The feeding habits of the African wildcat (*Felis silvestris cafra*), a facultative trophic specialist, in the southern Kalahari (Kgalagadi Transfrontier Park, South Africa/Botswana)

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Abstract

The seasonal feeding habits of the African wildcat, *Felis silvestris cafra* in the riverbed ecotone of the Kgalagadi Transfrontier Park were investigated over a period of 46 months. The diet was analysed through visual observations on eight habituated (three female and five male) radio-collared wildcats, supplemented with scat analysis. Murids formed the bulk of the biomass in the diet (73%), followed by birds (10%) and large mammals (> 500 g) (9%). Although reptiles (6%) and invertebrates (2%) were frequently caught they contributed less to the overall biomass of the diet. There were significant seasonal differences in the consumption of five food categories that related to changes in availability. Fluctuations in prey abundances could be the result of seasonal rainfall and temperature fluctuations, or long term variability in rainfall resulting in wet and dry cycles. As predicted the lean season (hot-dry) was characterised by a high food-niche breadth and high species richness. Despite sexual dimorphism in size in the African wildcat, both sexes predominantly fed on smaller rodents, although there were differences in diet composition with males taking more large mammals and females favouring birds and reptiles. These results indicate that African wildcats are adaptable predators that prefer to hunt small rodents, but can change their diet according to seasonal and longer-term prey abundances and availability.

Keywords: African wildcats, *Felis silvestris cafra*, feeding habits, diet, prey abundances, southern Kalahari

Introduction

The African wildcat, *Felis silvestris cafra* (Forster, 1780) has a substantial geographical range, stretching throughout the African continent, it is only absent from tropical forests and true deserts (Nowell & Jackson, 1996). In many parts of its range it is a common small predator (Stuart, 1981) with a very broad habitat tolerance (Skinner, Chimimba & Smithers, 2005). Despite its wide distribution, the African wildcat, like most small felid species (Nowell & Jackson, 1996), has not been well studied. Understanding the natural history of a species in its natural environment is important when formulating conservation and management strategies. This study provides a detailed description of the seasonal food habits of the African wildcat, based on direct observations in the southern Kalahari.

Discussions on whether to classify predators as generalists or specialists are widespread in the ecological literature (Futuyama & Moreno, 1988). Predators tend to be generalist hunters when the abundance of profitable prey is low, becoming more specialised when prey abundance increases (Pyke, Pulliam & Charnov, 1977). An obligatory trophic specialist, for example the aardwolf (Richardson, 1987) almost exclusively feeds on one species, regardless of abundance or whether other alternative prey is available, whereas a facultative specialist may be more opportunistic and changes its primary prey item when other profitable prey is available (Glasser, 1982). The prey composition in the diet of a generalist hunter would be expected to show seasonal variation, depending on the abundance and availability of the prey species (Pyke *et al.*, 1977).

Classical optimum foraging theory predicts that the diet of a facultative specialist will be more diverse during lean seasons than during abundant seasons, in response to the decreased availability of preferred food types (Perry & Pianka, 1997). This may lead to seasonal modifications in activity and foraging behaviour to satisfy their nutritional needs (Gittleman & Thompson, 1988; Gedir & Hudson, 2000). In addition, several predatory animals show sex specific preferences for prey size. This is particularly apparent in felids, such as bobcat, *Lynx rufus* (Fritts & Sealander, 1978; Litvaitis, Clark & Hunt, 1986), Eurasian lynx, *Lynx lynx* (Molinari-Jobin, Molinari, Breitenmoser-Würsten & Breitenmoser, 2002) and cheetah, *Acinonyx jubatus* (Mills, du Toit & Broomhall, 2004).

Numerous studies have investigated the feeding habits of the European wildcat (*Felis silvestris*). These include populations occurring in: Scotland (Hewson, 1983); France (Condé, Nguyen-Thi-Thu-Cuc, Valliant & Schauenberg, 1972); the Apennines (Ragni, 1978); the Iberian Peninsula in Portugal (Sarmento, 1996; Carvalho & Gomes, 2004); Spain (Gil-Sánchez, Valenzuela & Sánchez, 1999; Moleón & Gil-Sánchez, 2003; Malo, Lozano, Huertas & Virgós, 2004); Hungary (Biró, Lanszki, Szemethy, Heltai & Randi, 2005) and in the Carpathians (Kozena, 1990; Tryjanowski, Antczak, Hromada, Kuczynski & Skoracki, 2002). Most of these studies concluded that the preferred prey for wildcats are murids and that they may be classified as facultative specialists on different prey items depending on prey availability (Aurelio, Lozano, Huertas & Virgós, 2004; Lozano, Moleón & Virgós, 2006). In contrast, limited information is available on the feeding habits of the African wildcat, although it is reported that murids resembles the major component of their diet (Smithers, 1971; Stuart, 1977; Smithers & Wilson, 1979; Palmer & Fairall, 1988).

The feeding habits of the African wildcat are analysed by examining (i) the prey composition and overall diet, (ii) the seasonal and/or annual variation in overall prey composition and potential increase in diet variety in response to seasonal changes in food availability, (iii) sexual size dimorphism and differences in relation to prey type, foraging strategies, and consequently niche partitioning between wildcat sexes. Finally, a general comparison is drawn between feeding habits of the African wildcat and European wildcat.

