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HOME RANGE OF FERAL HOUSE CATS (*FELIS CATUS* L.) IN FOREST OF THE ORONGORONGO VALLEY, WELLINGTON, NEW ZEALAND.

Summary: The home ranges of four male and five female feral house cats *(Felis catus)* were studied by radio-telemetry. In the narrow, steep-sided valley the home ranges of cats were linear, with an average length of 6.34 km for males and 3.83 km for females; only large males crossed the river. Females with kittens had small home ranges of 0.84 to 2.0 km. Home ranges of animals of the same sex, including breeding females, overlapped considerably. The social organisation of feral cats at low density differs little from that of higher-density free-ranging domestic cats.

Keywords: Feral cat, domestic cat, *Felis catus*, radio-telemetry, territory, social organisation, home range.

Introduction

We have studied the home range of feral house cats *(Felis catus* L.) in forest of the Orongorongo Valley, Wellington, using radio-telemetry, as part of studies of the ecology of feral cats in New Zealand (Fitzgerald and Karl, 1979; Karl and Best, 1982; Fitzgerald and Veitch, 1985); with the long-term aim of better management of predators and conservation of native fauna.

Current information from other sources is sparse, or may not be applicable. Domestic cats, associated with man in cities, dockyards and on farms, have overlapping ranges and are sociable to some degree (LaundrÈ, 1977; Macdonald and Apps, 1978; Dards, 1978; Corbett, 1979; Liberg, 1980; Panaman, 1981; Izawa, Doi and Ono, 1982; Natoli, 1985), though they have been considered as essentially solitary because they hunt alone (Kleiman and Eisenberg, 1973). However, their behaviour might be affected by their dependence on man for food and shelter. Studies of home range and social interactions of feral cats so far are inconclusive (Corbett, 1979; Jones and Coman, 1982; Konecny, 1983; Brothers, Skira and Copson, 1985).

Study Area

The Orongorongo Valley is a long, steep-sided valley on the west of the Rimutaka Range, east of Wellington. The ridges rise to 160-442 m a.s.l. on the west side of the valley and to 700-941 m a.s.l. on the east (Figs 1 and 2). The D.S.I.R. Research Area of about 1200 ha, extending over 4 km of the valley floor and to the crest of the ridge on either side, was the site of our earlier study of the food habits of cats (Fitzgerald and Karl, 1979). However, several cats that we trapped and radio-tagged within the Research Area travelled well beyond it and they determined the size of the study area, i.e. from near the mouth of the Orongorongo River to about 16 km up the valley.

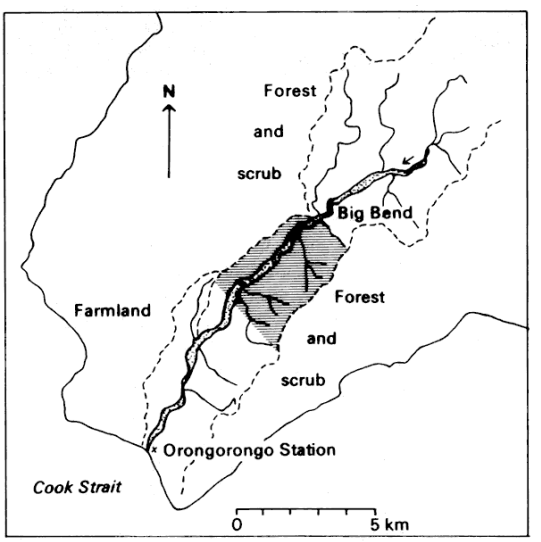

Figure 1: *The lower Orongorongo Valley, showing the D.S.I.R. Research Area (hatched). Dotted lines show major ridges.*

The valley floor consists largely of a stony riverbed over which the river frequently changes course; recently flooded areas consist of bare gravel, and the older, more stable areas are covered with grass, low vegetation and scrub. In the northernmost 1-2 km the river is narrow with large boulders and deep pools but downstream the river widens, meandering with many riffles.

The southern third of the study area is in rough pasture and scrub and the northern two-thirds in forest. Most of the forested lowland terraces and gentler slopes have mixed rata/podocarplbroadleaf forest and the ridges have hard beech *(Nothofagus*

Figure 2: *Aerial view down the Orongorongo Valley to the sea, from point marked with arrow in Fig.1 Photo: N.Z. Geological Survey, D.S.I.R.*

truncata) or black beech *(N. solandri)*. Higher on steep slopes on the east side of the river is a zone of scrub and above 600 m chiefly silver beech *(N. menziesii)* forest. A detailed description of the vegetation is given by Campbell (1984).

