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Home range size, habitat utilisation and movement patterns of suburban and farm cats *Felis catus*

David G. Barratt

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The movements of 10 house cats (4 desexed females, 5 desexed males and 1 intact male) living on the edge of a suburb adjoining grassland and forest/woodland habitat, and a neighbouring colony of seven farm cats, were examined using radio-telemetry over nine months Nocturnal home range areas of the suburban cats varied between 0 02 and 27 93 ha (mean 7 89 ha), and were larger than diurnal home range areas (range 0 02 to 17 19 ha – mean 2 73 ha) Nocturnal home range areas of cats from the farm cat colony varied between 1 38 and 4 46 ha (mean 2 54 ha), and were also larger than diurnal home range areas (range 0 77 to 3 70 ha – mean 1 70 ha) Home ranges of cats in the farm cat colony overlapped extensively, as did those of cats living at the same suburban residence There was no overlap of home ranges of female cats from different residences, and little overlap between males and females from different residences Four of the suburban house cats moved between 390 m and 900 m into habitat adjoining the suburb Polygons describing the home ranges of these animals were strongly spatially biased away from the suburban environment, though the cats spent the majority of their time within the bounds of the suburb Movements further than 100–200 m beyond the suburb edge were always made at night There is evidence that home range sizes and spatial movement patterns of house cats are largely determined by a) the density and spatial distribution of cats utilising separate food resources, b) the personality and social dominance of individual cats, c) the location of favoured hunting and resting/sunning sites, and, d) barriers such as busy roads

D G Barratt, Applied Ecology Research Group, Univ of Canberra, P O Box 1, Belconnen, ACT, 2601, Australia (dbarratt@anca gov au) (present address Forest Biodiversity Directorate, Australian Nature Conservation Agency, GPO Box 636, Canberra, ACT, 2601, Australia)

Movements by house cats into natural environments adjoining residential areas, particularly remnant native habitat patches, and their potential impact on faunal populations in these areas, has been raised as an issue of concern in Australia in recent years (Osborne and Williams 1991, Paton 1991, Seebeck et al 1991). Unlike domestic cats living in other environments, the movement patterns and home ranges of well-provisioned suburban house cats have scarcely been studied The small amount of work which has been done (Chipman cited in Bradshaw 1992, Bradshaw 1992, Das 1993) suggests the average home range size of solitary suburban cats (<1 ha) lies at the lower end of the distribution of home range sizes of domestic cats Both Bradshaw (1992) and Das (1993) reported some suburban house cats living adjacent to parkland may forage close to their homes in parkland habitat, though not necessarily disproportionately compared with surrounding urban or suburban environments Bradshaw (1992) recorded diurnal observations only, while Das (1993) investigated nocturnal activity

Work by Langham and Porter (1991) on feral cats in rural New Zealand, and Macdonald and Apps (1978) on farm cats in the U.K., appears to be the only

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research where differences in nocturnal and diurnal home range sizes and habitat utilisation have been examined Regular movements by both feral cats and house cats between suburban areas and nature reserves surrounding the Australian capital, Canberra, had been suspected prior to the commencement of this study (Osborne and Williams 1991) but no quantitative work describing the temporal and spatial extent of this movement had been done A diverse and interesting flora and fauna had been identified in parts of these reserves (Ingwersen et al 1974, Kukolic 1990, Osborne and McKergow 1993, Osborne et al 1993) The aim of this study was to examine diurnal and nocturnal movements and habitat utilisation by house cats living on the edge of residential suburbs The work was part of a larger study of the potential impact of suburban house cats on wildlife in Canberra

The terms used to define different types of cats in this paper are based on the definitions of Liberg and Sandell (1988) The term 'domestic cat' refers to all categories of *Felis catus* House cats live in close association with a household which assumes responsibility for feeding them A farm cat is a house cat living on an agricultural farm A suburban cat is a house cat living at a suburban residence Feral cats are domestic cats not attached to a particular household

Study area

Canberra (35°17'S, 149°13'E) is an inland city situated ca 600 m a s l and 144 km from the south-east Australian coast in the ACT Summers are warm to hot with maximum temperatures averaging 28°C Winters are cold with maximum temperatures of 11°C on average Average monthly rainfall is highest in spring (October 69 mm) and lowest in winter (June 38 mm), but is generally fairly evenly distributed throughout the year

The suburb in and around which the study was conducted was ca 20 yr old when the study commenced A remnant open forest community abutted the suburb at one end, bounded by a poorly drained grassland The rest of the land adjoining the suburb was cleared rural land characterised by grazed open woodland habitat, with small grazed remnant woodland and open forest patches A 20–50 m grassy nature strip separated the suburb from adjoining rural/reserve land A three lane arterial road ran north-south through the western part of the study area The road was bounded by a six metre embankment and associated drainage line which supported a thick cover of tall grass and occasional small trees A farm homestead and farm buildings were situated on the southern edge of the study area (see Figs 1 and 2) A second farm abutted residential homes in the north-west of the study area (Figs 1 and 2) Habitat on this farm consisted of numerous small inner paddocks containing farm buildings, animal yards and ungrazed scrub, surrounded by larger paddocks of grazed open woodland and patches of grazed open forest

