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

Jose I Gonzalez Rojas [Corresp., Equal first author, 1], **Miguel A Cruz Nieto** [1], **Antonio Guzman Velasco** [1], **Irene Ruvalcaba Ortega** [1], **Alina Olalla Kerstupp** [1], **Gabriel Ruiz Ayma** [Equal first author, 1]

[1] Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León, San Nicolas de los Garza, Nuevo Leon, México

Corresponding Author: Jose I Gonzalez Rojas
Email address: jose.gonzalezr@uanl.mx

We determined dietary niche breadth of burrowing owls *Athene cunicularia* Molina, 1782 in Llano La Soledad, Galeana, Nuevo Leon in northern Mexico, considering prey type, frequency of occurrence, and biomass. We compared these data among three winter seasons (2002-2003, 2003-2004, 2004-2005) by analyzing 358 pellets and identifying 821 prey items. Vertebrates accounted for 87% of consumed biomass of which 74% represented mammals. Most of mammal biomass consumed were Cricetid rodents (58%). Ninety percent of prey items were invertebrates, most of which were insects (84%); beetles were the most commonly found in pellets (55%). Niche breadth based on 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. There was and significant association between relative biomass of rodent species and invertebrate families with wintering season. This association was driven mainly by changes in composition and frequency of these types of prey during the second season, which was likely 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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José I. González Rojas[1]*, Miguel A. Cruz Nieto[1], Antonio Guzmán Velasco[1], Irene Ruvalcaba-Ortega[1], Alina Olalla Kerstupp[1], Gabriel Ruiz-Ayma[1].

[1] Universidad Autónoma de Nuevo León (UANL), Facultad de Ciencias Biológicas, Laboratorio de Biología de la Conservación y Desarrollo Sustentable. Nuevo León, México.

*Corresponding Author:

José I. González Rojas

Ave. Universidad s/n. Cd. Universitaria, 66455, San Nicolas de los Garza, Nuevo Leon, Mexico

Email address: jose.gonzalezr@uanl.mx

Abstract

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

INTRODUCTION

The Burrowing Owl (*Athene cunicularia* Molina, 1782; Fig.1); has shown a significant negative population trend in United States for almost 50 years (-0.91%/yr.; 1966-2015; *Sauer et al.*, 2017). In Canada is this decline especially steep (-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). In the U.S. Burrowing Owl it is considered as a National Bird of Conservation Concern U.S. Fish and Wildlife Service [*USFWS]* 2008; whereas 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 function of multiple threats such as habitat fragmentation, decreased availability of prey, increased predation, inclement weather, vehicles strikes, environmental contaminants, and loss of burrows (*Environment Canada*, *2012*). Food availability, in particular, is one of the most important natural limiting factors in populations during winter (*Newton, 1998; McDonald et al., 2004*).

The winter diet of the Burrowing Owl has been mostly studied in the United States in Texas, Nevada, and California, as well as in other countries in North, and South America and consists of invertebrates, small mammals, and reptiles *(Plumpton & Lutz, 1993*). Invertebrates are consumed most frequently (*Poulin, 2003*) but mammals compose 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*). However, frequency of occurrence of insect orders is highly variable, both temporally and spatially. Beetles (Coleoptera) and crickets (Gryllidae) consumption ranged from

20% to 80%. On the other hand, mammal species, which include Deer Mice (*Peromyscus manicualtos*), Silky Pocket Mice (*Perognathus flavus*) and Kangaroo Rats (*Dipodomys merriami*), are reported to be as high as 98% (*Ross & Smith, 1970; Coulombe, 1971; Butts, 1976; Tyler, 1983; Barrows, 1989; Mills, 2016*). In British Columbia, Canada, indicate that 56% of their diet is insects, such as earwigs and beetles (*Morgan, 1993*). The only report of the Burrowing Owl's winter diet in Mexico has been done in central Mexico in the state of Guanajuato, where78% of prey items were invertebrates, while the remaining 22% were vertebrates (*Valdez-Gómez, 2003*), while and biomass was more evenly distributed among Orthoptera (26.8%), Lepidoptera (20.6%) and rodents (20.9%; *Valdez-Gómez et al., 2009*). Diet during the breeding season has also been analyzed in the states of Durango and Nuevo León, where insects were the most frequent prey items (67-84%) and mammals represented 50% of the biomass (*Rodríguez-Estrella, 1997, Ruiz-Aymá, 2019*).

