Winter diet of Burrowing Owls in the Llano La Soledad, Galeana, Nuevo León, México

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Abstract

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high annual rainfall. The second season also showed a statistically significant narrower niche (Ro=0.96) and the smallest overlap (0.45 vs. 0.76) among the three winters.

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

INTRODUCTION

North American Burrowing Owl (*Athene cunicularia* Molina 1782) populations are distributed from southwest Canada, through the western and central USA (although 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 that is 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, 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 of discontinuous vegetation with low shrubs allows high visibility for hunting, observing predators, and keeping watch over its burrow (*Coulombe 1971; Howell & Webb 2004*). The Burrowing Owl is strongly associated with Black-tailed Prairie Dogs (*Cynomys ludovicianus*) and Mexican Prairie Dogs (*C. mexicanus*) colonies in Mexico, using their burrows for protection against predators as well as for 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). A decline has been even steeper 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 México 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 factors limiting populations during the winter (*Newton 1998; McDonald et al., 2004*). The majority of the studies regarding the winter diet Burrowing Owl have been conducted in the United States (Texas, Nevada, California) as well as in 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 weight (*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 occurrence of insect orders is highly variable, both temporally and spatially. The beetles (Coleoptera) and crickets (Gryllidae) volume of prey ranged from 20% to 80% in the collected pellets. Conversely, mammal species, including North American Deer Mouse (*Peromyscus maniculatus*), Silky Pocket Mouse (*Perognathus flavus*), and Merriam's Kangaroo Rat (*Dipodomys merriami*), represented 98% of prey counted in the collected pellets (*Ross & Smith 1970; Coulombe 1971; Butts 1976; Tyler 1983; Barrows 1989; Mills 2016*). A study in British Columbia, Canada, indicated that 56% of the prey were 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% were invertebrates (*Valdez-Gómez 2003*). Weight 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 weight (*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 but more birds consumed 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 as well as abundance of prey (*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; so far 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, (2) that differences in rainfall will also affect diet niche breadth.

STUDY AREA AND METHODS

Site Description

Llano la Soledad is a plains habitat located in the northeastern Mexican state of Nuevo León, 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 - 24° 18’ 54.12” N, 100° 23’ 41.48” W; Figure 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. Llano La Soledad also contains the largest colony of the Mexican Prairie Dog (*Treviño & Grant 1998*). Therefore, it represents the most extensive, 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, 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 winters (2002–2003, 2003–2004, 2004–2005) to collect population density data.

Each pellet was analyzed and quantified according to the mentioned by *Ruiz-Ayma et al.,* (*2019*). The remains were separated into parts; the most prominent structures used to identify each group were the following: elytra, heads, tarsi, mouthparts, chelae, and stingers for arthropods; bones, teeth, feathers and scales, for mammals, birds and reptiles. We counted the number of prey items of each species in each pellet. 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 as well as mouthparts (Orthoptera, arachnids) were counted as individuals. The weight of each prey species in each pellet was also estimated. 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 Autónoma de Nuevo León/Facultad de Ciencias Biológicas; for insects, data reported by Olalla (2014); for spiders, median weights were obtained from live specimens of the Arachnology collection at the Facultad de Ciencias Biológicas/Universidad Autónoma de Nuevo León. 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); invertebrates were identified to Borror et al. (1989). Any vertebrate prey items that could not be identified to the species level were included in the unidentified category.

The percentage of frequency of occurrence (FO%) was calculated for each taxonomic level of prey (orders, classes, genera, species) by dividing the number of pellets, in which each kind of item was found, by the total number of pellets collected. 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 convert to percentage. The weight percentage (W%) was estimated as the total weight of each prey taxon divided by the combined estimated total weight of all prey taxa, multiplied by 100. The index of relative importance was calculated as: IRI = (N% + W%) FO%, where N% = numerical percentage, W% = weight percentage, and FO% = percentage of frequency of occurrence (*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 was divided by the total IRI, then multiplied by 100 to obtain the percent IRI (IRI%).