Methods

Recruitment of cats for monitoring

Homes bordering a nature reserve and rural land in Canberra were surveyed to ascertain the density and distribution of house cats and willingness of residents to allow the movements of their cats to be monitored Residents willing to participate in the study were given a questionnaire in which they provided information about their cat(s) and cat management practices Cats whose movements were unimpeded by their owners were selected for radio-tracking in preference to restricted animals

A colony of farm cats living at a farmhouse abutting the residential suburban edge were also incorporated into the study with their owner's permission The cats were kept as mousers by one of the farm managers and were fed once each day in the early evening near the centre of the group of farm buildings The homestead and farm buildings, around which the cat's activity was centred (referred to as the 'farm core'), were only separated from residential houses by an arterial road (see Figs 1 and 2)

Unlike the domestic cats from surrounding residential homes, the farm cats had never been handled and were approachable to within a few metres only In order to attach radio-collars therefore, the cats had to be trapped and sedated Trapping for feral cats was also conducted in the nature reserve and rural land adjoining the suburban study site immediately prior to the commencement of radio-tracking Between six and 12 wire cage baited-hook possum traps, baited with sardines in oil wrapped in gauze, were placed ca 300 m from the suburb edge for four nights each week over four weeks.

Radio-telemetry methods

Tracking was carried out on foot using a Sirtrack three element hand-held yagi antenna and Telonics TR4 receiver The location of an animal was ascertained either by visual contact or by approximating its position to within 10 m by triangulation from 2 or 3 points The radio-collars consisted of a 30 g transmitter encased in dental acrylic and moulded onto a standard buckle-up leather house cat collar, with a 20 cm rubber encased whip aerial The total collar weight represented between ca 0 75% and 3% of the body weights of the cats in the study. Radio-collars were rotated among the suburban

cats, as more cats were available to be tracked than there were radio-collars As radio-tracking progressed, collars were preferentially assigned to cats whose home ranges continued to increase with each tracking period

Cats were located hourly to obtain information on activity and movement patterns Information on the type of habitat at each location, and whether the cat was resting or active was recorded Tracking was done in four or six hour shifts separated by at least 12 h such that 24 observations representing each hour of the clock were collected per cat per week Palomares and Delibes (1992) argue that home range data may be biased if it is not representative (by random or systematic sampling) of all parts of the 24 h cycle, with interval lengths between consecutive observations dependent upon the total activity levels and temporal activity patterns of the animal. According to White and Garrott (1990), consecutive locations may be considered statistically independent if sufficient time has elapsed for the animal to move from any point in its home range to any other point Field observations in the present study indicated that all cats were capable of moving from one end of their home range to the other in the one hour interval between consecutive locations during tracking shifts Data were collected over six weeks in each of spring 1993, summer 1993/94 and autumn 1994

Data analysis

Home range estimates were calculated using minimum convex polygon, harmonic mean, bivariate ellipse and weighted bivariate ellipse techniques Although the parametric bivariate ellipse methods had the advantage of being able to provide estimates of precision of home range calculations, thus allowing statistical comparison of home range estimates, the assumption of bivariate normally distributed data was very rarely met and use of these two techniques was eventually abandoned

The sample size required for the harmonic mean technique is large ($n > 100$) because the underlying distribution must be estimated from the data, rather than fitting an assumed parametric distribution (Ackerman et al 1990) The number of independent nocturnal or diurnal observations collected in this study for seven of 17 cats was < 100 In addition, the harmonic mean technique was overly sensitive to scale parameters, as has been identified previously (Spencer and Barrett 1984, Worton 1987) As a consequence, this technique poorly described the spatial utilisation patterns of most cats by including large areas never visited by an animal, or excluding areas such as linear transit routes between heavily utilised areas, such that several discrete home ranges were mapped.

