APPENDIX 1

Techniques used in the study of African wild cat, *Felis silvestris cafra*, in the Kgalagadi Transfrontier Park (South Africa/Botswana)

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Abstract

The techniques used for the capture, marking and habituation of African wild cats (*Felis silvestris cafra*) in the Kalahari are described and evaluated in this paper. African wild cats were captured, with either baited cage traps or chemical immobilisation through darting. Darting proved to be a more efficient and less stressful way of capturing cats. Very high frequency (VHF) radio collars fitted with activity monitors were especially effective in the open habitat of the Kalahari for locating and maintaining contact with cats; they also aided in determining if the cats were active or resting in dense vegetation. The habituation of individual cats to a 4×4 vehicle proved to be time consuming, but it provided a unique opportunity to investigate the feeding ecology and spatial organisation of cats through direct visual observations.

Keywords: Kalahari, capture techniques, chemical immobilisation, habituation

Introduction

The African wild cat (*Felis silvestris cafra*), is widely distributed throughout the African continent and listed by the International Union for Conservation of Nature (IUCN) as least concern (Nowell, 2008). However, status and density estimates of African wild cats are poorly known throughout most of its range. Therefore, the ecological status of wild cat populations is frequently determined from incomplete or unverified data (Nowell & Jackson, 1996). Previous research efforts on African wild cats have focused on scat analyses and opportunistic sightings of cats in their natural environment (Palmer & Fairall, 1988; Smithers, 1971; Smithers & Wilson, 1979; Stuart, 1977; Stuart, 1982). The aim of this study was to gain insight into the population genetics and behavioural ecology of African wild cats in the southern Kalahari. This required the capture of cats for the fitting of radio collars, taking morphometric measurements and obtaining DNA samples. Radio telemetry was crucial for locating individual cats for the collection of data on feeding behaviour, home range and movement patterns. Investigating the foraging and social behaviour relied on the habituation of certain individuals for direct observations.

Steel, wire, mesh and Tomahawk cage traps are widely used in the live trapping of small mammals, for example in the European wild cat and domestic cats (Biró, Szemethy & Heitai, 2005), lynx (Breitnemoser & Haller, 1993), kodkod (Dunstone *et al*. 2002), Blanford's foxes (Geffen *et al*. 1992; Geffen & MacDonald, 1993), leopard cat (Grassman & Tewes, 2005), caracal (Marker & Dickman, 2005; Melville, 2004), black-footed cats (Sliwa, 2004, 2006), dhole (Grassman *et al*. 2005), ferrets (Norbury, Norbury & Heyward, 1998) and civits (Jennings, Seymour & Dunston, 2006).

The successful capture and release of an animal is not only determined by the capture of the animal, but also by how the animals are handled, transported and kept after capture (Ebedes, Du Toit & Van Rooyen, 1996). This paper provides detailed information on the methodology involved in capturing, immobilising and habituating of African wild cats in the southern Kalahari.

Study area

Kgalagadi Transfrontier Park

This study was initiated in March 2003 and continued until December 2006 (46 consecutive months) in the Kgalagadi Transfrontier Park (KTP), which comprises the Kalahari Gemsbok National Park (South Africa) and the adjacent Gemsbok National Park in Botswana. The KTP is a 37,000 km^2 semi-arid wilderness area in the southern Kalahari, described as the western form of the Kalahari Duneveld (Mucina & Rutherford, 2006), consisting of extreme open savannah of *Acacia erioloba*, *Acacia haemotoxylon* and desert grasses. The study was primarily conducted in a 53 km^2 area surrounding the Leeudril waterhole (26º28'17.7" S, 20º36'45.2" E), in the south of the park, and included the Nossob riverbed together with adjacent calcrete ridges, *Rhigozum* veld and dune areas (Fig. 1).

Methods

All capture, darting and handling of African wild cats were approved by the ethics committee, University of Pretoria, (EC 030305-007) and SANParks Animal Use and Care Committee (SANParks AUCC). Approval to conduct research in the Botswana side of the KTP was obtained from the Office of the President: OP 46/1 CVII (48) with a supplementary permit from the Department Wildlife and National Parks (9 July 2006).

1. Capture techniques

1.1 Cage traps/Drop door traps

Cage traps (50cm x 50cm x 150cm) were constructed from welded mesh, with a single sliding door. A stepping plate mechanism towards the rear end of the cage activated the trap

door. The size of the cages permitted cats to enter fully before depressing the plate, causing the door to drop. Bait, either locally bought chicken pieces or fresh road kills, suspended from a wire over the plate was used as lure. Additionally, cat urine was collected opportunistically whenever following a focal cat, stored in plastic bags and was added to baited traps as supplementary attractant for other cats (six out of 12 cats were caught with the use of urine as attractant). Cages were sometimes camouflaged by hiding them in vegetation, or covering the sides (only two of the 12 cats were caught when the cages were camouflaged). The stepping plate was covered with soil to give it a more natural feel.

The traps were set late in the afternoons and checked daily, early in the mornings. When a cat was found inside the trap, the far end was covered with a blanket in an attempt to provide a measure of security for the cat. A 40cm × 40cm crush plate, attached to a steel rod, was inserted at the front of the trap and, slowly and gently, the cat was pushed towards the back of the cage. In this way, the cat could be trapped at the far end of the cage, from where it was possible to hand inject it through the wire mesh. Zoletil^{R} (Tiletamine hydrochloride with Benzodiazephine derivative Zolazepam in 1:1 combination), at a dosage of approximately 2.5mg/kg was used for all cats caught by this method.

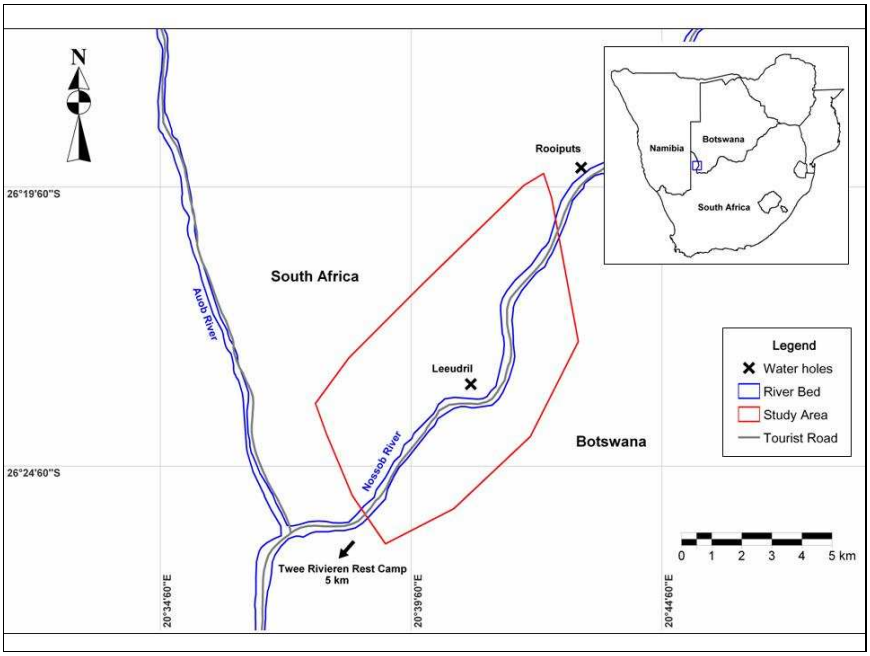

Figure 1 Study site in the KTP, indicating the area, around the Nossob riverbed and Leeudril waterhole where African wild cats, *Felis silvestris cafra*, were radio collared and monitored

Once anaesthetised, cats could be removed from the cages without difficulty, whereupon standard body measurements were taken (Table 1). A small skin sample was collected for molecular analysis and, if relevant, a radio collar was fitted. All procedures were conducted as quickly as possible, and in the immediate vicinity of the trap. On completion of the necessary procedures, the cat was returned to the shaded cage and left to recover from anaesthesia. It was released when it had fully recovered.

1.2 Darting

A CO_2 rifle (Dan-inject JM Standard model) was used to propel a standard dart syringe (10.5mm, 1.5 mL capacity) and fitted with a small rubber stopper to reduce penetration. Owing to the small size of the cats, it was necessary to lower the CO_2 pressure in the rifle as much as possible to reduce the projectile velocity and, in so doing, lessen the impact and therefore the chances of injury to an animal. As a trade-off, the range over which the dart could be propelled had to be reduced. Cats were thus always stalked to within 10m.

Cats caught by darting were immobilised with a combination of drugs and an appropriate antidote as follows (P. Buss and D. Govender, pers. comm.): either Butorphanol (1.38 mg/kg) and Medetomidine (0.4 mg/kg), with the antidote of Antipamezole administered at five times the Medetomidine dose (mg) intramuscularly and Naltrexone administered at 10 times the Butorphanol dose (mg) intramuscularly, or Zoletil (1.58 mg/kg) and Medetomidine (0.07 mg/kg), with the antidote of Antipamezole administered at 6.25–12.5 times the Medetomidine dose (mg) intramuscularly. Zoletil does not have an antidote.

2. Radio collars

African wild cats were fitted with radio collars from Africa Wildlife Tracking CC, weighing 80g – 85g, with external antennae of 20cm and a battery life of up to 18 months. Radio collars were each fitted with an activity monitor to assist in the remote detection of cat activity. Cats were detected with a two or three element handheld Yagi antenna by traversing the home range of the individual study animal and using the dune crests as high vantage points, using a Telonics handheld receiver.

3. Habituation

The open, clear spaces of the Kalahari provide ideal conditions for visual observation of animals (Begg, 2001; Mills, 2003), although the stealthy nature of cats, especially at night, required close proximity to the focal animal at all times. All radio collared cats were habituated to the presence of the research vehicle, allowing the researchers to closely follow individual cats without any obvious influence on their behaviour. This was achieved by

Table 1 Standard body measurements collected from all African wild cats trapped and darted during 2003 – 2006 in the Kgalagadi Transfrontier Park. TL = total length, HB = head body length, T = tail length, E = ear length, hf s/u = hind foot, measured in (cm) and mass (kg). The sex and means of capture are included. Sub adult cats, kittens and cats with insufficient data (*) were not included in the calculation of averages and standard deviation (SD)

ID	Sex	Status	TL	HB	T	Hf s/u	E	Mass (kg)	Capture method
002	♂	Adult	93.5	62.5	31	15.5	7	5	Cage trap
009	♂	Adult	93.4	63	30.4	15.4	7.4	4.9	Cage trap
010	♂	Adult	104	69	35	15.3	7.3	5.9	Road kill
012	♂	Adult	106.6	68	38.6	15.7	6.5	6	Cage trap
014	♂	Adult	97.5	63	34.5	15.2	6.8	5.7	Cage trap
015	♂	Adult	96.3	60.6	35.7	15.5	6.8	4.2	Cage trap
017	♂	Adult	104.8	67	37.8	15.2	6.2	5.7	Cage trap
022	♂	Adult	100.6	63.8	36.8	16	7.5	6	Dart
023	♂	Adult	98.3	63.7	34.6	15.6	7.1	4.1	Dart
024	♂	Adult	98.8	62.8	35.7	16.2	7	6.1	Dart
026	♂	Adult	100.4	66.6	33.8	15.5	8	5.2	Dart
027	♂	Adult	96.8	60.8	36	15.8	7.9	4.4	Dart
031	♂	Adult	102.1	67.6	34.5	16.1	7.1	5	Cage trap
004	♀	Adult	90	59	31	14.5	6.2	4.5	Cage trap
005	♀	Adult	108	67	41	15	7.4	4	Cage trap

006	♀	Adult	98	64	34	14	7.5	4	Cage trap
007	♀	Adult	92.3	60.3	32	14.5	6.6	3.4	Cage trap
008	♀	Adult	96	62	34	15.7	7.7	4.6	Cage trap
028*	♀	Adult	-	-	-	-	-	4.3	Dart
029*	♀	Adult	90.3	58.7	31.6	-	6.8	4.1	Dart
030	♀	Adult	89.6	58.7	30.9	15.7	7.5	3.6	Dart
032	♀	Adult	88.6	57.4	31.2	13.3	6.4	3.7	Dart
034	♀	Adult	89	54	35	15	7.2	3.7	Dart
040	♀	Adult	98.9	61.8	37.1	15.5	7.1	4.4	Dart
001*	♂	Sub adult	78	46	32	15.5	6.8	3.3	Road kill
016*	♂	Sub adult	89	56.5	32.5	14.8	5.6	3.3	Dart
025*	♂	Kitten	84.4	52.9	31.5	14.7	6.5	3.1	Dart
033*	♂	Kitten	82.4	51.4	31	14.2	7.3	2.2	Dart
036*	♂	Kitten	79.6	51.3	28.3	12.8	7.2	2.3	Dart
037*	♂	Kitten	79.6	52.1	27.5	13.5	7	2.6	Dart
039*	♂	Kitten	77.7	48.5	29.2	13.8	6	1.9	Dart
Average	♂	(n = 14)	99.2 ± 4.07	64.4 ± 2.73	34.8 ± 2.29	15.7 ± 0.45	7.2 ± 0.51	5.2 ± 0.68	
Average	♀	(n = 9)	94.3 ± 6.10	60.2 ± 3.67	34.0 ± 3.16	14.8 ± 0.77	7.1 ± 0.53	4.0 ± 0.42	

patiently following cats daily for the first week after initial capture and collaring, at a distance of 50m – 100m, while keeping the engine running. Habituation appeared to be facilitated by keeping the engine running in the beginning and slowly moving closer to the cats. After one week, the following distance was gradually decreased, until the cats could be followed from a distance of 10m – 30m without them looking back at the vehicle. Wild cats were followed on a rotational system, allowing continuous monitoring of a focal animal every night. Cats were located at night by radio tracking, with the initial visual contact being made with a 1,000,000-candle spotlight. Once a cat was located, the headlights of the research vehicle were usually sufficient to follow cats, with the spotlight used only periodically to re-establish contact when lost in patches of denser vegetation, or when cresting sand dunes. Care was taken to keep the spotlight trained behind the cat – to neither influence their hunting success negatively by blinding them, nor positively, by dazzling prey animals.

