Food habits of Geoffroy's cat (*Leopardus geoffroyi*) in agroecosystem habitats of Buenos Aires, Argentina

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Abstract. Geoffroy's cat (*Leopardus geoffroyi*), a small wild cat of South America, showed in the last years a decline in population abundance mainly related to both habitat destruction and hunting. The increasing human population densities and the consequent demand for food and natural resources will rapidly erode and fragment its remaining habitats. In Argentina most studies about Geoffroy's cat diet have been conducted in protected areas or in their surroundings, while there are no studies conducted in purely agricultural systems. We described the diet composition of *Leopardus geoffroyi* and its seasonal variations in an agricultural ecosystem to contribute knowledge of its ecology and natural history. The study was carried out from spring 2008 to spring 2011. A total of 494 scats were analyzed and at least 695 prey-items were identified. The diet included 81.58% of mammal prey, representing 93.32% of the potential biomass ingested. Within mammals, the principal prey were rodents, representing 79.57% of the total prey items and 59.39% of the total potential biomass consumed. Small rodents account for a great proportion of prey items, while larger species, as the caviid *Cavia aperea*, contributed more biomass. The diet plasticity may enhance the persistence of Geoffroy's cat populations in variable and anthropized ecosystems.

[Keywords: : small wild cats, diet, mammal prey, agricultural ecosystems]

RESUMEN: **Hábitos alimentarios del gato montés (*Leopardus geoffroyi*) en agroecosistemas de Buenos Aires, Argentina.** La abundancia del gato montés (*Leopardus geoffroyi*), un pequeño felino silvestre sudamericano, se ha reducido principalmente por la destrucción de su hábitat y por la caza. En la Argentina, la mayoría de los estudios sobre la dieta del gato montés se llevaron a cabo en áreas protegidas y en sus alrededores, mientras que no existen estudios en sistemas puramente agrícolas. Describimos la composición de la dieta de *L. geoffroyi* y sus variaciones estacionales en un sistema agrícola con el fin de contribuir al conocimiento de su ecología e historia natural. Desde la primavera de 2008 hasta la primavera de 2011 analizamos un total de 494 heces e identificamos 695 ítems presa. La dieta incluyó 81.6% de mamíferos, lo cual representó 93.3% de la biomasa potencialmente ingerida. Entre los mamíferos, la presa principal fueron los roedores, que representaron 79.6% del total de los ítems presa y 59.4% del total de la biomasa potencialmente ingerida. Los pequeños roedores significaron una gran proporción de los ítems presa, mientras que las especies de mayor tamaño, como el cávido *Cavia aperea*, contribuyeron mayormente en función de la biomasa ingerida. La plasticidad de la dieta del gato montés podría permitir la persistencia de sus poblaciones en ecosistemas variables y antropizados.

[Palabras clave: pequeños felinos silvestres, dieta, mamíferos presa, ecosistemas agrícolas]

INTRODUCTION

Global analyses show that among terrestrial mammals, many carnivores are the most threatened, and many within the families *Felidae* (Fischer de Waldheim 1817), *Canidae* (Fischer 1817) and *Ursidae* (Fischer de Waldheim 1817) appear to be suffering the severest population declines and range contractions (Ceballos et al. 2005; Schipper et al. 2008). One of the causes may be the human intolerance of such predatory carnivores which is frequently based on misconceptions about the potential risk they pose to livestock and humans (Treves & Karanth 2003). Additionally, other species are threatened because they occupy unique ecological niches, or because they are habitat or diet specialists (Karanth & Chellam 2009).

Populations of vulnerable carnivore species are unable to persist under human land uses that engender conflicts over habitat, space or prey (Treves & Karanth 2003). The increasing human population densities and the consequent demand for food and natural resources will rapidly erode and fragment remaining carnivore habitats. A common consequence of such conflict has been the

