FERAL PIGS IN THE SOUTH-WEST OF WESTERN AUSTRALIA

-FINAL REPORT TO FERAL PIG COMMITTEE

(K.B.MASTERS, 1979)

FINAL REPORT - FERAL PIGS IN THE SOUTH- WEST

This report outlines the research conducted and results obtained during a 1977-79 investigation of the status of feral pigs in the jarrah forest system of the South- West of Western Australia. A more complete analysis of findings will be submitted to the University of W.A. for scrutiny as a Master of Science manuscript. Finance for the study has been provided by State Government departments of Agriculture, Agriculture Protection, Fisheries and Wildlife, Forestry, Metropolitan Water Supply and Public Works.

Introduction

The ability of pigs to establish themselves in suitable environments is recognised on a world scale. Members of the pig family are naturally distributed throughout Eurasia south of 58 degrees N. latitude as well as Africa and many island countries adjacent these mainland continents. Successful introductions mostly of domestic forms, have occurred in parts of North America, Hawaii, New Zealand and Australia. Where feral pigs occur their presence may be viewed as desirable or undesirable depending on how they adapt to each environment and on local human attitudes. In North America, for example, feral pigs are generally considered a valuable asset as a big game animal despite recognition of the fact that in large numbers pasture and rangeland damage can be severe (Patten, 1974). The emphasis there is in maintaining numbers at a reasonable level. In countries with environments not well adapted to the disturbing influence of eutherian mammals feral pigs are less readily tolerated. Thus the general attitude in Australia and New Zealand is to treat these animals as vermin. As most of Australia's feral pigs occur in a broad band across N.S.W., Queensland and the Northern Territory it is here also that feral pigs have received most attention. The close-to-plague numbers experienced in some of these areas combined with a

high incidence of disease, attacks on livestock and pasture damage have led to a situation where eradication is given high priority (Corner and Pearson, 1975; Ecos, Aug 1977; Giles, 1978). Creating a policy on feral pigs of the South-West requires information about how well pigs have become established here, the nature and extent of present problems and, the likelihood of the situation deteriorating.
Specific possible problem areas include the following:
Feral pigs may represent 1) a threat to livestock through direct attacks or through the transmission of infectious disease, 2) a threat to crops, pastures, fences and farm water supplies,
3) a threat to native flora and fauna, 4) a significant vector of the destructive "jarrah dieback" fungus and,
5) a threat to water quality in catchment areas.
The present study is seen as a first step in determining the exact problem status of feral pigs of the South- West. Through a systematic field collection of information concerning basic feral pig biology and a detailed look at some of the above areas of concern it has been possible to make an assessment of the success and impact of the animal in this environment. In addition a study made of several possible control methods has allowed an insight into the future of reducing pig numbers in problem areas.

History of Feral Pigs in the South-West

There are very few written accounts of the establishment and spread of feral pigs in this area- most of this information comes from interviews with older residents.

The introduction of pigs into the forest of the South-West began early in the history of European settlement. Most of the pigs that became feral at this time probably did so through a process of gradual transition from a freely roaming domestic state. The spread of feral pigs thus tended to follow the spread of settlement; the first colonies formed on the coast and tended to avoid more rugged parts of the Darling Ranges.

It was not until large scale timber milling became profitable that the jarrah forest was settled on a large scale. This occurred during the 1870's and probably marks the time when pigs first became established in the area. During the years of "spot milling" pig hunting from horseback was a popular passtime for the large population resident in the Darling Ranges. At the close of this era in the 1950's feral pigs were well established in the forest between Jarrahdale and Collie, the major concentrations apparently being along the western edge of the range. The natural spread of pigs through this area was aided by sporadic releases of domestic stock, mostly of Berkshire and Tamworth breeds. In the past 20years feral populations of the coast have been virtually eliminated whilst those in the forest have persisted and continued to extend their range. The greatest extension has been in a southward direction beyond Collie towards Donnybrook, Bridgetown and Boyup Brook. Reports indicate that there has been some recent intrusion into the forests of the deep south near Nannup.

Present Distribution

To follow up a feral pig questinnaire/interview survey conducted in 1977 and after looking into the feasibility of an aerial survey,a method of determining pig distribution based on a ground survey was developed. This consisted of a system of transects run at five mile intervals throughout the forest and located on the forestry reference grid. At each location six transects radiated for 100m at 0^{o}, 60^{o}, 120^{o},180^{o}, 240^{o},and 300^{o}. Pig disturbance within 1m of the transect was translated to a linear distance on the 100m tape. Five levels of disturbance were recognised:

1) Greater than 20m total disturbance at each location.
2) 2-20m " " " " "
3) Less than 2m " " " " "
4) Disturbance present but not recorded on transects.
5) No sign of pig activity in vicinity of transects.

The distribution of pig activity determined in this way was considered to be a reliable indicator of pig distribution which reflects relative concentrations rather than absolute distribution limits. The results of the survey are represented in figure 1. Activity levels are consistently high in association with the major river systems, paticularly where a large part of their course is through restricted access, forest quarantine areas.

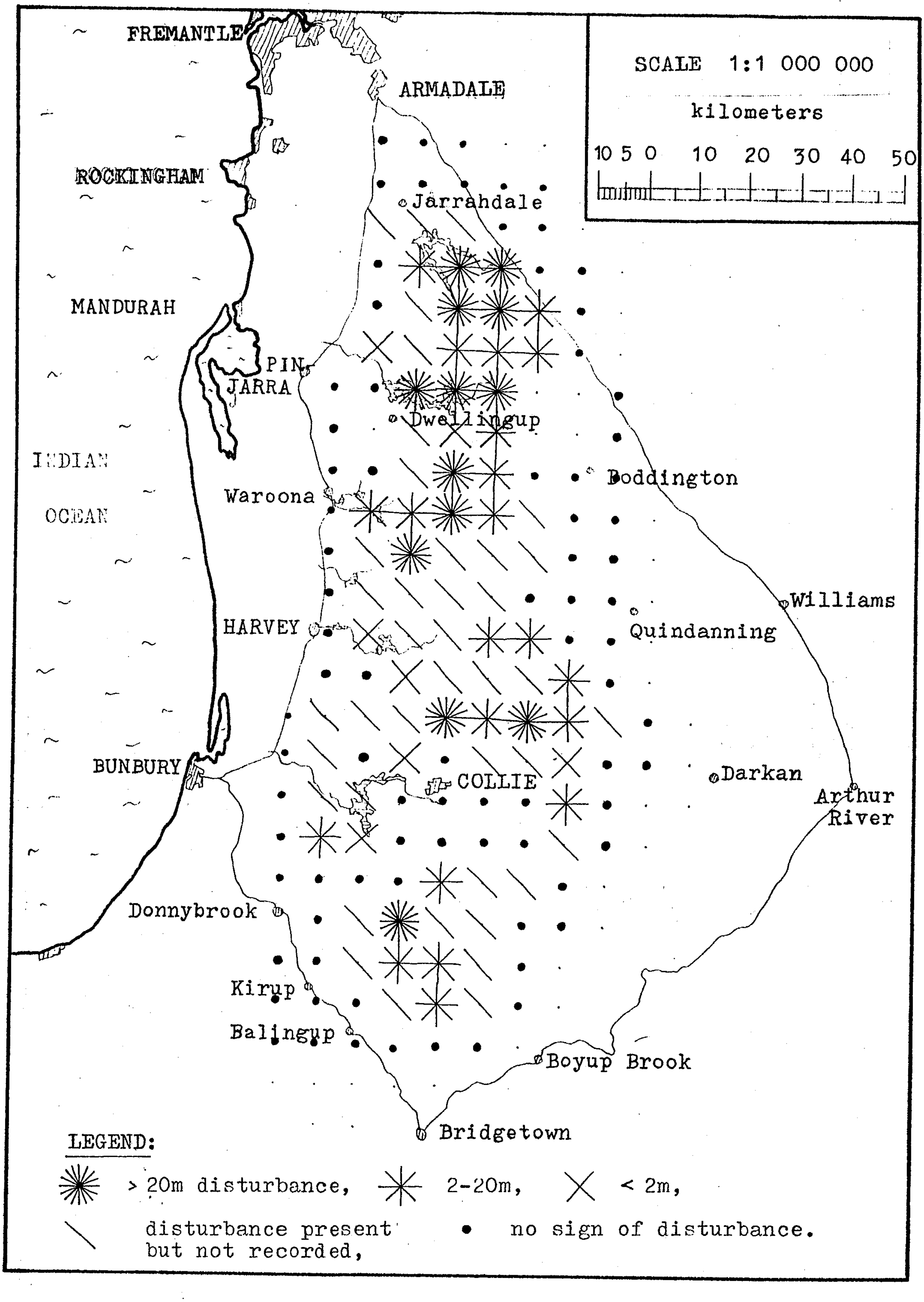
Population Size

Density of the population varies considerably over the affected area and appears to depend on several factors including favourability of habitat, hunting pressure and duration of infestation. It is likely that,as reported elsewhere, there is also considerable variation in population size between "good" and "bad" years (eg, Giles,1978; Pine and Gerdes, 1973). Based on tag- recapture and other data collected on pig movements the density of pigs around the South Dandalup Dam was estimated by crude Lincoln Index as being 2-4 pigs km^{-2}. Catch per unit effort indicated that this was a high density relative to that of most of the forest in which pigs are found. It was considered that whilst isolated small areas probably support higher densities than this, the majority of the forest area is much less favourable for pigs and the average density over the entire range almost certainly falls below 1pig km^{-2}. This places the estimated total 1979 population size at below 10 000 pigs. With an annual hunter kill of about 2 000 (1977 questionnaire/ interview survey) hunting at these densities becomes a significant factor in the dynamics of the population. The figure of 10 000 pigs is perhaps ~~is perhaps~~ lower than it might be due to the unfavourable dry conditions of 1978-79 when recruitment into the population appeared low (see pop$^{\underline{n}}$ structure and dynamics). Annual rainfall for the area has been below average since 1974.