In general, minimum convex polygons did not obviously include large areas not utilised by animals, and home range estimates calculated using minimum convex polygons were consistently lower than those calculated using the harmonic mean technique

Differences in the distribution of nocturnal and diurnal locations among broad habitat types were tested for each cat using χ^2 analysis Differences between nocturnal and diurnal home ranges, and nocturnal and diurnal distances moved from home (maximums) were tested using paired t-tests or their non-parametric equivalents Home was defined as the cat owner's house for suburban cats, and the farm building at which each cat spent the majority of its time resting for farm cats The effect of gender on home range size and maximum distances moved from home was tested using t-tests or their non-parametric equivalent Quantitative analyses of cat age and neutering age effects were not conducted because of the small total sample size

Results

Seven suburban cats whose movements were unimpeded by their owners and two suburban cats that were confined most evenings from late evening (ca 10 PM) until early morning (ca 6 AM) were initially recruited Seven cats living at the farmhouse abutting the residential suburb edge were also radio-collared The density of cat owning households in the suburb edge area was calculated to be ca 2 7 ha^{-1} and the density of house cats was ca 4 ha^{-1}

The trapping campaign conducted on land abutting the suburban radio-telemetry site resulted in the capture of only two cats over 149 trap nights Both animals turned out to be domestic pets One (Simba) had already been recruited to the study The owner of the second animal (Jasper) agreed to allow monitoring of the cat's movements to continue The age, gender, sexual status, and age when neutered (where applicable) of each cat tracked during the study are shown in Table 1 The ages of the farm cats were not known precisely, but were estimated by the farm manager

Between 46 and 466 locations were recorded per cat over the entire tracking period The number of radio-locations recorded for each cat varied because of the loss of one suburban cat and two farm cats in road traffic accidents, the occasional inability to locate animals, and the rotation of collars from animals with static home range sizes to more active animals with expanding home ranges

Home range size

Mean nocturnal and diurnal range sizes for male and female farm and suburban cats estimated using minimum convex polygons are shown in Table 2 Also shown are mean straight-line distances to the furthest

Table 1 Gender, age and sexual status of radio-collared cats

Cat name (or ID code) and gender	House code	Age (yr)	Sexual status	Age desexed (mths)
SUBURB				
Blossom (f)	3	5	desexed	7
Tiddles (f)	3	7	desexed	20
Merry (f)	5	2	desexed	6
Gismette (f)	2	1	desexed	5
Gismo (m)	2	1	desexed	5
Jasper (m)	3	3	intact	N/A
Pippin (m)	5	2	desexed	6
Mitzie (m)	4	6	desexed	~6
Horse (m)	1	10	desexed	unknown
Simba (m)	6	1	desexed	6
FARM				
Female A	N/A	~1	intact	N/A
Female B	N/A	~3	intact	N/A
Female C	N/A	~1	intact	N/A
Female D	N/A	~1	intact	N/A
Female E	N/A	~1	intact	N/A
Male A	N/A	~1	intact	N/A
Male B	N/A	~1	intact	N/A

nocturnal or diurnal radio-location from home for each cat. Nocturnal home ranges were significantly larger than diurnal home ranges (Wilcoxon Sign Rank, $S = 45$ $DF = 16$ $p = 0.018$) Distances to the furthest radio-location from home were not significantly different between night and day (Wilcoxon Sign Rank, $S = 28\ 5$ $DF = 16$ $p = 0\ 186$) because cats occasionally hid during the day in farm buildings, houses, tall grass, drains and rabbit warrens, some distance from their homes

Variation in home range size between individuals in the farm cat colony was relatively small Variation in maximum distance moved from farm buildings was also relatively small, particularly at night In contrast, there was more than an order of magnitude difference in home range size between suburban cats. Variation in maximum distances moved from home was also large

Cat gender had no effect on home range size of farm cats, either at night (Wilcoxon Rank Sum, $Z = 0\ 590$ $DF = 6$ $p = 0\ 561$), or during the day ($Z = 0\ 194$ $DF = 6$ $p = 0\ 847$) Equally, gender had no effect on the maximum distance moved from home at night ($Z = -0\ 968$ $DF = 6$ $p = 0\ 333$) or during the day ($Z = -0\ 782$ $DF = 6$ $p = 0.434$) There was no significant difference in home range sizes between desexed male and female suburban cats at night ($Z = -0\ 320$ $DF = 8$ $p = 0\ 749$) or during the day ($Z = 0\ 107$ $DF = 8$ $p = 0\ 915$), and no significant difference in maximum distances moved from home at night ($Z = -0\ 642$ $DF = 8$ $p = 0\ 521$) or during the day ($Z = -0\ 642$ $DF = 8$ $p = 0\ 521$)

The nocturnal home range of the one intact (not desexed) suburban male, Jasper, was relatively large However, two desexed suburban cats, one male (Simba) and one female (Tiddles), had nocturnal home ranges of a similar size (Table 2) Straight-line distances to the

Table 2 Nocturnal and diurnal home range areas (95%) and maximum range areas (100%) estimated using minimum convex polygons (MCP) Straight-line distances to furthest locations from home (Largest move) are also shown

