Winter diet of burrowing owls in the Llano La Soledad, Galeana, Nuevo Leon, Mexico

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We determined the dietary niche breadth of the Burrowing Owl (*Athene cunicularia* Molina, 1782) in Llano La Soledad, Galeana, Nuevo Leon in northern Mexico, by considering prey type, numerical percentage, biomass percentage, percentage of frequency of occurrence, and IRI percentage. The study compared data from three winters (2002–2003, 2003–2004, 2004–2005) by analyzing 358 pellets and identifying 850 prey items. Invertebrates constituted 90% of prey items, which mostly included insects (85%); beetles were the most common insects found in pellets (70%). Vertebrates made up 84% of consumed biomass, of which 83% were mammals. Most of the mammal biomass consumed consisted of cricetid rodents (41%). Niche breadth based on the frequency of occurrence and biomass confirmed the Burrowing Owl as a generalist species with mean values per year ranging between 0.68 and 0.82. Additionally, there was a significant association between the relative biomass of rodent species and invertebrate families in winter. This association was mainly driven by changes in composition and frequency of these prey species during the second winter, probably caused by high annual rainfall. The second season also showed a significantly narrower niche (0.68 vs. 0.82) and the smallest overlap (<47% vs. 88%) among the three winters.

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Abstract

We determined the dietary niche breadth of the Burrowing Owl (*Athene cunicularia* Molina, 1782) in Llano La Soledad, Galeana, Nuevo Leon in northern Mexico, by considering prey type, numerical percentage, biomass percentage, percentage of frequency of occurrence, and IRI percentage. The study compared data from three winters (2002–2003, 2003–2004, 2004–2005) by analyzing 358 pellets and identifying 850 prey items. Invertebrates constituted 90% of prey items, which mostly included insects (85%); beetles were the most common insects found in pellets (70%). Vertebrates made up 84% of consumed biomass, of which 83% were mammals. Most of the mammal biomass consumed consisted of cricetid rodents (41%). Niche breadth based on the frequency of occurrence and biomass confirmed the Burrowing Owl as a generalist species with mean values per year ranging between 0.68 and 0.82. Additionally, there was a significant association between the relative biomass of rodent species and invertebrate families in winter. This association was mainly driven by changes in composition and frequency of these prey species during the second winter, probably caused by high annual rainfall. The second season also showed a significantly narrower niche (0.68 vs. 0.82) and the smallest overlap (<47% vs. 88%) among the three winters.

Key words: biomass, burrowing owl, grassland, niche breadth, winter diet, Chihuahuan Desert.

INTRODUCTION

The North American Burrowing Owl (*Athene cunicularia* Molina 1782) populations are distributed from southwest Canada, through the west and central USA (but also in Florida) and Mexico. However, most northern populations migrate to the southern USA and Mexico (*Marks et al.,* 1999). This bird is a predator of importance able to maintain its prey population in stable numbers (*Coulombe 1971*). The Burrowing Owl is considered an opportunistic predator (*Rodriguez-Estrella 1997*) with diurnal activity, although hunting mainly at dawn and dusk (*Coulombe 1971*). It lives in open areas like grasslands, deserts, and disturbed areas (*Coulombe 1971; Butts 1976; Ruiz-Ayma et al*., *2019*). Moreover, its habitat with discontinuous vegetation and low bushes allows the Burrowing Owl to increase its visibility to hunt, observe predators, and keep watch over its burrow (*Coulombe 1971; Howell & Webb 2004*). It is strongly associated with Black-tailed prairie dogs (*Cynomys ludovicianus*) and Mexican prairie dog (*C. mexicanus*) colonies in Mexico, using their burrows for protection against predators and nesting (*Coulombe 1971*; *Butts 1976*; *Coulombe 1971*; *Ruiz-Ayma et al*., *2019*).

The Burrowing Owl has shown a significant negative population trend in the United States for approximately 50 years (−0.91%/yr.; 1966–2015; *Sauer et al*., 2017). This decline is especially steep in Canada (−6.42%/yr.; 1966–2015; *Sauer et al*. 2017), where it is listed as an endangered species (Committee on the Status of Endangered Wildlife in Canada [*COSEWIC*] 2006). Additionally, the Burrowing Owl is a National Bird of Conservation Concern (U.S. Fish and

Wildlife Service [*USFWS]* 2008). Simultaneously, in Mexico it is protected under the "Special Protection" category (Secretaria de Medio Ambiente y Recursos Naturales [*SEMARNAT*] 2010). The current population status of the Burrowing Owl is a result of multiple threats such as habitat fragmentation, decreased prey availability, increased predation, inclement weather, vehicle strikes, environmental contaminants, and loss of burrows (*Rodriguez-Estrella 2006*, *Enríquez and Vázquez-Pérez 2017*).