Bodily Appearance

In the present study pigs examined were measured, and where possible weighed; coat colour was recorded and an estimate of condition made.

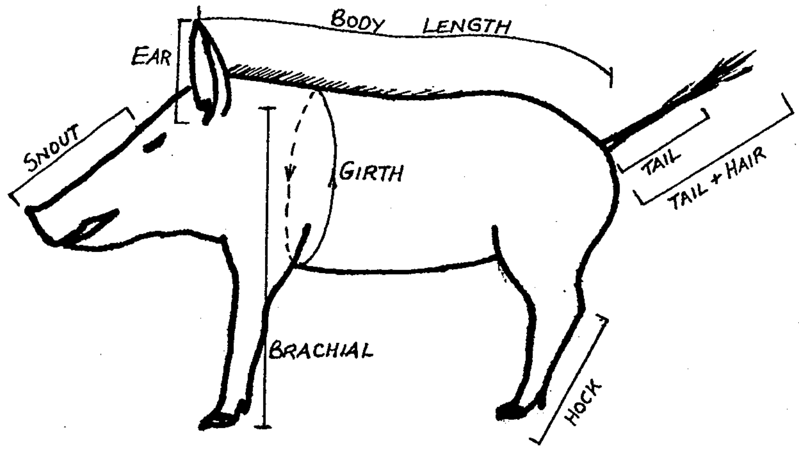
FIGURE 1 DISTRIBUTION OF FERAL PIG ACTIVITY IN THE SOUTH - WEST (OCT-DEC 1978)



Morphometrics:

Nine standard body measurements were routinely recorded. Level of accuracy for each measurement corresponds to that suggested by Ansell (1965).

FIGURE 2. Measurements recorded



- Body length (nuchal crest to rump over curves- nearest 1cm)
- Heart girth(body circumference immediately posterior to forelegs- nearest 1cm)
- Snout length (tip of snout to midway between eyes- 1cm)
- Brachial height (tip of scapula to tip of hoof- 1cm)
- Hock length (point of hock to tip of hoof- 1cm)
- Tail length (anus to distal end of last caudal vertebra with tail at 30-40^{o} above horizontal- 1cm)
- Tail+hair (anus to longest tail hair- 1cm)
- Ear length (tip of ear to base of notch of external auditory meatus- 1mm)
- Mane length (longest hair taken from back of neck- 1mm)

Average recorded measurements for adult feral pigs examined during the study are:

TABLE 1. Average adult measurements- South West feral pigs (cm)

	Length	Girth	Snout	Brach	Hock	Tail	T(+hair)	Ear	Mane
Male	106	96	22	66	27	26.4	44.2	15.0	7.7
Female	100	91	21	61	25	24.8	40.3	13.9	7.6
%Diff.	5.7	5.2	4.5	7.6	7.4	6.1	8.8	7.3	1.3

Similar measurements performed on domestic pigs revealed that the pig is, as tradition suggests a more rangily built animal; shorter lenghtwise but of longer limbs and larger snout. Hair on the coat and tail is longer and the tail tends to be straight except in pigs with large quantities of fat. Ears are reduced in size compared with those of the average domestic pig.

Weight

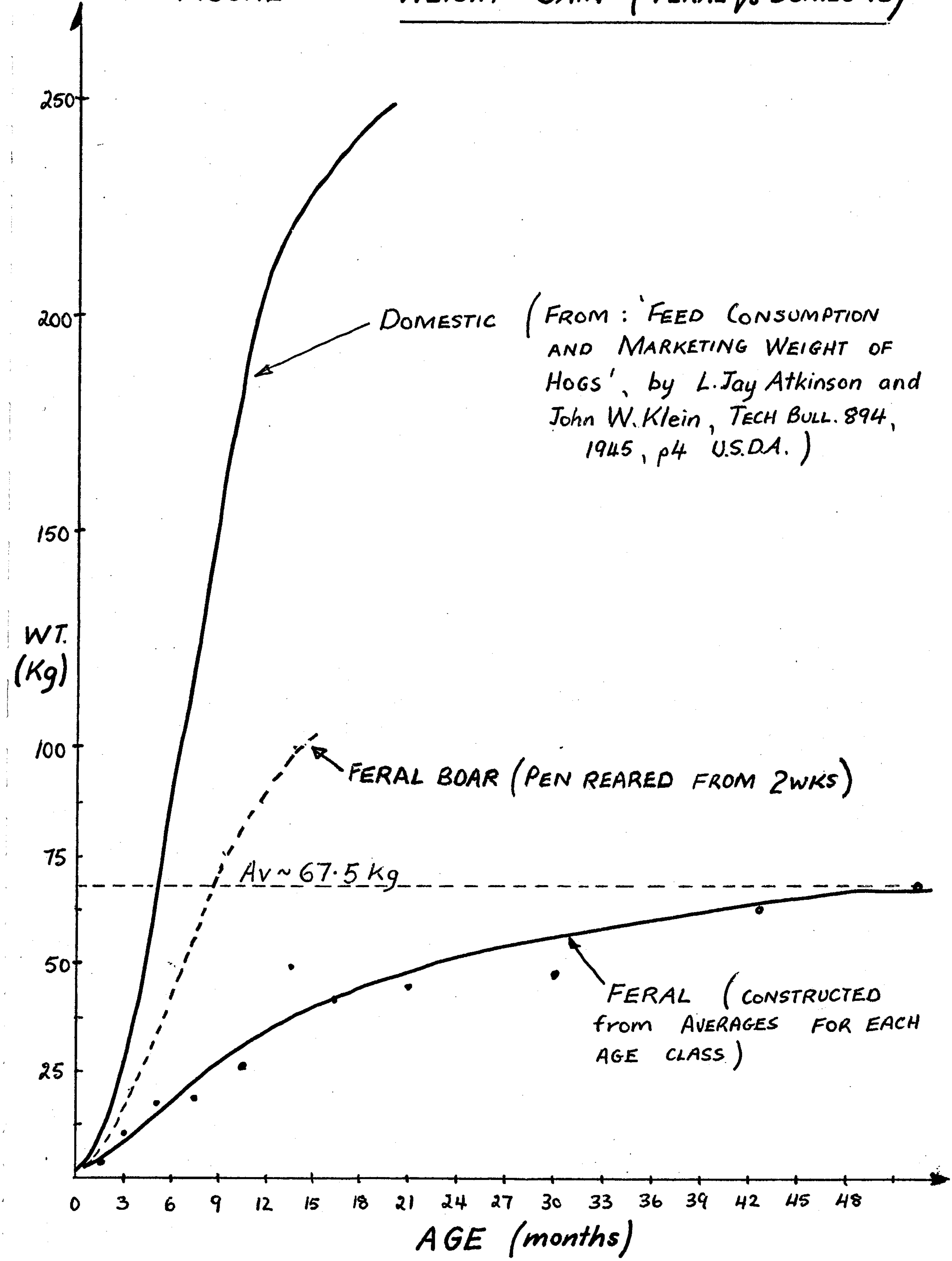
Average live weight of adult feral pigs observed was 59.8kg (S.D.=26.2) for males and 39.6kg (S.D.=11.9) for females. Maximum weights recorded were 115kg (male) and 75kg (female). Much larger pigs than this have from time to time been caught, for example, a boar caught at Wilga in July 1979 was reported to weigh 175kg (A.McKenzie, pers comm.). These pigs are usually very fat, have a similar body conformation to a domestic pig and are probably not far removed from domestication. On a strict bush diet in seasons such as those experienced in the past 2-3 years pigs from older feral populations appear unlikely to exceed 140kg liveweight.

The average weight of pigs of both sexes observed during 1978-79 was lowest in Autumn and highest in Winter indicating that the period between these two seasons is the main time of year for weight gain. Recaptured pigs indicate that weight can be rapidly gained and lost, particularly in sows. One sow, for example, lost 20kg in 3mths (Aug-Nov) whilst lactating whilst another gained 14kg in 2mths (Feb-Apr) following weaning.

Average weight gain of feral pigs with age is estimated by Figure 3 of weights and estimated ages of pigs examined. Included for comparison is a typical weight-gain curve of domestic pigs and the weight gain of a pen-reared feral boar caught at 2 weeks and 2kg. A male litter mate of this pig was tagged but has not yet been recaptured.

The big difference in growth rates is partly due to differences in dietary plane as shown by the intermediate weight gain of the pen-reared feral pig. Most people who have raised "feral" pigs in captivity state that they do much less well than domestic pigs raised under the same conditions

FIGURE 3 WEIGHT GAIN (FERAL Vs DOMESTIC)



suggesting that the slower growth rate of feral pigs is also largely attributable to breed.

Condition

A subjective estimate of condition was used which was based on that used by J.Giles for feral pigs in N.S.W. External features provide an index to fat reserves:

Score	Appearance	Depth of backfat
4	Ex.condition, body rounded.	10mm
3	Gd cond.- hips not palpable.	2-10mm
2	Av.cond.- hips readily palpable.	0-2mm
1	Poor cond.- hips prominent, spine readily palpable.	0
0	V.poor- emaciated, hips and spine prominent, live animals weak.	0

The seasonal variation of pig condition estimated using this score is shown in Figure 4. On a yearly basis the average condition of boars was higher and more stable than that of sows. The average condition of sows peaked in August following several months of abundant food supplies. This coincides with the time of year when a high proportion of the sows are pregnant. Soon after farrowing occurs, lactation begins and average condition declines. Area appeared to exert an effect on pig condition; those living near farms were generally of better condition than those in the bush. It was however difficult to separate this effect from the fact that most of the "farm" pigs came from areas south of Collie and were therefore of slightly different breed.