Variation in 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 *Perognathus sp.*, *Onychomys leucogaster* consumed during dry years and birds during wet years (*Conrey, 2010*).

Information of the Burrowing Owls' winter diet in Mexico is limited and temporal variation has not been examined. Thus, our objective was to determine the wintering diet composition and dietary niche breadth of Burrowing Owls during three winter seasons (2002-2003, 2003-2004, 2004-2005) in northern Mexico (Llano La Soledad, in the southern Chihuahuan Desert). We predicted that in a year with high rainfall, diet composition will be different than in drier years, and that will likely affect dietary niche breadth.

STUDY AREA AND METHODS

Site descriptions

Llano la Soledad is a plain located in northeastern Mexico, state of Nuevo Leon, municipality of Galeana, within the Grassland Priority Conservation Area "El Tokio" (CEC & TNC 2005, Pool & Panjabi 2011), which is 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. 2). It is a State Natural Protected Area (*Diario Oficial de la Federación, 2002*) and internationally known for its importance for shorebird conservation (*WHSRN, 2004*). 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, such as Golden Eagle (*Aquila chrysaetos)*, Long-billed Curlew (*Numenius americanus)*, Mountain Plover (*Charadrius montanus)* and Worthen's Sparrow (*Spizella wortheni)* (*Macias et al., 2011*). The Llano La Soledad also contains the largest colony of Mexican Prairie Dogs (*Cynomys mexicanus)* (*Treviño & Grant, 1998*) and therefore represents the most extensive and continuous habitat in terms of burrow and food availability for the Burrowing Owl in northeastern Mexico.

The area is dominated by open grasslands with 80% bare ground and 20% plant cover: 3% of grass and 17% of forbs and shrubs. The most common species are: Spear Globemallow (*Sphaeralcea hastulata*), Four Wing Saltbush (*Atriplex canescens*), Three Awn (*Aristida ssp*.) and Burrograss (*Scleropogon brevifolius*), Creeping Muhly (*Muhlenbergia repens*), Sand Muhly (*M. arenicola*) and Grama (*Bouteloua karwinskii*) (*Cruz-Nieto, 2006*). The semi-arid climate features temperatures ranging from 6 to 25 °C with an annual average of 16 °C (*CONAGUA, 2019*). Average annual precipitation is 427mm (*INEGI, 2005*). Annual rainfall for 2002-2004 years, was obtained from the closest (~6 km) meteorological station in La Carbonera (19032; *CONAGUA, 2019*).

Pellet Collection and Analyses

Pellets were collected at the entrances of burrows, from the first week of October through the first week of March over three winter seasons: 2002-2003, 2003-2004, and 2004-2005. We Collected pellets from burrows every third day. We analyzed and quantified the remains of each pellet according to the methods of *Errington*, (*1930; 1932*) and *Marti,* (*1987*). We identified mammals according to *Anderson*, (*1972*) and *Roest*, (*1991*), herpetofauna following *Smith & Taylor*, (*1950)* and *Smith & Smith,* (*1993*), birds following *Howell & Webb*, (*2004*) and *Dunn*, (*2006*), and invertebrates according to *Borror et al.*, (*1989*). All vertebrate prey items that could not be determined to the species level were included in the unidentified category.

We estimated biomass multiplying weight for the frequency of occurrence of each type of prey, assuming there was one individual per pellet. For mammals we used the median of the weight for each species to avoid overestimation (*Holt & Childs,* 1991). Medians were obtained from data given for Mexico by *Ceballos & Oliva,* (*2005*). For reptiles, we used specimens from the Herpetology Laboratory collection at the Universidad Autonoma de Nuevo Leon/Facultad de Ciencias Biologicas; for insects, data reported by *Olalla* (*2014*); and for spider, median weights were obtained from live specimens of the Arachnology collection at the Facultad de Ciencias Biologicas/Universidad Autonoma de Nuevo Leon.

