

Diet and abundance of bobcat (*Lynx rufus*) in the Potosino-Zacatecano Plateau, Mexico

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The Potosino-Zacatecano Plateau (PZP) is characterized by a system of hills surrounded by ridges where the bobcat is the only wild felid; however, there is no information on the basic ecology of this species in this region. The objective of this work was to determine the diet and abundance of the bobcat in Cerro del Peñón Blanco, San Luis Potosí. The diet was inferred from the analysis of prey remains in feces; in addition, the minimum number of bobcats in the study area was estimated by camera traps placed in Cerro del Peñón Blanco, San Luis Potosí. Diet composition was expressed as percentage of occurrence. Individual bobcats were identified by the distinctive morphological characteristics of each. Seventy five scat samples were collected and analyzed. The diet included 14 taxa, with the rabbit *Sylvilagus audubonii* as the species most frequently consumed. The mouse *Peromyscus* spp. was the rodent species with the highest frequency of occurrence; however, no single species was dominant. We identified seven bobcat individuals: three males, three females and one of unknown sex. The bobcat diet allows inferring how this feline uses landscape in the study area, feeding on its main prey in foothills fragmented patches and complementing its diet with prey present in Peñón Blanco. The study area still provides sufficient prey base for the bobcat.

El altiplano Potosino-Zacatecano (APZ) se caracteriza por presentar un sistema de elevaciones rodeadas de lomeríos donde el gato montés es el único felino silvestre, sin embargo, no existe información sobre la ecología básica de esta especie en la región. El objetivo de este trabajo fue determinar la dieta y abundancia del gato montés en el cerro del Peñón Blanco, San Luis Potosí. La dieta se obtuvo del análisis de los restos de presas halladas en excretas y se estimó el número mínimo de gatos monteses en la zona de estudio por medio de trampas-cámara colocadas en el Cerro del Peñón Blanco, San Luis Potosí. La composición de la dieta se expresó como porcentaje de aparición. Los distintos individuos se identificaron por la presencia de características morfológicas distintivas. Se colectaron y analizaron 75 excretas. La dieta estuvo compuesta por 14 taxa, siendo la especie más común el conejo *Sylvilagus audubonii*. El ratón *Peromyscus* spp. fue la especie de roedor con mayor frecuencia de aparición, sin embargo, ninguna especie fue dominante. Se identificaron siete individuos de gato montés, tres machos, tres hembras y uno de sexo desconocido. La dieta del gato montés permite identificar como este felino usa el paisaje en la zona de estudio, alimentándose de su presa principal en las zonas bajas fragmentadas y complementando su dieta con presas presentes en el Peñón Blanco. La zona de estudio aún cuenta con una base de presas adecuada para el gato montés.

Keywords: camera-trapping; diet; feces; fragmentation; lagomorphs.

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Introduction

The Chihuahuan Desert is the largest arid zone in North America, and one with the highest biodiversity in the world (Hoyt 2002; Loa-Loza *et al.* 2009; Rzedowski 2005). Its southernmost portion corresponds to the Potosino-Zacatecano Plateau (PZP). This region is characterized by a system of elevations (e. g., ridges and rock outcrops) surrounded by hills and plains (INEGI 1985). Some of the elevations are covered by relicts of oak forest (*Quercus potosina* and *Q. Greggii*; Cabrera-Rodríguez 2015) that provide shelter for priority species for conservation in Mexico, such as the golden eagle (*Aquila chrysaetos*; Loa-Loza *et al.* 2009). However, many of these ridges and flat areas have been modified by anthropogenic activities such as cattle ranching, rainfed agriculture and mining (Martínez-Montoya *et al.* 2012).

The bobcat (*Lynx rufus*) is a felid whose historical distribution in Mexico stretched from the border with the United States south to the state of Oaxaca (Hall 1981). In Mexico, this species is not listed under any risk category (SEMARNAT 2010), although local bobcat populations have become isolated as a result of anthropic fragmentation processes (Lopez-González *et al.* 2015).

Most of the studies about bobcat in Mexico have analyzed their food habits, abundance and density in virtually undisturbed semi-desert and temperate habitats (Lopez-González *et al.* 2015; Medellín and Bárcenas 2010). These studies reveal that the bobcat diet consists mainly of lagomorphs (Aranda *et al.* 2002; Delibes *et al.* 1997; Luna-Soria and López-González 2005; Medellín and Bárcenas 2010).

The bobcat is the only wild felid currently inhabiting the PZP (Dalquest 1953, Martínez de la Vega *et al.* 2016). Its

presence serves as an indicator of the conservation status of this region, as this feline requires territories with abundant prey base (Butrey 1979; McCord and Cardoza 1982; Sunquist and Sunquist 1989, 2000). In spite of its ecological importance, *L. rufus* is perceived to be a major predator of goats by local communities located in the PZP (Martínez-Montoya et al. 2012). However, this claim has not been evaluated and there is a lack of baseline information on the ecology of the bobcat in PZP.