The two main prey species, rats *(Rattus rattus)* and rabbits *(Oryctolagus cuniculus),* are distributed patchily. We snap-trap quarterly for rodents (Fitzgerald, 1978; Fitzgerald and Karl, 1979) and in trapping over 5 years near the floor of the valley and in silver beech the overall capture rates in lowland beech and silver beech forest were 0.65 and 0.76 rats/loo trap nights respectively, about one-quarter the capture rate of 2.57 rats/100 trap nights in lowland mixed rata/podocarp/broadleaf forest. Rabbits are mainly restricted to patches of grass, low vegetation and scrub on the floor of the valley. Some of these areas support only one or two pairs of rabbits separated from other rabbits by the river or by steep forested slopes. Rabbits live above-ground in dense scrub but dig short burrows (stops) for breeding.

Mice *(Mus musculus)* are fairly evenly distributed through forest near the floor of the valley and at about similar densities in the silver beech forest, but their numbers fluctuate considerably from year to year (Fitzgerald, 1978). Adult possums *(Trichosurus vulpecula)* are eaten as carrion, and young are probably killed by cats at the age when they leave their mothers' backs. Possum trappers operated in parts of the study area and skinned possum carcasses were sometimes available to cats.

Birds are a small part of the diet of cats in the Oron goron go Valle yand those eaten are mainl y ground-feeding introduced species, such as blackbird *(Turdus merula),* thrush *(T. philomelos),* chaffinch *(Pringilla coelebs)* and hedgesparrow *(Prunella modularis)* (Fitzgerald and Karl, 1979).

Methods

Cats were caught using drop-door cage traps (illustrated by Veitch, 1985) baited with fish heads. We operated two trapping regimes: (1) general trapping, on the eastern side of the river with traps set along the vehicle track, foot tracks and bush edge (the number set and their sites varied between trapping periods); and (2) specific trapping, with a few traps set close to (usually within 200 m of radio-located cats. Because of the size of the traps, difficult terrain and dense vegetation, only 3-6 traps could be set near an animal. Specific trapping was carried out when the transmitter battery began to fade, and continued until the animal was caught or the transmitter ceased functioning.

Trapped cats were run into a retaining sleeve, weighed, and anaesthetised intramuscularly with ketamine hydrochloride at a rate of 10 mg per 1 kg body weight. Each cat was fitted with a radio transmitter and ear-tagged with a numbered metal tag. They were held in the trap for about an hour after dosing, to recover sufficiently to be released.

The radio transmitter emitted a pulsed signal on 160 MHz, as used by Ward (1985) and had an effective life of about 3 months. The transmitters weighed about 25 g which represented, on average, less than 1% of the cat's body weight. The transmitter chip, battery and reed switch were set in a moulded hard plastic case with SYLGARD 184 encapsulating resin. A transmitter, with a loop aerial, was put over the cat's head and the excess aerial was taken up by doubling it on to itself and crimping a "D" size bird band at each end of the doubled up aerial.

The signals were received on an A VM LA12 receiver and hand-held, 3-element yagi directional aerial. Because of the steeply dissected nature of the country strong signals could be picked up at distances varying from 2.5 kilometres to only a few hundred metres. Cats were located during daylight, and we endeavoured to obtain a morning and afternoon fix on each cat. The intervals between radio-fixes varied because of the distances involved and the difficulty of locating animals regularly. Some animals were located on most attempts but others, especially those furthest north from the Field Station, were often not found. Cats were usually located to within an area of about 10 m diameter but because of the dense vegetation

were not often seen. Attempts to fix their position more accurately or to see the cats usually ended in them being disturbed and moving away.

The cats mainly used the riverbed, and the forested terraces and lower slopes, so home ranges tended to be linear. Conventional analyses using either non-statistical polygon techniques or statistical models based on the assumption that the data conform to a probabilistic distribution (Smith, 1983; Rhoades and Langham, 1984) are not applicable to such ranges. We have therefore expressed home ranges chiefly in terms of cumulative length of home range, but because ranges that are described as linear do have some width we have included, as two other measures of range size, the cats' shortest distance from the centre of the riverbed, and height above the riverbed. The very steep hillsides, deeply dissected by side streams, make reliable estimates of area of home range almost impossible; however, to get an approximate idea of the area of home ranges we have multiplied range length by the average of the distance from the cat to centre of the riverbed at each fix.