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elimination of carnivores from human-dominated landscapes (Karanth & Chellam 2009). In the Pampean region, the increase of agriculture produced a decrease in natural habitat areas, which frequently remain as linear corridors along roadsides and railways (Bonaventura et al. 1988; Ellis et al. 1997; Busch et al. 2001). One of the most important changes observed during the 20th century was the replacement of livestock fields by crops, with the consequent fragmentation of natural habitats. According to some estimates in the Rolling Pampas, approximately 90% of the land is devoted to crops as soybean, wheat, corn and sunflower (Viglizzo et al. 2001; Paruelo et al. 2005). These habitat changes may affect prey availability for predators due to changes in species identity, relative abundances and vulnerability (Fedriani et al. 2001; Fedriani & Kohn 2001; Sovada et al. 2001; Pia et al. 2003; Farias & Kittlein 2008). The effect of land use may vary according to the predator species considered, its habitat use, food requirements and degree of specialization. While some species may decrease their hunting efficiency in agricultural habitats, other species may be benefited by food subsidies associated to increases in prey abundance as a consequence of human activities (Mukherjee et al. 2004).

Land use changes may be reflected in the diet composition of predators, but although diet and its variations are the most studied aspects of the ecology of carnivore predators (e.g., Pereira et al. 2006; Farias & Kittlein 2008; Radović & Kovačić 2010; Bisceglia et al. 2011; Pereira et al. 2011; 2012; Trigo et al. 2013) most studies were conducted in natural or low disturbed habitats. Studies about foraging behavior and diet composition of carnivores in urban or agricultural systems are less frequent (e.g., Gehrt 2004; Biró et al. 2005; Eagan et al. 2011; Krauze-Gryz et al. 2012). In Argentina, most studies about carnivores diet have also been conducted in protected areas or in their surroundings, with natural vegetation and low human intervention (e.g., Vuillermoz 2001; Canepuccia et al. 2007; Bisceglia et al. 2008; Varela et al. 2008; Pereira 2009; 2010; Bisceglia et al. 2011; Pereira et al. 2012; Santillán et al. 2014), although studies in small reserves or in areas with different levels of human intervention have quantified the effect of livestock and agriculture on the diet of carnivores (Pia et al. 2003; Farias & Kittlein 2008; Pereira 2009; Pereira et al. 2012).

The Geoffroy's cat (*Leopardus geoffroyi*, d´Orbigny and Gervais, 1844) is a solitary, primarily nocturnal small felid, distributed in South America from southern Bolivia and the Paraná basin of southern Brazil to the southern tip of Patagonia (Nowell & Jackson 1996; Cuellar et al. 2006; Canepuccia et al. 2007). The Geoffroy's cat is a habitat generalist, occupying open woodland, bushy areas, open savannas, marshes (Cuellar et al. 2006; Canepuccia et al. 2007, 2008; Caruso et al. 2012), river deltas (Pereira et al. 2005) and tall grasslands (Manfredi et al. 2006). This species usually disposes its faeces in latrines placed in conspicuous sites, over trees, rocks, or clumps of grasses (Manfredi et al. 2006; Soler et al. 2009). *L. geoffroyi* has been described as an opportunistic predator that consumes mainly mammals, especially small rodents and medium to big sized birds (Manfredi et al. 2004; Bisceglia et al. 2008; Canepuccia et al. 2007; Sousa & Bager 2008). It can also prey on larger prey as hares (Sousa & Bager 2008). There are no studies about the Geoffroy's cat diet conducted exclusively in agricultural systems, although Castillo et al. (2008) registered its presence in these habitats in the Argentine pampas. Our aim was to describe the diet composition of *L. geoffroyi* and its seasonal variations in an agricultural ecosystem to contribute knowledge of its ecology and its natural history.

MATERIALS AND METHODS

Study Area

We studied the food habits of Geoffroy's cat in agroecosystems in Exaltación de la Cruz Department (34°19' S and 59°14' W), Buenos Aires province, Argentina. The study area is located in the Rolling Pampas, eco-region that includes part of Buenos Aires, Córdoba and Santa Fe provinces, within banks of La Plata and Paraná rivers at northeast, Salado River at southwest and Matanza river at southeast. This region presents a highly rolling topography in comparison with other neighbor areas, forming an exoreic drain system (Bilenca & Miñarro 2004). The climate is sub-humid temperate, with a mean annual temperature of 16 °C and an annual precipitation ~1000 mm. Originally, the area was covered by grasslands, with a vegetation structure that corresponded to a prairie in humid years and pseudo-steppe or steppe during dry years (Soriano et al. 1991). The vegetation was represented by tall perennial grasses, as *Nassella* spp. (Trin., É. Desv.) and *Piptochaetium* spp. (J. Presl.). Nowadays, 90%