All protocols were performed according to the guidelines adopted by the ethics committee of the Facultad de Ciencias Biológicas of the Universidad Autónoma de Nuevo León. However, to comply with Mexican regulations, we obtained a permit (SGPA/DGVS/01588/10) granted by the Secretaría del Medio Ambiente y Recursos Naturales/Subsecretaría de Gestión para la Protección Ambiental/Dirección General de Vida Silvestre.

Statistical Analyses

For each winter season, we estimated niche breadth with 95% confidence intervals (CIs) using Smith's measure (FT) (Smith 1982), considering years to be statistically different when the 95% CIs did not overlap. This measure considers the availability of the resource and varies from 0 (minimal) to 1 (maximal) and is therefore a standardized measure; it is a convenient measure to be used because its sampling distribution is known (Smith 1982). A species with wide niche breadth is a generalist, while a species with a narrow niche breadth is a specialist. In addition, the overlap index of Horn (Ro) (1966) was calculated for the numerical and weight percentage using the Ecological Methodology software 7.2 (Krebs 2011). This index varies from 0 (no common resources) to 1 (complete overlap).

To test for an association between years and the diet composition, we used χ^2 contingency tests (Zar 1998) followed by Cramer's phi coefficient (ϕc, Cohen 1988) as a measure of effect size, where values $\phi c \leq 0.20$ represented a weak association; $0.20 < \phi c \leq 0.60$ a moderate association, and $\phi c > 0.60$ a strong association. For years, we used annual rainfall (Meteorological station in La Carbonera; 19032; CONAGUA 2019). For the diet, the number of items and weight were used for classes, orders, and families of vertebrates and invertebrates, as well as the number of items and weight for rodent species. These analyses were conducted using PAST 3.14 (Hammer et al., 2001).

RESULTS

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

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

Smith's measure of niche breadth was wide, corresponding to a generalist species. These values are consistent for the three winters, so there is no statistically significant difference in the numerical percentage between winters (2002-2003: FT = 0.79, 95%CI = 0.73–0.84; 2003-2004: FT = 0.81, 95%CI = 0.76–0.86; 2004-2005: FT = 0.82, 95%CI = 0.77–0.87; all three winters combined: 2002-2005: FT = 0.77, 95%CI = 0.73–0.80; Figure 2a). On the other hand, the niche breadth based on the weight percentage was lower for the second winter (2003-2004: FT = 0.65, 95%CI = 0.60–0.69; Figure 2b) than for the other two years (2002-2003: FT = 0.81, 95%CI = 0.77–0.84; 2004-2005: FT = 0.73, 95%CI = 0.69–0.76; all three winters combined: 2002-2005: FT = 0.71; 95%CI = 0.70–0.63; Figure 2b). The decrease in niche widht in the second winter coincided with the precipitation of 505 mm in 2003, above the long-term average (396 mm, 1956–2014), greater than the other two winters (2002: 288 mm; 2004: 304 mm).

Horn's index showed greater overlap in the numerical percentage between the first and the second winters (Ro = 0.96) than the overlap found between the first and third winter (Ro = 0.86) and between the second and third winter (Ro = 0.83). Regarding the weight percentage, this index showed greater overlap between the first and third winter (Ro = 0.76), than between the first and second winter (Ro = 0.45), and the second and third winter (Ro = 0.45).

Based on the ϕc values, there was a weak association between the winters and the number of items for vertebrates classes ($\chi2 = 5.82$, df = 4, $p < 0.0001$, $\phi c = 0.18$) and a moderate association for families ($\chi2 = 14.26$, df = 10, $p < 0.0001$, $\phi c = 0.20$) and rodent species ($\chi2 = 15.07$, df = 10, $p < 0.0001$, $\phi c = 0.43$). We found a weak association between winters and the number of elements for invertebrate classes ($\chi2 = 15.43$, df = 2, $p < 0.0001$, $\phi c = 0.14$) and a moderate association for orders ($\chi2 = 65.22$, df = 12, $p < 0.0001$, $\phi c = 0.21$) and families ($\chi2 = 221.50$, df = 32, $p < 0.0001$, $\phi c = 0.38$).

In terms of weight, there was a weak association between winters and weight for vertebrates classes ($\chi2 = 89.09$, df = 4, $p < 0.0001$, $\phi c = 0.17$), a moderate association for families ($\chi2 = 643.93$, df = 10, $p < 0.0001$, $\phi c = 0.47$), and a strong association for rodent species ($\chi2 = 1010.4$, df = 10, $p < 0.0001$, $\phi c = 0.61$).