	Diurnal range size (ha)			Nocturnal range size (ha)		
Cat name (or ID code) and gender	n (obs)	MCP 95% (100%)	Largest move (m)	n (obs)	MCP 95% (100%)	Largest move (m)
FARM						
Female E	97	0 77 (0 86)	170	78	1 38 (3 23)	340
Female C	259	1 75 (4 39)	340	207	1 44 (2 77)	160
Male B	258	1 77 (3 34)	280	206	1 59 (7 40)	270
Female A	261	3 70 (23 38)	730	202	2 42 (5 99)	290
Female B	259	1 52 (4 39)	280	206	3 18 (9 67)	350
Female D	259	1 48 (1 79)	180	206	3 30 (5 53)	310
Male A	258	0.91 (1 43)	110	189	4 46 (7 48)	280
MEAN ± SD	95%	1 70 ± 0 89	299 ± 191		2 54 ± 1 08	286 ± 58
n (cats) = 7	(100%)	(5 65 ± 7 35)			(6 01 ± 2 27)	
SUBURB						
Mitzie - (M)	52	0 14 (0 50)	80	69	0 02 (0 11)	40
Blossom - (F)	51	0 04 (0 13)	60	69	0 04 (0 07)	30
Gismette - (F)*	242	0 46 (0 76)	80	38	0 08 (0 35)	90
Horse - (M)	33	0 02 (0 02)	20	13	0 23 (0 37)	90
Merry - (F)	117	0 09 (0 83)	50	82	0 27 (0 94)	130
Pippin - (M)	114	0 08 (0 66)	120	82	0 89 (1 38)	180
Gismo - (M)*	100	4 36 (8 16)	390	24	6 70 (7 90)	360
Jasper - M	246	17 19 (39 90)	900	205	20 54 (43 56)	940
Simba - (M)	196	0 23 (1 00)	130	137	22 16 (33 09)	720
Tiddles - (F)	150	4 64 (4 77)	830	120	27 93 (28.14)	850
MEAN ± SD	95%	2 73 ± 5 12	266 ± 315		7 89 ± 10 57	343 ± 338
n (cats) = 10	(100%)	(5 57 ± 11 67)			(11 59 ± 15.83)	

* Regularly confined between 10 PM and 6 AM
M = male, (M) = neutered male, (F) = neutered female

furthest locations from home for each of these cats (Jasper, Tiddles and Simba) were also similar (Table 2)

Home range overlap

Home ranges of related suburban cats living at the same residence (Gismo and Gismette, Tiddles and Blossom) overlapped completely (Figs 1 and 2). Unrelated cats living at the same residence (Tiddles and Jasper, Blossom and Jasper, Merry and Pippin) had completely overlapping core areas (house and yard), and were amicable to one another in these areas, but tended to have non-overlapping outer home range areas (Figs 1 and 2) The home ranges of all farm cats also overlapped completely around feeding and sleeping sites (farm buildings) Individuals or groups of two to three cats monopolised different farm buildings or other cover as resting and hiding sites

There was no overlap of home ranges between radio-collared female suburban cats living at separate residences (Figs 1 and 2) Spatial overlap of home ranges of males from separate homes, and males and females from separate homes, was evident (Figs 1 and 2) However, radio-collared males from separate homes appeared to actively avoid each other's core areas (house and yard) Contact, physical or visual, between radio-collared cats from separate residences was not observed, and was rarely observed between radio-collared cats and other cats in the study area

Table 3 Habitat utilisation by suburban cats The total number of locations (n) and the proportion locations occurring in each habitat type are shown

		Habitat utilisation (%)		
Cat	n	Home/yard	Suburb	Rural/reserve
Tiddles	270	35 9	45 9	18 2
Gismo	124	57 3	23 4	19 3
Jasper	451	68 5	13 7	17 8
Simba	333	70 3	12 0	17 7
Gismette	280	72 1	25 4	2 5
Pippin	196	83 2	16 8	0
Merry	199	83 9	14 1	2 0
Horse	46	91 3	8 7	0
Mitzie	121	92 6	7 4	0
Blossom	120	97 5	2 5	0
Mean ± 2 SE		75 3 ± 2 7	17 0 ± 2 2	7 8 ± 1 9

Habitat utilisation – suburban cats

With the exception of Tiddles, the suburban cats spent the majority of their time (between 57% and 98% of locations) within their own home or yard environment (Table 3) Six of 10 suburban cats moved beyond the suburb edge Four of the cats that utilised areas beyond the suburb edge moved significant distances (>100 m) into the non-suburban habitat All four had home ranges spatially biased away from the suburban environment into the adjoining habitat (ca 70–90% of their home range area – see Figs 1 and 2), though they spent the majority of their time at home or within the suburban environment (81–82% of locations – Table 3)