Results

Nine cats (four male, five female) were trapped and fitted with radio transmitters between April 1981 and May 1983. The periods for which cats carried active transmitters, and the weights of cats, are shown in Fig. 3. Three females had been trapped and tagged previously. Lena was first trapped as a kitten weighing 0.8 kg on 19 March 1976, Nanny as an 0.8 kg kitten on 15 February 1979, and Lucy as an adult weighing 2.0 kg on 16 November 1979. During the present study Lena was 6 years old, Nanny was 2 years old, and Lucy was at least 2 years old. Some time between March 1976 and February 1982 Lena's right front foot had been amputated above the wrist, probably by a gin trap set for possums. The injury had completely healed, she walked on it, and ran with a slightly rolling gait. Despite the disability she was in good condition and in autumn 1982 reared two kittens. None of the males had been trapped before.

Records on two cats ceased when they shed their transmitters, on five when the batteries expired and they could not be recaptured, and on four cats when they died (two of unknown causes, one in a gin trap and one was shot).

Cats were difficult to recapture; when the transmitter batteries weakened we made considerable effort to re-trap cats but only three out of seven were recaptured. Females seemed to be more trappable when they were feeding kittens; four of the five

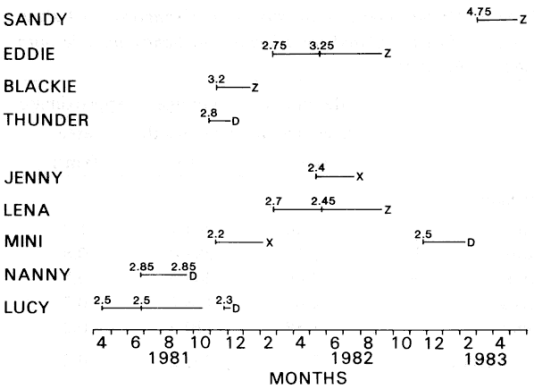

Figure 3: *Periods of radio-tracking cats, with weight in kg at capture and fate (D = died. X = shed transmitter,* Z = *battery faded).*

females were lactating when trapped and two whose transmitter batteries expired were lactating when recaptured one to nine months later (Fig. 3). Of the lactating females, Lena had small kittens still in the natal den and the others had larger kittens at heel. Sandy was possibly the father of Lena and Mini's kittens because both litters included a tortoiseshell female kitten.

Range length

All the radio-tagged cats spent most of their time in the valley floor but sometimes moved up the gullies of side streams. Because the Orongorongo Valley is narrow and steep-sided, the cats' home ranges were linear: ranges of females were about 18 times longer than wide, and of males about 28 times longer than wide. Maximum range lengths, in a straight line, for the five females ranged from 1.89 km to 6.40 km and for the four males from 4.75 km to 8.60 km (Table 1).

Ranges of both females and males were largely revealed within 10 records taken irregularly over 20-40 days (Figs 4a-c). The major exception was that females with kittens moved over a smaller area and the lengths of their ranges were then 0.25-0.5 the length without kittens. Mini, radio-tagged in November 1981, revealed her range of 4.0 km with five records over 11 days and her recorded range did not increase substantially over the next 80 days (Fig. 4a). When retrapped in November 1982 she was lactating, and subsequent sightings of her kittens suggested that they had already left the natal den. With kittens, her recorded range was restricted to just over 2.0 km long (the northern half of her range) for

Table 1: *Home range size of cats in the Orongorongo Valley. Range widths calculated for Blackie and Sandy include both sides of the river.*

	Maximum range length	Average range length	Approximate area (km^2)
Females			
Lucy	6.40	264.1	1.7
Nanny	2.75	283.0	0.8
Mini	4.08	205.3	0.8
Lena	4.02	178.2	0.7
Jenny	1.89	110.3	0.2
Average	3.83	208.2	0.8
Males			
Thunder	4.75	114.3	0.5
Eddie	5.60	176.6	1.0
Blackie	6.41	245.6	1.6
Sandy (radio)	8.60	358.0	3.1
Sandy (sighting)	13.92		5.0
Average (radio only)	6.34	223.6	1.4

at least 65 days. Eleven days later she was found shot near the south end of her range, giving a recorded range 3.85 km long during the second radio-tracking period.

Similarly, Lena had two kittens about seven days old in the natal den when she was trapped; they left the den 22-26 days later and were seen with Lena until day 43 of radio-tracking (Fig. 4c). Lena's range throughout this period and until day 73 was 0.84 km long. Over the next five days her range increased to 4 km long and she remained within that range for the next 120 days. Two other females, Nanny and Jenny, both lactating when trapped, had ranges of 1 to 1.5 km for about 60 days; their ranges then began to increase (Fig. 4a) but Nanny was caught in a gin trap and Jenny slipped her transmitter before their ranges stabilised again.

