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Trapping and demographics of feral cats (*Felis catus*) in central New South Wales

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Abstract. A total of 76 feral cats (*Felis catus*) (29 individuals; 47 recaptures) was trapped during 6027 trap-nights using both cage and leg-hold traps from November 1994 to August 1996 at Lake Burrendong in central New South Wales. No significant difference was found in the relative capture efficiency between cage and leg-hold traps ($P > 0.05$). Overall capture efficiency was 1.3 cats per 100 trap-nights, although this varied seasonally, being higher in late autumn and early winter. Most cats were caught with rabbit as bait, and visual and olfactory lures added to baits did not appear to increase capture efficiency, although the power of the test was limited. Most captured cats were adult males weighing 4.37 ± 0.14 kg; these were larger than the females (3.34 ± 0.06 kg). Litters, comprising 2–5 kittens, were born between September and March.

Introduction

Feral cats (*Felis catus*) are notoriously difficult to trap. They do not take baits readily (Risbey *et al.* 1997) and bait visitation and ingestion rates are variable and usually low (Paton 1994; Christensen and Burrows 1995; Short *et al.* 1997). Nevertheless, live trapping is essential if animals are to be radio-collared for studies on movements, habitat use or social organisation. Live-trapping is also one of the main methods used for population control, particularly in areas where domestic cats are present, or where populations have already been reduced and individual cats need to be targeted (e.g. Berruti 1986; Bloomer and Bester 1992).

Although some studies have used different types of traps for catching feral cats (e.g. Veitch 1985; Bloomer and Bester 1992; Lee 1994), none has reported their relative effectiveness or evaluated factors that influence capture efficiency. This study evaluates two types of live traps and 32 different bait and lure combinations used for trapping feral cats. Factors that influence capture efficiency, including season and rabbit abundance, are also examined, and demographic information on cats is presented.

Methods

Study area

Trapping was conducted in a 90-km^2 area on the eastern shore of Lake Burrendong (32°40′S, 149°10′E) in central New South Wales from November 1994 to August 1996. The major land use for the area is water catchment under the agistment of sheep (*Ovis aries*) and cattle (*Bos taurus*). The area is hilly with undulating slopes extending down to a flat foreshore, which has been extensively cleared of trees for grazing. Perennial grasses (e.g. *Bothriochloa macra*, *Danthonia* sp. and *Stipa* sp.) dominate the foreshores while the higher slopes are dominated by white box (*Eucalyptus albens*) and some yellow box (*E. melliodora*) with native pines (*Callitris* spp.) also being common.

Feral cats and red foxes (*Vulpes vulpes*) are established throughout the study area and rabbits (*Oryctolagus cuniculus*) were abundant until the arrival of Rabbit Calicivirus Disease (RCD) in June 1996 (Saunders *et al.* 1998). Rabbits were the staple prey for cats at Burrendong before and after the advent of RCD (Molsher *et al.* 1999). Climate is temperate with cool to cold winters (2–15°C) and warm to hot summers (14–33°C). Annual average rainfall is 614 mm. Drought conditions prevailed in the study area from March 1994 to December 1995 (Molsher *et al.* 1999).

Traps used

Wire mesh cage traps (40 cm by 40 cm by 60 cm, treadle operated) and Victor Soft-Catch™ rubber-jawed leg-hold traps (No. 1.5, Woodstream Corp., Lititz, PA, USA) were used to trap feral cats. On occasions, leg-hold traps of other sizes (Nos 1 and 3, same supplier) were also used but the results were not considered to differ from those of the No. 1.5 traps and the data were pooled. Trapping was conducted in most months of the study in the first year (November 1994 to November 1995), but primarily in autumn and winter in the second year (January 1996 to August 1996). Relative success of the two types of traps, and of the different bait and lure combinations that were successful in catching cats, were compared using the *G*-test (with William's correction: Sokal and Rohlf 1994). Capture efficiency was defined as the number of cats

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trapped per 100 trap-nights (Boggess *et al.* 1990) (where a trap-night was the exposure of one trap for one night). A recapture was any animal that had been trapped previously in any trapping session and in either trap type.