Prey availability is one of the most important natural limiting factors in populations during the winter (*Newton 1998; McDonald et al., 2004*). Most of the Burrowing Owl winter diet studies have been conducted in the United States (Texas, Nevada, and California) and other countries in North and South America (*Littles et al., 2007; Nabte et al., 2008*; *De Tommaso et al., 2009*; *Andrade et al., 2010)*. In most studies, the Burrowing Owl diet consists mainly of invertebrates, small mammals, and reptiles *(Plumpton & Lutz 1993; Littles et al., 2007; De Tommaso et al., 2009*). Invertebrates are consumed most frequently (*Poulin 2003*), but mammals make up most of the biomass (*Andrade et al., 2004*; *Littles et al., 2007*; *Nabte et al., 2008*; *De Tomasso et al., 2009*; *Andrade et al., 2010*; *Carevic et al., 2013*). The frequency of occurrence of insect orders is highly variable, both temporally and spatially. Consumption of beetles (Coleoptera) and crickets (Gryllidae) ranged from 20% to 80% in pellets. Conversely, mammal species, including North American Deer Mouse (*Peromyscus maniculatus*), Silky Pocket Mouse (*Perognathus flavus*), and Merriam's Kangaroo Rat (*Dipodomys merriami*), have 98% occurrence in pellets (*Ross & Smith 1970; Coulombe 1971; Butts 1976; Tyler 1983; Barrows 1989; Mills 2016*). A study in British Columbia, Canada, indicated that 56% of their diet is insects, such as earwigs and beetles (*Morgan et al., 1993*). The only study of the winter diet from Mexico comes from central Mexico in Guanajuato, where 78% of prey items were invertebrates (*Valdez-Gómez 2003*).

Biomass data were more evenly distributed among Orthoptera (26.8%), Lepidoptera (20.6%), and rodents (20.9%; *Valdez-Gómez et al., 2009*). The breeding season diet has also been analyzed in Durango and Nuevo Leon, where insects were the most abundant prey items (67%–84%); mammals represented 50% of the biomass (*Rodríguez-Estrella 1997; Ruiz-Aymá et al., 2019*).

Variation in the diet has been associated with prey availability, suggesting that small mammals are selected over invertebrates when their densities are sufficiently high (*Silva et al., 1995*). A change in prey composition has also been associated with rainfall, with more grasshoppers and some rodents (e.g., *Perognathus sp.*, *Onychomys leucogaster)* consumed during dry years and birds during wet years (*Conrey 2010*). The quantity and pattern of precipitation in arid and semi-arid environments can also influence the quality of the habitat and prey abundance (*Ernest et al., 2000*; *Reed et al., 2007*; *Thibault et al., 2010*). It is well established that, in general, an increase in precipitation increases coverage and small mammal diversity (*Ernest et al., 2000*; *Thibault et al., 2010*).

Information on the winter diet of Burrowing Owls in Mexico is limited, and temporal variation has not been examined. Thus, our objective was to determine the diet composition and dietary niche breadth of Burrowing Owls over three winters (2002–2003, 2003–2004, 2004–2005) in northern Mexico (Llano La Soledad, in the southern Chihuahuan Desert). Our hypotheses are (1) that the diet composition in years with high rainfall will be different than in drier years, and (2) that differences in rainfall will also affect diet niche breadth.

STUDY AREA AND METHODS

Site Description

Llano la Soledad is a plain habitat located in the northeastern Mexican state of Nuevo Leon, municipality of Galeana, within the Grassland Priority Conservation Area "El Tokio" (*CEC & TNC 2005, Pool & Panjabi 2011*). This area is a part of the Chihuahuan Desert ecoregion (25° 9' 8.87" N, 101° 6' 8.00" W and 24° 18' 54.12" N, 100° 23' 41.48" W; Fig. 1). It is a State Natural Protected Area (*Diario Oficial de la Federación 2002*) internationally known for its importance for shorebird conservation (*WHSRN 2005*). It is also part of an important bird area "Pradera de Tokio" (AICA-NE-36; *Del Coro & Márquez 2000*) that harbors vulnerable bird species both endemic and migratory. The Llano La Soledad also contains the largest colony of the Mexican Prairie Dog (*Cynomys mexicanus)* (*Treviño & Grant 1998*). Therefore, she represents the most extensive and continuous habitat in terms of burrows and food availability for Burrowing Owls in northeastern Mexico (*Ruiz-Ayma et al., 2016*). Open grasslands dominate the area with 80% bare ground and 20% plant cover (3% of grass and 17% forbs and shrubs) (*Cruz-Nieto 2006*). The semi-arid climate features temperatures ranging from 6°C to 25°C with an annual average of 16°C (*CONAGUA 2019*) and average annual precipitation of 427 mm (*INEGI 2005*).

Pellet Collection and Analyses

Pellets were collected every other day at active burrows located along 20 random transects of 1 km × 200 m, representing an area of 400 ha (5% of the Natural Protected Area). We traveled the transects daily from the first week of October through the first week of March over three wintering seasons (2002–2003, 2003–2004, and 2004–2005) to collect population density data. Each pellet was analyzed and quantified according to the methods of *Ruiz-Ayma et al.,* (*2019*). The remains were separated into parts; the most prominent structures used to identify each group were th following: elytron, heads, tarsi, mouthparts, chelae, stingers (arthropods), bones, teeth, scales, and feathers (birds, reptiles, and mammals). Only the most representative structures were counted among the groups to avoid over-counting prey items. For mammals, only mandibles and cranium were counted as an individual. For birds, the skull, and for reptiles, the head and limbs were counted. In the case of insects, the heads (Coleoptera) or mandible and mouthparts (Orthoptera, arachnids) were counted as individuals.