Lucy's range reached a plateau after 10 records in the first 44 days and remained stable for the next three months. In spring (mid September) she moved considerably south of her usual range and well up one of the side streams and spent at least three days there. *After* this excursion she returned to her previous range and remained largely within it for the remaining 70 days of her life. She may have moved out of her usual range to mate, because when retrapped 64 days later at the end of November she was lactating. Lucy's cumulative range length from the time she was retrapped in June was very similar to that determined when the transmitter was first fitted.

All four males had long home ranges, between 4.75 km for Thunder and 13.92 km for Sandy. The differences in range size probably reflect age and social status. Sandy was the largest adult male; his range length increased rapidly to 8.2 km by day 35 and then gradually to 8.6 km at day 74 by which time the battery was weakening. He could not be retrapped but his transmitter was found on day 163 near a farmhouse at the mouth of the Orongorongo River. If he shed his transmitter there, this would increase his range length to 13.92 km. A large ginger cat fitting Sandy's description was seen on 5 January 1984 (almost 5 months later) about 0.75 km north of where the transmitter was found. He has been seen several times since, within his radio-revealed home range and was still present in March 1986. Blackie's range increased to 6.4 km over two months and we then lost contact with him as the batteries weakened. Thunder, weighing 2.8 kg when tagged, was located on only three days before he was found dead on day 41. Another young male, Eddie, weighing 2.75 kg when first trapped, had a maximum cumulative range of 5.6 km. After he was first trapped his range quickly reached 3.9 km and he remained within this range for more than five months before extending his range northward.

River-crossings

All the records for the females and Thunder were on the east side of the river. Eddie was found only on the east side of the river for the first 5.5 months that he was radio-tracked. He then moved north where the river is narrow and crossed to the west side of the river. In contrast, the two larger males (Blackie, 3.2 kg; Sandy, 4.75 kg) frequented both sides of the river about equally; Sandy was found 13 times on the east side and 12 times on the west, and Blackie was found nine times on each side of the river.

These two cats crossed the river most often in the northern part of the study area. We have compared the number of times on successive fixes within tracking sessions that Blackie and Sandy were found on the same or opposite sides of the river in the north and south part of the ranges (using Big Bend as the dividing point, Fig. 1). They crossed on four out of seven occasions in the north section and only once out of twenty-three occasions in the south section. The difference between the two areas is highly significant (Fisher's exact test $p = 0.006$) and suggests that the