Coat Colour

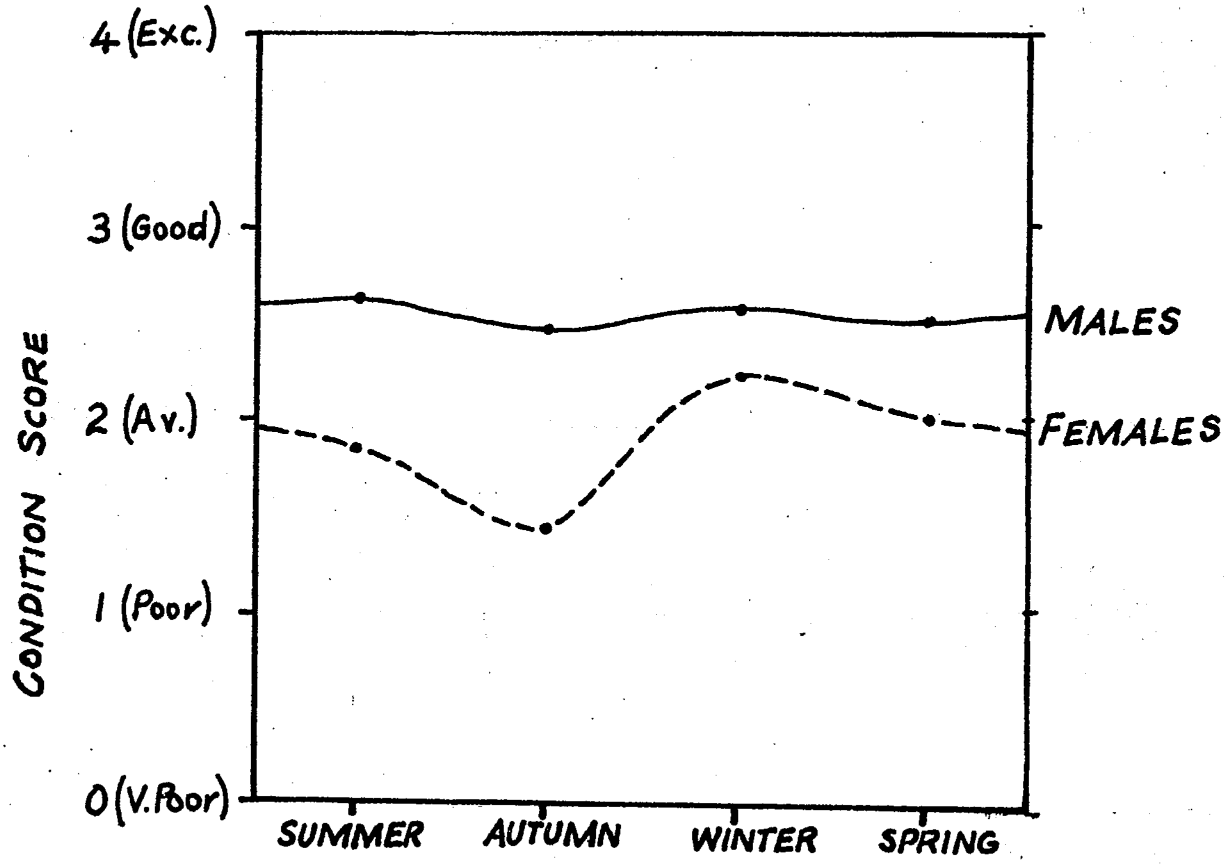
From records of reported feral pig captures and sightings from 1975-79 the following colour frquencies are evident:

Table 2 Colour Phenotype Frequency

Solid black	Black/White	Solid white	Solid red	Other
228(50.8%)	200(44.5%)	12(2.7%)	2(0.4%)	7(1.6%)

FIGURE 4

Average Seasonal Condition of FERAL PIGS (132 observations, 1978-79)



Colours listed as other include combinations of red, white, black and a tan colour occasionally observed.
\Colour frquency varied considerably between areas. The ratio of Black: Black/White is shown below in a breakdown between forestry divisions.

TABLE 3 Ratio of Black: Black/White in forestry divisions

Kirup	Collie	Harvey	Dwellingup
0.39	0.70	1.22	1.54

Considering that most domestic breeds in W.A. are solid white in colour it is perhaps surprising to find a high incidence of the darker phenotypes amongst feral populations. This situation is repeated elsewhere in the world wherever both feral and domestic pigs occur. It has been argued that this is due to several reasons. Firstly, although white breeds such as the Landrace and Large White are the preferred domestic pig at present in W.A. the dominant breeds when feral pigs were becoming established in the South-West were darker ones such as the Berkshire, Tamworth and Large Black. Secondly, it has been suggested (eg Brisbin, 1977) that pigs of darker colouration have a selective advantage over white pigs in free range situations. The predominance of the black phenotype is additionally surprising when it is considered that "self white" usually behaves as a dominant over all other colours (Hetzer,1945). One would expect white to become quickly established in the population in the absence of any colour selection. These facts considered it becomes apparent that the presence of the white phenotype is an indication of recent additions to the population. Extending this idea it appears that as we move south from the Dwellingup to Kirup forestry divisions the proportion of pigs of recent feral origin increases. This is in agreement with the results of the questionnaire/interview survey.

MOVEMENTS

Information on the daily and seasonal movements of feral pigs was collected by tag-recapture and radio location methods.

A. Tag-recapture:

Ear tagging of feral pigs begun by a private hunter, Mr J.Gillard under the direction of the Dept of Agriculture (Bunbury office) in 1975 was continued and extended during 1978 and 1979. 84 pigs tagged in the present study added to 110 previously tagged. To date 49 recaptures have been accurately reported. The results of these recaptures are presented below:

Table 4 Feral pig movements from tag-recapture data.

Class	N$^{\underline{o}}$	Distance travelled between captures(km)			Time elapsed between captures(mths)		
		$\bar{x}$	range	S.D.	$\bar{x}$	range	S.D.
Males	16	5.6	0-11	3.9	5.6	0.25-31	8.1
Females	23	5.2	0-16	4.4	6.8	0.12-44	8.8
Juv's	2	9.6	0	0	0.75	0	0
Sub's	5	0.8	0.2-1.5	0.5	1.2	1.5-2	0.6
Adults	42	5.7	0-16	4.1	7.4	0.12-44	8.9
Total	49	5.4	0-16	4.2	6.4	0.12-44	8.5

A "t" testof between sex variation in mean distance travelled revealed no significant difference indicating that the seasonal movements of females are as wide ranging as those of males. Insufficient accurate data prevented a good comparison of seasonal changes in distances travelled between captures. Distance travelled was not correlated with time elapsed between captures; seasonal range of movement is therefore probably no greater than daily range. Contrary to popular opinion, hunting with dogs did not appear to disperse pigs significantly more than other methods of capture.

B. Radio Location studies of movement:

3 radio transmitter inverted "L" type collars were obtained from A.V.M. (Illinois). Receiving apparatus was constructed from a 27MHz C.B. radio. The system was converted to operate at the more suitable frequency of 150MHz.

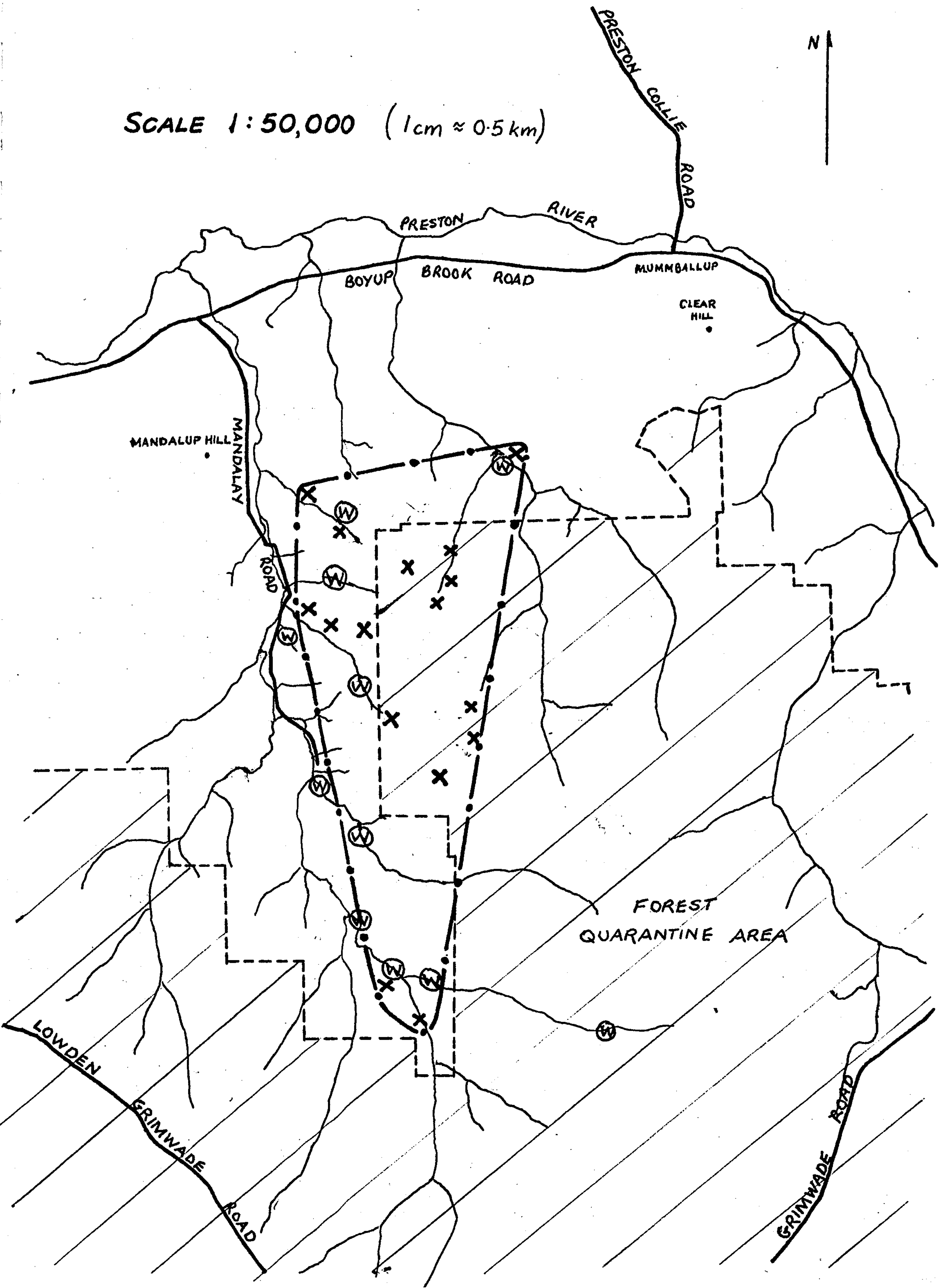
The purpose of radio location of pigs was threefold;
1) to help verify tag-recapture data,
2) to gather some information on daily habits and,
3) to provide a comparison of the effect of area and season on pig movements.