The strong association observed in the rodents species during the second winter season was due to the greater consumption of Spotted Ground Squirrel (*Xerospermophilus spilosoma*) and Mexican Woodrats (*Neotoma mexicana*), as well as decreased consumption in Merriam's Kangaroo Rat during the same period (Table 1). There was a moderate association between winters and weight for invertebrate classes ($\chi2 = 14.82$, df = 2, $p < 0.0001$, $\phi c = 0.24$), orders ($\chi2$

= 58.72, df = 10, $p < 0.0001$, $\phi c = 0.34$), and families ($\chi2 = 97.86$, df = 26, $p < 0.0001$, $\phi c = 0.44$).

DISCUSSION

Our findings provide additional evidence that the Burrowing Owl is a generalist, opportunistic predator. Invertebrates (mainly arthropods) were the most common, 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%; however, it was higher than the 78% reported by *Valdez- Gómez* (*2003*) for Mexico. Insects contributed 84% to the diet of the Burrowing Owl, which was very similar among the winters, varying between 83%–87%. This value is greater than the 63% reported in Mexico (*Valdez- Gómez 2003*) but lower 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% during the years considered for the study. Beetles are not frequently observed as prey in North America, and were mostly 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 prey (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*). On the other hand, crickets are commonly 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, 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 areas and grasslands. The second-most frequently consumed prey species in our study were grasshoppers (27%) for the three years studied; *Valdez-Gómez (2003)* reported this same group (15%), while *Littles et al., 2007* mentioned Lepidoptera (13%). When analyzing our data, a variation in the numerical percentage was observed amongthe arthropod groups, for example, the spiders presented a value of 8% in the first year, decreasing in the rest of the years. Insects, such as Scarabaeidae, decreased in the third year (1%), whereas Tenebrionidae was only present in the third winter season, while Gryllidae increased in the third winter season (11%) (Table 1). The wide variety of insect prey consumed at of Llano de la Soledad, N.L., confirms the opportunistic foraging of the Burrowing Owl; in other words, it feeds on whatever is available in a natural habitat (*Jaksic & Marti 1981*; *Jaksic 1988*; *Green et al., 1993*; *Littles et al., 2007*). Vertebrates contributed 10% to the diet of Burrowing Owls, which is lower than the 21% recorded in Guanajuato, Mexico (*Valdez- Gómez 2003*), but 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 lower 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 the IRI, invertebrates were the main food component, with insects, particularly Coleoptera and Orthoptera, being the most abundant. However, there was larger prey (vertebrates, 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 represented 10% of total prey items, they accounted for 84% of the total weight consumed, similar to the findings of other authors (*Littles et al., 2007; Nabte et al., 2008*; *Carevic et al., 2013*). Mammal weight was 83%, varying between 62%-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 weight, falling within the range of 37%–95% found in other studies (*Littles et al., 2007; Nabte et al., 2008; Andrade et al., 2010*). Changes in rodent weight during the second winter regarding the consumption of vertebrates drove the main differences in niche breadth and prey composition among the years studied. These differences coincided 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 have affected their availability for 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*).

Conclusions

These results represent the first systematic effort to investigate the winter diet of Burrowing Owl in prairie dog colonies in northeastern Mexico. 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. Temporal studies that include prey availability in disturbed and undisturbed areas of the southern Chihuahuan Desert would clarify the dynamics of prey use, as well as the of preference for this vulnerable owl species. It would also be instructive to examine the effects of variation in vertebrate weight consumption on the survival of Burrowing Owl 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 as well as other species (Golden Eagle, Long-billed Curlew, Mountain Plover, Worthen´s Sparrow). 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.

Acknowledgments

We are grateful to the Universidad Autonoma de Nuevo Leon through the support program for Scientific and Technological Research (PAICyT).

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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 total number 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 total number of pellets (n), number of items (I), numerical percentage (N%), weight (W), weight percentage (W%), number of pellets in which taxonomic group was present (P), frequency of occurrence percentage (FO%), index of relative importance (IRI), and percentage IRI (IRI%).

