November 1990 and March 1992. Not all animals within the area were collared. Regular sightings suggested that at least five uncollared individuals had ranges primarily within the area defined by all LOCs.

Figure 7 showed that most home ranges had some degree of overlap. The maximum overlap for two males was *c.* 70%, and for females *c.* 90% (a mother–daughter pair, both sexually mature). At Abba R. males sighted within a female's home range were frequently in association with a resident female (in the same or adjacent trees). The relationship between estimates of home range size at Abba R. and the number of LOCs on which the estimate was based increases sharply up to 20 LOCs, and relatively slowly for subsequent LOCs (Figure 9). At Abba R. 10 LOCs were spread over 3–5 weeks, but in rare cases up to 10 weeks.

At Abba R. estimates of female home range size based on both 20 and 30 LOCs varied from 0.18 to 0.90 ha. For males estimates for 20 or 40 LOCs varied from 0.44 – 3.60 ha and 0.60 – 3.60 ha, respectively.

At Locke Estate records for two males and two females were adequate to provide an estimate of home range size (Figure 8). The male values were 0.4 and 1.3 ha (15 LOCs over 8 months); the females, 0.35 ha (18 LOCs over eight months) and 0.2 ha (14 LOCs over 4 months). The male and female with the larger home ranges both lived in the western part of Locke Estate where *P. occidentalis* density was lower. Those with smaller home ranges lived in the more densely occupied areas in the south east *A. flexuosa* woodlands.

At Yendicup two collared females had home ranges of 2 and 2.5 ha (from 19 LOCs over five months).

Home range of females were lowest when females were accompanied by young weighing <200 g. Figure 10 shows the area used at Abba R. by a female and her small young, and contrasts this with LOCs determined after the young reached *c.* 250 g. Females tended to use a single nest tree when the young was 120–200 g.

At Abba R. male #2 had the largest range and showed a unique pattern of home range usage, using 3.6 ha (40 LOCs) over five months, and only 0.6 ha (20 LOCs) over the following three months. Male #2 died in July 1991, the collar showed signs of it having been eaten. There was no indication that #2 was not mature when first caught. Records for the young male (#39) suggest that if #2's home range usage over summer represented 'dispersal', then the pattern was not shared by all young males.

Social interactions

The frequency of sightings of males closely associated with females are summarised in Table 7 for six Abba R. males which used home ranges of different sizes.

Dispersal

The LOCs for three Abba R. females accompanied by dependent young in summer 1990–91 and the LOCs determined for the young (collared during autumn and winter 1991) are shown in Figure 11.

Two females with female offspring showed different patterns of home range usage. One pair tended to use opposite ends of the natal range, but shared 90% of the natal range in common. The other mother-daughter pair showed a different pattern with the young using two core areas, one within the natal range and one 100 m south. The mother died February 1992, and the daughter was subsequently found on two occasions (March 1992) in the natal nest trees after weaning her first young in the area 100 m south. The young male's home range included the main natal tree during the first ten LOCs, but not subsequently. After weaning, his mother was restricted to a smaller area on the margin of the natal range where she was sighted frequently in the company of a male for *c.* 10 LOCs.

In all three cases young appeared to establish ranges adjacent to or overlapping with their natal home range.

At Locke Estate, two young (one female, one male) that were first caught in the natal range were sighted at least 400 m away (female weighed 750 g, male weighed *c.* 700 g). This suggested that at Locke Estate young dispersed earlier and move further.

Activity

All animals at Locke Estate, Abba R. and Yendicup emerged from their rest sites about 10–15 minutes after darkness and returned to the rest site at first light.

At Locke Estate and at Abba R. observations were made in wet windy weather and this appeared to have little impact on activity. In summer 1990–91 some casual observations suggested that *P. occidentalis* at Abba R. may have emerged later on hot nights. Most of their active period was spent in the tree species that contributed the major dietary component (see Diet). Most time was spent amongst foliage, although animals were often sighted resting on branches or trunks.

There were two observed interactions between *P. occidentalis* and *T. vulpecula* at Abba R. over use of a runway; neither resulted in aggressive interaction.

Hollows at Abba R. and Yendicup and dreys at Locke Estate were the most commonly recorded rest sites.

At Abba R. all females used hollows in *E. gomphocephala*. Dreys were used infrequently and only by males. At Abba R. two males were recorded resting on the ground in late February and early March; one on two occasions only in September and the other regularly (for six of nine successive daytime LOCs in late February and early March). At Locke Estate two females were resting on the ground on separate occasions during summer. At Leschenault Peninsula two lactating females rested on the ground infrequently over December and January. These animals were only found on the ground on days following a day with maximum temperature of at least 32°C (though not on all such days). Despite the observations of *P. occidentalis* using rabbit burrows to escape capture, there were no telemetry observations of burrows being used as rest sites.

DIET

Diet of *P. occidentalis* was studied by microscopic analysis of plant fragments in faecal pellets, and direct observations of what they eat.

Faecal Pellet Analysis

Both estimates of abundance of plant species in the diet (see Methods) showed that for those sites with *A. flexuosa*, the foliage of that species is the major dietary component and

accounted for 80 percent or more of faecal epidermal fragments, regardless of site or season (Table 8). At the two sites that lack *A. flexuosa*, the foliage of *E. marginata* accounts for more than 88% of faecal epidermal fragments.

Comparing values for the major component in different seasons shows that any seasonal variation that does occur accounts for a difference of less than 13% between the maximum and minimum percentages. Variation between sites and seasons is best assessed using the number of epidermal types recognised other than *A. flexuosa* or *E. marginata* (Table 9).

Samples that have a minor component of 10% or more tend to have more diverse epidermal types (maximum of 7 at Abba R.; 9 at Emu Point; 5 at Yallingup Ridge and 1 at Yendicup) suggesting that *P. occidentalis* browse small amounts of several plant species or parts to supplement the intake of the major dietary plant. At Locke Estate, *Acacia truncata* accounts for 6–10% of plant fragments, and at Emu Point Chalet, 6–8%. *A. truncata* is common at some sites, but it has not been recorded at the Abba R. study site. A few plants of *A. saligna* do grow at Abba R. so it seems likely that the epidermis of *A. truncata* is similar to that of another plant species (possibly *A. saligna*) that occurs at Abba R. At Yallingup Ridge, *A. flexuosa* forms the major dietary component even though it is not as common as at other sites. At Yallingup Ridge 50% of trees (in a sample of 20) were *A. flexuosa*, while this species at Abba R., Locke Estate and Forrest Beach accounted for 75%, 80% and 100% of trees respectively. At Emu Point Park *P. occidentalis* have access to a variety of garden exotics, but *A. flexuosa* forms the major dietary component. These data suggest that if *A. flexuosa* was available it was usually preferred by *P. occidentalis* as a major dietary component. However at Abba R. in October 1991, 19.7% of plants eaten were other than *A. flexuosa*. This indicated that some important seasonal shifts in dietary preference away from *A. flexuosa* leaves occurred selectively.

Sightings

The results of diet analysis using faecal pellets can, for some sites, be confirmed by comparing the results with those showing the frequency of sightings of *P. occidentalis* in different tree species. Table 10 shows the percentage of sightings in different trees and different parts of the tree for a sample of forty *P. occidentalis* sightings at Yendicup and Abba R. At Yendicup and Abba R. 75% and 77%, respectively, of sightings were in foliage. At both sites the largest group of sightings was amongst the foliage of the species identified as the major dietary component. The results at Yendicup suggest that Marri foliage may form a dietary component, consequently, the low level of Marri in faecal pellets from the Perup area seems more likely due to the methodological problem discussed, rather than the lack of Marri in their diet.

FOLIAGE NUTRIENTS

Leaf Nutrient Levels in Different Species

Comparison of the nutrient levels for different species (Table 11) shows that *Hardenbergia comptoniana* leaves tended to have higher nutrient levels than those of most myrtaceous plants sampled. In June *H. comptoniana* leaves were mostly young and fresh, the result of a growth spurt after the onset of rains in autumn. In February, older leaves have lower nutrient levels, with P and K levels comparable to myrtaceous leaves but with N still higher. In February Ca levels were higher than in all but *E. gomphocephala*.

Agonis flexuosa leaves tended to have higher levels of nutrients than the eucalypts, but *E. calophylla* had slightly higher K. Levels of N, P, and K in *E. gomphocephala* comparable to those of *A. flexuosa*, but Ca was higher.

All plants, except *E. marginata*, showed some seasonal variation in levels of most leaf nutrients. Seasonal changes in *E. calophylla* were restricted to levels of K.

Leaf Nutrient Levels in Agonis flexuosa

Because of the relative importance of *A. flexuosa* to *P. occidentalis* density at coastal sites, we concentrated on investigating changes in the nutritional quality of *A. flexuosa* leaves. Covariation in the levels of nutrients in different *A. flexuosa* trees was investigated using PCA.

The PCA extracted two significant factors. Factors 1 and 2 explained 53.0%, and 29.9% of the variation. The plot of these two factors (Figure 12) indicated that N and P loaded most heavily on factor 1, followed by Ca; K had little effect on this factor. Only K and Ca loaded heavily on factor 2.

These data indicate that the relationships between these nutrients was dominated by the covariance between P and N, but that covariance between K and Ca was also important.

Seasonal Variation

Within sites Peppermint was observed to conform to a relatively uniform annual pattern of flowering, leaf growth and leaf fall. Peppermint flowered between September and November. New leaves were produced quickly, starting mid-flowering, and by February most of the old leaves from the previous season had been shed. The timing of these changes in southern sites were up to six weeks later than at northern sites. In the summer of 1991-92 Peppermint at Leschenault Peninsula was in full flower two weeks earlier than at Abba River.

Nutrient levels for samples of each species collected in a single month at each site were averaged to summarise nutrient levels as shown in Figure 13.

The general trend is for N levels to rise throughout the calender year within sites while other nutrients rise or remain constant. The pattern for Abba River and Wilsons Inlet differs by showing a drop in levels of K throughout the year.

Differences between the patterns of seasonal variation at Locke and Abba River were assessed using CVA. For each site a discriminant vector was determined that summarised differences between relative nutrient levels in October and February samples. Figure 14 shows the magnitude of each nutrients discriminant coefficient at each site.

The CVA extracted a significant function for seasonal variation at both Locke Estate and Abba River. N was a small contributer to explained variance at both sites, but clearly with the other nutrients the pattern of seasonal change varied greatly between sites. P and K were important influences at both sites but at Locke Estate K loaded heavier than P while the converse was the case at Abba R. Ca differed considerably between seasons at Locke Estate but did not at Abba R.

Between Sites Variation

Because of the complex patterns of covariation in our data set, between site variation was assessed using CVA of raw values for February and June (or July) leaf collections of *A. flexuosa*. Later we attempt to compare nutritional quality of *E. marginata* at Perup with that for *A. flexuosa* sites.

June–July

The CVA for the Summer (February) data extracted two significant functions. Function 1 explained 56% and function 2, 39% of the variation between sites. The plot of these functions (Figure 15) revealed four principal groups of sites: LO - AB; E; LN and EG - LB. Only Sites E, LO and AB had extant populations of *P. occidentalis*. The two groups containing extant populations separate on function 1. Nutrients loading heavily on this function are N and K (Table 12). These two groups (E; LO–AB) separated from the other groups on both functions 1 and 2 so again the distinction between sites with and those without extant *P. occidentalis* related principally to the nutrients P, N and K, and to a lesser extent Ca (Table 12).

The CVA for the winter (June–July) data extracted three significant functions. Function 1 explained 48%, function 2, 29% and function 3, 16%). The plot of the first two functions (Figure 16) again revealed four principal groups of sites ER, M1–WI–BU–EC; M2–EG; and LN–LS–LC. K and Ca load heavily on function 1, N and Ca load heavily on Function 2 and K only loads heavily on function 3. ER has a high coefficient on both functions 1 and 2 (Table 12). Interestingly ER is a site located near to a sewerage dump, consequently plants close to this site have an altered nutrient resource.

Only three of these sites have populations of *P. occidentalis* (ER, BU, and EC). ER separates from all other sites on both functions 1 and 2 which indicates that N, K and Ca foliage levels are all important in this separation. The sites BU and EC (and M1, WI) differ from the other groups on function 1 and from ER and the M2–EG group also on function 2. Once again it suggests that all nutrients except P are important in this distinction. However BU, EC, M1 and M2 differ from the Leschenault sites (LN, LS, LC) principally on function 1 suggesting that it is K and Ca only that is important in distinguishing these latter two groups.

Although the results of this CVA on summer and winter data are not strictly comparable (because they are based on different combinations of sites), some conclusions may be drawn.

Sites with extant populations of groups of *P. occidentalis* differ in both summer and winter from all sites without *P. occidentalis* in the levels of K and to a lesser extent Ca, in foliage; the other nutrients N and P are important to distinguish certain sites groups with or without *P. occidentalis*. Both N and P are important in summer but N only in winter.

These data are also helpful in choosing sites that would be suitable for translocation of *P. occidentalis*. For example, from Figure 16 the sites M1 and WI are closely grouped with BU and EC. These latter two sites have abundant *P. occidentalis* so that on nutrient foliage indices M1 and WI could be considered perhaps more satisfactory for restocking with *P. occidentalis* than other site groups where *P. occidentalis* are not extant (M2, EG, LN, LS and LC). Other habitat indicators at M1 and WI would appear to be also favourable to *P. occidentalis*.

Comparison of nutritional quality of E. marginata and A. flexuosa

Comparison of the Perup and Busselton sites in terms of nutritional quality is complicated by the different patterns of covariation in nutrient levels for different species. Comparison of *E. marginata* results with those for *A. flexuosa* sites for February was made by calculating the position of the mean February nutrient levels using the discriminant function coefficients from the February (*A. flexuosa*) between sites analysis. This comparison showed that at Perup, *E. marginata* had a pattern of covariation in nutrient levels that was similar to that found in *A. flexuosa* at Locke Estate and Abba R. Mean nutrient levels in Abba R. and Locke Estate *A. flexuosa* were slightly higher than in Perup *E. marginata* in February.

Emu Point: Within site variation in Peppermint nutrient levels

The Emu Point site (see map, Figure 4). Figure 17 shows nutrient levels associated with

different sampling sites. Nutrient levels are higher for those samples collected within a *P. occidentalis* home range than for the EPC sample, which was collected in an area ca 300m from the nearest home range. The highest nutrient levels are for EPR, the sample from near the septic tanks. Unfortunately no February collection could be made at this site because the *A. flexuosa* trees sampled in July were cut down in December to facilitate the replacement of the septic holding tanks.

HABITAT

The patchy distribution of *P. occidentalis* indicated that site quality varied considerably throughout the southwest of Western Australia. Site characteristics with the potential to influence the abundance of *P. occidentalis* included the following:

- Vegetation characteristics (including floristics, structure, abundance of hollows, nutritional quality of dietary plants);
- Climatic parameters; and
- Habitat disturbance history (including fire and fox)

These site characteristics are discussed separately below, except for nutritional quality (see separate section). Descriptions of vegetation at different sites are in Appendix I.

Vegetation

P. occidentalis were most frequently observed in trees, and our dietary studies show tree leaves formed the major dietary component. These results suggested that characteristics of trees in an area were more likely to influence abundance of *P. occidentalis* than is the understorey vegetation.

Floristics

Apart from urban Busselton *P. occidentalis* all populations were in vegetation where trees of at least one of the following species were common: *Agonis flexuosa*, *Eucalyptus gomphocephala*, *E. calophylla*, *E. marginata*, *E. megacarpa* (Bullich), *E.wandoo* (Wandoo). At some sites *A. flexuosa* was the only tree species present (e.g. Forrest Beach, Geographe Bay). *P. occidentalis* were only associated with *E. gomphocephala* at Ludlow where it grew with *A. flexuosa* and/or *E. calophylla* and *E. marginata*. Only at Two Peoples Bay was *P. occidentalis* associated with *E. megacarpa*, which at this site, often grew with *A. flexuosa*. On the Leeuwin Ridge, near Yallingup, *E. marginata* and *E. calophylla* grew with *A. flexuosa*. *A. flexuosa* did not occur at Perup, where most trees were *E. marginata, E. calophylla* and *E. wandoo*. Perup was the only extant *P. occidentalis* population known outside the range of *A. flexuosa*.

From these observations the vegetation types, based on tree species, that support *P. occidentalis* are:

- Eucalypt woodland of *E. marginata* and *E. callophylla*, with or without *E. wandoo*
- Eucalypt woodland or forest with *A. flexuosa*
- *A. flexuosa* woodland or forest

The urban population of *P. occidentalis* in Busselton occurred in habitat quite different to the nearby natural populations. Although *A. flexuosa* was the major tree species present in the urban areas, plant diversity was much higher. Captive *P. occidentalis* are known to eat a variety of exotic plants (Ellis and Jones 1992). Rita and Norville Watts reported that exotic species favoured by urban *P. occidentalis* included rose flowers, and apricot and loquat leaves .

The understorey at sites with *P. occidentalis* was highly variable, ranging from open areas with winter pasture to dense natural vegetation. At both Geographe Bay and Ludlow, *P. occidentalis* lived in trees under which grazing by domestic stock had occurred for more than 25 years. Where *P. occidentalis* were known to occur in *A. flexuosa* woodland, the understorey often included the exotic Arum Lily, and/or sedges of the genus *Lepidosperma*. Both these elements appeared to be associated with relatively higher soil water content, and were often on the margins of watercourses or in depressions. At Perup, and particularly at the Mordalup site, Heart-Leaf *(Gastrolobium bilobum)* is a relatively common component of the understorey.

Vegetation structure

Vegetation structure, was described by the presence of strata of different heights, and the percentage cover of each strata. A more detailed description of structural features of tree strata was obtained for some sites by collecting a set of variables from a sample of trees (minimum of twenty trees measured) at different sites.

Observations at Abba R. suggested that *P. occidentalis* tended to move between trees through the canopy rather than descending to ground level. Presumably this was more energy efficient and minimises exposure to terrestrial predators. *P. occidentalis* which occupied areas with higher vegetation cover had access to more trees via the canopy than did those living in open woodland (Figure 18). In open woodland *P. occidentalis* presumably descended to ground level more frequently, and travelled further between trees.

In much of urban Busselton, structural aspects of habitat are independent of vegetation characteristics (e.g. boundary fences provide an extensive network of runways above ground level).

Hollow Abundance

Natural hollows were the principal rest sites in vegetation dominated by eucalypts. The abundance of hollows was strongly influenced by the the dominant tree species (Figure 19).

Trees with hollows were rare in *A. flexuosa* forest, but were common when the vegetation had a eucalypt species as a dominant or codominant.

For all three eucalypt species there was a significant increase in tree hollows with increase in the diameter of trees at breast height (Table 20). Consequently sites with older trees were likely to have more hollows than those with younger stands.

Climatic parameters

The pattern of distribution of *P. occidentalis* documented in this study support observations by Shortridge (1909) who considered that *P. occidentalis* were often coastal and were associated with watercourses and swamps. However, at many such sites, fresh water was only available during winter and spring. Interestingly, despite this association with water our telemetry studies at Abba R. showed no evidence that *P. occidentalis* made excursions from their winter home ranges to access potable water during summer months.

Field observations of *P. occidentalis* that use dreys revealed that on hot days *P. occidentalis* use evaporative cooling by licking feet and tail base to maintain an acceptable body temperature. If water for cooling was not obtained by drinking from potable water, then perhaps it was obtained from condensation on the foliage during the latter part of the night.

Condensation occurs when the minimum air (or leaf surface temperature) falls below the dew point. Dew point varies with humidity and air pressure and the dew point values shown in Figure 21 were derived assuming a uniform atmospheric pressure and a relative humidity (RH) half-way between the contours shown on the map.

The 12 degree minimum isotherm includes the Perup area and the Stirling Ra. If humidity was uniform and constant then these two areas would have dew more frequently in January than areas with higher daily minimums. Overlaying the 60% RH contour line shows that most of the area included within the 12 degree minimum isotherm has an average 9 am RH of less than 60%. The Perup lies within the only area that regularly has a 9 am RH of more than 60% and a minimum of 12 degrees. Consulting a Psychometric chart shows that for a minimum temperature of 15 degrees and a RH of 65% the dew point (at 1013 h Pa) is about 12 degrees. Thus the Perup has dews more frequently than other areas which also have the 12 degree January minimum.

The RH values used are based on a 9 am reading, which is about 3.5 hours after sunrise in January. It is likely that if calculations were based on RH levels taken before sunrise a more accurate description of the occurrence of dews during summer would be possible. Such measurements are not available from the Bureau of Meteorology.

These climatic parameters indicate that the only known inland *P. occidentalis* population of substance occurs within an area where dews occur more frequently in January than in other inland areas.

On a much smaller scale variation in both topography and vegetation structure is likely to influence the amount of condensation on foliage. Valleys between high ridges with watercourses in them are likely to have dews more frequently, and these areas are also more protected from winds that may prevent cooler pockets of air from forming. Dense vegetation may also provide protection from wind.

On a similar scale is the variation in humidity expected to occur near the coast. Figure 21 shows the 60% RH contour running near to and parallel to the coast north of Busselton. Further south the 70% RH contour passes north of the Hardy Inlet (Peppermint) *P. occidentalis* population. At the SE extreme of the *P. occidentalis* distribution Two Peoples Bay lies on the 60% RH contour where this crosses the coast.

Site disturbance history

All southwestern sites examined showed evidence of disturbance. Two Peoples Bay and Mordalup were the only sites not affected by weeds and obvious human activity (we know of no logging at Mordalup). Most sites showed major disturbance as a result of human landuse, including clearing or thinning out of trees, pastoral use and urban development.

Two main aspects of site disturbance are associated with the impact of the fox and fire.

Fox

Fox scat or spoor were seen at Abba R., Locke Estate, Geographe Bay, Forrest Beach, East Augusta, Yendicup and Two Peoples Bay. Fox were assumed to be responsible for the death of animals at Locke Estate, Abba River and Geographe Bay. It seems likely that fox were potential predators for all *P. occidentalis* populations, except perhaps urban populations in Busselton or Albany. Domestic pets may replace fox as predators in these areas. The sites with lower fox densities were thought to be Perup and Two Peoples Bay which have good conservation status for other rare southwestern vertebrates and have been baited to lower the fox numbers.

Fire

The Albany sites under the care of the Albany Town Council were burned on a six year cycle. Sometimes fires occurred more frequently. The only Emu Point site to show no evidence of past fires was the area in the immediate proximity to EPR or the large dam. This area included the home ranges of at least two *P. occidentalis* and was probably well protected from fire by its higher moisture levels and by its adjacent caravan dwellers.

CALM's management of fuel levels using prescribed burns affects Yendicup and the areas on the Blackwood at Schroders Pool and Sues Bridge. The Abba R. site showed almost no evidence of fire, which was excluded by grazing the area during winter months. Ian Rotheram (pers comm, CALM, Busselton) points out that even cool burns in areas with old *E. gomphocephala* trees are likely to reduce hollow abundance because the fire easily ignites the base of these trees (which are almost always damaged by termites).

Agonis flexuosa forest showed the effect of past fires dramatically. Hot fires killed those limbs that were defoliated in fire, and the tree regenerates from rootstock in a 'mallee' form with many stems. Locke Estate had a mosaic pattern in growth habit of *A. flexuosa* suggesting a complex fire history. Some patches at Locke Estate were dominated by *A. flexuosa* with a tall major trunk (dead but still standing) and a lower strata of trees that seem to represent germination of seedlings after fire. This contrasts with sites such as East Augusta and Two Peoples Bay Office where the growth habit of *A. flexuosa* was much more uniform. At Locke Estate *A. truncata* occurred throughout the site, but it was at its densest along the margin of the highway. It also occurred on road verges only at Geographe Bay.

Unfortunately meaningful records of fire history were not available for most areas: when fire history was available it was rarely possible to distinguish between cool burns and wildfires.

REST SITES

Types of Rest sites used by P. occidentalis

P. occidentalis mostly use either dreys or tree hollows as rest sites during daylight. Field observations (this study) showed that sometimes *P. occidentalis* rest on the ground during daylight, or in trees, sitting amongst creepers, foliage or on branches. If chased to ground *P. occidentalis* sometimes evaded capture by escaping into rabbit burrows, and some animals released into trees after processing proceeded directly to burrows. These were the only records we have of *P. occidentalis* using rabbit warrens.

All three drey types appear to to be constructed by *P. occidentalis*.

Table 13 shows that in *A. flexuosa* woodlands, hollows were rare (< 3% of trees have hollows) and dreys were common. In areas where eucalypts dominate hollows were more abundant (> 5% of trees have hollows) and dreys were rare. All sites where drey use predominated were less than two kilometres from the ocean.

At the Two Peoples Bay, there was a high abundance of both dreys and hollows. This pattern differed from other populations. It is probably due to the complex vegetation mosaic in which vegetation units tend be smaller than the home range size of *P. occidentalis* determined at the major study sites. Further, at Two Peoples Bay, dreys were often found in shrubs in the understorey (frequently in *Hibbertia* or *Bossea*). The mean height above ground of 14 dreys at Two Peoples Bay was 1.6 m (0.6 - 3.6 m). Drey occupancy rate was 6%.

At Locke Estate a total of 132 rest sites were recorded. These were classified as: platform

19%, well-maintained dreys 52%, derelict dreys 28% and Stags or ground 1%. The majority of these rest sites were recorded in *Acacia truncata* (51%). Most rest sites recorded in *A. flexuosa* were associated with the creeper *Hardenbergia comptoniana* 20% although a further 10% were found in *A. flexuosa* alone. *Melaleuca preisii* had 14% rest sites associated with it and most of these were platforms in forks or on larger branches. Six (4%) rest sites were in low dense foliage of *Rhagodia* sp., generally less than 2 m above the ground. The mean height above the ground of all rest sites was 5.2 ± 2.0 (0–17) m . The occupancy rate of these rest sites by possums varied between 13% (February 1992) and 19% (January 1992).

P. occidentalis adults used dreys alone or in association with a dependent young or a recently weaned juvenile. Of the 64 captures made from rest sites at Locke Estate none were of the adults together. Two males and two females used either 6 or 7 rest sites of which 5 or more were dreys. One female was found resting on the ground in dense *Lepidosperma* on a single occasion.

At Abba R., telemetry studies showed that hollows were most frequently used by most animals. However two males monitored did use dreys, one as a major rest site for several months during summer. Figure 22 shows the distribution of all dreys found at the Abba River study site. Most dreys observed were in trees in the watercourse. Females used 3–5 nest trees a year and males 2–8 annually.

Drey and Hollow Microclimate

The temperature of four hollows at Abba R., and three dreys and one rest site at Locke Estate was recorded during warmer weather in late summer. The internal temperature was compared to air temperature at 1 m above ground level. The results are shown in Figure 23.

The hollows provided a relatively stable internal temperature throughout the day, and were much cooler than air temperature during the hottest part of the day. Drey temperatures hardly differed from air temperature and some readings yielded drey temperatures higher than air temperature, presumably for relatively short periods when patches of shadow did not protect the drey from direct sunlight. Rest site 7 was amongst a clump of *R.baccata* climbing on *A. flexuosa* trunks where *P. occidentalis* had been observed during daylight on three occasions. There was no drey at rest site 7. Comparing the three drey temperature profiles with that for rest site 7 shows that dreys were no cooler than a naturally occurring 'cool spot'.

PREDATION

Predation may be an important population regulatory factor. The only observations we have that provide evidence about predation relate to fox and tiger snake (*Notechis scutatus*). Fox observations were made at Locke Estate and Abba River, but some information about the occurrence of fox at other sites is given in the section on Habitat. Information about predation by cats comes from reports from other people.

On a single occasion at Locke Estate an adult female *P. occidentalis* accompanied by two young (estimated weight *c.* 150g) was sighted in *R. bacata* in Peppermint 2–3 m above the ground. A tiger snake was seen (head up) in the clump of *R. baccata* about 0.5 m below the lowest of the young. The observer's approach disturbed the snake which turned and proceeded quickly to ground.

At Abba River the remains of a collared male *P. occidentalis* recovered had been attacked by a fox. Two large puncture wounds on the neck and shoulders suggested the animal was taken while alive, and that fox rather than cat was responsible. Collars affixed to a male at both Locke Estate and Abba R. were recovered without the possums. These showed damage similar to that of the male killed at Abba River.