Statistical Analyses

We estimated niche breadth and their 95% confidence intervals for each season using Smith's measure (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% confidence intervals as statistically different.

To test for an association (α = 0.05) of prey frequency and biomass among taxonomic levels and years we used X^2 contingency tests (*Zar, 1998*). We also calculated and interpreted Cramér's phi coefficient (**ϕ_c**) as a measure of the effect size of the association (Cohen 1988). These analyses were conducted using PAST 3.14 (*Hammer et al., 2001*).

RESULTS

We analyzed 358 pellets, and found 821 items from 26 taxa. We recorded 7 orders and 17 families of invertebrates, 6 genera of small mammals, 2 genera of reptiles, and 1 avian genus. Vertebrates represented 10% and invertebrates 90% of prey items consumed during the three winter seasons, but the proportions were inversed for biomass, with vertebrates composing 84% and invertebrates 16% of biomass consumed. Rodents composed 7% of the prey items eaten, but 82% of the biomass particularly Cricetid rodents. Insects, primarily from the orders Coleoptera (55%) and Orthoptera (27%) represented 84% of consumed items but contributed only to 12% of the biomass (Fig. 3; Tables 1, 2).

Niche breadth measures were wide, indicating, as expected, a generalist species, with consistent overall estimates for both frequency of occurrence (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 2003-04 (Table 3, Fig. 4). This also coincided with above average (395 mm; 1956-2014) annual precipitation of 505 mm during 2003, compared with drier years: 288 mm (2002) and 304 mm (2004).

There was a highly significant and small correlation between yearly parameters and prey items of invertebrate classes (X^2=23.13, *df*=2, *p*<0.0001**,** ϕ_c =0.18) and orders (X^2=47.14, *df*=8, *p*<0.0001,

ϕ_c =0.18), and moderate with families (X^2=215.2, *df*=32, p<0.0001, ϕ_c =0.38). There were weak to strong associations between biomass and year at every taxonomic level (Table 4). Year associations with vertebrate taxonomic levels were primarily caused by a 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 2). Changes in prey composition and relative biomass during the second season were also evident from niche overlap indices, which show the smallest values when compared to the first and third seasons (0.45 and 0.47), and greater frequency of occurrence, ranging from 0.78 to 0.87 (Table 5). Birds on the contrary, were very stable among years with a relative biomass between 11 and 13% (Table 2).

DISCUSSION

Our findings provide additional evidence that the burrowing owl is a generalist and opportunistic predator. Invertebrates (mainly arthropods) were the most frequent food items, corroborating previous studies that have shown that overwintering Burrowing Owls feed mainly on arthropods and small mammals (*Ross & Smith, 1970; Coulombe, 1971; Butts, 1976; Tyler, 1983; York et al., 200; Valdez- Gómez, 2003; Littles et al., 2007; Hall et al., 2009*).

Invertebrates represented 90% of prey items consumed, which is similar to results from other studies (*Littles et al., 2007; Caveric et al., 2013; Cavalli et al., 2014*) as they report values ranging from 93% to 98%, but higher than the 78% reported by *Valdez- Gómez* for Mexico (*2003*).

Insects represented 84% of the items in the diet, which was very similar among the seasons, varying between 83 and 87%, which is greater than the 63% reported in México (*Valdez- Gómez, 2003*) and less than the 91% reported in southern Texas (*Littles et al., 2007*).

Beetles were the most-frequently consumed insects overall with 55%, and a maximum variation of 10% between years. Beetles have been observed as a consumed insect order, which is not common in North America and has only been observed during the breeding season (39%-54%; e.g. *Haug, 1985; Green et al., 1993; Floate et al., 2008*) and more prevailing in South America (e.g. *Andrade et al., 2010; Cavalli et al., 2013*). In most studies in North America, crickets (Gryllidae) were the most frequently ingested insects (*York et al., 2002; Valdez- Gómez, 2003; Littles et al., 2007; Hall et al., 2009*). At the family level, Carabid beetles were the most frequently consumed (25%) in our study, 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 (*Smith, 1940; 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 plowed fields (*Carmona, 1998*); however, these types of fields were not common in our study area, and the closest were around 10 km away.

