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Short Note

Home range size and habitat selection of Geoffroy's cat (*Leopardus geoffroyi,* Felidae, Carnivora) in the pampas grassland

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Abstract

This study examined the spatial ecology of Geoffroy's cats, *Leopardus geoffroyi*, living in a protected area surrounded by croplands in the Argentine grasslands. A total of six different adults were marked with 14 radio-collars from 2001 to 2005 but only three (one female and two males) produced a meaningful amount of data (54–135 positions). Total home range size was 8.83±1.58 km^2 (100% Minimum Convex Polygon) and 7.27±2.23 km^2 (90% Fixed Kernel). Core areas averaged 1.46±0.84 km^2. Geoffroy's cats most frequently used Exotic Woodland areas followed by Rocky and Agricultural areas. All cats clearly avoided natural habitats and selected Exotic Woodland at the two levels of selection examined: within the study area and within home ranges. In our study area, Geoffroy's cats' home ranges were larger than all those previously recorded in natural areas. The Geoffroy's cat preference for Exotic Wood patches and avoidance of natural grasslands was likely due to the degradation of natural habitats caused by a dense population of feral horses. We also argue that woodlands can play an important role in the ecology of this species, either as refuge, hunting area or for territorial marking, regardless of their origin.

Keywords: Argentina; felids; habitat modification; radio-tracking; spatial ecology.

Numerous basic questions in ecology focus on understanding how animals are organized in space and time and the factors affecting spatial arrangement (Kernohan et al. 2001). Additionally, variations in social organization of several carnivore species might have important implications for conservation (Millspaugh and Marzluff 2001).

Two major sources of variation in carnivore home ranges are prey availability (Macdonald 1983, Kissui and Packer 2004) and human impacts, particularly those related to alteration and destruction of natural habitats (Gehrt et al. 2009, Oh et al. 2010). Similarly to home range size, habitat selection is considered an optimization process that is affected by factors such as food supplies, competitors, predators and human activities (Morrison et al. 1992).

The Geoffroy's cat, *Leopardus geoffroyi* (D'Orbigny and Gervais 1844), is one of the most common and widely distributed felids in Southern South America (Sunquist and Sunquist 2002). At the moment, habitat loss and fragmentation, which have been severe in the Pampas ecoregion (Bilenca and Miñarro 2004), are major threats to the conservation of this felid (Lucherini et al. 2008). The information available on the spatial ecology of *L. geoffroyi* (Johnson and Franklin 1991, Manfredi et al. 2006, Castillo et al. 2008, Pereira 2009, Pereira et al., 2011), along with its flexible food habits (Manfredi et al. 2004) has led to the hypothesis that Geoffroy's cat is capable of tolerating a certain level of habitat modification (Manfredi et al. 2006, Pereira et al. 2011). Nevertheless, it is still unclear to what degree Geoffroy's cats are adaptable to the extensive alterations suffered by the natural habitats in the Pampas ecoregion (Castillo et al. 2008).

The aim of the present study was to examine the home range and habitat selection of Geoffroy's cat at the border of a natural reserve, where protected semi-natural and modified habitats were available to individual cats. On the basis of information listed above, it was expected that Geoffroy's cats would have comparatively small home ranges and would prefer natural habitats with dense vegetation coverage over human-modified habitats.

The study was conducted at the border of Ernesto Tornquist Provincial Park (ETPP), a 6700 ha protected area and the private farms surrounding it. Within ETPP, the dominant vegetation community is grassland (Frangi and Bottino 1995), disturbed by a dense feral horse population. Surrounding lands are used for agriculture and as livestock pasture.

Geoffroy's cats were captured using box traps and leg-hold traps (1.5 Victor soft-catch®; for details see Manfredi et al. 2006, Luengos Vidal 2009). The captured cats were immobilized by an intramuscular injection of Zoletil (tiletamine hydrochloride–zolazepam hydrochloride; Madison, NJ, USA; Manfredi 2006). Only healthy adult animals were fitted with very high frequency (VHF) collars from different companies, where the weights of the collar never exceeded 3% of felids'

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body weight. The collared Geoffroy's cats were monitored during discontinuous tracking sessions. Successive locations with a minimum interval of 3 h between them were considered as biologically independent (Powell 2000). Minimum Convex Polygon (MCP) and the fixed Kernel Estimator (KE, Worton 1989) were used to estimate home range size. The area defined by 90% of the locations (90% MCP), excluding the most external 10% of the locations (outliers), was calculated (Powell et al. 2000). For the estimation of the size of core areas, the 40% KE was used. Home range analyses were performed with the RANGES V software (Kenward and Hodder 1999).