At Geographe Bay two of the thirteen *P. occidentalis* on site were presumed eaten by fox in the course of a three month study (as evidenced by characteristic kill signs). Fur tufts in a low drey showed that one of these animals was pulled from the drey.

An independent study (undertaken by BAJ) of the release of rehabilitated *P. occidentalis* to the wild showed that of five healthy animals released to Locke Estate, four were eaten (judged on damage to the four recovered collars, and two clear 'kill sites') within six weeks of release. This contrasts markedly with reintroduction of *P. occidentalis* at Leschenault Peninsula where a 1080 fox-baiting program was conducted prior to the release of 10 collared individuals. There have been no deaths to predation in the ensuing six months.

While it is probable that fox will eat *P. occidentalis* that have died for other reasons, our subjective judgement of this data is that most deaths referred to above were the result of predation rather than scavanging by fox.

Casual observations of the abundance of fox scat and spoor suggest that fox are much more abundant at Locke Estate than at Abba River. Abba River is baited yearly with 1080 egg baits for foxes, and in some years using 1080 in grain for rabbits. We have no record of baiting at Locke Estate.

Evidence of predation by cat is sparse, but at East Augusta a domestic cat carried home fresh *P. occidentalis* bodies (Gutha Rockyle, East Augusta resident, pers comm.). Alan Danks (CALM Two Peoples Bay, pers comm) reported that he was approached by a local resident with the back half of an adult female *P. occidentalis* (with live twins in the pouch) that was killed by a domestic cat.

Wildlife rehabilitators in the Busselton area (Rita Watts, and FAWNA members) report that some of the animals presented to them were injured by domestic cats and dogs.

ABUNDANCE CORRELATES

While abundance of *P. occidentalis* could not be accurately assessed for all sites visited using the preliminary survey data (see earlier section on Abundance), we were able to confidently assess relative abundance of 16 sites that were visited more regularly over the period of the study. These sites were dominated by *A. flexuosa* or *A. flexuosa* and *Eucalyptus* spp. (where *A. flexuosa* was more than 35% of the second strata foliage cover). The relative abundance (ranked 0-6 for sites, see Table 14) was based principally on density of faecal pellets and was confirmed by other observations.

These relative abundance ranking (RA) were compared with independent variables in Table 14. These are habitat parameters such as foliage density, foliage nutrient levels (N, K, P, Ca), number of tree strata, number of dominant plant species, measures of habitat disturbance such as extent of cutting of the dominant two vegetation strata, and evidence of recent fires measured by percentage of trees with fire scars, distance from fresh water or the ocean, and whether or not an area was known to have been baited for foxes during the last three years.

Explanation of the variables presented in Table (14) are provided in the caption to that table. The measures of nutrient levels in foliage presented in Table 14 are for N, K, P and Ca.

The forward stepwise multiple regression analysis of data in Table 14 for all 16 sites produced the following equations: RA = 11.745 potassium - 2.661; R^2= 0.710; P = 0.017. Potassium alone explained 71% of the variation observed in RA between the 16 sites investigated. No other variables in Table 14 contributed to this explained variation. The other nutrients (N, P and Ca) had correlations with RA of 0.327, 0.548 and 0.065; the highest correlation for other variables with RA was -0.363 for number of dominant plant species.

This equation highlights the importance of levels of foliage nutrients to the abundance of *P. occidentalis*.

While the importance of foliage nutrient levels to the abundance and distribution of *P. occidentalis* appears to be of paramount importance, it would be unwise to discount the extent of the influence of other disturbance factors such as alteration caused to habitat by recent European burning practices or cutting, and by the introduction of feral predators such as foxes, cats and dogs. Our measures of these disturbance factors are perhaps too coarse to display the associations that may exist between them and the abundance of *P. occidentalis*.

DISCUSSION

Distribution

This study quantified the past and present distribution of *P. occidentalis* using information from the literature, unpublished records and information as well as a questionnaire to conservation workers in the southwest of the state. There are now no populations in the Stirling Ranges or at Tutanning Nature Reserve. The most inland population appears to be at Perup Fauna Priority Area, east of Manjimup. The species range is now restricted to the south-west corner of the state and to the west of the line between Bunbury and Two Peoples Bay. It is possible that small extant populations still exist to the east and perhaps north of this distribution.

The locations presented in Figure 1 accord well with the statement by Shortridge (1909) that the species was abundant in most *A. flexuosa* forests and along the banks of rivers and swamps. However, viable populations also exist in some coastal towns (e.g. Busselton, Dunsborough, East Augusta) where *A. flexuosa* is abundant.

Abundance

There are only subjective estimates of *P. occidentalis* population abundance or density in the literature (How *et al.* 1987). Our nocturnal spotlighting, from a vehicle or on foot, in an array of habitats and at numerous sites allow assessment of relative estimates of abundance of *P. occidentalis*. Abundance varied between habitats, but in general the greatest abundance estimates occurred in habitats with abundant *A. flexuosa*.

Variation in foliage density and visibility make interpretation of these relative abundance estimates between sites and habitats difficult. The headtorching data from Emu Point suggested that this population had a higher abundance than at Locke Estate, but comparison between telemetry and mapping data indicated the reverse was the case. Pahl (1984) showed that abundance of *P. peregrinus* estimated by spotlighting at Lysterfield in Victoria varied by over an order of magnitude in adjacent habitats of that species. Similarly variable estimates of abundance were obtained for *P. occidentalis* in the Tuart forests at Ludlow where abundance adjacent to the Abba R. was nearly 10 times that recorded for the species in the central part of the Tuart forest at Ludlow (Hillcox pers. comm).

Density estimates for *P. occidentalis* populations were difficult to determine with any confidence because population estimates for Abba R. and Locke Estate indicated density varied markedly both within and between sites. At Locke Estate, for which the best estimate of population size was achieved, the density varied from between 2.5 ha^{-1}, if the whole *Agonis* forest on the reserve was considered, to 4.5 ha^{-1} when considering only areas with high drey abundance. Density at the central part of the Abba R. study site (5.5 - 6.4 ha^{-1}) was comparable to the more densely populated areas at Locke Estate. The density of *P. peregrinus* in Victoria showed seasonal variation that ranged from 12.4 ha^{-1} to 15.8 ha^{-1} over a 3 ha study site (How *et al.* 1984).

Demography

The growth rate of *P. occidentalis* pouch young of 0.417 ± 0.008 mm day^{-1} was considerably greater than that of *P. peregrinus* in Victoria (How *et al.* 1984) or for *P. herbertensis* in Queensland (Haffenden 1984). How *et al.* (1984: 262) noted that the growth rate for young and subadult *P. peregrinus* was not linear; an examination of that growth data over pouch life varied between 0.229 mm/day and 0.307 mm/day. The growth rate for *P. herbertensis* was 0.329 mm/day.

Young *P. occidentalis* emerged from the pouch at about 104 days of age with a headlength of about 50 mm. How *et al.* (1984) report *P. peregrinus* emerge from the pouch between 125–130 days when the headlength was 42–43 mm. Lactation in *P. occidentalis* ceases one month earlier than in *P. peregrinus*. These data indicate that young *P. occidentalis* grow faster. There was a suggestion that the rates of development of *P. occidentalis* Abba R. and Locke Estate may differ, but further data is required to confirm this.

Sex ratios in *P. occidentalis* vary significantly between our two major populations. At Abba R. the sex ratio did not differ significantly from parity in any of the four age categories. The sex ratio at Locke Estate favours females in all age categories although it was significantly different from parity (X^2_1 = 8.4; P<0.01) only amongst the adults. The combined pouch and dependent young age categories showed a significant (X^2_1 = 4.17; P<0.05) bias to females in the Locke Estate population. These data indicate that there could also be fundamental differences in the primary and secondary sex ratios between these two populations.

Births occur year round in *P. occidentalis* (this study and Ellis & Jones 1992). There appears are fewer young born during summer in the Busselton area. At Locke Estate there is a bimodality in births indicating two litter may be produced annually. Generally a single young was carried in the pouch, although at Locke Estate three instances (17% of observations) of twins were recorded. This reproductive pattern contrasts with *P. peregrinus* in Victoria where twins were the general case with about equal numbers of single young and triplets being recorded (How *et al.* 1984). Breeding in *P. peregrinus* was seasonal with a peak in May–June and a smaller peak in October–November; no births were recorded between mid-December and April (How *et al.* 1984, Pahl and Lee 1988).

Our limited data on survival suggests that mortality was greatest amongst juvenile *P. occidentalis* when they are beginning to disperse from their natal areas. This pattern of increased mortality amongst dispersing sub-adult individuals is characteristic of most marsupials except *Tarsipes* (Lee & Cockburn 1986).

Telemetry

The radiotelemetry studies of *P. occidentalis* at Abba R. revealed considerable overlap in their home ranges both between and within sexes, indicating that the species is not territorial.

This is the first published account of radiotelemetry studies on the range size and overlap for any *Pseudocheirus* spp. Consequently, data are not strictly comparable with earlier studies relying on CMR techniques only (Thomson and Owen 1964, Marsh 1967, How et al. 1984). However, the pattern of range usage and overlap with conspecifics appear similar to *P. peregrinus* in Eastern Australia.

Home ranges were smaller, on average, for individuals in higher density populations. At Abba R. female home range varied from 0.18–0.90 ha while males ranged from 0.60 – 3.60 ha. At Locke Estate, home ranges were 0.20 – 0.35 ha for females and 0.40 – 1.3 ha for males. Only females were monitored at Yendicup and their home ranges were 2.0–2.5 ha. Inions (1985) reported a home range of 2.6 ha for a male *P. occidentalis* at Perup.

Our data suggest that females ranged over a smaller area when accompanied by a dependent young or juvenile. At Abba R. many young establish home ranges adjacent to their natal areas, however, at Locke Estate limited data suggest young possums may disperse over 300 m from natal areas. No comparable dispersal data is available on *P. peregrinus* in southeastern Australia (How *et al.* 1984, Pahl 1987b).

Diet

The Western Ringtail Possum, *P. occidentalis*, like all other members of this arboreal genus, is an obligate foliovore.

Faecal analysis indicated that the major dietary item was leaves of one of the common Myrtaceous tree species in the habitat. At sites where *A. flexuosa* was common it constituted between 80–99% of the diet regardless of its abundance. At Yendicup and Mordalup, where *E. marginata*, *E. calophylla* are common and *A. flexuosa* is absent, over 90% of the diet consists of the leaves of these species. However, *E. calophylla* may be underestimated in our samples because the characteristic lower epidermis of the species was observed to break down quickly during the preparation of reference material. Consequently, there may be an underestimate of *E. calophylla* in our samples as the lower epidermis is essential to differentiating between these two eucalypt species.

In Eucalypt woodlands in eastern Australia Pahl (1987a) showed that the diet of *P. peregrinus* consisted of 61–98% of the dominant *Eucalyptus* spp., while over 95% of the diet in *Leptospermum laevigatum* thickets were of that species. He also noted that a higher proportion of understorey species were eaten at eucalypt sites where the dominant eucalypt species was not a preferred species. In the Tuart forests at Ludlow, *E. gomphocephala* was not a preferred species and over 95% of the diet consisted of *A. flexuosa*. It is probable that a similar preference occurs at Yallingup Ridge, where a high proportion of 'unknown' epidermal tissue was found in February 1992. Up to 20% of the diet consisted of plants other than the common trees.

The Western Ringtail Possum is an exception amongst herbivorous southwestern Australian mammals in having a low tolerance to sodium monofluroacetate (1080) that is more typical of southeastern Australian mammals and considerably lower than other southwestern species (D. King pers. comm.). This clearly indicates that *P. occidentalis* does not consume the foliage of *Gastrolobium* spp. (that is renowned for its high natural levels of fluoroacetates) despite the abundance of *G. bilobum* at Perup, and the occurrence of *Gastrolobium* spp. at other sites.

Foliage Nutrients

In this study levels of potassium in foliage of food plants was strongly correlated with relative abundance of *P. occidentalis*. Levels of potassium appeared relatively constant throughout the year although at Abba R. and Locke Estate it fell slightly in October. In the section on conservation and management it is speculated that towards the end of the year *P. occidentalis* may shift its dietary preference a little to obtain supplementary potassium (perhaps to *H. comptoniana*). Study of eastern Australian forests has also shown that species diversity of arboreal marsupial fauna is also a correlate with leaf nutrient levels (Braithwaite *et al.* 1983, 1984). Inions (1985) showed that at Perup, *T. vulpecula* spend more time foraging in those areas of their home range that had higher levels of foliage nutrients. Our data show that *P. occidentalis* were most abundant in vegetation with *A. flexuosa* as a dominant in stratum 1 or 2 and that *A. flexuosa* foliage is relatively high in leaf nutrients.

Characterisation of these patterns of foliage nutrients may well be valuable predictors of suitable or favoured habitat for *P. occidentalis*.

Comparison of nutrient levels at different sites showed *A. flexuosa* sites with high possum abundance shared a common pattern of relative nutrient levels that distinguish Abba R. and Locke Estate from all other sites.

Habitat

P. occidentalis are arboreal and occupy a variety of forests and woodlands although they occur more frequently in relatively damp areas of *A. flexuosa* or eucalypt forest. *A. flexuosa* was a common or codominant species in the habitat of most currently known populations, the exception being the Perup populations. Some *P. occidentalis* populations existed in highly disturbed habitats, the most extreme of which was urban Busselton. Rest sites, food and arboreal pathways for *P. occidentalis* were all provided by the common trees in the habitat. Old eucalypts were particularly important in providing hollows which were used as rest sites and provided greater protection from extreme heat than the dreys built by possums in near coastal areas.

Extremes in temperature and humidity may impact on the distribution of *P. occidentalis*. Our study showed that at the inland site (Perup) where the species occurred, dews were more frequent in January (the hot summer period) than other inland areas, and that hollows, which provided greater protection from heat, were the sole rest sites used.

Foxes were present at most *P. occidentalis* sites, though the opportunity for them to catch *P. occidentalis* was probably higher in areas where trees were more widely spaced and ground cover was low or sparse. Locke Estate and Abba River had contrasting fire histories (none at Abba R. and an extensive burn history at Locke Estate), yet at both sites *P. occidentalis* were abundant.

Rest Sites

Populations of *P. occidentalis* were either predominantly hollow users or drey builders. Hollows were the principal diurnal rest sites of *P. occidentalis* at sites where the vegetation was dominated by eucalypts. Generally the older the eucalypt tree the greater the number of hollows available for rest sites. Dreys were built as rest sites where the dominant tree species was *A. flexuosa*. This pattern of hollow using or drey building populations has been recorded in Victoria (Pahl 1984), where *P. peregrinus* use available hollows in eucalypt forests and woodlands, but build dreys in dense *Leptospermum laevigatum* thickets where eucalypts were absent.

The pattern of distribution of hollow and drey use *P. occidentalis* at Abba R. and throughout the species range suggested that drey use was restricted to moister habitats. During hot weather the cooler hollows (compared to dreys) would ameliorate environmental heat stress and assist conservation of body water. Consequently, hollow availability and quality could be important determinant in the process of local extinction in *P. occidentalis*, especially in inland areas. Dreys have been shown to be far less effective than hollows in ameliorating high ambient temperatures in *P. peregrinus* (Pahl 1987b) as on extremely hot days (>36°) this species frequently left dreys to seek shelter in the shade under the canopy. The catastrophic effects of prolonged periods of hot days on drey using *P. peregrinus* was documented by Pahl (1987b) who found 22 carcases on the ground after a period of several hot days in April 1983.

Predation

Our findings support the widely held belief that the fox, *Vulpes vulpes*, is an important predator of *P. occidentalis*. Foxes occur at many sites and have been responsible for the deaths of several individuals wearing radiotransmitters. There is also evidence that cats, *Felis catus*, predate *P. occidentalis* and that this is not uncommon in urban populations of *P. occidentalis*. Pahl (1987b) lists foxes, dogs and goshawks as predators of *P. peregrinus* with powerful owls, cats and wedgetailed eagles recorded in the literature as feeding on this species.

Indirect evidence from our study suggests that variation in habitat characteristics and *P. occidentalis* behaviour at different sites may be a more important determiner of predation levels than predator density *per se*. At sites where trees were widely spaced and the understorey was sparse or grazed, *P. occidentalis*, must travel more frequently on the ground and therefore be more susceptible to predation.

While we appreciate the impact of fox predation on southwestern mammals, the period and scope of the project only allowed us to establish baseline biological information on selected populations of *P. occidentalis*. This information is prerequisite before any procedures are adopted to control foxes.

MANAGEMENT AND CONSERVATION RECOMMENDATIONS

Management Focus

Association between relative abundance of *P. occidentalis* and habitat and disturbance variables indicate that the nutritional levels of foliage were of considerable importance. *P. occidentalis* appeared to have an abundant supply of major food items (*A. flexuosa* and *Eucalyptus*) throughout the year. There was a trend, however, for them to utilise more of other species of plants in their diet towards the end of the year. Because K was the only important nutritional element in the major food plants that changed throughout the year (tends to decrease towards the end of the year in *A. flexuosa* only), it was possible that this slight dietary shift was to obtain supplementary K, perhaps from *Hardenbergia*. The adequate availability of food throughout the year was perhaps indicated by: their small home ranges; general lack of excursions from their home ranges; ability (at least of Locke Estate) to breed twice in a calender year which shows that lactation was not restricted by availability of food resources as was the case in many Australian mammals (see Tyndale Biscoe, 1973); population stability (twins are rare compared to congerics – and juveniles take up home ranges close to their natal home range).

It would appear, then, that factors that are likely to regulate population numbers of *P. occidentalis* within their present distribution, relate not to food or space (they are not territorial) but to shelter and predation. Shelter relates to both rest site availability and the continuity of the canopy.

It would appear that in the near coastal study sites containing *A. flexuosa*, either as a dominant or co-dominant tree, adequate hollows or sites for dreys occur and adequate branch connections exist between the foliage of adjacent trees (neither is a significant correlate with relative abundance of *P. occidentalis*). We document that older stands of *Eucalyptus* provide the most abundant hollows and that sites with the best branch connections between trees are those with the highest percentage canopy cover. Further, at Locke Estate the majority of dreys are built in *Acacia truncata* despite the fact that this *Acacia* is a minor element of the vegetation, also, dreys are more common in *A. flexuosa* if a tree has *Hardenbergia* creeper because it afforded good material for drey construction.

Clearly, management strategies aimed at providing *P. occidentalis* with favourable shelter should focus on methods of maintaining and preferably enhancing availability of rest sites and canopy connections between trees. This could be achieved by:

- protection of old and senescent trees, especially *Eucalyptus*;
- maintenance of *Acacia truncata* trees and *Hardenbergia* climbers in *A. flexuosa* dominated associations;
- reduction of processes that artificially thin forest (cutting, predation on seedlings, fire) and reduce foliage connections;
- provision of artificial rest sites (nest boxes);

Exotic predators, such as foxes and cats, may be an important factor in influencing the abundance of *P. occidentalis*. Direct evidence (fox kills) and circumstantial evidence from the impact of foxes on other small mammal species in the South West would support this. Elimination of fox and cat is also a priority project, particularly in those areas where foliage density is low.

We recommend that separate field trials be carried out in *Eucalyptus* and *A. flexuosa* to determine the relative importance to abundance of *P. occidentalis* of foliage connections, seral stage, and fox baiting. Also, in *Eucalyptus* the provision of artificial nest boxes and in *A. flexuosa* the presence of *Acacia truncata* and *Hardenbergia* (both as a source material for dreys and its potential role as a supplement for K in their diet) be evaluated.

If *Acacia truncata* and *Hardenbergia* are proven to be associated with *P. occidentalis* abundance in sites dominated by *A. flexuosa*, then an ecological study should be carried out on these plant species to determine the conditions that favour them in *A. flexuosa* associations.

Selection of sites for restocking with P. occidentalis.

Reintroduction of *P. occidentalis* to areas from which they have disappeared is an important aspect of the conservation of the species in the southwestern Western Australia. Selection of such areas needs to be carried out with care. The results of our grouping of study sites on the basis of the nutritional status of their foliage, facilitates such a selection process – particularly as levels of potassium are closely correlated with relative abundance of *P. occidentalis*. From Figure 16 it is apparent that the two Busselton sites and M1 and WI form a tight group on the basis of their levels of foliage nutrients. The other two groups (leaving aside the aberrant Emu Point site which is located on a sewerage dump) are quite distinct. *P. occidentalis* was found only in the first (at Busselton) of these three site groupings and at Emu Point. Our results show that the sites M1 and WI would appear to be the best prospects for reintroduction of *P. occidentalis* because they appear to have foliage of preferred nutritional status (as well as other habitat requirements). Wilsons Inlet (WI) also had very high mean February levels of K (0.71 % gm^{-1}) and a moderately high PCI coefficient value for all nutrients (0.63) (February data are not available for M1).

Population requirements

Some global management strategies may be applied to *P. occidentalis* in southwestern Western Australia, such as predator control, maintenance of canopy connections and preservation of older trees. However, our data indicate that populations in *A. flexuosa* dominated associations (e.g. Locke Estate) had different life history strategies from those in *Eucalyptus* dominated associations (e.g. Abba R.). For example, apart from the obvious differences of an emphasis in drey and hollow use in *A. flexuosa* associations, Locke Estate had a statistically higher proportion of female pouch young and dependent young than Abba R., and some Locke Estate females bred twice a year; Abba R. females bred only once. This would indicate that more biological information is required for populations in these different vegetation types because sensitive management of the species may require different strategies be adopted in *Agonis* associations from those applied to *Eucalyptus* associations.

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TABLE CAPTIONS

Table 1: Summary of sites surveyed for both *P. occidentalis* (WRP) and *T. vulpecula* (BTP), the survey activities and the survey results. Codes for survey activity are as follows: HT: headtorching, VS: vehicle spotlighting, WS: spotlighting on foot, DS: day search, NS: night search.Abundance is shown as possums sighted per unit (per hour or per kilometre). Figures in brackets following the abundance figure show the number of possums seen/the number of sightings (possums in the same or adjacent trees). The number of possums seen gives an indication of the sample size used to derive the abundance figures.

Table 2: Faecal pellet abundance rank for *P. occidentalis* and *T. vulpecula* at different sites. 0, no pellets fund; 5 abundant. * indicates no pellets were found though other evidence showed possum presence.

Table 3: Drey abundance and occupancy rates at different sites. Drey abundance is quantified as dreys encountered per hour. Occupancy rate is the number of dreys occupied when checked per the total checked.

Table 4: Mean measurements of adult *Pseudocheirus occidentalis* external characters [$\bar{x} \pm$ SE (n)] in southwestern Western Australia.

Table 5: Sex ratios of *P. occidentalis* in the four age categories for Abba R. and Locke Estate populations and for combined populations.

Table 6: The percentage of *P. occidentalis* observed at Abba R. with full pouches.

Table 7: The percentage of sightings for each of six male *P. occidentalis* in the company of another adult, and the area of forest used by males at Abba R.

Table 8: Contribution of different plant species to the diet of *P. occidentalis*, expressed as a percentage of the total surface area and as a percentage of the number of fragments counted. Month indicates the month of collection of pellets and codes for plant species are as follows: A: *A. truncata*, H: *H. comptoniana*, HP: *H. comptoniana* pods, HI *Hibbertia* sp, J: *E. marginata*, M: *E. calophylla*, P: *A. flexuosa*, R: *R. baccata*, U: unknown. All codes relate to leaves except that for *H. comptoniana* pods. The number of pellets counted for each site or season is given in Table 9.

Table 9: The relative contribution of the major plant food (*A. flexuosa* or *E. marginata*) to the diet of *P. occidentalis* at different sites and in different seasons. The percentages are derived using the percentage of fragments counted. The number of pellets counted per sample is shown. The number of different epidermal types recognised within the unknown category in a sample is listed for each site.

Table 10: The position at first sighting for *P. occidentalis* at Yendicup and at Abba R., expressed as a percentage of forty sightings for each site.

Table 11: Average and standard deviation for values of N, P, K, and Ca in different plant species in February and June or July. Some figures result from averaging species results from different sites. n, sample size marked with an asterisk were from by pooled collections from six trees prior to chemical analysis; all others are from a single tree.

Table 12: Standardised canonical variate coefficents based on the four nutrient levels in *A. flexuosa* leaves from 6 sites in February and 10 sites in June–July.

Table 13: Hollow and drey abundance at different *P. occidentalis* sites. The dominant vegetation type (as defined in Habitat, Vegetation floristics) for the site is listed. The abundance of hollows is listed as a percentage and as the number of trees in the sample which had at least one hollow higher than 1 m above ground level. Drey abundance is quantified as dreys per hour during day-search. The maximum distance of the site from the ocean and from the nearest substantial body of water (read from maps) is also shown.

Table 14: Relative abundance of *P. occidentalis* at 16 coastal or near coastal sites which had *A. flexuosa* as a dominant or co-dominant tree. See Appendix I for description of site codes. Habitat and other variables presented for each site are as follow: Vegetation type, 1 – *A. flexuosa* only, 2 – *A. flexuosa* and *Eucalyptus*. Number of tree species; Number of common plant species, i.e. those above 10% of the cover, excluding exotic weeds or pasture; number of vegetation strata; percentage foliage cover in both strata 1 and 2; average number of branch connections with adjacent trees; mean nutrient foliage levels in February of N, K, P, and Ca; percentage of trees with at least one hollow; percentage of trees with burn scars; evidence of cutting of trees, – 1 none, 2 – some; distance from fresh water or ocean; fox baiting during the last three years, 1 – none, 2 – some.

TABLE 1

Site Code	Site name	Survey outcome		Survey activity		Quantitative night survey results *P. occidentalis*			Quantitative night survey results *T. vulpecula*		
		WRP	BTP	DS	NS	HT possums per hr	VS possums per km	WS possums per hr	HT possums per hr	VS possums per km	WS possums per hr
S1	Beverley	0	+	+	+	-	0	-	-	0.6 (2/2)	-
S2	Tuttaning	0	+	-	+	-	0	-	-	0.4 (5/5)	-
S3	Boyagin	0	0	-	+	-	0	-	-	0 -	-
S4	Pingelly	0	+	+	+	-	-	0	-	-	3.0 (2/2)
S5	Melros	0	+	+	-	-	-	-	-	-	-
S6	Yalgorup NP	0	0	+	-	-	-	-	-	-	-
S7	Yalgorup NP	0	0	+	-	-	-	-	-	-	-
S8	Yalgorup NP	0	0	+	-	-	-	-	-	-	-
S9	YNP, Martins Tank	0	+	+	+	0	-	-	3.0 (3/2)	-	-
S10	YNP L. Haywood	0	+	+	-	-	-	-	-	-	-
S11	Leschenault Pen	0	+	+	+	-	0	-	-	0.1 (2/2)	-
S12	Collie R.	+	?	+	-	-	-	-	-	-	-
S14	Ludlow Swamp	+	+	+	+	-	0.9 (6/4)	-	-	0.2 (1/1)	-
S15	Ludlow Settlement	+	+	+	+	-	-	2.6 (2/2)	-	-	4.0 (3/3)
S16	Abba	+	+	+	+	5.0 (10/5)	3.0 (5/3)	1.8 (8/6)	2.0 (2/2)	0.6 (1/1)	1.5 (7/5)
S17	Ruabon	+	0	+	+	2.7 (2/2)	-	-	0	-	-
S18	Forrest Beach	+	+	+	+	4.0 (3/2)	0.7 (2/1)	-	0.8 (1/1)	-	-
S19	GBDS	+	0	+	+	6.0 (3/1)	0.3 (1/1)	0	0	0	0
S21	Locke	+	0	+	+	0.9 (1/1)	-	1.0 (1/1)	0	-	0
S22	Yallingup Ridge	+	+	+	-	-	-	-	-	-	-
S23	Ellensbrook	+	?	+	-	-	-	-	-	-	-
S24	Boranup	+	?	+	+	0	-	0	0	-	0
S25	East Augusta	+	0	+	+	8.0 (4/2)	0.8 (2/3)	-	0	0	-
S25	East Augusta North	0	+	+	-	-	0	-	-	0.2 (1/1)	-
S26	Scott R.	0	0	+	+	-	0	-	-	0	-
S27	Sues Bridge	0	+	+	+	-	-	0	-	-	2.6 (4/4)
S28	Schroders Pool	+	+	+	-	-	-	-	-	-	-
S29	Alexander Bridge	0	0	+	-	-	-	-	-	-	-

TABLE 1 cont.