Prey Items	2002-2003 (n=125)							2003-2004 (n=116)							2004-2005 (n=117)							Total (n=358)							
	I	N%	W	W%	P	FO%	IRI	I	N%	W	W%	P	FO%	IRI	I	N%	W	W%	P	FO%	IRI	I	N%	W	W%	P	FO%	IRI	IRI%
Vertebrates	21	6.93	220.61	67.58	15	12.00	894.13	30	11.90	830.70	94.06	15	12.93	1370.23	32	10.85	359	77.56	11	9.40	831.18	83	9.76	1410.31	84.11	41	11.45	1075.10	10.29
Mammalia	16	5.28	201	61.58	10	8.00	534.88	17	6.75	827	93.64	11	9.48	951.94	26	8.81	359	77.56	11	9.40	812.06	59	6.94	1387	82.72	31	8.66	776.40	7.43
Cricetidae	4	1.32	66	20.22	2	1.60	34.46	6	2.38	482	54.58	4	3.45	196.42	11	3.73	152	32.73	6	5.13	186.97	21	2.47	700	41.71	12	3.35	148.09	1.42
Deer Mouse (*Peromyscus maniculatus*)	2	0.66	45	13.79	2	1.60	23.12	3	1.19	67.50	7.64	1	0.86	7.61	3	1.02	67.50	14.58	2	1.71	26.66	8	0.94	180	10.73	5	1.40	16.30	0.16
Western Harvest Mouse (*Reithrodontomys megalotis*)	2	0.66	21	6.43	2	1.60	11.34	1	0.40	10.50	1.19	1	0.86	1.37	8	2.71	84	18.15	4	3.42	163.70	11	1.29	116	6.89	7	1.96	16.00	0.15
Mexican Woodrat (*Neotoma mexicana*)	-	-		-	-	-	-	2	0.79	404	45.74	2	1.72	80.23	-	-	-	-	-	-	-	2	0.24	404	24.09	2	0.56	16.59	0.13
Heteromyidae	4	1.32	135	41.36	3	2.40	102.43	4	1.59	65	7.36	4	2.59	23.14	9	3.05	208	44.83	4	3.42	163.70	17	2	408	24.31	11	3.07	80.84	0.77
Merriam’s Kangaroo Rat (*Dipodomys merriami*)	3	0.99	127.50	39.06	3	2.40	96.12	1	0.40	42.50	4.81	1	0.86	4.49	4	1.36	170	36.73	2	1.71	65.10	8	0.94	340	20.28	6	1.68	35.57	0.34
Silky Pocket Mouse (*Perognathus flavus*)	1	0.33	7.50	2.30	1	0.80	2.10	3	1.19	22.50	2.55	2	1.72	6.45	5	1.69	37.50	8.10	2	1.71	16.74	9	1.06	68	4.03	5	1.40	7.11	0.07
Sciuridae	-	-	-	-	-	-	-	2	0.79	280	31.70	1	0.86	28.01	-	-	-	-	-	-	-	2	0.24	280	16.70	1	0.28	4.73	0.05
Spotted Ground Squirrel (*Spermophilus spilosoma*)	-	-	-	-	-	-	-	2	0.79	280	31.70	1	0.86	28.01	-	-	-	-	-	-	-	2	0.24	280	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	12	3.68	4	3.20	16.00	11	4.37	-	-	3	2.59	-	6	2.03	-	-	1	0.85	-	21	2.47	12	0.72	8	2.23	7.13	0.07
Emberizidae	1	0.33	12	3.68	1	0.80	3.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-throated Sparrow (*Amphispiza bilineata*)	1	0.33	12	3.68	1	0.80	3.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12	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	7.61	2.33	1	0.80	2.13	2	0.79	3.70	0.42	2	1.86	1.05	-	-	-	-	-	-	-	3	0.35	11.31	0.67	3	0.84	0.86	<0.01