Conversely, in South America, although coleopterans have been found to be highly consumed and preferred by the burrowing owl, their relative abundance was higher in agricultural areas than in vegetated sand-dunes (*Cavalli et al., 2013*). These authors suggested that coleopterans may also have been common in owls' 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 item (32%) of all prey items on a barrier island, where vast expanses of the native vegetation occur in comparison to agricultural and grassland, in grasslands, fire suppression has allowed brush species such as Honey Mesquite (*Prosopis glandulosa*) to invade the remaining native pastures and most remaining grasslands are dominated by exotic grass species that were introduced for cattle.

The second-most frequently consumed prey items in our study were the grasshoppers (22%), while *Valdez- Gómez, 2003* reported to this same group (15%) and *Littles et al., 2007*, mentioned Lepidoptera (13%). Our data showed variation in relative frequency of consumption among arthropod groups, with the greatest frequency of occurrence of spiders during the first season (<10%); and a decrease in the presence of Scarabeidae and an increase of Tenebrionidae and Gryllidae occurrence in the third year (Table 1).

In addition, the Burrowing Owls' consumption at Llano de la Soledad showed more variation, which is an indicator of a natural habitat and typical of an opportunistic predator that feeds on what is available (*Jaksic & Martí, 1981; Jaksic, 1988; Green et al., 1993; Haug et al., 1993; Littles, 2007*).

Vertebrates represented 10% of the remaining prey items consumed by the Burrowing Owls, which was 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 consistent as the most frequently vertebrate with 74%, in comparison with 70% reported by *Littles et al.*, (*2007*) and 86% by *Valdez- Gómez* (*2003*).

We found that Silky Pocket mice were the most common rodent prey (19%), followed by the Western Harvest Mouse (15%), the Deer Mice and Merriam’s Kangaroo Rats (14% each). In contrast, the most commonly found rodents in Guanajuato were deer (39%) and Silky Pocket Mice (35%; *Valdez- Gómez, 2003*); while in Texas the most common were Northern Pigmy (23%) and Fulvous Harvest Mice (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 on each region.

Even though vertebrates only represent 10% of prey items, they accounted for 87% of the total biomass consumed, which is similar to other authors' findings (*Littles et al., 2007; Nabte et al., 2008; Carevic et al., 2013*). Mammals biomass was of 74% varied between 62 and 82% between 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 to 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 composed 58% of the biomass, which falls within the range of 37 to 95% found in other studies (*Littles et al., 2007; Nabte et al., 2008; Andrade et al., 2010*).

As previously stated, within vertebrates, changes in rodent species biomass use during the second season drove the main differences in niche breadth and composition among years. This difference coincides with a high annual rainfall that may have produced irruptive population events (*Greenville et al., 2012*), or caused changes in rodent species' population densities, which would affect their availability and their selection as prey by the Burrowing Owl (*Silva et al., 1995*). Although this was not measured, temporal variation in populations of all the prey species in our study have been associated with rainfall, more strongly for the species we found changed the most, such as Merriam's Kangaroo Rat, Silky Pocket Mice, 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 southern Chihuahuan Desert would clarify the dynamics of prey use and preference for this vulnerable owl species. Examining the effects of the variation in vertebrate biomass consumption on survival of Burrowing Owls during wet and dry years would also be informative, 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, 1987; 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. Management and conservation of this population depends on the depth of our knowledge of this species, and one of the key components is its feeding ecology.

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Table 1(on next page)

.Percentage of prey consumed by burrowing owl

Frequency of occurrence (%) of prey items from 358 Burrowing Owl pellets collected in Llano La Soledad, Galeana, N.L., Mexico.