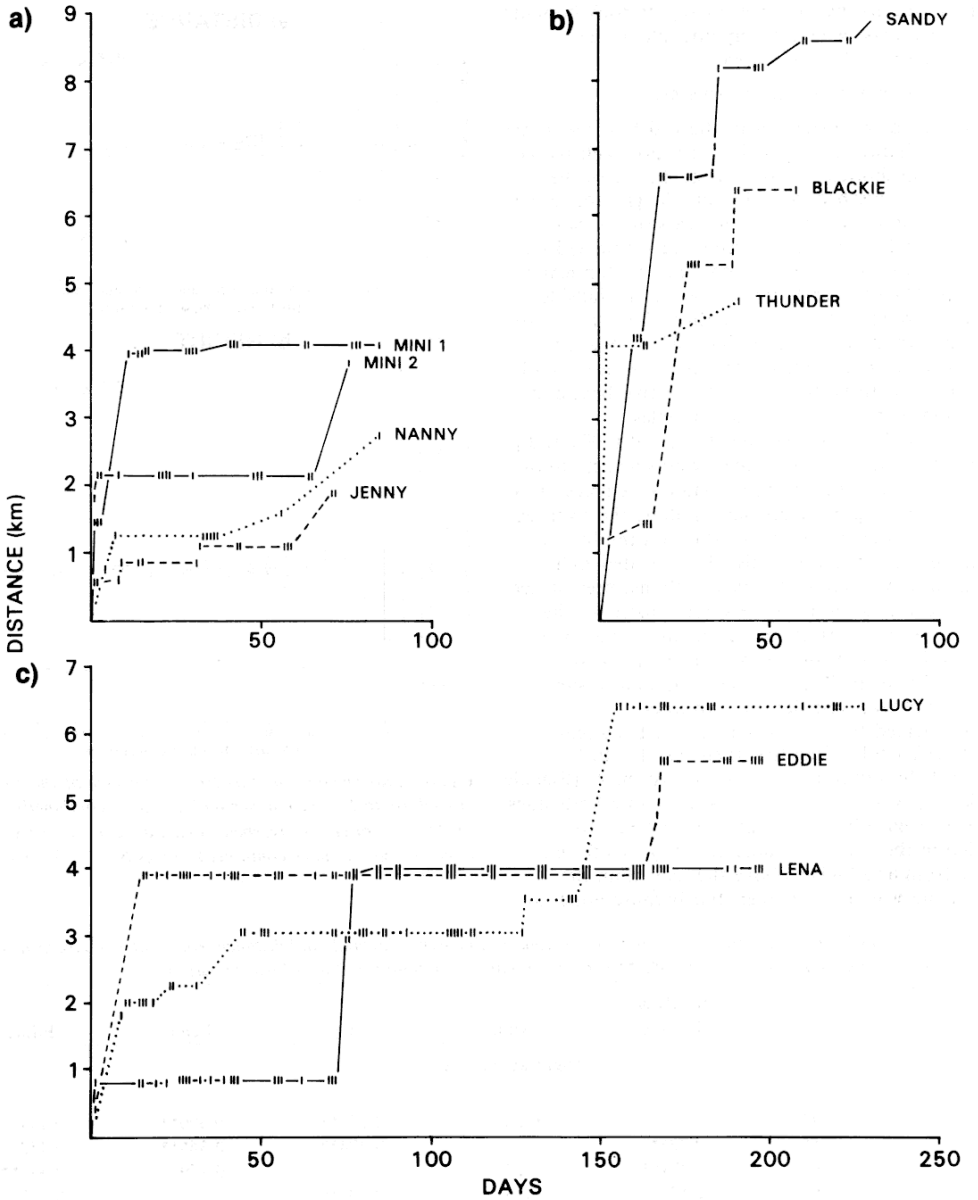

Figure 4: *Cumulative home range lengths with time. Symbols indicate days on which fixes were obtained. (a) females with records 3 months, (b) males with records 3 months, (c) females and male with records > 6 months.*

cats may be crossing the river mainly by rock-hopping or on fallen logs, which is only possible in the northern part of the study area.

Range width and height above riverbed

We have used two measures of the width of the home range and, indirectly, of habitat use. For each fix we recorded the shortest distance from the cat to the centre of the riverbed, and the cat's height above the riverbed. Combining the fixes for cats of the same sex, the females were always recorded within 1150 m of the centre of the riverbed and males within 600 m (Fig. 5a). The cats rarely moved far up the hilbides. Females were recorded no more than 280 m above the riverbed, and males no more than 160 m (Fig. 5b). Females spent significantly more time (as measured by the number of fixes) further from the riverbed, and higher above the riverbed than did males (Kolmogorov-Smirnov two-tailed test $p < 0.005$ and $p < 0.001$ respectively). The males, who spent more of their time close to the riverbed than did females, may have been feeding more on rabbits along the riverbed, but we have insufficient information on the food of individual cats to confirm this. We recorded eight individual prey, mainly at dens of kittens; prey at dens were three young rabbits (one whole rabbit weighed 315 g), a rat and a blackbird. In addition Nanny was seen carrying a bird, probably a blackbird, and remains of two small rabbits were found at a site where Sandy was recorded for two days.

We located four cats (Mini, Lucy, Lena and Eddie) sufficiently often that their results can be compared. In addition, fixes of the two males (Blackie and Sandy) with rather similar ranges using both sides of the river have been combined so they can be included in the analysis (Table 2). Lucy was found further from and higher above the river than the males; Lena was found higher, but because much of

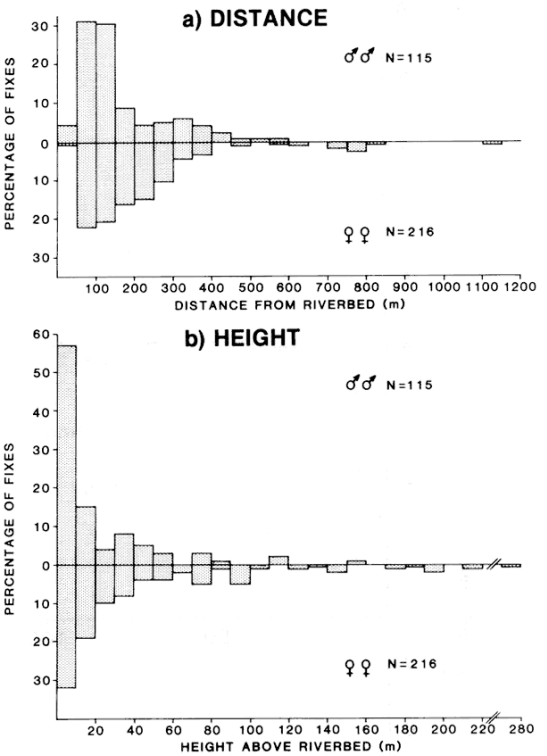

Figure 5: *(a) Distance of cats from the centre of the riverbed at each radio-fix (all females and all males combined). (b) Height above the riverbed of cats at each radio-fix (all females and all males combined). males N* = 115, *females N* = 216.

