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ASPECTS OF THE ECOLOGY OF FERAL PIGS *(SUS SCROFA)* IN THE MURCHISON AREA, NEW ZEALAND*

Summary: Seven feral pigs *(Sus scrofa),* radio-tracked in relatively undisturbed rough pasture and forest near Murchison, New Zealand, for periods of 18-186 days, occupied home ranges of 28-209 ha. The immature pigs were significantly more active and had significantly larger home ranges than the adults, particularly adult females. The pigs were mainly nocturnal but they varied individually. The frequency of grazing and the rooting up of pasture and bracken *(Pteridium esculentum)* varied seasonally. Some of the pigs preferred pasture and bracken in their home ranges while others preferred mixed beech *(Nothofagus* spp.) forest. The number of pigs and their use of habitat were probably related to the seasonal availability and quality of food and shelter. Farrowing occurs throughout the year but peaks during spring. Litter sizes ranged from 1-9. Density was roughly 12-43 pigs per km^2 compared with 3-8 per km^2 in a nearby, more heavily hunted area.

Keywords: home ranges; movements; activities; habitat preferences; reproduction; population density; group size; feral pig; *Sus scrofa;* New Zealand.

Introduction

Feral pigs *(Sus scrofa)* are widespread in New Zealand but are generally considered to be a minor, often local pest, whose numbers are limited by recreational hunting. However, there is increasing concern about their potential for transmitting diseases such as foot and mouth disease. Despite this there have been only two studies on the ecology of feral pigs in New Zealand since Wodzicki's (1950) survey - by Challies (1975) on Auckland Island and Martin (1975) in North Canterbury. My aim was to obtain more information on their home range, movements and general ecology.

Study Area

The study was carried out within the Nelson Forest Conservancy in the Mount Harte area near Murchison from October 1983 to May 1984. Martin (1972) recommended that this area should receive high priority for the control of pigs.

The 600 ha study area ranged in altitude from 200 m to 850 m. The major habitats as determined from an aerial photograph were pasture and bracken *(Pteridium esculentum)* (62.4%), mixed beech *(Nothofagus* spp) forest (37%), and swamp (0.6%). The pasture and bracken were often mixed. Annual rainfall at Murchison, 6 km to the west, ranged from lloo mm to 1900 mm per year but rainfall and temperatures vary locally. From October 1983 to May 1984, 870 mm of rain fell in the study area, mainly during the spring and January. Mean minimum and maximum temperatures (with standard deviations) during the study were 8.6 ± 3.1∞C and 20.4 ± 3.4 ∞C, respectively, with extremes of 2∞C and 29∞C February and March were the hottest, driest months.

Methods

Data were obtained by radio-tracking a small sample of pigs and observing the whole population in the study area.

Capture and handling

Pigs were either trapped, or caught with the help of dogs. Two weld mesh panel traps (Boreham, 1981) were erected near fresh signs of pig activity (e.g. rooting, tracks and faeces) and baited with carrion, bread, fruit, vegetables and grain. Trapping success was poor because birds and brushtail possums *(Trichosurus vulpecula)* often ate the bait and sprung the traps. Two adult sows were caught in one trap during December and seven immature pigs were caught in the second trap in October, and frequently recaptured thereafter until March.

From late October onwards 1 caught most pigs by chasing them on foot with the aid of dogs. I then anaesthetised the pigs with an intramuscular injection of Ketalar (ketamine hydrochloride) at a rate of 15 mg kg^{-1} body weight followed by an equal amount of Rompun (xylazine hydrochloride) to minimize the adverse side effects of Ketalar. Unlike Baber and Coblentz (1982) I found a 1:1 mixture of both drugs ineffective.

The two adult sows were restrained in the trap with lassoes and then anaesthetised, whereas the

*This study was carried out as part of a scientific exchange with Ecology Division, DSIR, New Zealand.

immature pigs were restrained by hand. All pigs caught were weighed, measured, ear-tagged and aged according to their pattern of tooth eruption and wear (Barrett, 1978).

Radio-tracking

Radio transmitters (403 MHz frequency), similar to those described by Newgrain and Horwitz (1979), were attached to the necks of seven pigs on collars made of car seat-belt material. The collars were attached to a chest harness made of plastic-coated, multi-strand, stainless steel wire encased in vinyl tubing in an attempt to keep the transmitters on top of each pig's neck. However, two harnesses eventually broke and the transmitters slid around under the throat.

Faulty construction, rather than wear, caused two transmitters to break down. Two pigs shed their collars, probably because they were too loose, and the method of attachment was generally unsatisfactory because it did not accomodate growth. Five of the pigs showed signs of abrasion under the front legs and around the neck from the collars and harnesses when examined 5-8 months after initial capture.

The pigs were located with a portable, multi-channel UHF receiver and Yagi directional antenna. Most bearings on the pigs' positions were made within 100-200 m of them, although signals could be received from 10 km away when in "line of sight". Usually it was possible to obtain only 2-3 cross bearings at this close distance because of the need to approach downwind. Care and experience were necessary in obtaining bearings because of signal bounce and attenuation from ridges, gullies and dense forest.