The percentage of frequency of occurrence (FO%) was calculated for each trophic category (species, genera, orders, classes) of the total Burrowing Owl diet analyzed. It was calculated by dividing the number of pellets, in which each kind of item was found, by the total number of pellets collected. Meanwhile, the numerical percentage (N%) was calculated by dividing the number of items in each prey category by the total number of prey items found in all pellets. In both cases, it was multiplied by 100 to obtain the percentage.

The relative importance index was calculated as: IRI = (N% + V) FO%, where N% = numerical percentage, V = volumetric percentage, and FO% = percentage of frequency of occurrence. In this case, the volume was replaced by the biomass percentage (Bs%) (*Martin et al. 1996; Hart et al., 2002; Marti et al., 2007; Santana et al., 2019; Muñoz-Pedreros et al., 2020; Rocha et al., 2021*). The IRI obtained was divided by the total IRI and multiplied by 100 to obtain the percentage (IRI%).

Mammals were identified according to *Anderson* (*1972*) and *Roest* (*1991*), herpetofauna according to *Smith & Taylor* (*1950)* and *Smith & Smith* (*1993*), birds according to *Howell & Webb* (*2004*) and *Dunn* (*2006*), and invertebrates according to *Borror et al.*, (*1989*). In addition, all vertebrate prey items that could not be identified to the species level were included in the unidentified category.

The biomass percentage (Bs%) was estimated as the total biomass of each prey taxon divided by the combined estimated total biomass of all prey taxa, multiplied by 100. For mammals, we used the median of the weight for each species to avoid overestimation (*Holt & Childs* 1991). The medians were obtained from data given for Mexico by *Ceballos & Oliva* (*2005*). For reptiles, birds, and mammals, we used specimens from Herpetology, Ornithology, and Mammalogy collections at the Universidad Autonoma de Nuevo Leon/Facultad de Ciencias Biologicas; for insects, data reported by Olalla (2014); and for spiders, median weights were obtained from live specimens of the Arachnology collection at the Facultad de Ciencias Biologicas/Universidad Autonoma de Nuevo Leon. All protocols were performed according to the ethical guidelines adopted by the ethics committee of the Facultad de Ciencias Biologicas of the Universidad Autonoma de Nuevo Leon. However, to comply with Mexican regulations, we have a permit (SGPA/DGVS/01588/10) that is granted by the Secretaria del Medio Ambiente y Recursos Naturales/Subsecretaria de Gestion para la Proteccion Ambiental/Direccion General de Vida Silvestre.

Statistical Analyses

An estimation of niche breadth and their 95% confidence intervals (CI) for each winter was done using Smith's (FT) measure (*Smith 1982*), and their overlap using Horn's index (1966) with Ecological Methodology 7.2 (*Krebs 2011*) software. We considered niche breadth estimates with non-overlapping 95% CI as statistically different.

To test for an association ($\alpha = 0.05$) of prey frequency and biomass among taxonomic levels and years, we used χ^2 contingency tests (*Zar 1998*). We also calculated and interpreted Cramér's phi coefficient (ϕc) as a measure of the effect size of the association (*Cohen 1988*) in annual rainfall for the years 2002–2004 (Meteorological station in La Carbonera; 19032; *CONAGUA 2019*). These analyses were conducted using PAST 3.14 (*Hammer et al.,* 2001).

RESULTS

During the three winters, with an average of 11 per winter, we counted 34 Burrowing Owls, and we collected and analyzed 358 pellets. In this study, we identified 850 prey items from 26 taxa. The identified prey items represent 7 orders and 17 families of invertebrates, 6 genera of small mammals, 2 genera of reptiles, and 1 avian genus. Vertebrates accounted for 10% and invertebrates accounted for 90% of total prey items consumed during the three winters, whereas biomass vertebrates contributed 84% and biomass invertebrates contributed 16%. Rodents, particularly cricetids, comprised 2% of all prey items eaten but 41% of the biomass.

Insects, primarily from the orders Coleoptera (IRI% = 40; N% = 56%) and Orthoptera (IRI% = 16; N% = 27%), represented 82% of consumed items but contributed only 11% of the biomass (Table 1).

Niche breadth measures were wide, indicating a generalist species, with consistent overall estimates for both frequency (FT = 0.77; 95%CI = 0.74–0.80) and biomass (FT = 0.74; 95%CI = 0.70–0.77). However, the niche breadth based on biomass was significantly smaller for the winter of 2003–2004 (Fig. 2). This also coincided with the precipitation of 505 mm in 2003 above the long-term average (396 mm, 1956–2014) and less than the other two years (288 mm, 2002; 304 mm, 2004).