Materials and methods

1. Study area

The study was conducted from March 2003 to December 2006 (46 months) in the Kgalagadi Transfrontier Park (KTP). The main study area (53 km^2) was along the southern part of the Nossob riverbed and surrounding dune areas (Fig. 1). The KTP, shared between South Africa and Botswana, is a 37,000 km^2 area in the semi arid southern Kalahari system, although our study area only included cats in the riverbed ecotone.

The vegetation of the Kalahari is described as the western form of the Kalahari Duneveld comprising an extremely open scrub savanna (Mucina & Rutherford, 2006). For the purpose of this study, four main habitat types were identified: (i) the dry riverbed, (ii) the calcrete ridges, (iii) the adjacent *Rhigozum* veld, and (iv) the sandy dune areas. For more detailed descriptions of the vegetation see Bothma & De Graaf (1973) and van Rooyen, van Rensburg, Theron & Bothma (1984).

2. Climate and rainfall

The study site is characterised by low, irregular annual rainfall (Mills & Retief, 1984) and receives between 200mm and 250mm annually. The irregularity of the rainfall plays a major role in the vegetation of the KTP (Leistner, 1967) and these cycles influence the availability of food and animal movement patterns (van Rooyen, 1984). According to Nel and colleagues (1984), rodent numbers in the Kalahari fluctuate between seasons with a slow build up as rainfall increases following by sudden decreases. Variation in seasonal temperatures and factors such as rainfall, seed production and vegetation cover are involved in the fluctuations of rodent species and numbers.

Three seasons are recognized in the KTP: (i) A hot-wet season (HW) from January to April, characterised by mean monthly temperatures equal to or greater than 20ºC, with 70% of the annual rainfall falling; (ii) a cold-dry season (CD) from May to August with mean monthly temperatures below 20ºC and little rainfall and (iii) a hot-dry season (HD) from September to December with monthly temperatures approximately 20ºC and generally not more than 20% of the annual rainfall (Mills & Retief, 1984).

Monthly rainfall records for the weather station at Twee-Rivieren rest camp (26°28'17.7"S, 20°36'45.2"E), approximately 15km to the south-west of the study site were used (South African Weather Bureau). The first year of the study (2003) was a year with below average rainfall with 122 mm recorded. All subsequent years (2004 – 2006) had average or above average rainfall (272 ± 41 mm per annum).

3. Data collection

Behavioural observations

African wildcats were either caught in cage traps or by the use of a dart gun (Herbst & Mills in prep). After a radio collar was fitted the cats were followed from a vehicle at a distance of 50 to 100 meters using the radio signal while they were being habituated to the vehicle. Visual contact was re-established until the cats could be followed from 10 - 30 meters without any obvious influence on their behaviour. During the course of the study 1538 hours were spent observing habituated cats (Table 1). Cats were selected on a rotational system and followed for an average of 6.0 ± 3.2 hours of observation periods (range 1 to 14 hours). Thick vegetation and long grass sometimes precluded direct visual contact with the cats for short periods.

All hunting and feeding activities were recorded and timed to the nearest minute. The term hunting attempt is subjectively defined as any interaction between an African wildcat and a potential prey animal, where the cat moved towards the prey with considerable interest, caution and/or increased speed. A 1,000,000 candle power spotlight was occasionally used during night observations, although the vehicle's lights were usually sufficient to allow observations and record prey type. The beam of the spotlight was aimed slightly behind the cat to avoid illuminating the cat or prey item.

An observational study on a predominantly nocturnal animal, like the African wildcat, unavoidably has certain limitations (Sliwa, 2006). The disturbance caused by vehicle noise and light may have influenced the outcome of some hunts, particularly where larger prey species for example hare (*Lepus* sp.), springhare (*Pedetes capensis*) and spotted thick-knee (*Burhinus capensis*) were involved. Hunts could have been affected both positively for the cats where prey were blinded by lights and caught more easily, or negatively where prey were startled into fleeing, disrupting a stalking approach by a cat. Such effects are difficult to quantify, but we believe that our results show a slight bias against larger prey and that smaller prey such as mice was unaffected since cats often waited at a hole for a mouse to emerge without the spotlight being used.

Rodent trapping

Rodent trapping was conducted to assess seasonal changes in relative abundance (R_a). On four consecutive nights, once during every season, two grids were set in each of the four habitats. Each grid consisted of 49 Sherman traps (7 x 7 traps) set ten meters apart. Traps were checked each morning; they were closed during the day due to high daytime temperatures and opened approximately two hours before sunset. The traps were re-baited every afternoon with a mixture of peanut butter, oats and vegetable oil. All rodents captured were marked with a spot of purple ink before being released, to ensure identification of recaptures (Begg, Begg, du Toit & Mills, 2003). Data for each trapping period were pooled for statistical analyses. The R_a was expressed as the number of individuals caught per 100 trap nights during the trapping period. Recaptures were excluded.

Transect lines: diurnal rodents, reptiles and birds

To monitor seasonal variation in diurnal reptile, bird and rodent, especially whistling rat (*Parotomys brantsii*) numbers, 5 x 100m transect lines in each of the habitats were walked over four consecutive days during each of the three seasons (hot-wet, hot-dry and cold-dry). All rodents, reptiles and birds were recorded.

