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DENNING ECOLOGY OF *Conepatus chinga* (CARNIVORA: MEPHITIDAE) IN A GRASSLAND RELICT OF CENTRAL ARGENTINA

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ABSTRACT. In order to investigate the factors affecting den site selection in *Conepatus chinga*, we identified and characterized 199 (males: n = 108, females: n = 91) dens used by 7 radio-tracked skunks from August 2002 to October 2005 in a protected area of the Argentine Pampas grassland. Skunks frequently reused dens (25.1%), without significant differences between sexes. Although *C. chinga* are solitary animals, our data indicate that males and females may be able to share dens, presumably in the breeding season. Den sites were not homogeneously distributed within an animal's home range, being the density in core areas greater than in middle and border regions of home ranges. This study confirmed that *C. chinga* selects specific habitat characteristics for its den sites and suggests that the access to prey is a major factor in their selection.

RESUMEN. Uso y selección de madrigueras por parte de *Conepatus chinga* (Mephitidae) en un relictos de pastizal pampeano del centro de Argentina. Para investigar los factores que afectan la selección de madrigueras de *Conepatus chinga*, identificamos y caracterizamos 199 (machos: n = 108, hembras: = 91) madrigueras utilizadas por siete zorrinos equipados con radiotransmisores en el periodo comprendido entre agosto de 2002-octubre de 2005, en un área protegida en los pastizales pampeanos de Argentina. Frecuentemente los zorrinos reutilizaron sus madrigueras (25,1%), sin encontrarse diferencias significativas entre ambos sexos. Aunque los zorrinos comunes son considerados animales solitarios nuestros resultados indican que tanto machos como hembras pueden compartir las madrigueras, presumiblemente en la época de apareamiento. Las madrigueras no estuvieron homogéneamente distribuidas dentro de las áreas de acción de los zorrinos, con mayor densidad en las áreas núcleo que en las regiones medias y externas de las áreas de acción. Este estudio confirma que *C. chinga* selecciona hábitats específicos para sus madrigueras y sugiere que el acceso a las presas es el principal factor que determina esta selección.

Key words: Habitat selection. Molina's hog-nosed skunk. Radiotelemetry.

Palabras clave: Radiotelegrafía. Selección de hábitat. Zorrino común.

Suitable den sites are a basic habitat requirement for skunks (Mephitidae, Carnivora) (Bixler and Gittleman, 2000; Lesmeister et al., 2008). Skunks use dens to shelter from inclement weather (Hwang et al., 2007; Cantú Salazar et al., 2009) and predators (Cantú Salazar et al., 2009; Castillo et al., 2011a); moreover, dens are the site of birth and early maternal care of offspring (Rosatte and Larivière; 2003; Castillo, 2011). Selection of habitats surrounding dens may influence den use, because it may affect safety from predators or disturbance (Grand, 2002; Mitchell and Lima, 2002; Spencer, 2002) and access to food resources (Rubin et al., 2002; Lyons et al., 2003; Castillo et al., 2011a), so understanding the factors that influence den selection is valuable for the species management.

Although it is one of the most widespread South American mammals, little is known about the biology and ecology of the Molina's hog-nosed skunk *Conepatus chinga* (Molina, 1782). A previous study showed that *C. chinga* selected specific habitat characteristics (i.e., patches with tall grasses) for their den sites in a farmland area. Two major factors were proposed to explain these selections: predation risk and access to food (Castillo et al., 2011a). To test these two hypotheses we predict that if access to food is an important driver of dens site selection, dens would be concentrated in the most productive habitat. Specifically, we expect that skunks select for their dens the habitat where their prey items (i.e., scorpions, and larvae of Lepidoptera and Coleoptera; Castillo, 2011) are most abundant. Alternatively, if the risk of predation is the major factor affecting den site selection, we may expect dens to be concentrated in the habitat offering the greatest vegetation cover. In this study, we collected data on denning habits, particularly den site selection and use by radio-collared *C. chinga* in a protected area located in the Pampas grasslands of Argentina.

The Ernesto Tornquist Provincial Park (henceforward ETPP) preserves one of the last fragments of the native Pampas grassland, the most populated and degraded ecoregion in Argentina (Bertonatti and Corcuera, 2000). This 6700 ha protected area is located in the central part of the Ventania mountain range,

southern Buenos Aires province, Argentina. Its altitude ranges from 450 m to 1172 m asl. The climate is temperate with mean 500-800 mm annual precipitation. Its vegetation is characterized by native grassland but introduced tree/shrub patches are also frequent (Zalba and Villamil, 2002).