Comparison of nocturnal and diurnal utilisation of the rural/reserve habitat by cats that moved further than ca 100 m into these areas is shown in Table 4 The amount of time spent by Gismo in non-suburban habitat was equally divided between night and day primarily because of the crepuscular nature of his activity peaks Tiddles and Simba utilised areas beyond the suburb edge more at night than during the day and only moved significant distances (>100 m) into the rural/reserve habitat at night (see Figs 1 and 2) Jasper was the only cat to spend more time beyond the suburban edge during the day than at night, as he often rested during the day in tall grass near culvit entrances in the road embankment

Travel routes during the day appeared primarily determined by available cover (including drains, tall grass, fences and shrubs etc) and the location of resting, sunning and hunting sites close to home, a result consistent with the observations of other workers (Liberg 1980, Panaman 1981, Warner 1985) At night, travel routes were influenced by the location of favoured hunting sites toward the outer edges of home range areas, such as farm buildings, tall grass and forest habitats

Habitat utilisation – farm cat colony

All cats in the farm colony spent the vast majority of their time (88–97% of locations) in and around the farm buildings and small paddocks and yards immediately surrounding the farm homestead (Table 5) The rest of their time was spent in the paddocks beyond the farm core, fairly evenly divided between relatively open grazed paddocks and small patches of ungrazed scrub along the arterial road embankment and surrounding the large water reservoir to the north west of the farm buildings None of the farm cats were ever located in the suburban environment abutting the farm to the north and east However, two cats were killed by traffic on the arterial road separating the farm from the suburb immediately to the east of the farm homestead

During the day, all farm cats spent the majority of their time in farm buildings and other cover, apparently to avoid people and farm dogs, and also to avoid high daytime temperatures in late spring and summer Locations beyond the farm core comprised <4% of diurnal observations for six of the seven farm cats (Table 6) The only exception, female A, was observed hunting in rabbit warrens up to 900 m from the farm core while raising a litter Similar diurnal behaviour by female