Prey categorisation

Prey items recorded through direct observations were summarised into seven categories: large mammals (500 - 2000g), small mammals (<500g), birds, reptiles, insects, unknown and other (scorpions and solifugeds). Identification of rodents to the species level was often difficult, as they were consumed whole. Where it was possible to identify a rodent the average body mass of that species presented in the literature was used (Begg *et al*., 2003; Skinner *et al*., 2005). Where rodents could not be identified they were collectively grouped as: *Rodents*, and the body mass used was 50g (calculated as the average body mass of all identified rodent species eaten). The body mass estimates for reptiles, birds and invertebrates were obtained from Begg *et al*. (2003). For prey composition analyses, the three categories: insects, unknown and other were pooled into a single category, *Invertebrates*, to simplify analyses and assigned a mass of 2g.

Prey items are presented as percentage frequency (i.e. the number of food items caught as the percentage of the total number of food items caught) and percentage biomass. The biomass of individual prey items in each prey category was summed to provide an estimate of the biomass contribution of each food category in each season.

4. Scat analysis

Scat analyses of 52 samples were used to supplement observational feeding data in an attempt to determine unidentifiable prey items. Scats were collected opportunistically while following a focal animal, placed in a brown paper bag, numbered and air dried. Scat analyses followed the methodology of Putman (1984) and Reynolds & Aebischer (1991). The scat was washed in water over a sieve to separate undigested remains and dried for two days in an oven at 30°C. The undigested remains were separated into a Petri dish and teeth, jaw fragments, bones, feathers, non-digestible plant material and other identifiable remains were separated from the remainder of the scat, which was predominately hair. No attempt was made to identify hair remains. To study the variation in diet composition, the remains were pooled into sub-categories of: large mammal remains, small mammal remains, bird, reptile, invertebrates and plant material. The data were analysed as percentage frequency of occurrence (number of times food category is present in sample/total number of scats analysed x 100) and percentage of occurrence (number of times food category is present/total number of occurrences of all food items x 100) (Manfredi, Lucherini, Canepuccia & Casanave, 2004).

5. Statistical analysis

An index of dietary diversity for each season from observational data was calculated using Levin's formula for niche breadth (Erlinge, 1981; Lode, 1994): $N_B = 1 / \Sigma p_i^2$ where p_i = the proportion of observations in food category i of the diet. Results for males and females are presented combined as well as separately. Differences between sexes were tested using the Chi Square test of statistical significance for bivariate tabular analysis (χ^2) (Siegel, 1956). The Spearman Rank correlation coefficient (r_s) was used to investigate relationships between prey abundance and their percentage contribution to diet and small mammal, insect and reptile consumption. The statistical package *Statistica 7.1* (Statsoft, Inc. 1984-2006) was used for all tests, with significance set at $P < 0.05$ for the two-tailed tests.

Results

1. Overall diet and prey composition

During the study 2553 prey items were observed to be caught by African wildcats, of which 81% could be identified to one of the five food categories and comprising 26 species (Appendix 1). Nineteen percent of the food items were classified as unknown as they were too small and consumed too quickly to be identified. Rodents, reptiles and invertebrates had the highest percentage occurrence in the scats of African wildcats (Table 2) and confirm visual observations where rodents, insects and reptiles had the highest percentage occurrences.

Vertebrates

Mammals made up 82% of the cumulative prey biomass consumed (73% small mammals and 9% large mammals), followed by 10% birds and 6% reptiles. The remaining 2% consisted of invertebrates (Appendix 1). The most common prey items captured were small mammals (44%) followed by reptiles (23%) (Appendix 1). Small mammals almost exclusively consisted of murids with only one recorded insectivore, a Bushveld elephant shrew (*Elephantulus intufi*).

Invertebrates

Invertebrate prey was difficult to identify from visual observations. Scat analyses suggest that the majority of unidentifiable prey items may be included in the invertebrate category (Table 2). If insects, other and unknown prey items are pooled into the single category *Invertebrates*, they contribute 30% to the total number of prey items caught. However, only 2% of the total biomass of the diet of African wildcats comprised invertebrates (Appendix 1).

Plant material

On two occasions cats were observed to consume vegetal material, grass (*Eragrostis* sp.) and leaves of the unpalatable *Radyera urens*. Plant material was not included in the analysis although it was frequently found in the scats of African wildcats (42.3% frequency of occurrence) (Table 2). The nutritional value of plants is very low (Kozena, 1990; Moleón & Gil-Sánchez, 2003) and ingestion could have been both incidental (plants sticking to the prey or content of the digestive tract of prey) and intentional, either to supplement micronutrients, or to aid digestion and regurgitation of indigestible parts, particularly fur (see Sladek (1972) in Kozena (1990)).

2. Seasonal variation in the diet

When combining data for male and female cats, Levin's measure of niche breadth, as well as species richness were highest in the hot-dry and hot-wet seasons with the cold-dry season the lowest. This is in contrast with optimal foraging theory since it is expected that niche breadth and species richness should be higher in the cold season. However, when the lean period (the cold-dry season from 2003 to the end of the hot-wet season in 2004 (Fig. 2)) was excluded a dramatic decrease in Levin's measure of niche breadth in both the hotter seasons of the year was detected (Table 3).

