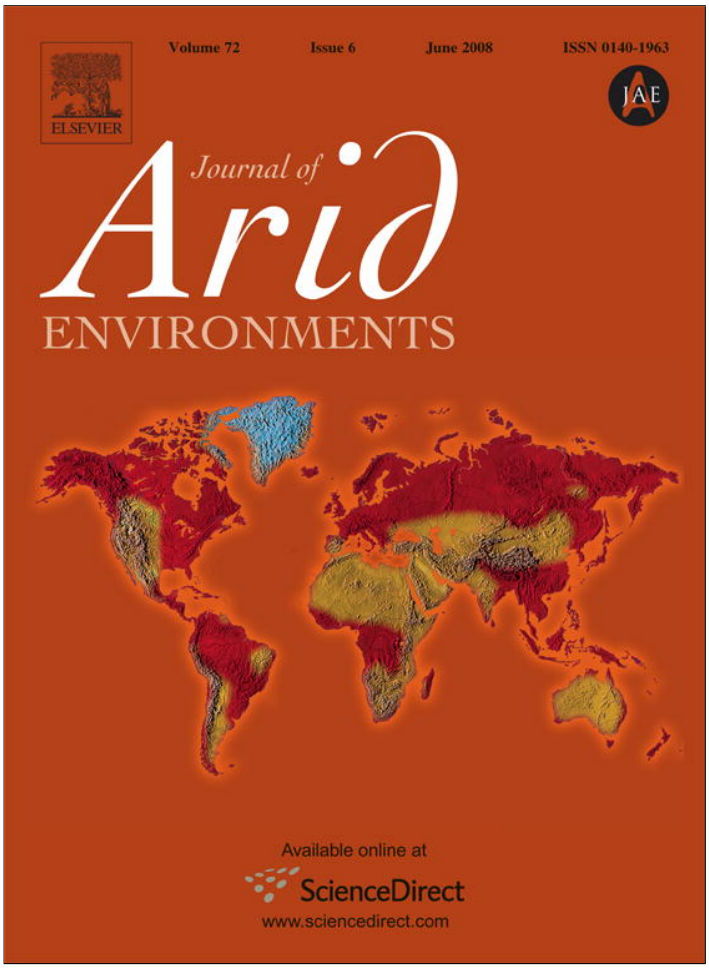

ELSEVIER

Journal of Arid Environments 72 (2008) 1120–1126

Journal of Arid Environments

www.elsevier.com/locate/jaridenv

Short Communication

Food habits of Geoffroy's cat (*Leopardus geoffroyi*) in the central Monte desert of Argentina

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Received 16 August 2007; received in revised form 10 October 2007; accepted 12 November 2007
Available online 21 December 2007

Abstract

Geoffroy's cat (*Leopardus geoffroyi*) is a little-known South American felid. Here we report the first detailed data on its seasonal food habits in a protected area of the central Monte desert, Argentina. We collected and analyzed 182 scats, identifying a total of 441 prey items, with 2.4 ± 1.5 prey items per scat (range = 1–10). Our results confirm that, as with most other felids, Geoffroy's cat is a small-sized predator specialized in capturing vertebrates. Small mammals were the most frequent prey items, representing at least the 63.3% of the food items in each season. The Sigmodontinae rodents *Akodon molinae* and *Calomys musculinus* were the most important prey throughout the study period, whereas birds and reptiles were consumed mainly during warmer seasons. Seasonal differences in diet composition were higher between warmer and colder seasons, suggesting that diet composition is constrained by seasonal fluctuation and disponibility of prey.

Keywords: Diet; Felidae; Geoffroy's cat; *Leopardus geoffroyi*; Niche breadth; Scats analysis

Geoffroy's cat (*Leopardus geoffroyi*) is a primarily nocturnal small felid distributed from Bolivia and southern Brazil throughout southern Argentina and Chile. Little is known

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0140-1963/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jaridenv.2007.11.003

about the ecology of this species (Lucherini et al., 2004), which is classified as "near threatened" (Nowell, 2002). Most of the range of Geoffroy's cat encompasses arid and semi-arid environments, such as the Monte desert or the Patagonian steppes, although it uses a wide range of habitat types including grasslands, open forests, and wetlands (Perovic and Pereira, 2006; Ximénez, 1975).

Geoffroy's cat has been described as an opportunistic predator, feeding mainly upon introduced lagomorphs and small rodents in Patagonia (Johnson and Franklin, 1991; Novaro et al., 2000) and on small rodents and waterbirds in the Pampas grasslands of Argentina (Canepuccia et al., 2007; Manfredi et al., 2004; Vuillermoz, 2001). At present, no data about feeding habits of Geoffroy's cat is available for the Monte desert, an endemic eco-region of Argentina. Here, we described quantitatively the seasonal diet of a population of Geoffroy's cats living in a protected area of the Monte eco-region.