This work determined the diet of the bobcat across an area surrounded by a fragmented landscape, where ridges act as important relicts and shelters for biodiversity, specifically in *El Peñón* and other nearby elevations where the existing vegetation cover provides suitable habitats (Martínez-Montoya et al. 2012). This study contributes baseline information on the ecology of bobcat in PZP and its trophic relationship with goats.

Materials and Methods

Study area. The study was carried out in *Cerro del Peñón Blanco*, a mount located in the municipality of Salinas, to the northwest of the state of San Luis Potosí (22° 27' 44" N, -10° 43' 00" W), with an altitudinal range of 2,120 and 2,750 m. It is located 13 km southeast of the city of Salinas de Hidalgo, 8 km southwest of highway 57 and on the border between the states of San Luis Potosí and Zacatecas. Two communities are located in the mount foothills. *El Alegre* and *San Juan sin Agua*, each with less than 100 inhabitants (INEGI 1997; Figure 1).

The local climate is dry and semi-cold, with summer precipitation (June to September) and occasional drizzles in January; mean annual precipitation is 391 mm. Mean annual temperature ranges between 16 °C and 18 °C (INEGI 2009). The vegetation communities include scrubland

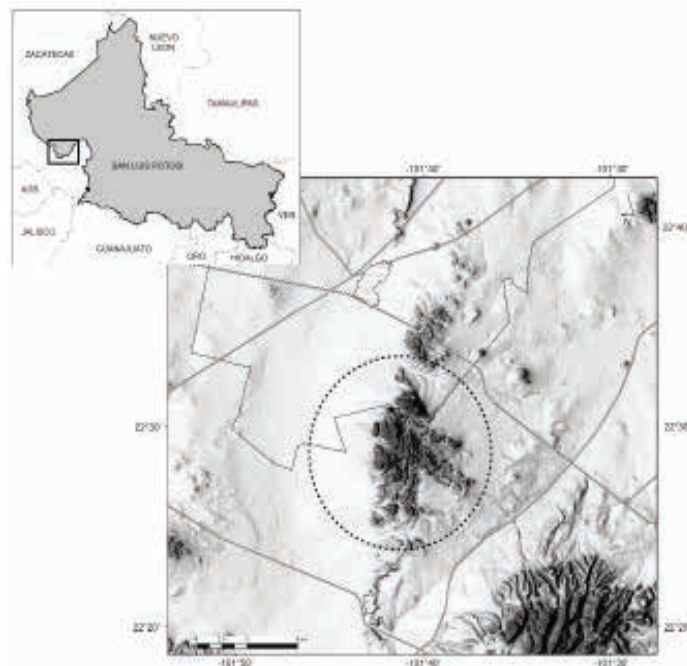


Figure 1. Location of Peñón Blanco in the Potosino-Zacatecano Plateau, Mexico. The dotted line marks the area of study.

(“matorral crasicale”) and relicts of oak forest in the higher elevations (INEGI 1997). The original vegetation in the surrounding area was microphyll xeric shrub, yucca scrub, carbon scrub and cactus shrub (Rzedowski 2005). The dominant species are creosote bush (*Larrea tridentata*), alicocha (*Opuntia bradtiana*), mesquite (*Prosopis laevigata*), and Chinese palmtree (*Yucca filifera*). The local vegetation has been disrupted by excessive grazing by bovine cattle and goats, urbanization, mining operations and the opening up or expansion of terrestrial communication routes (Martínez-Montoya et al. 2012).

Diet Characterization. Diet components were quantified through the location, collection, identification and analysis of feces along dirt roads, livestock paths used by wildlife, and stream beds. Scat samples were collected once a week between June and November 2011 from nine latrines located throughout the study area. One week prior to the start of the field surveys, the area was walked to collect and dispose of all bobcat feces accumulated up to that time, to ensure that any feces analyzed in the study were one week old maximum.

Bobcat feces were differentiated *in-situ* from those of other carnivores also inhabiting the study area (e. g., coyote *Canis latrans*, and gray fox *Urocyon cinereoargenteus*) by comparing their physical characteristics and identifying the respective footprints and associated sign (*sensu* Aranda 2012). Any scats of questionable origin or weathered were discarded. Scat samples were placed in airtight Ziplock^{MR} bags containing water and 10 g of powder detergent, and were soaked for at least 5 days. Afterwards, samples were washed under running water in 6-mm and 3- mm mesh sieves. Once washed, the content was oven-dried at 40 °C for 24 hours.