Where possible, I stalked each pig daily and plotted its position on an enlarged aerial photograph. In addition I recorded whether it was active or stationary as determined by observation or signal characteristics, whether it was at a resting site, the type of habitat and the weather. I also carried out twenty "24-hour surveillances" in which I attempted to locate each pig every two hours by cross bearings. The sizes of the home ranges were determined by the convex polygon method (Macdonald, Ball and Hough, 1980), using a digitising planimeter, and compared by two-factor (unweighted means) ANOVA (Winer, 1971). Habitat preferences were determined using the method of Neu, Byers and Peek (1974). Unless otherwise stated, standard errors of means are presented rather than standard deviations.

Observations

I covered the same 4.6 km route through the area on foot each day, but often deviated to locate pigs more precisely or to inspect previously used habitat. I counted and described all pigs seen and recorded their age class, sex (whenever possible), colour, group size and composition, activities, and the habitat and weather. A group was defined as an assemblage of pigs all within 50 m of each other and keeping in contact by feeding or moving together. Pigs were aged from their estimated body weight, as follows: piglets (<10 kg), immatures (10-25 kg), adults (>25 kg). The 10 kg weight limit for piglets appeared appropriate as four piglets of 9.4-9.8 kg were approximately three months of age according to tooth eruption. This is about the normal weaning age for pigs in Australia (Masters, 1979; Pavlov, 1983). The upper weight limit of 25 kg for immature pigs was based on the minimum weight of female pigs in Australia before puberty or the initiation of oestrus (Anon., 1981; Pavlov, 1983). My estimates of body weight were about 10% too high when compared with the actual weights of 26 pigs killed in the area, and were altered accordingly.

The birth dates of piglets and immatures were calculated from their estimated weights, using a mean growth rate of 93 g day^{-1}. The mean gain in weight of five pigs recaptured from 1-4 times each after intervals of 23-195 days was 92.7 ± 2.9 g day'. (92.4 ± 5.0 g day^{-1}. while piglets, and 93.0 ± 3.0 g day^{-1}. for immature pigs). This compares with 73-113 g day^{-1}. for piglets and 36-82 g day^{-1} for 3-6 month old pigs in California (Pine and Gerdes, 1973), 74-76 g day^{-1}. for pigs in semi-arid New South Wales (Pavlov, 1980), and approximately 93 g day^{-1}. for one year old pigs in Western Australia (Masters, 1979).

Results

Home Ranges

The home ranges of the seven radio-tracked pigs varied from 28 to 209 ha (Table 1). The immature pigs occupied significantly larger home ranges than the adults ($F=29.86$; 1,3df; $p<0.05$) and the males occupied significantly larger home ranges than the females ($F= 12.40$; 1,3df; $p<0.05$). The shapes of the home ranges were slightly elongate, lengths ranging from 0.7-2.7 km, widths from 0.6-1.3 km and length/width quotients from 1.2-2.1. The adult males used significantly larger areas per month ($F=21.18$; 1,6 df; $p<0.01$) and per 24 hours ($F=6.38$; 1,23 df; $p<0.05$) than the adult females (Tables 2 and 3), particularly during January when the females and their recently weaned young spent most of the time on one bracken covered hillside. Immature female No.2

Table 1: *Home ranges of pigs radio-tracked in the Mt Harte area.*Transmitter failed or pig lost harness.*

Pig No. & Sex	Initial age (months)	Initial wt (kg)	No. days pig carried a working transmitter	No. days located	No. different locations	Home range (ha)
1F	5	11	31*	18	22	117.0
2F	6	26	18*	12	24	66.0
3F	24	33	116	56	109	28.0
4F	24	38	169	64	106	38.5
5M	6	21	43*	29	58	209.0
6M	22	48	53*	29	50	38.0
7M	24	64	186	79	130	69.0
Mean			88	41	71	80.8 ± 24.2

Table 2: *Monthly home range areas of radio-tracked pigs at Mt Harte. Figures in parentheses indicate the number of pigs radio-tracked.*

Month	Mean home range area (ha) ± SE of mean		
	Immature	Adult females	Adult Males
Oct.	41.1 ± 21.2(3)	—	—
Nov.	29.9 ± 9.6(3)	—	—
Dec.	3.8(1)	44.8 ± 1.9(2)	58.0(1)
Jan.	—	8.5 ± 5.9(2)	68.1 ± 18.8(2)
Feb.	—	12.0 ± 9.4(2)	40.7 ± 14.7(2)
March	—	21.1 ± 0.3(2)	59.4(1)
April	—	13.0(1)	58.0(1)
May	—	15.6(1)	—

used the largest area (37 ha) and the adult females the smallest area (0.1 ha) during a 24 hour period (Table 3).

Movements

The radio-tracked pigs covered on average 0.8 - 1. 7 km per 24 hours (maximum 3.6 km per 24 h) as the sum of the distances between successive "fixes" (Table 3). The oldest boar twice made nocturnal excursions of about 2.4 km into the home ranges of the two sows when they were probably in oestrus, but it and the other adult boar usually restricted their movements to short journeys between adjacent valleys. The intervening ridges formed no barrier to their movements and, in fact, signs of pigs were found on open grassy ridges at altitudes of 1500 m elsewhere in the district. The two adult sows were the most sedentary, mainly remaining with their litters in an area with plentiful grass, bracken and water. The immature pigs were more mobile, crossing from one partly open valley into an adjacent forest-covered valley. The immature male sometimes traversed the length of the valley to feed on improved pasture at the foot of the valley.