	Winters			
	2002-2003	2003-2004	2004-2005	Total
	(n=125)	(n=116)	(n=117)	(n=358)
Mammals				
Peromyscus maniculatus	0.7	1.2	1.0	1.0
Dipodomys merriami	1.1	0.4	1.4	1.0
Perognathus flavus	0.4	1.2	1.7	1.1
Xerospermophilus spilosoma		0.8		0.2
Reithrodontomys megalotis	0.7	0.4	2.8	1.3
Neotoma mexicana		0.8		0.2
Rodent unidentified	2.8	2.0	2.1	2.3
Birds				
Amphispiza bilineata	0.4			0.1
Birds unidentified	1.1	4.4	2.1	2.4
Reptiles				
Holbrookia maculata	0.4			0.1
Aspidoscelis inornata		0.4		0.1
Reptiles unidentified		0.4		0.1
Insects	83.1	83.1	86.9	84.4
Coleoptera				
Elateridae		0.8	2.1	1.0
Carabidae	25	26.2	24.6	25.2
Scarabaeidae	16.9	18.1	1.4	11.8
Curculionidae	6.7	6.9	5.9	6.5
Cerambycidae	4.9	2.8	7.3	5.1
Passalidae		6.5	2.1	2.7
Buprestidae			0.7	0.2
Tenebrionidae			6.9	2.4
Orthoptera				
Acrididae	24.3	17.3	23.9	22
Gryllidae	1.1	2.4	11.1	5.0
Hymenoptera				
Vespidae	0.7			0.2
Formicidae		2.0	0.7	0.9
Dermaptera				
Forficulidae	3.5		0.3	1.3
Arachnids	9.5	4.8	2.1	5.5
Araneae				

Theraphosidae	2.1		1.0	1.1
Araneidae	6.0	1.6		2.6
Solifugae				
Eremobatidae	1.4	3.2	0.3	1.6
Thelyphonida				
Thelyphonidae			0.7	0.2
Total ítems	284	248	289	821

Table 2(on next page)

Biomass from winter diet consumption of burrowing owl

Biomass percentage (%) of prey from Burrowing Owl pellets (358) collected from Llano La Soledad, Galeana, N.L., Mexico.

	Winters			
	2002-2003	2003-2004	2004-2005	Total
	(n=125)	(n=116)	(n=117)	(n=358)
Mammals				
Peromyscus maniculatus	10.7	6.4	11.4	8.7
Dipodomys merriami	30.2	4.0	28.8	16.4
Perognathus flavus	1.8	2.1	6.4	3.3
Xerospermophilus spilosoma		26.5		13.5
Reithrodontomys megalotis	5.0	1.0	14.2	5.6
Neotoma mexicana		38.2		19.5
Unidentified rodents	14.2	3.6	7.6	6.9
Birds				
Amphispiza bilineata	2.9			0.6
Unidentified birds	8.5	12.5	12.2	11.6
Reptiles				
Holbrookia maculata	1.8			0.4
Aspidoscelis inornata		0.4		0.2
Unidentified reptiles		0.4		0.2
Insects				
Coleoptera	4.7	2.0	4.9	3.4
Elateridae		0.02	0.1	0.03
Carabidea	1.7	0.6	1.2	1.0
Scarabaeidae	1.1	0.4	0.1	0.5
Curculionidae	0.9	0.3	0.6	0.5
Cerambycidae	1.0	0.2	1.1	0.6
Passalidae		0.4	0.3	0.3
Buprestidae			0.2	0.1
Tenebrionidae			1.5	0.4
Orthoptera				
Acrididae	9.3	2.3	6.7	5.0
Gryllidae	0.3	0.2	2.0	0.7
Hymenoptera				
Vespidae	0.1			0.02
Formicidae		0.002	0.1	0.03
Dermaptera	1.9		0.1	0.4
Forficulidae	1.9		0.1	0.4
Arachnids	8.7	0.5	5.7	3.6
Araneae				
Theraphosidae	7.6		2.7	2.3
Araneidae	0.7	0.06		0.2
Solifugae				

Eremobatidae	0.5	0.4	0.1	0.3
Thelyphonida				
Thelyphonidae			2.9	0.8
Total (g)	422	1056	591	2070

Table 3(on next page)

Results of niche width with frequencies of winter diet consumption

Niche breadth estimate and 95% confidence intervals based on frequency of occurrence data and biomass.