Table 2: *Differences between cats for height above river (figures above the diagonal) and distance from centre of riverbed (figures below the diagonal) at radio-fixes (* p < .05, ** P < .01; Kolmogorov-Smirnov 2-tailed test D values).*

	N	Sandy & Blackie	Mini	Lucy	Lena	Eddie
			Height above river			
Sandy & Blackie	43		0.207	0.536**	0.390**	0.211
Mini	55	0.326*		0.424**	0.365**	0.152
Lucy	68	0.479**	0.248*		0.169	0.374**
Lena	65	0.196	0.151	0.304**		0.219
Eddie	66	0.200	0.158	0.311**	0.041	
			Distance from river centre			

her home range was in steep country, not further from the river than Sandy and Blackie. In contrast, Mini tended to frequent forest on old fans of sidestreams, which spread out giving wide areas that did not rise very high above the river. Eddie occupied the same home range as did Lena.

Range overlap

The ranges of most of the cats overlapped considerably with the ranges of at least one neighbour of the same sex. To compare the ranges of concurrent animals the study was divided into two periods, from April 1981 to January 1982 (Lucy, Nanny, Mini, Blackie and Thunder) and from February 1982 to May 1983 (Mini, Lena, Jenny, Eddie and Sandy) (Fig. 6a-b). During the first period the ranges of the two breeding females, Lucy and Nanny, overlapped somewhat, but Mini, whose range overlapped extensively with Lucy's, was radio-tracked only after Lucy had died. In the second period the ranges of all three breeding females overlapped, and that of Lena completely covered that of Jenny. Although Mini was radio-tracked after the other two females, her range in this period was similar to that in the first, and there is no reason to suppose that it differed in the intervening months. Similarly, Lena, who was the oldest of the females, was probably present in her revealed home range during the first tracking period and would have overlapped extensively with Lucy and Nanny. The high proportion of fixes in one locality for Nanny, Lena, and Jenny (Fig. 6) reflect periods when these females had young kittens with them and did not move far.

Two cats, Lena and Eddie, held almost identical home ranges for much of the study (Fig. 6b) and were sometimes found close together; Eddie may have been one of Lena's offspring from a previous litter. They were both trapped on 24 February 1982, 170 metres apart, and both retrapped on 20 May sixty metres apart. Eddie was found inside Lena's home range throughout the first five months they were radio-tracked; only in the sixth month did he move north outside Lena's range.

Activity and den sites

Cats were active by day and by night but also spent long periods resting. Sometimes a cat moved almost from one end of its home range to the other in a few hours but at other times it remained in the same locality for several days. The greatest distances moved per hour during the day were 478 and 418 m/h by Lucy and 260 m/h by Mini; most of the other movements recorded were of less than 200 m/h. Over

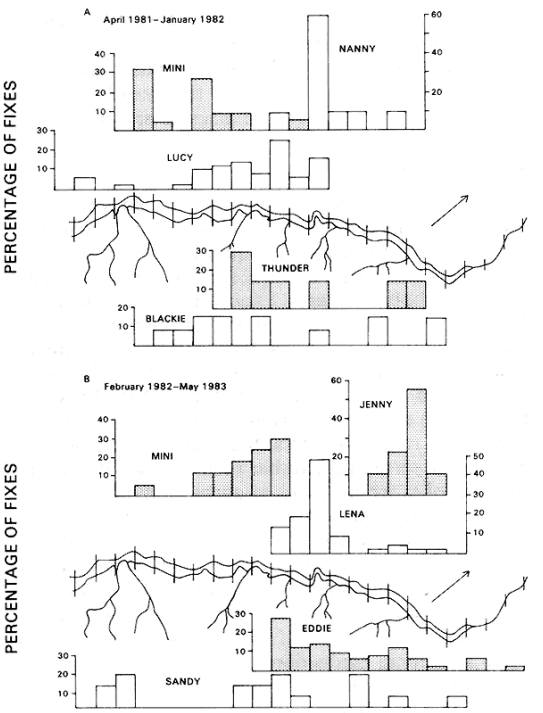

Figure 6: *Distributions of cats along the Valley, based on radio-fixes and captures. (a) records for animals April 1981-January* 1982, *(b) records for animals February 1982-February* 1983. *Valley subdivided at 0.5 km intervals.*

24 hours, females without kittens moved on average about 750 m and the subadult male Eddie about 1.3 km.