of the land is devoted to crops as soybean, wheat, corn and sunflower (Viglizzo et al. 2001; Paruelo et al. 2005), so the landscape is a matrix of cropfields with grassland corridors along their edges (borders) and a mixture of exotic and native woody species forming woodlots. Along borders, a spontaneous and particular flora had developed (Soriano et al. 1991), dominated by species such as *Nasella neesiana* (Trin. & Rupr., Barkworth), *Jarava plumosa* (Spreng., S.W.L. Jacobs & J. Everett), *Paspalum dilatatum* (Poiret), *Bromus catharticus* (Vahl), the forbs *Solidago chilensis* (Meyen) and *Senecio grisebachii* (Bacher) and the thistles *Carduus acanthoides* (Linnaeus), *Cirsium vulgare* (Savi and Tenore) and *Cynara cardunculus* (Linnaeus) (Bonaventura & Cagnoni 1995; Bilenca & Kravetz 1998). Woodlots are small patches of about 0.5 to 2.5 ha composed by trees of about 5 m high, and their saplings. Woodlots are highly variable according to the dominant species of tree. The most frequent species are eucalyptus (*Eucalyptus* sp., Smith), ombú (*Phytolacca dioica*, Linnaeus), privet (*Ligustrum* sp., Linnaeus), willows (*Salix* spp., Linnaeus) and the honey locust (*Gleditsia triacanthos*, Linnaeus). Seasonal changes in plant phenology and in the stage of development of crops caused seasonal qualitative and quantitative variations in resources, both in cropfields and borders (Busch et al. 1997; Hodara & Busch 2006). The borders have abundant vegetation cover throughout the year, while cropfield cover varies from low cover after ploughing and sowing to high cover when crops are mature (Busch et al. 1997; Hodara & Busch 2006).

According to studies developed in and around the study area, potential mammalian prey species for the Geoffroy's cat in the study area include sigmodontine, caviid and commensal rodent species (Busch & Kravetz 1992; Bilenca & Kravetz 1995; Busch et al. 2000; Hodara & Busch 2006; Bilenca et al. 2007). Other potential preys for the Geoffroy's cat are European hares (*Lepus europaeus*, Pallas 1778), opossums and many passerines and raptor species. Geoffroy's cat eventually consumed small reptiles, amphibians and insects (Sousa & Bager 2008).

Sampling Design

Diet. Sampling was carried out seasonally from November 2008 to December 2011 (a total of 26 sampling events). In each sampling, an area of 300 km^2 was covered during 3 days, searching Geoffroy's cat latrines and scats within woodlots, roads and railways. Cropfields and its borders were discarded because very few latrines or scats were found during preliminary samplings. Characteristics of woodlots and surrounding fields were recorded. In woodlots Geoffroy's cat faeces were found on medium and large-sized trees, like Ombú and Eucalyptus. Tree-forks were 1-2 m high and, in general, trees were pruned or broken, generating additional surfaces that were used by Geoffroy's cat. Woodlots with juvenile trees did not present Geoffroy's cat latrines. Faeces were assigned to *L. geoffroyi* by size and form, since there are no other wild felids with similar weight and aspect of faeces in northern Buenos Aires province. Although the domestic cat is present in the area, it is usually found near human houses, while Geoffroy's cat faeces were found in small woodlots distant from human dwellings. On the other hand, domestic cats bury or semi-bury their scats (Lozano & Urra 2007), while Geoffroy's cat deposes its scats in conspicuous sites (Soler et al. 2009). In road and railways, we found both *L. geoffroyi* and Pampas Fox (*Lycalopex gymnocercus*) scats, which were differentiated by form.

Rodent community. Rodent samplings were conducted simultaneously with fecal samplings in three cropfields and their borders of the study area placed within the home range area of Geoffroy's cats detected by the presence of latrines. Sampling sites were located at a distance greater than 200 m in order to give independent estimates of rodent abundance and species composition. At each site, we placed 25 trapping stations spaced at 10 m intervals in one border and another two lines of 25 trapping stations in the field perpendicular to the border trapping line. There was one Sherman trap (23x7.7x9.1 cm) at each trapping station, which was baited with a mixture of peanut butter, bovine fat and rolled oats. Traps were checked every morning for three consecutive days. Animals were handled according to the 14346 Argentina National law of animal care and ASM guidelines (Sikes et al. 2011). Captured individuals were identified to species level, individually marked with ear tags, and released at the capture site.