We spotlighted skunks from a vehicle and restrained them manually (Castillo et al., 2011b). Captured individuals were chemically immobilized (Castillo et al., 2012). Healthy adult animals were fitted with radiocollars and monitored during discontinuous tracking sessions. Successive locations with a minimum interval of 2 h between them were considered as biologically independent (Castillo et al., 2011b). Den sites were located via "homing in" (following increasing intensity of radiocollar signal until the den was identified; White and Garrott, 1990). Because *C. chinga* activity is mostly nocturnal (Castillo, 2011) all the sites where a skunk remained inactive during the day were considered occupied dens for the purposes of this study (Doty and Dowler, 2006). Den structures were categorized as either underground or above-ground burrows. Dimensions (width and height) of entrances were recorded when possible.

We calculated the 99% fixed Kernel method (Worton, 1989) to build the home range from all locations of each skunk. Home ranges were then divided into core (delimited by the 45% Kernel), middle (45% to 80%) and border region (the area occupied by the 20% most external locations). Ranges V (Kenward and Hodder, 1996) software was used for all these analyses. We calculated the densities of dens in border, middle and core areas of the home range for each skunk by dividing the number of dens in each region by its area (Jordan et al., 2007). To test our predictions, we used Google Earth satellite imageries to classify the area into 4 exclusive habitat types: (1) High rocky coverage area (HRA), steep areas characterized by the presence of consolidated rock with shallow canyons; (2) Low rocky coverage area (LRA), areas with moderate slopes where rock outcrops are isolated; (3) Woodland: a wood patch composed by introduced trees (predominantly *Pinus* sp. and *Eucalyptus* sp.); in this habitat the

density of feral horses was high; (4) Grassland: a fenced area, where horses were excluded and grasses (predominantly *Paspalum quadrifarium*) were denser and taller than in the remaining habitats. In both rocky areas the vegetation was dominated by herbaceous species (genera *Grindelia* and *Festuca*) and the shrub *Discaria longispina* (Zalba and Villamil, 2002) whose height and density were negatively influenced by the presence of large numbers of feral horses (Scorolli et al., 2006).

Habitat selection was evaluated using compositional analysis (Aitchison, 1986). Habitat availability within the home range (100% Minimum Convex Polygon) and proportional utilization (dens) by each animal were first converted to log-transformed ratios. Compositional analysis employs radiocollared animals as sampling units, and considers all habitat types simultaneously. Because the minimum number of individuals for statistical inference from compositional analyses is six (Aebischer et al., 1993), the sexes were pooled. When a habitat was available but not used or when it was neither used nor available, a value of 0.01% was assigned to it, a substitution that does not affect the outcome of the category rankings (Aebischer et al., 1993). In agreement with Johnson (1980), we defined habitat selection as the disproportionate use of a habitat relative to its availability. Following Aebischer et al. (1993), we adopted the term habitat preference on a relative scale only, for ranking habitat selection relative to specific, alternate habitats.

Based on the main prey items found in the feces of *C. chinga* (Donadio et al., 2004; Castillo, 2011), we used pitfall traps (Ausden, 1996) to estimate the abundance of invertebrates available at ground level. Nine traps of 10 cm in diameter and 7 cm deep (filled with salt water solution and placed in pits deep enough to bury the cups up to the rim on the ground) were settled in 20x20 grids. In each habitat type and season (autumn, winter, spring and summer) we activated three randomly located grids that were active for three consecutive nights. The abundance was calculated as the average number of individuals captured per grid. This analysis only included the main prey items found in the diet of skunks from the same

area: Coleoptera, Coleoptera larvae, Lepidoptera larvae, and scorpions, which totaled 69.2% of the ingested items (Castillo, 2011).

To examine the relationship between den site location and selected landscape features, we used ArcView 9.3[®] to calculate distances (m) from each den site to the nearest stream and grassland. We determined the same distances for uniformly distributed random points (generated in equal number to dens) and investigated differences between den sites and random points with Student's t-tests. For all statistical procedures we used SPSS software (SPSS Inc. 2008) and $P \leq 0.05$ values were considered significant.

We identified and characterized a total of 199 (males: $n = 108$, females: $n = 91$) den sites of 7 *C. chinga* (3 males and 4 females) that were radiotracked from August 2002 to October 2005. Most used dens were found in above-ground burrows ($n = 170$, 85.4 %) and the dimensions of their entrances ($n = 77$) were ($X \pm SD$) 21.5 ± 9 cm (height) and 25.7 ± 1.06 cm (width).