Trap sites were chosen to minimise capture of non-target species and included the following: under bushes, beside vehicle tracks, beside logs, on animal runways and at rabbit warrens. Cage traps were set squarely on the ground with the doors of traps bent upwards to increase the openness of the entry space (Veitch 1985). Leg-hold traps were set just below ground level and tethered to a stake. They were most commonly set at the entrance to fallen hollow logs so as to provide cover for the trapped individual and also to allow the bait to be hidden from view of non-target bird species. The bait at leg-hold traps was tethered on wire (usually to the log) and positioned approximately 10–15 cm behind (i.e. furthest from the approaching cat) the plate of the trap. Both types of traps (cages and leg-holds) were usually operated simultaneously and in the same general area. However, only a single trap was usually set at each trap site and traps were set approximately 200 m apart. Leg-hold traps were set for up to eight nights and then pulled up and moved to a new area at the next trapping session. Cage traps were left at the same location for up to two months and were usually closed between trapping sessions or occasionally wired open. Set traps were checked each morning from first light, left set and checked again in the afternoon.

Types of baits

A variety of baits and lures (olfactory and visual) were used in the first year of the study. Baits included rabbit, chicken, beef, cow carcass, lamb, kangaroo, ham, bacon, house mouse, fish, mussels, shrimp paste, dried squid, tinned cat food, dry Whiskettes™ (commercially produced cat food), tinned sardines and tuna, and commercially produced PUSSON baits (Animal Control Technologies Pty Ltd). No live or cooked baits were used. About a handful of bait was deposited in each trap. Baits were deposited only inside the trap, while olfactory lures were sometimes sprayed outside the trap. Olfactory lures included synthetic fermented egg (SFE), catnip (dried and spray) and tuna oil. Visual lures included aluminium tags attached to string, pink flagging tape, flashing bicycle lights and toy windmills on sticks. Lures were not always used in conjunction with baits. Although many types of bait were used in the first year of the study, only a single bait type was deposited in each trap. In the second year, freshly killed rabbit was the only bait used. Where the rabbit bait had dried out after several days of exposure, SFE was added to increase its olfactory attractiveness. Baits were replaced if missing and if exposed for more than a week.

Rabbit abundance

Indices of rabbit abundance (number seen per kilometre) were derived from monthly spotlight counts that were conducted by the Pest Animal Control CRC Predator–Prey Project. A 100-W spotlight was used from the top of a vehicle travelling at about 10 km h^{-1}. Transect lengths ranged from 9 to 44 km in the first year of the study (July 1994 to July 1995), but thereafter were standardised to 30 km with counts repeated over three consecutive nights. The relationship between rabbit abundance and capture efficiency across sampling sessions was evaluated using the Pearson product-moment correlation coefficient (Sokal and Rohlf 1994).

Demography

Trapped adult cats were anaesthetised and then radio-collared to examine home range and habitat use (Molsher 1999). Anaesthetics used were Ketamine (22 mg kg^{-1}) and Rompun (1.1 mg kg^{-1} Xylazine) injected intramuscularly and for smaller cats 'Domitor' (50–150 μg kg^{-1} intramuscular) was used with Antisedan (2–5 times the previous dose of Domitor in μg kg^{-1}) used as the reversing drug. Adult cats (females >2.5 kg, males >3.4 kg) were fitted with Sirtrack or AVM two-stage radio-transmitters that were encased in epoxy resin and attached to a leather collar with a 22-cm vertical whip aerial. Adult cats were also fitted with sheep swivel eartags ('Leader' 34 mm by 10 mm, diameter 5 mm, weight 1.8 g). Cats were weighed and their body length (occipital condyle to anus) recorded. General condition (subjective assessment) and trap-related injuries were also noted. Recaptured cats were sometimes re-weighed if it was possible to do so without undue stress to the animal.

The sex and age of each captured cat was determined. Three age classes were determined from body weight: juveniles, subadults and adults (Brothers *et al.* 1985). Juveniles were not fully-grown (females <1.9 kg, males <2.2 kg); subadults were fully-grown but had not bred (females 1.9–2.5 kg, males 2.2–3.4 kg); adults were fully grown and usually had bred (females >2.5 kg, males >3.4 kg). The approximate ages of juvenile and subadult cats were estimated from body size. Adult females were classified as lactating or not lactating. Observations of cats accompanied by kittens were also recorded.

Demographic information was obtained from a further 18 individual cats that were trapped in leg-hold traps as non-target animals by the Pest Animal Control CRC Fox Sterility Project (Kay *et al.* 2000).