Collars were fitted in two areas:
-A marginal farming area - Lowden - adult sow (G).
-Water catchment area adjacent South Dandalup Dam - adult boar(L) and sow(B).

Sow G was tracked between January and September of 1979.
Sow B and boar L were fitted with collars in Nov 1979 - their movements are still being monitored. Results from sow G are shown in Figure 5 and the early results from location of sow B and boar L are shown in Figure 6.

The home range of sowG showed little seasonal change in size but a shift in the use of the area. Summer was marked by greater dependence upon open water sources and increased nocturnal activity. Daylight activity was at its greatest in the cooler months and in well sheltered gullies during hotter months. No daylight activity was observed in open paddocks, however signs indicated that that pigs had been active in paddocks during the day towards the end of Autumn. Pasture damage occurred in both wet and dry seasons- observations indicated that guildford grass bulbs were the target of much activity in pastures in the summer whilst earthworms were the target of much of the winter activity. It is significant that the only source of water available to sow G during the dry beginning of 1979 was that in farm dams and creeks. Pigs could not have survived in this area during the summer of 1978-79 without access to the farm. This observation is potentially important in terms of controlling pig numbers.

FIGURE 5 RADIO LOCATION SITES (MARKED x) - SOW G (246/296)



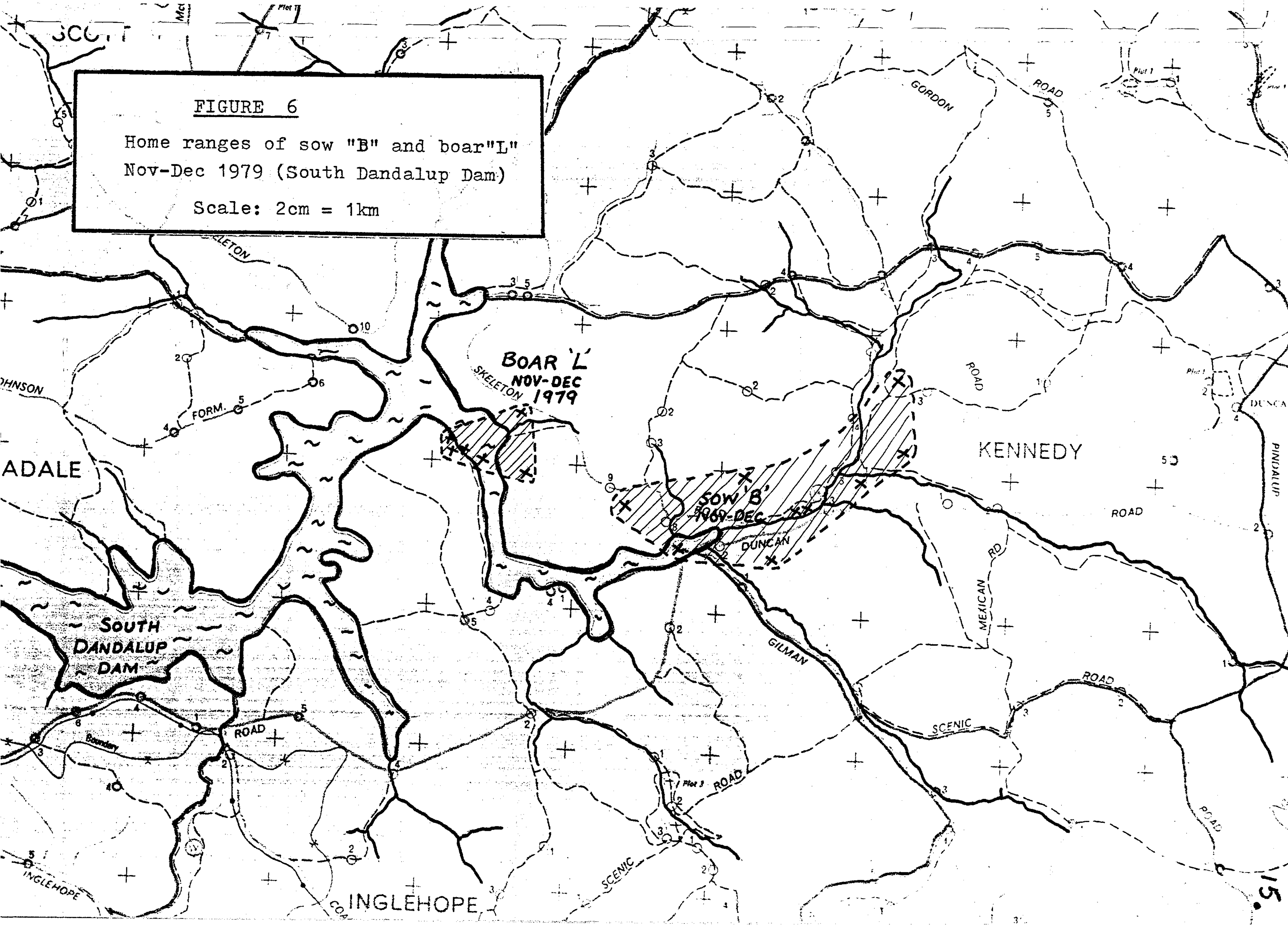


FIGURE 6

Home ranges of sow "B" and boar "L" Nov-Dec 1979 (South Dandalup Dam)

Scale: 2cm = 1km

The pattern of activity emerging at South Dandalup Dam is for pigs to remain in a relatively small area close to wet gullies. Where pigs have a choice daylight activity is preferred, digging in gullies or amongst Pteridium and Macrozamia in higher areas. On hot days pigs are forced to "camp up" and activity is restricted to dawn and dusk with some activity also occurring on moonlit nights. This pattern is expected to become more pronounced as temperatures increase during the summer.

REPRODUCTION

The parameters important in determining population replacement rate include breeding interval, litter size and survival, age to maturity and proportion of sows contributing to breeding. Estimates of these have been made using data available from the questionnaire, Ag Dept and hunter records and that collected in the present study.

Breeding interval:

Amongst mature domestic sows estrus occurs approximately every 21days and breeding is year round. Gestation period lasts about 114days and estrus does not recommence until 3-7days after weaning following a period of at least 15days of lactation. (Dzuik,1977). Whilst no observations have been made in the present study of gestation period, studies of others on wild, domestic and feral pigs suggest that there is little variation from 114 days within the Sus genus. Considerable variation does, however occur in lactation period and the time at return to estrus. Feral pigs in the South- West were observed to have weaned successfully as early as 1-2 mthsin several cases where it is thought the mother may have been taken by hunters. Generally however, nipples of sows were found to remain functional whilst accompanied by piglets up to about 3mths of age. Of course the weaning process began much earlier; piglets estimated as being 2wks old were observed digging and eating in dirt turned by the mother and autopsies of piglets always revealed some plant matter in the gut. Often the stomach of piglets was found to contain a high percentage of Persoonia berries, suggesting that these play an important part in the weaning of young and reducing the nutritional stress of lactation on sows.

From the data gathered it is difficult to say how soon after weaning do sows, on average return to estrus and conceive the next litter. However, for 7 sows that were recaptured, and for which information on reproductive state was accurately recorded, the breeding interval is by extrapolation almost exactly 1 year; the extrapolated month of weaning occurring for all cases between October and March. This is consistent with figure 7 of observed reproductive state of sows versus season. Figure 7 is based on 179 separate observations between 1975 and 1979 and shows clearly the influence of season on breeding in feral pigs of the South-West area. Whilst some breeding occurs throughout the year there is a pronounced peak in the number of sows pregnant during the winter. Comparing this figure with that of seasonal influence on sow condition reveals that condition is probably the most important effect in determining when any sow will breed.

Litter size:

The average number of young in 72 litters reported between 1975 and 1979 was 5.3(S.D.=1.8). Litter size varied from 1-10. In addition the reproductive tracts of 11 pregnant sows revealed an average of 6.6 embryos/sow(S.D.=1.3, range=4-8)

Variation in litter size was tested for effects of sow size and condition, season, area and year. The only significant effect was that of area; pigs with access to farms had larger litters (sig. at 0.05 level) than pigs without such access. Litters were also larger but not significantly so in areas of lower density and in the years 1975 and 1976 than in the following 3 years.