On average, 25.1% of den sites were reused by skunks (males: 23.1%, females: 27.4%). We observed that studied animals reused den sites for a mean of $2.6 (\pm 0.4, SD)$ times without significant differences between sexes (males: 2.53 ± 0.17 , females: 2.64 ± 0.4 ; $t = 0.43$, $df = 5$, $p = 0.68$). Frequently (42.6% of the occasions), *C. chinga* reused dens on consecutive days. In five occasions, two radiocollared skunks (one female and one male) shared dens. In one of these observations we were able to spot that the two adults were accompanied by their pups.

Mean home range size for radiotracked skunks was 178.6 ha (range: 94.1-420.2 ha; $n = 7$). Border regions had a mean size of 86.1 ha (range 46.3-182.1 ha), middle regions of 48.7 ha (range 24.2-121.8 ha) and core areas of 43.1 ha (range 17.7-116.3 ha). Because we did not detect variations between skunks in den locations in the three regions ($X^2 = 11.51$, $df = 12$, $p = 0.5$), we pooled all individual dens and found that both the number ($F = 4.01$, $df = 20$, $p = 0.036$) and density of dens ($F = 9.76$, $df = 20$, $p = 0.01$) were significantly greater in core areas than middle and border regions (Table 1).

Conepatus chinga utilized habitats to locate den sites in a non-random manner in the study

Table 1

Spatial distribution of *Conepatus chinga* dens (n=199) within the home ranges of 7 radiotagged animals in a grassland relict of central Argentina. Different superscript letters indicate significant differences between pairs of regions ($p < 0.05$; ANOVA Test).

	Core region	Middle region	Border region
Number of dens \pm SD	14.6a \pm 8.3	6.6b \pm 5.1	7.3b \pm 2.8
% of total dens	51.3	23.1	25.6
Density (n° dens/ha) \pm SD	0.43a \pm 0.2	0.15b \pm 0.1	0.1b \pm 0.1

area ($\Lambda = 0.24$, $df = 3$, $p = 0.04$, **Table 2**, **Fig. 1**). Comparison of den site habitats and home range habitat compositions revealed that LRA, HRA, woodland and grassland were ranked first to fourth. LRA and HRA were significantly selected over grassland, whereas no significant difference was found between LRA, HRA and woodland (**Fig. 1**).

Grassland was the habitat with the highest abundance of Coleoptera, whereas woodland showed the lowest abundances of these invertebrates (**Fig. 2**). LRA had the greatest abundances of both types of larvae and scorpions (**Fig. 2**).

We found no variations between den sites (ds) and random points (rp) in distance to streams (ds: 178.1 ± 116.4 m, rp: 203.2 ± 175.5 m; $U = 19535$, $p = 0.81$). However, den sites were located closer to grassland than random points (ds: 305.2 ± 341.9 m, rp: 883.6 ± 578.6 m; $U = 8140$, $p < 0.001$).

This study confirmed that *C. chinga* selects specific habitat characteristics for its den sites. LRA was the most preferred environment in the

study area. This habitat presented the highest abundance of 3 of the 4 main items of *C. chinga* diet. Even if skunks do not have important natural predators in the area, they can probably be attacked by black-chested buzzard-eagles (*Geranoaetus melanoleucus*) (Hiraldo et al., 1995; Massoia and Pardiñas, 1996) and Pampas foxes (*Lycalopex gymnocercus*). Because grasslands (the less preferred habitat) offered the best protection from predators, our data are indicative that food availability is a more important factor than protection from predation in *C. chinga* selection of den sites.

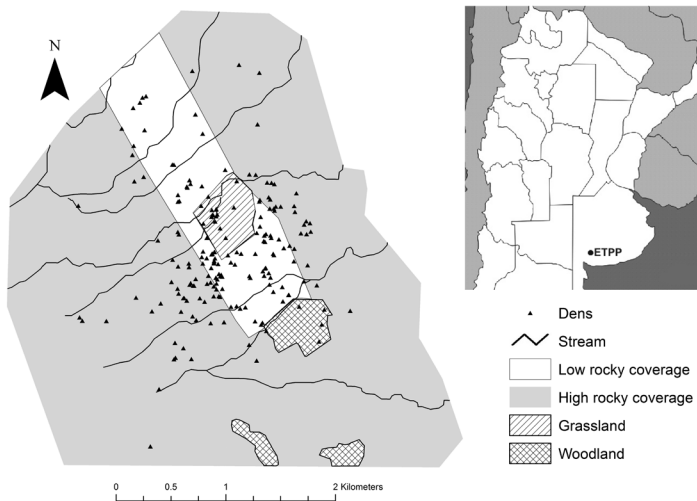
Although skunks can dig their burrows (Castillo et al., 2011a) and readily use burrows excavated by other species (e.g., armadillos in our study region, Castillo, 2011), skunks mainly placed their dens in above-ground rocky shelters in our study area. This can be explained by the difficulty to dig in the rocky soil present along the study area. In fact, the majority of underground burrows are adjacent to streams where the substrate is less hard. The fact that in our study area the grassland habitat has few rocky