Results

Capture efficiency

In all, 76 cats (29 individuals with 47 recaptures) were trapped during 6027 trap-nights using both cage and leg-hold traps (Table 1). No significant difference was found in the capture efficiency between cage and leg-hold traps in 1995 ($G = 2.31$, d.f. = 1, $P > 0.05$) or 1996 ($G = 0.71$, d.f. = 1, $P > 0.05$) (Table 2). Overall capture efficiency was 1.3 cats per 100 trap-nights.

Most cats were trapped in late autumn and early winter, especially in June 1995, when 4.8 cats were trapped in cages per 100 trap-nights. The highest capture efficiency in June 1995 occurred at a period of low rabbit densities during the drought (Fig. 1); however, this pattern did not occur in the second year and no relationship was detected overall ($r = 0.14$, $n = 13$, $P = 0.63$).

Trap-related injuries and multiple recaptures

Injuries suffered by cats in cage traps were generally minor and involved mostly self-inflicted abrasions to the face. However, one cat and one fox caught in leg-hold traps were more seriously injured. The fox broke its leg and was immediately euthanased. The cat was captured repeatedly within a relatively short period (6 times in one month, 10 times in total) and its left front leg was swollen and it limped on release. This cat was found dead two months later.

By comparison, those cats that were trapped repeatedly in cages did not appear to suffer any serious injuries. One cat was re-trapped 13 times in an eight-month period and remained in good condition. Two other cats were re-trapped six times (primarily in cages) and did not suffer trap-related injuries. In all, 23 cats were never re-trapped, while the remaining 21 were re-trapped once.

Table 1. Numbers of animals caught in cage and leg-hold traps from November 1994 to August 1996
The number of recaptured cats is shown in parentheses

Year	Trap type	*Felis catus*	*Vulpes vulpes*	*Trichosurus vulpecula*	*Oryctolagus cuniculus*	*Rattus rattus*	Bird	*Varanus varius*	Other reptile	No. of trap-nights
1994	Cage	4 (3)	0	2	0	1	2	22	8	694
	Leg-hold	0	0	0	0	0	0	0	0	44
1995	Cage	45 (26)	0	4	4	1	8	17	4	2742
	Leg-hold	6 (5)	1	2	1	0	4	2	0	728
1996	Cage	15 (9)	0	4	2	13	11	15	0	1443
	Leg-hold	6 (4)	0	0	0	0	4	0	0	376
Total	Cage	64 (38)	0	10	6	15	21	54	12	4879
	Leg-hold	12 (9)	1	2	1	0	8	2	0	1148

Table 2. Relative success (no. per 100 trap-nights) of cage and leg-hold traps in catching feral cats from November 1994 to August 1996
The number of recaptured cats is shown in parentheses

Cage type	No. of cats	No. of trap-nights	Capture efficiency	Trap-nights per cat	Trap-nights per new cat
November 1994 – November 1995					
Cage	49 (29)	3436	1.4	70	172
Leg-hold	6 (5)	772	0.8	129	772
Total	55 (34)	4208	1.3	77	200
January 1996 – August 1996					
Cage	15 (9)	1443	1.0	96	240
Leg-hold	6 (4)	376	1.6	63	188
Total	21 (13)	1819	1.1	87	227

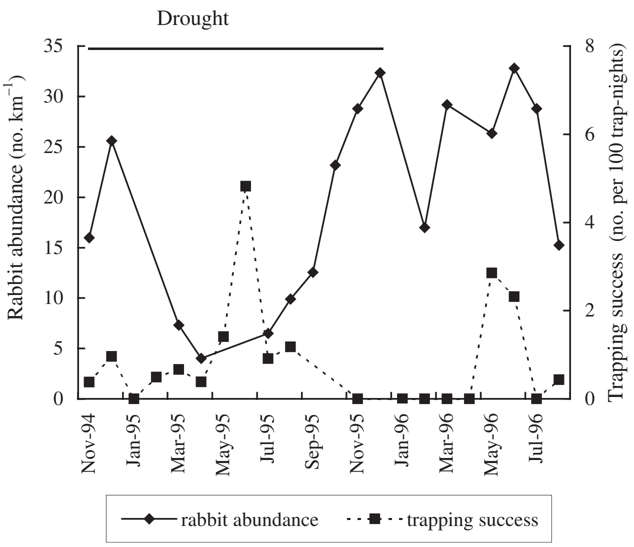

Fig. 1. Relationship between capture efficiency of cats and rabbit abundance between November 1994 and August 1996. Indices of rabbit abundance were derived from spotlight counts conducted by the Pest Animal Control CRC Predator–Prey Project.