Results

1. Capture success

1.1 Cage traps

African wild cats were frequently spotted during opportunistic searches and cage traps were placed in close vicinity to these spots. Seven of the ten cats caught in the study site were trapped after being spotted in a specific area. Only three cats were caught by randomly placing the traps in the study site. Trapping success for African wild cats in the Kalahari was 1.4 cats per 100 trap nights. The trapping frequency between wild cats is highly variable and for African wild cats it was estimated at 73 trap nights per new cat, compared to the results of the European wild cat (*Felis s. silvestris*) (Biró *et al*. 2004; Corbett, 1979), at 860 and 299 trap nights per new cat, respectively. Trapping of feral domestic cats (*Felis s. catus*) ranged between 75 and 823 trap nights per new cat (Barratt, 1997; Biró *et al*. 2004; Bromley, 1986; Corbett, 1979; Daniels *et al*. 2001; Molsher, 2001, 2006), for lynx (*Lynx canadensis*) it was 67 trap nights per new cat (Mech, 1980), ocelot (*Leopardus pardalis*) was 116 trap nights per new cat (Dillon & Kelly, 2008) and leopard cat (*Prionailurus bengalensis*) 405 trap nights per new cat (Grassman *et al*. 2005). The main drawback of cage traps appeared to be the reluctance of wild cats to enter, as well as their non-selective nature (Table 1). Loss of bait could possibly have been attributed to the ineffective setting of cages. Bait was stolen on numerous occasions, by smaller mammals such as the yellow mongoose (*Cynictis penicillata*) and rodents; in some instances it was consumed by ants.

Table 2 The percentage capture success expressed as the total of cages (*n* = 1244) used during all the trapping days (*n* = 301) in the KTP

ID	Scientific name	Total	%
Empty cages		870	69.9
Bait stolen from cage		120	9.6
Cape fox	*Vulpes chama*	113	9.1
Black backed jackal	*Canis mesomelas*	38	3.1
African wild cat	*Felis silvestris cafra*	17	1.4
Genet	*Genetta genetta*	2	0.2
Porcupine	*Hysterix africanis*	1	0.1
Spotted hyena	*Crocuta crocuta*	1	0.1
Springhare	*Pedetes capensis*	1	0.1

1.2 Darting

During two darting expeditions, consisting of four nights each (10–14 hours per night), in August 2005 and January 2006, a total of 18 African wild cats were successfully darted, with only one injury reported. Cats were spotted by driving up and down the riverbed, constantly scanning with spotlights in two vehicles and looking for retinal reflections. When cats were spotted, the research vehicle slowly moved in the direction of the cat, maintaining visual contact with the vehicle headlights and a spotlight. Assistants with spotlights in the second vehicle acted as spotters, and when necessary, pedestrian herders directed the cat towards the darting vehicle. The cat was slowly approached until it stopped and a clear shot was possible. Cats were darted from a distance of no more than 10m. Once successfully darted, a cat was followed at a distance of 30m – 40m, with spotlights, until it became fully immobilised. This was important, as a premature approach could have caused the cat to flee, leading to a temporary loss of contact with a highly vulnerable animal. Within 10min – 15min after the drugs were administered, it was possible to walk up to the cat and carefully cover the head and eyes with a blanket. Standard body measurements and genetic samples were taken, and in two cases the cats were fitted with radio collars. Antidotes were very effective and cats regained full motor control within minutes after administering.

African wild cats did not appear to associate the vehicle with the darting procedures, as two cats that were fitted with radio collars were easily habituated to the vehicle afterwards. The majority of cats were darted primarily to collect genetic material for molecular analysis and

were not approached again afterwards. Owing to the risk of missing the small target area on the thigh of a cat and potentially injuring it, only qualified, experienced wildlife veterinarians were employed in darting.

African wild cats were immobilised on 31 occasions (13 cats were hand injected and 18 cats were darted). No fatalities were recorded, although the fate of the injured one is not known.

2. Radio collaring

Radio collaring proved to be invaluable for finding and following cats, as they do not return to a fixed den site and are difficult to find at night. The estimated total home range sizes (100% Minimum Convex Polygon) were: adult male = 13.17km² ± 7.32km² (*n* = 5) and adult female = 11.75km² ± 2.01km² (*n* = 3) (Chapter 4). In total, 12 African wild cats were radio collared. Only one female cat showed a slight irritation to the radio collar, symptomised by localised hair loss ten days after been collared. Symptoms lasted for four weeks, with hair growing back gradually. The cat was monitored daily until all symptoms had disappeared. On two occasions, damaged radio collars were retrieved, (three weeks and two months after being fitted) suggesting that the cats had fallen prey to a larger predator (one unknown and one confirmed from tracks as a caracal, *Caracal caracal*). Two radio-collared cats disappeared (a young female, two months after being fitted and a young male, two days after), either as a result of malfunctioning radio collars or emigration to an area outside the range searched. External antenna of radio collars broke off within 2–6 months, however, this did not seem to make a difference in the detection of cats, because the cats had known home ranges (Chapter 4) and searching for a signal from high dunes was almost always successful.

3. Habituation

On average, the habituation period took 73.8 h ± 63.9 h (*n* = 8), although large individual differences occurred (Table 2). In general, females were easier to habituate (average 36.7 h ± 5.8 h; *n* = 3). Three radio-collared and habituated females had litters during the study period and dens and kittens could be approached without difficulty. Kittens were extremely curious and would investigate the research vehicle of their own accord. Male cats were more difficult to habituate (96 h ± 74 h; *n* = 5), as they move faster and over a much larger area than females, making observations of males more difficult. Habituation was lost quickly and maintaining the maximum degree of habituation required that weekly contact with each cat was maintained.

Habituated African wild cats were visually observed for 1,538 hours (males for 657 hours, females for 881 hours) on a rotational basis. Continued observations of selected individuals

provided detailed information on sexual and seasonal differences in diet, foraging behaviour, movement patterns, reproduction and inter-specific interactions.

Discussion

Long-term and intensive field studies on smaller cats are still exceptional and even the common species have not been well studied (Macdonald & Loveridge, in press; Nowell & Jackson, 1996). The reason for this is the relative difficulty associated with studying small felids. Previous research on African wild cats was based on opportunistic sightings, scat and stomach analysis (Palmer & Fairall, 1988; Smithers, 1971; Smithers & Wilson, 1979; Stuart, 1977). Their nocturnal behaviour and general shy and elusive nature, make it practically impossible to study cats in their natural environment without the aid of radio telemetry. Radio telemetry has become more reliable and efficient since the 1980s (Nowell & Jackson, 1996); recently, radio collars have been designed smaller, lighter and reliable enough for the use on smaller cats. However, in spite of the advances in technology, the time required to catch smaller cats for radio collaring purposes poses a challenge. The trapping frequency of African wild cats is comparable with frequencies of the trapping of feral domestic cats (*F. s. catus)* (Barratt, 1997; Molsher, 1999, 2001). This is much lower than the results on European wild cats *(F.s. silvestris*) (Biró *et al*. 2004; Corbett, 1979), which are difficult to catch, the reason possibly being that these populations in Europe have declined, are fragmented and, in many places, are already extinct (Nowell, 2008). For black-footed cats (*Felis nigripes*), the trapping frequency was one cat for 100–200 trap nights (including recaptures) (A. Sliwa, pers. comm.). African wild cats in the Kalahari were regularly spotted during our study period, therefore it is believed that densities are much higher in the Kalahari than in Europe.

The results in this study not only confirm the difficulty of catching African wild cats, but also emphasise the general low success rate of trapping small carnivores in the southern Kalahari. Mainly trap door cages, with various combinations of bait and urine to attract cats were used. Positioning cages in areas of high animal activity should increase the selectivity of the trapping efforts (Boddicker, 1999). Our results suggest that, after an extensive search in the riverbed with a spotlight and placing of traps close to sightings of cats, the success of trapping increased in comparison with randomly placed traps.

The use of a CO_2 Dan inject dart gun proved to be the best method in the capture of free range African wild cats. The time and cost effectiveness of this capture method was enhanced with the use of drugs combined with antidotes. Once all the data and measurements were collected from the cats, they could be revived with the antidote and the darting operation could continue. Special care and qualified personnel (two wildlife

veterinarians and four assistants in two vehicles) were needed to assist with darting operations, because the target animal was so small. The cost of qualified veterinarians and personnel needed in a darting operation is high; however, to obtain a representative sample size using only conventional trapping methods might have taken the researcher another few years of intensive fieldwork.

It was relatively easy to habituate African wild cats to a research vehicle (590 hours were needed to habituate eight cats). The Kalahari is the ideal location to study small carnivores, such as African wild cats, because the openness of the environment makes it possible to follow them, even at night (Begg 2001; Mills 2003). Although there were large individual differences between the times needed to habituate individuals (Table 2), it was possible to collect data on feeding, hunting, reproduction and mating behaviour of African wild cats (Herbst & Mills, 2010). To achieve this, radio telemetry was essential and because African wild cats do not travel to the same extent than larger felids, it was feasible to traverse the whole study area in a few hours in search of a signal. This was enhanced by using high dunes as a vantage point.

Conclusion

For dispersed and elusive animals, radio collaring might be the key to obtaining appropriate data (Kenward, 2001). Despite the advances in the use of satellites for radio tracking – platform transmitter terminals and global positioning system collars – they remain relatively expensive in comparison with the VHF transmitters (Kenward, 2001). In this study visual observations of habituated cats fitted with VHF transmitters enabled us to record valuable behavioural information on a nocturnal and secretive animal that more sophisticated and expensive tracking devices could not. This is the first report on the methodology of darting of wildcats (*F. silvestris*), and it proved to be a more efficient and less stressful method than cage trapping of African wild cats in the KTP.

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APPENDIX 2

Prey items captured by African wild cats in the Kgalagadi Transfrontier Park

Prey items captured by African wild cats in the Kgalagadi Transfrontier Park during 2003 to 2006 documented from direct observations. Prey items presented in prey categories and in order of decreasing cumulative mass (measured in grams, g) of prey items consumed by African wild cats. Percentage occurrence is the number of times the food category is present/total number of occurrences of all food items and the percentage of the total biomass consumed from direct observations are included

Species identified	Scientific name	Number caught	Average individual body mass (g)	Mass consumed (g)	Percentage occurrence	Percentage of total biomass consumed
Larger mammals						
Spring hare	*Pedetes capensis*	3	2000	6000		
Hare sp.	*Lepus* sp.	2	2000	4000		
Ground squirrel	*Xerus inauris*	1	625	625		
Sub-total		6	4625	10625	0.24	12.4
Small mammals						
Rodents (unidentified)		1100	50	55000		
Brant's gerbil	*Tatera brantsii*	50	65	3250		
Brant's whistling rat	*Parotomys brantsii*	28	80	2240		
Striped mouse	*Rhabdomys pumilio*	19	32	608		
Damaraland mole-rat	*Fukomys damarensis*	3	131	393		
Hairy footed gerbil	*Gerbillurus paeba*	11	26	286		
Short-tailed gerbil	*Desmodillus auricularis*	2	46	92		
Pygmy mouse	*Mus indictus*	6	5	30		
Bushveld elephant shrew	*Elephantulus intufi*	1	42	42		
Sub-total		1220	477	61941	47.79	72.2

Birds						
Lark sp.		50	60	3000		
Namaqua sand grouse	*Pterocles namaqua*	8	300	2400		
Cape turtle dove	*Streptopelia capicola*	9	150	1350		
Spotted thick-knee	*Burhinus capensis*	1	320	320		
Namaqua dove	*Oena capensis*	1	42	42		
Sub-total		69	872	7112	2.70	8.3
Reptiles						
Common barking gecko	*Ptenopus garrulous*	488	5	2440		
Sand snake	*Psammophis* sp.	5	200	1000		
Giant ground gecko	*Chondrodactylus angulifer*	34	23	782		
Ground agama	*Agama aculeate*	13	25	325		
Kalahari tree skink	*Mabuya occidentalis*	5	10	50		
Sub-total		545	263	4597	21.35	5.4
Invertebrates						
Locusts	Order Orthoptera	47	4	188		
Moths	Order Lepidoptera	80	2	160		
Insects (unidentified)		73	2	146		
Formicidae	Order Hymenoptera	5	2	10		
Antlion	Order Neuroptera	3	2	6		
Beetle	Order Coleoptera	2	2	4		
Scorpion	*Opistophthalmus wahlbergii*	5	5	25		
Solifugidae		4	2	8		
Unknown		494	2	988		
Sub-total		713	23	1535	27.93	1.7
Total		**2553**	**6260**	**85810**		

APPENDIX 3

The number of hours of observations on eight African wild cats (male = 5, female = 3) for each hour of the day in each season in the Kgalagadi Transfrontier Park from April 2003 to December 2006. HW = hot-wet, CD = cold-dry and HD = hot-dry