Bones, feathers and scales were identified by comparison vs. reference collections and identification guides (Elbroch 2006; Scott and McFarland 2014). For the identification of hairs, slides were prepared to examine the medulla and cortical scales using the technique by Williamson (1951). Slides were compared against material from the collection of mammals of the Laboratory of Population Ecology, School of Biology, Benemérita Universidad Autónoma de Puebla. Components in scat samples were identified to the lowest taxonomic level possible.

The frequency and percentage of occurrence of the different species in feces was calculated. The percentage of occurrence was determined as: $PA_i = (FA_i/N) \times 100$. Where: FA_i = Frequency of occurrence of species *i*. N = Total number of components in the scat samples analyzed.

Variations in the frequency of food items were determined by applying a G-test under the null hypothesis that species share the same frequency. In case of significant differences, paired G-tests were conducted for significant differences in the frequency of each item vs. the expected frequency (Zar 2010).

Estimate of the minimum number of individuals. In parallel with the collection of scats, eight simple camera-trap stations were installed (DeerCam[®]DC200, 35 mm) across

Peñón Blanco following the criteria by Heilbrun et al. (2003), distance between stations was 200 to 600 m. Cameras were set to operate 24 hours with 5 minutes between triggers. Due to the lack of trees in the study site, cameras were installed on wooden stakes at 30 cm above the ground. No baits were used in any station.

The minimum number of individuals during the sampling period was determined. The distinctive traits of individual bobcats used in the analysis of photographs included spot pattern, scars, facial ruff shape and color, sex and body size (Heilbrun et al. 2003, 2006; Figure 2). The identification and quantification of captures-recaptures were conducted according to the guidelines proposed by Heilbrun et al. (2003), namely a) only photographs of an individual bobcat that could not be associated with another captured previously were considered as initial captures; b) recaptures were determined even in cases where there were no photographs of the complete individual, provided its identity could be fully established; c) any poor-quality photographs that could not be classified as an initial capture or a recapture were discarded; d) In all cases, at least three natural characteristics (e. g., tail stripes, scars, face marks, or facial

ruff patterns) were used to identify individuals and to determine recaptures; e) the identification of a single different trait was considered as sufficient to consider that two photographs represented different individuals.

Results

A total of 75 scat samples of *L. rufus* were collected and analyzed, from which food items belonging to 14 different taxa were identified. Mammals were the most frequent prey, with 11 spp. To a lesser extent, the diet also included birds, reptiles and invertebrates (Table 1).

Differences were observed in the frequency of occurrence of the various taxa in the diet ($G = 114.73$; g. l. = 13; $P = 0.001$). The rabbit *S. auduboni* was the species with the highest percentage of occurrence. The frequency of occurrence of this lagomorph in feces was significantly higher relative to any other species ($P < 0.001$). The raccoon (*Procyon lotor*) and invertebrates were consumed with lower-than-expected frequencies ($P < 0.05$). No rodent species was consumed more frequently than any other prey taxa. No goat remains were identified in any of the scat samples analyzed.



Figure 2. Bobcat individuals photographed in the Peñón Blanco in the Potosino-Zacatecano Plateau, Mexico

Table 1. Diet of the bobcat at Peñón Blanco, Potosi-Zacatecas Plateau, Mexico.

Species	Frequency of occurrence	Percentage of occurrence
Mammals		
Rodents		
<i>Chaetodipus nelsoni</i>	13	5.1
<i>Neotoma mexicana</i>	19	7.5
<i>Peromyscus boylii</i>	19	7.5
<i>Peromyscus maniculatus</i>	11	4.3
<i>Peromyscus</i> sp.	28	11.1
<i>Peromyscus truei</i>	23	9.1
<i>Otospermophilus variegatus</i>	21	8.3
Lagomorphs		
<i>Lepus callotis</i>	23	9.1
<i>Sylvilagus audubonii</i>	58	22.9
Carnivores		
<i>Procyon lotor</i>	2	0.8
Unidentified Mammal	11	4.4
Birds		
Unidentified bird	10	4.0
REPTILES		
<i>Sceloporus</i> sp.	8	3.2
Invertebrates		
Invertebrates	7	2.8

A sampling effort of 630 trap-nights yielded 32 separate photographs (*sensu* O'Brien *et al.* 2003) of nine species of wild animals (Table 2). Twelve of these photographs were of bobcat (Table 2), with nine being useful for the identification of individual specimens. The remaining photographs were excluded due to poor image quality, showing an individual in a position that restrained an accurate observation of its characteristics, or for being partial pictures that hindered a reliable identification. As a minimum, three males, three females and one individual of undetermined sex were identified. All individuals, except for female LH1 and male LM02, were photographed only on one occasion. Recaptures occurred in the same camera-trapping site.