There was a highly significant, but low association between winters and prey items for invertebrate classes ($\chi^2 = 23.13$, $df = 2$, $p < 0.0001$, $\boldsymbol{\phi_c} = 0.18$) and orders ($\chi^2 = 47.14$, $df = 8$, $p < 0.0001$, $\phi_c = 0.18$), and a moderate association for families ($\chi^2 = 215.2$, $df = 32$, $p < 0.0001$, $\phi_c = 0.38$). There were weak to strong associations between biomass and year at every taxonomic level. Annual associations with vertebrate taxonomic levels were primarily caused by greater consumption of mammal (rodents) biomass, particularly, Spotted Ground Squirrel (*Xerospermophilus spilosoma*) and Mexican Woodrats (*Neotoma mexicana*). During the second (wet) year, Merriam´s Kangaroo Rat (*Dipodomys merriami*) consumption decreased during the same period (Table 1). Changes in prey composition and relative biomass during the second winter were also evident from niche overlap indices, which showed the smallest values compared to the first and third winter (0.45 and 0.47), and greater FO, ranging from 0.78 to 0.87.

DISCUSSION

Our findings provide additional evidence that the Burrowing Owl is a generalist and opportunistic predator. Invertebrates (mainly arthropods) were the most common and abundant food items, corroborating previous studies, showing that overwintering Burrowing Owls feed mainly on arthropods and small mammals (*Ross & Smith 1970; Coulombe 1971; Butts 1976; Tyler 1983; York et al., 2002; Valdez- Gómez 2003; Littles et al., 2007; Hall et al., 2009*). Invertebrates composed 90% of the total prey items consumed, similar to other studies (*Littles et al., 2007; Caveric et al., 2013; Cavalli et al., 2014*) that report values ranging from 93% to 98%, but higher than the 78% reported by *Valdez- Gómez* for Mexico (*2003*). Insects contributed 84% in the diet to the Burrowing Owl, which is very similar among the winters and varyies between 83% and 87%. This value is greater than the 63% reported in Mexico (*Valdez- Gómez 2003*) and less than the 91% registered in southern Texas (*Littles et al., 2007*).

Beetles were the most frequently consumed insects (56%), with an average variation of 11% between years. Beetles are not frequently observed as prey in North America, mainly they have been recorded during the breeding season (39%–54%; *Haug 1985; Green et al., 1993; Floate et al., 2008*), whereas for South America beetles are more common as preys (e.g., *Andrade et al., 2010; Cavalli et al., 2014*). In most North American studies, crickets (Gryllidae) were the most frequently ingested insects (*York et al., 2002; Valdez- Gómez 2003; Littles et al., 2007; Hall et al., 2009*). In our study, carabid beetles were the most frequently consumed (26%), while other authors report Gryllidae (crickets; *Valdez- Gómez 2003*; *Littles et al., 2007*). *Jonas et al.,* (*2002*) observed a positive correlation between native vegetation and beetles, whose consumption by Burrowing Owls in our study was likely related to the high proportion of native vegetation in Llano La Soledad. Beetles have an affinity for native vegetation (*Crisp et al., 1998; Jonas et al., 2002; Littles et al., 2007*), whereas crickets are common in disturbed areas (*Jonas et al., 2002*) in North America, especially in grazed and overgrazed pastures, abandoned pastures (*Jonas et al., 2002*), abandoned crop fields, lawns, old fields, and other grassy areas (*Cade & Otte 2000; Moulton et al., 2005*), as well as in tilled and cultivated fields (*Carmona 1998*); however, these types of fields were uncommon in our study area, the closest being approximately 10 km away. Conversely, in South America, although beetles are highly consumed and preferred by the Burrowing Owl, their relative abundance was higher in agricultural areas than in vegetated sand-dunes (*Andrade et al., 2010*; *Cavalli et al., 2014*; *Cadena-Ortiz et al., 2016*). These authors suggested that beetles may also have been common in the owl diet because they require little effort to capture, particularly when they are abundant near burrows. *Littles et al.,* (*2007*) reported that beetles were the second-most consumed (32%) of all prey species on a barrier island, where vast expanses of the native vegetation occur compared to agricultural and grassland. The second-most frequently consumed prey species in our study were grasshoppers (22%), *Valdez- Gómez (2003)* reported this same group (15%), and *Littles et al., 2007*, mentioned Lepidoptera (13%). When analyzing our data, a variation in the numerical percentage was observed between the arthropod groups, for example, the spiders presented a value of 8% in the first year and a decrease in the rest of the years. Insects, such as Scarabaeidae, decrease in the third year (1.36%), whereas Tenebrionidae are only present in the third season and Gryllidae increase in the third winter season (10.85%) (Table 1). The wide variety of insect prey consumed in the diet of

Llano de la Soledad, N.L., reaffirms the behavior of opportunistic hunters; in other words, it feeds on what is available in a natural habitat (*Jaksic & Marti 1981*; *Jaksic 1988*; *Green et al., 1993*; *Littles et al., 2007*). Vertebrates contributed 10% of the diet of Burrowing Owls, less than the 21% recorded in Guanajuato, Mexico (*Valdez- Gómez 2003*), and greater than the 2% recorded in southern Texas (*Littles et al., 2007*). However, rodents were the most frequent vertebrates with 71%, similar to the 70% reported by Littles *et al.* (2007) and less than 86% of Valdez-Gómez (2003).