Time of day	Hours ♀			Total	Hours ♂			Total
	HW	CD	HD		HW	CD	HD	
00:00 - 01:00	15.5	13.2	14.2	42.9	6.4	12.3	19.5	38.2
01:00 - 02:00	13.2	7.2	15.5	35.9	3.2	7.3	15.4	25.9
02:00 - 03:00	13.3	6.3	14.3	33.9	2	6.2	10.3	18.5
03:00 - 04:00	9.2	4	13.2	26.4	1	2.5	7.3	10.8
04:00 - 05:00	9.8	3	10.5	23.3	1.3	1.5	6.7	9.5
05:00 - 06:00	7.3	4	5.7	17	1.2	1.8	5.6	8.6
06:00 - 07:00	2	4	5.6	11.6	1.5	2.5	5.2	9.2
07:00 - 08:00	2	8.4	7.2	17.6	1	2	2.2	5.2
08:00 - 09:00	1	10.2	10.8	22	1	2	4.3	7.3
09:00 - 10:00	1	10.3	10.3	21.6	1	2	2.3	5.3
10:00 - 11:00	1	10.4	10.2	21.6	1	2.4	3.5	6.9
11:00 - 12:00	1	8.3	9.8	19.1	1	2.6	3.1	6.7
12:00 - 13:00	1	7.5	5.2	13.7	1	2.5	2.8	6.3
13:00 - 14:00	1	7.2	6.5	14.7	1	3.6	3.5	8.1
14:00 - 15:00	1	8.4	6.3	15.7	1.3	2.2	5.3	8.8
15:00 - 16:00	1	8.1	7.8	16.9	2	9.2	7.5	18.7
16:00 - 17:00	1	15.4	10.2	26.6	4	15.3	11.4	30.7
17:00 - 18:00	6.4	25.1	15.3	46.8	8.4	22.2	18.1	48.7
18:00 - 19:00	27.2	25.5	25.4	78.1	16.3	25.5	27.1	68.9
19:00 - 20:00	25.3	25.6	25.1	76	16.2	24.3	24.4	64.9
20:00 - 21:00	25.1	26.2	25.5	76.8	15.6	27.1	26.2	68.9
21:00 - 22:00	25.2	31.4	25.2	81.8	16.5	26.1	25.3	67.9
22:00 - 23:00	24.6	24.5	28	77.1	15.3	25.5	21.3	62.1
23:00 - 00:00	23.2	18.3	22.5	64	11.1	20.3	19.3	50.7
Total	238.3	312.5	330.3	881.1	130.3	248.9	277.6	656.8

APPENDIX 4

The allelic frequencies at 18 polymorphic microsatellites among African wild cats (AWC), Kalahari domestic cat (KDC) and a reference collection of domestic cats (DCRef)

	Locus:	Pop	N	Allelic frequency																
Allelic size (bp)				134	136	140	142	144	146	148	150	152	154							
	FCA005	AWC	114	0	0	0.009	0.123	0.105	0.219	0.351	0.132	0.053	0.009							
		KDC	50	0	0	0	0.02	0.14	0.02	0.48	0.16	0.18	0							
		DCRef	42	0.071	0.048	0	0.071	0.048	0.095	0.357	0.095	0.119	0.095							
Allelic size (bp)				130	132	134	136	138	140	142	144	146	148	150	152	154	156	162		
	FCA026	AWC	114	0.237	0.061	0.035	0.079	0.009	0.026	0.009	0.009	0.105	0.07	0.088	0.114	0.14	0.009	0.009		
		KDC	50	0.02	0	0	0.1	0	0	0	0.02	0.18	0.06	0.58	0	0	0.04	0		
		DCRef	42	0.024	0.024	0	0	0.024	0	0	0.071	0.095	0.071	0.357	0.071	0.238	0.024	0		
Allelic size (bp)				86	88	90	96	98	102	104	106	108	110	112	114	116				
	FCA069	AWC	114	0.009	0.035	0.07	0.009	0.009	0.035	0.07	0.228	0.211	0.246	0.061	0.018	0				
		KDC	50	0	0	0	0.42	0.02	0	0	0.1	0.08	0.16	0.1	0.12	0				
		DCRef	42	0	0	0	0.143	0	0	0	0	0.095	0.548	0.167	0.024	0.024				
Allelic size (bp)				116	118	120	122	124	126	128	130	132	134	136	138	140	142			
	FCA075	AWC	114	0.018	0.009	0.009	0.044	0.053	0.123	0.132	0.14	0.167	0.184	0.07	0.035	0.018	0			
		KDC	50	0	0.04	0	0	0	0	0	0	0.22	0.38	0.1	0.04	0.22	0			
		DCRef	42	0.024	0.024	0	0	0	0	0.024	0	0.024	0.071	0.071	0.167	0.357	0.238			
Allelic size (bp)				126	130	132	136	138	140	142	144	146	148	150	152	154	156	158	160	162
	FCA097	AWC	114	0.044	0.035	0.026	0.07	0.088	0.026	0.053	0.079	0.175	0.07	0.044	0.061	0.14	0.035	0.018	0.026	0.009
		KDC	50	0	0	0	0	0.06	0	0	0.08	0.34	0.42	0.1	0	0	0	0	0	0
		DCRef	42	0	0	0	0	0.119	0.167	0	0.167	0.167	0.19	0.143	0.048	0	0	0	0	0
Allelic size (bp)				179	181	183	185	187	189	191	193	195	197	199	201	203				
	FCA105	AWC	114	0.061	0.018	0.044	0.193	0.202	0.053	0.184	0.14	0.061	0	0.026	0.009	0.009				
		KDC	50	0	0	0	0	0.114	0.205	0.068	0.227	0.045	0.023	0.205	0.068	0.045				
		DCRef	42	0	0	0	0	0	0.167	0.286	0.286	0.095	0.024	0.119	0.024	0				

Allelic size (bp)				120	122	124	126	128	130	132	134					
	FCA105	AWC	114	0.018	0.061	0.114	0.079	0.307	0.281	0.114	0.026					
		KDC	50	0	0	0.08	0	0.16	0.06	0.52	0.18					
		DCRef	42	0	0.19	0.214	0	0.119	0.095	0.31	0.071					
Allelic size (bp)				137	141	143	145	147	149	151	153	155	157	159	161	163
	FCA201	AWC	114	0.009	0.044	0	0.018	0.018	0.202	0.14	0.167	0.105	0.132	0.105	0.053	0.009
		KDC	50	0	0.44	0.06	0	0	0	0.06	0	0.12	0	0.32	0	0
		DCRef	42	0	0	0.19	0	0.048	0	0.143	0.024	0.167	0.167	0.262	0	0
Allelic size (bp)				206	208	210	212	214	215	216	217	218	220	222	224	226
	FCA220	AWC	114	0	0.018	0.009	0.053	0.158	0	0.096	0	0.14	0.219	0.123	0.149	0.035
		KDC	50	0.104	0	0.021	0	0.063	0	0.542	0	0.271	0	0	0	0
		DCRef	42	0	0	0.167	0	0.31	0.024	0.381	0.048	0.048	0.024	0	0	0
Allelic size (bp)				152	156	158	160	164	166	168	170	172	174	176	178	180	182
	FCA224	AWC	114	0	0.098	0.009	0.036	0.018	0.009	0.071	0.018	0.188	0.17	0.188	0.134	0.027	0.036
		KDC	50	0.04	0	0.02	0.64	0	0.02	0	0	0.06	0.08	0.14	0	0	0
		DCRef	42	0.024	0	0	0.762	0	0	0	0	0.095	0.071	0.024	0	0.024	0
Allelic size (bp)				152	154	156	158	160	162	164	166	168	170	172		
	FCA229	AWC	114	0.07	0.018	0.009	0.105	0.219	0.289	0.184	0.053	0.026	0.009	0.018		
		KDC	50	0	0	0	0.04	0.02	0	0	0.22	0.6	0.06	0.06		
		DCRef	42	0	0	0	0	0	0	0.119	0.167	0.595	0.071	0.048		
Allelic size (bp)				154	156	158	160	162	164	166	168	170	172	174		
	FCA240	AWC	114	0.009	0	0	0.289	0.289	0.035	0.07	0.158	0.044	0.105	0		
		KDC	50	0.14	0.28	0.02	0	0	0.08	0	0.04	0	0.42	0.02		
		DCRef	42	0.071	0.167	0.048	0	0	0.095	0	0.048	0.048	0.405	0.119		
Allelic size (bp)					177	179	181	183	185	187	189	191	193	195	197	199
	FCA293	AWC	114	114	0.035	0.237	0.123	0.096	0.026	0.035	0.175	0.132	0.018	0.079	0.026	0.018
		KDC	50	50	0	0.22	0	0.04	0.04	0.36	0.2	0.02	0.12	0	0	0
		DCRef	42	42	0	0.19	0.071	0.024	0.071	0.405	0.024	0.095	0.119	0	0	0
Allelic size (bp)				116	118	120	122	124	126	128	130	132	134	136	138	
	FCA310	AWC	114	0.009	0.018	0.018	0.096	0.325	0.149	0.167	0.158	0.009	0.009	0.044	0	
		KDC	50	0	0	0.06	0.1	0.32	0.02	0.06	0.04	0	0	0.4	0	
		DCRef	42	0	0	0.238	0.024	0.095	0.143	0	0	0	0.024	0.381	0.095	

Allelic size (bp)				151	153	155	159	163	167	171							
	FCA441	AWC	114	0.053	0.009	0.14	0.386	0.298	0.105	0.009							
		KDC	50	0.18	0	0.24	0.12	0.36	0.1	0							
		DCRef	42	0.024	0.024	0.119	0.31	0.262	0.238	0.024							
Allelic size (bp)				188	192	196	200	204	208								
	FCA453	AWC	114	0.579	0.096	0.079	0.184	0.061	0								
		KDC	50	0.14	0.06	0.3	0.3	0.16	0.04								
		DCRef	42	0.286	0.071	0.381	0.19	0.071	0								
Allelic size (bp)				135	137	149	151	153	155								
	FCA651	AWC	114	0.009	0	0.509	0.368	0.105	0.009								
		KDC	50	0.84	0.16	0	0	0	0								
		DCRef	42	0.857	0.143	0	0	0	0								
Allelic size (bp)				190	192	194	196	198	200	202	204	206	224	226	230	232	234
	FCA678	AWC	114	0.018	0.079	0.035	0.061	0.114	0.272	0.158	0.044	0.088	0.044	0	0	0.053	0.035
		KDC	50	0	0	0	0	0	0.25	0	0.023	0	0.636	0.023	0	0.068	0
		DCRef	42	0	0	0	0	0	0	0	0	0	0.333	0.262	0.048	0.357	0

APPENDIX 5

Published book chapter: In Biology and Conservation of Wild Felids, Oxford University Press (in press)

Chapter 26

Black-footed cats (*Felis nigripes*) and African wild cats (*Felis silvestris lybica*): a comparison of two small felids from South African arid lands

Alexander Sliwa, Marna Herbst, and Gus Mills

Some of the leading causes for the decline of felid populations are habitat loss, habitat degradation and persecution. Africa's two smallest cat species, the black-footed cat (BFC) (*Felis nigripes*) and the African wild cat (AWC) (*Felis silvestris*) occur in southern Africa's grasslands and semi deserts and are affected by all these causes of decline. Additionally, AWC are threatened by hybridisation with domestic cats (*Felis silvestris catus*) (Smithers 1983; Nowell and Jackson 1996; Macdonald *et al*., Chapter 22, this volume). Our objectives were to: (1) explore the origins of and morphological differences between the two species; (2) compare their life history and ecological parameters; (3) compare ecological factors that impact species abundance and distribution; and (4) identify gaps in research knowledge, particularly with relevance to conservation management of the species. While variation in diet, home range size, resting site use and activity patterns were present between the two species, we could not discern significant differences in these parameters, or in population threats. We propose that collaborative research and concerted action planning will maximise the efficiency of financial resources to develop applied conservation solutions for both species.

26.1 Introduction

The BFC, also called the small-spotted cat, is the smallest cat species in Africa and amongst the smallest in the world. Endemic to the arid grassland, dwarf shrub and savannah of the Karoo and Kalahari in the western parts of southern Africa (Fig. 26.1) (Smithers 1983) it has the most restricted distribution of any African cat species (Nowell & Jackson 1996). It shares much of its habitat with the widespread AWC, which ranges throughout most of the African continent (Fig. 26.1; Smithers 1983; Nowell & Jackson 1996). Erratic rainfall affects the food resources in the Kalahari study area of the AWC described here and throughout the distribution range of the BFC (Leistner 1967; Nel *et al*. 1984; van Rooyen 1984).