Non-target species

In total, 132 non-target animals were trapped in both cage and leg-hold traps in 6027 trap-nights (2.2 animals per 100 trap-nights) (Table 1). Lace monitors (*Varanus varius*) (n = 56 captures) were the most common non-target species trapped, particularly during the warmer months (November–March) in cage traps. Birds, mostly corvids, were also trapped frequently (n = 29), particularly in autumn and early winter.

Types of bait

A variety of baits and lures (32 combinations) were used in the first year of the study (Table 3). No significant difference was found when visual or olfactory lures were added to the baits (G = 4.73, d.f. = 1, P > 0.05); however, the power of the test was limited given the large number of bait and lure combinations and variation in trap-nights.

Seven bait and lure combinations were successful in catching cats; however, no significant difference in capture efficiency was found between them (G = 4.08, d.f. = 1, P > 0.05) (Table 4). Most cats (n = 40) were caught on rabbit as bait, but this was the most extensively used bait.

Demography

Of the 47 cats trapped, 32 were male and 15 were female. At the time of first capture, most cats were adults (n = 35, 11 female and 24 male), while the remainder were subadults (n = 8, 2 female and 6 male) and juveniles (n = 4, 2 female and 2 male). Mean (±s.e.) body weight for adult female and male cats was 3.34 ± 0.06 kg and 4.37 ± 0.14 kg respectively;

Table 3. Number of trap-nights per bait type for the trapping of feral cats (*n* = 55) in both cage and leg-hold traps from November 1994 to November 1995
The number of cats trapped is shown in parentheses

Bait type	Bait only	Visual lure added	Olfactory lure added	Total
Rabbit	2181 (40)	106(2)	466 (5)	2753
Chicken	269 (4)			269
Beef	37		10	47
Cow carcass	86			86
Lamb	3		38	41
Kangaroo	52			52
Ham	4		3	7
Bacon bones	35			35
House mouse	12			12
Fish	369 (2)	3	154	526
Mussels	2			2
Shrimp paste			42	42
Dried squid			58	58
Tinned cat food	52	5	29	86
Dry Whiskettes	11	4	78 (1)	93
Tinned sardines			12	12
Tinned tuna			6	6
'Puss On'	26	26 (1)	4	56
No bait			25	25
Total no. of trap-nights	3139	144	925	4208
No. of cats	46	3	6	55
Capture efficiency	1.47	2.08	0.65	1.31

Table 4. Variation in capture efficiency (no. cats per 100 trap-nights) of seven types of baits and lures that were successful in catching cats (*n* = 55) in cage and leg-hold traps
VL1 = aluminium tags; VL2 = toy windmill & aluminium tags; OL1 = synthetic fermented egg (SFE); OL2 = catnip, tuna oil and SFE (3)

Bait type	No. cats	No. of trap-nights	Trap success
'Puss-on' & VL1	1	26	3.8
Rabbit & VL2	2	106	1.9
Rabbit	40	2181	1.8
Chicken	4	269	1.5
Whiskettes & OL1	1	78	1.3
Rabbit & OL2	5	466	1.1
Fish	2	369	0.5

mean (±s.e.) body lengths were 46.5 ± 0.75 cm and 49.2 ± 0.70 cm respectively. The heaviest cat was a male, 5.68 kg. Most cats trapped were black (*n* = 22), while the remainder were brown tabbies (*n* = 18), grey tabbies (*n* = 5) or orange (*n* = 2).

Cat breeding

All known litters were born between September and March, on the basis of estimated birth dates of trapped juvenile and subadult cats (*n* = 12), sightings of kittens (*n* = 3), lactating trapped cats (*n* = 2), and litters born to radio-collared cats (*n* = 3). Litters were located in the base of hollow tree trunks (dead and living) and among boulders. Litter sizes ranged from 2 to 5 kittens (*n* = 6). Mortality of kittens appeared to be high as subsequent locations of litters indicated reductions from initial litter sizes.

Discussion

Capture efficiency for cats at Burrendong (1.3 per 100 trap-nights) was lower than that reported on islands (7.3: Berruti 1986) and in areas associated with human settlement (9.2: Liberg 1980; 21: Page and Bennett 1994). Numerous factors can influence capture efficiency, including cat density, trap type, trapper experience, season, prey abundance and proximity to human settlement. Cats are difficult to trap when at low densities (Rauzon 1985), and easier to trap around human settlements particularly around rubbish dumps and camping grounds (Lee 1994). No published data were available from rural areas to allow comparisons with this study.