Small mammals and reptiles were the most numerous prey items and together contributed more than 57% of the prey numbers eaten in each season (Table 4). Small mammals contributed to more than 65% of the cumulative biomass consumed by

African wildcats in any season, but show significant variation between seasons (χ^2 = 275.26, d.f. = 2, P < 0.001) (Table 4). The frequency of reptile consumption also showed significant seasonal variation, being most common in the hot-wet season (χ^2 = 326.01, d.f. = 2, P < 0.001) when they contributed 18% to the biomass of the diet, compared to less than 1% during the cold months.

The percentage biomass contributed by birds ranged from 17% during the cold-dry months to 1.6% in the hot-wet season also indicating significant seasonal variation (χ^2 = 75.95, d.f. = 2, P < 0.001). During the hot-dry season birds and reptiles contributed 12.8% to the overall biomass of the diet of African wildcats. Although the relative frequency of unidentifiable prey items was high, especially during the hot seasons, the contribution to the total biomass cat's diet was low (< 4%).

No significant seasonal variation was observed in large mammals (χ^2 = 2.51, d.f. = 2, P = NS). Large mammals were rare in the diet (<1%) (Table 4). Four out of 16 hunting attempts on large mammals were successful and contributed 9% to the total biomass of prey consumed.

Insects, other (scorpions, solifugeds) and unidentifiable prey items (all invertebrates) did not contribute more than 4% of total prey biomass in any single season (Table 4). Almost all unidentified prey items (97%) observed during the study was recorded within a single year between the hot-dry season of 2003 and the cold-dry season of 2004. During this period, rodent numbers were at their lowest (Fig. 2). In addition, the consumption of these three categories showed significant seasonal variation (insects: χ^2 = 93.51, d.f. = 2, P < 0.001; other: χ^2 = 147.06, d.f. = 2, P < 0.001; unknown: χ^2 = 86.61, d.f. = 2, P < 0.001), being most highest during the hot-wet and hot-dry seasons.

3. Influence of changes in prey availability in the diet

Although the consumption of small mammals varied markedly during the course of the study, no clear seasonal pattern was evident. The study period (2003 – 2006) was characterised by initial low rodent densities followed by an increase in numbers when rainfall was higher and a slight decline in numbers towards the end (Fig. 3).

Reptile, insect and bird consumption were significantly negatively correlated with the consumption of small mammals during each season of the study (insects: $n = 11$, $r_s = -0.69$, $P < 0.05$; reptiles: $n = 11$, $r_s = -0.73$, $P < 0.05$; birds: $n = 11$, $r_s = -0.64$, $P < 0.05$; Fig. 4). However, the cold-dry season of 2003 showed a different trend in bird consumption. At that time the only radio-collared cat spent most of her time hunting close to a waterhole, where she caught birds perching on the side of the reservoir or birds sitting around the waterhole. Once the rains came, she remained around the water hole but changed her diet to rodents (Herbst unpubl. data). For all radio collared cats the consumption of birds was negatively correlated with rainfall ($n = 11$, $r_s = -0.67$, $P < 0.05$), however, none of the other food categories were.

Between the cold-dry season of 2003 and the hot-wet season of 2004, rodent numbers were low and small mammals contributed less than 10% of the percentage prey caught. During this time reptiles and insects increased in importance as prey items (Fig. 4). From the cold-dry season of 2004 until the end of the hot-dry season in 2006, small mammals made up more than 64% of the total diet of African wildcats and contributed more than 68% of the biomass in each season, with a dramatic reduction in other prey selected.

4. Sexual differences in body size and diet of African wildcats

Body size

African wildcats show distinct differences in the body mass of sexes, with males being 31% heavier than females. In addition, males exhibit significantly longer head body length and Hf s/u (hind foot, *sine unguis*) than females (Table 5).

Diet

Small mammals and reptiles were the two most important prey items for both sexes and when combined contributed more than 55% of the prey items in both males and females (Table 6). Small mammals were also the largest contributors to cumulative biomass consumed (males 85%; females 63%). Larger mammals were the second-most important contributor to total prey biomass in the males' diets (11%) but were unimportant for females (only one of the 16 hunting attempts on large mammals was by a female). Birds were the second-most important contributor to total prey biomass in females (15%) (Table 6).

In all seasons, the prey diversity was higher for females than males (Table 7). For both sexes the highest prey diversity was in the hot dry season (males = 1.73 and females = 3.86). Females exhibited the lowest niche breadth index in the cold dry season, whereas for males the niche breadth index in the hot wet and cold dry seasons was similar.

Discussion

The African wildcat (*F. s. cafra*) is a medium-sized carnivore in the KTP and, similar to its European counterpart *F. s. silvestris,* prefers to prey on smaller rodents. It is able to supplement its diet with a range of prey species (insects, birds and mammals) (Sarmento, 1996; Moleón & Gil-Sánchez, 2003; Malo *et al.*, 2004). In the KTP, prey abundance fluctuates markedly and the cats are able to change their diet according to these changes in prey numbers.