Data analysis

The diet composition of Geoffroy's cat was determined on basis of prey remains, like bones, feathers and insect remains present in scats. We considered three levels for classification of prey: prey type, prey item

and prey species. The first level (prey types) included "Mammals", "Birds", "Reptiles", "Insects","Unidentified vertebrates" and "Unidentified remains". The second level (prey items) for mammalian types was differentiated according to order in "Rodents", "Marsupials" and "Lagomorphs". For birds we differentiated between "Passerines" and "Raptors" (Falconiforms and Strigiforms). Reptile prey items were classified as "Scaled reptiles". Insect remains were not differentiated at any level. The third level (prey species) was differentiated according to genus or species, if possible.

Since sample sizes for some of the seasons were low, the data from the three years of study were combined, obtaining one estimative value of the contribution of each prey category to the diet per season. The number of individuals of each prey category per season was also added in order to estimate the global contribution along the studied period.

Except for insects, which were only registered as present or absent in the diet, the quantification of the contribution of the rest of the prey categories to the diet was analyzed in function of its occurrence in the scats and the potential biomass ingested, in order to consider the large variation in size of prey categories. The occurrence of each item was quantified as a percentage of occurrence (PO, Equation 1). We used this term following Sousa & Bager (2008) and Pereira et al. (2012) in order to allow comparisons, where n_i is the number of individuals of prey category i (Sousa & Bager 2008).

$$PO = (n_i / \sum n_i) \times 100 \qquad \text{Equation 1}$$

The number of individuals of each prey category found in the fecal pellets was determined from the number of jaws and teeth for mammals; peaks, claws and large bones for birds; and scales and bones for reptiles (assuming a single individual in the scat from the presence of scales and bones). The presence of insects was recognized from elytra and heads.

The estimation of the potential biomass ingested (PBI, Equation 2) was calculated for each prey species following Figueroa Rojas & Corales Stappung (2004) and Santos Moreno & Alfaro Espinola (2009), where PBI_i is the percentage potential biomass ingested of prey species i, PO_i is the percentage of occurrence of prey species i and w_i is the mean mass of

prey species i. PBI for each prey item was calculated as the sum of its corresponding PBI prey species. PBI for each prey type was calculated as the sum of its corresponding PBI prey items.

$$PBI\%_i = [(PO_i \times w_i) / \sum (PO_i \times w_i)] \times 100$$
$$\text{Equation 2}$$

Body mass of mammalian and reptile prey species was obtained from literature (Miño et al. 2001; Gómez Villafañe et al. 2004; Fraschina 2011; Palacios et al. 2012). For birds, the mean body mass of passerines and raptors was estimated considering the body mass of the most frequent species in the study area, according to Naroski & Yzurieta (2012).

Statistical analysis

Variation in diet composition along seasons (spring, summer, autumn and winter) was evaluated by a Log-Linear test (Norman & Streiner 1996), using the R software version 2.11.1 (R Development Core Team 2010). In this test, the significance of the main effects evaluate if marginal values are different, while the interaction between prey item and season analyze if there is a variation in diet composition along the year.

Variation in diet composition was analyzed at both prey item and species level. Since the number of individuals (n_i) for some of the prey items (Marsupials, Passerines, Raptors and Scaled reptiles) was below the minimum required for statistical analysis (n=5), they were grouped in new categories as follows: Passerines and Raptors as "Birds" and Marsupials and Scaled reptiles as "Others". Unidentified vertebrates were also included in the analysis under the category "Others". Thus, the categories considered were: Rodents, Lagomorphs, Birds and Others. "Unidentified remains" was not included in this analysis. At prey species level, the only ones suitable for comparison were the rodent species.