The study was conducted in Lihue Calel National Park (LCNP, 37°57′S, 65°33′W; 9900 ha), La Pampa Province, Argentina. This area is composed of flat terrain except for a large, isolated set of bare rocky hills. The vegetation is characterized by a mosaic of creosote bush flats of the genus *Larrea*, grasslands dominated by bunch grasses (e.g., *Stipa* spp.), and mixed shrub patches (e.g., *Condalia microphylla* and *Prosopis flexuosa*) (Cano et al., 1980). Mean daily temperatures are below 8 °C in winter and above 25 °C in summer. Annual rainfall is 498 mm (±141 SD), mostly concentrated within October–March. No permanent water bodies exist in the study area.

Several sigmodontinae and hystricognath rodents and passerine birds are potential prey for Geoffroy's cat within Lihue Calel. European hare (*Lepus europaeus*), armadillos (*Zaedyus pichiy* and *Chaetophractus villosus*), the Patagonian mara (*Dolichotis patagonum*), lizards, and amphibians constitute alternative food resources.

Food habits of Geoffroy's cats were determined by analyzing fresh scats collected seasonally from winter 2005 (mid-August) to fall 2006 (mid-May), following the protocol described in Reynolds and Aebischer (1991). Scats were collected mainly from latrines used regularly by Geoffroy's cats, as recorded by radio-tracking, visual sightings, or camera trapping. Feces of Geoffroy's cat were distinguished from those of Pampas fox (*Lycalopex gymnocercus*) and puma (*Puma concolor*) by size and form. On the other hand, Pampas cat (*Leopardus colocolo*) and jaguarundi (*Puma yaguarondi*) are very rare in the area (Lihue Calel National Park—Conservation Value Species Register, Period 1995–2006) and they have never been recorded using Geoffroy's cat latrines (unpublished data). Up to four different fecal samples were collected in each latrine per season when more than four samples were found at the same place. In cases when more than one sample was collected per latrine, diet compositions of these latrines were represented as the average prey composition contained in these feces.

Scats were dried at 60 °C for 48 h and examined following the standard method of drying and washing materials through a 0.5 mm mesh sieve (following Reynolds and Aebischer, 1991). Diagnostic remains (hair, bones, nails, teeth, feathers, and scales) were identified to species level with keys (Busch, 1986; Chehébar and Martín, 1989; Pearson, 1995) and reference collections. The number of individual prey in each fecal pellet was determined from the number of jaws and teeth for mammals, beaks and bones for birds, and scales and bones for reptiles.

Samples were grouped seasonally, considering summer (February), autumn (May), winter (August), and spring (November) periods. Contribution of a particular prey item in the diet was reported as the number of times the item was found as percentage of all food

items found (percent occurrence; PO) and as the percentage of scats in which the item was found (percent frequency of occurrence; %FO). Diet composition expressed as relative frequency tends to over-estimate the importance of large prey items and under-estimate the importance of small prey items (Ackerman et al., 1984; Karanth and Sunquist, 1995; Reynolds and Aebischer, 1991). For this reason, Fedriani and Travaini (2000) suggested that it is preferable to estimate the prey biomass represented by scat remains. However, since that in this work we found that different prey types displayed relatively similar body sizes, a bias would not be expected and, therefore, the relative frequency of each food item would be a good estimator of the diet composition of this cat in this area. Diet correlations among seasons were analyzed using two-tailed Spearman's rank correlation coefficients (Zar, 1996).

The seasonal diet diversity was calculated using the Shannon–Wiener (H') index, and seasonal values were compared using the Hutcheson test (Zar, 1996). The seasonal trophic niche breadth was estimated using the standardized Levins measure (FNBsta) (Krebs, 1989). A "Boostrap" technique was used to estimate FNBsta values and their associated variances (Jaksic and Medel, 1987) and significant differences among values were explored using one way-analysis of variance (ANOVA) followed by Tukey-test multiple comparisons (Zar, 1996).

Based on home range sizes of Geoffroy's cats monitored by radiotelemetry in the area (Pereira et al., 2006; J. Pereira, unpublished), individuals recorded during camera-trapping surveys (J. Pereira, unpublished), characteristics of latrines (mainly distance between them), and characteristics of feces collected in each latrine (mainly size and diameter), we estimated that fecal samples analyzed here belong to, at least, 12 different Geoffroy's cats per season.

A total of 182 scats were analyzed, 68% of which were found in middens located at the base of trees or in arboreal middens in the crook of trees. The remaining were found in rock crevices (17%) or along roadsides (15%).