Site Code	Site name	Survey outcome		Survey activity		Quanitaitive night survey results *P. occidentalis*			Quanitaitive night survey results *T. vulpecula*		
		WRP	BTP	DS	NS	HT possums per hr	VS possums per km	WS possums per hr	HT possums per hr	VS possums per km	WS possums per hr
S30	Gardener R.	0	0	+	+	-	0	-	-	0	-
S31	Yendicup	+	+	+	+	-	2.3 (18/10)	-	-	1.8 (14/10)	-
S32	Mordalup	+	+	+	+	-	0.7 (11/9)	-	-	0.8 (9/7)	-
S34	Denmark	0	0	+	+	-	-	0	-	-	0
S35	Wilsons Inlet	0	0	+	-	-	-	-	-	-	-
S36	Wilsons Inlet (E)	0	0	+	+	-	0	-	-	0	-
S38	West Cape Howe NP (W)	0	0	+	-	-	-	-	-	-	-
S39	West Cape Howe NP	0	0	+	+	-	0	-	-	0	-
S40	Cosy Corner	0	0	+	+	-	0	-	-	0	-
S42	King R.	0	0	-	+	-	0	-	-	0	-
S43	Lower Kalgan	0	0	+	+	-	0	-	-	0	-
S44	Emu Point	+	0	+	+	1.8 (8/5)	0.5 (2/1)	2.4 (6/4)	0	0	0
S45	Mt Melville	0	0	+	+	-	0	0	-	0	0
S46	Mt Clarence	0	+	+	+	-	-	0	-	-	1.0 (1/1)
S47	L.Seppings	0	0	+	+	0	-	-	0	-	-
S48	Middleton Beach	0	0	+	+	-	-	0	-	-	-
S49	Porongorup NP	0	0	+	+	-	0	-	-	0	-
S50	Stirling Ra. 7 k out	0	+	+	-	-	-	-	-	-	-
S51	Stirling Ra. WGF	0	+	+	-	-	-	-	-	-	-
S52	Stirling Ra. Magog	0	+	+	+	-	-	-	-	-	-
S53	Stirling Ra. Talyaberlup	0	+	+	+	-	-	0	-	-	2.0 (2/1)
S54	Kambellup	0	+	+	+	-	-	0	-	-	0
S55	TPB Area	0	0	-	+	-	0	-	-	0	-
S56	TPB, N Lake	+	0	+	+	-	-	0	-	-	-
S57	TPB, Office	+	0	+	+	-	-	2.0 (1/1)	-	-	-
S58	TPB, TFG	+	0	+	+	-	-	0	-	-	-
S59	TPB, LFG	+	0	+	+	0.8 (1/1)	-	0	-	-	-
S60	TPB, UFG	+	0	+	+	-	-	0	-	-	-
S61	TPB, Robinsons	+	0	+	+	-	-	0	-	-	-

TABLE 2

Site Code	Site Name	Faecal Pellet Abundance code	
		P.occidentalis	*T.vulpecula*
S1	Beverley	0	5
S4	Pingelly	0	5
S5	Melros	0	1
S9	YNP, Martins Tank	0	4
S10	Yalgorup NP, L. Haywood	0	2
S11	Leschenault Pen	0	0 *
S14	Ludlow Swamp	2	2
S15	Ludlow Settlement	4	2
S16	Abba	4	3
S18	Forrest Beach	5	2
S19	GBDS	2	0
S21	Locke	4	0
S23	Ellensbrook	0 *	0
S25	East Augusta	4	0
S27	Sues Bridge	0	2
S28	Schroders Pool	1	2
S31	Yendicup	3	2
S32	Mordalup	2	2
S44	Emu Point	3	0
S46	Mt Clarence	0	1
S50	Stirling Ra. 7km out	0	2
S51	Stirling Ra. WGF	0	1
S52	Stirling Ra. Magog	0	1
S53	Stirling Ra. Talyaberlup	0	3
S54	Kambellup	0	2
S55	TPB Area	1	0
S56	TPB, N Lake	0 *	0
S57	TPB, Office	1	0
S58	TPB, TF Gully	1	0
S59	TPB, FB Gully	2	0
S61	TPB, Robinsons	2	0

TABLE 3

Site Code	Site Name	DREYS Dreys/hr	OCCUPANCY RATE No occ. dreys per total checked %	raw
S14	Ludlow Swamp	0	-	-
S15	Ludlow Settlement	0	-	-
S16	Abba	0.3	50	1/2.
S18	Forrest Beach	3.0	29	2/7.
S19	GBDS	2.5	25	4/16.
S21	Locke	4.5	33	3/9.
S23	Ellensbrook	1.0	0	0/1.
S25	East Augusta	3.5	33	2/6.
S44	Emu Point	3.0	22	2/9.
S56	TPB, N Lake	1.0	100	1/1.
S57	TPB, Office	0	-	-
S58	TPB, TFG	8.0	0	0/8.
S59	TPB, LFG	4.0	0	0/3.
S60	TPB, UFG	8.0	0	0/4.
S61	TPB, Robinsons	6.6	-	-
S27	Sues Bridge	0	-	-

TABLE 4

	Adult ♂♂	Adult ♀♀
Weight (g)	1039 ± 14.9 (44)	1062 ± 12.5 (77)
Headlength (mm)	72.07 ± 0.51 (44)	72.05 ± 0.36 (76)
Ear length (mm)	29.56 ± 1.08 (43)	31.54 ± 0.67 (76)
Tibia length (mm)	74.84 ± 3.20 (43)	78.28 ± 2.00 (76)
Tail base (mm)	166.8 ± 8.9 (44)	201.5 ± 9.9 (76)
Tail length (mm)	331.9 ± 18.7 (44)	376.3 ± 7.6 (76)
Base /length (%)	47.86 ± 1.57 (39)	53.48 ± 2.37 (74)

TABLE 5

Adults	Pouch Young			Dependent Young		Juveniles			
	♂	♀	?	♂	♀	♂	♀	♂	♀
Abba River	4	3	3	5	4	6	6	21	16
Locke Estate	6	14	4	3	6	3	9	20	43
Σ *P. occidentalis*	12	17	12	9	10	13	18	53	89

TABLE 6

Month 1991	# females sighted with full pouch	# WRP sighted	% of Possum sighted with full pouch
Jan	1	6	17
Feb	0	7	0
Mar	0	4	0
Apr	0	6	0
May	0	15	0
Jun	0	2	0
Jul	1	6	17
Aug	4	19	21
Sep	3	9	30
Oct	2	6	33
Nov	1	4	25
Dec	2	7	28

TABLE 7

Possum #	% sighting with adult	Area (ha)
2	16	3.60
8	42	1.30
10	20	0.44
15	17	0.85
39	6	0.72
54	25	1.20

TABLE 8

Site name	Month	Plant Species	Plant Species % by Surface Area	No. of fragments
Abba	2	A	00.9	00.7
Abba	2	H	00.5	00.3
Abba	2	HI	00.0	00.1
Abba	2	P	95.6	96.1
Abba	2	U	03.0	02.3
Abba	5	P	95.9	98.1
Abba	5	U	04.1	01.8
Abba	8	A	00.7	00.1
Abba	8	P	95.3	97.3
Abba	8	U	04.3	02.1
Abba	10	A	00.0	00.1
Abba	10	H	02.9	00.2
Abba	10	HI	01.0	01.3
Abba	10	HP	00.0	00.1
Abba	10	P	82.6	80.3
Abba	10	R	00.8	01.1
Abba	10	T	00.0	00.2
Abba	10	U	15.3	16.9
Emu Point Chalet	2	A	07.4	03.1
Emu Point Chalet	2	P	84.2	89.0
Emu Point Chalet	2	U	08.5	08.0
Emu Point Chalet	6	A	06.3	02.5
Emu Point Chalet	6	P	93.5	90.1
Emu Point Chalet	6	U	00.2	00.3
Emu Point Park	2	A	01.7	02.0
Emu Point Park	2	P	93.8	95.5
Emu Point Park	2	U	00.0	04.1
Emu Point Park	6	A	00.4	00.3
Emu Point Park	6	P	80.9	88.8
Emu Point Park	6	U	18.7	11.1
Forrest Beach	2	P	99.6	99.5
Forrest Beach	2	U	00.4	00.5
Forrest Beach	6	A	00.0	00.3
Forrest Beach	6	P	98.4	99.4
Forrest Beach	6	U	01.5	02.1
Locke	2	A	10.3	04.9
Locke	2	P	85.8	93.1
Locke	2	R	00.9	00.3
Locke	2	U	00.3	01.5
Locke	10	A	06.5	02.9
Locke	10	H	00.9	00.3
Locke	10	P	90.5	94.6
Locke	10	U	03.0	01.8
Yallingup Ridge	2	A	06.8	00.6
Yallingup Ridge	2	P	79.1	86.3
Yallingup Ridge	2	U	20.2	13.1
Yedicup	6	J	90.7	87.4
Yedicup	6	M	03.4	04.0
Yedicup	6	U	06.0	08.6
Mordalup	7	J	98.4	97.5
Mordalup	7	U	01.4	02.5

TABLE 9

Site name	# Pellets	Month	Major species	% Major species	% Unknown species	# Epidermal types included in Other
Abba	14	2	P	96.14	3.86	5
Abba	14	5	P	98.07	1.93	2
Abba	16	8	P	97.25	2.75	3
Abba	10	10	P	80.30	19.70	7
Emu Point Chalet	8	2	P	89.00	11.00	3
Emu Point Chalet	16	6	P	90.13	9.88	3
Emu Point Park	8	2	P	95.50	4.50	2
Emu Point Park	8	6	P	88.75	11.25	9
Forrest Beach	8	2	P	99.50	0.50	0
Forrest Beach	16	6	P	99.44	0.56	2
Locke	16	2	P	93.13	6.88	3
Locke	16	10	P	94.56	5.44	5
Yallingup Ridge	8	2	P	86.25	13.75	5
Yendicup	16	6	J	87.36	12.64	1
Mordalup	16	7	J	97.52	2.48	1

TABLE 10

AT YENDICUP

	JARRAH			MARRI			*E.RUDIS*	*HAKEA*	*XANTHORRHEA*
	Foliage	Branch	Trunk	Foliage	Branch	Trunk	Branch	Foliage	Foliage
%	42.5	7.5	12.5	17.5	5	7.5	2.5	2.5	2.5

AT ABBA

	PEPPERMINT			TUART			*H.COMPTONIANA*
	Foliage	Branch	Trunk	Foliage	Branch	Trunk	Foliage
%	70	15	7.5	2.5	0	0	5

TABLE 11

Species	Mo	N		P		K		Ca		
		Average	Stdev	Average	Stdev	Average	Stdev	Average	Stdev	n
Hardenbergia	6	3.363	0.26	0.202	0.00	1.740	0.31	0.631	0.25	3
Hardenbergia	2	2.234	0.20	0.053	0.02	0.757	0.14	1.795	0.80	3
Jarrah	6	0.925	0.22	0.031	0.01	0.484	0.29	0.199	0.01	2 *
Jarrah	2	0.927	0.19	0.025	0.02	0.484	0.09	0.144	0.06	6
Marri	6	0.933	0.76	0.028	0.00	0.581	0.21	0.230	0.06	3 *
Marri	2	1.062	0.19	0.032	0.03	0.786	0.08	0.241	0.07	6
Wandoo	6	0.043	0.05	0.411	0.02	0.280	0.05	0.043	0.11	2 *
Wandoo	2	0.763	0.14	0.017	0.00	0.823	0.04	0.218	0.01	2
Tuart	7	1.163	0.06	0.072	0.02	0.441	0.08	0.734	0.27	3
Peppermint	2	1.200	0.10	0.060	0.03	0.570	0.11	0.440	0.12	6
(Locke)	6	1.410	0.07	0.070	0.02	0.590	0.11	0.410	0.01	2 *

* indicates these samples pooled from six trees, prior to chemical analysis

TABLE 12

	Function 1	Function 2	Function 3
February N	0.72857	0.7459	NS
P	0.0828	1.2172	
K	0.7855	−0.7276	
Ca	−0.4293	−0.4278	
Variation explained (%)	57	39	
June–July N	0.2671	0.7005	−0.6382
P	0.2903	0.3707	−0.5833
K	0.6948	0.4243	0.5787
Ca	−0.6914	0.6722	0.2352
Variation explained (%)	48	29	16

TABLE 13

Site	Vegetation type	ABUNDANCE Hollows %	Hollows raw	Dreys /hr	DISTANCE to water km	to ocean km
S18 Forrest Beach	Peppermint	0	0 in 20	3.0	< 1	< 1
S19 GBDS	Peppermint	0	0 in 20	2.5	< 1	< 1
S25 East Augusta	Peppermint	0	0 in 20	3.5	< 1	< 2
S44 Emu Point	Peppermint	0	0 in 40	3.0	< 1	< 1
S21 Locke	Peppermint	3	2 in 60	4.5	< 2	< 2
S15 Ludlow Settleme	Marri & Peppermint	5	1 in 20	0	< 4	< 4
S22 Yallingup Ridge	Marri & Peppermint	10	2 in 20	0	< 3	< 3
S31 Yendicup	Marri & Jarrah	15	6 in 40	0	<12	c.90
S16 Abba	Tuart & Peppermint	20	12 in 60	0.3	< 4	< 4
S32 Mordalup	Marri, Jarrah, Wandoo	20	8 in 40	0	< 2	c.90
S60 Two Peoples Bay	Marri & peppermint	25	5 in 20	8.0	< 2	< 2

TABLE 14

Site	P.occ. abun.	Veg. type	# tree sp.	# of common plant sp	# strata	% fol cover strata 1	% fol cover strata 2	Average # connections	Mean K	Mean N	February $\chi_{gm^{-1}}$ P	February $\chi_{gm^{-1}}$ Ca	Hollow abun.	% Trees with burn scars	% Trees dead	Evidence of cutting N = 1 Y = 2	Distance water (km)	Baiting N = 1 Y = 2
S15	5	2	4	6	4	15	40	2.8	-	-	-	-	0	5	20	2	4	1
S16A	5	2	2	4	3	15	90	4.5	.6	1.17	.06	.31	25	0	5	2	4	2
S16B	5	2	2	3	3	30	80	2.6	.72	1.13	.06	.59	25	5	5	2	4	2
S16C	5	2	2	2	3	15	65	2.8	.65	1.18	.05	.28	10	0	0	2	4	2
S18	6	1	1	5	2	80	0	3.0	-	-	-	-	0	0	0	1	1	1
S19	3	1	1	4	2	70	15	2.5	-	-	-	-	0	10	5	1	1	2
S21A	5	1	2	7	3	10	90	3.4	.58	1.26	.04	.49	10	40	5	1	2	1
S21B	5	1	2	6	4	5	70	3.1	.56	1.12	.08	.37	0	5	0	1	2	1
S21C	5	1	1	4	4	8	50	3.7	-	-	-	-	0	5	0	1	2	1
S22	3	2	5	5	3	70	35	3.6	-	-	-	-	10	55	0	1	3	1
S23	1	1	2	6	4	90	30	4.4	-	-	-	-	0	0	0	1	2	1
S24	1	2	3	9	4	10	80	3.0	-	-	-	-	0	0	0	2	2	1
S25	5	1	2	11	3	85	40	3.2	-	-	-	-	0	0	0	1	1	1
S44A	4	1	1	3	2	90	0	3.3	.48	1.18	.05	.34	0	0	0	1	1	1
S44B	4	1	4	8	2	90	0	3.6	.38	1.09	.03	.44	0	0	5	1	1	1
S59	2	2	3	11	3	70	0	0.7	-	-	-	-	25	2.5	10	1	1	2

FIGURE CAPTIONS

Figure 1: Localities of all *P. occidentalis* populations extant between 1990–1992. Site codes are as follows: A: Collie R. (S12); B: Peppermint Grove (S13); C: Ludlow, Ruabon and Forest Beach (S14–18); D: GBDS (S19) and Busselton (S20); E: Locke Estate (S21); F: Yallingup Ridge (S22); G: Ellensbrook (S23); H: Boranup (S24); I: East Augusta (S25); J: Perup (S31, S32); K: Elleker (S41); L: Albany area (S44–48); M: King R. (S42); N: Two Peoples Bay (S56–61).

Figure 2: Distribution of all *P. occidentalis* locality records. Populations extant between 1990–1992 are indicated by a triangle. Records associated with a population not verified as extant are represented by numbers: the year given is that of the most recent record. The basis for each record is also given. WAM, denotes a W.A. Museum specimen. If available site descriptions are given in Appendix 1. Codes are as follows: 1: Chidlow (pers. comm. from a trapper's son, early 1940's); 2: Kalamunda (Douglas, 1980); 3: Pingelly, (sighting, 1982); 4: Tuttaning Reserve (WAM, 1961); 5: Donnybrook (WAM, 1932); 6: Newlands (WAM, 1932); 7: Margaret R. (Shortridge, 1909, bone in cave); 8: Blackwood R. (sightings, 1987); 9: Palgarrup (roadkill, 1990); 10: Pemberton (WAM, 1916); 11: Northcliffe (sightings, 1975); 12: William Bay (bone); 13: West Cape Howe (sightings, *c.* 1975); 14: Cranbrook (WAM, 1908, Tunney's specimens); 15: Kamballup (reported roadkill, 1987); 16: Porongorup (bone).

Figure 3: Map showing the distribution of dreys (◊), platforms (u) and sightings (●) at Geographe Bay.

Figure 4: Map showing the distribution of dreys (◊) and sightings (●) at Emu Point.

Figure 5: Map showing the distribution of dreys (●) at Locke Estate.

Figure 6: Period of births for *P. occidentalis* in south-western Australia. Data are derived by aging pouch young from headlengths using the algorithm presented in this paper for dependent and juvenile young using the weight relationship in Ellis & Jones (1992). A = Abba River; B = Busselton; F = Forest Beach; G = Geographe Bay; L = Locke Estate.

Figure 7: All LOCs (see text for explanation) associated with the Abba R. *P. occidentalis* telemetry study between November 1990 and March 1992. (□ Females and ■ males. Lines enclose LOCs for a single animal).

Figure 8: All LOCs (see text for explanation) associated with the Locke Estate *P. occidentalis* telemetry study between November 1990 and March 1992. (□ Females and ■ males. Lines enclose LOCs for a single animal).

Figure 9: The relationship between the estimates of *P. occidentalis* range size at Abba R. and the number of LOCs on which the estimate is based for (a) females and (b) males.

Figure 10: Home range size for *P. occidentalis* female #53 (at Abba R.) while accompanied by young 120–200 g (■), and after the young reached about 250 g (□).

Figure 11: Home ranges of *P. occidentalis* adult females and their 'independent' young at Abba R. The mother's range is represented by solid squares, and the offspring by open symbols (□: male #39,△: female #13, ◊: female #52).

Figure 12: Plot of PCA coefficients for factors 1 and 2 based on analysis of *A. flexuosa* foliage nutrient levels (N, K, P, Ca) at ***all*** sites.

Figure 13: Mean level of nutrients in *A. flexuosa* samples at different sites and in different months. Codes are as follows: A: Abba R., G: GBDS, L: Locke Estate, W. Wilsons Inlet E, E: Emu Point (all EP sites except EG), EG: Emu Point Griffiths, LP: all LP samples. The month of collection is shown as a figure following the code.

Figure 14: Magnitude of each nutrient's discriminant coefficient on the discriminant function that describes the seasonal contrast (February and October samples) in *A. flexuosa* foliage nutrient levels (N, K, P, Ca) for Locke Estate and Abba R. (site results analysed separately).

Figure 15: Plot of group centroids resulting from CVA of *A. flexuosa* foliage nutrient levels (N, K, P, Ca) in October and February at Locke Estate and at Abba R. Site codes are as follows: A: Abba R., E: Emu Point chalet, EG, Emu Point, Griffiths St, LO: Locke Estate, LB: Leshenault Peninsula, Belvederere, LN: Leshenault Peninsula, North.

Figure 16: Plot of group centroids resulting from CVA of *A. flexuosa* foliage nutrient levels in June-July. Site codes are as follows: M1 and M2: Martins Tank, LS: Leschenault Peninsula South, LC: LP Central, LN: LP North, WI: Wilsons Inlet, ER: Emu Point "ridge", EC: EP "chalet", EG: EP Griffiths St, BU: a group of Busselton sites including Abba R., Locke Estate, Ludlow and Geographe Bay Development Site.

Figure 17: Levels of nutrients in *A. flexuosa* samples at Emu Point.

Figure 18: The relationship between the number of trees that are joined at canopy level (mean number of connections/tree) and the percentage of vegetation cover (for the most extensive tree strata) at different sites. Sites without *A. flexuosa* (■), those with both *A. flexuosa* and *Eucalyptus* (□) and those with *A. flexuosa* only (◊).

Figure 19. Abundance of trees with at least one hollow (n = 20) expressed as a percentage of trees at sites with different forest types.

Figure 20. Hollow abundance and tree size: estimates of number of hollows in *E. calophylla* (□); *E. marginata* (■) and *E. gomphocephala* (◊) trees of different diameter at breast height (DBH).

Figure 21. Map showing the average minimum daily temperature isotherms, average (9am) relative humidity contour lines and calculated dew point for January.

Figure 22. Map showing the distribution of dreys (▲) and platforms (u) at Abba R.

Figure 23: Plot showing the difference between rest site and ambient temperature for Abba R. *E. gomphocephala* hollows and Locke Estate dreys. The air temperature and rest site temperature was recorded five times during daylight hours in February for four hollows at Abba R. (1-4), and three dreys (5, 6 & 8) and one rest site (7- no drey) at Locke Estate.

FIGURE 1

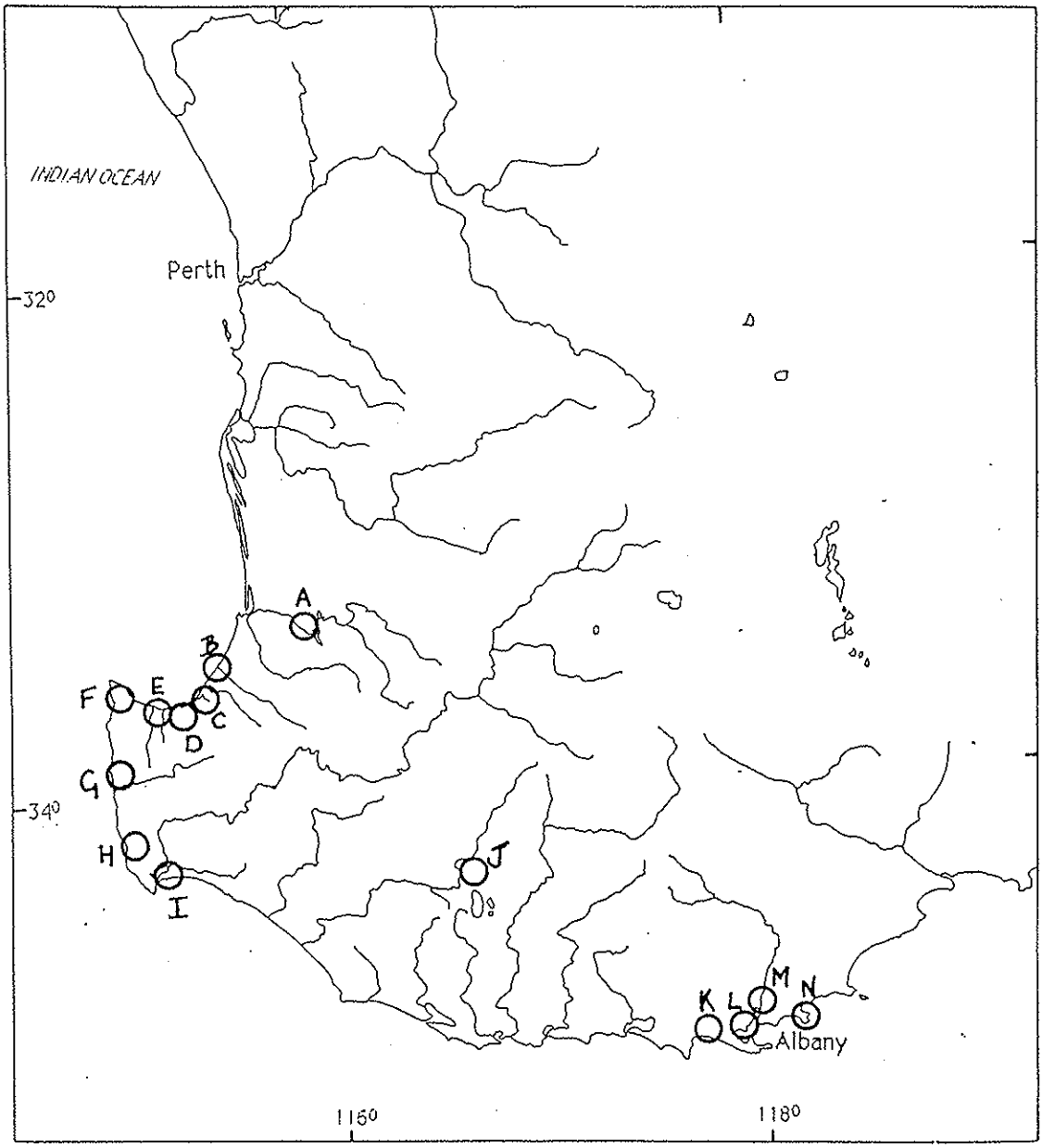


FIGURE 2

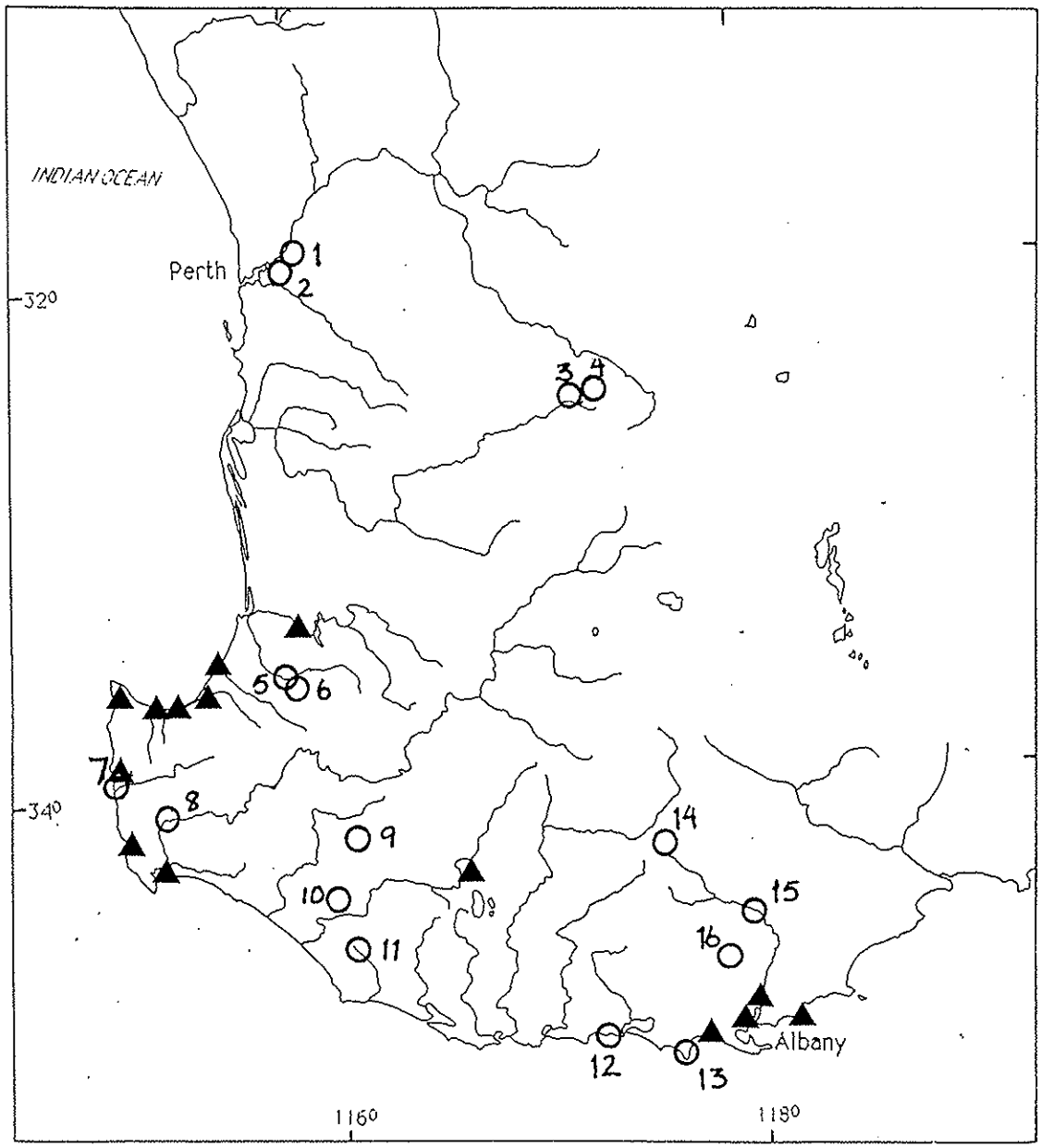

INDIAN OCEAN
Perth
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Albany
32°
34°
116°
118°