The straight line distances between the locations of the pigs at noon each day were not correlated with the actual distances they covered during' the intervening 24 hours. This supports the view of Laundre *et al*. (1987) that it is not valid to use daily point relocations to assess animal movements. There was a significant correlation, however, between the area used per 24 hours and the distance covered by the pigs per 24 hours ($r=0.595$, $p<0.01$, $n=42$).

Table 3: *Areas used per* 24 *hours and movements by radio-tracked pigs at Mt Harte. The number of locations per* 24 *h represent different location sites, not repeated locations at the same time. SE = Standard error of mean.*

Pig	No. 24 h tracking periods	No. locations per 24 h	Area Used per 24 h (ha) Mean ± SE	Range	Distance covered/24 h (km) Mean± SE	Max
Immature FI	2	4	2.5 ± 1.2	1.4-3.7	0.82 ± 0.25	1.07
Immature F2	2	3-10	18.8 ± 18.5	0.3-37.3	1.70 ± 1.42	3.12
Adult F3	9	3-14	2.4 ± 0.9	0.1-7.4	0.83 ± 0.24	2.06
Adult F4	8	2-11	2.6 ± 1.2	0.1-7.9	0.76 ± 0.22	2.02
Immature M5	9	3-10	8.4 ± 2.3	1.4-23.5	1.27 ± 0.33	3.57
Adult M6	4	4- 9	7.8 ± 2.4	2.2-11.9	1.25 ± 0.24	1.77
Adult M7	10	3-11	7.1 ± 2.1	1.1-23.1	1.05 ± 19	2.36
Mean	6.3	5.4	6.0 ± 1.1	0.1-37.3	1.03 ± 0.11	2.28

Activities

The radio-tracked pigs were active on 336 (or 36%) of the 936 occasions on which they were located (Table 4). Individual activity indices varied from 21-73%. The immature pigs were significantly more active than the adults (X^2 = 47. 54; 1 df; p<0.01) and the males were significantly more active than the females (X^2 = 9.12; 1 df; p<0.01). There was no consistency in the time at which the seven pigs were active but overall they were significantly more nocturnal than diurnal (X^2 = 14.43; 1 df; p<0.01) with the main period of activity between 2000-0400 h (Fig. 1). The pigs were significantly more active on moonlit rather than dark nights (X^2 = 8.86; 1 df; p<0.01), and when in swamps and on open pasture than when in bracken (X^2 = 18.42; 1 df; p<0.01) or forest (X^2 = 11.37; 1 df; p<0.01).

The dominant activities of all pigs observed in the area between 0500 and 2100 h were grazing and rooting up of bracken or the ground (Table 5). Piglets fed, especially by grazing, much more often than older pigs. Adults fed the least and rested or moved more often than other pigs.

The main grazing periods during daylight were early morning, mid afternoon and evening. As grazing

Table 4: *Degree of activity exhibited by radio-tracked pigs under different environmental conditions. *Mean only applies to total pigs under overall conditions and for all specific conditions listed.*

Conditions	No. of times pigs located	Percentage of times pig(s) active in each situation	
		Mean*	Range
Overall conditions			
Pig 1F	26	73	-
Pig 2F	27	52	-
Pig 3F	228	34	-
Pig 4F	232	21	-
Pig 5M	65	66	-
Pig 6M	91	57	-
Pig 7M	267	29	-
Total pigs	936	36	21-73
Specific conditions			
Daylight	779	33	20-72
Dark	157	49	28-100
Dark night	481	31	7-69
Moonlit night	455	40	23-77
Using pasture	97	50	36-100
Using bracken	473	32	16-75
Using forest	349	35	22-69
Using swamp	17	77	57-100

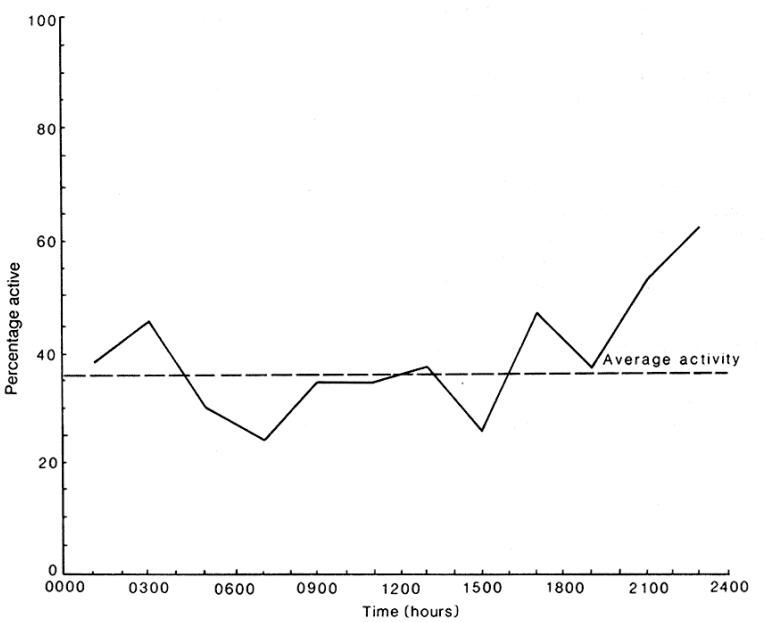

Figure 1: *Periods of above and below average activity per* 24 *hours for seven radio-tracked pigs at Mt Harte.*