Although the relative effectiveness of different types of traps has not been previously evaluated, some studies have indicated that leg-hold traps appeared to be more effective than cages in catching cats (Lee 1994). In this study no significant difference in capture efficiency was found between the two types of traps; however, the power of the test was limited given the small number of cats captured in leg-hold traps. Cage traps were used more often than leg-holds as they were less labour intensive to set and appeared to cause fewer injuries, particularly where an animal had become 'trap-happy'. Nevertheless, leg-hold traps resulted in only two serious injuries in this study, which is consistent with other studies, in which no or minimal injuries were sustained by cats (Meek *et al.* 1995; Fleming *et al.* 1998). Leg-hold traps may be more effective than cage traps for feral cats that have had minimal exposure to humans. In contrast, the relative success of cage traps at Burrendong might have been due to the continual human presence and the associated stock fences and vehicles, such that a wire cage trap and human odour may not have been too unfamiliar to the cats.

Capture efficiency varied seasonally, being higher in late autumn and early winter, which may have reflected a period of low food availability for cats. Although rabbit abundance increased in the second year of the study during autumn and winter, the relative availability of subadult and kitten rabbits was low (personal observation). Cats prefer subadult rabbits to adults (Catling 1988) and the availability of alternative prey (e.g. reptiles and grasshoppers) during this period was low (Molsher 1999). This, therefore, might have reflected a period of low food availability for cats. Feral cats elsewhere have been shown to take significantly more baits when rabbit abundance is low (Short *et al.* 1997). Similarly, in Scotland, increased capture efficiency was recorded for wildcats (*Felis silvestris*) in autumn and winter (Corbett 1979), and was associated with declines in food availability and bad weather. Alternatively, increased capture efficiency in autumn and winter may have reflected greater energetic needs of cats during the colder months or increased dispersal by young adult cats, thereby increasing their encounter rate with traps. Young males usually disperse from their mothers' home range when they are 1–3 years old (Dards 1978, 1983; Liberg 1980).

At Burrendong, most cats were trapped using rabbit as bait, although no significant difference in capture efficiency was found. Rabbit is the staple prey for cats at Burrendong (Molsher *et al.* 1999), and it appeared that cats more readily accepted a bait with which they were familiar rather than novel baits. Visual and olfactory lures added to baits did not significantly increase capture efficiency; however, the power of the test was limited given the large number of bait and lure combinations and the variation in trap-nights.

The male bias detected here has been reported elsewhere (Jones 1977; van Aarde 1978; Jones and Coman 1982*b*; Brothers *et al.* 1985; Konecny 1987; Calhoon and Haspel 1989; Edwards *et al.* 1997) and probably reflects a trapping bias due to sexual differences in behaviour, rather than a disproportionate sex ratio (van Aarde 1978). At Burrendong, male cats occupied larger home ranges than females (Molsher 1999) which would increase their encounter rate with traps.

Weights of cats reported in this study were similar to those reported elsewhere in Australia (Jones 1977; Brothers et. al. 1985). Coat colour variation, however, presumably reflected the founder effect (Van Aarde and Robinson 1980). At Burrendong, most were black cats and tabbies, while on Macquarie Island most were orange with few black cats recorded (Jones 1977; Brothers *et al.* 1985).

Litter sizes of 2–5 and births between September and March are consistent with other studies of feral cats (e.g. van Aarde 1978; Jones and Coman 1982*a*). In south-eastern Australia, females dropped two litters a year with a mean litter size of 4.4 and births were recorded in all months except April (Jones and Coman 1982*a*). Most litters, however, were born between September and March with a primary peak in September–October and a secondary peak in December–January (Jones and Coman 1982*a*). Similarly, on Macquarie Island mean litter size was 4.7 with most births occurring between October and March and a peak early in the season (Brothers *et al.* 1985).

Recommendations for trapping of feral cats

The results presented here indicate that in central New South Wales, trapping for cats is best in late autumn and early winter, when capture efficiency is highest. Trapping during this period would also avoid capture of non-target reptiles. Baits that reflect the cats' staple prey for the particular area may improve capture efficiency.

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