Phrynosomatidae	1	0.33	7.61	2.33	1	0.80	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12	7.61	0.45	1	0.28	0.16	<0.01
Lesser Earless Lizard (*Holbrookia maculata*)	1	0.33	7.61	2.33	1	0.80	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12	7.61	0.45	1	0.28	0.16	<0.01
Teiidae	-	-	-	-	-	-	-	1	0.40	3.70	0.42	1	0.86	0.70	-	-	-	-	-	-	-	1	0.12	3.70	0.22	1	0.28	0.09	<0.01
Little Striped Whiptail (*Aspidoscelis inornata*)	-	-	-	-	-	-	-	1	0.40	3.70	0.42	1	0.86	0.70	-	-	-	-	-	-	-	1	0.12	3.70	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	105.81	32.42	110	88.00	11043.06	222	88.10	52.47	5.94	101	87.07	8187.73	263	89.15	103.84	22.43	106	90.60	10109.28	767	90.24	266.56	15.81	317	88.55	9390.13	89.86
Insecta	253	83.50	68.64	21.03	106	84.80	8864.00	210	83.33	47.63	5.39	95	81.90	7266.30	257	87.12	81.67	17.64	104	88.89	9311.97	720	84.71	202.38	12.05	305	85.20	8243.25	78.89
Coleoptera (Beetles)	168	55.45	19.90	6.10	94	75.20	4628.22	152	60.32	21.00	2.38	77	66.38	4161.81	153	51.86	30.33	6.55	81	69.23	4044.07	473	55.65	72.83	4.33	252	70.39	4221.85	40.40
Elateridae	-	-	-	-	-	-	-	2	0.79	0.18	0.02	1	0.86	0.70	6	2.03	0.54	0.12	6	5.13	11.05	8	0.94	0.72	0.04	7	1.96	1.92	0.02
Carabidea	86	28.38	7.10	2.18	83	66.40	2029.37	65	25.79	6.50	0.74	58	50.00	1326.68	74	25.08	7.40	1.60	63	53.85	1436.87	225	26.47	22.50	1.34	204	56.98	1584.74	15.17
Scarabaeidae	49	16.17	4.80	1.47	49	39.20	691.55	45	17.86	4.50	0.51	39	33.62	617.52	4	1.36	0.40	0.09	3	2.56	3.71	98	11.53	9.80	0.58	91	25.42	307.81	2.95
Curculionidae	19	6.27	3.80	1.16	18	14.40	107.00	17	6.75	3.40	0.38	15	12.93	92.15	17	5.76	3.40	0.73	16	13.68	88.79	53	6.24	10.60	0.63	49	13.69	93.97	0.90
Cerambycidae	14	4.62	4.20	1.29	14	11.20	66.20	7	2.78	2.10	0.24	7	6.03	18.21	23	7.80	6.90	1.49	19	16.24	150.81	44	5.18	13.20	0.79	40	11.17	66.66	0.64
Passalidae	-	-	-	-	-	-	-	16	6.35	4.32	0.49	14	12.07	82.54	6	2.03	1.62	0.35	4	3.42	8.15	22	2.59	5.94	0.35	18	5.03	17.77	0.14
Buprestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.68	1.04	0.22	1	0.85	0.77	2	0.24	1.04	0.06	1	0.28	0.08	<0.01
Tenebrionidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	7.12	9.03	1.95	14	11.97	180.51	21	2.47	9.03	0.54	14	3.91	11.77	0.11
Orthoptera (Grasshoppers, crickets and bush-crickets)	73	24.09	40.38	12.37	68	54.40	1983.56	53	21.03	26.61	3.01	43	37.07	891.20	101	34.24	50.53	10.92	68	58.12	2624.53	227	26.71	120.37	7.18	179	50.00	1694.29	16.21
Acrididae	70	23.10	39.33	12.05	65	52.00	1827.92	47	18.65	24.51	2.78	37	31.90	683.57	69	23.39	39.33	8.50	53	45.30	1444.58	186	21.88	106.02	6.32	155	43.30	1221.05	11.69
Gryllidae	3	0.99	1.05	0.32	3	2.40	3.14	6	2.38	2.10	0.24	6	5.17	13.56	32	10.85	11.20	2.42	28	23.93	317.51	41	4.82	14.35	0.86	37	10.34	58.74	0.56
Hymenoptera (Ants, bees and wasps)	2	0.66	0.36	0.11	2	1.60	1.23	5	1.98	0.02	<0.01	2	1.72	3.42	2	0.68	0.01	<0.01	1	0.85	0.58	9	1.06	0.38	0.02	5	1.40	1.51	0.01
Vespidae	2	0.66	0.36	0.11	2	1.60	1.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.24	0.36	0.02	2	0.56	0.14	<0.01
Formicidae	-	-	-	-	-	-	-	5	1.98	0.02	<0.01	2	1.72	3.42	2	0.68	0.01	<0.01	1	0.85	0.58	7	0.82	0.02	<0.01	3	0.84	0.69	0.01