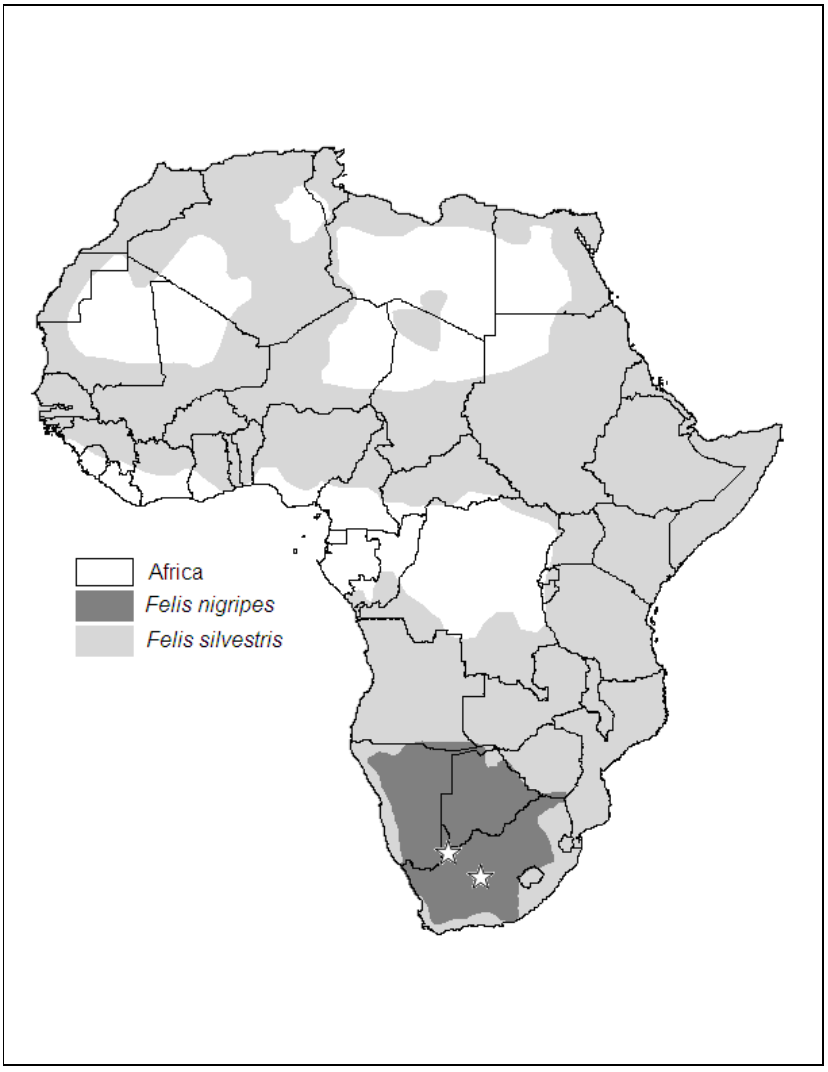

Fig. 26.1 Distribution of the African Wild cat, *Felis silvestris* and Black-footed cat *Felis nigripes* in Africa. The two stars mark the location of the study areas.

Although the species differ markedly both in coat patterns and size (Fig. 26.2) there is considerable confusion by the general public, and thus in their distribution records in southern Africa (A. Sliwa, pers. obs.). However, the contemporary distribution of the two species suggests that the BFC is sensitive to habitat and climatic variables, while the AWC has a very broad ecological niche, inhabiting almost all African habitats, with the exception of the tropical rainforests and true deserts. Within the northern portion of the AWC's distribution, the sand cat (*Felis margarita)* inhabits the driest parts of the Sahara (Sunquist and Sunquist 2002), a small cat similar in several morphological adaptations to the BFC (Huang *et al.* 2002). Reflecting this, AWCs inhabiting truly arid habitats are smaller in stature and mass, i.e. the *gordoni* wildcats of the Eastern Arabian peninsula average only 77-78 % in head-

body length (♂♂ 50.3 to 65 cm; ♀♀ 47 to 60 cm) and 51-53% (♂♂ 2.7 kg to 5.1 kg; ♀♀ 2.0 to 3.9 kg) in mass compared to other wildcat subspecies (unpublished data measurements on *F. s. gordoni* by Breeding Centre for Endangered Arabian Wildlife, Sharjah, United Arab Emirates; Phelan and Sliwa 2005; Kalahari *silvestris* – Herbst unpublished data).

Fig. 26.2 (a) African Wild cat female © M. Herbst

Fig. 26.2 (b) Black-footed cat male © A. Sliwa.

All African *Felis* species have been little studied (Nowell and Jackson 1996), thus no clear limitations for their ecological separation have been defined. In this chapter we summarise what is known about the behaviour and ecology BFCs and AWCs from two intensive field studies in South Africa and make suggestions for future research and conservation measures.

26.2 Origin and size

The two cat species belong to the old world domestic cat lineage (Johnson & O'Brien 1997; Werdelin *et al*., Chapter 2, this volume), however, the BFC is thought to have diverged from the other *Felis* species about three million years ago (Johnson *et al.* 2006). The wild cat (*Felis silvestris)* of Europe, Africa, and Asia has been the subject of continuous taxonomic debate. Nowell and Jackson (1996) divided wild cats into four groups: (i) the *silvestris* group comprising the heavily furred forest cats of Europe and the Caucasus; (ii) the *ornata* group including the light-bodied steppe cats of Asia; (iii) the *lybica* group comprising the long legged African wild cats of Africa and the near East; and (iv) the domestic cat, *Felis silvestris catus*. Genetic analysis confirms that these four groups of 'wildcats' are phylogenetically very close to each other (Pocock 1907; Driscoll *et al*. 2007; Macdonald *et al.*, Chapter 22, this volume), and that interbreeding may severely threaten the status of true wild cats. This process is accelerated by habitat loss and increased contact with human settlement and associated domestic cats (Macdonald *et al*. 2004, Yamaguchi *et al*. 2004a, 2004b, Macdonald *et al*., Chapter 22, this volume).

BFCs were shorter (♂♂ = 45 / ♀♀ = 40 cm HB) and smaller in mass (♂♂ = 1.9 / ♀♀ = 1.3 kg) than AWCs (♂♂ = 65 / ♀♀ = 60 cm HB;♂♂ = 5.1 / ♀♀ = 3.9 kg) in the respective study areas close to Kimberley and Twee Rivieren, South Africa (Sliwa 2004; Herbst unpublished data), the difference in body mass being almost threefold. Smaller size allows the BFC to conceal itself better in very short vegetation and find refuge in burrows of fossorial mammals, most commonly those of springhares (*Pedetes capensis*), but also in those of the Cape ground squirrel (*Xerus inauris*), South African porcupine (*Hystrix africaeaustralis*) and aardvark (*Orycteropus afer*). In parts of its distribution the BFC utilises abandoned hollow termitaria (Smithers 1983; Olbricht & Sliwa 1997). In contrast, the Kalahari AWCs spent most of the day resting under dense bushes and vegetation (85%), holes and caves (11%) and open shade (4%) (n = 304; observations of cats resting or sleeping before an activity period; Herbst unpublished data).

26.3 Study areas

The results of the only two in-depth field studies into the behaviour and ecology of these small African cat species provide the basis for comparing them in this chapter. A study of both species in sympatry is still lacking, however the present study areas are only 500 km apart in relatively similar habitat in the Northern Cape Province, Republic of South Africa (Fig. 26.3a, b).

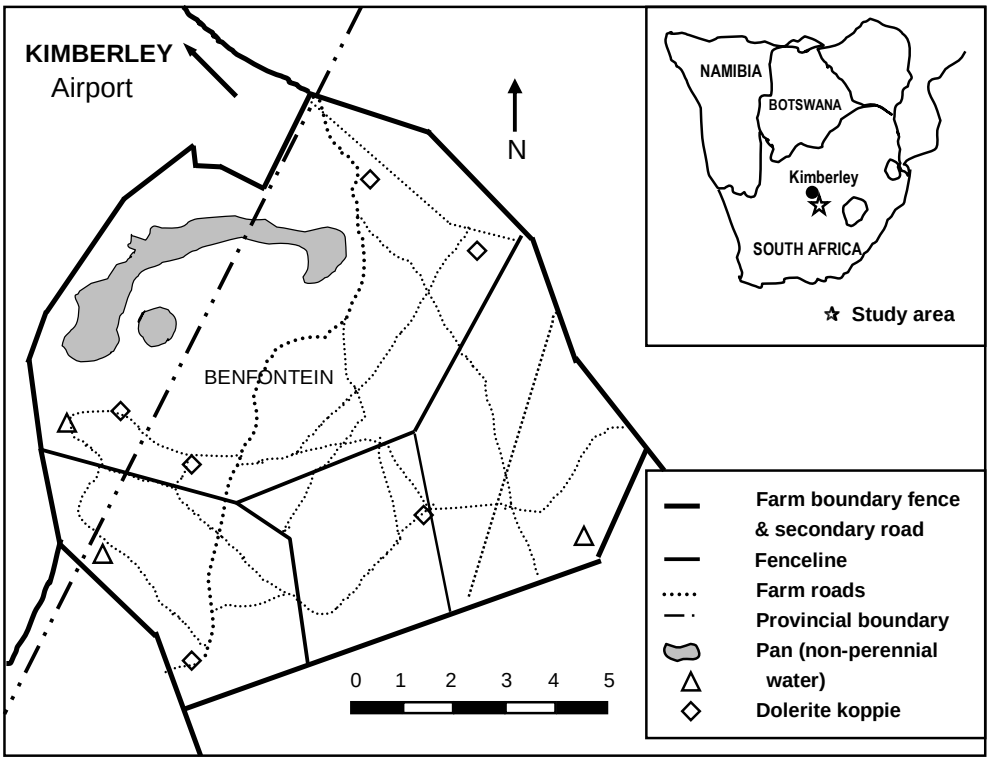

Fig. 26.3 (a) Study area for BFCs, the game farm 'Benfontein', on the border of the Northern Cape and Free State provinces, South Africa. To the northwest of the boundary fence, marked by a thick black line, is Kimberley airport. The pan (solid grey) in the northern part of the study area, the road system, and some special features are shown.

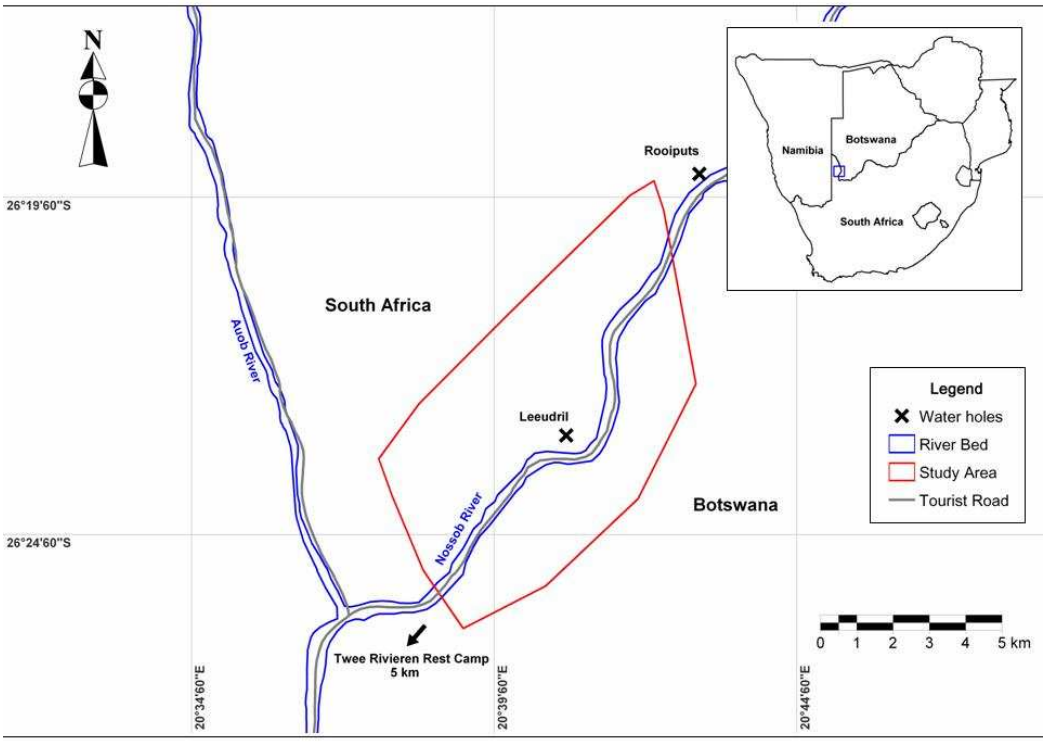

Fig. 26.3 (b) Map of study area for AWCs around the Leeudril waterhole, indicating the riverbed and associated vegetation in the Kgalagadi Transfrontier Park. The Nossob River forms the unfenced border between South Africa and Botswana

The BFC study took place between December 1992 and September 1998 on the 114 km² game farm 'Benfontein' (28°50'S; 24°50'E), owned by De Beers Consolidated Mines Ltd., 10 km south-east of Kimberley, (Fig. 26.3a). This area lies at the centre of the known distribution of BFCs (Nowell and Jackson 1996). The study area encompassed 60 km² with a variety of arid vegetation communities (Sliwa 1996, 2004, 2006) including the elements of three major biomes: Kalahari thornveld, pure grassveld, and Nama Karoo, which meet in the Kimberley area (Acocks 1988). An ephemeral pan and its specialised plant communities in the north dominate the farm, but in the south the vegetation changes into grassveld and finally Kalahari thornveld with deeper sandier soils on higher ground. Grass length ranges from ≤ 5 cm close to the pan to > 100 cm in the Kalahari thornveld, where scattered camelthorn trees (*Acacia erioloba*) are interspersed in an open savannah. The climate is 'semi-arid continental' (Schulze and McGee 1978), with cool, dry winters (mean T = 8°C in July) and hot summers (23°C in January). Annual rainfall was 431 ± 127 mm for the last 50 years (Weather Bureau, Dept. Environmental Affairs, Pretoria) and occurs mainly in spring and summer. For analysis, the year was divided into three seasons of four months each: winter – May-August; summer – November-February; autumn/spring – March-April and September-

October. Populations of wild bovids, springbok (*Antidorcas marsupialis*), blesbok (*Damaliscus dorcas*) and black wildebeest (*Connochaetes gnou*) are harvested at irregular intervals for sport hunting and are culled for meat, but aside from this, human activity in the study area is minimal. In the southeastern quarter of the farm, varying numbers of cattle (*Bos taurus dom.*) are grazed.