Litter survival:

From records of litter size and age an estimated mortality curve was constructed for juveniles(Figure 8). This shows average mortality of young between uterus and weaning to be approximately 27%. Since some litters experience 100% loss and are thus not recorded this figure is to be considered conservative. No estimates of the frquency with which total loss of the litter occurs were made, however on at least one occasion in the bush and several in pens feral sows lost the entire litter. It is likely

FIGURE 7 REPRODUCTIVE STATE OF SOWS - SEASONAL CHANGES (1975-1979)

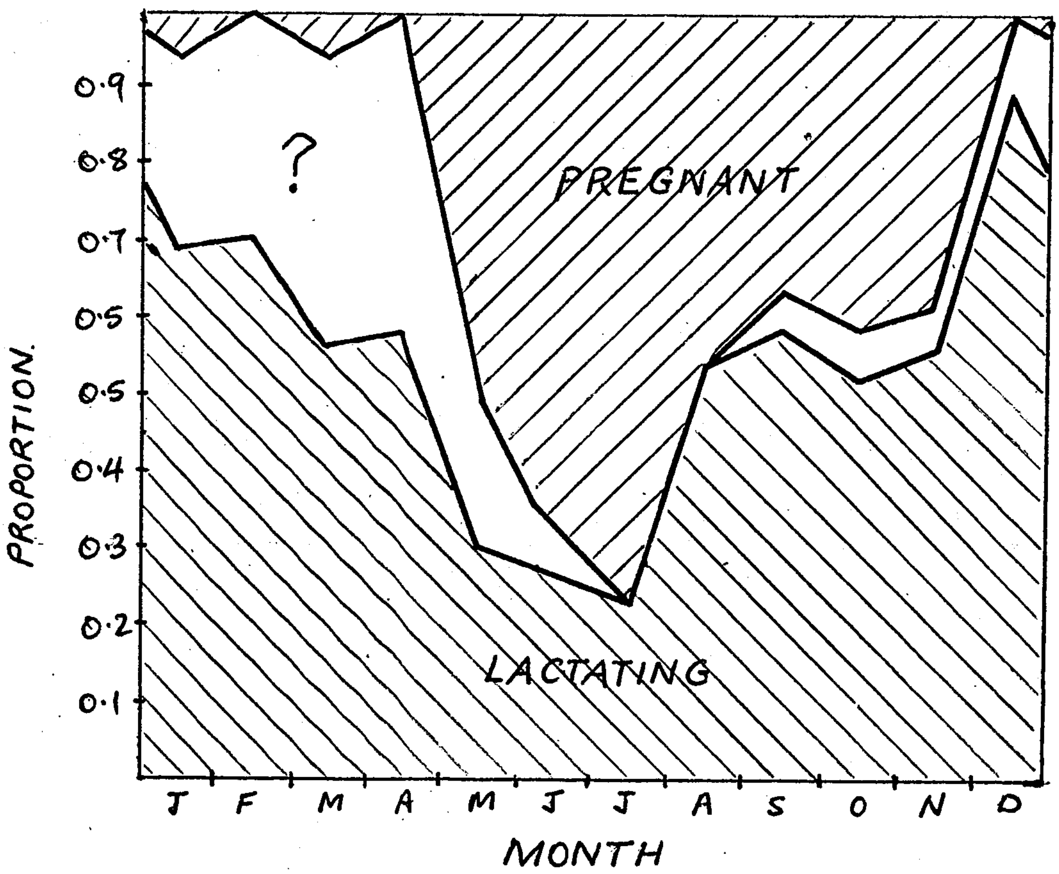
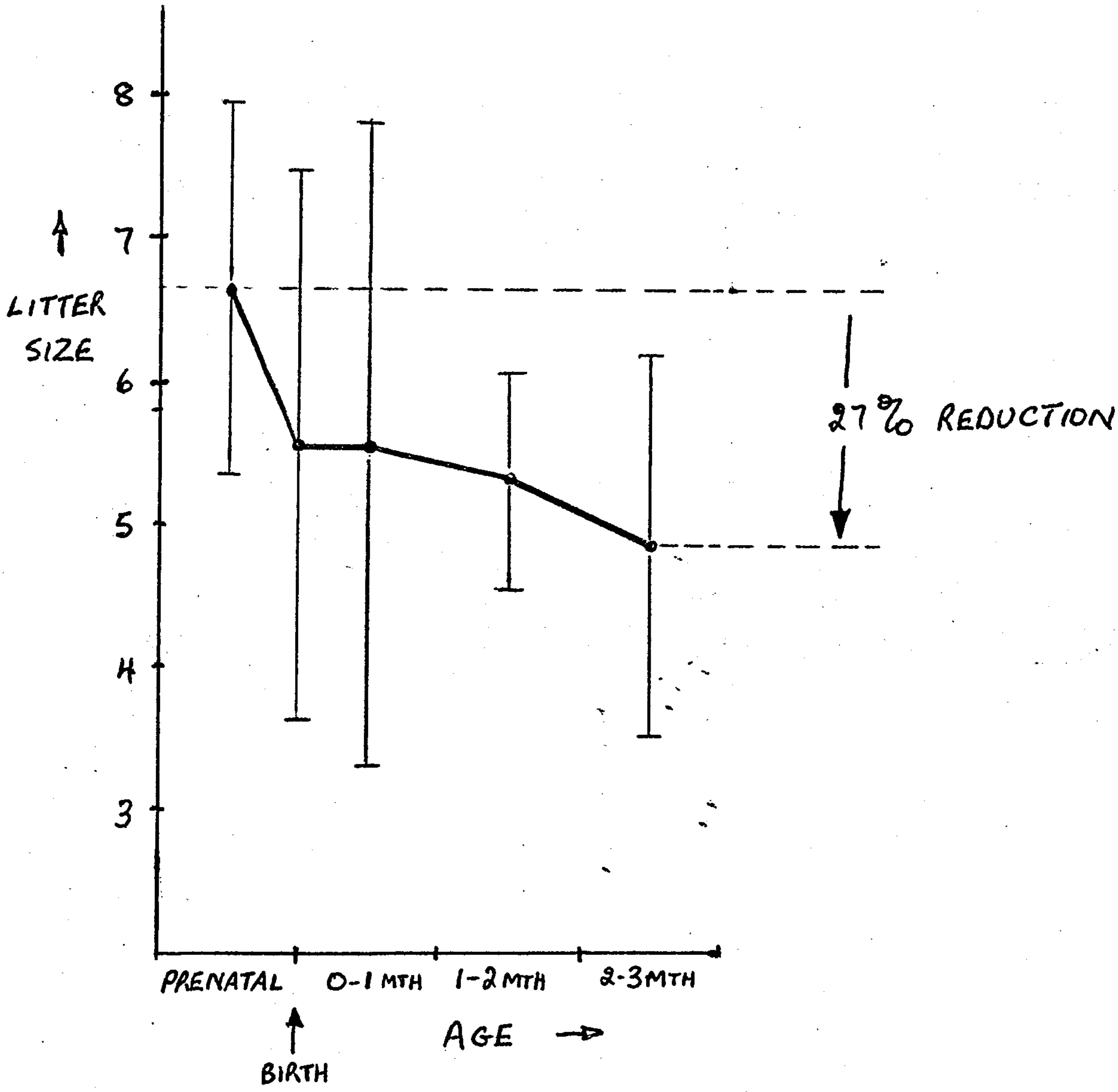


FIGURE 8 ESTIMATED PRENATAL AND JUVENILE MORTALITY (AVERAGE LITTER SIZE Vs AGE, S.D.'s SHOWN)



that prenatal survival is affected by the presence of such diseases as Leptospirosis and Parvovirus that have been recovered from feral pigs of the South-West. Starvation appears to be the most likely cause of juvenile mortality particularly during the drought conditions of summer; young caught in the bush at this time of year are generally in very poor condition compared with those caught in wetter seasons. Other factors that may contribute to juvenile mortality include predation by eagles and dingoes, blowfly strike and suffocation during the first few days in the nest.

Age to Maturity and Proportion of Breeding Sows:

Puberty is reached in domestic pigs (both male and female) at between 4 and 9 months. Genetic, nutritional and social factors all contribute to variation in the onset of reproductive maturity. Body size of feral pigs appears important when maturity is reached in determining whether breeding will follow. In gilts 20-25kg is usually the minimum weight at which breeding has been reported to occur. Whilst domestic gilts reach this weight by 4mths feral gilts generally take much longer; the present study revealed that many gilts do not reach this weight until they are 9-12 months of age. The proportion of sows breeding relative to the recorded age and weight is shown below:

Table 5 Proportion of sows breeding

A. Versus age

Age class (mths)	Proportion of sows breeding
4-6	0
6-9	0
9-12	0.4
12-15	-
15-18	1.0
18-24	1.0
24-36	1.0
>36	1.0

B. Versus weight

Weight class (kg)	Proportion of sows breeding
15-24	0.06
25-34	0.94
35-44	1.0
45-54	1.0
55-64	1.0
65-74	1.0
75-84	1.0

Poulation Structure and Dynamics

With catching methods used (dogs and traps) the sex ratio of feral pigs in the South-West did not differ significantly from 1:1. The proportion of females in the catch tended to be greater in adult classes (0.56) than in juvenile classes (0.47) however these were not differences that were significant at the 0.05 level. The prepondrrance of females in the adult catch was attributed to three reasons:

1) Because adult females are more gregarious than males the chance of any capture involving a multiple number of females is increased.

2) Once located the chance of capturing an adult boar was considered less than that of capturing an adult sow.

3) General hunter policy is to release captured sows but remove boars.

The first two of these causes are artifacts of catching methods whilst the third represents a real potential cause of more females occurring in adult classes.

Determination of age was based on tooth eruption schedules; these have been constructed by other workers for use with domestic and wild pigs and applied successfully to feral pigs elsewhere. There appears little variation in the sequence and timing of tooth eruption amongst pigs of the Sus genus or amongst genetically similar pigs raised on different nutritional planes. The eruption schedules of Matschke(1967) and Sisson and Grossman (1953) were thus used with reasonable confidence in ageing feral pigs of the South-West up to three years. Twelve age classes were recognised. In addition a more general classification into juveniles, subadults and adults was made as follows:

Juveniles- up to 3mths.
Subadults- 3mths to 25kg or 15 mths.
Adults - over 25kg or over 15mths.

The population age structure of pigs captured in 1978 and 1979 in the forest quarantine areas of Harvey and Dwellingup is shown in Figure 9. The ratio of non-adults:adults in the population throughout the South-West for the years 1975-79 is estimated in Table 6.