	2002-2003	2003-2004	2004-2005	Total
	(N=125)	(N=116)	(N=117)	(N=358)
Frequency of occurrence				
Smith's measure (95%CI)	0.80	0.82	0.82	0.77
	(0.74-0.85)	(0.76-0.87)	(0.77-0.87)	(0.74-0.80)
Frequently consumed items (>5%)	5	5	6	5
Biomass				
Smith's measure (95%CI)	0.82	0.68	0.77	0.74
	(0.77-0.87)	(0.61-0.74)	(0.71-0.82)	(0.70-0.77)
Frequently consumed items (>5%)	6	4	7	7

Table 4(on next page)

Biomass per year with association by level of consumption of the winter diet

Association test (X2) of biomass between year and taxonomic level. Cramer's phi coefficient (ϕc) is included as a measure of its effect size.

Taxonomic Level	X^2	p	ϕ_c
Vertebrates			
Classes	16.7	<0.001	0.07
Species (Rodents)	1067.3	<0.001	0.59
Invertebrates			
Classes	11.8	0.003	0.21
Orders	69.4	<0.001	0.36
Families	111.9	<0.001	0.45

Table 5(on next page)

Niche analysis using Horn's index.

Niche overlap among wintering seasons using Horn's index. Upper diagonal was estimated from frequency of occurrence data (FO) and below diagonal was calculated from biomass data.

Biomass\FO	2002-2003	2003-2004	2004-2005
2002-2003	-	0.873	0.78
2003-2004	0.451	-	0.801
2004-2005	0.884	0.472	-

Figure 1

Image of the study species

Burrowing owl in Galeana, Nuevo Leon; Mexico.