The AWC study was conducted from March 2003 to December 2006 in the Kgalagadi Transfrontier Park (KTP). The main study area was along the southern part of the Nossob riverbed and surrounding dune areas (26°28'17.7"S, 20°36'45.2"E) (Fig. 26.3b). The KTP, incorporating the Kalahari Gemsbok National Park (South Africa) and the neighbouring Gemsbok National Park (Botswana), is a 37 000 km² area in the semi-arid southern Kalahari system, which forms part of the South West Arid biotic zone (Eloff 1984). The KTP is a wilderness area with minimum human impact; only limited tourism activities are present on two main roads in the riverbeds of the park. Herds of springbok, blue wildebeest (*Connochaetes taurinus*), red hartebeest (*Alcelaphus buselaphus*) and gemsbok (*Oryx gazella*) are dominant and large predators such as lion (*Panthera leo*), leopard (*Panthera pardus*), spotted hyaena (*Crocuta crocuta*), brown hyaena (*Hyaena brunnea*), and cheetah (*Acinonyx jubatus*), and smaller carnivores such as caracal (*Caracal caracal*), black-backed jackal (*Canis mesomelas*), Cape fox (*Vulpes chama*), honey badger (*Mellivora capensis*), small-spotted genet (*Genetta genetta*) and various raptor species are common in the KTP.

The vegetation of the Kalahari is described by Acocks (1988) as the western form of the Kalahari thornveld comprising an extremely open scrub savannah. Four main habitat types were identified and described as: (i) the dry riverbed and immediate surroundings; (ii) the adjacent *Rhigozum* veld; (iii) the sandy dune areas; and (iv) the calcrete ridges and limestone plains. For more detailed descriptions of the vegetation see Bothma and De Graaf (1973). The study site is characterised by low, irregular rainfall (Mills and Retief 1984), varying between 200 mm and 250 mm annually. Three seasons are recognised in the KTP: (i) a hot-wet season (HW) ranging from January to April, with mean monthly temperatures equal to or greater than 20ºC, with 70% of the annual rainfall falling during this period; (ii) the cold-dry season (CD) ranging from May to August with mean monthly temperatures below 20ºC and scarce rainfall; and (iii) the hot-dry season (HD) ranging from September to December with monthly temperatures approximately 20ºC and rainfall generally not more than 20% of the annual rainfall (Mills and Retief 1984).

26.4 Methods

BFCs were detected with a spot lamp at night, then were either followed to a hole and dug out by hand, or caught with a net while hiding on the ground. They were also trapped in specially made wire-cage traps, 30 x 30 x 100 cm, baited with dead birds. BFCs were anaesthetised by intra-muscular injection of 20 mg/kg ketamine-hydrochloride and 10 mg/kg acetyl-promazine in order to fit custom-built radio-collars. All radio-transmitters (AVM Instrument Co., Livermore, CA, USA) operated in the 148-150 MHz frequency range. The radio-collars weighed 50 g and had a battery life of 6-8 months. Cats were weighed to the nearest 50 g, measured, and aged based on a combination of tooth wear, body mass, reproductive condition, and subsequent territorial behaviour. A cat was classified as adult when it had permanent dentition with slight discolouring or chipping and adult body size and mass or in females had used nipples. It was classified as subadult if it was independent, had clean white unchipped teeth and, in females, unused nipples with <1 kg body mass. Resident adult males spray marked on a regular basis while non-resident males and subadult males did not. Twenty-one BFCs (six adult males, nine adult females, two subadult females - one became a resident adult, and four subadult males - three of which became resident adults during the study) were captured a total of 50 times. Twenty cats were radio-collared but three collars either stopped transmitting or were dropped after two to six days (Sliwa 2004). The remaining 17 individuals were each radio-tracked discontinuously over a period of 418 ± 355 days (mean ± SD; range: 16-1254 days).

AWCs were either caught in cage traps (10 cats), or immobilised while free-ranging by using a dart gun (18 cats). Cage traps (50cm x 50cm x 150cm) were baited with chicken pieces. A crush plate enabled a hand injection to be administered. AWCs were then immobilised with 25mg/ml Zoletil® (Tiletamine hydrochloride with Benzodiazephine derivative Zolazepam) in order to fit them with radio-collars. Radio-collars weighing 80-85 g from African Wildlife Tracking CC. were used, with a battery life of approximately 18 months. Trapping cats with cage traps did not prove to be very efficient with 1.4% success rate (n = 1244; trap nights = 301). Darting free ranging cats was more effective. It was possible to approach cats with a vehicle at night and temporarily deprive them of sight them with a spotlight. Qualified SANParks wildlife veterinarians used a CO_2 rifle (Dan-inject JM Standard model) with a standard dart syringe (10.5 mm; 1.5 ml capacity) and fitted with a stopper to reduce penetration. Cats were only darted when a clear shot was possible from a distance of 10 meters. Eighteen cats were successfully darted with a combination of drugs (Butorphanol:Medetomidine and Zoletil:Medetomidine) and antagonists (Naltrexone for Butorphanol, and Antipamezole for Medetomidine - Zoletil does not have an antidote) (Herbst

et al. in prep). In all cases, a small skin sample, taken from a nick in the ear was collected for DNA analysis and, if relevant, a radio-collar was fitted. Eight AWCs, consisting of 3 adult females and 4 adult males and 1 young male were radio-collared.

Cats in both studies were observed directly from a four-wheel-drive vehicle after an initial habituation period of 1-3 weeks. At night, cats were observed with a low-powered handheld spot lamp and focal animals were closely followed at a distance of 10 - 100 m. We kept the beam of the spot lamp slightly behind the cat to avoid illuminating the prey or the cat. When a prey item was caught the observer attempted to identify it to the species level, where possible, and its average mass was taken from the literature and museum mammal collections for later diet analysis (Sliwa 2006, Herbst unpublished data; Tables 26.1, 26.2 and 26.3). Details of the focal cat's behaviour together with the location and length of the dominant vegetation since the last observation were recorded onto an audio recorder whenever the cat changed direction or behaviour, or after 15 minutes. Single fixes were also recorded sporadically. The BFC study included 12 observation periods, each lasting a mean of 50 ± 29 days. A total of 17 450 fixes was obtained while following BFCs over a distance of 2000 km for 3125 hours, including 1600 hours of direct observation (Sliwa 2004). For AWCs, 10 979 fixes and 1538 hours of direct observations were recorded (Herbst unpublished data).

Table 26.1 Non-mammalian prey species (for mammals see Table 26.2) captured by *F. nigripes* on Benfontein Farm, on the border of the Northern Cape and Free State provinces, South Africa; their frequency of consumption, and average mass.

Scientific name	Species identified	No. caught	Average individual body mass (g)	Mass consumed
Invertebrates:				
Solpuga sp.	Solifuge	1	1.0	1
Opisthothalmus glabrifrons	Shiny burrowing scorpion	7	1.0	7
Hodotermes mossambicus	Harvester termite (alates)	~390 (5 x)	0.15	58.5
Planipennia	lacewings, antlions	34	0.5	17
Saltatoria	locusts and grasshoppers	93	1.5	139.5
Lepidoptera	large moths + beetles	26	1.0	26
Total Invertebrates	> 10 Species	~551	~	**249**
Reptiles + Frogs				
Lamprophis fuliginosus	Brown house snake	7	5 - 80	154
Lycophidion capense	Cape wolf snake	1	50	50
Mabuya capensis	Cape skink	1	4	4
Pachydactylus capensis	Cape gecko	3	3	9
Pachydactylus mariquensis	Marico gecko	2	3	6
Pyxicephalus adspersus	Giant bullfrog	1	400	250
Pseudaspis cana	Mole snake (juv.)	1	110	110
Tompterna cryptotis	Tremolo sand frog	1	5	5
Total Reptiles/Amphibians	**8 species**	17		**588**
Birds				
Anthropoides paradisea	Blue crane (chick)	1	130	130
Anthus cinnamomeus	Grassveld pipit	5	25	125
Calandrella cinerea	Redcapped lark	29	26	754
Cercomela sinuate	Sicklewinged chat	1	18.5	18.5
Chersomanes albofasciata	Spike-heeled lark	128	26	3328
Cisticola aridula	Desert cisticola	17	10	170
Columba guinea	Speckled pigeon	1	347	300
Eremopterix verticalis	Greybacked finchlark	4	18	72
Eupodotis afraoides	White-quilled bustard	5	670*	2110
Francolinus levaillantoides	Orange River francolin (scav.)	1	*370*	-
Galerida magnirostris	Thickbilled lark	1	30	30
Malcorus pectoralis	Rufouseared warbler	2	10	20
Mirafra apiata	Clapper lark	51	32	1632
Mirafra sabota	Sabota lark	1	25	25
Mirafra africanoides	Fawncoloured lark	1	20	26
Myrmecocichla formicivora	Southern Anteating chat	9	48	432
Oenanthe pileata	Capped wheatear	1	28	28
Pterocles Namaqua	Namaqua sandgrouse	1	180*	150
Rhinoptilus africanus	Doublebanded courser	8	89	712
Telophorus zeylonus	Bokmakierie	1	65	65
Turnix sylvatica	Kurrichane buttonquail	5	42	210
Unidentified small birds		13	20	260
Eggs of respective:	black bustard, coursers, larks	2+3+6	40, 10, 2.5	125
Nestlings of larks		5	~10	50
Total Birds:	**21 species**	**302**		**10773**

* for calculation - 20% of mass for feathers and bones that were left over

Table 26.2 Mammals consumed by black-footed cats. Average mass of mammals were taken from Skinner & Smithers (1990) and the collection of the McGregor Museum, Kimberley. *Antidorcas*, *Cynictis*, *Lepus*, *Pronolagus*, and *Xerus* were included in Fig. 26.6a as 'larger mammals'. All the other mammal taxa were pooled into 'smaller mammals'.

Scientific name	English name	Number consumed	Average mass of one (g)	Mass consumed
Antidorcas marsupialis [1]	Springbok (only scavenged)	1	3000*	1100
Crocidura sp.	Reddish-grey musk shrew	17	9	153
Cynictis penicillata	Yellow mongoose	2	830*	900
Dendromus melanotis	Grey climbing mouse	75	9	675
Desmodillus auricularis	Cape short-tailed gerbil	5	52	260
Gerbillurus paeba	Hairy-footed gerbil	152	26	3952
Lepus capensis [1]	Brown hare	13	1500*	4330
Malacothrix typica	Large-eared mouse	595	16	9520
Mus minutoides	African Pygmy mouse	276	7	1932
Pronolagus rupestris [1]	Smith's red rock rabbit (juv.)	1	1600*	200
Saccostomus campestris	Pouched mouse	2	46	92
Tatera leucogaster	Bushveld gerbil	87	71	6177
Xerus inauris [1]	Ground squirrel	2	600*	520
Unidentified rodent		16	10	160
Total: Mammals	**14 species**	**1246**		**29971**

Table 26.3 Prey items captured by African wild cats in the Kgalagadi Transfrontier Park during 2003 to 2006 documented from direct observations. Prey items presented in prey categories and in order of decreasing cumulative mass (g) of prey items consumed by African wild cats.

Species identified	Scientific name	Number caught	Average individual body mass (g)	Mass consumed (g)	% occurrence
Larger mammals					
Spring hare	*Pedetes capensis*	3	2000	6000	
Hare sp.	*Lepus* sp.	2	2000	4000	
Ground squirrel	*Xerus inauris*	1	625	625	
Sub-total		6	4625	10625	0.24

Small mammals					
Rodents (unidentified)		1100	50	55000	
Brant's gerbil	*Tatera brantsii*	50	65	3250	
Brant's whistling rat	*Parotomys brantsii*	28	80	2240	
Striped mouse	*Rhabdomys pumilio*	19	32	608	
Damara mole-rat	*Cryptomys damarensis*	3	131	393	
Hairy footed gerbil	*Gerbillurus paeba*	11	26	286	
Short-tailed gerbil	*Desmodillus auricularis*	2	46	92	
Pygmy mouse	*Mus indictus*	6	5	30	
Bushveld elephant shrew	*Elephantulus intufi*	1	42	42	
Sub-total		1220	477	61941	47.79
Birds					
Lark sp.		50	60	3000	
Namaqua sand grouse	*Pterocles namaqua*	8	300	2400	
Cape turtle dove	*Streptopelia capicola*	9	150	1350	
Spotted thick-knee	*Burhinus capensis*	1	320	320	
Namaqua dove	*Oena capensis*	1	42	42	
Sub-total		69	872	7112	2.70
Reptiles					
Common barking gecko	*Ptenopus garrulous*	488	5	2440	
Sand snake	*Psammophis* sp.	5	200	1000	
Giant ground gecko	*Chondrodactylus angulifer*	34	23	782	
Ground agama	*Agama aculeate*	13	25	325	
Kalahari tree skink	*Mabuya occidentalis*	5	10	50	
Sub-total		545	263	4597	21.35
Invertebrates					
Locusts	Order Orthoptera	47	4	188	
Moths	Order Lepidoptera	80	2	160	
Insects (unidentified)		73	2	146	
Formicidae	Order Hymenoptera	5	2	10	
Antlion	Order Neuroptera	3	2	6	
Beetle	Order Coleoptera	2	2	4	
Scorpion	*Opistophthalmus wahlbergii*	5	5	25	
Solifugidae		4	2	8	
Unknown		494	2	988	
Sub-total		713	23	1535	27.93
Total		**2553**	**6260**	**85810**	**100**

26.5 Life history and ecology comparisons

26.5.1 Social organisation and spatial system

Both species are solitary. A maximum of ten adult BFCs were radio-collared simultaneously in summer 1998 in the 60 km² study area, with no further cats sighted, giving an estimated

density of 17 adults/100 km² (Sliwa 2004). During 2005-2006 a total of 10 AWCs were radio collared on the 53 km^2 study area and three non radio-collared cats were regularly sighted, giving a minimum estimate of 25 cats/100 km^2. Mean annual home range sizes, using the 100% minimum convex polygon method (MCP) (Mohr 1947), was 20.7 ± 3.1 km² for five male BFCs, and 10 ± 2.5 km² for seven adult females (Sliwa 2004). Mean annual home range (100% MCP) was 9.8 ± 3.4 km² for four male AWCs, and 6.1 ± 1.1 km² for three females. This suggests that despite their smaller size, BFCs have home ranges 64-111% larger than AWCs between the studies, although this difference could have been due to prey resources.