We found that the Western Harvest Mouse was the most common rodent prey (19%), followed by the Silky Pocket Mouse (15%), Deer Mouse, and Merriam's Kangaroo Rat (13% each). In contrast, the most commonly found rodents in Guanajuato were Deer Mouse (39%) and Silky Pocket Mouse (35%) (*Valdez- Gómez 2003*); whereas in Texas, the most common were Northern Pigmy (23%) and Fulvous Harvest Mouse (19%) (*Littles et al., 2007*). All of these rodent species are distributed in U. S. and Mexico, mostly within arid areas of both countries, and their variation as the most consumed prey per region is consistent with the capacity of the Burrowing Owl to use what is likely most available in each region. According to IRI, invertebrates were the main food component, with insects, particularly Coleoptera and Orthoptera, being the most abundant. However, there was larger prey (vertebrates and arachnids) that were either eaten rarely or predominated in the samples because they were digested at a slower rate, as mentioned by *Hart et al.* (*2002*) (Table 1).

Even though vertebrates only represent 10% of total prey items, they accounted for 84% of the total biomass consumed, similar to the findings of other authors (*Littles et al., 2007; Nabte et al., 2008*; *Carevic et al., 2013*). Mammal biomass was 83% and varied between 62% and 93% among years, which is higher than what has been reported for Texas (52%) (*Littles et al., 2007*) and Mexico (25%; *Valdéz-Gómez et al., 2009*), but within the 25%–95% reported in Argentina and Chile (*Andrade et al., 2004; Nabte et al., 2008; De Tomasso et al., 2009; Andrade et al., 2010; Carevic et al., 2013*). Cricetid rodents comprised 42% of the biomass, falling within the range of 37%–95% found in other studies (*Littles et al., 2007; Nabte et al., 2008; Andrade et al., 2010*).

As previously stated, changes in rodent species biomass during the second winter within vertebrates drove the main differences in niche breadth and prey composition over the years. These differences coincide with a high annual rainfall that may have resulted in irruptive population events (*Greenville et al., 2012*) or caused changes in population densities of rodent species, which would affect their availability and selection as prey by the Burrowing Owl (*Silva et al., 1995*; *Thibault et al., 2010*; *Ernest et al. 2000*). Although this was not measured, the temporal variation in populations of all prey taxa in our study have been associated with rainfall, more strongly for the species we found had changed the most, such as Merriam's Kangaroo Rat, Silky Pocket Mouse, Spotted Ground Squirrel and Western Harvest Mouse (*Whitford 1976; Brown & Zeng 1989; Brown & Ernest 2002*).

Temporal studies that include prey availability in disturbed and undisturbed areas of the southern Chihuahuan Desert would clarify the dynamics of prey use and preference for this vulnerable owl species. It would also be instructive to examine the effects of variation in vertebrate biomass consumption on the survival of Burrowing Owls during wet and dry years, especially considering climate change scenarios. Another relevant aspect of the temporal framework for diet studies is their relationship with pesticides and indirect exposure to contaminated prey, which is likely, although with limited evidence at the moment (*Haug & Oliphant 1990; James et al., 1990*).

Finally, it is also important to highlight that Llano La Soledad grasslands are key to maintaining healthy populations of the Burrowing Owl and other species (*Aquila chrysaetos, Numenius americanus, Charadrius montanus, and Spizella wortheni*). The conservation and management of this population depend on the depth of our knowledge of the natural history of this species, including its foraging ecology.

Conclusions

These results represent the first systematic effort for the winter diet of Burrowing Owl in prairie dog colonies in northeastern Mexico. Furthermore, these results provide new information on the winter prey consumption of the Burrowing Owl. The southern Chihuahuan Desert, where the study was conducted, contains the largest expanse of Mexican prairie dog colonies harboring winter populations of Burrowing Owl and other birds with conservation status in North America.

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Table 1(on next page)

Analysis of the winter diet of the Burrowing Owl in Llano La Soledad, Galeana, Nuevo Leon, Mexico. For each taxonomic group in each of three winters and all years combined, the table shows the number total of pellets (n), number of items (I), numerical pe

Analysis of the winter diet of the Burrowing Owl in Llano La Soledad, Galeana, Nuevo Leon, Mexico. For each taxonomic group in each of three winters and all years combined, the table shows the number total of pellets (n), number of items (I), numerical percentage (N%), biomass percentage (Bs%), number of pellets (P), frequency of occurrence percentage (FO%), index of relative importance (IRI), and percentage the IRI (IRI%).