To estimate the degree of feeding specialization of Geoffroy's cat, the breadth of the food niche in each sampling was calculated using the "B" index of Levins (1968), standardized according to Cowell & Futuyma (1971) "Bsta", and averaged by season. This index varies between 0 (when only one prey is consumed) and 1 (all preys are equally consumed). Niche values close to 1 mean a uniformly distributed diet, with no single prey predominating (i.e., generalist

diet). Values close to 0 indicate that few preys are consumed in high proportions (i.e., specialist diet, Sousa & Bager 2008). The index was calculated in function of PO for each prey species, except for birds where PO for prey type was used. All unidentified categories were not included in this analysis. In order to compare Bsta values among seasons we estimated confidence intervals using InfoStat statistical program in its 2014 version (Di Rienzo et al. 2014).

RESULTS

Diet

A total of 494 scats were analyzed and at least 695 remains were identified. Most scats were found under trees or on their forks within small woodlots, while few were found along railways or roadsides. Considering the global contribution, 89.5% of the diet remains was identified. The main prey type consumed were mammals, followed by birds. Reptiles were poorly represented while insects were present in all sampling periods, although few remains per scat were found (Table 1). Diet remains that could not be identified (10.5%) corresponded to unidentified vertebrates (5.9%) and unidentified remains (4.6%). The global diet included 81.6% of mammalian prey, representing 93.3% of the potential biomass ingested. Within mammals, the principal prey were rodents, representing 79.6% of the total prey items and 59.39% of the total potential biomass consumed (Table 1), while lagomorphs represented only 1.7% of the total number of items found but 32.2% of the potential biomass ingested. Marsupials were the least consumed item representing 0.3% of total items and 1.7% of PBI. Considering bird remains, 6.9% were assigned to Passerines and 0.72% to Raptors, representing similar values of potential biomass ingested (0.97% and 1.01% respectively). Reptiles accounted for 0.29% of the remains, representing 4.70% of the potential biomass ingested.

Rodent remains were assigned to seven categories of prey species/genus: *Calomys* spp. (that includes the non-distinguishable remains of *Calomys laucha* and *Calomys musculinus*), *Rattus* spp. (that includes the non-distinguishable remains of *Rattus norvegicus* and *Rattus rattus*), *Akodon azarae*, *Oligoryzomys flavescens*, *Holochilus vulpinus*, *Cavia aperea* and "Unidentified rodents". Among them, *Calomys* spp. showed the highest percentage of occurrence in the diet (29.21%), followed by *C.*

aperea (13.96%). Each of the remaining rodent categories accounted for less than 10% of the total number of items (Table 1). Considering the potential biomass ingested, *C. aperea* was the most important prey specie (42.04%), followed by *Rattus* spp. (12.30%). Each of the remaining rodent categories represented less than 3% of the potential biomass ingested (Table 1). The remains of marsupials and lagomorphs were assigned to *Didelphys albiventris* and *L. europaeus,* respectively. *Salvator merianae* (Duméril & Bibron, 1839) was the only Scaled reptile species found.

The proportion of prey items in the diet varied among seasons (Prey-item x Season: Dev=22.79, n=16, df=9, P<0.01, log-linear analysis) (Table 2). Rodents were the most consumed prey item throughout the year, followed by Birds. Lagomorphs and Others were the least consumed items. Geoffroy's cat consumed the two last items in similar numbers in spring, but Lagomorphs were more consumed in autumn, and Others were more consumed in summer and winter. For rodents, prey species were consumed differentially among seasons (Prey-species x Season: Dev=58.41, n=20, df=12, P<0.01, log-linear analysis) (Table 3). *Calomys* spp. was the most consumed prey species throughout the year, except in winter when the number of consumed individuals (ni) of *Calomys* spp. and *C. aperea* were similar.

Considering the non-rodent prey species, the marsupial *D. albiventris* was only consumed in summer, while the lagomorph *L. europaeus* was ingested in all seasons except in winter. Although the PO representation of these mammalian species was poor in all seasons (PO_i<2%), in terms of potential biomass *L. europaeus* represented the 29.27%, 47.35% and 45.93% in spring, summer and autumn, respectively. The marsupial *D. albiventris* reached 9.86% of the PBI when it was consumed in summer (Table 1). Among birds, passerines were consumed throughout all seasons, representing less than 12% of the PO and less than 2% of the PBI. Raptors were only ingested in spring and winter reaching 0.63% and 2.35% of the PO, and 0.73% and 3.97% of the PBI in spring and winter, respectively. The reptile *S. merianae* was consumed only in spring and represented 1.26% of the PO and 17.07% of the PBI in the diet in this season (Table 1).