Figure 2

Location map of the study area

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

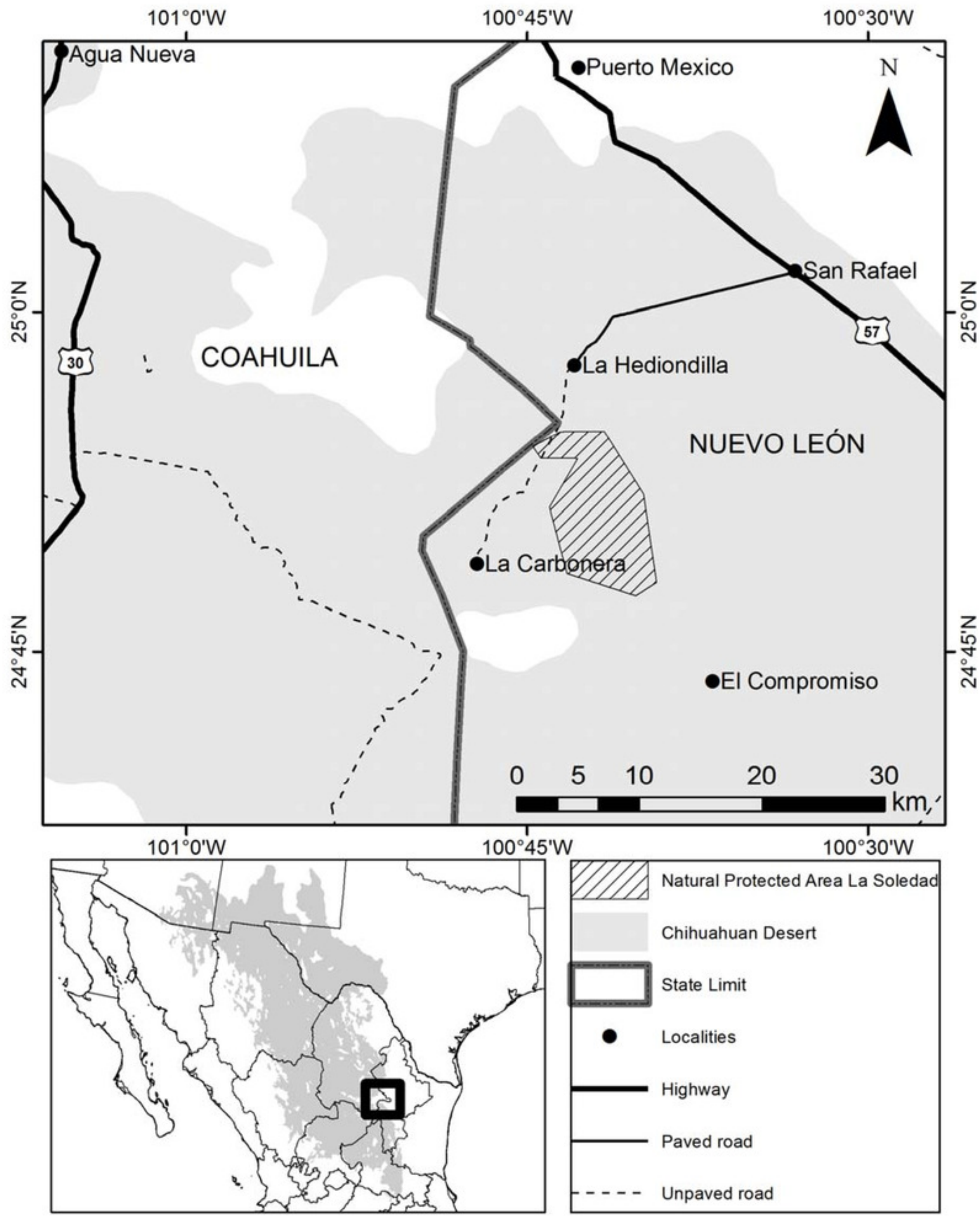

101°0'W
100°45'W
100°30'W
Agua Nueva
Puerto Mexico
N
San Rafael
25°0'N
57
30
COAHUILA
La Hediondilla
NUEVO LEÓN
La Carbonera
24°45'N
El Compromiso
0 5 10 20 30
km
Natural Protected Area La Soledad
Chihuahuan Desert
State Limit
Localities
Highway
Paved road
Unpaved road

Figure 3

Remains of winter prey from the Burrowing owl

Remains of winter prey from the Burrowing owl: A) Pellets; B) Head with antenna, mandible, compound eye of beetle; C) Bones and teeth; D) Femur and tibia of grasshopper; E) Tibia and mandible of beetle; F) Chelicera and palpal tibia of arachids.