Based on Landsat satellites imageries (2000), the area was classified into four habitat types. (1) Rocky Area (which covered 50.5% of the study area), with a prevalence of rocks and relatively rugged terrain. Vegetation was dominated by species of the herbaceous genuses *Grindelia* spp. and *Festuca* spp. and the shrub *Discaria longispina* (Zalba and Villamil 2002). (2) Tall Grassland (25.5%), consisting of grassland with an average height of approximately 1 m and concentrated in the wettest areas. The predominant species were *Paspalum quadrifarium*. (3) Agricultural Area (9.5%): cropland (mostly barley). (4) Exotic Woodland (14.5%): patches of various species of pine (*Pinus* spp.) and poplar (*Populus* spp.) with a dense understorey of broom (*Spartium junceun*), which grow mainly along small streams in the farms adjacent to ETPP.

Two different levels of habitat selection were analyzed. (1) Within home range, through the comparison of the proportion in habitats in the area delimited by 100% MCP and the frequency of use (third order of selection; Johnson 1980). (2) Within the study area, comparing the habitat composition in the home range of radio-collared Geoffroy's cats with that within the study area (second order of selection; Johnson 1980). Habitat selection was analyzed by the χ^2-test for goodness-of-fit of utilized to available habitat types (Neu et al. 1974). If a significant difference was detected between expected and observed utilization frequencies Bonferroni confidence intervals were calculated to determine which habitat types were preferred and avoided (Byers et al. 1984, Kiyota et al. 2004). In all tests, a statistical significance of 0.05 was considered significant.

Six individuals, two males and four females were fitted with radio-collars between December 2001 and July 2005. In total, these individuals were fitted 14 radio-collars. The most common problems identified were the incorrect design of the mechanism for fastening the collar to the neck of the animal (n=7) and anticipated battery depletion (n=4). As a consequence, a total of 299 positions (range: 54–135 positions per individual) were obtained from only three animals (two males, M1 and M2; one female, F2). The mean (±SD) size of home range was 8.83±1.58 km^2 (100% MCP), 6.09±1.11 km^2 (90% MCP) and 7.27±2.23 km^2 (90% KE, Table 1). Home range sizes were similar between sexes when calculated by 90% MCP (one male/female), whereas the males showed a home range 1.7 times larger than the female with KE (Table 1). Core areas averaged 1.46±0.84 km^2 and represented only 10.4% of total size of F1's home range, whereas this proportion was considerably larger for M1 (19.1%) and M2 (27.5%, Table 1).

Table 1 Sample size, home range and core area size (km^2) for three Geoffroy's cats monitored in the Pampas grassland of Argentina.

ID	Locations (n)	Home range		Core area
		MCP 90%	KE 90%	KE 40%
F2	135	6.1	4.87	0.51
M1	54	4.98	7.67	2.11
M2	110	7.2	9.28	1.77

M, Male; F, Female.

Radio-tracked individuals did not use the different habitats homogeneously (X^2=13.8, df=6, p=0.05, Table 2). Rocky Areas and Tall Grasslands were the predominant habitats in the study area (Table 2). Nevertheless, these natural habitats were clearly avoided at both levels of selection, with the partial exception of M1 (Table 3). On the contrary, all cats showed a positive selection towards Exotic Woodland both when establishing their home-ranges and within home range (Table 3).

Contrary to expectations, the home ranges of the Geoffroy's cats monitored in this study were larger than those previously recorded (Johnson and Franklin 1991, Manfredi et al. 2006, Pereira 2009), with the exception of one male from an extensively altered farmland area (Castillo et al. 2008). This result can be related to the overgrazing impact on the grassland by the dense population of feral horses living within the park

Table 2 Habitat Composition (%) in the study area, habitat composition (%) in home range (HR) and use of habitat (percentage of radio-telemetry locations attributed to every habitat, UH) by three Geoffroy's cats in the Pampas grassland of Argentina.