In relation to the degree of feeding specialization of Geoffroy's cat, the Bsta

Table 1. Diet composition of *Leopardus geoffroyi* during the three studied years. The values in the table represent the percent numerical frequency (PO) and the potential biomass ingested (PBI) of each prey item in the bulk of faeces collected in each season. Values on Bsta confidence interval row are the niche breadth. Numbers in parentheses (n) in the first line indicate the number of scats analyzed at each season. For insects, p=presence, a=absence.

Tabla 1. Composición de la dieta de *Leopardus geoffroyi* durante los tres años estudiados. Los valores en las tablas representan la frecuencia numérica porcentual (PO) y la biomasa potencialmente ingerida (PBI) de cada ítem presa en el total de heces recolectadas en cada estación del año. Los valores del intervalo de confianza en la línea "Bsta" corresponden a la amplitud de nicho. Los números entre paréntesis (n) en la primera línea indican el número de heces analizadas en cada estación del año. Para los insectos, p=presencia, a=ausencia

Prey category			Spring (n=113)		Summer (n=89)		Autumn (n=162)		Winter (n=130)		Total (n=494)	
Prey types	Prey items	Prey species	PO (%)	PBI (%)	PO (%)	PBI (%)	PO (%)	PBI (%)	PO (%)	PBI (%)	PO (%)	PBI (%)
Mammals			81.76	81.03	80.99	90.53	84.08	99.54	78.24	95.04	81.58	93.32
	Rodents		79.87	51.76	76.86	33.32	81.63	53.61	78.24	95.04	79.57	59.39
		Akodon azarae	9.43	1.10	1.65	0.24	10.20	1.44	13.53	2.28	9.35	1.31
		Calomys spp	24.53	1.62	38.02	3.09	36.33	2.90	17.06	1.63	29.21	2.32
		Oligoryzomys avecens	11.95	1.34	2.48	0.34	3.27	0.44	9.41	1.54	6.62	0.90
		Cavia aperea	15.09	37.75	9.09	27.99	11.02	33.33	20.59	74.70	13.96	42.04
		Holochilus vulpinus	1.89	1.90	0,00	0.00	0.00	0.00	0.00	0.00	0.43	0.52
		Rattus spp	6.92	8.05	6.61	1.66	11.02	15.50	8.82	14.89	8.78	12.30
		Unidentified	10.06	---	19.01	---	9.80	---	8.82	---	11.22	---
	Marsupials	*Didelphis albiventris*	0.00	0.00	1.65	9.86	0.00	0.00	0.00	0.00	0.29	1.68
	Lagomorphs	*Lepus europaeus*	1.89	29.27	2.48	47.35	2.45	45.93	0.00	0.00	1.73	32.25
Birds			10.69	1.90	11.57	1.66	3.27	0.46	8.24	4.96	7.63	1.98
	Passerines		10.06	1.17	11.57	1.66	3.27	0.46	5.88	0.99	6.91	0.97
	Raptors		0.63	0.73	0.00	0.00	0.00	0.00	2.35	3.97	0.72	1.01
Reptiles	Scaled reptiles	*Salvator merianae*	1.26	17.07	0.00	0.00	0.00	0.00	0.00	0.00	0.29	4.70
Insects			p	---	p	---	p	---	p	---	p	---
Unidentified vertebrates			5.66	---	5.79	---	6.12	---	5.88	---	5.90	---
Unidentified remains			0.63	---	1.65	---	6.53	---	7.65	---	4.60	---
Remains			159		121		245		170		695	
Bsta confidence interval (sampling events)			0.59 - 0.87 (n=4)		0.33 - 0.85 (n=3)		0.21 - 89 (n=3)		0.40 - 0.81 (n=3)		0.53 - 0.72 (n=13)	

Table 2. Log-Linear results for the variation in diet composition of *Leopardus geoffroyi* (rodents, birds, lagomorphs and others) according to the seasons (Spring, Summer, Autumn and Winter).