FIGURE 9

FERAL PIG
POPULATION AGE STRUCTURE
QUARANTINE AREA 1978-79

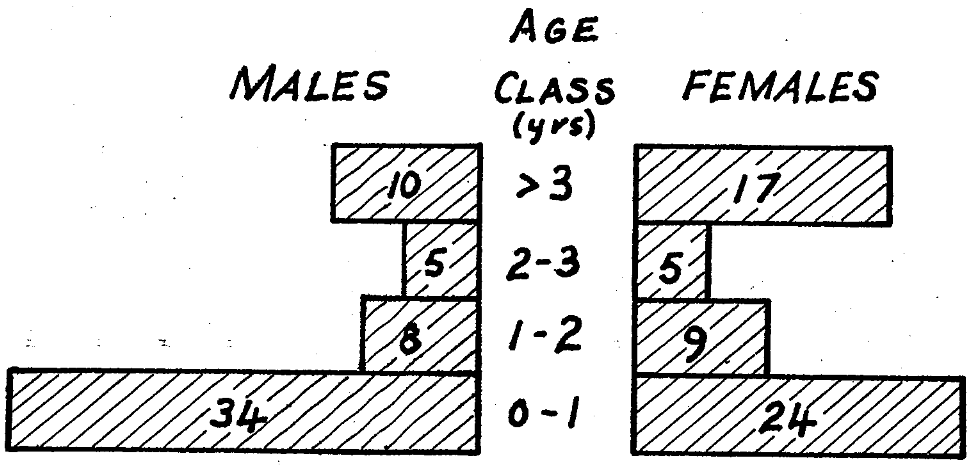


TABLE 6

RATIO OF NON-ADULTS : ADULTS 1975-1979

1975	1976	1977	1978	1979
1·35	1·85	1·49	0·83	0·77

Since 1975 there has apparently been a progressive decrease in the rate at which young are recruited into the adult population. This can probably be attributed to the below average rainfall received in the area since 1974 , that is, it seems likely that an abundance of water stimulates breeding or enhances juvenile survival. A further effect on population age structure appears to be hunting. Hunting pressure has been conveniently divided into areas of high and low pressure with the imposition of quarantine in early 1976; this restricted vehicular access to large areas of the forest. During 1978-79 the proportion of non-adult to adult pigs in these areas of forest was estimated from capture data to be 0.59(108 observations) inside the quarantine area, and 1.32(167 observations) outside the quarantine area. This suggests that density is important in regulating breeding activity and/or juvenile survival thus tending to offset any reduction in numbers brought about by hunting or control programmes.

Mob Structure and Social Behaviour

The social tendencies of pigs belonging to each class; juvenile, subadult or adult and male or female were analysed from capture data. The method assumes that when two pigs are caught together it is an indication of their mutual attraction. When pigs are consistently caught alone non-social behaviour is indicated. The following table of captures made during 1978-1979 reveals these tendencies:

Table 7 Frequency of Class Associations on Capture

		Juv.	Male subadult	Female subadult	Male adult	Female adult
Pair captures	Juv.	4	-	-	-	-
	Male sub.	0	1	-	-	-
	Fem. sub.	0	1	2	-	-
	Male adult	0	0	0	1	-
	Fem. adult	4	3	4	4	3
Lone pig		0	4	1	20	9
More than two		35	3	4	6	19

Strong gregarious tendencies are indicated in juveniles and in females of all ages. Males tend to increasingly avoid company with age; in fact in only one of 16 cases where boars older than 2 years of age were caught was the pig not alone, and this was when a sow was in estrus.

In the jarrah forest mob size rarely exceeds 12 individuals usually consisting of 1or 2 sows accompanied by the most recent litter. Subadult females tend to remain loosely attached to the nucleus mob whilst subadult males form small "bachelor" groups. In more open country mobs of 30-40 pigs have been reported consisting of all ages and sexes. It has been argued that in dense bush mob contact is difficult to maintain and mobs fracture into the typical units seen. There is probably also less emphasis on "safety in numbers"in the bush.

Diet

During 1978-79 the food habits of feral pigs of the South-West were determined through field observation of activity and fecal content and laboratory analysis of stomach contents. Records of the activity and collection of material in the area from which stomachs were taken facilitated identification of often highly masticated food in the gut. Crude macro- analysis was performed on the contents of 35 stomachs. Composition was determined on the basis of estimated volume. It was possible in all cases to place the important and consistently observed items in broad categories and in most cases it was possible to identify items much further. The results of these analyses are given in Table 8 and Figure 10.

Explanation of item classes:

Macrozamia: In Autumn pigs are strongly attracted to the ripening "pineapples" of the cycad *Macrozamia reidlei*. Several stomachs were observed at this time of year to be full of the red flesh of the zamia nut. In later months pigs apparently return to eat the kernel, however ripe flesh and kernel were never observed in the same stomach. One hunter reported having seen a pig feeding at a ripe zamia palm with a mouth full of nuts chewing off the flesh and spitting out the hulled kernels in rapid succession. When zamias are ripe the kernel contains a

STOMACH CONTENTS ANALYSIS

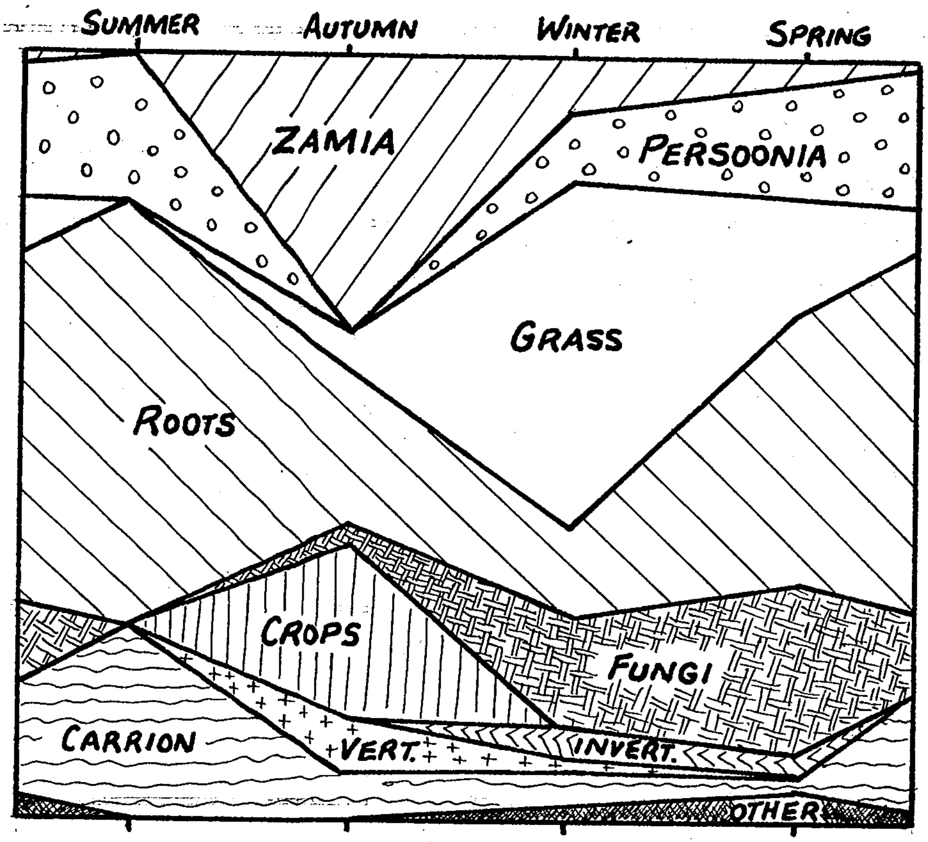
(A) MONTHLY ITEM CLASS FREQUENCY:

TABLE 8

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOT.
Macrozamia	-	-	0	5	1	3	2	0	2	0	0	0	13
Persoonia berries	-	-	0	0	0	1	3	0	6	4	0	1	15
Green grass	-	-	1	2	1	5	4	1	6	3	0	0	23
Roots	-	-	1	2	1	4	2	1	6	3	0	2	22
Fungi	-	-	0	0	1	3	3	0	1	0	2	0	10
Invert's	-	-	0	1	1	4	3	1	3	2	0	0	15
Vertebrate	-	-	0	2	1	1	1	0	1	0	0	0	6
Carrion	-	-	0	2	0	1	4	1	2	0	0	1	11
Crop	-	-	0	4	0	0	0	0	0	0	0	0	4
Tot stomachs	0	0	1	6	2	7	4	1	6	4	2	2	35

(B) % TOTAL COMPOSITION (EST. VOL.)

FIGURE 10



highly carcinogenic agent "macrozamin" which is also a strong emetic; pigs have apparently learnt to avoid this by not eating the kernel until the macrozamin has broken down, a similar practice to that of aborigines. In areas rich in zamia palms these kernels are frequently seen scattered about the palm following predation by pigs.

Persoonia berries: Ripe berries of the common understorey species Persoonia longifolia were observed on the ground from about July. They form a major part of the Winter and Spring diets of pigs, particularly young pigs during the weaning process. Berries are consumed whole by the young pig; older pigs usually crush the seed. Small numbers of berries continued to be eaten into the summer by which time they had deteriorated and probably weren't of much nutritive value.

Green grass: This item class includes green grass, forbs and aerial browse of any description. The following identifications were made: Xanthorrhoea Preissii - rushes.

Oxalis spp.

Hypochoeris radicata

Trifolium subterraneum

Vertebrates: Includes vertebrates considered to have been caught by the pig and not consumed as carrion.

Frogs - Heliophorus eyrei

Reptiles- Hemiergis initialis initialis, Phyllodactylus marmoratus, Menetia greyii.

Birds- Acanthiza inornata - fledgling

Carrion: Mostly of mammalian origin- bone often observed to be finely crushed. Includes Macropus irma

M. fuliginosis

Roots: Includes roots and bulbs of the following:

Pteridium esculentum

Bossia ornata

Macrozamia reidlei

Oxalis spp.