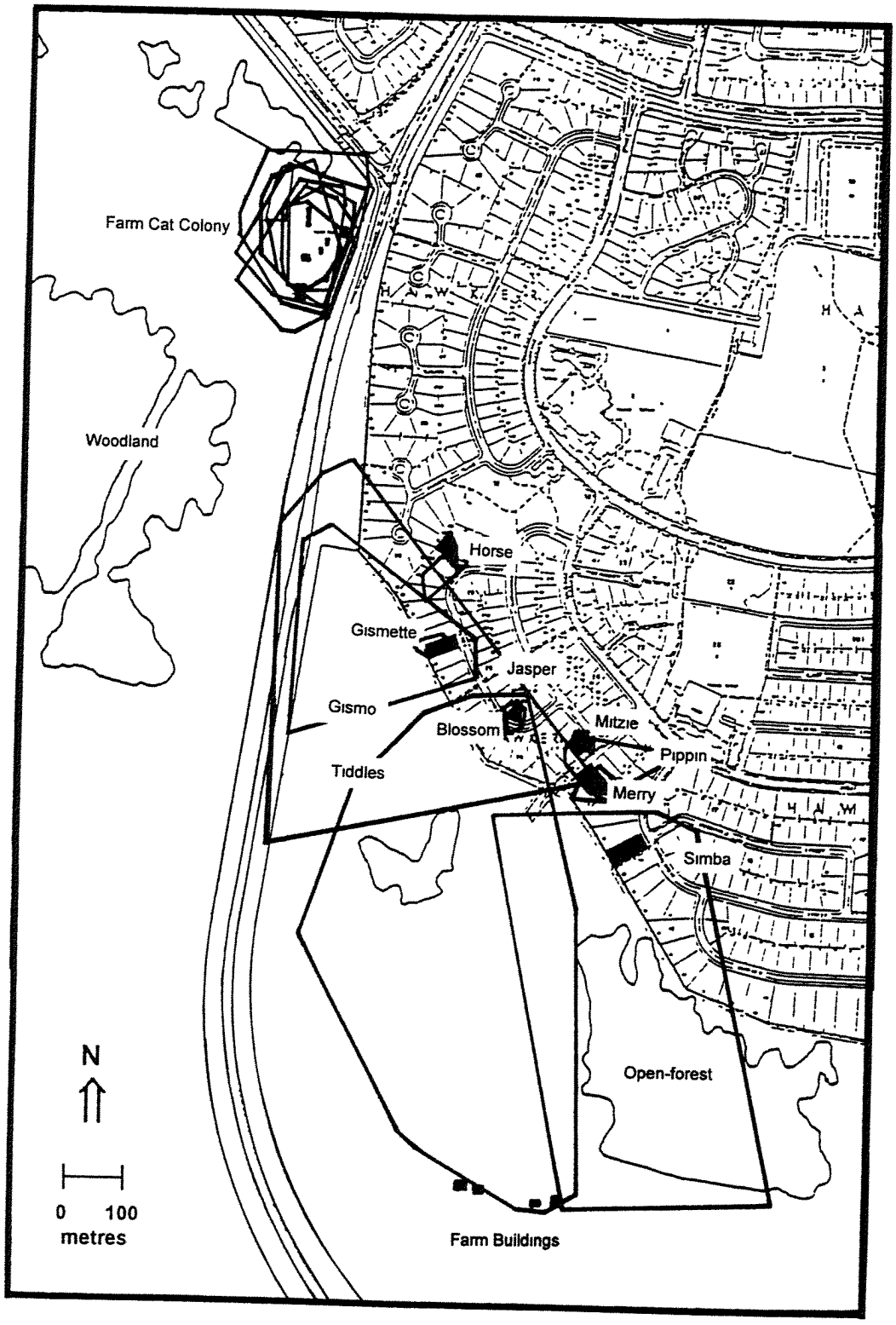

Fig 1 Nocturnal home ranges of farm and suburban house cats, estimated using 95% minimum convex polygons The location of residential properties where radio-collared cats lived are shaded black House codes (1–6) for cats given in Table 1 are ordered from north (1) to south (6) The 'core' area of the farm inhabited by the farm cat colony (see text) is also indicated

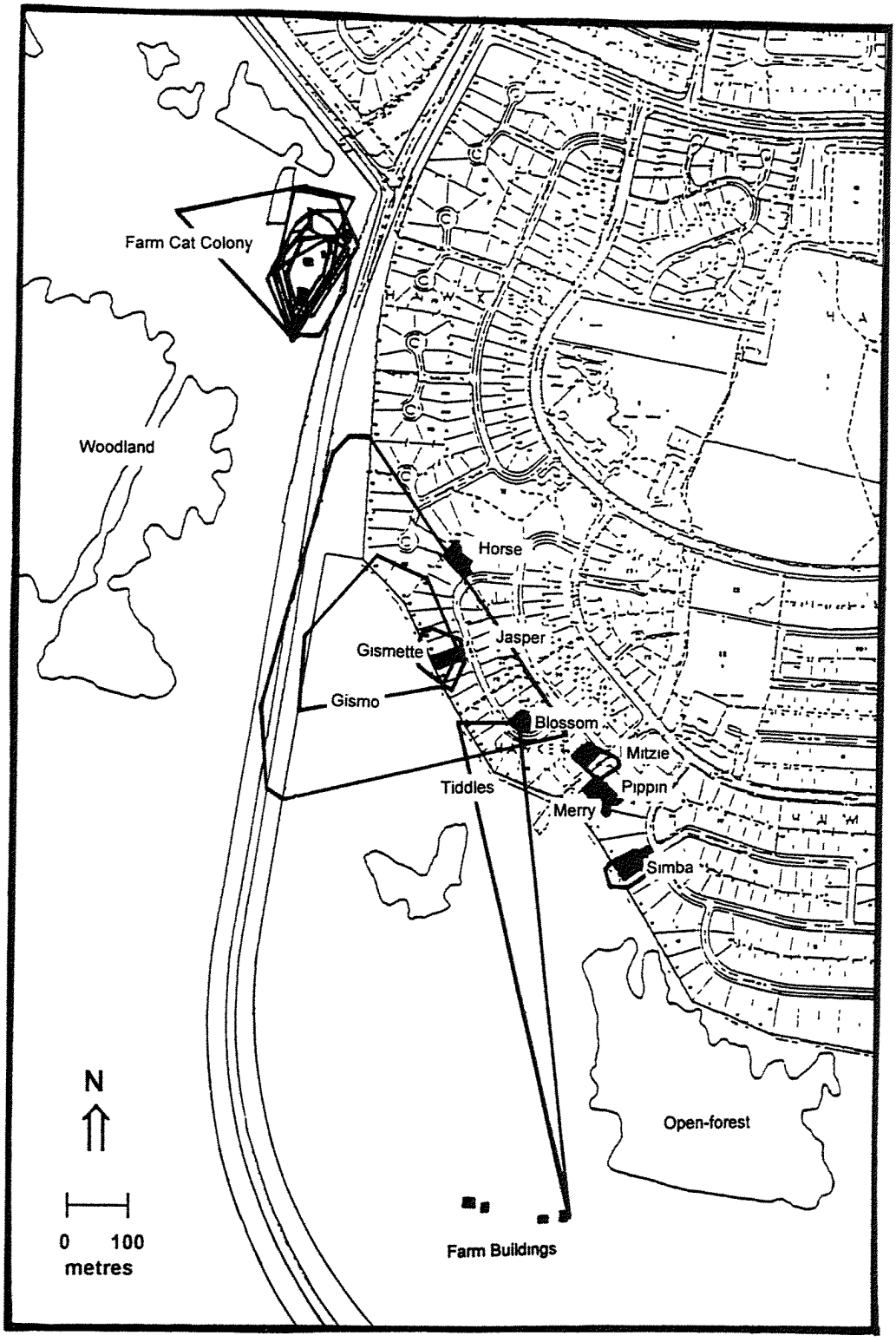

Fig 2 Diurnal home ranges of farm and suburban house cats, estimated using 95% minimum convex polygons. The location of residential properties where radio-collared cats lived are shaded black House codes (1–6) for cats given in Table 1 are ordered from north (1) to south (6) The 'core' area of the farm inhabited by the farm cat colony (see text) is also indicated