At least 441 prey items were found in the scats, and mean number of prey items per scat was 2.4 ± 1.5 (range = 1–10). Small mammals were the food item most frequently preyed upon during the study period, representing up to 93.8% of the diet composition in fall (Table 1). Sigmodontinae rodents *Akodon molinae* and *Calomys musculinus* were the most important prey species throughout the study period, both in PO and %FO. Representation of birds in the diet was higher during spring (29.8%) and summer (23.2%). Other prey items, such as lizards, marsupials or lagomorphs were poorly represented in the samples, with frequencies lower than 6.9% (Table 1). Significant differences ($P > 0.05$) were detected only between diet compositions of winter and summer (Table 2).

Diet diversity tends to be maximum in fall and minimum in winter (Table 1), but statistical differences were non-significant ($\alpha = 0.05$) throughout the year (Table 2). Standardized food niche breadth was maximum during the fall and minimum during the winter (Table 1), and this parameter showed significant differences ($P < 0.01$) for each season throughout the year (ANOVA, $F = 47.12$). The only non-significant difference for this parameter was found between the spring and summer values ($P = 0.458$).

Our results confirm that, as with most felids (see a revision in Nowell and Jackson, 1996), Geoffroy's cat is a small-sized predator specialized in capturing vertebrates. Throughout the year, consumption of small mammals (<400 g) by this cat was always greater than 60%. The high frequency of small mammals in the Geoffroy's cat diet was also observed in the Pampas grassland (Manfredi et al., 2004; Vuillermoz, 2001) and the

Table 1
Seasonal diet composition, diet diversity (H') and standardized trophic niche breadth (STNB) of Geoffroy's cat in the central Monte desert, Argentina

Prey	Winter ($n = 48$)		Spring ($n = 55$)		Summer ($n = 46$)		Fall ($n = 33$)	
	PO	%FO	PO	%FO	PO	%FO	PO	%FO
Mammalia	91.7	88.6	63.3	61.1	73.6	76.2	93.8	93.2
Didelphimorphia	–	–	–	–	–	–	1.5	1.7
Thylamys sp.	–	–	–	–	–	–	1.5	1.7
Rodentia	91.7	88.6	61.8	59.2	72.8	75.1	92.3	91.5
Akodon azarae	5.8	8.2	3.8	3.7	1.6	2.2	3.1	3.4
Akodon molinae	45	35	13.7	12	20.8	17.4	13.8	13.6
Calomys musculinus	16.7	15.2	16	15.7	21.6	19.6	15.5	13.6
Unidentified Cavidae	1.7	2.3	6.1	7.4	8.8	12	21.5	23.5
Ctenomys sp. cf. *C. azarae*	2.5	3.5	0.8	0.9	1.6	2.2	4.6	5.1
Graomys griseoflavus	3.3	4.7	4.6	4.6	4	5.4	7.7	8.5
Eligmodontia typus	10.9	11.5	9.2	7.5	5.6	6.5	15.4	11.9
Reithrodon auritus	–	–	1.5	0.9	6.4	6.5	–	–
Oligoryzomys longicaudatus	–	–	1.5	1.9	–	–	1.5	1.7
Unidentified Cricetidae	5.8	8.2	4.6	4.6	2.4	3.3	9.2	10.2
Lagomorpha	–	–	1.5	1.9	0.8	1.1	–	–
Lepus europaeus	–	–	1.5	1.9	0.8	1.1	–	–
Aves	8.3	11.4	29.8	30.6	23.2	19.5	3.1	3.4
Reptilia	–	–	6.9	8.3	3.2	4.3	3.1	3.4
Total prey items	120		131		125		65	
H'	0.74		0.93		0.89		0.95	
STNB	0.36		0.45		0.47		0.59	

Diet compositions are expressed as percent occurrence (PO) and percent frequency of occurrence (%FO).

Table 2
Comparison of Geoffroy's cat diet composition (Spearman's rank correlation) and diet diversity (Hutcheson test) between pairs of seasons in the central Monte desert, Argentina

Comparison	Diet composition			Diet diversity		
	n	r_s	P	t	df	P
Winter–Spring	13	0.69	0.008	−3.462	197	>0.05
Winter–Summer	12	0.52	0.084	−2.778	195	>0.05
Winter–Fall	12	0.58	0.046	−4.167	181	>0.05
Spring–Summer	13	0.81	0.001	0.790	199	>0.05
Spring–Fall	14	0.62	0.017	−0.427	191	>0.05
Summer–Fall	14	0.56	0.036	−1.312	194	>0.05

n = number of compared food items; r_s = Spearman's r; t = t-test; df = degrees of freedom.

Patagonian steppe (Novaro et al., 2000) of Argentina or in a coastal plain of southern Brazil (Sousa and Bager, 2007). According to Mukherjee et al. (2004), small mammals are highly profitable for carnivores in terms of metabolic energy; these authors estimated that up to 70% of the daily metabolizable energy in the jungle cat (*Felis chaus*) and the caracal (*Caracal caracal*) is obtained from rodents. Therefore, Geoffroy's cats may prey upon

mainly on small rodents because they contribute to satisfy cats' protein balance and to fulfill their basic energetic requirements. In addition, small rodents are usually a relatively abundant food resource for predators, and the consumption of this prey type could be advantageous in terms of amount of ingested energy vs. search effort and manipulation risk.