In the Orongorongo Valley, cats did not have permanent dens but could be found resting in any part of their home range. Sandy was once disturbed from a dry, sheltered 'nest' in a leaning, hollow stump but was not found there again. However, females kept their young kittens in one den, usually in the hollow base of a tree, until they weighed about 450-500 g (about 7 weeks old). Lena had young kittens when she was trapped and radio-tagged. She was at the den with the kittens whenever we checked from 0820 h to 1745 h over the next 22 days. On 18 March 1982 the kittens weighed 440 and 445 g; four days later they had moved to another hollow tree about 140 m away and weighed 510 and 485 g. From then on Lena and the kittens moved about frequently, usually to places

where they could hide in holes in tree stumps, fallen logs, or in dense thickets of kiekie *(Freycinetia baueriana)*. All the other lactating females that were trapped had larger, active kittens that moved frequently from one sheltered place to another.

Discussion

The behaviour of cats in the Orongorongo Valley was probably influenced by the distribution of their prey, giving results that differed somewhat from those of other studies. Firstly, because the cats fed chiefly on rats and rabbits (Fitzgerald and Karl, 1979) which were plentiful only in the bottom of the long, steep-sided valley, the cats' home ranges were rather linear and more akin to the ranges of carnivores living in streams and rivers, e.g. mink (Gerell, 1970; Birks and Linn, 1982) and otters (Erlinge, 1968), than to feral cats in less rugged habitats. Secondly, the cats were hunting dispersed prey rather than taking concentrated food supplies from houses or garbage dumps and did not have permanent dens (c.f. Laundre, 1977; Panaman, 1981; Izawa *et al.,* 1982; Natoli, 1985). However, our results on the cats' use of home ranges and their social organisation are generally consistent with other studies. Also, the few animals we studied were a large proportion of the population; we did not catch additional adults despite considerable trapping, and most cats seen on the research area were identifiable as radio-tagged cats.

The range lengths of most females and of a sub adult male were reliably estimated but those of some lactating females and the adult males were probably underestimated. Bekoff, Daniels and Gittleman (1984) suggest that 100-200 fixes are needed for reliable estimates of the size of home ranges of large carnivores, but that for smaller species fewer fixes suffice. Range length of our cats was usually revealed with 10 fixes taken over 20-40 days; more fixes would probably be needed to measure area instead of length.

The size of home ranges of house cats in different habitats varies about 200-fold. Home ranges of female cats associated with man vary from an average of 0.84 ha to 112 ha (Dards, 1978; Macdonald and Apps, 1978; Corbett, 1979; Liberg, 1980; Warner, 1985). Among feral cats, females in the Galapagos Islands had home ranges of 82 ha (Konecny, 1983), those in the Orongorongo Valley about 80 ha (this study) and in semi-arid Victoria, Australia, 170 ha (Jones and Coman, 1982). Densities are even more varied; from 23.5 cats/ha on a Japanese island where cats fed on fish wastes (Izawa *et al.,* 1982), to about 2 cats/ha in the Portsmouth dockyards (Dards, 1983), 1.2 cats/ha on uninhabited Herekopare Island, New Zealand (Fitzgerald and Veitch, 1985) and about 0.025 cats/ha in Victoria, Australia (Jones and Coman, 1982).

The home ranges of adult male cats in the Orongorongo Valley, like those elsewhere, were much larger than those of adult females and the subadult male (Dards, 1978; Macdonald and Apps, 1978; Corbett, 1979; Liberg, 1980; Jones and Coman, 1982; Konecny, 1983; Warner, 1985). The ranges of adult males in the Orongorongo Valley also differed from those of females in two other respects; the adult males frequently crossed the river whereas females did not, and the adult males were usually recorded closer to the river than the females were (Fig. 5a & b). The concentration of activity close to the river by adult males may reflect more hunting on rabbits. Gibb, Ward and Ward (1978) found that a large male was more successful at killing adult rabbits than were females. Females scavenged off the male's kills, and on 3 occasions when they did kill adult rabbits themselves they were supplanted by the male.

The home ranges of young males may be more similar to those of females than to those of adult males. Eddie, first trapped at 2.75 kg, lived within the same home range as Lena for 5.5 months before expanding his range northwards and hunting on both sides of the river. Other studies show that young males do not disperse from their mothers' home ranges until they are 1-3 years old (Liberg, 1980; Dards, 1978; 1983), and then may be forced out by other cats in the group (Liberg, 1980; Warner, 1985).