Table 5: *Activities of pigs during daylight at Mt Harte.*

Age class	No. observations	% observations pigs were:— Moving	Resting	Grazing	Rooting	Total feeding
Piglets	369	6	0	57	37	94
Immatures	421	8	13	39	40	79
Adults	145	18	9	31	42	73
Total pigs	935	12	6	42	40	82

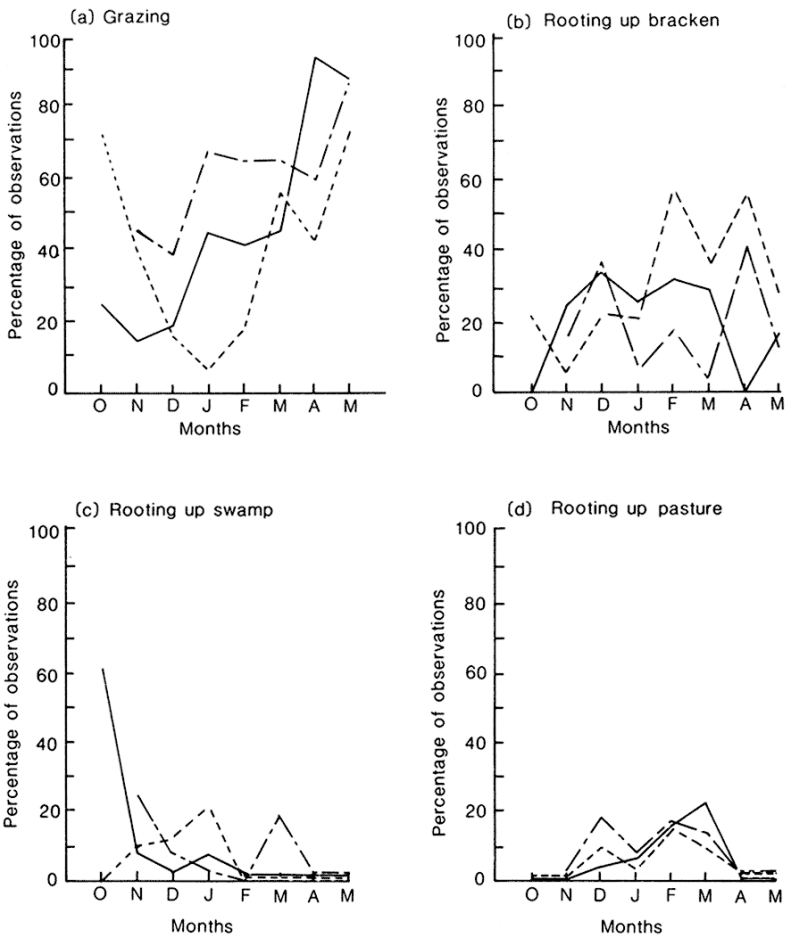

Figure 2: *Monthly changes in the observed activities of pigs at Mt Harte. Dotted lines refer to adults, unbroken lines to immatures and broken lines to piglets.*

activity decreased, more pigs were observed rooting in swamps, bracken or pasture. Most diurnal movements occurred early each morning, around noon or during the late evening.

Despite the shortness of the study, monthly changes were noticed in the activities of the pigs at Mt Harte and in the general district. During September some pigs in the district ventured onto improved pastures and fed on items obtained by rooting up pasture or turning over cowpats (e.g. earthworms and insects), on carrion (e.g. sheep *(Ovis aries)* and cows (*Bos Taurus*)), or placentas shed by ewes after lambing, on sick lambs, and on grass. These visits ceased during early October and thereafter the pigs remained on more marginal farmland or undeveloped land. At Mt Harte marked changes occurred from October onwards in how often pigs were observed grazing but were less evident in other feeding activities (Fig. 2). Piglets and immatures were observed grazing significantly more often during January-May (276 of 452 observations) than during October-December (99 of 338 observations; $X^2 = 77.02$; 1df; $p<0.01$). Adults, in contrast, were observed grazing significantly more often during October-November (22 of 39 observations) and during March-May (12 of 22 observations) than during December-February (11 of 84 observations; $X^2=23.20$; 1df; $p<0.01$, and $X^2 = 15.27$; 1df; $p<0.01$, respectively).

Rooting up of pasture, bracken, forest floors or swamps occurred on almost every night throughout the study. No correlation was found between fresh rooting and rainfall. Most rooting during the summer was in softer ground, such as along drainage lines, amongst rushes *(Juncus* spp.), sedges *(Carex* spp.) or bracken, in previously rooted ground, or in the shade of trees. Some turf in the middle of pastures was lightly rooted up during summer, possibly in search of scarab larvae. During November bracken began to regenerate, particularly where it had been burnt the previous autumn, and from December to April increasingly large areas were rooted up, especially by adults. Rooting up of swamps was a major activity of immature pigs during October but not thereafter.