Fungi: The winter/ spring period saw a variety of fungi appearing in pig stomachs examined. These were believed to be mostly underground fungi. In November several pigs caught in pine plantations had fungi in the stomach- possibly Rhizopogon.

Disease and Parasites

During the 1978-79 field survey blood serum samples were collected from 117 pigs, blood smears were made for 96 pigs, rectal swabs were taken of 124 pigs and 49 autopsies were performed. The following was the recorded incidence of disease and parasitism from results of laboratory tests to date:

Disease:

	(+) cases 1978-79	Ag.Dept 1975-77
Brucellosis	0/82	0/17
Leptospirosis pomona	1/95	3/51
" tarassovi	10/95	3/51
" hardjo	0/95	3/51
Parvovirus	22/81	5/7
Arborvirus	0/63	34<1/10(RRV)
Sparganosis	?	-
Toxoplasmosis	?	2/50
Babesia	1/94	-
T.B. (*M.scrofulaceum*)	1/24	-

The following Salmonella serotypes were isolated from rectal swabs submitted to the Public Health Dept:- S.anatum, birkenhead, blukwa, chester, eastbourne, houten, livingstone and orion.

Parasites: External :

Haematopinus suis - present on all pigs examined

Amblyomma ambolimbatum, *Ixodes australiensis* } - common on all pigs during dry months

Internal:

Metastrongylus spp -common parasite of lungs- 5cases

Physocephalus sexalatus- light infestations only- 6cases

Cysticercus tenuicollis- found in penned feral pig- 1case

Echinococcus granulosis- 2 cases

Ascaris suum - 3 cases in penned feral pigs

ENVIRONMENTAL IMPACT OF FERAL PIGS IN THE SOUTH- WEST

It is obvious that pigs have readily adapted to the conditions of the South- West jarrah forest and their range and numbers continue to increase. They apparently possess an ability to successfully invade both virgin and disturbed environments aided by a high intelligence, rapid rate of population replacement and extreme generalist diet. This makes feral pigs a potential threat to agricultural and conservation interests alike.

Farm damage by pigs is relatively easy to assess in terms of economic loss; assessing damage in the forest is a much less easy task. Observations can be made of the extent of disturbance of soils and vegetation as a direct result of pig activity, however lengthy studies are required to assess how far reaching is the disturbing influence on total forest ecology. It would be necessary to determine how permanent are any alterations to the structure of the forest and whether the structure continues to change or if pigs have already reached a situation of balanced equilibrium with the environment. Such an analysis is beyond the scope of the present study,however some investigations have been made into areas of immediate concern. These include a look at the relationship between pigs and the "jarrah dieback" fungus, *Phytophthora cinnamomi* and pigs and native fauna as exemplified by the short-nosed bandicoot,*Isoodon obesulus*.

Pigs and Phytophthora

It is widely feared that pigs may represent an important factor in the spread of dieback in the jarrah forest, either through acting as a vector or through increasing the susceptibility of the forest to natural spread of the disease.

Conditions on topographically low sites in the forest are suitable throughout most of the year for sporulation and, therefore, spread of the disease in soil. Here, however, it appears *P. cinnamomi* is already widespread and there is little hope of protecting such sites from further infection(Shea, pers comm, 1979). On the other hand, moisture and temperature regimes of upland sites in the northern jarrah forest are only suitable for infection usually for a relatively short period in the spring. It is these sites which receive most attention in terms of protection against infection.

The activities of feral pigs during this critical time as the weather becomes warmer and before soils dry out on the upland sites, suggest that they may be responsible for the formation of new infection foci on higher ground. It has been considered that pigs may carry infected material in several ways; - 1) on external parts of the body, particularly following wallowing and on the hooves.

2) via the gut following ingestion of infected material. Both ideas have undergone some testing with negative result. Samples of mud carried by six pigs caught in the forest were tested for the presence of P. cinnamomi. All those tested to date have been taken in the winter when temperatures are likely to be too low for sporulation to occur. To test this idea further more pigs need to be collected soon after wallowing in warmer weather. Observations of pig habits suggest that wallowing commences on a large scale during the first hot days in spring.

In a laboratory experiment in 1978 2 domestic pigs were presented with lab.-cultured chlamydospores in a standard pig mash. These were fed at two concentrations; 10spores/gm and 100spores/gm of mash. No P.cinnamomi was recovered in the feces and mash contols innoculated with the same concentrations and incubated at 4C and 38C revealed that this was due,at least partly to the temperature of the gut. It was concluded that a more bulky diet innoculated with more resistant, naturally produced chlamydospores may increase the probability of recovering P.cinnamomi from the feces.

The second effect that feral pigs may have in the spread of dieback is in increasing the vulnerability of upland sites to infection. Shea(1977) has shown that any disturbance which reduces canopy and litter cover,increases average soil temperatures and extends the period during which upland sites are susceptible to infection by P. cinnamomi. Whilst the effect of pigs in reducing ground cover has not as yet been quantified, anyone who has seen an area disturbed by pigs will realise that this effect is likely to be very important in aiding the establishment of P. cinnamomi in such an area. Added to this is the observation made in the present study, that amongst the plants that are highly favoured by pigs are several leguminous species, particularly Bossia ornata, that have been shown to have a suppressive effect on the spread of the dieback fungus. Pigs certainly appear to have the potential to exert a strong influence in the spread of P. cinnamomi - this requires further investigation.

Pigs and Bandicoots.

It is a well recognised fact that many species of the native fauna have been displaced by introduced animals better adapted to living in human-disturbed systems. This occurs through a process of direct competition/predation or through alteration of habitat.

In an attempt to assess the impact of feral pigs on the native fauna of the South-West the short-nosed bandicoot was chosen as an indicator species. This animal was chosen as being an easily trapped,ubiquitous animal with considerable apparent overlap of the niche coordinates that have been adopted by feral pigs. In July 1979, two similar areas were selected; one where feral pigs were plentiful and the other where there were no pigs. Tomahawk traps were set for bandicoots in each area for 228 trap nights with the following results:

Pig infested area	Pig free area
no bandicoots (114 trap nights)	2 bandicoots (114 trap nights)

Whilst there is some indication on the basis of these results, that pigs exert an effect on the bandicoot population a greater number of bandicoots need to be trapped for a statistically significant result.

CONTROL

Central to the question of feral pig control is the defining of acceptable levels of density. What constitutes an acceptable density varies with the interest: From a conservation point of view pigs at any density must be regarded as undesirable. Where conservation of the native environment also affects forestry and water catchment pursuits additional emphasis is to be placed on the elimination of an animal such as the feral pig. In the absence of exotic livestock disease,agricultural interests, on the other hand, are unlikely to regard feral pigs as a problem until such time as they reach a density level where farm damage becomes significant. Whilst complete eradication is generally the desired goal,experience in other parts of the world suggests that this is unrealistic in most circumstances and that the best that can be hoped for is a reduction to a lower, more acceptable density. Perhaps, considering the keen sport based around the feral pig in the South-West, a policy which aims at reduction rather than elimination would be more widely received.

Methods used elsewhere in the control of pigs include poisoning, bonus payment to hunters, trapping, use of electric fencing and introduction of disease. The use of poisoning has been considered the most widely applicable method in terms of logistic feasibility and effect. Whilst the reduced densities of pigs in areas of the South-West of heavy hunting pressure bears some testimony to the effectiveness of hunters in maintaining lower than normal densities, the history of relying on private hunting as a means of pest control is not good. Trapping and electric fencing have been used to good effect where small populations of pigs are involved, however control by these means on the scale envisaged in the South-West is not feasible.

In the present study an analysis was made of the efficacy of control using a poisoning technique. Trials were conducted in two representative areas: 1) The farming district of Lowden-Grimwade.

2) The water catchment area of the Serpentine Pipehead Dam.

It was hoped to compare two poisons, 1080 and warfarin, however approval for the use of 1080 was not obtained until late in the trials period. Poisons and method of presentation were chosen to minimise the possible risk to humans and native fauna. Before the trials several weeks were spent screening various baiting methods. The one considered most suitable involved burying poisoned apples 10-15cm below ground level and placing half a dozen unpoisoned apples on the surface. This method was considered superior to other methods tested because apples (1) were apparently more attractive to pigs than were other baits including oats, pig pellets, pears and several stone fruits;

(2) were more readily available and at lower cost than other baits tested;

(3) made measurements of bait quantity consumed easier than did other baits;

(4) were easier to remove at the end of the pdsoning period- oats and pig pellets tended to be lost and scattered;

(5) provided a convenient vehicle for both poisons, and

(6) were, when buried, very pig-specific.

The format adopted for the trials was;

2 weeks of free feeding
1 week of poisoning
2weeks of free feeding
1 week of poisoning
2 weeks of free feeding

The trial period was from mid-Feb to mid-April, 1979.

The function of free-feeding was two-fold;

(i) it attracted pigs into a situation where they would readily accept the bait which would later be poisoned, and

(ii) it provided an index of pig density before and after poisoning and thus a method of assessing efficacy.

Sites for bait-laying at Lowden-Grimwade were selected close to water holes occurring in the forest adjacent farming land. From early January pig activity at 34 holes was monitored; by the time of the trials over 1/3 of these had dried up or otherwise become unsuitable for pigs to regularly visit. During the trials 21 sites were used for bait-laying.

At Serpentine 7 areas of the bush showing high pig activity levels were selected for the laying of baits during the first free feed and first poison phases. A further 3 sites were added to this during the second free feed.

All sites in both areas were treated similarly; 3-6 holes were dug 3-20m apart, 6-8 apples were placed in each hole, they were covered with dirt and a similar number of apples placed on the surface. Where possible each site was checked on alternate days and the quantity of bait taken and the type of animal feeding recorded. This was done throughout the 8week trial period, both poison and free feed phases. Whilst it was found that birds, kangaroos, foxes, sheep and small mammals often took surface apples, only pigs ever took buried apples that were also poisoned.