FIGURE 3

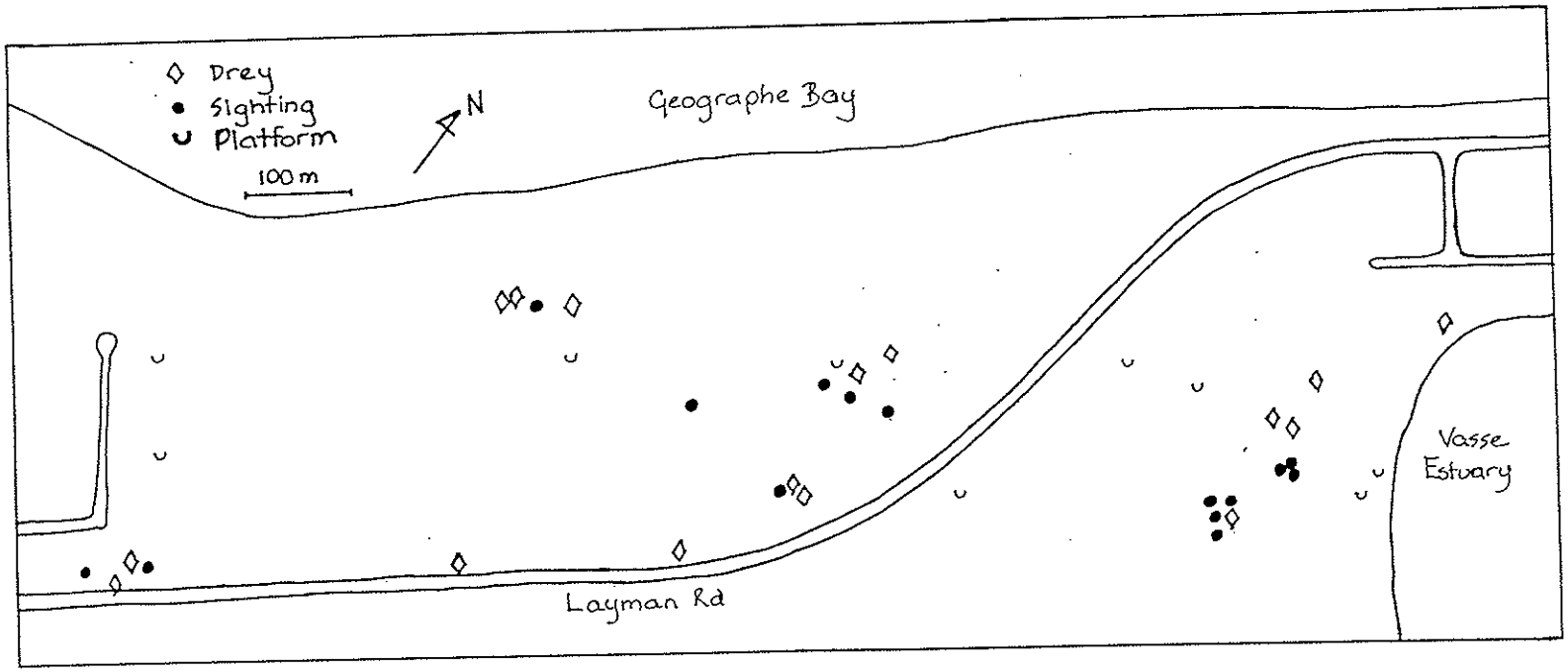

Drey
Sighting
Platform
100 m
N
Geographe Bay
Vasse Estuary
Layman Rd

FIGURE 4

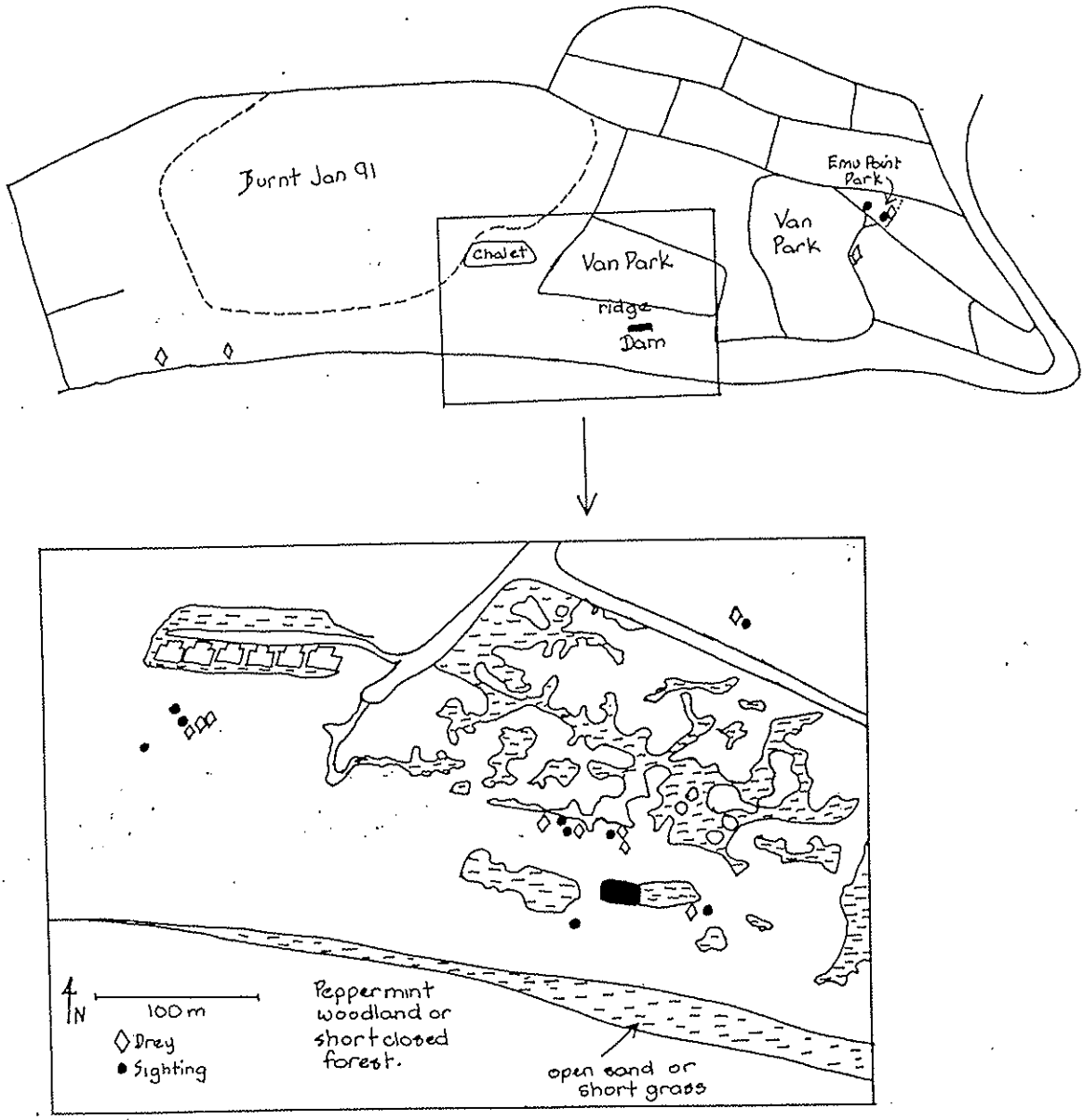

Burnt Jan 91
chalet
Van Park
ridge
Dam
Emu Point Park
Van Park
N
100 m
Drey
Sighting
Peppermint woodland or short closed forest.
open sand or short grass

FIGURE 5

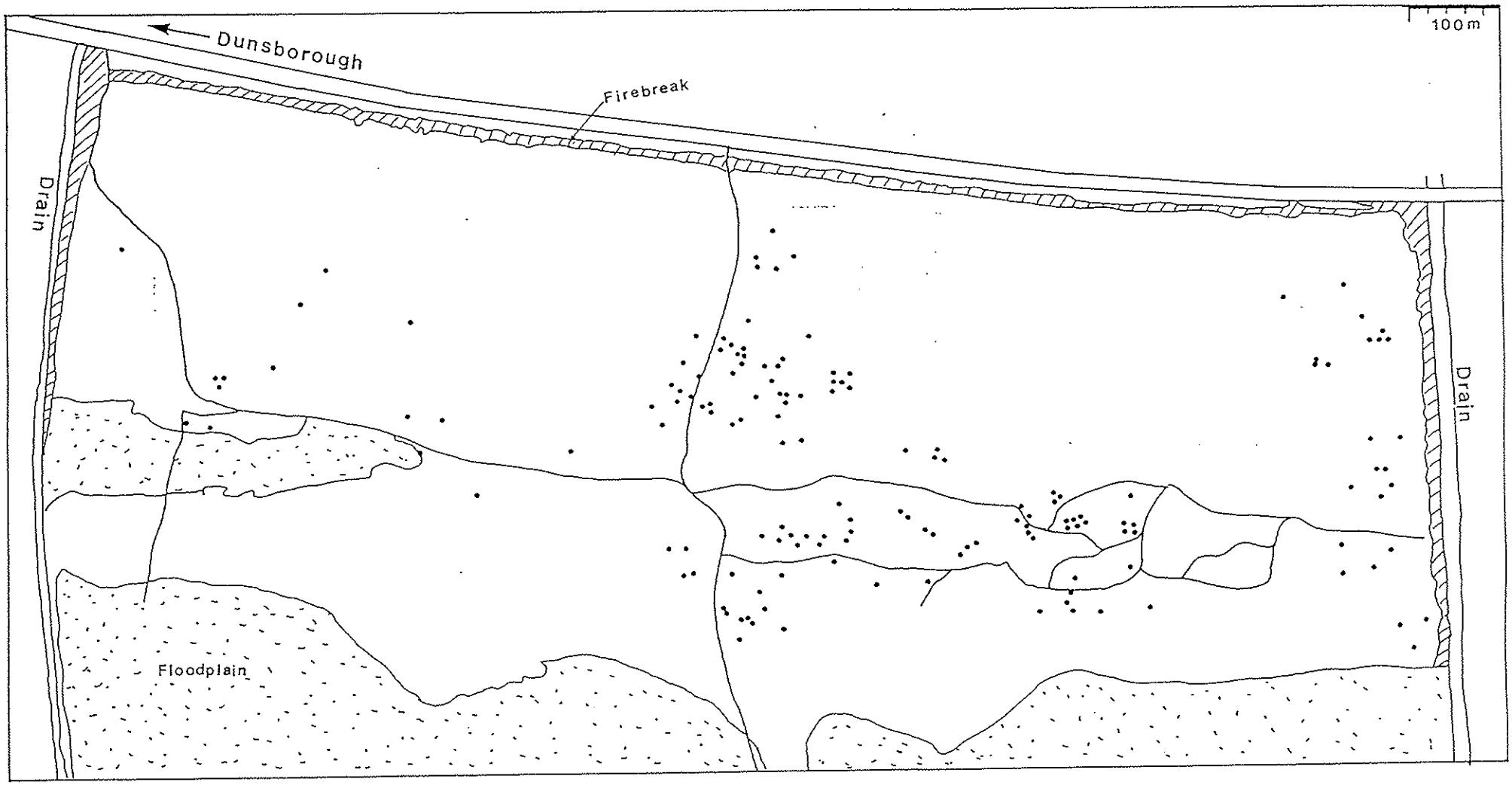


FIGURE 6

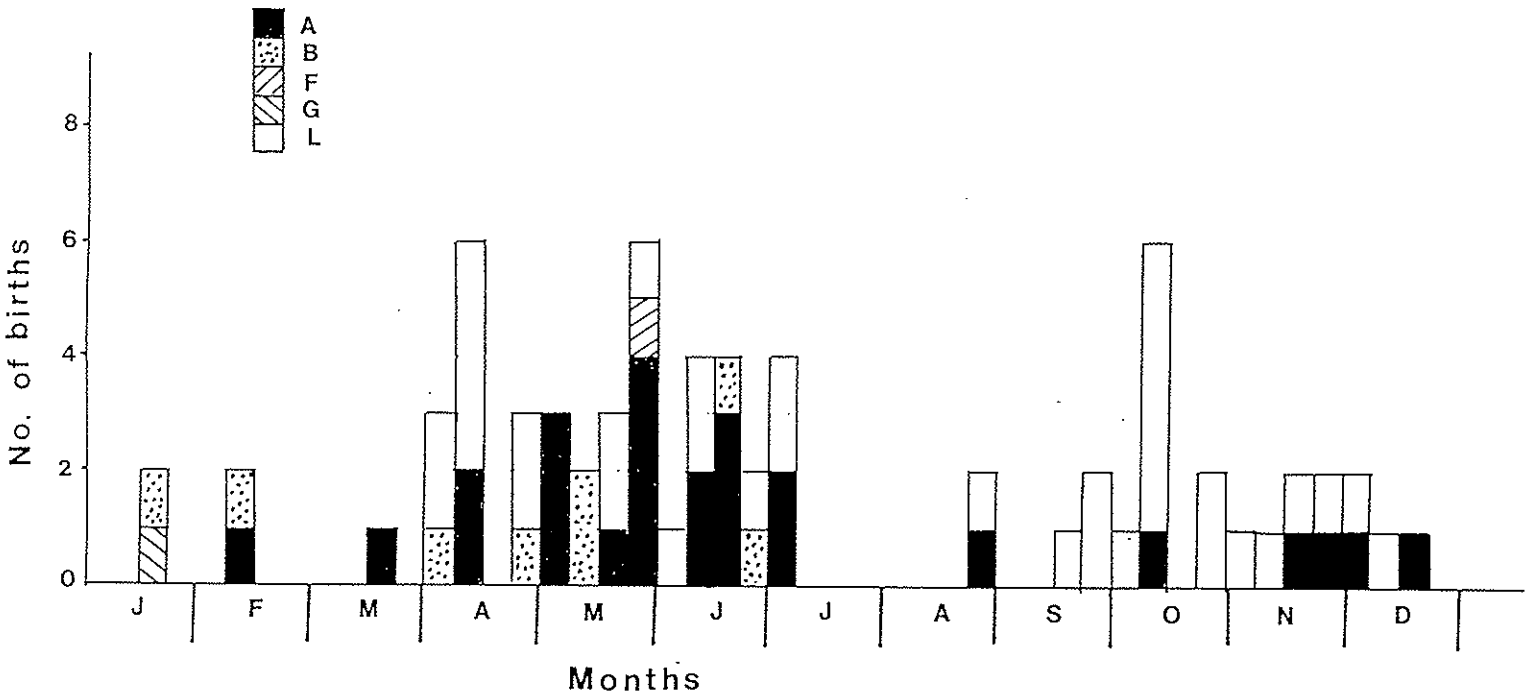
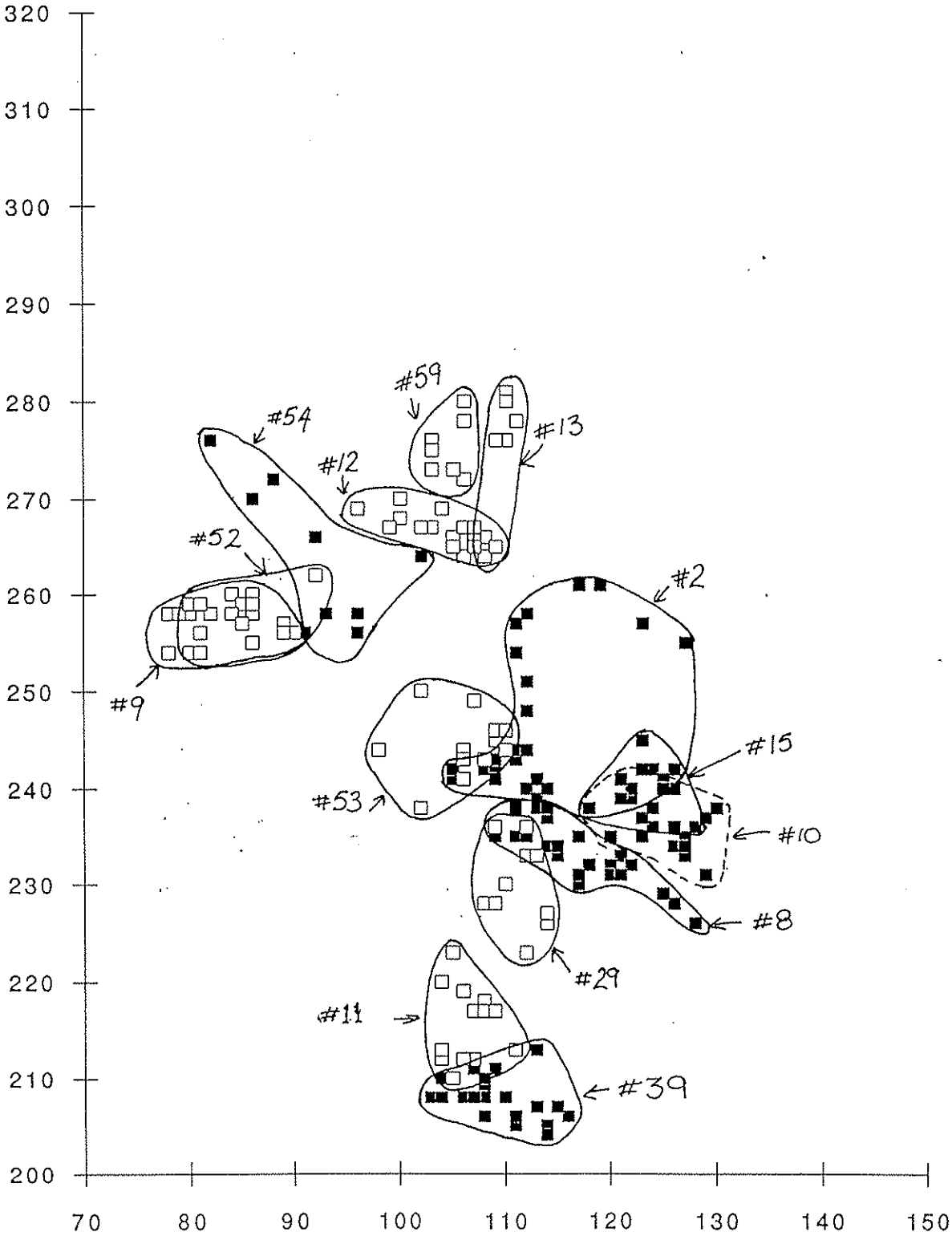


FIGURE 7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300
290
280
270
260
250
240
230
220
210
200
70
80
90
100
110
120
130
140
150
#59
#54
#13
#12
#52
#2
#9
#15
#53
#10
#8
#29
#11
#39