Fresh wallows were first noticed in mid-November and were increasingly evident until the end of March and then abruptly less often during April. They were usually in swampy gullies and creek beds and in pastures bordering creeks. Nearby logs or trees were often coated with mud where the pigs had rubbed.

Habitat use

The home ranges contained a different mix of habitat types from that in the study area as a whole. For example, the proportion of forest was 0.37 in the study area but averaged 0.51 in the home ranges and those for bracken-pasture and swamp were 0.62 *vs* 0.48 and 0.006 *vs* 0.014, respectively. No consistent preferences were shown for the different habitats within the home ranges (Table 6). The two immature females showed no preferences, the immature male, one adult male and both adult females showed significant preferences for bracken-pasture, but the other adult male showed a significant preference for forest.

A total of 842 direct observations of diurnal habitat use by the population of pigs in the study area was also obtained but the radio-tracking results demonstrated the inadequacy of using this technique to assess habitat preferences.

Seasonal changes occurred in habitat use by the radio-tracked pigs (Fig. 3). Forest was most used during spring and autumn, pasture during early summer, bracken during summer and swamp in autumn. These seasonal changes were usually reflected by the pigs' shift to other parts of their home range containing more of that particular habitat.

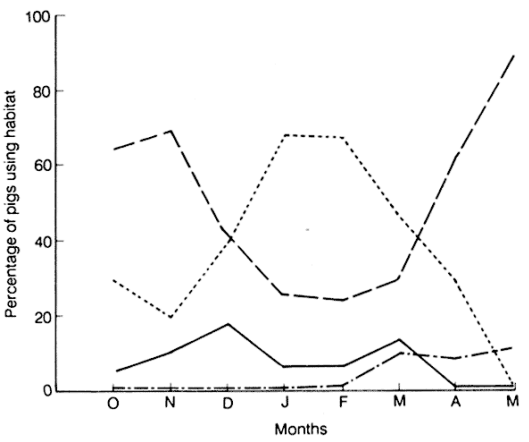

Figure 3: *Monthly changes in habitat use by radio-tracked pigs at Mt Harte. Dotted lines refer to bracken, dashed lines to forest, solid lines to pasture, and dot-dash lines to swamp.*

Resting sites were usually scooped out depressions in the soil at the base of trees or in long grass and bracken, either near the forest edge, at the top of a ridge, or at the head of a gully. Most sites had obvious trails leading to them, with much dung on the trails, especially at junctions or before they emerged onto open pastures.

Table 6: *Habitat preferences of radio-tracked pigs at* Mt *Harte.*

Habitat	Proportion of home range	No. actual locations	No. expected locations	Proportion located/ habitat (incl. 95% confidence intervals)
Immature F1:				
Bracken/pasture	0.56	13	14	0.50 (0.28-0.72)
Forest	0.44	13	12	0.50 (0.28-0.72)
	χ^2 = 0.15, 1 df, $p > 0.05$			
Immature F2:				
Bracken/pasture	0.42	8	11	0.30 (0.09-0.51)
Forest	0.56	19	15	0.70 (0.49-0.92)
Swamp	0.02	0	1	—
	χ^2 = 2.89, 2 df, $p > 0.05$			
Adult F3:				
Bracken/pasture	0.68	197	155	0.86 (0.81-0.92)
Forest	0.29	24	65	0.11 (0.06-0.15)
Swamp	0.03	7	8	0.03 (0-0.06)
	χ^2 = 37.37, 2 df, $p < 0.01$			
Adult F4:				
Bracken/pasture	0.42	184	97	0.79 (0.73-0.86)
Forest	0.57	45	132	0.19 (0.13-0.26)
Swamp	0.01	3	3	0.01 (0-0.03)
	χ^2 = 135.4, 2 df, $p < 0.01$			
Immature M5:				
Bracken/pasture	0.13	22	8	0.34 (0.20-0.48)
Forest	0.86	43	56	0.66 (0.52-0.80)
Swamp	0.01	0	1	—
	χ^2 = 28.52, 2 df, $p < 0.01$			
Adult M6:				
Bracken/pasture	0.57	68	52	0.75 (0.64-0.86)
Forest	0.42	22	38	0.24 (0.13-0.35)
Swamp	0.01	1	1	0.01 (0-0.04)
	χ^2 = 11.66, 2 df, $p < 0.01$			
Adult M7:				
Bracken/pasture	0.61	78	162	0.29 (0.23-0.36)
Forest	0.38	183	101	0.69 (0.62-0.75)
Swamp	0.01	6	4	0.02 (0-0.05)
	χ^2 = 111.1, 2 df, $p < 0.01$			

The two adult females displayed significant preferences for resting sites amongst bracken (often under a log), especially on one particular hillside that received the early morning sun. During January and February they were located on this hillside on 50% and 100% of occasions, respectively. Adult male No. 7 displayed a significant preference for resting sites in forest. None of the other pigs displayed any significant preferences for resting sites.