Prey Items	2002-2003 (n=125)						2003-2004 (n=116)						2004-2005 (n=117)						Total (n=358)						
	I	N%	Bs%	P	FO%	IRI	I	N%	Bs%	P	FO%	IRI	I	N%	Bs%	P	FO%	IRI	I	N%	Bs%	P	FO%	IRI	IRI%
Vertebrates	21	6.93	67.58	15	12.00	894.13	30	11.90	94.06	15	12.93	1370.23	32	10.85	77.56	11	9.40	831.18	83	9.76	84.11	41	11.45	1075.10	10.29
Mammalia	16	5.28	61.58	10	8.00	534.88	17	6.75	93.64	11	9.48	951.94	26	8.81	77.56	11	9.40	812.06	59	6.94	82.72	31	8.66	776.40	7.43
Cricetidae	4	1.32	20.22	2	1.60	34.46	6	2.38	54.58	4	3.45	196.42	11	3.73	32.73	6	5.13	186.97	21	2.47	41.71	12	3.35	148.09	1.42
Deer Mouse (*Peromyscus maniculatus*)	2	0.66	13.79	2	1.60	23.12	3	1.19	7.64	1	0.86	7.61	3	1.02	14.58	2	1.71	26.66	8	0.94	10.73	5	1.40	16.30	0.16
Western Harvest Mouse (*Reithrodontomys megalotis*)	2	0.66	6.43	2	1.60	11.34	1	0.40	1.19	1	0.86	1.37	8	2.71	18.15	4	3.42	163.70	11	1.29	6.89	7	1.96	16.00	0.15
Mexican Woodrat (*Neotoma mexicana*)	-	-	-	-	-	-	2	0.79	45.74	2	1.72	80.23	-	-	-	-	-	-	2	0.24	24.09	2	0.56	16.59	0.13
Heteromyidae	4	1.32	41.36	3	2.40	102.43	4	1.59	7.36	4	2.59	23.14	9	3.05	44.83	4	3.42	163.70	17	2	24.31	11	3.07	80.84	0.77
Merriam's Kangaroo Rat (*Dipodomys merriami*)	3	0.99	39.06	3	2.40	96.12	1	0.40	4.81	1	0.86	4.49	4	1.36	36.73	2	1.71	65.10	8	0.94	20.28	6	1.68	35.57	0.34
Silky Pocket Mouse (*Perognathus flavus*)	1	0.33	2.30	1	0.80	2.10	3	1.19	2.55	2	1.72	6.45	5	1.69	8.10	2	1.71	16.74	9	1.06	4.03	5	1.40	7.11	0.07
Sciuridae	-	-	-	-	-	-	2	0.79	31.70	1	0.86	28.01	-	-	-	-	-	-	2	0.24	16.70	1	0.28	4.73	0.05
Spotted Ground Squirrel (*Spermophilus spilosoma*)	-	-	-	-	-	-	2	0.79	31.70	1	0.86	28.01	-	-	-	-	-	-	2	0.24	16.70	1	0.28	4.13	0.05
Unidentified rodents	8	2.64	-	8	6.40	-	5	1.98	-	2	1.72	-	6	2.03	-	1	0.85	-	19	2.24	-	11	3.07	-	-
Aves	4	1.32	3.68	4	3.20	16.00	11	4.37	-	3	2.59	-	6	2.03	-	1	0.85	-	21	2.47	0.72	8	2.23	7.13	0.07
Emberizidae	1	0.33	3.68	1	0.80	3.21	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12	0.72	1	0.28	0.23	<0.01
Black-throated Sparrow (*Amphispiza bilineata*)	1	0.33	3.68	1	0.80	3.21	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12	0.72	1	0.28	0.23	<0.01
Unidentified birds	3	0.99	-	3	2.40	-	11	4.37	-	3	2.59	-	6	2.03	-	1	0.85	-	20	2.35	-	7	1.96	-	-
Reptilia	1	0.33	2.33	1	0.80	2.13	2	0.79	0.42	2	1.86	1.05	-	-	-	-	-	-	3	0.35	0.67	3	0.84	0.86	<0.01
Phrynosomatidae	1	0.33	2.33	1	0.80	2.13	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12	0.45	1	0.28	0.16	<0.01
Lesser Earless Lizard (*Holbrookia maculata*)	1	0.33	2.33	1	0.80	2.13	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12	0.45	1	0.28	0.16	<0.01