Resident adult male BFCs' ranges overlapped with up to four different females. Intra-sexual overlap was slight for adult males (2.9%), but considerable for females (40.4%) (Fig 26.5a). Home ranges were relatively stable with mean shifts in range centres from one season to the next of 835 ± 414 m. In addition, the extent of overlap of seasonal ranges of the same individuals was 68 ± 11% (Sliwa 2004). Resident adult male AWCs' range overlapped with up to four different females. Intra-sexual overlap between adult females was 39.8% but only 5.8% between adult male cats (Fig 26.5b). However, when a subadult male was included in the analysis the overlap increased to 9.7%. The social organisation is thus very similar between the two species and both adhered to the 'classical' felid system (Kitchener 1991; Sunquist and Sunquist 2002).

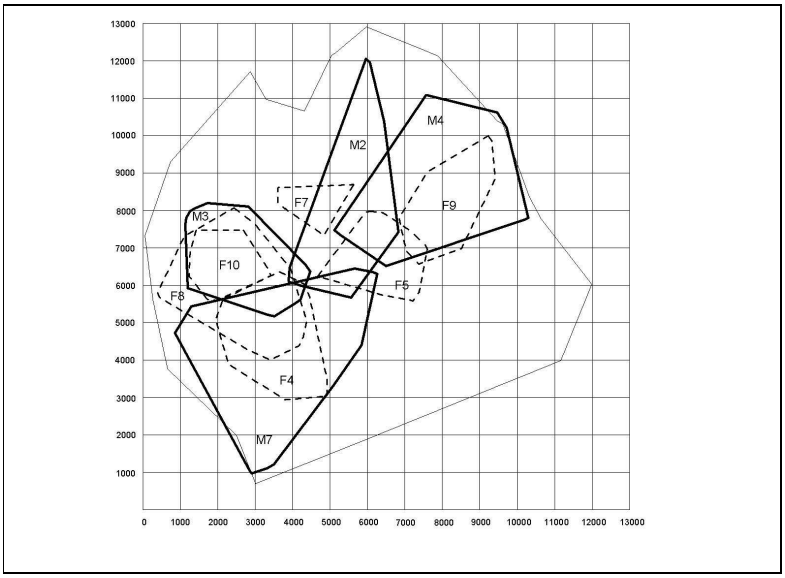

Fig.26.5 (a) 100% MCP home ranges calculated from all records for 10 seasonal ranges of black-footed cats tracked during the summer or non-mating season 1998 (January, February, March) on a 1 km² grid. Outline of the boundary fence of 'Benfontein' game farm given. Males = thick solid lines, females = thin broken lines.

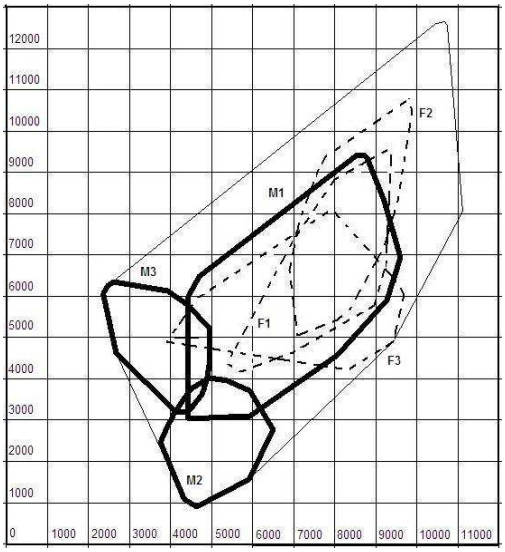

Fig.26.5 (b) 100% MCPs home ranges calculated from all records for 6 seasonal ranges of African wild cats tracked during 2004 and 2005 on a 1 km^2 grid. Outline of overall area of study site given. Males = thick solid lines, females = thin broken lines.

26.5.2 Communication

Female BFC marking frequency varied from no sprays/night to up to 268/night. Males' marking frequencies ranged widely from 0 to 598 sprays/night during the mating season. Adult resident males spray mark regularly (mean = 18 sprays/km) in contrast to non-resident and subadult males who mark only rarely (~1 spray/km) (Sliwa 2004; Sliwa unpublished data). Females left an average of 6.5 ± 10.7 marks/km (range = 0 – 44). Females exhibit urine scent marking patterns depending on their current reproductive state. The highest spray marking frequency (36 sprays/hr) of one female occurred one and a half months before conception of her litter, dropping to a lower frequency (<1 spray/hr) during pregnancy, while being entirely absent when she reared young (Molteno *et al*. 1998). Urine marks were deployed in proportion to intensity of use (Molteno *et al*. 1998). The primary function of urine spraying in females is likely advertisement of reproductive condition and may play an additional role in social spacing (Sunquist 1981).

Female AWCs showed urine spray marking patterns that were related to their current reproductive status. In all cases where females increased spray marking (n = 10) they either had kittens (n = 5) or they were in the presence of a male cat (n = 5). Spraying varied from zero to 50 sprays per observation period (observation period = eight hours or more of continuous following), giving an estimated 3.6 ± 8.7 sprays/km. The primary function of spray

marking for females is probably to advertise their reproductive status to male cats, however, unlike with BFCs, spray marking was still performed by females raising young. Male AWCs show much less spatial and seasonal variation in spray marking than females and spraying ranged from 0 – 183 sprays per observation period and an estimated 13.6 ± 23.5 sprays/km moved. BFCs are seasonal breeders while AWCs seem to be more opportunistic with females already coming into oestrous while they are still suckling kittens. Thus the variation in spray marking between the two species might be explained by a difference in the mating system.

Male BFCs have a surprisingly loud call, reminiscent to that of a large domestic tomcat, with calling bouts spaced 10 to 30 minutes apart (n = 19) between July and December, coinciding with the mating seasons. They usually called after sniffing a urine spray mark, often after demonstrating flehmen. Female 'loud' calling, similar to that of males, was heard only once, when two competing males moved away from her (Sliwa, unpublished data). The 'loud' call probably supplements spray marking, serving both as spacing and attracting mechanisms during the brief female oestrous, lasting for only 36 hours (Leyhausen and Tonkin 1966; Sliwa unpublished data). The tonal frequency is an octave lower than in the larger bodied *Felis* species (Peters *et al*., in press). In addition BFCs utter softer vocalisations while communicating between mother and kittens and during mating between the male and female (Sliwa, unpublished data).

Both male and female AWCs have a loud call which is mostly evident when male cats are calling females and vice versa. The 'prau' call described by Dards (1983) and Leyhausen (1979) is a short, relative high-pitched cry, with a rapid rise in frequency and may be repeated. As with BFCs, 'loud' calling by the male AWCs usually follows after sniffing a urine spray mark followed by flehmen behaviour. The purpose of these calls is possibly to attract, advertise receptiveness or establish spacing between cats (Kitchener 1991). On two occasions male cats uttered a surprising loud whining-singing sound while courting a female. Females may, in addition, call loudly to kittens after returning from a hunt to locate them in dense vegetation. Upon reunion much softer vocalisations and rubbing between the mother and her kittens occurs. Softer vocalisations were also evident during mating between male and female cats. In summary, both species are not very vocal in general and use vocalisations in a similar context, although only in brief periods throughout the year.

26.5.3 Reproduction and mating behaviour

Wild BFCs mate between late July and March, leaving only four months where no mating occurs. The main mating period starts at the end of winter, in July and August (7 of 11 (64%) matings) resulting in litters born in September/October (Sliwa, unpublished data). One or more males follow the female, who is receptive for only 36 hours (Leyhausen and Tonkin 1966; Sliwa unpublished data) and copulate up to 10 times (Sliwa, unpublished data; n = 3 mating sequences). After a 63-68 day gestation period (Schürer 1988; Olbricht and Sliwa 1997) an average of two kittens (1 – 4) are born inside a springhare burrow or hollow termitarium (Smithers 1983; Olbricht and Sliwa 1997). On the day of parturition, females only leave the maternal den for several hours. However, after four days they will have resumed their normal routine of hunting throughout the night only returning at dawn to suckle the kittens (Olbricht and Sliwa 1997), leaving the kittens for up to 10 continuous hours per night. After their first week, kittens are moved frequently, perhaps to reduce the risk of predation. In their second month they start to eat solid food and are weaned at two months (Olbricht and Sliwa 1995). The mother carries prey back to them, both while at the den and later when kittens are left in patches of long grass waiting for her return. Older kittens are presented with live prey that they learn to hunt and kill, as observed in cheetahs (Caro 1994). Kittens become independent at about five months, when their milk dentition is replaced by permanent dentition. Up to two litters may be raised by a female in a year. One female had litters in February and then eight months later in October 1994 (Olbricht and Sliwa 1997; Molteno *et al.* 1998).

For the AWC no clear seasonality in breeding was evident. However, from all litters (n = 15) observed during the study period, eight were conceived during the hot-dry seasons, four during the hot-wet seasons and three in the cold-dry seasons. At the beginning of the study (2003) food availability was low and no litters were conceived for a 14 month period. However after an increase in rodent numbers each female produced up to four litters in a 12 month period. An average of 3 kittens (1 – 5) per litter was born, with kittens being born in dense vegetation, holes in the ground or small crevices in calcrete ridges. Kittens were moved frequently to new dens. They emerged from the den (n = 5) after 7-10 days, not wandering further than a few metres. The mother spent most of her time at the den and made short hunting trips around the den area. As kittens developed the mother stayed away for extended periods, leaving the kittens in dense vegetation or in close proximity to trees. Initially she hunted for herself and returned to the den to suckle the kittens. However as kittens approached five weeks of age she carried live prey back to the kittens. The kittens played and practised their hunting skills on the stunned prey and either ate it or left the dead

prey for the mother, who ate it or covered the remains. Kittens remained with the mother for 2 to 4 months after which they dispersed.

Males spent on average 1.7 ± 0.5 days (n = 6) with a receptive female while chasing, playing and courting. Mating involves grabbing the female by the scruff of neck and the female lunging after successful stimulation (Smithers 1983; Sunquist and Sunquist 2002). Male cats did not assist in the rearing of kittens although they twice visited females with kittens.

26.5.4 Social interactions

For both species of cats very few intra-specific interactions were observed. Adult BFCs of opposite sex met rarely (two incidences) outside the mating season, resulting in a brief nose-to-nose sniff of each other. Agonistic interaction was observed only once between males during the mating season, where the resident cornered and threatened the transient while vocalising, however no physical contact took place. A subadult male encountered an adult female on two occasions, travelled for 300 and 160 m with her while attempting to play. Because a subadult male is unlikely to approach a strange female we tentatively assume this interaction was between a mother and offspring. No such visits were recorded while a female was attending to kittens. A radio-marked subadult male played with another subadult cat on one occasion (Sliwa, unpublished data). In the AWC older kittens did return to the den (n = 3), especially when litters were born shortly after each other, sometimes within a three month period. These older kittens played with the younger siblings (observed in two different litters, in one of which the older kitten returned for three consecutive nights) and joined the mother on hunting forays. On these occasions the mother did not provide prey to the older kitten, who hunted its own prey and the older kitten did not return to the den with the mother. No provisioning of food to younger siblings was observed.

For both species of cats very few intra-specific interactions were observed and AWCs were solitary except for the short periods (2 – 4 months) when females cared for kittens or during the brief mating periods, when males trailed receptive females (1-2 days). Twice male cats visited dens with kittens. The mother remained with the kittens, pulling her ears back and uttering a soft hissing sound after which the male left. Often in encounters (n = 12), AWCs may stare at each other for several minutes at a distance without any interactions after which they walk away from each other. Two males were observed fighting, spitting, scratching and caterwauling after which they ran away from each other. On three occasions the dominant male cat in the study area stalked up to smaller subadult male cats and chased them away.

26.5.5 Inter-specific interactions

On five occasions black-backed jackals circled cornered adult BFCs. Each time the BFC attacked, succeeding in driving the jackal away (Olbricht and Sliwa 1997; A. Sliwa, pers. obs.). However, kittens and inexperienced subadult cats are more likely to be in danger of predation, particularly when two jackals are involved. In the three cases this was observed, both jackals attempted to bite the cat in the back, making it more difficult even for an adult cat to stand its ground, although no incident of killing was directly observed. Black-backed jackals also stole hares (*Lepus* sp) from AWCs on two of the six occasions they were seen to catch one, having being attracted by the noise of the chase through vegetation (as opposed to the sounds of the prey – on only one occasion did a hare cry out loud). Afterwards, the cat successfully took cover in thick vegetation. Although larger mammals such as hares contribute a large amount of food for an AWC, the pirating of kills (kleptoparasitism) by jackals probably contributes to the cats' preference for hunting smaller rodents.