FIGURE 8

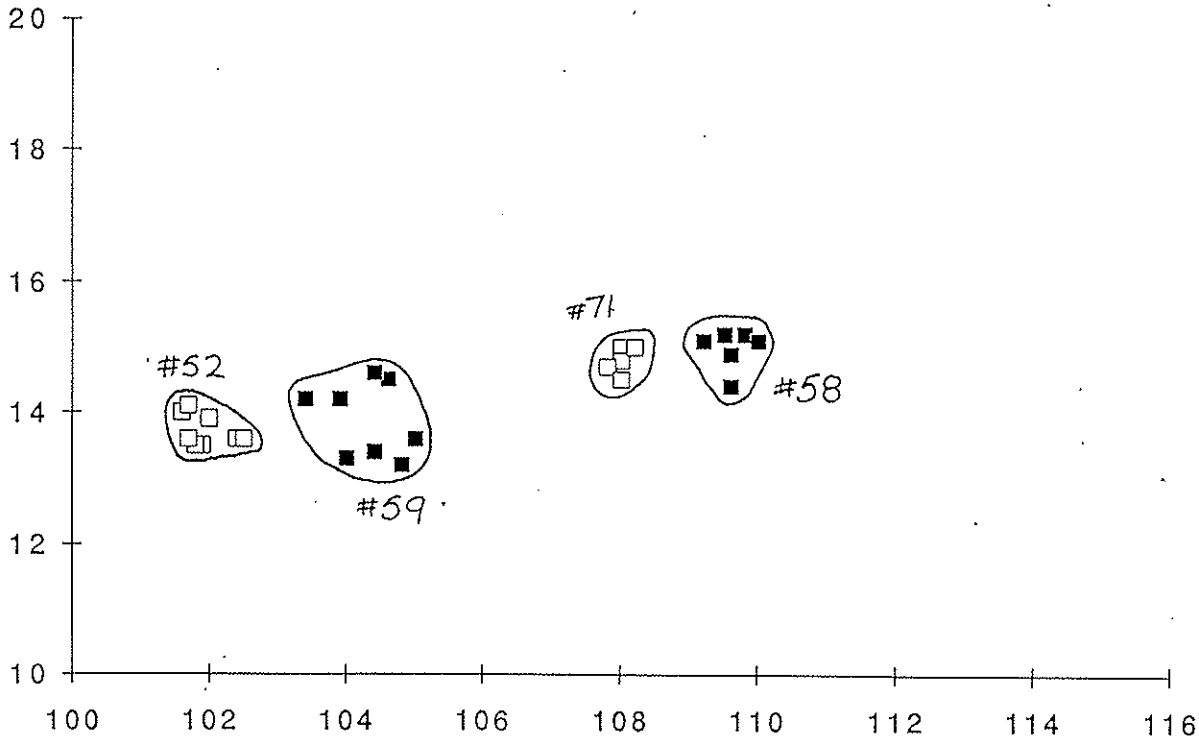


FIGURE 9A

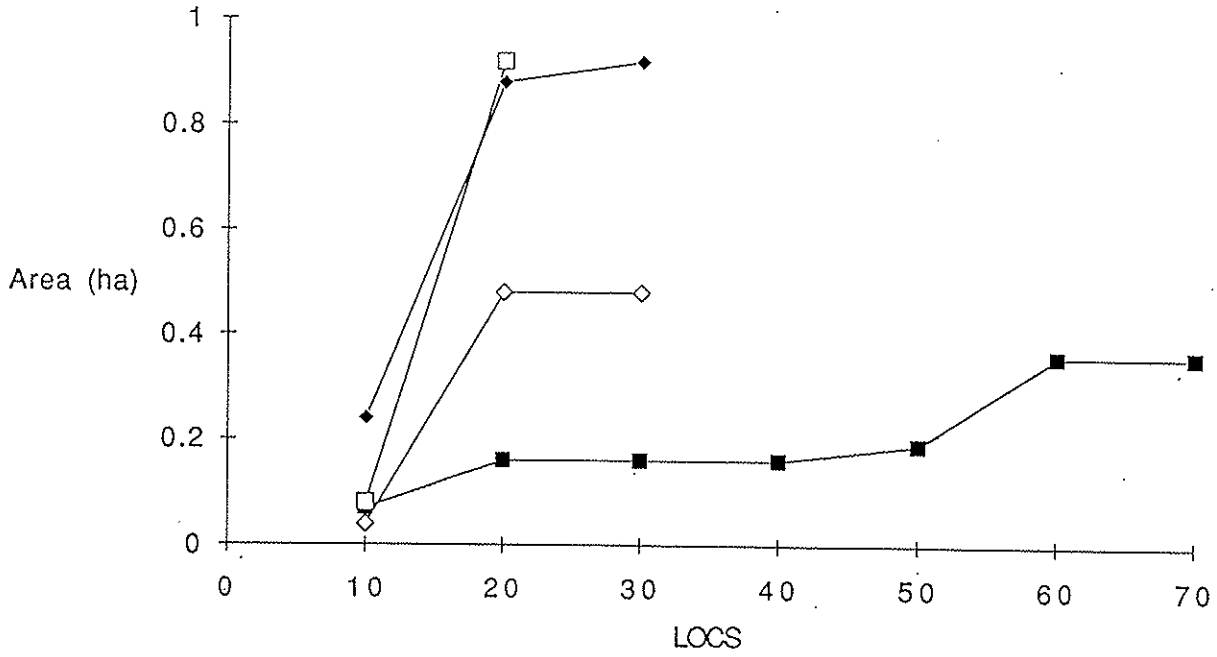


FIGURE 9B

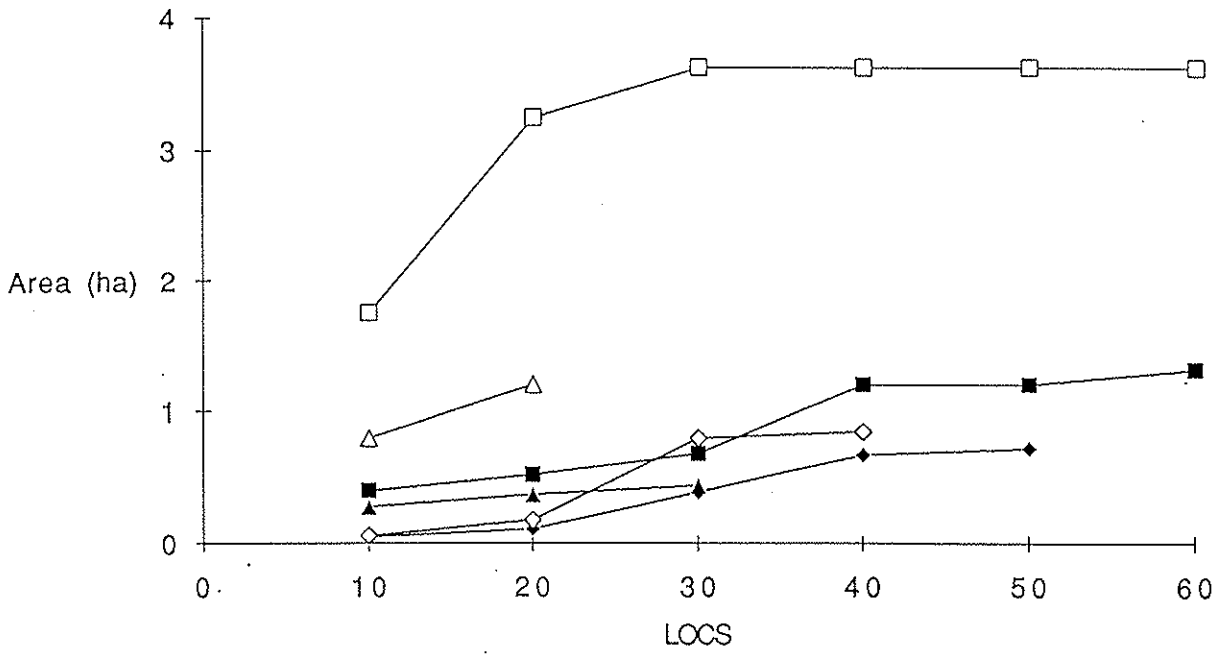


FIGURE 10

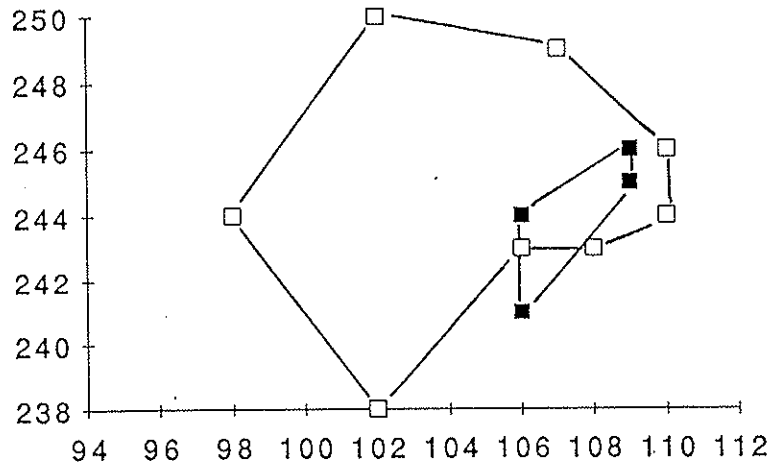


FIGURE11

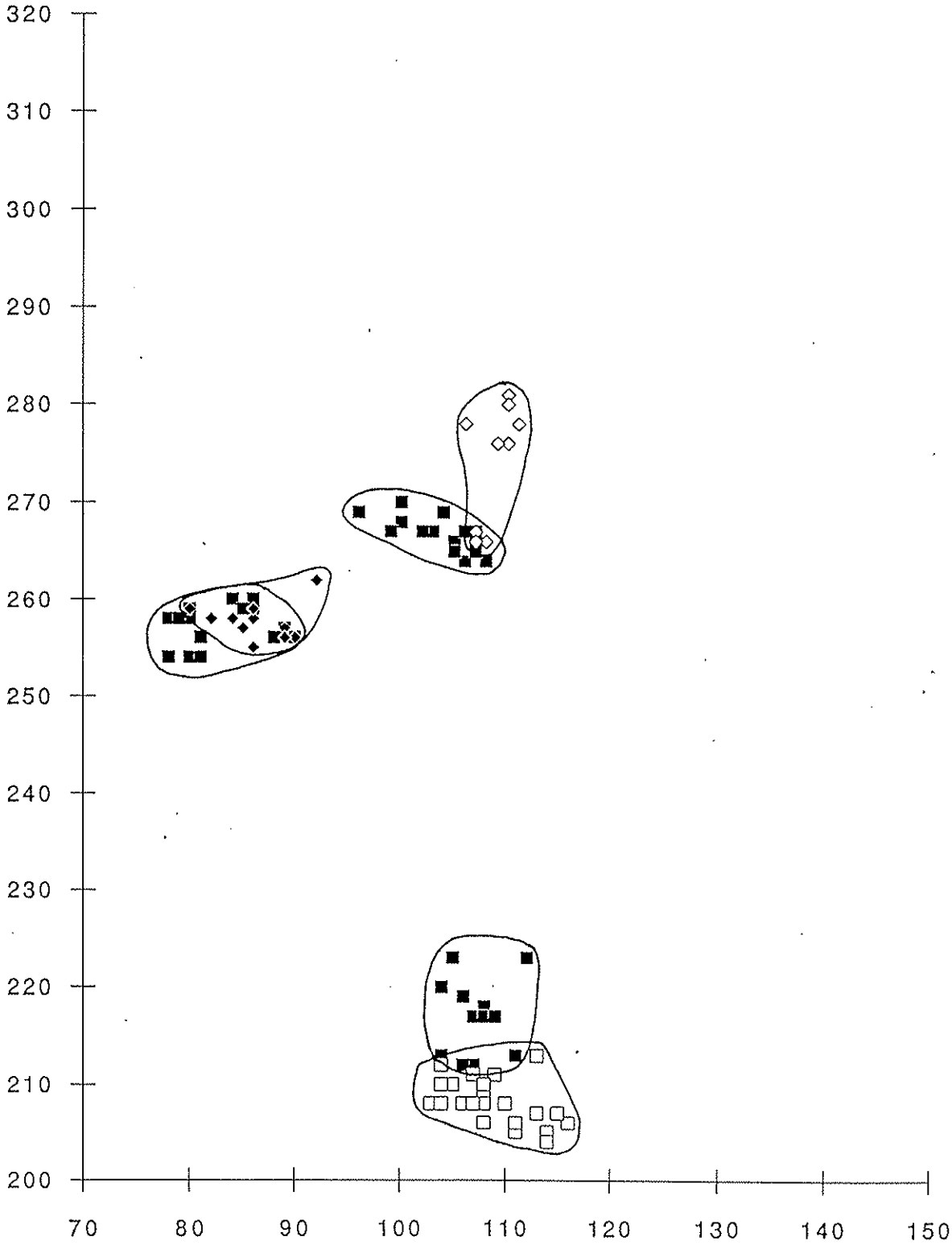

320
310
300
290
280
270
260
250
240
230
220
210
200
70
80
90
100
110
120
130
140
150

FIGURE 12

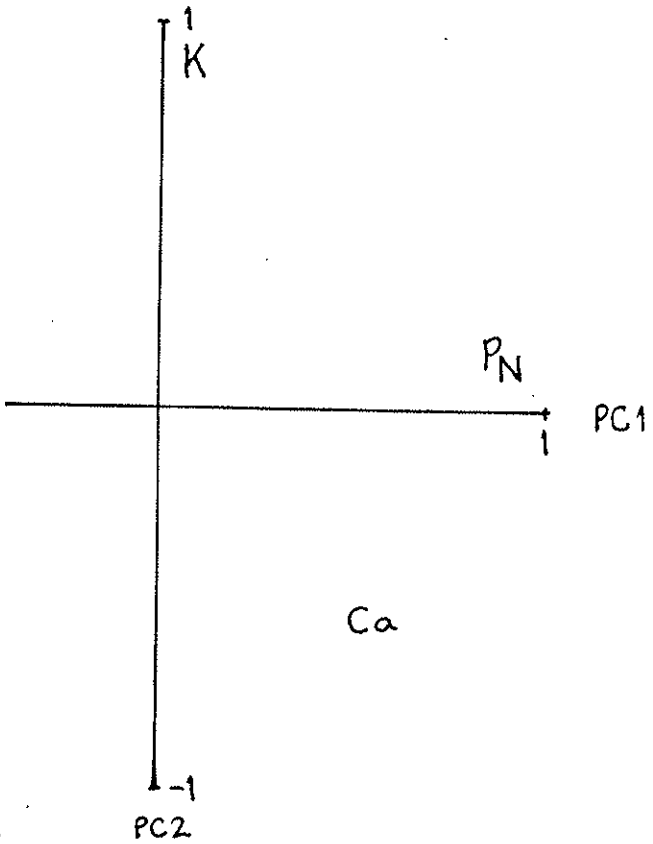


fig NQ1

FIGURE 13

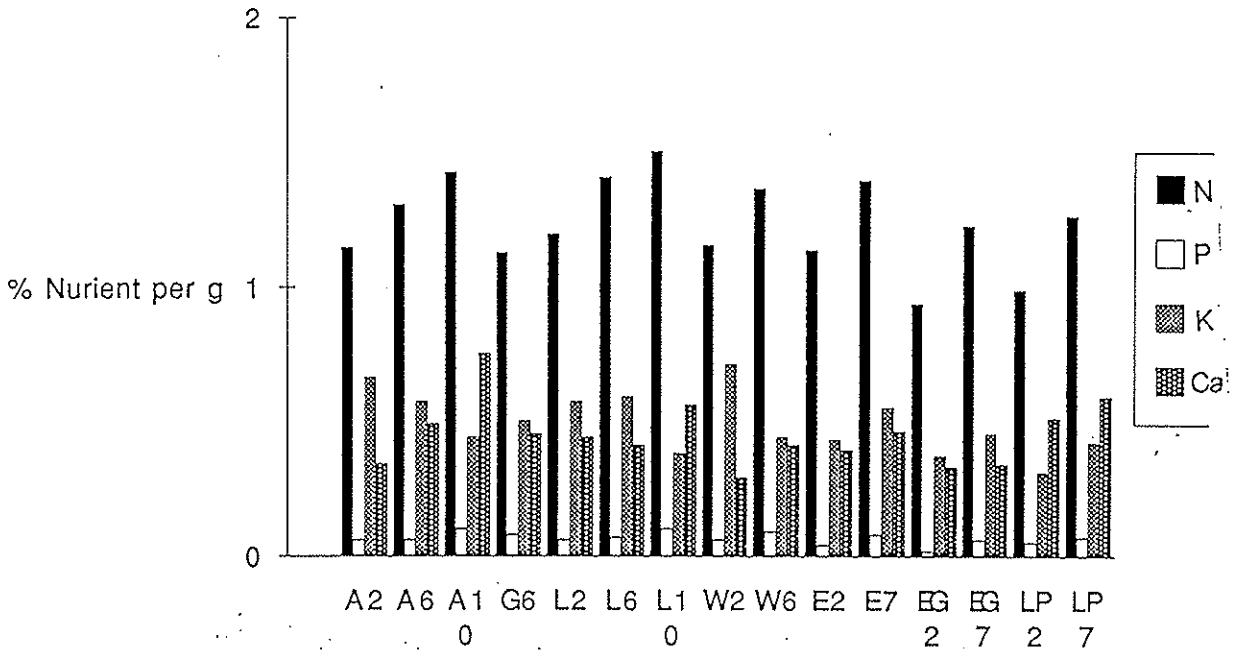

2
1
0
% Nurient per g
N
P
K
Ca
A2
A6
A10
G6
L2
L6
L10
W2
W6
E2
E7
EG2
EG7
LP2
LP7

FIGURE 14 (a) Locke

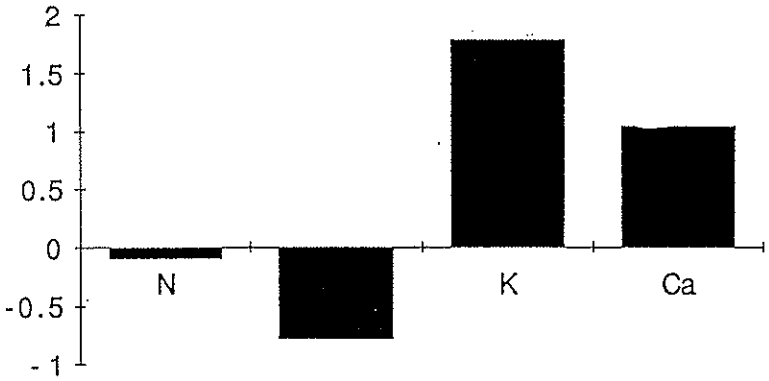


FIGURE 14 (b) Abba

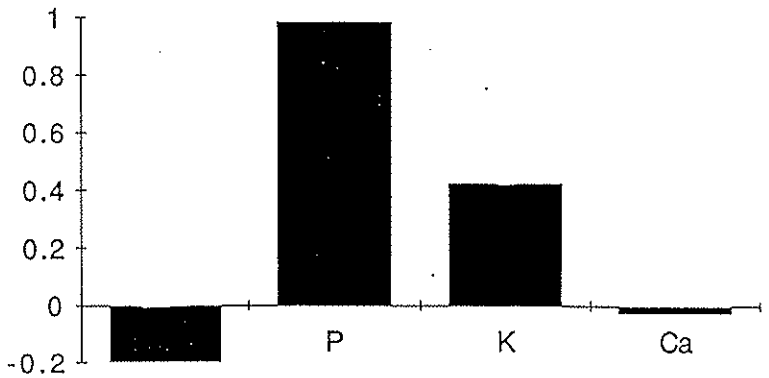
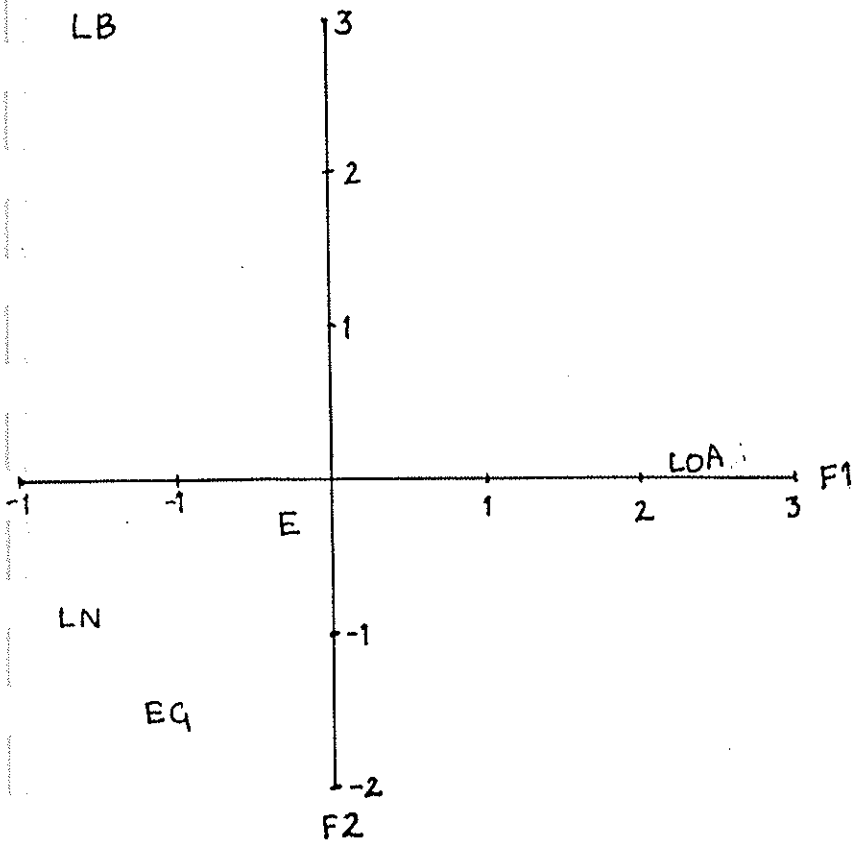


FIGURE 15



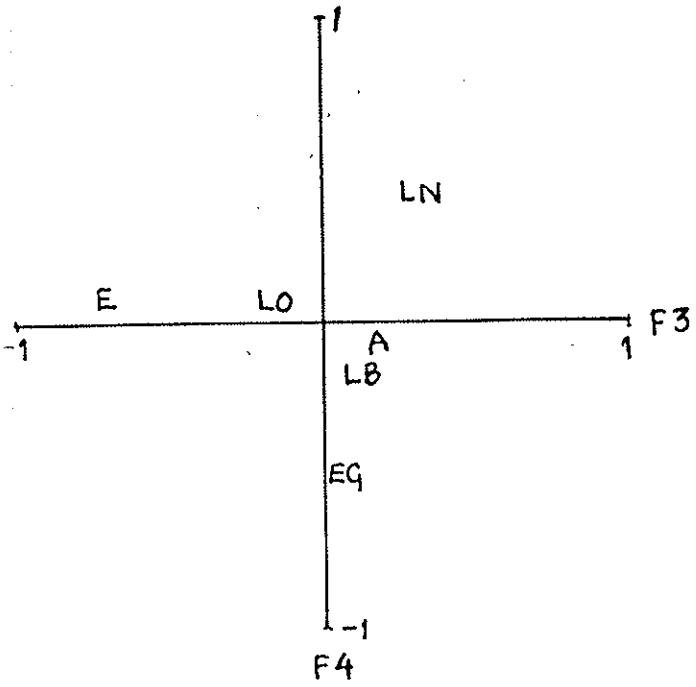


FIGURE 16

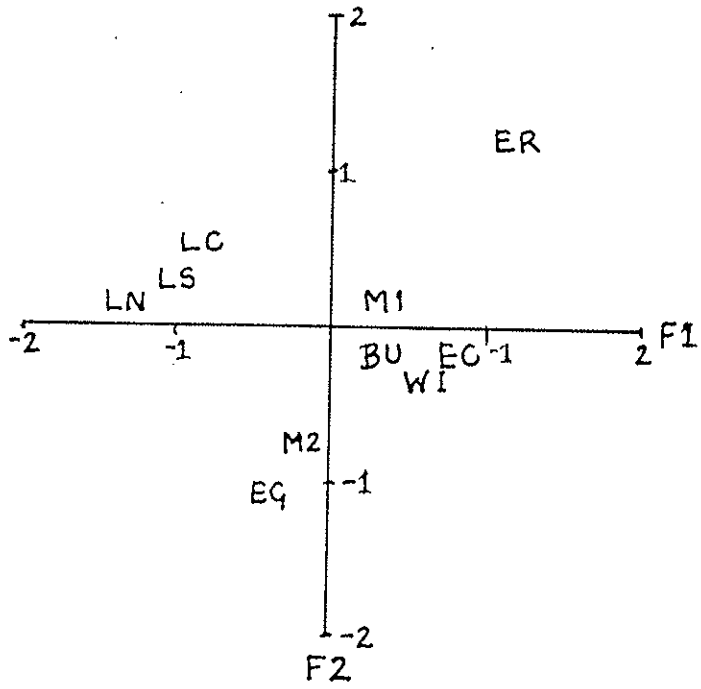


FIGURE 17

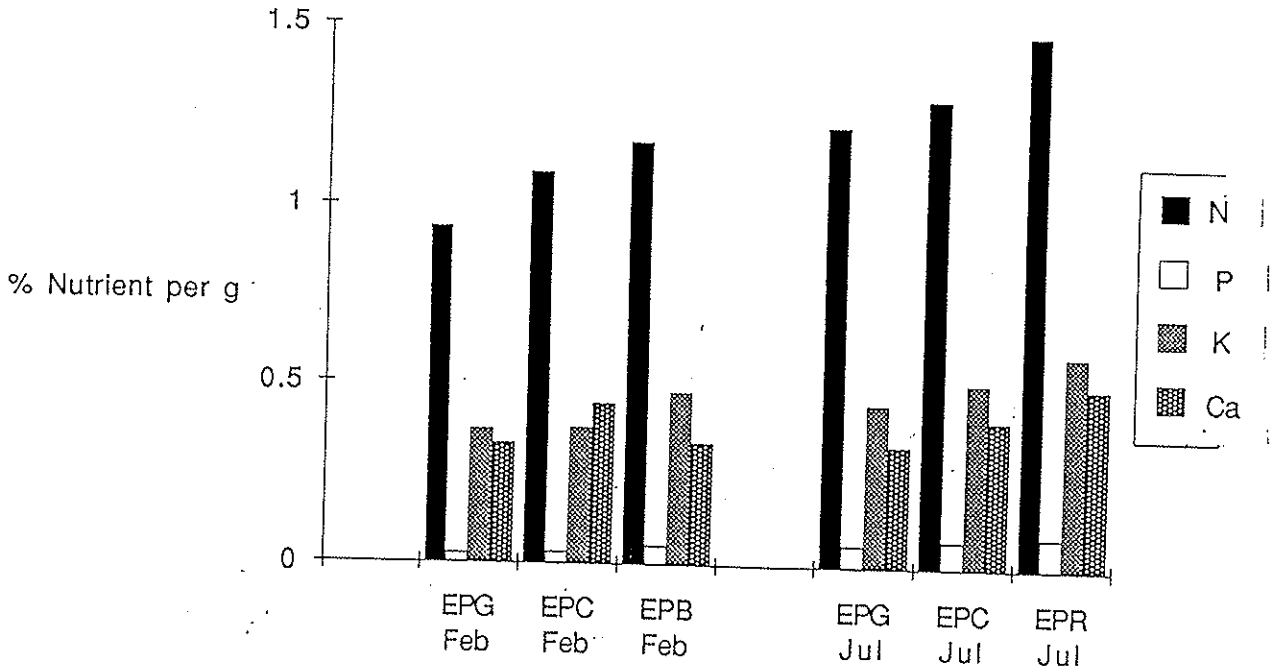

1.5
1
0.5
0
% Nutrient per g
N
P
K
Ca
EPG Feb
EPC Feb
EPB Feb
EPG Jul
EPC Jul
EPR Jul

FIGURE 18

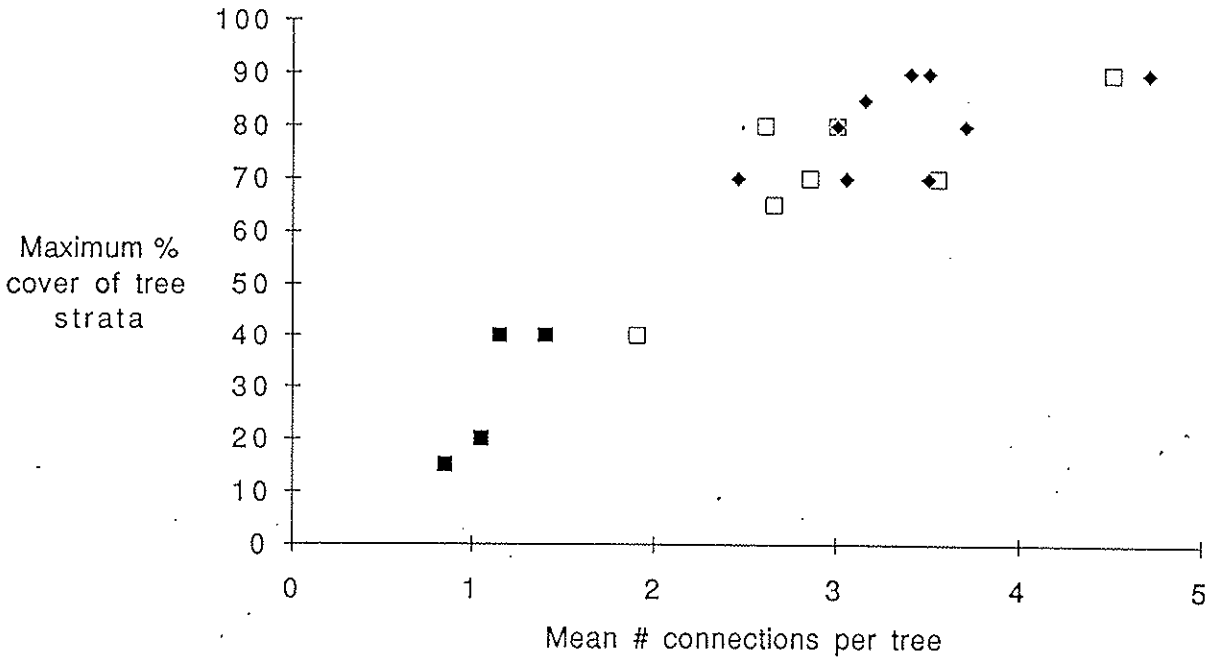

Maximum % cover of tree strata
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Mean # connections per tree

FIGURE 19

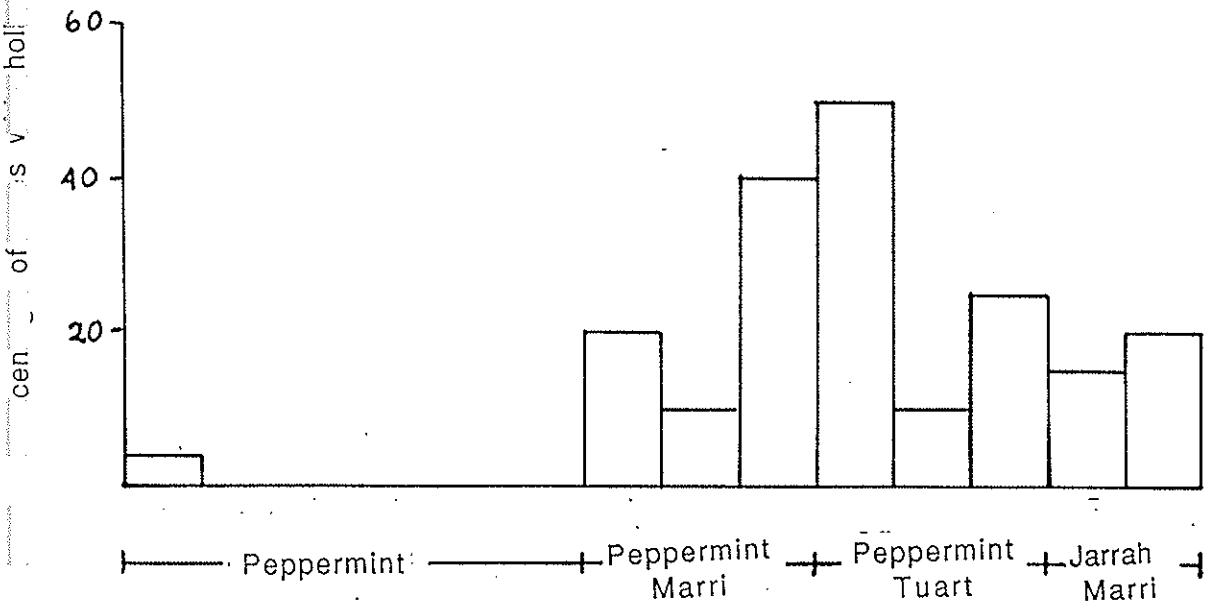

60
40
20
Peppermint
Peppermint Marri
Peppermint Tuart
Jarrah Marri

FIGURE 20

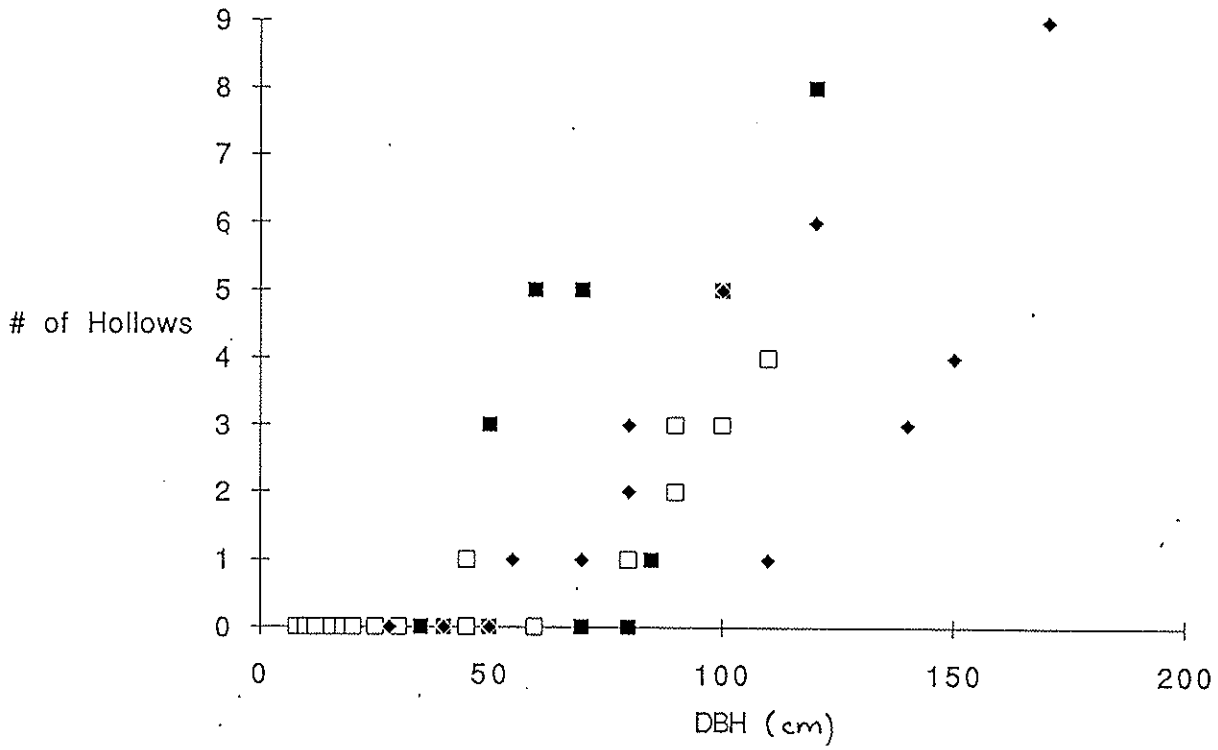


FIGURE 2.1

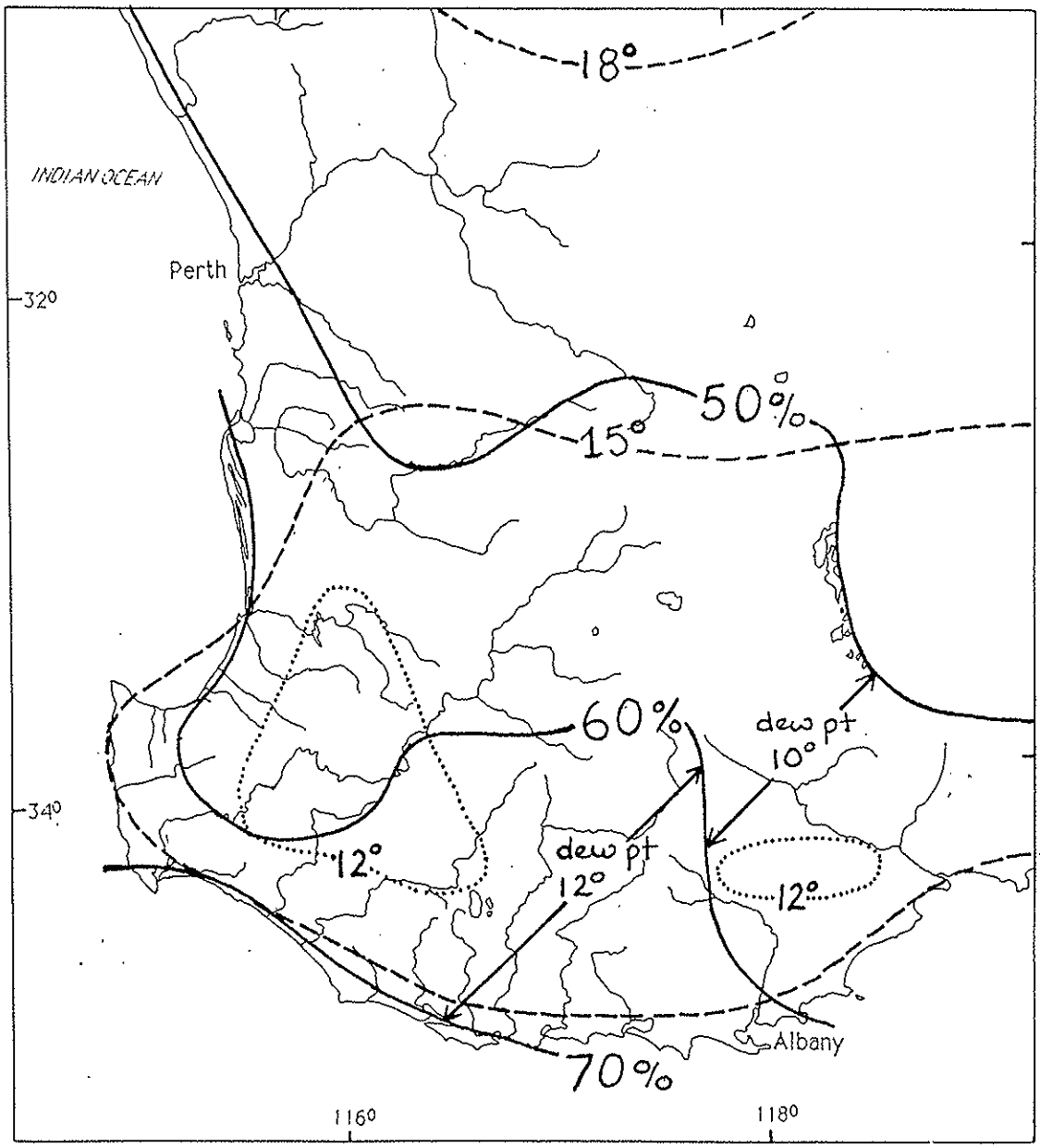

18°
INDIAN OCEAN
Perth
32°
50%
15°
60%
dew pt
10°
34°
12°
dew pt
12°
12°
Albany
70%
116°
118°