Teiidae	-	-	-	-	-	-	1	0.40	0.42	1	0.86	0.70	-	-	-	-	-	-	1	0.12	0.22	1	0.28	0.09	<0.01
Little Striped Whiptail (*Aspidoscelis inornata*)	-	-	-	-	-	-	1	0.40	0.42	1	0.86	0.70	-	-	-	-	-	-	1	0.12	0.22	1	0.28	0.09	<0.01
Unidentified reptiles	-	-	-	-	-	-	1	0.40	-	1	0.86	-	-	-	-	-	-	-	1	0.12	-	1	0.28	-	-
Invertebrates	282	93.07	32.42	110	88.00	11043.06	222	88.10	5.94	101	87.07	8187.73	263	89.15	22.43	106	90.60	10109.28	767	90.24	15.81	317	88.55	9390.13	89.86
Insecta	253	83.50	21.03	106	84.80	8864.00	210	83.33	5.39	95	81.90	7266.30	257	87.12	17.64	104	88.89	9311.97	720	84.71	12.05	305	85.20	8243.25	78.89
Coleoptera (Beetles)	168	55.45	6.10	94	75.20	4628.22	152	60.32	2.38	77	66.38	4161.81	153	51.86	6.55	81	69.23	4044.07	473	55.65	4.33	252	70.39	4221.85	40.40
Elateridae	-	-	-	-	-	-	2	0.79	0.02	1	0.86	0.70	6	2.03	0.12	6	5.13	11.05	8	0.94	0.04	7	1.96	1.92	0.02
Carabidea	86	28.38	2.18	83	66.40	2029.37	65	25.79	0.74	58	50.00	1326.68	74	25.08	1.60	63	53.85	1436.87	225	26.47	1.34	204	56.98	1584.74	15.17
Scarabaeidae	49	16.17	1.47	49	39.20	691.55	45	17.86	0.51	39	33.62	617.52	4	1.36	0.09	3	2.56	3.71	98	11.53	0.58	91	25.42	307.81	2.95
Curculionidae	19	6.27	1.16	18	14.40	107.00	17	6.75	0.38	15	12.93	92.15	17	5.76	0.73	16	13.68	88.79	53	6.24	0.63	49	13.69	93.97	0.90
Cerambycidae	14	4.62	1.29	14	11.20	66.20	7	2.78	0.24	7	6.03	18.21	23	7.80	1.49	19	16.24	150.81	44	5.18	0.79	40	11.17	66.66	0.64
Passalidae	-	-	-	-	-	-	16	6.35	0.49	14	12.07	82.54	6	2.03	0.35	4	3.42	8.15	22	2.59	0.35	18	5.03	17.77	0.14
Buprestidae	-	-	-	-	-	-	-	-	-	-	-	-	2	0.68	0.22	1	0.85	0.77	2	0.24	0.06	1	0.28	0.08	<0.01
Tenebrionidae	-	-	-	-	-	-	-	-	-	-	-	-	21	7.12	1.95	14	11.97	180.51	21	2.47	0.54	14	3.91	11.77	0.11
Orthoptera (Grasshoppers, crickets and bush-crickets)	73	24.09	12.37	68	54.40	1983.56	53	21.03	3.01	43	37.07	891.20	101	34.24	10.92	68	58.12	2624.53	227	26.71	7.18	179	50.00	1694.29	16.21
Acrididae	70	23.10	12.05	65	52.00	1827.92	47	18.65	2.78	37	31.90	683.57	69	23.39	8.50	53	45.30	1444.58	186	21.88	6.32	155	43.30	1221.05	11.69
Gryllidae	3	0.99	0.32	3	2.40	3.14	6	2.38	0.24	6	5.17	13.56	32	10.85	2.42	28	23.93	317.51	41	4.82	0.86	37	10.34	58.74	0.56
Hymenoptera (Ants, bees and wasps)	2	0.66	0.11	2	1.60	1.23	5	1.98	<0.01	2	1.72	3.42	2	0.68	<0.01	1	0.85	0.58	9	1.06	0.02	5	1.40	1.51	0.01
Vespidae	2	0.66	0.11	2	1.60	1.23	-	-	-	-	-	-	-	-	-	-	-	-	2	0.24	0.02	2	0.56	0.14	<0.01
Formicidae	-	-	-	-	-	-	5	1.98	<0.01	2	1.72	3.42	2	0.68	<0.01	1	0.85	0.58	7	0.82	<0.01	3	0.84	0.69	0.01
Dermaptera (Earwigs)	10	3.30	2.45	4	3.20	18.40	-	-	-	-	-	-	1	0.34	0.17	1	0.85	0.38	11	1.29	0.52	5	1.40	2.53	0.02
Forficulidae	10	3.30	2.45	4	3.20	18.40	-	-	-	-	-	-	1	0.34	0.17	1	0.85	0.38	11	1.29	0.52	5	1.40	2.53	0.02
Arachnida	29	9.57	11.40	19	15.20	318.76	12	4.76	0.55	10	8.62	45.79	6	2.03	4.79	3	2.56	2.56	47	5.53	3.76	32	8.94	83.03	0.79
Araneae (Spiders)	25	8.25	10.75	15	12.00	228.01	4	1.59	0.08	4	3.45	5.75	3	1.02	3.44	1	0.85	3.81	32	3.76	3.08	20	5.59	38.24	0.37
Theraphosidae	6	1.98	9.76	4	3.20	37.57	-	-	-	-	-	-	3	1.02	3.44	1	0.85	3.81	9	1.06	2.85	5	1.40	5.46	0.05
Araneidae	19	6.27	0.99	11	8.80	63.89	4	1.59	0.08	4	3.45	5.75	-	-	-	-	-	-	23	2.71	0.23	15	4.19	12.30	0.12

Solfugae	4	1.32	0.64	4	3.20	6.27	8	3.17	0.47	6	5.17	18.85	1	0.34	0.11	1	0.85	0.38	13	1.53	0.34	11	3.07	5.74	0.05
Eremobatidae	4	1.32	0.64	4	3.20	6.27	8	3.17	0.47	6	5.17	18.85	1	0.34	0.11	1	0.85	0.38	13	1.53	0.34	11	3.07	5.74	0.05
Uropygi (Whipscorpions or vinegaroons)	-	-	-	-	-	-	-	-	-	-	-	-	2	0.68	1.24	2	1.71	3.28	2	0.24	0.34	2	0.56	0.32	<0.01
Thelyphonidae	-	-	-	-	-	-	-	-	-	-	-	-	2	0.68	1.24	2	1.71	3.28	2	0.24	0.34	2	0.56	0.32	<0.01
Total vertebrates	21	6.93	67.58	15	12.00	894.13	30	11.90	94.06	15	12.93	1370.23	32	10.85	77.56	11	9.40	831.18	83	9.76	84.11	41	11.45	1075.10	10.29
Total invertebrates	282	93.07	32.42	110	88.00	11043.06	222	88.10	5.94	101	87.07	8187.73	263	89.15	22.43	106	90.60	10109.28	767	90.24	15.81	317	88.55	9390.13	89.86
Total	303	100	100	125	100	11937.19	252	100	100	116	100	9557.96	295	100	100	117	100	10940.46	850	100	100	358	100	10465.23	100

Figure 1

Location of State Natural Protected Area Llano La Soledad, Galeana, N.L., Mexico.