Table 2

Significance and relative ranking of habitat types derived from pair-wise log-ratio differences between habitat availability within the home range and proportional utilization (dens) for *Conepatus chinga* in a grassland relict of central Argentina. Each mean element on the matrix was replaced by its sign; a triple sign represents significant deviation from random at $p > 0.05$.

	LRC area	HRC area	Woodland	Grassland	Rank
Low rocky coverage (LRC) area	0	+	+	+++	1
High rocky coverage (HRC) area	-	0	+	+++	2
Woodland	-	-	0	+	3
Grassland	---	---	-	0	4

Fig. 1. Spatial distribution of *Conepatus chinga* dens in the study area, a grassland relict in southwestern Buenos Aires province, Argentina.



outcrops that can be used by skunks as shelters, together with the result that shows that den sites were closer to grassland than expected, suggests that den availability may be a confounding factor that needs to be addressed by future studies on denning selection in skunks. Contrary to other species of skunks (Rosatte and Larivière, 2003; Hwang et al., 2007; Lesmeister et al., 2008), dens were not associated with streams in *C. chinga*. We suggest that the presence of several streams that cross the study area (Fig. 1) reduced the importance of the access to water as a limiting factor that affected the distribution of skunk dens.

The mean number and the relatively frequent reuse of individual dens of *C. chinga* in the present study are similar to those described for this species in a farmland area of the same region and

both were large compared to similar studies of other species of skunks (Larivière and Messier, 1997; Norbury et al., 1998; Cantú Salazar, 2002; Hwang, 2005). Also similar to the farmland area, core areas were the portion of individual home ranges that had the greatest number and density of dens (Castillo et al., 2011a). These results confirm the great importance of this resource in *C. chinga* (Castillo et al., 2011a).

Conepatus chinga are solitary animals (Castillo et al., 2011b) and the use of the same den by two individuals had not been previously described in *C. chinga* (Castillo et al., 2011a). Our data indicate that males and females may share dens, presumably in the breeding season, and thus that these mephitids are able to show certain flexibility in their denning behavior.

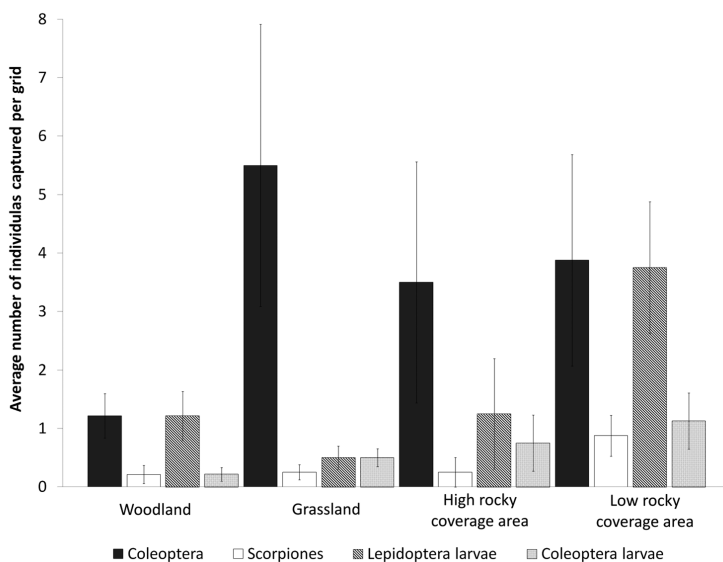


Fig. 2. Abundance (mean number of individuals captured per grid \pm Standard Error) of the main prey of *Conepatus chinga* for different habitat types in a grassland relict in southwestern Buenos Aires province, Argentina.

It is concluded that dens are important resources in *C. chinga* spatial ecology, and that food availability strongly influence their selection.

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