On three occasions in the Kimberley study site, BFCs, on sensing an AWC, squatted low until the AWC passed without detecting them. Recently two radio-marked adult BFCs were reported killed by a caracal and one by black-backed jackal (2007, B. Wilson and J. Kamler, pers. comm.). There were numerous interactions between BFCs with other species resulting in the investigation of the other species or vice versa with no specific outcome, e.g. aardwolf (*Proteles cristatus*), South African hedgehog (*Atelerix frontalis*), springhare, springbok, and even ostrich. Once, a male BFC stole a *Tatera* gerbil kill from a striped polecat (*Ictonyx striatus*), by driving it away. Also a marsh owl (*Asio capensis*) trailed a hunting BFC on three consecutive nights and captured small birds flushed by it (Sliwa 1994).

On five occasions AWCs avoided larger predators (leopards, lions, cheetahs and caracals) by running or hiding from them in dense vegetation. There have been records of caracals and leopards killing and consuming AWCs in the study area (M. Herbst and M.G.L. Mills, pers. obs.). African wild cats chased away Cape foxes and small-spotted genets on rare encounters. A giant eagle owl (*Bubo lacteus*) twice tried to grab a large adult male AWC on his back while the cat was crossing a clearing in the riverbed. The owl was unable to lift the cat and the cat then ran into thick vegetation.

26.5.6 Activity cycle and movement patterns

BFCs were strictly crepuscular and nocturnal, with cats leaving and returning to their dens within 30 minutes of sunset and sunrise (Olbricht and Sliwa 1997). Occasionally, though,

during particularly cold and wet conditions they were seen basking close to their den during daylight. Their activity period varied with the length of the night, according to the season, from 10-14 hours. They were active throughout the night, once they left the den at dusk until they returned to a den at dawn, travelling an average of 662 ± 89 m/hour (Fig. 26.4). Part of their activity involved sitting outside rodent burrows, for between 30-120 minutes and (judging by the constant movement of their ears) poising to pounce. On frequent occasions these longer stationary periods resulted in a successful pounce. BFCs used predominately grassy habitats and were never observed to enter rocky or more densely wooded habitats.

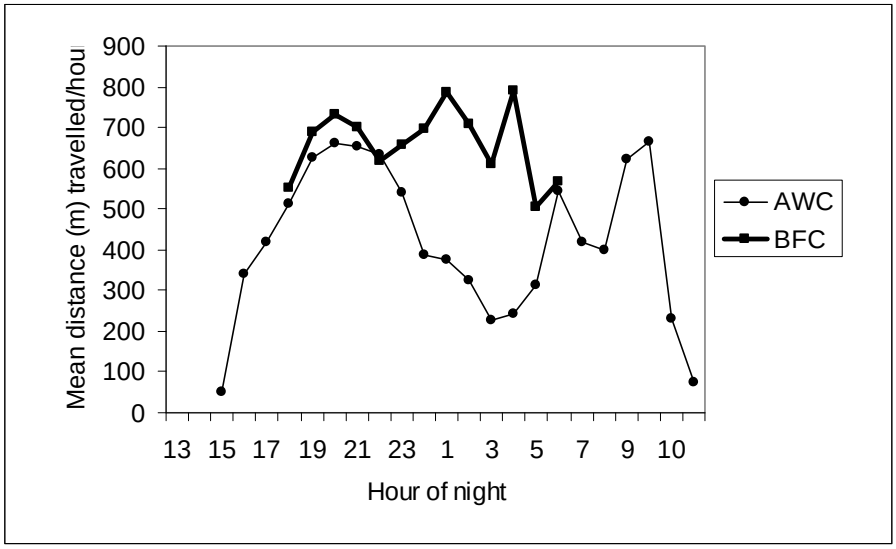

Fig. 26.4 Activity as a function of average distances moved during each hour of the day/night for black-footed cat (BFC; n = 10, 85 nights) and African wild cat (AWC; n = 8, 91 nights).

AWCs were not as nocturnal as generally believed (Smithers 1983; Sunquist and Sunquist 2002) and their activity patterns depend on season and food availability. Typically, they became active as the sun is setting, with a peak activity time between 20:00 and 22:00, followed by a slow decrease in activity in the pre-dawn hours. At dawn there was an increase in activity and they remained active until late in the mornings, especially in winter months (Fig. 26.4). There are periods when cats lie down in front of rodent burrows, waiting for prey to appear. Although the cats may close their eyes, their heads are up and their ears constantly move, remaining alert to the sounds around them (from 344 observations 27% resulted in successful kills, 9% were unsuccessful catching attempts and in 64% no attempts were made). Sometimes the cat would eventually lower the head and spread out laterally, resting and remaining in that position for several hours before continuing to hunt again. In contrast to BFCs, they do not have a shelter to which they return during the day. African wild

cats rest in thick vegetation (47%), in the shade of *Rhigozum* bushes (33%) or holes in the ground, trees, small crevices (16%) or just in the open (4%).

Average distances travelled per night by ten BFCs (5♂♂ / 5♀♀) during 85 nights, where they were continuously observed for their entire activity period, was 8.42 ± 2.09 km (4.42-14.61 km). For eight AWCs (5♂♂ / 3♀♀) on 94 nights the distance was 5.1 ± 3.35 km (1.07 - 17.37 km). So BFCs travelled about 65% further per night than AWCs, and this difference could have been influenced by prey abundance.

26.5.7 Diet

During the BFC study, 1725 prey items were consumed by 17 habituated cats (Sliwa 2006). Average prey size was 24.1 g ± 47.4 g (SD). Males fed on significantly larger prey than did females (8 ♂♂ average = 27.9 ± 53.2 g, n = 795 items; 9 ♀♀ = 20.8 ± 41.5 g, n = 930; Mann Whitney U-test: U = 349244, p = 0.042). Fifty-four prey species (Table 26.1 and Table 26.2) were classified by their average mass into different size classes for mammals, birds, amphibians/reptiles, and for invertebrates. Smaller mammals (5–100 g) constituted the most important prey class (54%) followed by birds (26%) and then larger mammals (>100 g; 17%) (Fig. 26.6a). Males and females took prey size classes at significantly different proportions, most notably for small birds (♀♀ = 21% vs ♂♂ = 13%) and larger mammals (♀♀ = 9% vs ♂♂ = 25%) (Sliwa 2006).

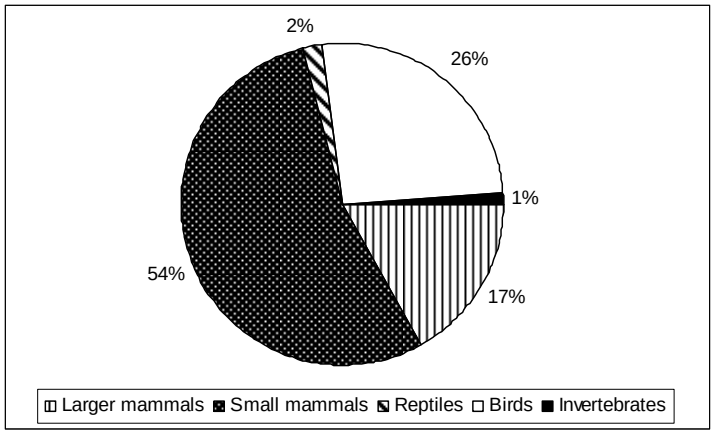

Fig. 26.6 (a) Prey composition from direct observations expressed as percentage of total biomass consumed by black-footed cats, pooled for 5 prey classes and for both sexes combined.

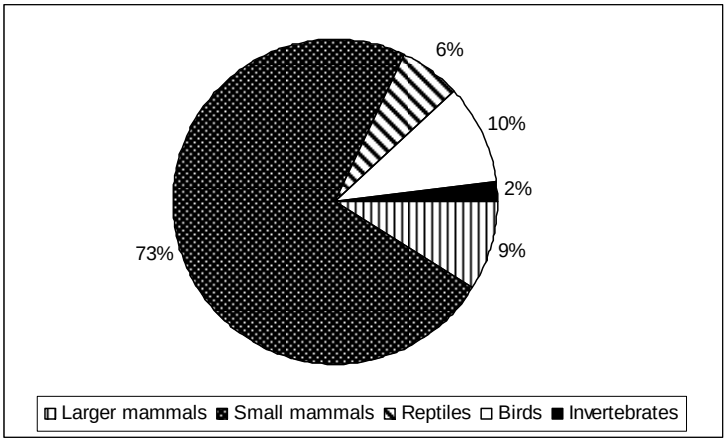

Fig. 26.6 (b) Prey composition from direct observations expressed as percentage of total biomass consumed by African wild cats, pooled for 5 prey classes and for both sexes combined

During the AWC study, 2553 prey items were observed being caught, of which 81% could be identified to one of five food categories (invertebrates, reptiles, birds, small mammals (<500 g), larger mammals (>500 g) and comprising 26 species (Table 26.3). Nineteen percent of the food items were classified as unknown as they were too small and consumed too quickly to be identified, thus data could be biased towards larger food items. From the hot-dry season of 2003 to the cold-dry season 2004 (Sept 2003 – Aug 2004), 97% of these total unknown food items were recorded when rodent numbers were lowest and invertebrate consumption was highest. Excluding unknowns, mammals made up 82% of the cumulative prey biomass consumed (73% small mammals and 9% larger mammals), followed by birds (10%) and reptiles (6%) (Fig. 26.6b). The most frequently captured prey items were small mammals (44%) followed by reptiles (23%). Small mammals almost exclusively consisted of murids with only one recorded insectivore preyed upon (Bushveld elephant shrew, *Elephantulus intufi*). During 1538 hours of observations on eight habituated AWCs, a total of 85.8 kg of prey items were consumed with small mammals contributing to 61.9 kg of the diet. There were no significant difference in the prey size of AWC sexes and both preferred small mammals. AWC females consumed more birds than males (Herbst unpublished data).

For an overall comparison between the diets of the two species, mammals made up 72% of the diet of BFCs compared to 82% of the diet of AWCs, birds made up 26% of the diet of BFCs compared to 10% of AWCs and invertebrates and amphibians/reptiles combined constituted just 2% of the total prey mass consumed by BFCs compared to the 8% for AWCs. With regard to mammals, the most common species taken by BFCs, the 16 g large-eared mouse (*Malacothrix typica*), was considerably smaller than the one most commonly taken by AWCs, the 65 g Brant's gerbil (*Tatera brantsi*). Although the diet composition of

both species rank mammals as the preferred prey item, birds seems to be more important in the diet of BFC than in the AWC. However seasonal prey availability is probably the most important determinant in the percentage of consumption of prey species in both BFC and AWC diet.

26.5.8 Seasonal variation in the diet

For the three 4 month seasons of the year recognised in the BFC study, ectothermic prey items were unavailable during winter, when larger birds and mammals (>100 g) were mainly consumed. Small rodents like the large-eared mouse (*Malacothrix typica*, 595 captures) were particularly important (34.5% of all captures, 23% of total prey mass) for females during the spring and early summer when they were suckling kittens. Male BFCs showed less seasonal variation than females in prey size classes consumed (Sliwa 2006). This sex-specific difference in prey size consumption may ultimately help to reduce intra-specific competition. Despite this difference, the largest part of the diet (57%) of both sexes was made up by small sized prey ((♀♀ = 66% vs ♂♂ =4 9) (Sliwa 2006; Fig. 26.7a).

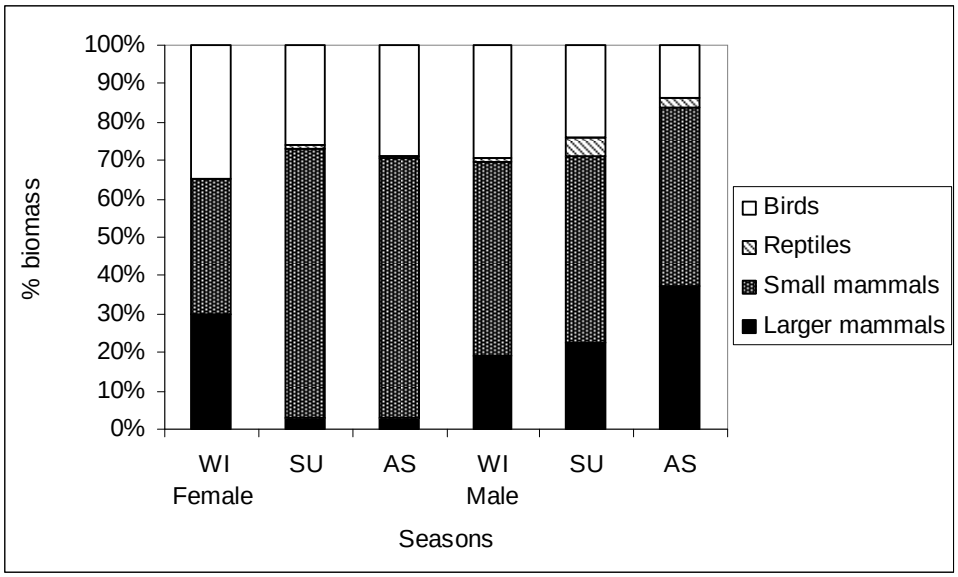

Fig. 26.7 (a) Total prey mass consumed in the four prey categories with percentages larger than 1.5% by male and female black-footed cats across different seasons from visual observations (WI = winter, SU = summer, AS = autumn/spring). Invertebrates were not considered.