Habitat	Study area	F1		M1		M2	
		HR	UH	HR	UH	HR	UH
RA	51.5	35.9	25.2	53	33.3	43.8	19.1
TG	24.5	21.2	11.4	26.1	1.9	20	3.6
AG	9.5	22.8	18.7	3.3	25.9	15.7	22.7
EW	14.5	20.1	44.7	17.7	38.9	20.5	54.5

M, Male; F, Female; RA, Rocky Area; TG, Tall Grassland; AG, Agricultural Area; EW, Exotic Woodland.

Table 3 Results of Bonferroni analysis of habitat selection by three Geoffroy's cats in the Pampas grassland of Argentina.

Habitat	F1		M1		M2	
	Study area	HR	Study area	HR	Study area	HR
RA	–	–	=	–	–	–
TG	–	–	+	–	–	–
AG	+	–	–	+	+	+
EW	+	+	+	+	+	+

M, Male; F, Female; RA, Rocky Area; TG, Tall Grassland; AG, Agricultural Area; EW, Exotic Woodland. (+) Proportion higher than expected, (–) proportion lower than expected, (=) proportion of use similar to the proportion expected.

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boundaries that appears to affect food resource abundance (Zalba and Cozzani 2004, Birochio 2008).

Also contrary to predictions was the finding that Geoffroy's cats preferred Exotic Woodlands and avoided natural habitats. Two main factors have been mentioned as drivers of habitat selection in Geoffroy's cat. (1) Dense cover, which would facilitate stalking prey and provide safe shelter for diurnal resting and (2) prey abundance (Manfredi et al. 2006, Pereira 2009). In our study area, two habitats could have provided abundant vegetation coverage: Exotic Woodland and Tall Grassland. We argue that the unexpected lack of preference towards natural grasslands was related to the previously mentioned effect of horses, which degraded and fragmented this habitat reducing both coverage and prey abundance (Zalba and Cozzani 2004, Birochio 2008). The increased use of Exotic Woodland might also be favored by the fact that this habitat offers a great diversity and abundance of birds including doves (*Culumba* spp.), an important dietary item at ETPP (Manfredi et al. 2004). Thus, our data support the hypothesis that wood patches might play an important role in the ecology of this species, either as refuge, corridors, hunting areas or for territorial marking (Manfredi et al. 2004, Pereira 2009, Soler et al. 2009), regardless of origin.

The limited information reported here enabled us to support the adaptability of *L. geoffroyi* (Pereira 2009). Nevertheless, our results indicate that this felids spatial requirements in Pampas are currently large and consequently the value of this ecoregion, which represents approximately 18.8% of its global distribution range, for Geoffroy's cat conservation is probably limited.

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Appendix I Period of duration of each radio-collar and the problems that caused the end of the monitoring period with each individual of Geoffroy's cat monitored in the Pampas grassland of Argentina.

ID	Beginning of monitoring	End of monitoring	Company	Cause of failure	Radiocollar recovery
F1 (n=21)	12-07-2001	03-23-2002	AVM	Radio-collar loss	Yes
M1 (n=54)	12-01-2001	02-27-2002	AVM	Radio-collar loss	Yes
	01-29-2002	06-30-2002	AVM	Battery failure	Yes
	11-08-2002	01-02-2003	AVM	Unknown	No
F2 (n=135)	01-11-2002	02-23-2003	AVM	Radio-collar loss	Yes
	04-19-2003	07-26-2003	AVM	Unknown	Yes
	09-04-2003	01-11-2004	Telonics	Unknown	Yes
	05-28-2004	10-17-2004	AVM	Battery failure	Yes
	01-21-2005	05-14-2005	AVM	Unknown	No
F3 (n=8)	01-27-2004	03-18-2004	Telemetry solution	Animal dead	Yes
F4 (n=8)	07-22-2004	08-27-2004	Telonics	Lack of signal gain	Yes
M2 (n=110)	03-19-2004	03-25-2004	AVM	Battery failure	Yes
	09-12-2004	05-26-2005	AVM	Battery end	Yes
	07-11-2005	06-09-2005	AVM	Unknown	No

M, Male; F, Female.

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