Table 4 Comparison of nocturnal and diurnal utilisation of the rural/reserve environment by suburban cats Analysis of utilisation of this environment type was only conducted with respect to those cats that spent a significant proportion of their time (more than six locations) in habitat beyond the suburb edge The total number of nocturnal and diurnal locations (n) and the proportion of locations in the rural/reserve environment are shown

	Diurnal observations		Nocturnal observations		Difference
Cat	n	% Rural/reserve	n	% Rural/reserve	
Gismo	100	19 0	24	20 8	+1 8 ns
Jasper	246	21 1	205	13 7	−7 4 *
Tiddles	150	6 7	120	32 5	+25 8 **
Simba	196	3 1	137	38 7	+35 6 **
Mean ± 2 SE		12 5 ± 2.8		26 4 ± 3 1	

χ^2 test * $p < 0.05$ ** $p < 0.01$

feral cats denning in barns in rural New Zealand has been documented (Langham and Porter 1991) In general, utilisation of habitats beyond the farm core was significantly greater at night than during the day, accounting for up to 24% of nocturnal observations (Table 6)

Discussion

Home range sizes of suburban house cats in this study were highly variable Home ranges of between 7 and 28 ha for four suburban cats were about an order of magnitude greater than the home ranges of four other suburban cats monitored They were also up to an order of magnitude larger than the home ranges of many urban and suburban house cats studied by Chipman (cited in Bradshaw 1992), Bradshaw (1992) and Das (1993), and up to 28 times greater than the one hectare prediction of Bradshaw (1992) for neutered suburban cats with no non-domestic nutritional requirements (see Table 7). Distances moved from home of up to 900 m were many times larger than observed for most of the house cats in this and other studies (Chipman cited in Bradshaw 1992, Bradshaw 1992, Das 1993)

The relatively large home range areas of some suburban house cats in this study were not solely a function of the use of nocturnal observations in calculating home range size The proportion of nocturnal to diurnal locations was about the same for all cats The differences in home range size were not obviously a function of gender, a finding consistent with work on urban feral cats (Page et al 1992) Also, large home ranges were not exclusive to cats that had not been neutered, though the specific effects of neutering on cat movements and home range size will be best demonstrated by controlled experiments All cats were fed by their owners at least once a day

For the suburban cats, contact between cats and overlap in home ranges was greatest among cats from the same residence, as observed also by Das (1993) Home ranges of female cats from separate houses in the present study did not overlap Not all female cats in the study area were monitored, though none of the radiocollared females had home range areas which encompassed properties containing resident female cats. Overlap in the home ranges of males from separate residences, and males and females from separate residences, was evident, though exaggerated by the minimum convex polygon range estimation technique These cats avoided one another in shared territory through the spatial detail and timing of their movements, as has been reported elsewhere (Leyhausen 1988, Bradshaw 1992, Page et al. 1992)

The results found here appear to support theory emerging from other recent studies of domestic cat behaviour (see Turner and Bateson 1988, Bradshaw 1992, Page et al 1992, Das 1993) which suggests home range areas and degree of overlap are primarily determined by kinship, the amount and spatial distribution of food resources, and the distribution of female cats Liberg and Sandell (1988) state territoriality observed between females from separate feral cat colonies or groups (see Leyhausen 1988), and between solitary female urban feral cats (Page et al 1992), should also be observed between solitary female house cats Like feral cat groups, house cats have defendable, predictable food patches – their primary homes The home range of a neutered suburban male cat may be expected to show less overlap with other cats than observed for feral male cats, presumably being based on food re-

Table 5 Habitat utilisation by farm cats The total number of locations (n) and the proportion of locations occurring in each habitat type are shown

Cat	n	Habitat utilisation (%)	
		Farm buildings/yards	Paddocks
Female A	463	88 7	11 3
Female B	465	90 9	9 1
Female C	466	96 4	3.6
Female D	465	92 7	7 3
Female E	175	96 5	3.5
Male A	447	88 1	11 9
Male B	464	95 0	5 0
Mean ± 2 SE		92 6 ± 1 4	7 4 ± 1 4

Table 6 Comparison of nocturnal and diurnal utilisation of paddocks beyond the farm core area by farm cats The total number of nocturnal and diurnal locations (n) and the proportion of locations beyond the farm core area are shown