Tabla 2. Resultados del análisis Log-Linear para la variación de la composición de la dieta de *Leopardus geoffroyi* (roedores, aves, lagomorfos y otros) en función de las estaciones del año (primavera, verano, otoño, invierno).

	df	Deviance	Resid. df	Resid. Dev.	$P(>|Chi|)$
Null			15	1033.11	
Prey-item	3	965.13	12	67.98	<0.01
Season	3	45.19	9	22.79	<0.01
Prey-item x Season	9	22.79	0	0	<0.01

Table 3. Log-linear results for the variation in the proportion of different rodents consumed by *Leopardus geoffroyi* (*Akodon azarae*, *Calomys* spp., *Oligoryzomys flavescens*, *Cavia aperea*, *Rattus* spp.), according to the season (Spring, Summer, Autumn and Winter).

Tabla 3. Resultados del análisis log-linear para la proporción de los diferentes roedores consumidos por *Leopardus geoffroyi* (*Akodon azarae*, *Calomys* spp., *Oligoryzomys flavescens*, *Cavia aperea*, *Rattus* spp.) en función de las estaciones del año (primavera, verano, otoño, invierno).

	df	Deviance	Resid. df	Resid. Dev.	$P(>|Chi|)$
Null			19	255.11	
Prey-item	4	148.21	15	106.90	<0.01
Season	3	48.50	12	58.41	<0.01
Prey-item x Season	12	58.41	0	0	<0.01

index showed that the diet was narrower in summer, autumn and winter than in spring, when it reached the highest breadth (Table 1). Confidence intervals for this index never reached the most extreme values (i.e., 0 and 1), suggesting an intermediate level of specialization.

Rodent community

Along the 16 sampling sessions, we captured a total of 344 individual rodents (218 *A. azarae*, 107 *Calomys* spp. 84 *C. laucha* and 23 *C. musculinus* and 19 *O. flavecens*). *Calomys* spp. represented more than 50% of the captures all along the study, although their representation decreased from spring- summer to autumn-winter, along with an increase in *A. azarae* and *O. flavescens*. Of the 2 species of the genus *Calomys*, most captures corresponded to *C. laucha* (*C. musculinus* did not exceed 1%).

Discussion

Most studies about the diet of carnivores have been conducted in protected areas or in their surroundings, with natural vegetation and low human intervention. In the present work, we studied the Geoffroy's cat diet exclusively in agricultural systems. Mammals, and specially rodents, were the main prey of the Geoffroy's cat in the studied agroecosystems. Among rodents, *Calomys* spp. were the most consumed species followed by *C. aperea*. However, in terms of PBI, the latter was the most important prey species. Similar food habits of this small felid were observed in Pampas grassland (Vuillermoz 2001; Manfredi et al. 2004), Monte scrubland (Bisceglia et al. 2008; 2011; Pereira et al. 2012), the Patagonian steppe (Novaro et al. 2000) and in Rio Grande do Sul fields (Trigo et al. 2013), while in wetlands the main prey were waterbirds (Canepuccia et al. 2007). Both according to Bisceglia et al. (2008) and in this work, the consumption of small mammals was higher than 60%, with low representation of European hares, contrasting to the diet in other regions as the Chilean and Argentina Patagonian steppes, where the percentages of occurrence of hares ranged from 22.8 to 57.4% (Johnson and Franklin 1991; Novaro et al. 2000). On the other hand, Manfredi et al. (2004), found that European hares are frequent in the diet of Geoffroy's cat with an occurrence that varied from 5% to 16%. Nevertheless, in terms of rodent consumption our results agree with the findings of Manfredi and co-authors (2004).

Relative importance of birds in the diet of Geoffroy's cat changed throughout the year, increasing during spring and summer. These seasonal variations were also observed by Vuillermoz (2001) in Pampean grasslands of Argentina, Bisceglia et al. (2008) for the Monte scrublands of Argentina and Sousa and Bager (2007) for southern coastal plains in Brazil. These authors, however, found a higher representation of birds in the cat diet with respect to our study. On the other hand, Canepuccia et al. (2007) observed a high representation of waterbirds in the cat diet in a coastal lagoon of the Pampean grassland, probably as a consequence of the local offer of food.