Optimal foraging theory predicts that a predator will choose a prey type that maximises the energetic benefit to the individual in the minimum required time (Perry & Pianka, 1997). Prey abundance, their activity cycles (Zielinski, 1988), accessibility and energy contribution are all important factors that influence prey choice and optimal hunting strategy. These prey parameters are, in turn, influenced by seasonal and annual weather conditions. This appears to be the case for African wildcats in the Kalahari ecosystem. Our initial investigations of annual seasonal differences (hot-wet, cold-dry and hot-dry seasons) were inconsistent. However, when we characterised our early study period (2003 and beginning of 2004) as a lean cycle with below average rainfall and low prey abundances and the latter period (mid-2004 to the end of 2006) as an abundant period a clearer picture emerged. Excluding the lean period leads to a decline in Levine's niche breadth index. Thus our results confirm the optimal foraging theory for African wildcats, as generalists and opportunistic hunters. These predators shift their diet according to food availability. Similar shifts have been documented in other small feline studies (Moleón & Gil-Sánchez, 2003; Malo *et al.*, 2004; Sliwa, 2006). Our results show rodents are the preferred prey item, with the highest contribution to biomass consumed throughout the year. The African wildcat thus fits the description of an intermediate specialist carnivore with a likely facultative trophic strategy (Glasser, 1984). Alternative prey items, especially reptiles and birds, change in importance depending on temperature, rainfall variability and consequently rodent abundance.

When rodent densities were low, they were eaten less frequently and the wildcats shifted to less profitable (Konecny, 1987) prey items, in particular reptiles, invertebrates and birds. This switch is apparently not due to a change in the abundance of the less profitable prey item but rather resulting from a decrease in the abundance of the preferred prey. This was evident at the start of the study when small rodent numbers were low and consumption of alternative prey was accordingly high. Following a wet period (2004) and a consequent increase in the abundance of rodents, there was a dramatic shift in the diet to small mammals (cold-dry season of 2004) despite reptiles still being readily available.

An increase in reptile and invertebrate consumption during the warmer months of the year coincides with increased activity of ectotherms and hence, greater availability of alternative prey (Branch, 1988; Begg *et al*., 2003). Of interest is the seasonal shift between bird and reptile consumption. Reptiles contribute greatly to overall biomass consumed by African wildcats, while during cold seasons, cats seem to increase bird consumption. It appears that birds are a substitute prey in colder months when reptile activity is low.

Although large mammals represent a low frequency (<1%) in the diet of wildcats, they contributed 9% to the total biomass of prey consumed, ranking them third after small mammals and birds. Therefore, from an energetic perspective, larger prey might be profitable to hunt. It has been estimated that a wildcat weighing 4 – 5kg needs a daily food intake of 1000g (Carbone, Mace, Roberts & Macdonald, 1999; Malo *et al*., 2004). One hare (*ca.* 1500g) is the energetic equivalent of nearly 20 rodents, and exceeds a cat’s daily energetic requirement. Rabbits are an important component of the diet of European wildcats in France and central Spain (Corbett, 1979; Sunquist & Sunquist, 2002; Malo *et al*., 2004).

However, other factors such as catching effort is important (Stephens & Krebs, 1986) and catching rodents may be, proportionate to their smaller size, less energetically demanding than capturing a hare. While rodents can be captured by pouncing, fleeing hares have to be chased, and upon capture, bitten at the nape of the neck and violently shaken until dead. There is also the increased risk of losing the kill of a larger mammal to competitors as two of the six kills were lost to jackals.

Male African wildcats are significantly larger than females and although small rodents were the dominant prey item for both sexes, sexual differences in diet composition were found, both in the frequency of species taken, as well as in the ranking of prey categories. Large mammals were ranked second in male cats' diets, whereas smaller prey items such as birds and reptiles contributed more to the females' diets. It seems that females concentrate on smaller prey, and therefore have a more diverse diet, whereas the larger males can hunt larger prey. This has been explained as a possible means of reducing intra-specific competition between sexes (Fritts & Sealander, 1978; Litvaitis *et al.*, 1986; Sliwa, 2006). Females, burdened with the high energy demands resulting from pregnancy, lactation, and provisioning for kittens may well benefit from more profitable, larger prey, but may lack the ability and strength to do so. A more diverse diet of smaller prey species may thus be a more optimal feeding strategy for them.

In conclusion, African wildcats are generalist and opportunistic predators that exhibit a wide dietary niche breadth. They also show evidence of sexual separation in diet composition reflected in selection of larger prey by the larger males, and greater utilisation of more numerous prey items by the smaller females. African wildcats adapt their hunting strategies according to annual and seasonal changes in prey abundances and availability. Small mammals, especially rodents comprised the bulk of the diet, while birds, reptiles and invertebrates increased in importance when rodent numbers were low. The understanding of these changes is important for the interpretation of multiple predator-prey interactions.

Acknowledgements

This research was supported by the Endangered Wildlife Trust's Carnivore Conservation Group (South Africa), the Elizabeth Wakemen Henderson Charitable Foundation, the Mammal Research Institute and the Molecular Ecology and Evolution

Program (Department of Genetics) at the University of Pretoria, the National Research Foundation (South Africa), the Kaplan Awards Program from Wildlife Conservation Society and the Skukuza Marathon Club. We thank South African National Parks (SANParks) and the Department of Wildlife and National Parks, Botswana for permission to conduct the study in the Kgalagadi Transfrontier Park.