Cat	Diurnal observations		Nocturnal observations		Difference
	n	% Paddocks	n	% Paddocks	
Female A	261	8 4	202	14 8	+6 4 *
Female B	259	2 7	206	17 0	+14 3 **
Female C	259	3 5	207	3.9	+0 4 ns
Female D	259	1 9	206	14 1	+12 2 **
Female E	97	3 1	78	3 8	+0 7 ns
Male A	258	2 3	189	23 8	+21 5 **
Male B	258	2 7	206	7 8	+5 1 *
Mean ± 2 SE		3 5 ± 1 1		12 2 ± 2 0	

χ^2 test * $p < 0\,05$ ** $p < 0\,01$

source distribution rather than the distribution of breeding females

Home range size should, therefore, be primarily determined by the density and distribution of cat owning houses Leyhausen (1988) and Page et al (1992) suggest more dominant, aggressive domestic cats tend to maintain larger ranges than subordinate cats, though subordinate animals may still fiercely defend core territories It appears then, that in this study, the presence of habitat uninhabited by house cats and with apparently no resident feral cats (i e , the rural/reserve land) encouraged the more dominant and aggressive of the suburban house cats to expand their ranges up to 1 km into this area

For the farm cat colony, theory suggests that given their abundant and predictable food resource (daily provision of ca 1 kg of tinned and dry cat food), and kinship between many individuals, these cats would have extensively overlapping home ranges (see Liberg and Sandell 1988, Kerby and Macdonald 1988, Leyhausen 1988, Bradshaw 1992) This was indeed the case The home range sizes of the farm cats were within the range found by other workers (see Table 7), though the male cats had range sizes similar to those of the females and relatively small compared to male farm cats in other studies (Table 7) Bradshaw (1992) states it may not pay male cats to attempt to mate with females from more than one group, either because other groups of females are too far away, or because they are too well defended "Under these circumstances male home ranges may not be any larger than females, and this has been found in two studies, under the very high population density of a Japanese fishing village, and the very patchy distribution of cats on Swiss farms" (Bradshaw 1992 147)

Yearling males living in cat colonies often disperse under increasing attack from older males However, the two males at the farm colony in this study were both about the same age and no older males were present The movement patterns of the farm cats appeared primarily determined by a combination of, a) territorial pressure from suburban cats to the north and east of the farm core, b) barriers in the form of busy arterial roads to the north and east of the farm core, and c) the

Table 7 Comparison of densities and home range sizes of house cats in different environments from this and previous studies

Environ	Sociality	Pop dens (n/ha)	Mean home range (ha) ± SD		Source
			Female (n)	Male (n)	
Rural	Colony	0 06	2–7 (3)	~ 60 (1)	Macdonald and Apps (1978)
Rural	Colony	0 3	0 7–15 (5)	–	Panaman (1981)
Rural	Colony and solitary	0 3–0 7	50 ± 41 (15)	350 ± 223 (5) 380 ± 367 (6)	Liberg (1984)
Rural	Colony and solitary	0 63	112 ± 21 (7)	228 ± 100 (4)	Warner (1985)
Rural	Colony	0 14	1 2–17 8 (6)	0 8–16 0 (3)	Turner and Mertens (1986)
Urban	Solitary	6 6	up to 0 12 (66)	up to 6 1 (17)	Chipman cited in Bradshaw (1992)
Suburb	Solitary	4 5	0 45 (1)	0 27 (1)	Bradshaw (1992)
Suburb	Solitary	NA	0.28 ± 0 15 (5)	0 53 ± 0 16 (8)	Das (1993)
Rural/ Suburb	Colony	~0 1–3 0	2 34 ± 0 82 (5)	3 03 ± 1 44 (2)	This study
Suburb edge	Solitary	~0 1–4 0	7 08 ± 12 04 (4)	8 44 ± 9 41 (6)	This study

location of habitats in which the cats hunted at night, and resting and sunning spots during the day

All except one of the suburban cats spent the majority of their time in the home or yard of their owner, while the farm cats spent the majority of their time within the farm core area Utilisation of habitat beyond the suburb edge by suburban cats, and beyond the farm core by farm cats, was largely nocturnal and to a lesser extent crepuscular, though cats occasionally sought refuge during the day in cover beyond the suburb edge and farm core area Nocturnal home ranges were larger than diurnal home ranges for all the suburban cats and all but one of the farm cats In habitat adjoining suburban environments therefore, nocturnal species are potentially at most risk of predation by house cats Nocturnal confinement should reduce the utilisation of non-suburban habitat by house cats living on suburban edges or on isolated properties Experimental research on the effect of neutering, nocturnal curfews and roads (as potential barriers to movement) on the movement patterns of house cats living close to different types of natural environments (forest, woodland, grassland) is required

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