Although previous studies in the study area reported strong seasonal variations in abundance of rodents (Miño et al. 2001; Gómez Villafañe et al. 2004; Busch & Hodara 2006; Fraschina 2011), both their percentage of occurrence in the cat diet and the potential biomass ingested of each prey category did not show great variations. These results suggest that rodents are the basis of the cat diet independently of their abundance variations, as was observed by Pereira et al. (2012) who proposed that Geoffroy's cats is not opportunistic predator with respect to sigmodontines. These authors concluded that, in ranches of Monte scrublands, the cat positively selects rodents throughout the year at the expense of other potential preys, such as hares or birds. This behavior could be related to the active search behavior, one of the hunting strategies used by small and medium sized felids (Emmons 1987; Jedrzejewski et al. 2002). Such behavior was observed in the study of Pereira et al. (2012), which determined an increase in the movement rate of Geoffroy's cats as an attempt to increase the encounter rate with prey, which appeared to be less abundant due to the human activities.

The high representation of *Calomys* spp. in the scats and its relative abundance in the local rodent community suggests that these rodents are consumed opportunistically. Rodents that use open habitats, like *Calomys* spp., suffer a periodic loss of vegetation cover in their habitat that could increase its vulnerability, facilitating their capture. Geoffoy's cats, as well as lions (*Panthera leo*) (Hopcraft et al. 2005), Canada lynxes (*Lynx Canadensis*) (Fuller et al. 2007) and leopard cats (*Prionailurus bengalensis)* (Rajaratnam et al. 2007), prefer to hunt in habitats where prey are easier to capture (Pereira et al. 2012). Such an oppor-

tunistic behavior in the Geoffroy´s cat was already proposed by other authors (Bisceglia et al. 2008; Novaro et al. 2000; Manfredi et al. 2004; Sousa & Bager. 2008).

The composition of the diet suggests that the Geoffroy´s cat hunts not only in fields (where *Calomys* spp. are more abundant) but also along other habitats such as field borders, where *C. aperea*, *A. azarae* and *O. flavescens* are found, and in woodlots, where *O. flavescens* is the most frequent rodent species (Fraschina 2011). The use of forested habitats like woodlots was reported for *L. geoffroyi* by Johnson & Franklin (1991), Manfredi et al. (2006) and Trigo et al. (2013). The Geoffoy's cat seems to be able to use many different habitats, with documented use of habitats greatly altered by deforestation, agriculture, ranching and planting of exotic trees (Trigo et al. 2013). On the other hand, the low percentage of prey typical of domestic and peridomestic habitats (as rats, house mice and poultry birds) suggests that the Geoffroy´s cat does not frequently hunt in these habitats, although rats were present in all seasons in the diet.

The diet of the Geoffroy's cat reflects consumption oriented to rodents. However, it is generalist in relation to the particular mammal/rodent species consumed. Differences in the niche breadth between spring and the other seasons were consistent with an opportunistic feeding behavior that increase the number of prey consumed according to their availability when the dominant is in low abundance (Elmhagen et al. 2002). An alternative point of view may be that the wider diet in spring is consequence of a change in habitat use, with a higher use of borders when cropfields are with low plant cover, before the development of summer crops.

In spite of the high representation of *Calomys* spp. remains in the diet, the main prey in terms of biomass ingested were *C. aperea* and *Rattus* spp. These species are the largest rodents in the study area (mean body weight=300 g for *Rattus* spp. and 645 g for *C. aperea*, in contrast to 20 g for the smaller rodent species), and may be selected because represent a more profitable prey than smaller rodent species. *Rattus* spp. is rare in cropfield habitats frequented by Geoffroy´s cats (Mills et al. 1991; Busch & Kravetz 1992; Fraschina et al. 2011), but cavies are common along field and road edges (Mills et al. 1991). Considering the potential biomass ingested and the percentage of occurrence, *C. aperea* is a fundamental prey in the diet composition of the Geoffroy's cat in agricultural areas. A similar conclusion was suggested by Palacios et al. (2012) to these felids, but for individuals of the Auca Mahuida Provincial Reserve of Neuquen province, Argentina.

The variable diet composition of *L. geoffroyi* among different studies suggest trophic adaptability of this species, which seems to be able to adjust its predatory behavior to exploit locally abundant food resources (Manfredi et al. 2004; Canepuccia et al. 2007; Palacios et al. 2012; Pereira et al. 2012; Trigo et al. 2013). Consequently, *L. geoffroyi*, may not be actually limited by food. Further studies about its ecology in human modified habitats are needed in order to assess the risk for its conservation.

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