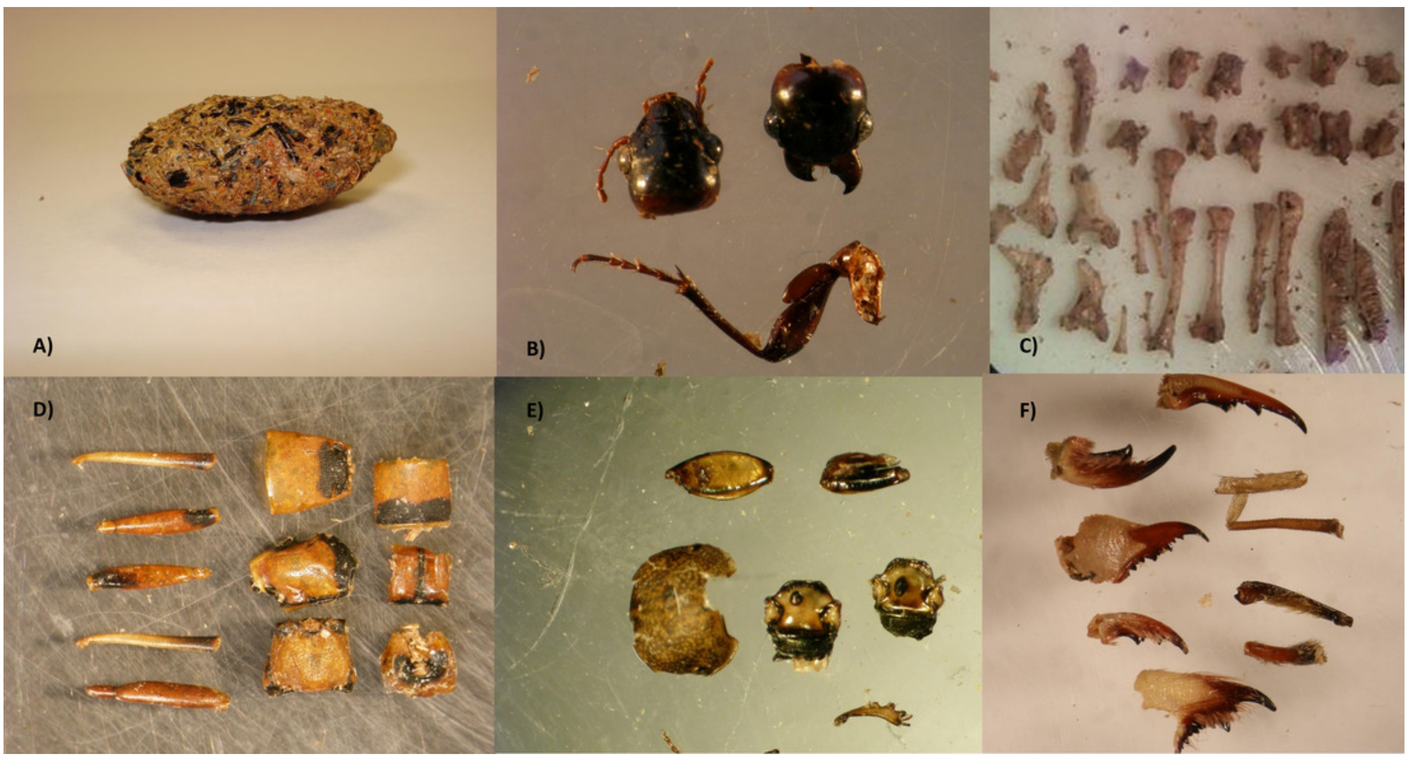
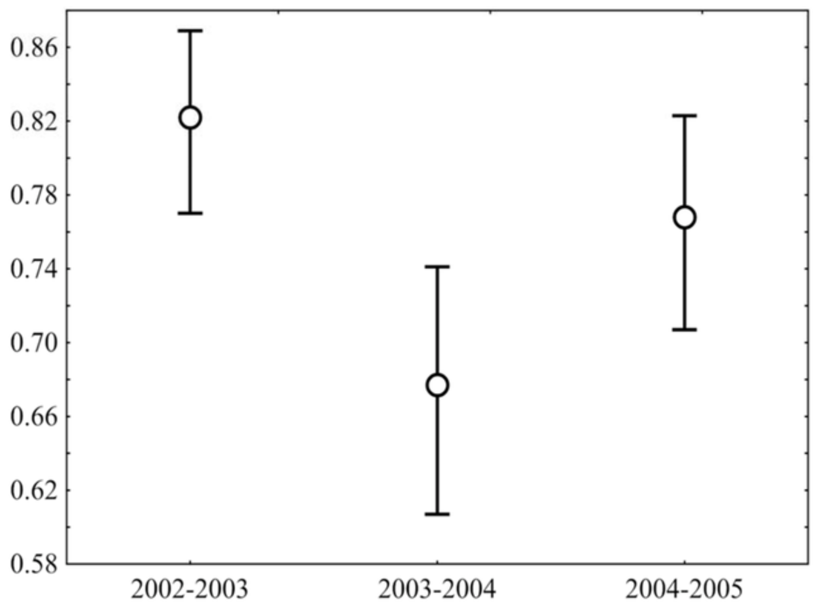


Figure 4

niche analysis confidence intervals

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


0.86
0.82
0.78
0.74
0.70
0.66
0.62
0.58
2002-2003
2003-2004
2004-2005