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Table 1 Time periods and total hours of direct observation of individual habituated cats for the duration of the study (Seasons and year indicated: CD = cold-dry, HD = hot-dry, HW = hot-wet and *n* = observation periods)

Cat ID	CD 2003	HD 2003	HW 2004	CD 2004	HD 2004	HW 2005	CD 2005	HD 2005	HW 2006	CD 2006	HD 2006	Hours
♀ VL01654	■	■	■	■	■	■	■	■	■	■		578
♀ VL01656		■	■	■	■	■	■	■	■			245
♀ VL01658					■	■						70
♂ VL01662				■	■	■	■	■	■	■	■	281
♂ VL01665							■	■	■	■	■	157
♂ VL01667									■	■	■	60
♂ VL01672										■	■	55
♂ VL01673										■	■	92
Hours	59	168	152	128	185	109	75	56	109	263	234	1538
	n = 11	*n* = 26	*n* = 18	*n* = 29	*n* = 33	*n* = 8	*n* = 22	*n* = 5	*n* = 23	*n* = 31	*n* = 33	

Table 2 Frequency of occurrence of the main food categories in the scats of African wildcats (scat: *n* = 52)

Food category	Percentage frequency of occurrence	Percentage of occurrence
Large mammals	3.8	1.5
Small mammals	88.5	33.4
Reptiles	69.2	26.3
Birds	3.8	1.5
Insects	50	19
Solifuges	5.8	2.2
Plant material	42.3	16.1
Total		100

Table 3 Seasonal differences in the niche breadth (Levin's niche breadth) and species richness of the diet of African wildcat (male and female pooled) in the KTP

	Season		
	Hot-wet	Cold-dry	Hot-dry
Niche breadth	3.0	1.4	3.5
Niche breadth (excluding lean season)	1.1	1.3	1.6
Species richness	20	16	23

Table 4 Seasonal differences in diet, expressed as percentage presence and percentage biomass contributed by each prey category to the overall diet of African wildcats in the KTP (CD = cold-dry, HD = hot-dry, HW = hot-wet) from direct observations

Prey category	Prey consumed					
	% Frequency			% Biomass		
	CD	HD	HW	CD	HD	HW
Large mammals	0.2	0.3	0	2.3	18.6	0
Small mammals	83.6	42.3	22.4	80.2	65.9	75.7
Reptiles	1	14.9	45.4	0.2	6.6	18.1
Birds	8.3	2.2	0.2	17	6.2	1.6
Insects	2.3	15.6	4.7	0.2	1.1	0.9
Other	0	0.7	0.1	0	0.1	0.04
Unknown	4.6	24.1	27.2	0.2	1.5	3.6

Table 5 Mean and standard deviation (SD) of standard body measurements of male and female African wildcats in the KTP. Total body length (head body length + tail), Hf s/u (hind foot)

	♂ Overall (*n* = 13)	♀ Overall (*n* = 9)	Two-tailed *t*-test	
Measurement	Mean ± SD	Mean ± SD	*t* - value	
Total body length (mm)	99.4 ± 4.18	94.8 ± 6.24	2.09	$P < 0.05$
Head – body length (mm)	64.6 ± 2.63	60.4 ± 3.85	3.09	$P < 0.05$
Tail (mm)	34.7 ± 2.46	34.4 ± 3.15	0.31	NS
Hf s/u (mm)	15.7 ± 0.46	14.7 ± 0.74	4.11	$P < 0.001$
Ear (mm)	7.1 ± 0.49	7.1 ± 0.55	0.13	NS
Mass (kg)	5.3 ± 0.67	4.0 ± 0.43	5.22	$P < 0.001$

Table 6 Sexual differences in the diet of African wildcats from direct observations (five male and three female) in the KTP expressed as the percentage frequency and percentage biomass contributed by each prey category to the overall diet and ranked accordingly (*n* = total food items). The niche breadth index and species richness of male and female diets are indicated

Prey category	Female diet (*n* = 1649)				Male diet (*n* = 712)				χ^2 (d.f. = 5)	χ^2 (d.f. = 5)
	% Frequency	Rank	% Biomass	Rank	% Frequency	Rank	% Biomass	Rank	% Frequency	% Biomass
Large mammals	0.12	6	6.97	4	0.28	6	11.45	2	-	-
Small mammals	26.32	3	63.46	1	85.53	1	83.45	1	$P < 0.001$	$P < 0.01$
Reptiles	28.87	2	10.41	3	8.85	2	1.64	4	$P < 0.001$	$P < 0.01$
Birds	3.34	5	15.30	2	1.69	4	3.26	3	NS	$P < 0.01$
Insects	12.07	4	1.30	6	2.11	3	0.15	5	$P < 0.001$	$P < 0.01$
Unknown	29.29	1	2.58	5	1.54	5	0.05	6	$P < 0.001$	$P < 0.01$
Niche breadth	2.91				1.35					
Species richness	26				18					

Table 7 Seasonal differences in diversity (Levin's niche breadth index) and species richness of the diet of male and female African wildcats separately (HW = hot-wet, CD = cold-dry, HD = hot-dry)

	Season		
	HW	CD	HD
Male	1.03	1.07	1.73
Female	2.97	2.21	3.86
Species richness ♂	8	10	19
Species richness ♀	17	15	24

Appendix 1

Prey items captured by African wildcats 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 wildcats. 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**		