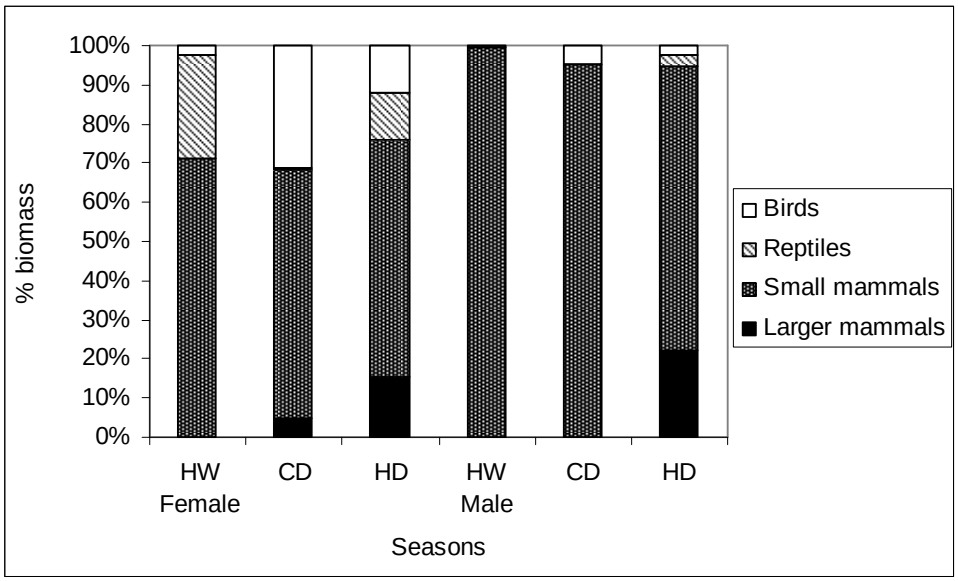

Fig. 26.7 (b) Total prey mass consumed in the four prey categories with percentages larger than 1.5% by male and female African wild cats across different seasons from visual observations (HW = hot-wet, CD = cold-dry, HD = hot-dry). Invertebrates were not considered.

Small mammals and reptiles were the most commonly consumed prey items by AWCs, and combined, these contributed to more than 57% of the prey numbers eaten in each season. Small mammals contributed more than 65% to the cumulative biomass consumed by AWCs over all seasons. During the study, reptiles showed significant seasonal variation, being most common in the hot-wet season (18% of the biomass of the diet of AWC), to less than 1% during the cold months when reptiles are known to hibernate (Branch 1998). The percentage biomass contributed by birds also indicates significant seasonal variation (hot-dry months = 17%, cold-dry months = 1.6%). Because the categories 'Insects', 'Unknown' and 'Other' contributed less than 1.5% to the total prey biomass consumed, these categories were omitted from the analyses. Although the dietary composition for both sexes differed significantly between seasons, small mammals contributed most to the total prey biomass eaten over all seasons (♂♂ = 70% and ♀♀ = 57%) (Fig. 26.7b).

26.5.9 Biomass consumed per distance moved

In order to compare the energy needs for both species we calculated the biomass consumed per night and the distance moved. The average prey mass consumed per night for BFCs was 237 ± 105 g (67 – 611 g) and for AWCs it was 401 ± 358 g (2 - 2250 g). The latter consumed an average of 107.9 ± 133.8 g/km travelled (range 0.94 – 979.9 g) while BFCs consumed only 30.3 ± 17.1 g/km (6.5 – 110.2 g). This translates to an average of 13.7 ± 17.2 (range 1 –

113) prey items captured by AWCs per night compared with 12.4 ± 5.3 (range 2 – 26) captured by BFCs. While the number of prey items caught per night is similar for the species, the difference in biomass consumed per kilometre travelled is 3.5 fold. When this is calculated for the two species per kg body mass, it is 18.9 g/km/kg of cat for BFCs (mean = 1.6 kg body mass for sexes pooled) and 24 g/km/kg for AWCs (mean 4.5 kg), a 38.6 % higher prey mass consumption per km and kg body mass.

During the hot-dry (HD) and hot-wet (HW) seasons, AWCs consumed more biomass per kilometre than during the cold-dry (CD) season (HD = 130.3 ± 177 g/km, HW = 107.8 ± 105.6 g/km, CD = 75.8 ± 48.4 g/km). However during the winter (i.e. CD) months the cats travel further per observation period (eight hours or more of continuous observations) (HD = 4.2 ± 2.5 km, HW = 4.8 ± 4.2 km and CD = 6.5 ± 3.4 km) and they are active over a longer period, including early afternoons and late mornings. BFCs consumed similar biomass per kilometre during all seasons (summer = 31.1 ± 15.7 g/km, winter = 29.5 ± 22.3 g/km, autumn/spring = 30.2 ± 14 g/km). BFCs travelled similar distances in all seasons (summer = 8.9 ± 2.1 km, winter = 8.7 ± 2.3 km, autumn/spring = 7.8 ± 1.8 km).

26.6 Conclusions and recommendations

We compared BFCs with AWCs to see if body size differences might also explain differences in the life history and ecology of these two small felid species (Table 26.4). Observed differences between the species may also reflect the environmental differences of the study areas and also the rainfall patterns of the study periods. Some possible but as yet not fully tested hypotheses are discussed below.

Both cats are mainly nocturnal, however AWCs are more flexible and hunt during daylight. BFCs have a set activity period from dusk till dawn and return to rest mostly within dens during daylight. This may reduce predation risk by diurnal raptors as well as persistent mobbing of BFCs by passerine birds, the latter seen often when they travel at dusk and dawn (Olbricht and Sliwa 1997). Although AWCs in the Kalahari face similar predation risks with even larger predators present, their larger body size may be more advantageous for hunting in daylight hours, possibly being less susceptible to diurnal raptor predation. Alternatively, a more diurnal activity regime might reduce inter-specific competition since the AWC is part of a carnivore guild of various smaller and similar sized carnivores in the Kalahari.

In many predator studies prey abundances and availability have been found to be a crucial factor in facilitating and determining distributions and co-existence (Creel and Creel 1996;

Durant 1998; Karanth and Sunquist 2000). BFCs and AWCs fed mainly on mammalian prey between 5 – 100 g. There was however a difference between the most frequently captured prey species. BFCs hunted mostly large-eared mice (*Malacothrix typica*) (mean = 16 g) (Sliwa 2006), whereas AWCs took Brant's gerbil (*Tatera brantsi*) (65 g). Expressed as prey mass per unit kilogram of cat, BFCs took 10 g of prey and AWCs 14.4 g of prey. Both species consumed a similar number of prey items each night, therefore the fact that the most commonly available rodent eaten by AWCs was larger than that eaten by BFCs resulted in a larger biomass consumed by AWCs. However, when comparing the percentage biomass consumed per unit (kg) body mass of cat, BFCs consumed 14.9% of their body mass per night compared to 8.9% for AWCs. This is probably due to the higher metabolism related to smaller body size in BFCs, and the need to cover longer distances per night to capture enough prey to sustain their energy needs. Despite the strong seasonal variation in biomass consumed per distance moved by AWCs (76-130 g/km), even the lowest prey mass consumed in the cold winter season by AWCs was 2.5 times that consumed by BFCs (30 g/km) (Table 26.4).

The distribution of BFCs may be influenced by the availability and abundance of certain prey species and prey sizes (i.e. the large eared mouse is absent in the Kalahari ecosystem and AWC study site). One could describe the BFC as a habitat specialist that shows a preference for grassland and avoids wooded or rocky areas. It moves further per night, while consuming less biomass per distance than the AWC. This is reflected in the larger annual home ranges and distances travelled per night of BFCs. Alternatively, these differences could have been due to differences in prey abundance between sites.

BFCs consumed more birds (26%) in comparison to AWCs (10%), probably resulting from their smaller size and agility, and being able to conceal themselves better in short vegetation. Thus, a greater abundance of small birds in a habitat may favour BFCs over AWCs. Although we could not compare bird abundance on each site, the body size of a cat may be negatively correlated with hunting success of small birds as demonstrated in the differential hunting success by BFC sexes. However, AWCs may not need to supplement their diet with birds and the larger sized and more abundant rodents might be sufficient for their dietary requirements. During seasons with low rodent numbers in the Kalahari AWCs changed their diet accordingly and took more invertebrates and reptiles during the warmer seasons than BFCs and, to a lesser extent, birds. Seasonal variation in the Kalahari contributed largely to differences in AWC diet and the biomass consumed per night, with less seasonal variation in the BFC study.

Table 26.4 A summary of the ecological and life history traits of African wild cats and Black-footed cats

	Study site	Years data collected	Adult Cats radio collared	Head body size (cm)	Weight (kg)	Resting places	Estimated densities (cats/ 100 km^2)	Home range MCP 100%	Intrasexual overlap	Urine spray marking/ km	Avg litter size (range)	Max litters per year	Activity	Distance travelled per night (km)	Biomass (g) per distance consumed
F. silvestris	Kgalagadi Transfrontier Park, Northern Cape, SA and Botswana	2003-06	♂ = 5 ♀ = 3	♂ = 65 ♀ = 60	♂ = 5.1 ♀ = 3.9	No fixed resting place - dense vegetation or in trees	25	♂ = 9.8 km^2 ♀ = 6.1 km^2	♂ = 5.8% ♀ = 39.8%	♂ = 13.6 ♀ = 3.6	3 (1-5)	4	Mainly nocturnal although active mornings and afternoons	5.1 ± 3.35	401 ± 358/night 108 ± 134/km
F. nigripes	Benfontein, Kimberley, Northern Cape/ Free State, SA	1992-98	♂ = 8 ♀ = 10	♂ = 45 ♀ = 40	♂ = 1.9 ♀ = 1.3	den sites in holes or hollow termitaria	17	♂ = 20.7 km^2 ♀ = 10 km^2	♂ = 2.9% ♀ = 40.4%	♂ = 12.6 ♀ = 6.5	2 (1-4)	2	Nocturnal	8.42 ± 2.09	237 ± 105/night 30 ± 17/km

Source: *Felis nigripes* (Sliwa 1994, 2004, 2006)

Felis silvestris (Herbst unpublished data)

BFCs consumed more birds (26%) in comparison to AWCs (10%), probably resulting from their smaller size and agility, and being able to conceal themselves better in short vegetation. Thus, a greater abundance of small birds in a habitat may favour BFCs over AWCs. Although we could not compare bird abundance on each site, the body size of a cat may be negatively correlated with hunting success of small birds as demonstrated in the differential hunting success by BFC sexes. However, AWCs may not need to supplement their diet with birds and the larger sized and more abundant rodents might be sufficient for their dietary requirements. During seasons with low rodent numbers in the Kalahari AWCs changed their diet accordingly and took more invertebrates and reptiles during the warmer seasons than BFCs and, to a lesser extent, birds. Seasonal variation in the Kalahari contributed largely to differences in AWC diet and the biomass consumed per night, with less seasonal variation in the BFC study.

The AWC was possibly better able to respond reproductively to temporary food restrictions and super abundances than the BFC, although a climatic variation between sites confounds this data. AWCs have larger litter sizes and may raise up to 4 litters per year, while reproduction can fail entirely in years with low prey abundance. Data for comparisons from the BFC is still lacking. AWC mothers take short hunting trips around the den, while female BFCs may need to travel longer distances to capture sufficient prey for their dependent offspring.

26.7 Research gaps in relation to conservation management

Both species were influenced by the presence of competitors and predators. A high density of mesocarnivores like jackals and caracal would both result in harassment, pirating of kills and even intra-guild predation. This has been observed in other predator guilds (Palomares and Caro 1999) specifically between foxes (*Vulpes macrotis, V. velox*, *V. vulpes*) and coyotes (*Canis latrans*) (Moehrenschlager and List 1996) and for large felids between tiger (*Panthera tigris*) and leopard (Seidensticker 1976) and among cheetah, lion and leopard (Caro 1994), but recently also proposed for smaller felid guilds in tropical America comprised of ocelot and oncilla (*Leopardus pardalis*, *L. tigrinus*,) (de Oliveira *et al*., Chapter 27, this volume). In South African farming communities where livestock depredation occurs, densities of jackals and caracals are regulated through predator control. In the protected area of the southern Kalahari there is little interference from human activities and predator numbers are mainly regulated by available food resources (Mills 1990).

Increasing human impact, through population growth and changes in land use patterns (small holdings farming, irrigation, overgrazing), may also affect the two cat species differently. The BFC avoids human contact (Olbricht and Sliwa 1997; Sliwa 2004), while a male AWC radio-monitored in the same study area stayed close to permanent water and human habitation (Sliwa, unpublished data). However, if species like jackals and caracals are removed from small stock farming areas this may be to the advantage of small cats especially the BFC. The AWC seems to have a higher tolerance to human-modified habitats, and may profit from increasing rodent populations associated with farming, however it may also be threatened in its genetic integrity through hybridisation (Nowell & Jackson 1996, Yamaguchi *et al.* 2004b) and disease transfer (Mendelssohn 1989; Macdonald *et al*. 2004) from domestic cats associated with man.

Studies of smaller African felids are in their infancy, especially within their carnivore guild. A number of key questions arise from our comparative research: (1) what are the maximum levels of habitat loss, degradation and fragmentation both species could tolerate? (2) What influences the distribution of the BFC – when does competition pressure from potential predators and competitors become too high, leading to its exclusion from certain areas? (3) Is conservation management for both species similar or mutually exclusive? (4) Could AWCs negatively affect BFC numbers, especially given this behaviour among other felid species?

There is an urgent need for comparative studies of small felids in order to address specific conservation questions. We trust that our studies will both contribute to the basic understanding of BFC and AWC ecology, as well as provide the baseline data for future research and conservation measures for small African felid studies.

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