FIGURE 22

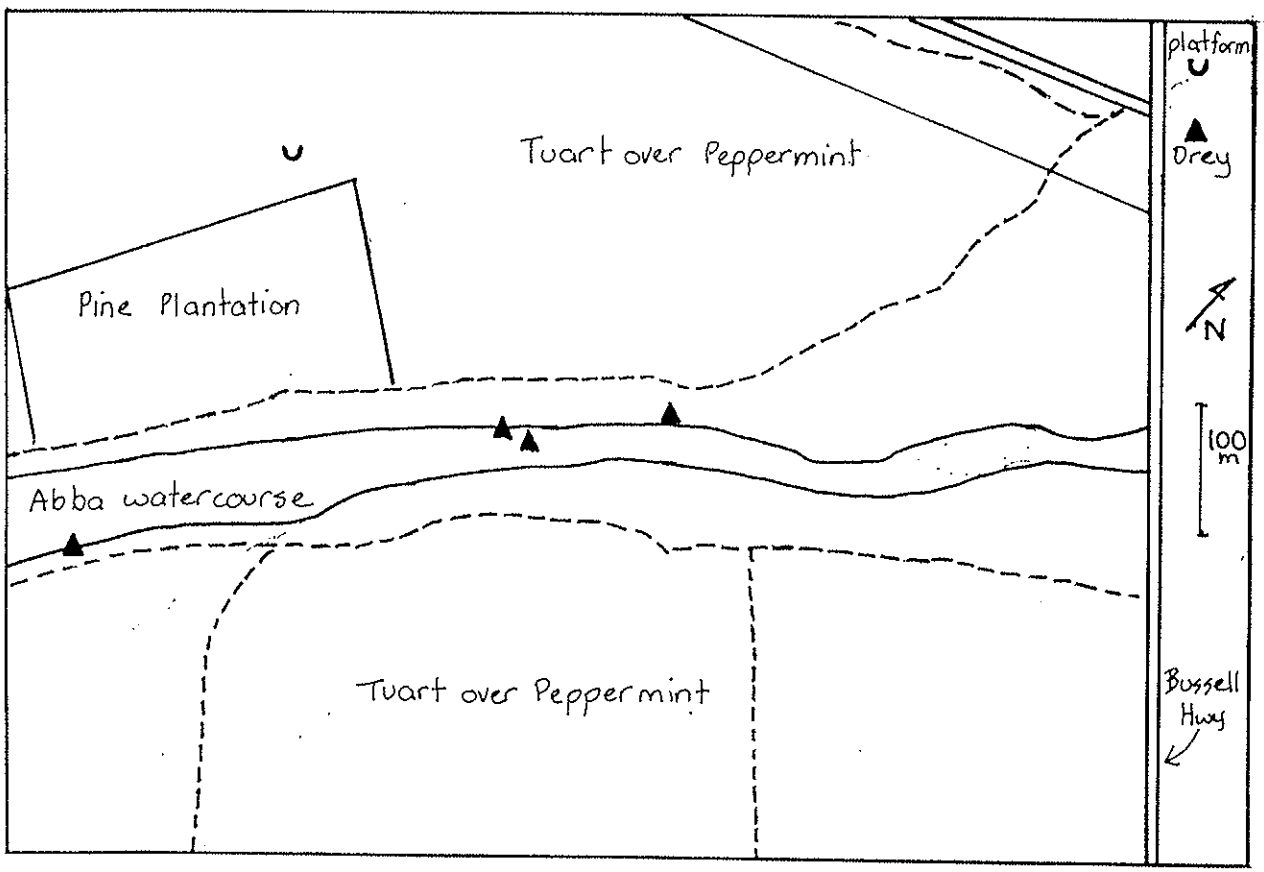
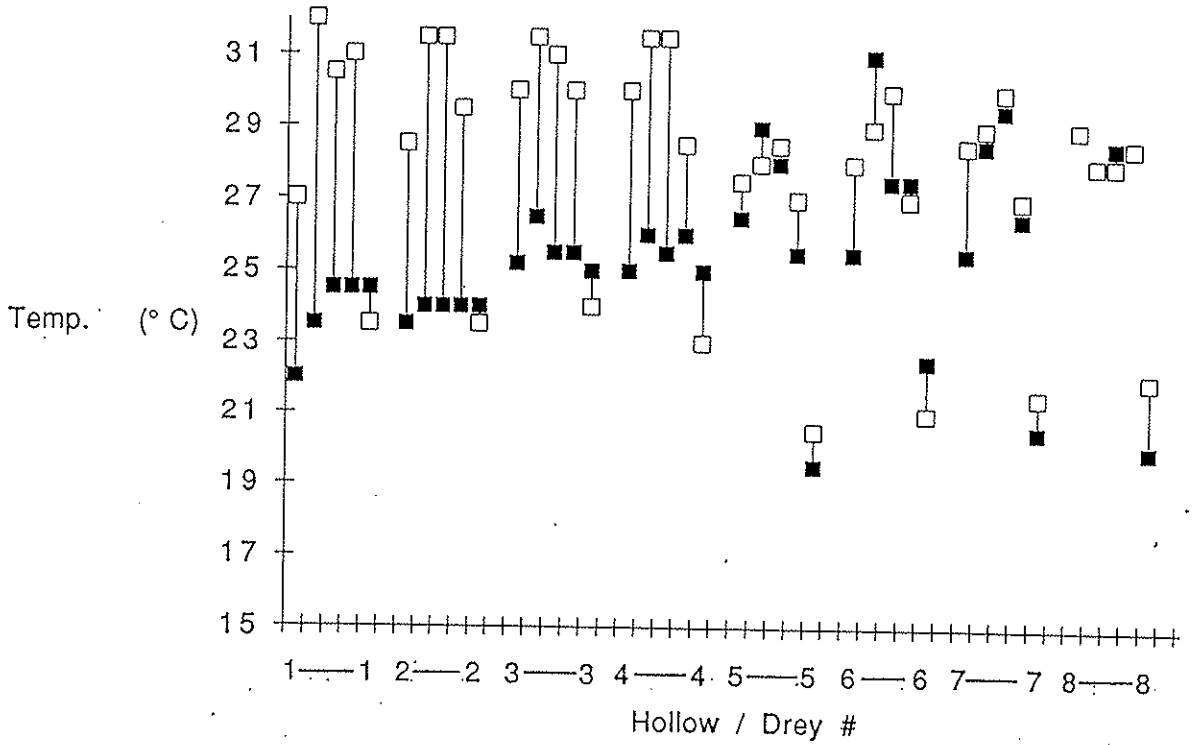

platform
Tuart over Peppermint
Orey
Pine Plantation
N
100 m
Abba watercourse
Tuart over Peppermint
Bussell Hwy

FIGURE 23



APPENDIX 1.

SITE DESCRIPTIONS

The Site List included in the Methods section deals with locality information. Descriptions of sites given here include reference to major habitat types and if available more detailed vegetation descriptions. Information specific to some sites or groups of sites is also presented. Most sites referred to in this document are included in the Site Descriptions. Exceptions include some localities referred to in Past Distribution and some sites associated with vague locality data. Most of the sites have been visited: exceptions are noted as such in Site Descriptions, and relate to roadkills or reliable reports of sightings. The S# is used in Figures and Tables. The location is given in UPPER CASE and further locality information and the short site name (as used in text) is given in lower case. To aid discussion of abundance and nutritional results some sites frequently referred to have been coded, and these codes, if used are shown here in bold. Reference to figure numbers indicates a site map is included elsewhere in the report.

S1: AVON RIVER, BEVERLEY Rise adjacent to river flats, with open *Eucalyptus loxophleba* and *E. rudis* and *Allocasuarina* growing on floodplain. *T. vulpecula* here.

S2: TUTTANING NATURE RESERVE Open Eucalypt (mostly *E. wandoo* and *E. salmonophloia*) woodland with patches of *Allocasuarina.*
T. vulpecula here.

S3: BOYAGIN NATURE RESERVE Open Eucalypt woodland (mostly *E. wandoo,* but with some *E. marginata* and *E. callophyla*). No possums seen during spotlighting.

S4: HASSEL'S FARM Pingelly. Gardens of exotics with some *E. salmonophloia* near house have *T. vulpecula*. Nearby *E. rudis* grows in watercourse through paddocks.

S5: MELROS Behind coastal dunes in valley with Tuart over Peppermint with a patchy complex understorey of *S. globulosum, Dryandra sp, Acacia sp, Olearia axillaris* and *Templetonia retusa.* This woodland has some patches of Peppermint adjacent to and included in the Tuart woodland. *T. vulpecula* here.

YALGORUP NP (S6–S10)
Throughout the Park variation in topography, soils, and drainage patterns and a relatively high diversity of tree species leads to a complex mosaic of vegetation associations.
S6: YALGORUP NP Tims Thicket Rd, a protected valley behind coastal dunes.
Strata 1: 12–14m, 50%, *E. gomphocephala*
2: 2–4m, 40%, *Dryandra sp, Acacia sp, E. gomphocephala*
3: 1–2m, 30%, *Olearia axillaris, Templetonia retusa, S. globulosum, Xanthorrhea* sp.
This area showed no sign of possum.

S7: YALGORUP NP Tims Thicket Rd, NE Park boundary: a protected valley between sandy ridges with *Banksia* woodland up the slope.
Strata 1: 8m, 20%, *A.flexuosa, Allocasuarina sp, Eucalyptus marginata, Eucalyptus decipiens*
2: 5–6m, 90%, *Acacia sp, Banksia grandis, B. littoralis, Allocasuarina sp, Olearia axillaris*
3: <1.5m, 50%, *Hibbertia* sp, *Pimelia* sp, *Xanthorrhea* sp, *Acacia* sp, *Macrozamia* sp
This area showed no sign of possum.

S8: YALGORUP NP White Hill Rd, Pinjarra Plain, open Tuart over Peppermint. No sign in day-search.

S9: YALGORUP NP, MARTINS TANK **YMT**
Martins Tank is a body of water lying between Lake Preston and Lake Clifton and the nature of the vegetation about its margins appears in comparison to the rest of the Park lush, implying good growing conditions for trees. Day search at Martins Tank yielded a high density of *T. vulpecula* faecal pellets. Parts of the Martins Tank area were cleared for settlement and grazing prior to their incorporation in the Park.
Three vegetation units were described:

1. Flat adjacent to western margin of lake
Strata 1: 18–22m, 10%, *E. gomphocephala*
2: 8–12m, 90%, *A. flexuosa*
3: 4–6m, <5%, *A. flexuosa, H. comptoniana*
This area showed large amounts of *T. vulpecula* faecal pellets.
A.flexuosa leaves collected July for nutrient analysis.
2. Flat adjacent to southern margin of lake.
Strata 1: 14–18m, 5%, *Eucalyptus calophylla*
2: 12–15m,10–50%, variably clumped, *A. flexuosa*
3: 1–1.5m,10%, *Xanthorrhea* sp.
4: < 0.5m, 100%, pasture
This site showed no evidence of *T. vulpecula*, but is immediately adjacent to S9(3). *A. flexuosa* leaves collected July for nutrient analysis.
3. Slope above flat adjacent to lake.
Strata 1: 12–15m, 8%, *E. gomphocephala, E. calophylla, E. marginata*
2: 6–10m, 75%, *A. flexuosa, B. grandis*
3: 2–4m, 10%, *A. flexuosa*
4:1–1.5m, 8%, *Xanthorrhea* sp.
This area is used by *T. vulpecula.*

S10: YALGORUP NP, LAKE HAYWOOD Flat adjacent to southwestern margin of lake.
Strata 1: 12m, 10%, *E. gomphocephala, Eucalyptus marginata*
2: 6–7m, 70%, *A. flexuosa, Banksia littoralis, E. gomphocephala*
3: 1–1.5m, 20%, *Lepidosperma sp, T. vulpecula* here.

S11: LESCHENAULT PENINSULA **LP** N of Bunbury: Also LP North (**LPN**), LP Central, (**LPC**), LP Belvedere, (**LPB**), LP South, (**LPS**)

Between the 1960's and early 1991 the Peninsula was used as a dump site for acidic liquid waste from the titanium processing plant in Bunbury. Fox density at this site was assessed by CALM using cyanide survey procedures in September, 1991. On the first day eight fox and a single cat were killed on a ten kilometre bait line with five baits per kilometre. On the two subsequent days a single fox was killed, taking the tally to ten fox in ten kilometres. In the early 1900's the site was grazed by cattle. Vegetation descriptions are provided for three sites, at the northern and southern ends of the *A. flexuosa* on the Peninsula, and in the central area where tuart dominates.
1. Leschenault South (**LPS**)
Strata 1: 11–14m, 75%, *A. flexuosa*
2: 4–7m, 10%, clumped, *A. flexuosa, H. comptoniana*
3: 1–2m, 5–15%, clumped, *Lepidosperma* sp.
This area showed no sign of possum.
A. flexuosa leaves collected July for nutrient analysis.
2. Leschenault Central (**LPC**)
Strata 1: 12–15m, 20%, *E. gomphocephala*
2: 10–13m, 60%, *A. flexuosa*
3: 1–3m, 30%, *S.globulosum, A. flexuosa, Clematis microphylla*
This area showed no sign of possum, but *T. vulpecula* were sighted in similar habitat further south.
A. flexuosa leaves collected July for nutrient analysis.
E. gomphocephala leaves collected July for nutrient analysis.
3. Belvedere (**LPB**)
Strata 1: 5–8m, 80%, clumped, *A. flexuosa,* with scattered *H. comptoniana*
Peppermint had multi-stemmed habit that results after hot burns.
This area showed no sign of possum.
A. flexuosa leaves collected February for nutrient analysis.
4. Leschenault North (**LPN**)
Strata 1: 12–14m, 60–80%, variably clumped, *A. flexuosa, H. comptoniana*
2: 0.5–2m, 15%, *S. globulosum*
3: 0.5–1m, 8%, *Lepidosperma* sp.
This area showed no sign of possum.

A. flexuosa leaves collected July and February for nutrient analysis.

S12: COLLIE RIVER In the river valley below Wellington dam Peppermint grows on flats adjacent to the river and the slopes above are dominated by Jarrah and Marri. Complex and dense understorey. *P. occidentalis* dreys seen here and sightings reports by CALM Officers in 1991 and 1992.

S13: PEPPERMINT GROVE BEACH Peppermint forest to 8m dominates the near-coastal dunes. Jim and Cheryl Campbell report regular *P. occidentalis* sightings.

LUDLOW FOREST (S14-S16)
The major habitat type in the forest is tuart over peppermint. Other vegetation associations include Jarrah-Marri, and *Eucalyptus rudis* and or *Melaleuca* spp in watercourses and swamps. Pine plantations have replaced the native forest in c. 25% of the forest. The forest grows on a plain on the inland side of the wetlands associated with the Vasse Inlet. Much of the Tuart habitat supports vigorous pasture growth and the fire risk associated with this is minimised by grazing cattle in the forest during the winter months. The forest has a long history of disturbance, with grazing since the late 1800's and timber cutting of Tuart since early this century. A CALM policy of Tuart regeneration has led to the forest being a patchwork of aged forest and younger stands. *P. occidentalis* and *T. vulpecula* were found to be present at all sites described. Other mammal species on site are fox, rabbit, cat, *M. fuliginosus, Phascogale tapotafa* and *Hydromys chrysogaster.*

S14: LUDLOW SWAMP Flat adjacent to swamp with *Melaleuca.*
Strata 1: 20-25m, 40%, *E. gomphocephala, E. calophylla* and *E. marginata*
2: 12-15m, 40%, *A.flexuosa*

S15: LUDLOW SETTLEMENT Flat adjacent to Ludlow R.
Strata 1: 15m, 15%, *E. rudis* and *E. calophylla*
2: 9-13m, 40%, *A. flexuosa, E. rudis* and *E. callophylla*
3: 4-5m, 10%, *A. flexuosa* and *Banksia littoralis*
4: 1-3m, 10%, *A. flexuosa* and *Pteridium* sp.

S16: LUDLOW ABBA RIVER **AB**
Flat adjacent to Abba R. The site is characterised by a high frequency of large Tuarts. A narrow watercourse associated with the Abba River transects the major study site and widens as it approaches the Wonnerup wetlands. Vegetation in the watercourse is patchy *Melaleuca pressii* and less frequently *E. rudis,* over pasture grass. Most years the creek flows May-June until November but pools persist until February-March when a single small pool remains. The watercourse shows heavy silting. A pine plantation occupies part of the area, and between the pines and the wetlands small patches of Peppermint, *E. rudis* and some eastern Australian eucalypts grow over pasture. This area was surveyed initially, but the main study area was restricted to the Tuart and Peppermint habitat type, described as follows:
Strata 1: 25-33m, 20-35%, *Eucalyptus gomphocephala,* partly clumped.
2: 10-15m, 60%, *A. flexuosa*
3: 2-4m, 8%, *A. flexuosa, H. comptoniana*

S17: RUABON Reserve with stunted Peppermint and heath. *P. occidentalis* seen in adjacent Peppermint growing in dense stands to 15m left in corners of cleared paddocks.

S18: FORREST BEACH A narrow dune within 1 km of the coast, but separated from it by a narrow lake (The Broadwater). On the landward side a strip of pasture land of *c.* 1 km width is separated from the dune by a road. *A. flexuosa* trees have been retained on much of the grazing land. The vegetation of the dune appears relatively undisturbed, save for the addition of exotic weeds. Other mammal species on site are rabbit and *Isoodon obesulus*. One *T. vulpecula* appeared on site in January 1991.
Strata 1: 5-10m, 80%, *A. flexuosa, H. comptoniana*
2: 1.5-3m, 60-70%, *S. globulosum*
3: 0.5-1m, 100%, pasture, *H. comptoniana,* Arum Lily
This area is used by *P. occidentalis.*

S19: GEOGRAPHE BAY DEVELOPMENT SITE **GBDS** A narrow rise of sand between

Geographe Bay and Vasse Inlet (map shown in Figure***). Part of the site was grazed for at least the last twenty years, and in some areas clearing has occurred. Peppermint woodlands are separated from the beach by coastal heath, and from the Inlet by a narrow area of sedge and grass. Generally the understorey is poor, the ground cover being dominated by winter weeds and pasture species. In some areas the leaves of the peppermint are yellowish rather than green. Other mammal species on site are fox, rabbit and cat.
Vegetation descriptions are provided for three different areas of peppermint woodland representative of the woodlands on site: NE of the site adjacent to Vasse Inlet; SW of the site, inland of Layman Rd; NW of site between the coast and Layman Rd.
1. Strata 1: 12–15m, 80% *A.flexuosa*
2: 2–4m, 5%, *A. flexuosa, S. globulosum, H. comptoniana,*
3: to 0.5m, 100%, pasture, Arum Lily
This area used by *P. occidentalis*.
2. Strata 1: 10–12m, 40–90% *A. flexuosa*
2: 2–3m, 50%, *A.flexuosa, S. globulosum*
3: 0.5–1m, 60%, *Lepidosperma* sp.
No possum sightings this area.
3. Vegetation is variably clumped with pasture between clumps: strata 2 and 3 are only present below *A. flexuosa.*
Strata 1: 11–13m, 70%, *A. flexuosa*
2: 1–2m, 5%, *S. globulosum, Lepidosperma* sp.
This area is used by *P. occidentalis*.

S20: BUSSELTON *P. occidentalis* are known to live in domestic gardens and Parks. Peppermint is by far the most common tree species in the urban area.

S21: LOCKE ESTATE (**LO**) Between the coast and the near coastal wetlands at the southern end of the coastal plain peppermint woodlands grow on a sandy rise 1–2 km wide. Locke Estate includes about 40 ha of peppermint woodland. Between 1962 and 1965 the area was under winter grazing by cattle, but much of the understorey appears intact, suggesting little disturbance as a consequence of the grazing. Other mammal species on site are fox, rabbit and *M. fuliginosus*.
In 1985 Peter Lambert prepared an internal Fisheries and Wildlife report summarising the occurrence of *P. occidentalis* on the Estate: "The *P. occidentalis* has virtually disappeared from the Estate's woodlands, once noted in the district for its large population of this species". One of us (RAH)visited the site and saw little evidence of *P. occidentalis*. The current population is in the range of moderate to high density, and most dreys associated with *P. occidentalis* sighted or caught during this study are in an area where Lambert found no dreys. *A. flexuosa* leaves were collected in February, June and October for nutrient analysis.
Vegetation descriptions are provided for three different areas judged to be representative of the woodlands on site.
1. Strata 1: 15–25m, 8%, *A. flexuosa, c.* 30% of trees >20m are senescent.
2: 5–10m, 50%, *A. flexuosa*
3: 3–5m, 30%, *A. flexuosa, Acacia truncata, H comptoniana*
4: 1–3m, 10%, *A. flexuosa, Hibbertia cuneiformis*
This area is used by *P. occidentalis*.
2. Strata 1: 10–15m, 60–70%, *A. flexuosa*
2: 2–4m, 8%, *A. flexuosa, H. comptoniana, H. cuneiformis, S.globulosum, Exocarpus* sp.
3: 1–2m, 8%, *A. flexuosa, Olearia* sp, *H. cuneiformis*
4: <1m, 8%, *Lepidosperma* sp.
This area is used by *P. occidentalis*.
3. Strata 1: 3–6m, 90%, *A. flexuosa, A. truncata*
2: <1m, 8%, *A. flexuosa, H. comptoniana, Lepidosperma* sp.
This area is used by *P. occidentalis*.

S22: YALLINGUP RIDGE **YR** On the Leeuwin–Naturalist Ridge near Yallingup Cave. Sandy laterite over limestone. Shallow valley with Peppermint along creek-line and Marri and sheoak on slopes: this patch cool burnt in spring 1991. Peppermint near creek not burnt. Fresh and burnt faecal pellets from *P. occidentalis* and *T. vulpecula* collected.
Strata 1: 8–10m, 70%, *Allocasuarina fraseriana*(40%), *E. calophylla* (30%), *A. flexuosa*
2: 6–8m, 35%, *A. flexuosa* (25%), *B. grandis, Hakea* sp.

3: < 1m, 25%, regenerating shrubs and seedlings

S23: LEEUWIN-NATURALISTE NP, ELLENSBROOK Small valley with creek in sandy hills on W slopes of Leeuwin-Naturaliste Ridge.
Strata 1: 8-10m, 90%, *A. flexuosa*
2: 5-8m, 30%, *A. flexuosa* and *Hakea* sp.
3: 2-5m, 20%, *S.globulosum*
4: 0-2m, 80%, three species of sedges
One fresh unoccupied *P. occidentalis* platform seen here.

S24: BORANUP NP Valley behind dune on western slope of Leeuwin-Naturaliste Ridge.
Strata 1: 12-16m, 10%, *Eucalyptus diversicolor* and *E. calophylla* (2%)
2: 8-12m, 80%, *A. flexuosa* and young *E. diversicolor* (5%)
3: 2-6m, 10%, *Hakea, Hibbertia, Acacia, Xanthorrhea*
4: 0-2m, 80%, *R. baccata* and sedge (20%)
P. occidentalis dreys and faecal pellets seen here, *T. vulpecula* reported to be here.

S25: EAST AUGUSTA Sandy flat adjacent to Hardy Inlet that as been subdivided to 5 and 1 acre blocks, some of which have been cleared. Most blocks retain some native bush.
Strata 1: 7-10m, 85%, *A. flexuosa* with *E. callophylla* (5%) and *H. comptoniana*
2: 5-8m, 40%, *A.flexuosa* (30%) and *Hakea* sp., *Banksia grandis* and *c.* microphylla
3: 0-2m, 80% *Lepidosperma, R.baccata, Hibbertia* and *Pteridium*

This site referred to by Ellis and Jones (1992). *P. occidentalis* dreys and sightings here 1991-92. The patch of Peppermint terminates abruptly to the north where it butts against open Eucalypt woodland over a patchy Peppermint mid-storey. *T. vulpecula* seen in the Eucalypt woodland, but no sign of *T. vulpecula* in the Peppermint forest.

S26: SCOTT RIVER NP A low sandy rise adjacent to swampy heath.
Strata 1: 8-15m, 40%, *E. callophylla* (30%) and *E. marginata*
2: 2-6m, 10%, *A. flexuosa*
3: 0-2m, 30%, *Bossea, A. flexuosa* and *Pteridium*
No sign of possum here.

S27: BLACKWOOD RIVER, SUES BRIDGE At Sues Bridge the Blackwood has, on its southern side a narrow flood plain with patches of dense (80%) Peppermint and *E. rudis* to 14-18m. In this area flooding appears to limit the understorey, but patches of sedge and *Bossea* occur in some areas. Up the slopes vegetation is open Eucalypt forest (Marri-Jarrah) recently burnt in a CALM proscribed burn.
T. vulpecula here, but no sign of *P. occidentalis*.