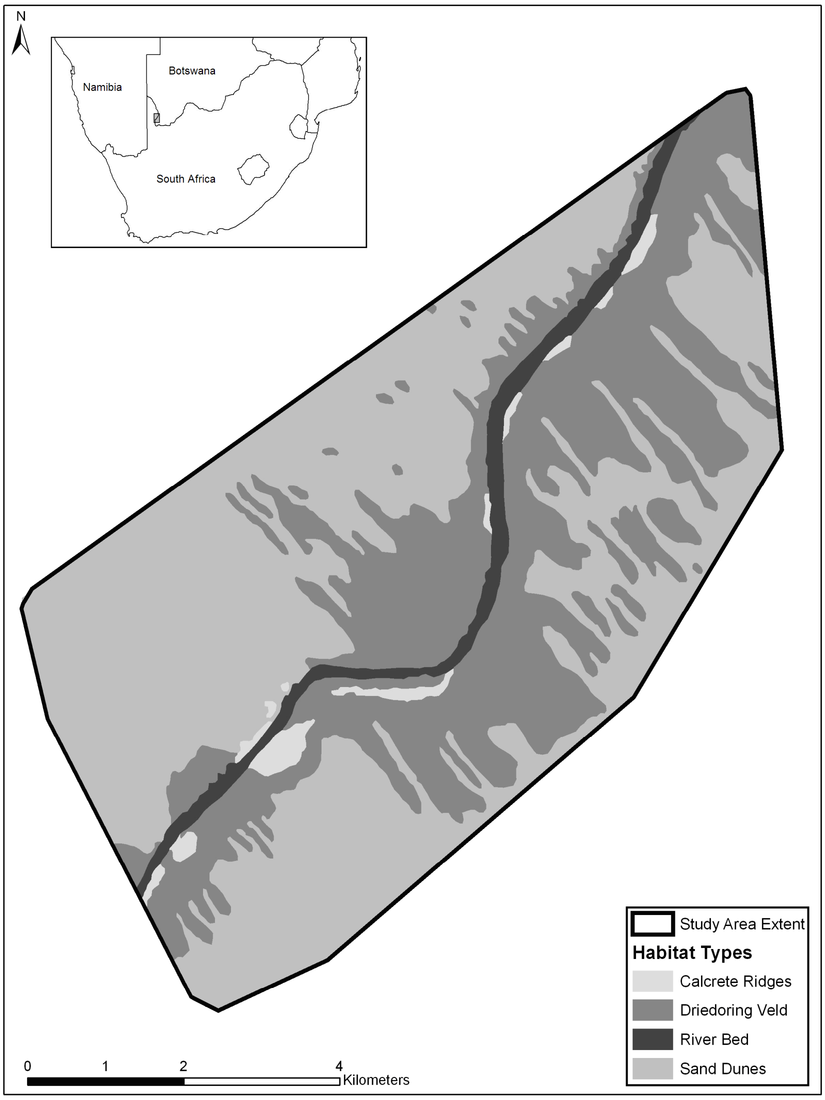

Figure 1 Map of study area in the Kgalagadi Transfrontier Park indicating the different habitat types

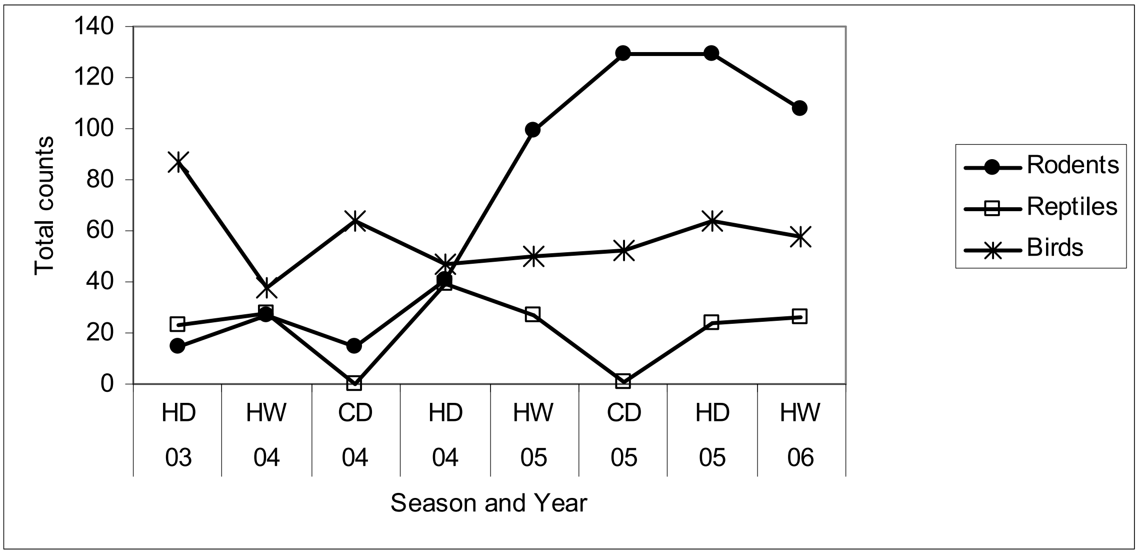

Figure 2 Total counts for small rodents, reptiles and birds on transect lines in all habitats pooled together for each season (HD = hot-dry, HW = hot-wet, CD = cold-dry) in the KTP from 2003 to 2006