Poisons: WARFARIN

Dose rate: 1.5g Technical Grade Warfarin/apple
= 30mg/kg (acute dose for 50kg pig)

The warfarin was applied to each apple by scooping out a hole with a sharp-edged teaspoon, pouring in the warfarin powder and replacing the scooped out cap. Each site had between 3 and 6 holes of 6 warfarin treated apples (6x3 Warfarin).

1080

-in the form of 1080-impregnated oats, each grain containing 7.5mg of 1080 and dyed with rhodamine red.

Dose rate: 7 grains were pressed into each apple and 8 apples placed in each of 3-6 holes at each site (8x3(-6) 1080). Lethal dose for 100kg pig= 28 grains (4 apples)

Treatment of sites:

	First poison	Second poison
Lowden-Grimwade	Warfarin 10 sites Control 11 sites	Warfarin 5sites 1080 5 sites Control 6 sites
Serpentine	Warfarin 6 sites Control 1 site	Warfarin 4 sites 1080 4 sites Control 2 sites

The changes recorded in the quantity of bait taken in each area during the 8weeks of the trials are recorded in Figures 11 and 12.

<u>Quantity of poison taken by pigs:</u>

			sufficient to kill(No.of pigs)
LOWDEN-GRIMWADE:	First poison	Warfarin	198
	Second poison	Warfarin	42
		1080	2
SERPENTINE:	First poison	Warfarin	216
	Second poison	Warfarin	60
		1080	11
	ie. Total possible kill	=	529 pigs(of greater than 50kg)

Whilst there was a decline in quantity of bait taken and general activity in both areas following poisoning (particularly at Serpentine) very few dead pigs were found. This was believed to be at least partly due to the slow acting nature of the main poison used- Warfarin; the dense bush associated with much of the area poisoned in each case probably also contributed. The overall effect in reducing pig numbers using this method was nevertheless considered to be very satisfactory.

A good comparison of the two poisons cannot be made because of the limited use of 1080 in the present study. However,1080 was applied during April 1979 using the "apple method" with excellent results on a farm at Lowden where pigs were ruining a potato crop. Both poisons appear to be very effective.

FIGURE 11

BAIT TAKEN DURING FERAL PIG POISONING TRIALS - GRIMWADE 1979

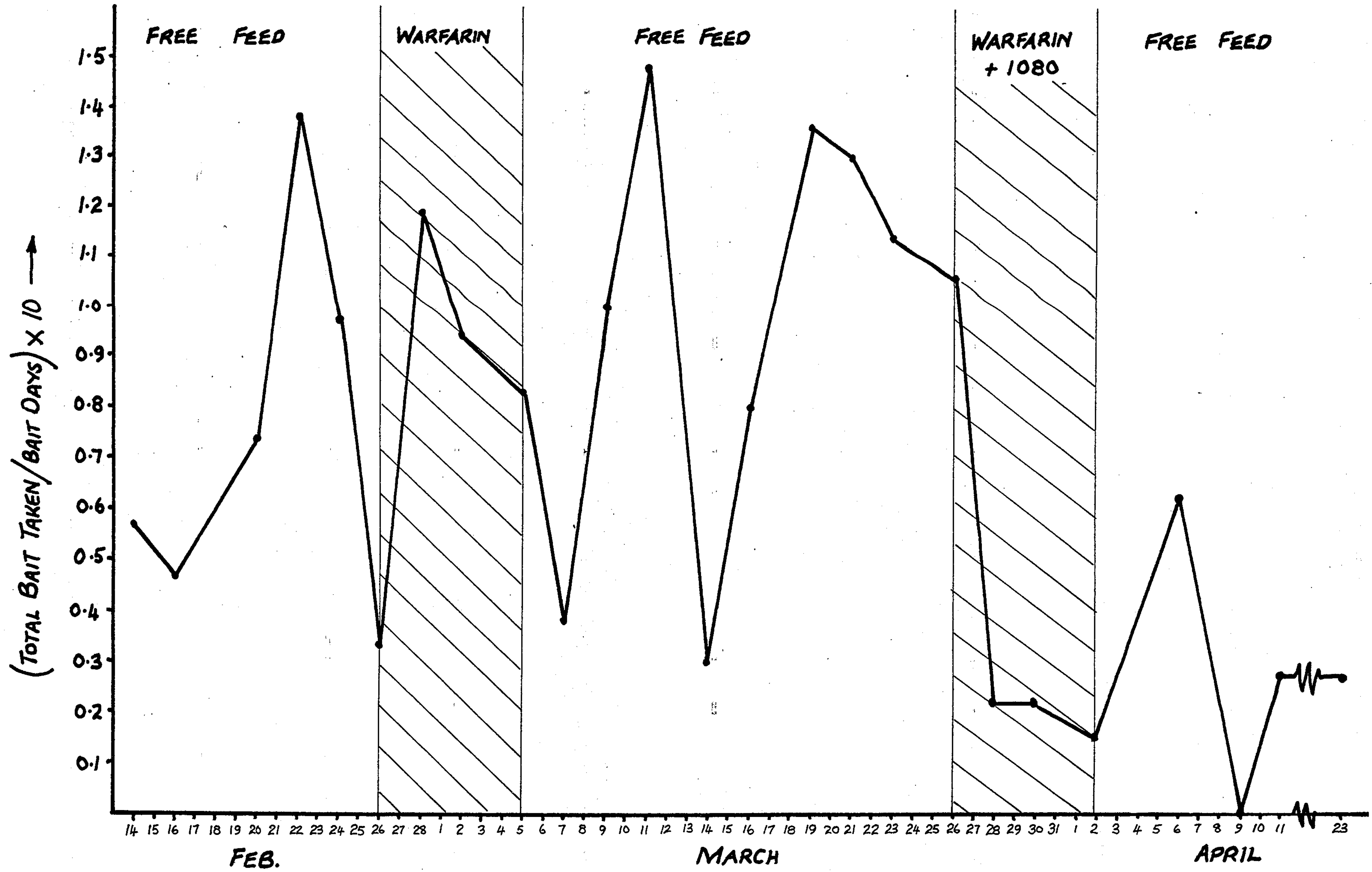
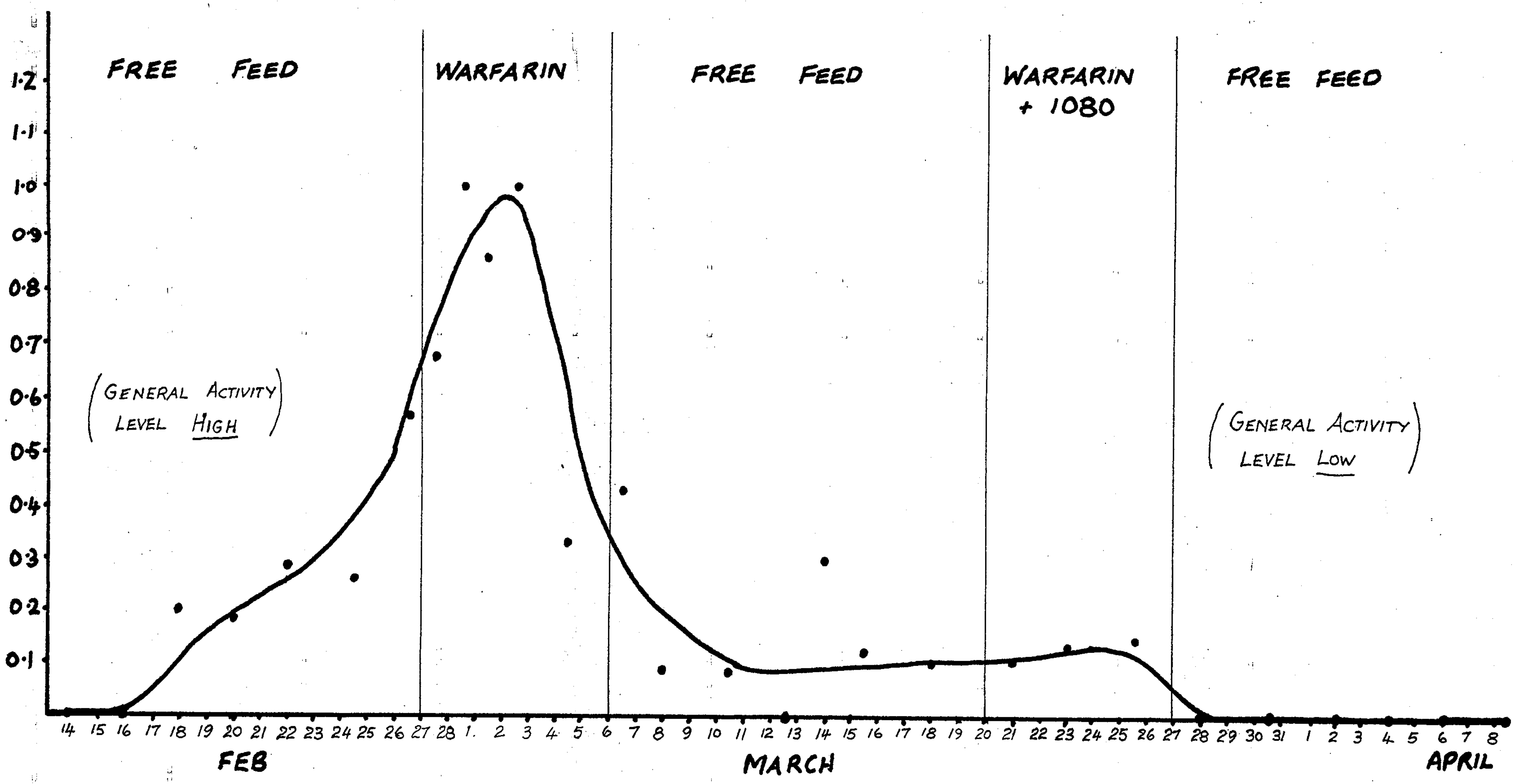


FIGURE 12:

BAIT TAKEN DURING FERAL PIG POISONING TRIALS - SERPENTINE 1979



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