There was variability in the pigs' temporal use of habitats. Four of the pigs mainly used pasture during daylight but the other three (including both adult females) mainly used it at night. All seven pigs showed a greater preference for bracken and forest during the day than at night and the adults were only located in swamps during the day.

Reproduction

Farrowing occurs throughout the year in the Mt Harte area (Fig. 4) but mostly during late winter and spring (Aug-Nov) and least during the main mating period in late autumn and winter (April-July).

Few data were collected on reproduction. Two pregnant sows were caught by hunters in the area during December and two radio-tracked sows were pregnant in mid-April. Two of the sows contained five and six embryos. The mean size of 29 litters observed with sows was 4.1± 0.3 (range 1-9). Three

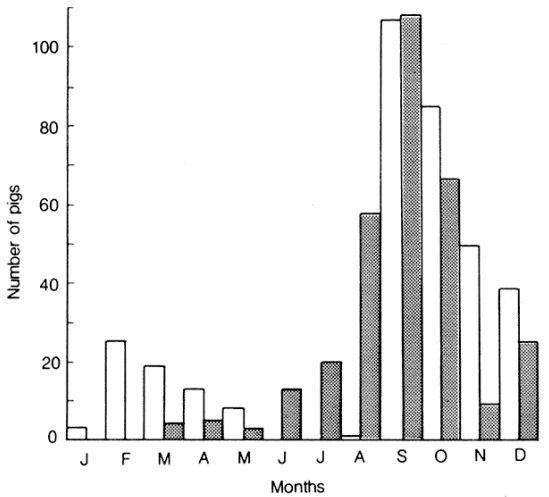

Figure 4: *Estimated birth dates of piglets and immatures observed at Mt Harte based on estimated body weights. Stippled bars represent immatures and plain bars represent piglets.*

lactating sows examined had 4, 4 and 5 active teats, respectively. The youngest of these sows (2 years old) weighed only 20kg but appeared to have recently lost considerable weight. Both radio-tracked sows gave birth to litters during early October 1983, weaned these during December when the piglets were approximately 10 weeks old, and were pregnant again in mid-April. They should have farrowed again during mid-July 1984, after the end of the study, thus producing two litters within 12 months.

Population characteristics

(a) Group sizes and composition

The pigs in the Mt Harte area lived in groups of 1-13 (Table 7). Groups of immature pigs were seen most frequently (33% of observations), followed by groups of piglets (30%), groups of adults (16%), groups consisting of a sow and piglets (13%), groups of mixed ages and sexes (8%), groups of adult females (5%) and groups of adult males (4%).

Pigs of mixed ages and sexes were the most gregarious, with a mean group size of 5.4 (Table 7), and adult boars the least so. All adult males observed were solitary except for one seen with two adult females and on two other occasions when two or three boars, respectively, were observed fighting over a sow in oestrus.

Table 7: *Composition and size of groups of pigs observed in the Mt Harte area.*

Group	No. groups	No. individuals	Nos. per group Mean	Range
Mixed group	18	97	5.4	2-13
Piglets + Adult F	29	145	5.0	3-10
Piglets only	67	228	3.4	1-9
Immatures only	74	242	3.3	1-11
Adults only	37	53	1.4	1-4
Adult F only	12	15	1.3	1-2
Adult M only	9	9	1.0	1
Total	225	765	3.4	1-13

Most pigs observed were black or light to dark brown with black patches. Frequencies based on 663 observations were as follows: black (53%), brown or ginger with black patches (38%), brown or ginger (6%), blotchy grey (1%) and miscellaneous (pale sandy colour with or without black spots, or brown and white; 2%).

(b) Age composition

A crude estimate of the age composition of the pigs was obtained from their estimated weights, based on 765 observations. A high percentage of young piglets (70%) were observed, a greatly reduced percentage of immature pigs (18%) and very few large or adult pigs (12%).

(c) Relative change in numbers of pigs observed

Fewest pigs were observed per day from the standard route during October (6.5 ± 0.3 day^{-1}). Thereafter, mean numbers observed increased to 11.2 $\pm$ 2 day^{-1} in December but then steadily declined to only 7.9 ± 1.9 day^{-1} in April. Mean numbers rapidly increased again to 17.5 ± 7.5 day^{-1} after the first snowfall during early May, possibly through immigration from adjacent higher country.

Discussion

Home ranges and movements

The areas used by the adult pigs are probably fair estimates of home range size during the study period because they appeared to be asymptotic with increasing number of radio locations (Fig. 5). The areas used by the immatures, however, continued to increase with additional locations and must be regarded as minimum estimates of home range size. Differences between adults and immatures in estimated home range size, therefore, may have been even greater if the immatures had been located as often over the same periods as the adults. Adult males are known to occupy larger home ranges than adult