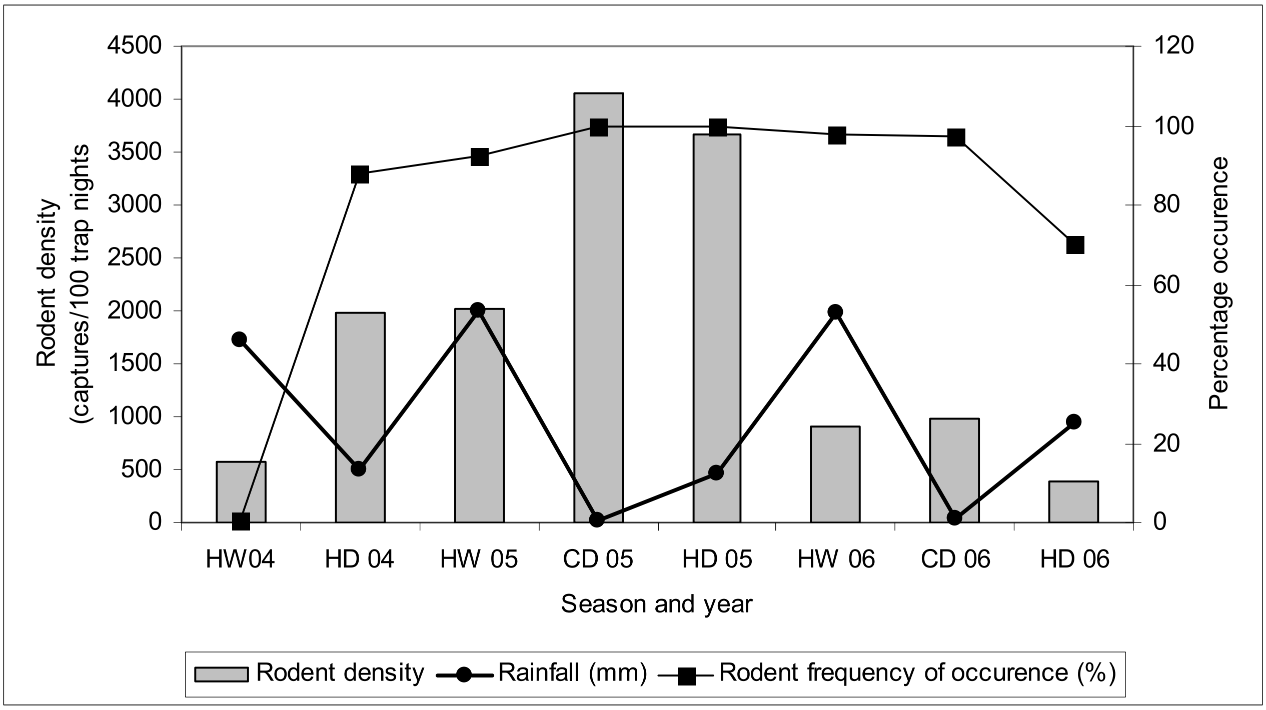

Figure 3 The relationship between percentage frequency of small mammals consumed by African wildcats, rainfall and the relative abundance of small mammals estimated from rodent trapping from the hot-wet season 2004 to the hot-dry season 2006

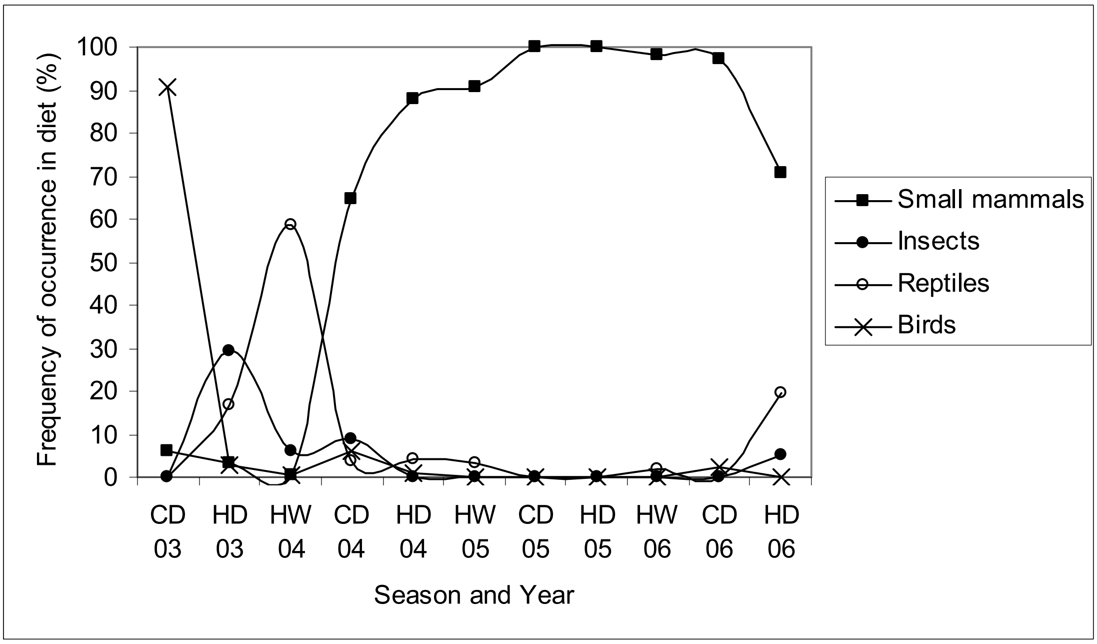

Figure 4 Annual and seasonal changes in the proportions of small mammals, insects, reptiles and birds in the diet of African wildcats in the KTP based on visual observations (CD = cold-dry, HD = hot-dry, HW = hot-wet)