S28: BLACKWOOD RIVER, SCHRODERS POOL On the northern side of Schroders Pool is a patch of Peppermint on riverine flats. This area had reports of *P. occidentalis* sightings. The area could not be accessed because of difficulty getting permission from the private landowner. On the southern side of the Blackwood the bank rises abruptly and the vegetation is open Eucalypt forest of Marri and Jarrah over a midstorey of scattered *B. grandis*. A few Peppermints grow within 10m of the normal waterline. The southern area had been recently burned in a CALM proscribed burn. *P. occidentalis* and *T. vulpecula* faecal pellets found here.

S29: BLACKWOOD RIVER, ALEXANDER BRIDGE At Alexander Bridge the narrow flood plain on the western side of the Blackwood has been developed as a picnic area. Trees are emergent Marri and a few Jarrah over a Peppermint midstorey. No possum sign found here.

S30:GARDNER RIVER, NORTHCLIFFE On the western banks of the Gardner River sheoak and Peppermint grow in a narrow band along the banks. Adjacent is Karri forest. No sign of possum found here. An uncooperative land owner on the eastern bank reported *P. occidentalis* present but denied access.

PERUP (S31-32)
The Perup lies in the Warren River catchment area. The area is relatively rich in marsupial fauna compared to other southwest areas, and this is generally attributed to the occurrence of Heart-leaf (*Gastrolobium bilobium*) which is one of the more potent poison plants found in the

southwest. The presence of such a toxic plant is assumed to severely disadvantage those taxa without a high degree of 1080 tolerance, thus limiting populations of introduced eutherians. This is the only inland area where *P. occidentalis* are known to persist as a viable population, and the only area where *P. occidentalis* occur without Peppermint.

Yendicup Swamp is the major geographical feature of the area around the CALM field station.The Mordalup Nature Reserve lies on the western bank of the Tone R. and is adjacent to The Perup Fauna Priority area.

S31: PERUP YENDICUP (**PY**) CALM has a small field station in the Perup Fauna Priority area to accommodate groups working or studying in the forest. The buildings lay within a one kilometre square most of which was previously cleared. The native vegetation is now regenerating in most of the cleared areas. Unlike much of the Perup this area is never closed due to dieback risk, and vehicle travel is possible around the perimeter firebreaks in all but the wettest periods. A major feature of the area is Yendicup Swamp, which occupies the SW corner of the area previously cleared. CALM Manjimup has spotlighing records for this area spanning about ten years and Graham Liddlow (pers comm) interprets these as suggesting that *P. occidentalis* numbers have increased over the last five years. In 1984 one of us (B.J) spotlighted around the same route as used during this work and saw no *P. occidentalis*. During this study a poor night's spotlighing for this area would be 3–4 *P. occidentalis* seen. This area is subject to fox control using 1080, but a fox was seen on site in 1991. Jarrah and Marri leaves were collected here in February and July for nutrient analysis. Two vegetation descriptions are available.

Both sites: sandy, lateritic rise adjacent to swamp. Area had cool proscribed burn in spring 1990.

1. Strata 1: 10–20m, 40%, *E.callophylla* (20%) and *E.marginata*
   2: 3–8m, 10%, clumped *B.grandis, E.callophylla* and *E.marginata*
   3: <1m, 5–10%, *Xanthorrhea,* cycads and several pea species.

2. Strata 1: 10–18m, 40%, *E. callophylla* (15%) and *E. marginata*
   2: 2–6m, 30%, *B. grandis* (15%), *E. callophylla* and *E. marginata*
   3: <1m, 5–10%, *Xanthorrhea,* Jarrah, marri and *B. grandis* seedlings

S32: PERUP MORDALUP (**PM**) The Mordalup NR is adjacent to a permanent pool on the Tone R. A narrow band of dense shrubby Melaleuca grows at the waters edge. At Mordalup vegetation descriptions were collected for two sites (both with lateritic soils).

Rise adjacent to Tone River

1. Strata 1: 15–20m, 10%, *E. marginata* (6%), *E. callophylla* and *E. wandoo*
   2: 8–14m, 15%, *E. marginata* (12%), *E. callophylla* and *E. wandoo*
   3: 2–5m, 10%, *E. marginata* and *E. callophylla*
   4: < 2m, 30%, *Xanthorrhea* (10%), *Gastrolobium bilobium* (10%, clumped), *Hypocalymma* sp. and several pea species.

Slopes above Tone River

2. Strata 1: 15–20m, 20%, *E. marginata* (15%), *E. callophylla*
   2: 6–8m, 15%, *E. marginata* (10%), *E. callophylla*
   4: < 2m, 15%, *Gastrolobium bilobium* (10%, clumped), *Xanthorrhea* (2%), *Acacia pulchella*

S33: MT SHADFORTH The 1986 roadkill reported from this area was picked up towards the bottom of a valley with Karri on the slopes and open Marri woodland over a dense heath understorey. No sign of possum found here, but *T. vulpecula* faecal pellets found *c.* 1 k SE in Karri forrest.

S34: DENMARK Sandy rise north of Wilsons Inlet. This was land marked for subdivision and within the town area. Vegetation was dominated by Marri and understorey appeared disturbed by frequent burns. No possum sign found here.

S35: WILSONS INLET WEST Ocean Beach Rd runs along the W margin of Wilsons Inlet and through some stands of dense Peppermint forest to *c.*15m. Day searches revealed no sign of possum.

S36: WILSONS INLET EAST (WI) Eden Rd runs along the peninsula to the south of Wilsons Inlet for about 8 k. Vegetation is predominantly Karri over a Peppermint midstorey, but some patches are peppermint forest and some are of Peppermint with *E. rudis* emergents. *Banksia littoralis* grows near the Inlet in some places and at its western end Eden Rd passes through some swampy areas with *Melaleuca*. A vegetation description was collected for the area from which Peppermint leaves were collected for foliage nutrient analysis in June and February. This site was towards the western end of Eden Rd where the road goes into private property. No sign of possum was found anywhere along Eden Rd.
Strata 1: 9-10m, 10%, *E.rudis*
2: 6-9m, 80%, *A. flexuosa* (75%) with *H. comptoniana,* and *E. rudis*
3: 0.5-2m, 15%, *A. flexuosa* (10%), *H. comptoniana, R. baccata, Hibbertia* sp, *S. globulosum*
4: < 0.5m, 90%, two species of sedge with exotic pasture and weeds.
No sign of possum here.

S37: LOWLANDS ROAD This site was not visited. Peter Collins (CALM wildlife Officer at Albany) reported *P. occidentalis* in Karri over Peppermint on his block.

WEST CAPE HOWE (S38-S40)
P. occidentalis are known from the West Cape Howe area. Prof Bet Main reports that in the early 1970's he regularly travelled the road into the Park at night and saw *P. occidentalis* in stands of Peppermint. These sites showed no sign of *P. occidentalis* in 1991. Prof Main also reports that soon after a wildfire about 1975 burned the Park adjacent to his house he observed an increase in sightings of *P. occidentalis* on his property, and for the following two years *P. occidentalis* appeared to be more numerous in the regrowth than before the fire. He also reports that numbers seem to have declined since the late seventies.

S38: WEST CAPE HOWE NP In the NW corner of West Cape Howe NP slopes facing the southern ocean have gullies with Peppermint and Bullich. No sign of *P. occidentalis* was found here. The vegetation (in terms of trees) and topography is similar to some parts of Two Peoples Bay.

S39: WEST CAPE HOWE NP, TORBAY HILL In the NE corner of the Park, near Torbay Hill, vegetation is a mosaic of Karri and Peppermint and more open Marri-Jarrah forest. On the southern side of Torbay Hill Peppermint forest grows in gullies.

S40: COSY CORNER A sheltered cove on Torbay Bay has a small flat behind the beach, part of which has been cleared for a salmon fishermen camp. The rest of the area is developed as a picnic area but the original Peppermint thicket still dominates the area. Salmon fishermen reported *P. occidentalis* sightings in December 1989, but no sure sign was found in 1990 despite extensive searches of the small area. (One drey-like structure was observed but these are sometimes seen in areas without *P. occidentalis*, and presumably result from dead vegetation caught in twigs as it falls. Sometimes rats have been observed resting in such spots.) Since we had no sightings of *P. occidentalis* or of recognisable dreys, and no faecal pellets were found, we conclude that in 1991 no *P. occidentalis* lived in this area.

S41: ELLEKER A farmer at Elleker (Allan Taylor) showed 1990 photo of a *P. occidentalis* displaced from a tree felled near the house. The vegetation around the house included garden and about 2 ha of original large trees and planted pines. The original trees had been thinned out. This area is surrounded by paddocks. The animal may have originated from a nearby reserve of Jarrah-Marri.

S42: KING RIVER Private land between King River townsite and Oyster Harbour has Jarrah-Marri woodland, in many areas parkland cleared. Maree Evans has been releasing rehabilitated *P. occidentalis* on her property. (Evans place has not been inspected.) No sign of possum found here.

S43: KALGAN RIVER, LOWER KALGAN A road follows the W bank of the Kalgan R. for 2 km north from the Two Peoples Bay Rd to the local ski Club. Ray Smith (CALM Wildlife Officer) reports *P. occidentalis* at the ski club *c.* 1975. This area is open Jarrah and Marri with some trees to 12m. The road also passes through some swampy areas and paddocks. No possum sign found here.

ALBANY AREA (S44-S48)

The Albany Town Council is responsible for the management of site S44-S48. The Council imposes a six year burn cycle for areas of bush in Albany.

S44: EMU POINT **EP** Albany. Also EP Park, (**EPP**), EP Ridge, (**EPR**), EP Chalet, (**EPC**), EP Bowls, (**EPB**) Map shown in Figure *** .

Emu Point is dominated by a small urban settlement and two caravan parks. A narrow reserve dominated by Peppermint separates the developed areas from the ocean. West of the developed area is a relatively large area of low Peppermint and most of this area was burnt in January 1991.

The settlement is served by septic sewerage, but a unique approach has been used to process the waste from one of the caravan parks. Sewerage is pumped from holding tanks in the park to a line of settling tanks on a small sand ridge between the caravan park and the reserve (site referred to as EP Ridge). The liquid outflow from these tanks runs into a large open dam. The 'water' in the dam either evaporates or drains into the sand.

Vegetation descriptions were collected for seven different areas. The location of these site is shown on Figure ***. Scientific names are not provided for all exotic plants.

1. Small patch of bush between the bowling club and caravan park
Strata 1: 6-8m, 70%, *A. flexuosa*
2: 3-4m, 90%, *Adenanthos* sp., *A. truncata*
This site was recently burnt (Autumn 1991), a patchy burn with the highest scorch marks to 2m on peppermint trunks. No possum sign found here.

2. Southwestern end of 1 (**EPB**)
Strata 1: 7-8m, 90%, *A. flexuosa*
2: < 1m, 100%, *Pelargonium* sp.and sedges
3. Adjacent to 2 (**EPB**)
Strata 1: 5-6m, 95%, *A. flexuosa*
2: < 1m, 100%, *Pelargonium* sp.and sedges
P. occidentalis drey and sighting here.
A. flexuosa leaves collected February for nutrient analysis.

4. In caravan park, trees over mowed grass.
Strata 1: 8-10m, 80%, *A. flexuosa, 5%* with Ivy (*Hedera* sp) to 7m
No possum sign found here.

5. Patch of Peppermint on NW margin of caravan park.
Strata 1: 5-7m, 80%, *A. flexuosa*
2: 1.5-2.5m, 15%, *S. globulosum, R. baccata*
3: < 1m, 100%, *Pelargonium* sp.and sedges and an exotic monocot climber.
No possum sign found here.

6. Peppermint adjacent to large sewerage dam
Strata 1: 6-7m, 80%, *A. flexuosa, Actinostrobus* sp. (<5%)
2: 1.5-2m, 10%, *S. globulosum*
3: < 1m, 90%, sedge, *Pelargonium* and grasses.
P. occidentalis drey and sighting here.

7. **EPR** Sandy ridge adjacent to caravan park where Peppermint grows over a series of septic tanks.
Strata 1: 6-7m, 70%, *A. flexuosa*
2: 1-3m, 15%, *S. globulosum, R. baccata, H. comptoniana,* the exotic monocot creeper and arum lily.
3: <1m, 10%, *Lepidosperma*
P. occidentalis dreys and sightings here.
A. flexuosa leaves collected February for nutrient analysis.

8. **EPG**, Griffiths St: open, clumped Peppermint to 5m, habit multi-stemmed.

No possum sign found here.
A. flexuosa leaves collected February and July for nutrient analysis.

9. **EPC**, Small valley below chalet accommodation, Peppermint to 5m with some *Hakea* and *Hardenbergia* and dense understorey of *S. globulosum.*
1. Strata 1: 3-6m, 90%, *A. flexuosa* (80%), *S. globulosum* (10%) *Hakea* and *A. truncata* (both < 2%)
2: < 1m, 80%, two species of sedge, *H. comptoniana* and *R. baccata*
Also with a midstrata of dead shrubs (killed but not burnt by the last fire) with the climbers *H. comptoniana* and *R. baccata* (30%, to 1m).
A. flexuosa leaves collected February and July for nutrient analysis.
P. occidentalis dreys and sightings here.

S45: MT MELVILLE On the lower southern slopes Marri (50%, 7-10m) and a few Jarrah grow over Peppermint (40%, to 6m). No possum sign here. Museum records recognise the " Mt Melville *P. occidentalis* population".

S46: MT CLARENCE On the northern slopes of Mt Clarence Marri and Jarrah (60%, to 10m) grows over open midstorey with Peppermint (10% to 5m). Btp here, but no sign of *P. occidentalis*. Peter Collins reports *P. occidentalis* sighted in nearby garden, December 1989.

S47: LAKE SEPPINGS Margins of the lake with dense *A. juniperum*. No sign of *P. occidentalis* here. All *P. occidentalis* records for this area predate a very hot burn in 1988.

S48: MIDDLETON BEACH Albany suburb where houses abut golfcourse, area is about 3 k SW Emu Point. Habitat appears restricted to gardens and parts of golfcourse with Peppermint and Pine trees. No sign here but museum records exist for the area, and Peter Collins reports a November 1989 sighting. (Possible that this relates to an animal displaced by the Lake Seppings fire).

STIRLING AND PORONGORUP RANGES (S49-S54)
P. occidentalis bone has been collected at Porongorup, and on the basis of the current mammal fauna of the Stirlings, Tunney's Cranbrook specimens and the reported Kambellup roadkill we believe the species to have been present at these sites. If *P. occidentalis* still live in the area it is most likely as small groups in 'prime' habitat. Scratch tracks (mostly on wandoo) and *T. vulpecula* faecal pellets showed that *T. vulpecula* occurred at all Stirling sites listed including Kambellup. There was no sign of possum at Porongorup.

S49: PORONGORUP NP This site name refers to a spotlight run (8 k) along the border of Porongorup NP.

S50: STIRLING RANGE NP 7 K OUT Unnamed gully with open Jarrah and Marri on slopes and dense diverse Eucalypts on creekline. *T. vulpecula* here.

S51: STIRLING RANGE NP WHITE GUM FLAT Picnic area in valley. Open Jarrah and Marri on slopes borders Wandoo on flat beside creekline. *T. vulpecula* here.

S52: STIRLING RANGE NP MAGOG Picnic area in valley below Mt Magog. Open Jarrah and Marri on lower slopes borders Wandoo on flat beside creekline. *T. vulpecula* here.

S53: STIRLING RANGE NP TALYABERLUP Valley with creek line and dense Eucalypt (5 or 6 sp.including *E. talyaberlup,* Yate and Bullich) over a patchy understorey. *T. vulpecula* here.

S54: KALGAN RIVER, KAMBELLUP River reserve along the Kalgan River: most of the area subject to flooding under extreme conditions. The area has been grazed, and on flats is mostly Wandoo over pasture. *T. vulpecula* here.

TWO PEOPLES BAY (**TPB**) (S55-S61)
Vegetation at Two Peoples Bay is characterised by the small scale of its complex mosaic pattern. The area is known to have good conservation status for vertebrates (Noisy Scrub Bird), and this may relate to the presence of *Gastrolobium* sp, the dense heath vegetation cover (that

makes life difficult for fox) and the rarity of extensive burns in the last 40 years (Allan Danks, CALM Officer, Two Peoples Bay, pers comm). Ellis and Jones (1992) report on *P. occidentalis* here in the early 1970's. An extensive fox baiting program has been carried out in the Two Peoples Bay area in the past few years.
All sites except that described as Two Peoples Bay Area (S55) showed sign of *P. occidentalis* as dreys and faecal pellets. Four days around Two Peoples Bay yielded only three *P. occidentalis* sightings.

S55:TWO PEOPLES BAY AREA This name refers to an area spotlighted along the Two Peoples Bay Rd from Goodga R to the CALM office. Vegetation is mostly Marri-Jarrah woodland with patches of swampy heath. Towards Two Peoples Bay vegetation is dominated by patchy Peppermint emergent from coastal heath, with one patch of Melaleuca and Peppermint along a stream. Unlike all other TBP sites this area showed no sign of possum.

S56: TWO PEOPLES BAY NORTH LAKE Sandy rises north of Gardener Lake. Jarrah and Marri (60%, to 8m) above Peppermint (40%, to 7m) in the valleys.

S57: TWO PEOPLES BAY OFFICE Flat adjacent to bay with forest of Peppermint (*c.* 60%), Yate *(Eucalyptus cornuta)* and Bullich (80%, to 15m) over shrubs and sedge (90%, to 1.5m), but with short grass in a picnic area.

S58: TWO PEOPLES BAY TICK FLAT GULLY Shallow gully with Bullich and Peppermint (70%, to 8m) over *Hibbertia* (90%, to 2m).

S59: TWO PEOPLES BAY LOWER FIREBREAK GULLY Protected gully with the lower part described generally as follows: Jarrah, Marri and sheoak (70%, 8 to 10m) with Peppermint (10%, to 6m) over shrub and sedge (40%, to 2m).

S60: TWO PEOPLES BAY UPPER FIRE BREAK GULLY Protected gully with the upper part described generally as follows: Jarrah, Marri and Bullich (80%, to 8m) and Peppermint (50%, to 5m) over shrub and sedge (50%, to 3m). Vegetation description for a specific site:
1. Strata 1: 3–5m, 70%, *E. marginata* (45%), *E. callophylla* (10%) and *A.flexuosa* (15%)
2: 4–2m, 30%, *A. juniperum, Solia heterophylla, Hibbertia* sp. and two *Acacia* sp.
4: < 1m, 80%, three species of sedge and *S. heterophylla*

S61: TWO PEOPLES BAY ROBINSONS GULLY Deep narrow gully with dense *E. megacarpa, A. flexuosa* and *Melaleuca* (to 10m in deepest part) over shrubs and sedge.

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EDITORIAL NOTE

The Council of the Western Australian Naturalists' Club (Inc) conducted a survey of members regarding frequency and format of *The Western Australian Naturalist*. Overwhelmingly, members supported the continuation of publishing original data on all branches of natural science pertaining to Western Australia. Members also supported retaining the previous editorial style.

Members have been concerned at the cost of publishing a quarterly journal and accepted a less frequent but larger publication.

Accordingly Council has decided to publish the Journal twice yearly in March and September. Each part will be at least twice the size of the previous quarterly parts. This will reduce production costs without any reduction in the numbers of published pages.

JOHN DELL
(Hon. Editor)

OBSERVATIONS OF CAPTIVE AND WILD WESTERN RINGTAIL POSSUMS *PSEUDOCHEIRUS OCCIDENTALIS*

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INTRODUCTION

Common Ringtail Possums, *Pseudocheirus peregrinus*, of south-eastern Australia have been the subject of a number of studies: field studies of natural populations have provided details of population biology, natural history, growth and reproduction (Thomson & Owen 1964; How *et al.* 1984; Pahl 1987a); Chilcott and Hume (1985) and Pahl (1987b) have studied diet and digestion; Hughes *et al.* (1965) and Pahl and Lee (1988) reported on reproduction in natural populations.

The ringtail possums of south-western Australia have been considered as a subspecies, *P. peregrinus occidentalis*, though Thomas (1888) accorded specific recognition to the south-western ringtails (herein referred to as Western Ringtail Possums). More recently, McKay (1984) suggested that *P. occidentalis* probably warrants species status. The Western Ringtail Possum was given rare and endangered status by the Western Australian government in 1983. How *et al.* (1987) reported an alarming decline in this possums' range.

There have been no published accounts of the biology of Western Ringtail Possums. Between 1969 and 1974, one of us (M.E.) made observations, which are summarised in this paper, of a captive group and two natural populations.

CAPTIVE ANIMALS

Of the eighteen Western Ringtail Possums kept in captivity, six were collected from the wild, one from East Augusta and five from Two Peoples Bay. A male collected in suburban Perth was assumed to be an escaped pet. Possums were kept at M.E.'s home until December 1971 and were held in three cages of wire mesh (1 m square and 2 m high, 3 m x 2 m and 2 m high and 2 m x 1 m and 2 m high) with solid roofs and nest boxes. The possums were subsequently moved to CSIRO's Helena Valley establishment where they were housed in the same cages plus another (4 m x 3 m and 4 m high) of similar construction.

Diet

All possums were given a vitamin and mineral supplement daily ("Petvite") and a ration of Peppermint *(Agonis flexuosa)* leaves. The possums showed a preference for fresh, young, green leaves rather than young leaves with red colouring or older foliage. A variety of other plant materials formed the remainder of the daily ration, according to availability. These included commercially available fruits and vegetables, banana leaves, fuschia leaves, hibiscus and rose flowers, tamarix leaves and bark, biscuits, Marri *(Eucalyptus calophylla)* and Bullich *(E. megacarpa)* leaves.

Water was available at all times. Some possums were regularly observed drinking while others did not appear to drink.

On one occasion, an adult female was seen consuming her faeces.

Behaviour

Scent marking

Both males and females were observed to mark tree limbs with fluid from the cloaca. This behaviour was commonly observed when an animal was moved to new surroundings, and especially if another possum had previously marked the limbs. On one occasion, an animal was observed to deposit fluid directly over that previously deposited by another possum.

Vocalisation

Captive animals were heard to make a challenge or warning bark that consisted of two to four short syllables.

Social behaviour

Some combinations of possums sharing cages resulted in fighting. Peaceful combinations usually consisted of a female and her offspring, including mature daughters. Adult males were often not tolerated by mature females, though males rarely initiated agonistic behaviour. It was clear some possums recalled previous fights since placing a male into a bag (for weighing) that smelled of a female who had attacked him, elicited uncharacteristic distress.

Possums were provided with nest boxes in their cages. Commonly, adult possums rested alone in the same nest box on consecutive days. Adult females shared their nest box with their young until the pouch-young was about 90 days old and nearly ready to make the first emergence from the pouch. The older sibling was evicted from the mother's nest box at this stage. On one occasion, an adult female and male shared a cage with their first young. When the next young was about 90 days old, the mother refused entry to the nest box to the elder daughter, who commandeered the male's box. The male moved into another (vacant) box. Occasionally an adult female shared its mother's nest box, and on a few occasions, a female just evicted from its mother's box shared a male's nest box. Rarely did an adult female share a nest box with an adult male.

A number of agonistic encounters were observed when a new possum was introduced to an already inhabited cage. Four types of attack were recognized:

1. swipe — front paw extended as in a slap
2. bite
3. scratch
4. 'tangle' — a full embrace with biting

Biting and scratching were usually aimed at either the head or tail of the opponent. Most aggressive encounters observed occurred when a male and female were put together (for mating), and were terminated by the observer removing the introduced possum. No submissive behaviour was observed; if an animal attempted to avoid conflict, it sat still as far as possible from the opponent.

On two occasions aggression between cage cohabitors was observed prior to the death of a possum. In one case, a female with two young, male offspring was collected from Two Peoples Bay when the young weighed ca. 170 g. Twenty weeks later, the two young were ca. 850 g. One evening, one of the twins was observed to be chasing its sibling. The next morning the sibling was found dead with extensive head injuries. On another occasion, an adult female was apparently killed by an adult male three days after being introduced into his cage.

Copulation and birth were never observed, though as mentioned earlier, on rare occasions an adult male and female shared a nest box.

Sex ratio

A total of 11 young were born to four females; five of these were male and six were female. This sex ratio did not differ from unity ($X^2_{0.05} = 0.90$, 1 *d.f.*, $p > 0.05$).

Litter size

On one occasion, two young (one female, one male) were born to a female which was born in captivity and had previously raised one young. One of the twins (the female) was found alive on the cage floor at ca. 35 g (ca. 50 days of age) and returned to the pouch. Two days later, it was dead.

Nine of the 11 young born appeared to be single births suggesting that 10% of births are of twins.

Fecundity

Data on the fecundity of captive females are limited because few lived longer than two years in captivity, and some did not have access to males. However, the best record of subsequent births was that of the first captive female collected as a subadult; it had almost constant access to a male. This female successfully raised four young during the first two years of maturity with the first three births occurring within one year (Figure 1). The greater period of time between the last two births may relate to the female's health; the growth of the last young appears slower than that of her earlier offspring.

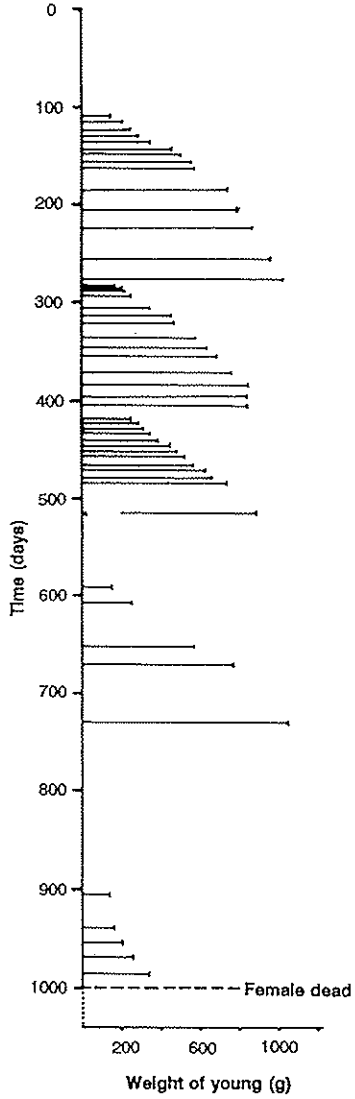

Figure 1: Reproductive chronology for the captive female with the longest reproductive life. Horizontal lines represent the weight of five successive young.

Growth of young

The growth of five young (three females and two males) was documented by frequent weighing starting about the time of first emergence from the pouch. Four of these young were fathered by a male of unknown geographic origin; the mother was from East Augusta. The fifth was the young of the first two (siblings) of the above pair.

The Non Linear Regression sub-programme of SPSSx (SPSS Inc. 1988) was used to compare the relative fits of the growth data to logistic, Gompertz and von Bertalanffy growth curves. Linear regression was used to check the suitability of a straight line growth model. The linear regression yielded a coefficient of determination (R^2) of 0.88 and all curves tested yielded an R^2 = 0.96. The von Bertalanffy equation (Cumulative growth (W) = $a(1-be^{Kt})^3$, where a is the asymptote of the curve, b is the corrected, average slope and K is the derived, initial mass) (Ricklefs 1968) provided the lowest weight at time zero (23 g versus 100 g and 116 g for the logistic and Gompertz equations, respectively). For our data, the equation was:

$$W = 1025\ (1 - 0.016\ e^{23})^3.$$

Clearly, the model's ability to extrapolate birth weights for pouch-young was impaired by our limited data on pre-emergence weights.

Because the date of birth was not known for any of the five young, individual growth curves were matched (for time) at a body weight of 200 g (Figure 2).