Dermaptera (Earwigs)	10	3.30	8	2.45	4	3.20	18.40	-	-	-	-	-	-	-	1	0.34	0.80	0.17	1	0.85	0.38	11	1.29	8.80	0.52	5	1.40	2.53	0.02
Forficulidae	10	3.30	8	2.45	4	3.20	18.40	-	-	-	-	-	-	-	1	0.34	0.80	0.17	1	0.85	0.38	11	1.29	8.80	0.52	5	1.40	2.53	0.02
Arachnida	29	9.57	37.17	11.40	19	15.20	318.76	12	4.76	4.84	0.55	10	8.62	45.79	6	2.03	22.17	4.79	3	2.56	2.56	47	5.53	64.18	3.76	32	8.94	83.03	0.79
Araneae (Spiders)	25	8.25	35.09	10.75	15	12.00	228.01	4	1.59	0.68	0.08	4	3.45	5.75	3	1.02	15.93	3.44	1	0.85	3.81	32	3.76	51.70	3.08	20	5.59	38.24	0.37
Theraphosidae	6	1.98	31.86	9.76	4	3.20	37.57	-	-	-	-	-	-	-	3	1.02	15.93	3.44	1	0.85	3.81	9	1.06	47.79	2.85	5	1.40	5.46	0.05
Araneidae	19	6.27	3.23	0.99	11	8.80	63.89	4	1.59	0.68	0.08	4	3.45	5.75	-	-	-	-	-	-	-	23	2.71	3.91	0.23	15	4.19	12.30	0.12
Solfugae	4	1.32	2.08	0.64	4	3.20	6.27	8	3.17	4.16	0.47	6	5.17	18.85	1	0.34	0.52	0.11	1	0.85	0.38	13	1.53	6.76	0.40	11	3.07	5.74	0.05
Eremobatidae	4	1.32	2.08	0.64	4	3.20	6.27	8	3.17	4.16	0.47	6	5.17	18.85	1	0.34	0.52	0.11	1	0.85	0.38	13	1.53	6.76	0.40	11	3.07	5.74	0.05
Uropygi (Whipscorpions or vinegaroons)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.68	5.72	1.24	2	1.71	3.28	2	0.24	5.72	0.34	2	0.56	0.32	<0.01
Thelyphonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.68	5.72	1.24	2	1.71	3.28	2	0.24	5.72	0.34	2	0.56	0.32	<0.01
Total vertebrates	21	6.93	220.61	67.58	15	12.00	894.13	30	11.90	830.70	94.06	15	12.93	1370.23	32	10.85	359	77.56	11	9.40	831.18	83	9.76	1410.31	84.11	41	11.45	1075.10	10.29
Total invertebrates	282	93.07	105.81	32.42	110	88.00	11043.06	222	88.10	52.47	5.94	101	87.07	8187.73	263	89.15	103.84	22.43	106	90.60	10109.28	767	90.24	266.56	15.81	317	88.55	9390.13	89.86
Total	303	100	326.42	100	125	100	11937.19	252	100	883.17	100	116	100	9557.96	295	100	462.84	100	117	100	10940.46	850	100	1676.87	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.