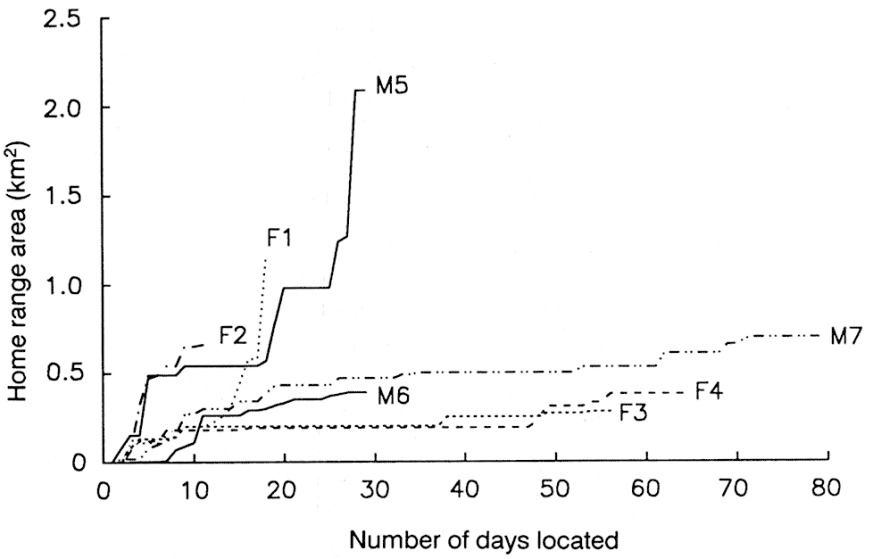

Figure 5: Cumulative home range area (km^2) in relation 10 radio-tracking effort (days located).

females (Mauget, 1980; Singer *et al.,* 1981; Baber and Coblentz, 1986) but no comparison has previously been made between immatures and adults.

The fact that the home ranges of the pigs at Mt Harte were so small compared with those of feral pigs in other countries (e.g. Kurz and Marchinton, 1972; Barrett, 1978; Giles, 1980; Mauget, 1980; Wood and Brennemann, 1980; Singer *et* al., 1981) may reflect the abundant food, water and shelter, the high density of pigs and the lack of serious disturbance by humans at Mt Harte, all factors affecting home range size and movements (Kurz and Marchinton, 1972; Wood and Brennemann, 1980; Singer *el al.,* 1981; Coblentz and Baber, 1987). The Mt Harte estimates are most similar to those (i.e. 20-288 ha) obtained by Coblentz and Baber (1987) in the mesic highlands of Isla Santiago, Galapagos, Ecuador. These highlands also contain high densities of pigs (e.g. 20-74 pigs per km^2) and abundant food for most of the year, and the pigs had not previously been subjected to control measures. In other respects, though, the information obtained at Mt Harte is similar to that obtained in other studies, such as the small farrowing home range (less than 40 ha) and small 24 hour home ranges (less than 60 ha) (Kurz and Marchinton, 1972; Wood and Brennemann, 1980; Singer *et al.,* 1981).

The only other study of the movements of feral pigs in New Zealand (Martin, 1975), based on trapping and observations, also indicated that feral pigs are relatively sedentary, rather than nomadic as described by Wodzicki (1950). Ten boars recorded by Martin made average movements of 3.2 ± 2.6 km (maximum 13 km) and 12 sows movements of 0.5 ~ 0.1 km (maximum 0.7 km) over periods of 1-25 months. The comparative mean for the Mt Harte pigs was 1.4 km (maximum of 2.7 km), but Martin's pigs lived in mostly open tussock country and were hunted much more intensively. Comparable figures for pigs inhabiting mountain pastures and rain forest in Hawaii were 1.9 km and 1.0 km, respectively, over periods of up to two years (Giffin, 1978).

Little is known about the response of pigs to hunting and other disturbances by man. Singer *el a1.* (1981) found that wild boar did not move so far after disturbance than when not disturbed. The pigs at Mt Harte usually shifted to another part of their home ranges when disturbed by the mustering of sheep or hunting but returned within one or two days. Hunting pressure at Mt Harte increased enormously from May 1984 onwards after the property was sold. During July 1984 sow No.4 was killed 0.5 km east of her previous home range and boar No.7 was killed 1.9 km north-east of his previous home range, in a more remote forest-covered valley.

Activity patterns

The variability in the periods during which the pigs at Mt Harte were active is probably due to a number of different factors. As pigs lack sweat glands and rely on behavioural thermoregulation, they restrict their diurnal activity to the early mornings and late afternoons during hot weather, and increase their nocturnal activity, particularly on moonlit nights or if subjected to increased disturbance (Hanson and Karstad, 1959; Kurz and Marchinton, 1972). They take advantage of temporary cool conditions, such as overcast or wet weather, to forage during daylight. Usually they revert to a more diurnal pattern of activity again in autumn and winter, especially if adequate food and cover is present and they are not seriously disturbed by human activity (Hanson and Karstad, 1959; Barrett, 1978; Pavlov, 1980).

The inactivity of adult sows at Mt Harte is typical of their behaviour around farrowing time (Kurz and Marchinton, 1972) and may also have been partly due to their concentrating their activities within one small area of their home range that appeared to contain plentiful food and shelter. The immature pigs, which were the most active, generally had the largest home ranges, but no significant correlation was found between the activity levels of the pigs and size of their home ranges or movements.

Habitat Use

Caution is necessary when interpreting the results on habitat use by the pigs at Mt Harte. Porter and Church (1987) described how *a priori* decisions necessary to define habitats and study area boundaries can result in spurious inferences about habitat preferences and do not allow examination of some important habitat characteristics, such as interspersion and juxtaposition of vegetation.