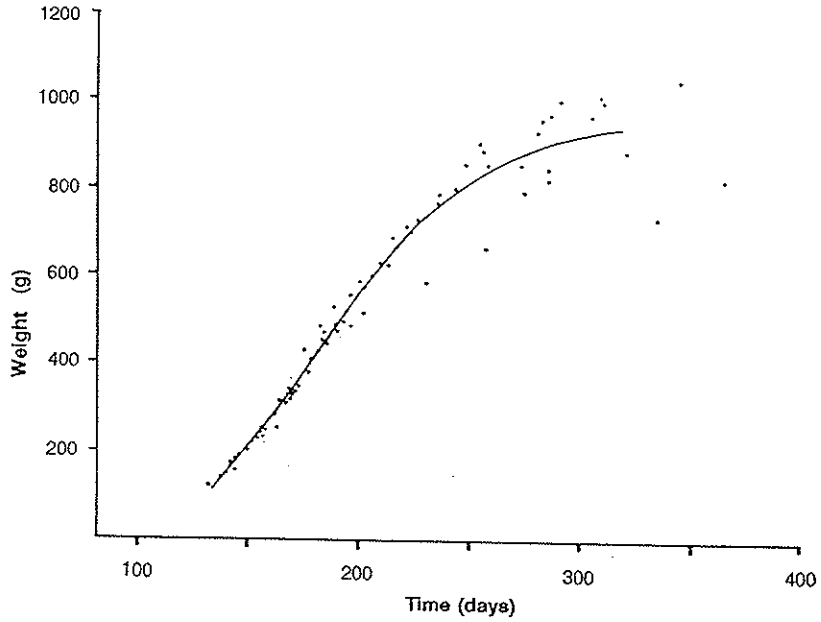

Figure 2: Growth of captive Western Ringtail Possums: most weights were taken after the first emergence from the pouch. Equation for the curve that best fitted the data was:
$W = 1025\ (1 - 0.016e^{23})^3$.

The best estimate of the duration of pouch life is based on the smallest young seen which was viewed when crown-rump length was ca 1 cm. This was 95 days prior to the young's first emergence at a body weight of 125 g. All ages referred to throughout these notes assume a pouch life of 100 days.

The observations cannot be used to suggest a gestation period or the duration of lactation. One female with a young of 500 g (age ca. 160 days) had one functional teat, and this was at least 40 days prior to the birth of the next young.

Young attained adult body weight (900-1000 g) at about 260 days.

Two females born in captivity produced young which were first detected when the mothers were 305 and 320 days old with body weights 1000-1100 g. Other females reproduced at body weights of ca. 900 g, but their age was unknown.

Causes of death

Fourteen possums (seven captive bred, and seven wild caught) died in captivity. The following list gives the animal's gender, age and circumstance of death for those possums that were born in captivity.

female; 22 months ; post mortem revealed impacted stomach with secondary liver degeneration and lack of body fat

female; 32 months; 'accidentally' killed by pet dog
female; 31 months ; accidental overdose of anesthetic
male; 14 months; sick (no response to penicillin) then dead
male; 10 months; post mortem showed lung degeneration
male; 5 months; sickened and died after mother's death
female; body weight 35 g; found on cage floor (its twin was still in the pouch)

The following list gives the animal's gender, the period it was kept in captivity, and its age at capture for possums collected from the wild.

male; 42 months; killed for post mortem, cause of illness focal hepatitis (*Corynebacterium xerosis* cultured from liver)
male; 2 months (adult); sickened and died (cause unknown)
female; 40 months (subadult); post mortem inconclusive, possible heart attack
female; 16 months (adult); unknown
male; 4 months (back young); killed by its twin
male; 8 months (back young); unknown, redback spider found in nest box
female; 3 days (adult); killed by male

WILD POPULATIONS

Drey use

Opportunistic observations of natural populations of Western Ringtail Possums were made at East Augusta and at Two Peoples Bay. Like the Common Ringtail Possum, the Western Ringtail Possum used dreys constructed from flexible twigs and vegetation for daytime shelter at both sites. Observations of the dreys were the main source of data in this section.

The shape and dimensions of a typical drey from East Augusta are shown in Figure 3. Dreys were located in trees or shrubs, often in dense clumps of vegetation such as vines or creepers. Twigs of Peppermint usually formed a major part of the drey; other materials observed included sedge leaves and bracken fronds which were available only from ground level.

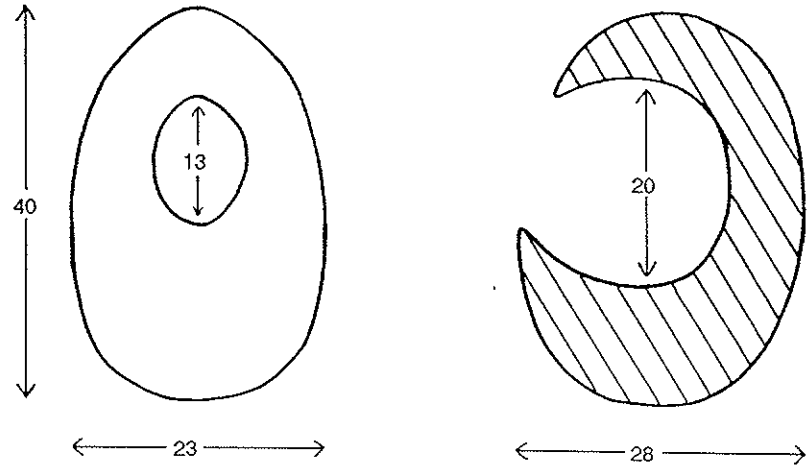

Figure 3: Shape and dimensions (cm) of a typical drey from East Augusta.

The height above ground of 14 dreys was recorded at each locality. At East Augusta the average height was 5.4 m (2.4-8.2 m), significantly higher than that at Two Peoples Bay, 1.6 m (0.6-3.6 m) (Student's $t_{27} = 8.30$, $p < 0.005$). At Two Peoples Bay, dreys were often located in shrubs of the understorey (below trees to 8 m), while at East Augusta, most dreys were in the trees (*A. flexuosa* to ca. 10 m) and the understorey was primarily of sedge and bracken.

At Two Peoples Bay, dreys at a number of sites were checked for occupancy. One hundred and three dreys were checked of which eight were occupied, giving an occupancy rate (number of dreys occupied by a ringtail/total number of dreys checked) of 8%.

At East Augusta 32 dreys were tagged between 1969 and 1972, all of which were occupied by a possum at some time. During four years, six marked dreys became derelict either falling from a tree or breaking apart. Persistence of dreys ranged from six months to at least 38 months.

A drey marked M11 was used for 38 months by at least three different possums. Records of the occupancy for this drey are shown in Table 1.

Table 1. Records of occupation of a single drey (M11) at East Augusta. The "O" denotes that the drey was occupied; the "E" empty.

Day	Drey	Occupant(s)
1	E	
337	E	
399	O	female and young
426	O	female (adult)
623	O	female and large young
624	O	unknown
625	O	unknown
645	E	
677	E	
688	O	male
735	O	unknown
766	O	unknown
767	E	
806	E	
807	E	
808	E	
813	O	female and young
837	E	
841	E	
843	E	
1045	O	male
1046	E	
1069	O	female (subadult)
1071	E	
1172	drey broken up	

Within one month of M11 breaking up, a new drey was built in the same position.

Summarising, the occupancy rate for all marked dreys at East Augusta showed 40% of dreys checked were occupied, while for M11 the occupancy rate was 45.8%.

On one occasion, three possums (a female with two young) were flushed from a drey at Two Peoples Bay. All other dreys were occupied by a solitary male or female, or a female and young.

Field weight

Adult possums were caught at both localities. From East Augusta, seven females had a mean weight of 1057 g (960-1100 g) and three males 1102 g (950-1250 g). From Two Peoples Bay, two females weighed 1080 and 1040 g and three males had a mean weight of 1078 g (1000-1160 g).

DISCUSSION

Comparing these observations of the Western Ringtail Possum with reports of the biology of the Common Ringtail Possum (Thomson and Owen 1964; How *et al.* 1984) shows a number of differences between the species. Drey occupancy results suggest social behaviour of the two species differs. In this study, Western Ringtails were never observed sharing nests, except for females with young. Thomson and Owen (1964) found adult Common Ringtails shared dreys in a variety of combinations; about half of the dreys contained a single animal, one third were occupied by a pair (male and female), and the remaining dreys contained the rarer cases of more than two adults or two adult

males. Observations of captive Western Ringtails suggest that drey-sharing may occur, but the field observations indicate adults do not share dreys on a regular basis, and that if drey-sharing does occur naturally, it is an unusual event.

Adult Western Ringtail Possums weigh about 950-1100 g, being considerably heavier than Common Ringtail Possums from Victoria (ca. 700-900 g). Most births were single in Western Ringtails, but twins are the norm for Common Ringtails. This suggests that the growth of young is likely to differ also, but our data are too sparse to comment with any confidence.

Smith and Lee (1984) describe trends in body size and reproductive patterns for Australian possums and gliders, and show that larger species tend to have smaller litters. They also suggest that the low nutritional value of a herbivorous diet may provide a selective advantage that encourages the evolution of larger body size. Applying these concepts to the major differences between the Western Ringtail Possum and the Common Ringtail Possum prompts the suggestion that Western Australian habitats may offer a lower quality food resource than that available in the eastern states. The more solitary social arrangements of Western Ringtail Possums may also be a response to a lower quality food resource. Further studies of dispersion patterns may allow evaluation of these suppositions.

ACKNOWLEDGEMENTS

The Ellis family made generous contributions to the maintenance of the captive ringtails; sons David and Michael maintained a continuous supply of Peppermint leaves, and wife Merle tended the possums during M. E.'s frequent absences on fieldwork in 1970-72. Post-mortems were carried out by M.P. Bond (Western Australian Department of Agriculture) and Dr Phil Harwood.

CSIRO (Helena Valley) provided accommodation for the captive ringtails in 1973 and 1974, and caretakers Ben Baker and Harold Davies tended the possums and made valuable observations. Catherine Meathrel kindly ran the growth data through the SPSSx package and provided valuable comment on the manuscript, as did Ric How and Darrell Kitchener. Funding to the Western Australian Museum from the Endangered Species Program of the Australian National Parks and Wildlife Service enabled the diaries to be collated through the part-time employment of the second author.

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EDITORIAL NOTE

The Council of the Western Australian Naturalists' Club (Inc) conducted a survey of members regarding frequency and format of *The Western Australian Naturalist*. Overwhelmingly, members supported the continuation of publishing original data on all branches of natural science pertaining to Western Australia. Members also supported retaining the previous editorial style.

Members have been concerned at the cost of publishing a quarterly journal and accepted a less frequent but larger publication.

Accordingly Council has decided to publish the Journal twice yearly in March and September. Each part will be at least twice the size of the previous quarterly parts. This will reduce production costs without any reduction in the numbers of published pages.

JOHN DELL
(Hon. Editor)

OBSERVATIONS OF CAPTIVE AND WILD WESTERN RINGTAIL POSSUMS *PSEUDOCHEIRUS OCCIDENTALIS*

By MIKE ELLIS and BARBARA JONES,
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INTRODUCTION

Common Ringtail Possums, *Pseudocheirus peregrinus*, of south-eastern Australia have been the subject of a number of studies: field studies of natural populations have provided details of population biology, natural history, growth and reproduction (Thomson & Owen 1964; How *et al.* 1984; Pahl 1987a); Chilcott and Hume (1985) and Pahl (1987b) have studied diet and digestion; Hughes *et al.* (1965) and Pahl and Lee (1988) reported on reproduction in natural populations.

The ringtail possums of south-western Australia have been considered as a subspecies, *P. peregrinus occidentalis*, though Thomas (1888) accorded specific recognition to the south-western ringtails (herein referred to as Western Ringtail Possums). More recently, McKay (1984) suggested that *P. occidentalis* probably warrants species status. The Western Ringtail Possum was given rare and endangered status by the Western Australian government in 1983. How *et al.* (1987) reported an alarming decline in this possums' range.

There have been no published accounts of the biology of Western Ringtail Possums. Between 1969 and 1974, one of us (M.E.) made observations, which are summarised in this paper, of a captive group and two natural populations.

CAPTIVE ANIMALS

Of the eighteen Western Ringtail Possums kept in captivity, six were collected from the wild, one from East Augusta and five from Two Peoples Bay. A male collected in suburban Perth was assumed to be an escaped pet. Possums were kept at M.E.'s home until December 1971 and were held in three cages of wire mesh (1 m square and 2 m high, 3 m x 2 m and 2 m high and 2 m x 1 m and 2 m high) with solid roofs and nest boxes. The possums were subsequently moved to CSIRO's Helena Valley establishment where they were housed in the same cages plus another (4 m x 3 m and 4 m high) of similar construction.

Diet

All possums were given a vitamin and mineral supplement daily ("Petvite") and a ration of Peppermint *(Agonis flexuosa)* leaves. The possums showed a preference for fresh, young, green leaves rather than young leaves with red colouring or older foliage. A variety of other plant materials formed the remainder of the daily ration, according to availability. These included commercially available fruits and vegetables, banana leaves, fuschia leaves, hibiscus and rose flowers, tamarix leaves and bark, biscuits, Marri *(Eucalyptus calophylla)* and Bullich *(E. megacarpa)* leaves.

Water was available at all times. Some possums were regularly observed drinking while others did not appear to drink.

On one occasion, an adult female was seen consuming her faeces.

Behaviour

Scent marking

Both males and females were observed to mark tree limbs with fluid from the cloaca. This behaviour was commonly observed when an animal was moved to new surroundings, and especially if another possum had previously marked the limbs. On one occasion, an animal was observed to deposit fluid directly over that previously deposited by another possum.

Vocalisation

Captive animals were heard to make a challenge or warning bark that consisted of two to four short syllables.

Social behaviour

Some combinations of possums sharing cages resulted in fighting. Peaceful combinations usually consisted of a female and her offspring, including mature daughters. Adult males were often not tolerated by mature females, though males rarely initiated agonistic behaviour. It was clear some possums recalled previous fights since placing a male into a bag (for weighing) that smelled of a female who had attacked him, elicited uncharacteristic distress.

Possums were provided with nest boxes in their cages. Commonly, adult possums rested alone in the same nest box on consecutive days. Adult females shared their nest box with their young until the pouch-young was about 90 days old and nearly ready to make the first emergence from the pouch. The older sibling was evicted from the mother's nest box at this stage. On one occasion, an adult female and male shared a cage with their first young. When the next young was about 90 days old, the mother refused entry to the nest box to the elder daughter, who commandeered the male's box. The male moved into another (vacant) box. Occasionally an adult female shared its mother's nest box, and on a few occasions, a female just evicted from its mother's box shared a male's nest box. Rarely did an adult female share a nest box with an adult male.

A number of agonistic encounters were observed when a new possum was introduced to an already inhabited cage. Four types of attack were recognized:

1. swipe — front paw extended as in a slap
2. bite
3. scratch
4. 'tangle' — a full embrace with biting

Biting and scratching were usually aimed at either the head or tail of the opponent. Most aggressive encounters observed occurred when a male and female were put together (for mating), and were terminated by the observer removing the introduced possum. No submissive behaviour was observed; if an animal attempted to avoid conflict, it sat still as far as possible from the opponent.

On two occasions aggression between cage cohabitors was observed prior to the death of a possum. In one case, a female with two young, male offspring was collected from Two Peoples Bay when the young weighed ca. 170 g. Twenty weeks later, the two young were ca. 850 g. One evening, one of the twins was observed to be chasing its sibling. The next morning the sibling was found dead with extensive head injuries. On another occasion, an adult female was apparently killed by an adult male three days after being introduced into his cage.

Copulation and birth were never observed, though as mentioned earlier, on rare occasions an adult male and female shared a nest box.

Sex ratio

A total of 11 young were born to four females; five of these were male and six were female. This sex ratio did not differ from unity ($X^2_{0.05} = 0.90$, 1 *d.f.*, $p > 0.05$).

Litter size

On one occasion, two young (one female, one male) were born to a female which was born in captivity and had previously raised one young. One of the twins (the female) was found alive on the cage floor at ca. 35 g (ca. 50 days of age) and returned to the pouch. Two days later, it was dead.

Nine of the 11 young born appeared to be single births suggesting that 10% of births are of twins.

Fecundity

Data on the fecundity of captive females are limited because few lived longer than two years in captivity, and some did not have access to males. However, the best record of subsequent births was that of the first captive female collected as a subadult; it had almost constant access to a male. This female successfully raised four young during the first two years of maturity with the first three births occurring within one year (Figure 1). The greater period of time between the last two births may relate to the female's health; the growth of the last young appears slower than that of her earlier offspring.

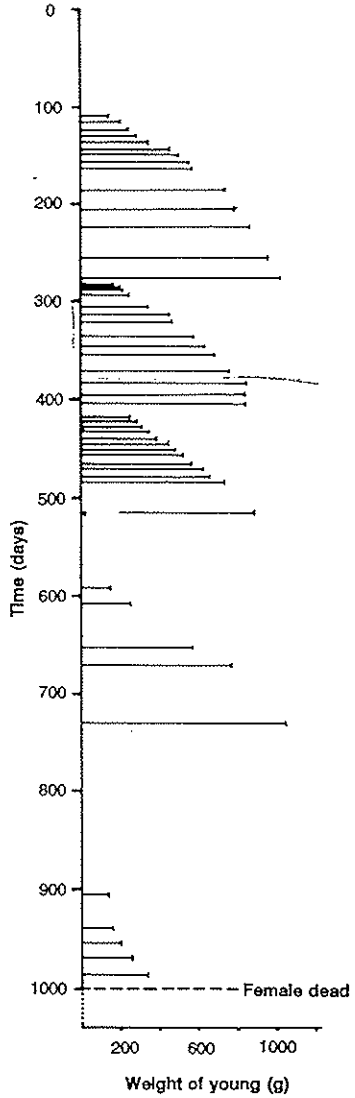

Figure 1: Reproductive chronology for the captive female with the longest reproductive life. Horizontal lines represent the weight of five successive young.

Growth of young

The growth of five young (three females and two males) was documented by frequent weighing starting about the time of first emergence from the pouch. Four of these young were fathered by a male of unknown geographic origin; the mother was from East Augusta. The fifth was the young of the first two (siblings) of the above pair.

The Non Linear Regression sub-programme of SPSSx (SPSS Inc. 1988) was used to compare the relative fits of the growth data to logistic, Gompertz and von Bertalanffy growth curves. Linear regression was used to check the suitability of a straight line growth model. The linear regression yielded a coefficient of determination (R^2) of 0.88 and all curves tested yielded an R^2 = 0.96. The von Bertalanffy equation (Cumulative growth (W) = $a(1—be^{Kt})^3$, where a is the asymptote of the curve, b is the corrected, average slope and K is the derived, initial mass) (Ricklefs 1968) provided the lowest weight at time zero (23 g versus 100 g and 116 g for the logistic and Gompertz equations, respectively). For our data, the equation was:

$$W = 1025\ (1 — 0.016\ e^{23})^3.$$

Clearly, the model's ability to extrapolate birth weights for pouch-young was impaired by our limited data on pre-emergence weights.

Because the date of birth was not known for any of the five young, individual growth curves were matched (for time) at a body weight of 200 g (Figure 2).

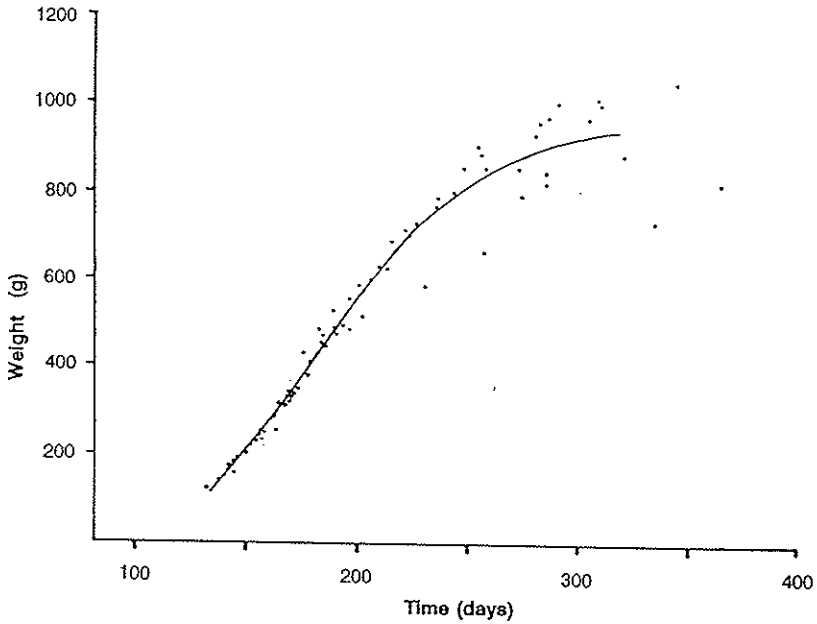

Figure 2: Growth of captive Western Ringtail Possums: most weights were taken after the first emergence from the pouch. Equation for the curve that best fitted the data was:
$W = 1025\ (1 — 0.016e^{23})^3$.

The best estimate of the duration of pouch life is based on the smallest young seen which was viewed when crown-rump length was ca 1 cm. This was 95 days prior to the young's first emergence at a body weight of 125 g. All ages referred to throughout these notes assume a pouch life of 100 days.

The observations cannot be used to suggest a gestation period or the duration of lactation. One female with a young of 500 g (age ca. 160 days) had one functional teat, and this was at least 40 days prior to the birth of the next young.

Young attained adult body weight (900-1000 g) at about 260 days.

Two females born in captivity produced young which were first detected when the mothers were 305 and 320 days old with body weights 1000-1100 g. Other females reproduced at body weights of ca. 900 g, but their age was unknown.

Causes of death

Fourteen possums (seven captive bred, and seven wild caught) died in captivity. The following list gives the animal's gender, age and circumstance of death for those possums that were born in captivity.

female; 22 months ; post mortem revealed impacted stomach with secondary liver degeneration and lack of body fat

female; 32 months; 'accidentally' killed by pet dog
female; 31 months ; accidental overdose of anesthetic
male; 14 months; sick (no response to penicillin) then dead
male; 10 months; post mortem showed lung degeneration
male; 5 months; sickened and died after mother's death
female; body weight 35 g; found on cage floor (its twin was still in the pouch)

The following list gives the animal's gender, the period it was kept in captivity, and its age at capture for possums collected from the wild.

male; 42 months; killed for post mortem, cause of illness focal hepatitis (*Corynebacterium xerosis* cultured from liver)
male; 2 months (adult); sickened and died (cause unknown)
female; 40 months (subadult); post mortem inconclusive, possible heart attack
female; 16 months (adult); unknown
male; 4 months (back young); killed by its twin
male; 8 months (back young); unknown, redback spider found in nest box
female; 3 days (adult); killed by male

WILD POPULATIONS

Drey use

Opportunistic observations of natural populations of Western Ringtail Possums were made at East Augusta and at Two Peoples Bay. Like the Common Ringtail Possum, the Western Ringtail Possum used dreys constructed from flexible twigs and vegetation for daytime shelter at both sites. Observations of the dreys were the main source of data in this section.

The shape and dimensions of a typical drey from East Augusta are shown in Figure 3. Dreys were located in trees or shrubs, often in dense clumps of vegetation such as vines or creepers. Twigs of Peppermint usually formed a major part of the drey; other materials observed included sedge leaves and bracken fronds which were available only from ground level.

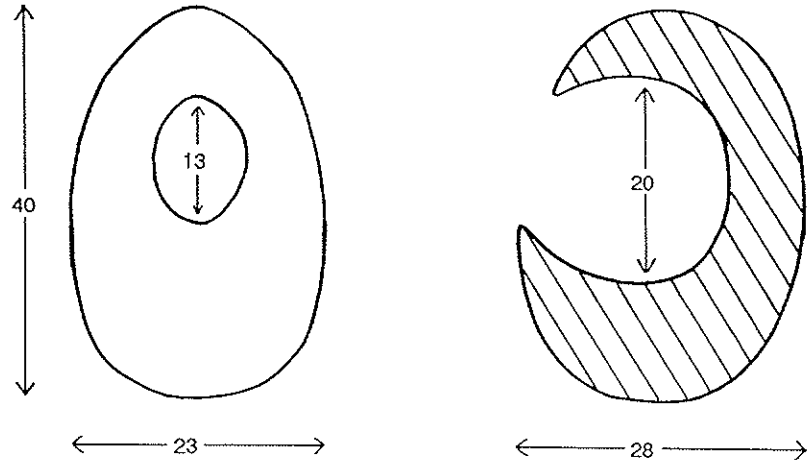

Figure 3: Shape and dimensions (cm) of a typical drey from East Augusta.

The height above ground of 14 dreys was recorded at each locality. At East Augusta the average height was 5.4 m (2.4-8.2 m), significantly higher than that at Two Peoples Bay, 1.6 m (0.6-3.6 m) (Student's $t_{27} = 8.30$, $p < 0.005$). At Two Peoples Bay, dreys were often located in shrubs of the understorey (below trees to 8 m), while at East Augusta, most dreys were in the trees (*A. flexuosa* to ca. 10 m) and the understorey was primarily of sedge and bracken.

At Two Peoples Bay, dreys at a number of sites were checked for occupancy. One hundred and three dreys were checked of which eight were occupied, giving an occupancy rate (number of dreys occupied by a ringtail/total number of dreys checked) of 8%.

At East Augusta 32 dreys were tagged between 1969 and 1972, all of which were occupied by a possum at some time. During four years, six marked dreys became derelict either falling from a tree or breaking apart. Persistence of dreys ranged from six months to at least 38 months.

A drey marked M11 was used for 38 months by at least three different possums. Records of the occupancy for this drey are shown in Table 1.

Table 1. Records of occupation of a single drey (M11) at East Augusta. The "O" denotes that the drey was occupied; the "E" empty.

Day	Drey	Occupant(s)
1	E	
337	E	
399	O	female and young
426	O	female (adult)
623	O	female and large young
624	O	unknown
625	O	unknown
645	E	
677	E	
688	O	male
735	O	unknown
766	O	unknown
767	E	
806	E	
807	E	
808	E	
813	O	female and young
837	E	
841	E	
843	E	
1045	O	male
1046	E	
1069	O	female (subadult)
1071	E	
1172	drey broken up	

Within one month of M11 breaking up, a new drey was built in the same position.

Summarising, the occupancy rate for all marked dreys at East Augusta showed 40% of dreys checked were occupied, while for M11 the occupancy rate was 45.8%.

On one occasion, three possums (a female with two young) were flushed from a drey at Two Peoples Bay. All other dreys were occupied by a solitary male or female, or a female and young.

Field weight

Adult possums were caught at both localities. From East Augusta, seven females had a mean weight of 1057 g (960-1100 g) and three males 1102 g (950-1250 g). From Two Peoples Bay, two females weighed 1080 and 1040 g and three males had a mean weight of 1078 g (1000-1160 g).

DISCUSSION

Comparing these observations of the Western Ringtail Possum with reports of the biology of the Common Ringtail Possum (Thomson and Owen 1964; How *et al.* 1984) shows a number of differences between the species. Drey occupancy results suggest social behaviour of the two species differs. In this study, Western Ringtails were never observed sharing nests, except for females with young. Thomson and Owen (1964) found adult Common Ringtails shared dreys in a variety of combinations; about half of the dreys contained a single animal, one third were occupied by a pair (male and female), and the remaining dreys contained the rarer cases of more than two adults or two adult

males. Observations of captive Western Ringtails suggest that drey-sharing may occur, but the field observations indicate adults do not share dreys on a regular basis, and that if drey-sharing does occur naturally, it is an unusual event.

Adult Western Ringtail Possums weigh about 950-1100 g, being considerably heavier than Common Ringtail Possums from Victoria (ca. 700-900 g). Most births were single in Western Ringtails, but twins are the norm for Common Ringtails. This suggests that the growth of young is likely to differ also, but our data are too sparse to comment with any confidence.

Smith and Lee (1984) describe trends in body size and reproductive patterns for Australian possums and gliders, and show that larger species tend to have smaller litters. They also suggest that the low nutritional value of a herbivorous diet may provide a selective advantage that encourages the evolution of larger body size. Applying these concepts to the major differences between the Western Ringtail Possum and the Common Ringtail Possum prompts the suggestion that Western Australian habitats may offer a lower quality food resource than that available in the eastern states. The more solitary social arrangements of Western Ringtail Possums may also be a response to a lower quality food resource. Further studies of dispersion patterns may allow evaluation of these suppositions.

ACKNOWLEDGEMENTS

The Ellis family made generous contributions to the maintenance of the captive ringtails; sons David and Michael maintained a continuous supply of Peppermint leaves, and wife Merle tended the possums during M. E.'s frequent absences on fieldwork in 1970-72. Post-mortems were carried out by M.P. Bond (Western Australian Department of Agriculture) and Dr Phil Harwood.

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