On the other hand, European hares represented less than 2% by numbers in the diet of Geoffroy's cats in our study area, whereas in Chilean and Argentinean Patagonian steppes the numeric frequencies varied from 22.8% to 57.4% (Johnson and Franklin, 1991; Novaro et al., 2000). European hares are also frequent in the diet of Geoffroy's cat in the Pampas grasslands, with occurrence frequency that varied from 5% to 16% (Manfredi et al., 2004). According to Jaksic (1986), low comsumption of lagomorphs is common in shrublands of southern South America, with predators hunting mainly the most abundant native rodents, sometimes "ignoring" dense population of introduced hares and rabbits. The relatively low presence of lagomorphs in the diet of the Geoffroy's cat in LCNP is unlikely due to "novel prey rejection" (Jaksic and Soriguer, 1981), because European hares have been in this area since 1900 (Grigera and Rapaport, 1983). More likely, the low incidence of lagomorphs in the diet of this cat is probably related to their ability to "escape by size". That is, adult European hares (mean weight = 3250 g) are too large to be captured by the relatively small Geoffroy's cats of LCNP (mean weight = 3500 g, Pereira et al., 2006). This mean body weight is 30–53% less than the reported for Geoffroy's cats in Patagonia (4940 g) or the Pampas (5180−7400 g) (Lucherini et al., 2006). Large size of adult European hares could constrain Geoffroy's cats from preying on them, while large or medium-sized rodents may be more easily handled.

Relative importance of birds in the diet of Geoffroy's cat in LCNP changed throughout the year, perhaps in association with seasonal fluctuations in their availability. Predation on birds (mostly passerines) increased during spring and summer, being the second most consumed item in these seasons. These results are mostly in agreed with the findings of Vuillermoz (2001) for the Pampas grasslands of Argentina and Sousa and Bager (2007) for southern coastal plains in Brazil. In contrast, Canepuccia et al. (2007) found in a coastal lagoon of the Pampas grassland that Geoffroy's cat diet was comprised mainly of waterbirds, but they also observed that the relative importance of birds in the diet changed throughout the year associated with seasonal fluctuations in their availability. The occurrence of birds in the Geoffroy's cat diet may depend both on season of the year and geographic location (or area characteristics). Geoffroy's cat may switch to eating more birds in areas where the bird densities are high or there are more large birds (as in Canepuccia et al., 2007). However, for a prey switch to be profitable there must be alternative prey that becomes more abundant than the preferred prey (Murdoch, 1969). In LCNP this condition is not fulfilled for Geoffroy's cats (personal observation), and a bird-dominated diet is not expected.

Seasonal differences in diet composition were higher between warmer and colder seasons, and this suggests that diet composition is constrained by seasonal fluctuation and availability of prey. This functional response is frequently found in carnivores that inhabit arid zones, where the resources are temporally fluctuant (Erlinge et al., 1984). As an example, reptiles in Lihue Calel constitute a seasonal food resource virtually unavailable during the colder months (Pereira et al., 2006), whereas passerine birds are more abundant in the area during spring and summer (Chebez et al., 1998). On the other hand, the reduction in the herbaceous layer during the colder months (which coincided with the

drought season in LCNP) may favored Geoffroy's cat predation upon the rodent species more strongly dependent on cover protection, such as *A. molinae* (Corley et al., 1995; Tabeni and Ojeda, 2005). This rodent species was the most frequent prey item during winter, probably as a result of its increased vulnerability to predation. This fact was also reflected in the narrow trophic niche breadth of Geoffroy's cat during this season, taking into account that *A. molinae* composed almost a half of the diet of this cat during this season.

Although it is dangerous to interpret the diet of a species based on just 1 year of data, this constitutes the first approach to the seasonal diet of this wild cat in the Monte desert. This information will help to elucidate factors affecting the relative abundance and habitat use of Geoffroy's cat and can be used to improve conservation planning for both this cat species and their prey in Southern South America.

We want to highlight the collaboration of M. Borro, R. Callico, V. Cosentino, V. Chillo, Y. Davies, C. De Angelo, M. Di Bitteti, H. Ferreira, N. Fracassi, G. García Ribeiro, N. Lonné, P. Moreyra, E. Muschetto, N. Nigro, A. Paviolo, L. Pazos, D. de Tommaso, M. Uhart, O. Vaccaro and M. Zamero. The Administración de Parques Nacionales and the LCNP personnel offered us the permits to conduct this research in the area and helpful assistance. K. Hodara, M. Busch and two anonymous reviewers provided valuable comments on the manuscript.

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