Discussion

The bobcat is the top predator in desert ecosystems where large carnivores (*i. e.*, *Puma concolor*) have been eliminated; hence, its diet is expected to consist of a broad variety of prey types available in the ecosystem (Sergio *et al.* 2006). The results of the diet composition were very similar to observations reported from non-fragmented desert environments in the United States (Fritts and Sealander 1978; Jones and Smith 1979; Koehler and Hornocker 1991) and Mexico (Aranda *et al.* 2002; Delibes *et al.* 1997; Luna and López 2005).

The analysis of the diet makes possible to identify how the bobcat uses the landscape in the study area. In this case, rabbits were the group with the highest percentage of occurrence in the feces analyzed, with *S. auduboni* being best adapted to flat areas and hills (Bond *et al.* 2002). This

Table 2. Photographs of wildlife captured at Peñón Blanco, Potosino-Zacatecano Plateau, Mexico.

Species	Independent Photographs	IAR*
<i>Canis latrans</i>	1	0.16
<i>Canis lupus familiaris</i>	1	0.16
<i>Conepatus leuconotus</i>	2	0.32
<i>Geococcyx californianus</i>	3	0.48
<i>Lynx rufus</i>	12	1.90
<i>Procyon lotor</i>	8	1.27
<i>Sciurus</i> sp.	1	0.16
<i>Otospermophilus variegatus</i>	1	0.16
<i>Urocyon cinereoargenteus</i>	3	0.48
Total	32	

* *sensu* O'Brien *et al.* 2003.

suggests that the bobcat forages mainly in the lower elevations of Peñón Blanco. Rabbits and hares are species that can tolerate the fragmentation of their habitat; however, this fragmentation increases the risk of being consumed by predators (Villafuerte *et al.* 1997). In this sense, the fragmentation adjacent to Peñón Blanco apparently does not affect the feeding ecology of the bobcat, since the conditions resulting from habitat fragmentation substitute the preferential consumption of lagomorphs.

The consumption of other prey types such as the rock squirrel, *Otospermophilus variegatus*, and lizards of the genus *Sceloporus*, which are abundant in rocky outcrops across Peñón Blanco (Martínez-Montoya *et al.* 2012), demonstrate the importance of this elevation has as a source of secondary prey items for the bobcat. The consumption of rock squirrels has been recorded in sites with rocky outcrops similar to Peñón Blanco, as is the case of Plomito in Sonora (Aranda *et al.* 2002), Sierra del Ajusco (Romero 1993) and La Malinche National Park (Cortés 1998).

As a group, rodents are key components of the diet of the bobcat in the study area. This group is particularly abundant in sites covered by grasslands interspersed with patches of scrub vegetation and rocky outcrops (Mellink 1991), which are located in the foothills of Peñón Blanco (INEGI 1985). The bobcat is an opportunistic hunter that forages on the most abundant prey items in its habitat (Lopez-Vidal *et al.* 2014), such as mice of the genus *Peromyscus*. Altogether, these mice accounted for 32 % of the diet, indicating that they are important prey for the bobcat in this region. These rodents likely serve as alternate prey items in areas where lagomorphs are relatively scarce. This has been reported for central Mexico, an area where rabbits are scarce due to hunting, leading to *Peromyscus* becoming the most important prey of bobcats (Cortés 1998).

The opportunistic behavior of *L. rufus* in the study area is highlighted by the presence of raccoon in its diet. This is the first record of bobcat predating on raccoon across its distribution range. The raccoon is a species strongly associated with water bodies (Valenzuela 2005), so that the presence

of temporary streams flowing down from Peñón toward lowlands, where some ponds remain even in the dry season, may favor their presence to the point of being the second most abundant species recorded by camera traps.

This study recorded no evidence of the predation of goats or sheep by bobcat. The predation of livestock by bobcat is poorly documented; therefore, it is considered as a species with low risk of conflict with humans (Inskip and Zimmermann 2009). The absence of livestock items in the diet suggests that anecdotal claims about this species as a predator of livestock may be a misperception of the local inhabitants rather than reflecting a genuine impact. Moreover, this finding also suggests that, in spite of the current fragmentation, the landscape in the study area still provides a sufficient prey abundance that allows maintaining the local bobcat population. However, the increase in grazing intensity by goat herds that roam freely across Peñón Blanco and its surrounding areas could lead to a decline in the abundance of the local populations of rodents and lagomorphs (Vorhies and Taylor 1933), resulting in the possibility of predation on livestock by bobcat.

The presence of seven bobcat individuals during the period of study highlights the importance of Peñón Blanco as a habitat for this species. Peñón Blanco, one of the highest elevations across an area of 2,000 km², has features that are preferred by the bobcat to establish burrows and daytime resting sites (e. g., rugged topography and presence of abundant rocky formations; Romero 2005), so it may be the site of confluence of the territories of various individuals. This hypothesis is further supported by the presence of abundant latrines ($n = 15$) in the highest sites of Peñón, where at least two individuals were photographed while performing territorial marking.

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