Location of State Natural Protected Area Llano La Soledad, Galeana, N.L., Mexico.

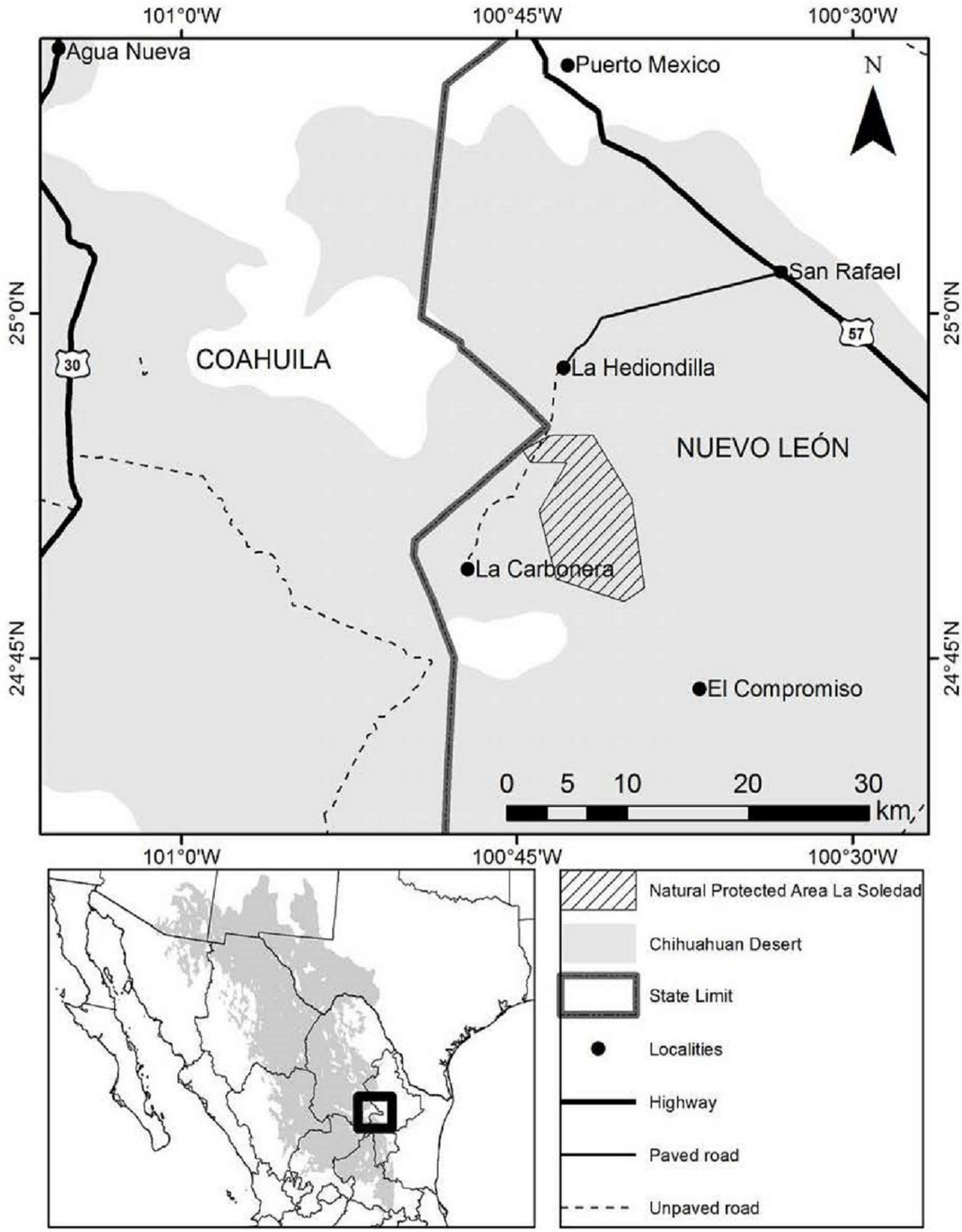
101°0'W
100°45'W
100°30'W
25°0'N
24°45'N
Agua Nueva
Puerto Mexico
N
San Rafael
57
30
COAHUILA
La Hediondilla
NUEVO LEÓN
La Carbonera
El Compromiso
0 5 10 20 30
km
Natural Protected Area La Soledad
Chihuahuan Desert
State Limit
Localities
Highway
Paved road
Unpaved road

Figure 2

Dietary niche breadth estimate (Smith 1982) and 95%CI of Burrowing Owl (*Athene cunicularia*) for three winter seasons (2002–2005) based on biomass.

Dietary niche breadth estimate (Smith 1982) and 95%CI of Burrowing Owl (*Athene cunicularia*) for three winter seasons (2002–2005) based on biomass.