The description of behaviour and social organisation of cats given by Leyhausen (1965; 1979), derived chiefly from domestic cats, also largely applies to feral cats. He described cats as having a 'first-order home', usually a room, and a home range consisting of a 'varying number of more or less regularly visited localities connected by an elaborate network of pathways'. The home ranges of neighbouring cats usually overlap, with both animals using the same pathways and hunting grounds, but at different times. Leyhausen (1979) used the terms 'home range' and 'territory' interchangeably, but emphasised (p. 218) that "territory" must be understood in terms of space and time. However, the cat's home range is not a territory in the strict sense of a fIXed area that is defended, and from which rivals are excluded (Brown and Orians, 1970), as the home ranges of both feral and domestic cats overlap considerably.

Although our cats did not have permanent dens or 'first order homes', feral cats in other studies may

have had them (Jones and Coman, 1982; Brothers *et al.,* 1985). Nor do we have evidence for or against the suggestion that cats avoid each other by using areas of overlap at different times.

In the Orongorongo Valley the females held overlapping home ranges. All three females studied during the second period were probably present during the first period and their inclusion would further increase the degree of overlap. We radio-tracked only one adult male at a time but Sandy was probably present when Blackie was radio-tracked and their ranges may have overlapped considerably.

In other studies of feral cats, Corbett (1979) found from radio-isotope tagged faeces that the range of one female included the range of the other but concluded, contradictorily, that 'cats of both sexes tended to live in separate ranges'. In southern Sweden feral males were 'evenly distributed, and usually had large....., partly overlapping home ranges' (Liberg, 1980, p. 344), but Liberg (p. 347) also described their ranges as 'more or less exclusive'. In the Galapagos Islands, of two dominant males one shared 51% of his home range with the second, and the second shared 76% of his range with the first (Konecny, 1983). In southeastern Australia the home range of two adjacent males and two adjacent females did not overlap, but other adults (not radio-tagged) were seen occasionally in their ranges (Jones and Coman, 1982).

Free-ranging domestic cats usually live in groups centred on farmhouses and associated buildings, and their home ranges overlap (Laundre, 1977; Macdonald and Apps, 1978; George, 1978; Corbett, 1979; Liberg, 1980; Panaman, 1981; Warner, 1985), though individuals within a group concentrate their hunting into areas where other individuals of the group rarely hunt (Panaman, 1981). However, the combined range of a group of females does not overlap that of any other group of females (Liberg, 1980). This pattern is found even at the highest densities of cats. In the Portsmouth dockyards most adult females lived in groups, sharing their ranges with one or more females, while adult males had large, overlapping ranges that covered the ranges of several groups of females (Dards, 1978; 1983). Likewise, in a Japanese village where cats fed on fish wastes at a few sites the home ranges of members of the same feeding group overlapped considerably (within and between sexes), but the ranges of cats belonging to different feeding groups overlapped very little (lzawa *et al.,* 1982).

Cats with overlapping home ranges living in a group at a farmhouse are closely related (Laundre, 1977; Macdonald and Apps, 1978; Liberg, 1980; Panaman, 1981). In one case where they were not, they had been introduced into the group as 2-3 month-old kittens (George, 1978). We do not know the relationship of the cats in the Orongorongo Valley but the oldest cat, Lena, may have been the mother of some of the others.

Although cats have been described as solitary animals (Kleiman and Eisenberg, 1973), Leyhausen (1965, p 257) emphasised that solitary animals are not necessarily asocial, or socially indifferent; 'the only mammal one could conceivably speak of as being socially indifferent is a dead one'. For cats are neither solitary and asocial nor territorial, but have a social structure that appears to be intermediate between that of some of the larger carnivores which hunt in packs, e.g. lion *Panthera leo,* hunting dog *Lycaon pictus* and spotted hyena *Crocuta crocuta* (Bertram, 1979), and that of the solitary, territorial leopard *Panthera pardus* (Bertram, 1982) and wild cat *Felis silvestris* (Corbett, 1979).

The sociality of house cats is seen in their overlapping home ranges and group living, and in breeding females nursing and guarding each other's kittens (Macdonald and Apps, 1978; Macdonald, 1983). Sociality seems to be strongest where man provides food and shelter and weakest among feral cats having dispersed prey and plentiful shelter. Liberg (1980) suggested that domestication of cats increased selection for grouping; if so this characteristic has been retained in populations of feral cats.

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