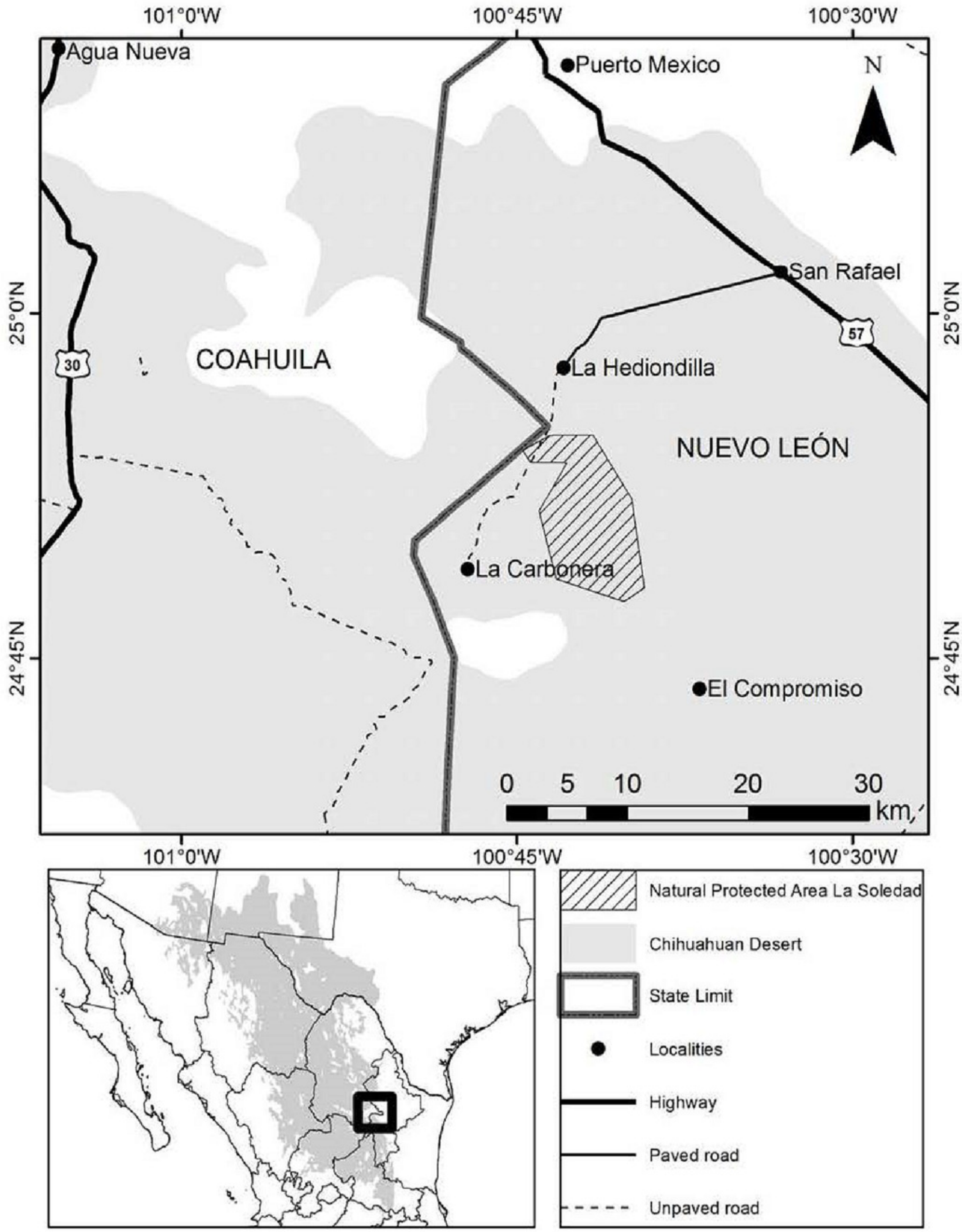
101°0'W
100°45'W
100°30'W
25°0'N
24°45'N
Agua Nueva
Puerto Mexico
N
San Rafael
57
30
COAHUILA
La Hediondilla
NUEVO LEÓN
La Carbonera
El Compromiso
0 5 10 20 30 km
Natural Protected Area La Soledad
Chihuahuan Desert
State Limit
Localities
Highway
Paved road
Unpaved road

Figure 2

Dietary niche breadth estimate (Smith 1982) and 95%CI for Burrowing Owls (*Athene cunicularia*) during three winter seasons (2002-2005) considered separately and combined based on A) numerical percentage and B) weight.

Dietary niche breadth estimate (Smith 1982) and 95%CI for Burrowing Owls (*Athene cunicularia*) during three winter seasons (2002-2005) considered separately and combined based on A) numerical percentage and B) weight.