In the present study, cover types were aggregated and the proportions of the main habitat types changed when the study area boundaries were extended from the home range of each pig to the total study area. This had little effect on the inferred habitat preferences of the radio-tracked adult pigs but did affect the perceived habitat preferences of the immature pigs, indicating a greater preference for forest.

Reproduction

The absence of a definite breeding season with peak births in spring as occurred at Mt Harte has also been reported for feral pigs elsewhere in New Zealand (Wodzicki, 1950), and in Australia, mainland U.S.A. and Hawaii (Lyman, 1962; Pine and Gerdes, 1973; Sweeney, Sweeney and Provost, 1979; Giles, 1980; Pavlov, 1980). The estimated litter size of 1-9 piglets (mean 4.1) at Mt Harte is comparable with litters of 4-6 and 6-10 for feral pigs in New Zealand (Holden, 1982; Wodzicki, 1950), 1-10 (means of 4.9-6.3) in Australia (Hart, 1979; Masters, 1979; Giles, 1980; Hone and Robards, 1980; Pavlov, 1980; Boreham, 1981), and 1-11 in the U.S.A. (Sweeney and Sweeney, 1982).

Population Characteristics

(a) Age Ratio

The high proportion of piglets, low proportion of immature pigs and few large pigs observed may not indicate that the population was expanding (Caughley, 1974), but that most of the piglets died or dispersed before they were classed as immature (over 10kg). Most studies of feral pigs and wild boars in other countries indicate that mortality during the first year of life is high, with the most favourable estimates ranging from 10-15% and mortality reaching 100% when conditions are un favourable (Jezierski, 1977; Barrett, 1978; Giles, 1980). Wodzicki (1950) suggested that significant mortality amongst autumn and winter-born piglets in New Zealand might occur because of adverse weather conditions and shortage of food. Local hunters in the Murchison area consider that exposure, parasites and diseases are the main mortality factors for piglets in the area and any piglet under 10 kg in weight in April is unlikely to survive the winter (D. Walker and A. Redwood, pers. comm.). In mid-April 1 found one dead piglet weighing I kg and in May another four, weighing about 5 kg, apparently dead from exposure after the first snowfall for the year.

(b) Densities

The method for assessing relative changes in the number of pigs in the area was necessarily not standardised and involved covering the route at variable speeds, different times of the day and with poor visibility, as in bracken. However, the trend was similar to that generally observed by the owner of the property, namely a decline in the numbers in the valleys in summer, when some pigs reputedly moved to higher ground and an increase in late autumn after the first snows fell on the higher country and when food probably became less abundant in the forest (D. Walker, pers. comm.).

During April and May 1984, 75 pigs were shot in the study area. This gives a crude minimum density

estimate of 12.5 pigs per km^2. After the property was sold, 260 pigs were killed in the area between June 1984 and May 1985. Most of these pigs weighed from 36-45 kgs (max 64 kg) although some litters of piglets were also killed (N. Hayton, pers. comm.). By May 1985 few pigs were observed in the area. Ignoring natality, natural mortality, emigration and immigration into the area during the year, and any surviviors of the hunting, this would give a crude density estimate of 43 per km^2. This corresponds to a medium density (35-123 pigs per km^2) of pigs in New Zealand according to Saywell (quoted by Wodzicki, 1950) and falls within the range (1-80 per km^2) quoted for feral pigs in Australia (Anon., 1978, 1981; Boreham, 1981) and in Europe and the USA (Singer, 1981). Crude estimates of pig densities based on hunters' kills in the nearby Tutaki valley ranged from 3-8 pigs per km^2.

Conclusion

This study shows that feral pigs living in a relatively undisturbed area of partly cleared hill country in New Zealand can be sedentary, contradicting the popular belief that pigs are semi-nomadic. The size of the home range of seven pigs rarely exceeded 2 km^2 and most pigs covered less than 3.6 km in their wanderings per 24 hours. Independent, immature pigs were generally the most active and mobile, while adult females were restricted to small areas with abundant food and shelter. Adult boars were also quite sedentary except for brief excursions away from their normal haunts when nearby sows were in oestrus.

In the Murchison area the seasonal movements and changes in activities, habitat use and density of the pigs appeared linked to the seasonal availability and quality of food and the pigs' requirements for shelter. Unfortunately, because of factors linked with the exchange visit, it was not possible to carry out the study over a complete year. With hindsight, it may have been more useful to have studied the pigs during late autumn and winter, rather than from spring to early autumn. According to local farmers and hunters (D. Walker and A. Redwood, pers. comm.) pigs more commonly visit improved farmland and damage pastures during autumn and winter, possibly because food within their previous home ranges is less plentiful. During this period they also reputedly come into more frequent contact with domestic livestock, particularly cattle, and consequently, this is when the chance of exotic disease transmission may be greatest. Further studies of feral pigs in similar farmland areas during autumn and winter could confirm whether such changes in movements and activities do occur and determine what effect control measures, notably hunting with dogs and spotlight shooting which are most often carried out during this period, have on populations of feral pigs.

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