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

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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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10 **Abstract**

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12 Llano La Soledad, Galeana, Nuevo Leon in northern Mexico, considering prey type, frequency

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19 generalist species with mean values per year ranging between 0.68 and 0.82. There was and

20 significant association between relative biomass of rodent species and invertebrate families with

21 wintering season. This association was driven mainly by changes in composition and frequency

22 of these types of prey during the second season, which was likely caused by high annual rainfall.

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24 overlap (<47% *vs.* 88%) among the three winters.

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

26 **INTRODUCTION**

27 The Burrowing Owl (*Athene cunicularia* Molina, 1782; Fig.1); has shown a significant negative

28 population trend in United States for almost 50 years (-0.91%/yr.; 1966-2015; *Sauer et al.,*

29 *2017*). In Canada is this decline especially steep (-6.42%/yr.; 1966-2015; *Sauer et al.,* 2017)

30 where it is listed as an endangered species (Committee on the Status of Endangered Wildlife in

31 Canada [*COSEWIC*] 2006). In the U.S. Burrowing Owl it is considered as a National Bird of

32 Conservation Concern U.S. Fish and Wildlife Service [*USFWS]* 2008; whereas in Mexico it is

33 protected under the "special protection" category (Secretaria de Medio Ambiente y Recursos

34 Naturales [*SEMARNAT*] 2010). The current population status of the Burrowing Owl is a function

35 of multiple threats such as habitat fragmentation, decreased availability of prey, increased

36 predation, inclement weather, vehicles strikes, environmental contaminants, and loss of burrows

37 (*Environment Canada, 2012*). Food availability, in particular, is one of the most important

38 natural limiting factors in populations during winter (*Newton, 1998; McDonald et al., 2004*).

39   The winter diet of the Burrowing Owl has been mostly studied in the United States in Texas,

40 Nevada, and California, as well as in other countries in North, and South America and consists of

41 invertebrates, small mammals, and reptiles *(Plumpton & Lutz, 1993*). Invertebrates are consumed

42 most frequently (*Poulin, 2003*) but mammals compose most of the biomass (*Andrade et al.,*

43 *2004; Littles et al., 2007; Nabte et al., 2008; De Tomasso et al., 2009; Andrade et al., 2010;*

44 *Carevic et al., 2013*). However, frequency of occurrence of insect orders is highly variable, both

45 temporally and spatially. Beetles (Coleoptera) and crickets (Gryllidae) consumption ranged from

46   20% to 80%. On the other hand, mammal species, which include Deer Mice (*Peromyscus*

47   *manicualtos*), Silky Pocket Mice (*Perognathus flavus*) and Kangaroo Rats (*Dipodomys*

48   *merriami*), are reported to be as high as 98% (*Ross & Smith, 1970; Coulombe, 1971; Butts,*

49   *1976; Tyler, 1983; Barrows, 1989; Mills, 2016*). In British Columbia, Canada, indicate that 56%

50   of their diet is insects, such as earwigs and beetles (*Morgan, 1993*). The only report of the

51   Burrowing Owl's winter diet in Mexico has been done in central Mexico in the state of

52   Guanajuato, where78% of prey items were invertebrates, while the remaining 22% were

53   vertebrates (*Valdez-Gómez, 2003*), while and biomass was more evenly distributed among

54   Orthoptera (26.8%), Lepidoptera (20.6%) and rodents (20.9%; *Valdez-Gómez et al., 2009*). Diet

55   during the breeding season has also been analyzed in the states of Durango and Nuevo León,

56   where insects were the most frequent prey items (67-84%) and mammals represented 50% of the

57   biomass (*Rodríguez-Estrella, 1997, Ruiz-Aymá, 2019*).

58   Variation in diet has been associated with prey availability, suggesting that small mammals are

59   selected over invertebrates when their densities are sufficiently high (*Silva et al., 1995*). A

60   change in prey composition has also been associated with rainfall, with more grasshoppers and

61   some rodents *Perognathus sp.*, *Onychomys leucogaster* consumed during dry years and birds

62   during wet years (*Conrey, 2010*).

63   Information of the Burrowing Owls' winter diet in Mexico is limited and temporal variation has

64   not been examined. Thus, our objective was to determine the wintering diet composition and

65   dietary niche breadth of Burrowing Owls during three winter seasons (2002-2003, 2003-2004,

66   2004-2005) in northern Mexico, (Llano La Soledad, in the southern Chihuahuan Desert). We

67   predicted that in a year with high rainfall, diet composition will be different than in drier years,

68   and that will likely affect dietary niche breadth.

69   **STUDY AREA AND METHODS**

70   **Site descriptions**

71   Llano la Soledad is a plain located in northeastern Mexico, state of Nuevo Leon, municipality of

72   Galeana, within the Grassland Priority Conservation Area "El Tokio" (CEC & TNC 2005, Pool

73   & Panjabi 2011), which is part of the Chihuahuan Desert ecoregion (25° 9' 8.87" N, 101° 6'

74   8.00" W and 24° 18' 54.12"N, 100° 23' 41.48" W; Fig. 2). It is a State Natural Protected Area

75   (*Diario Oficial de la Federación, 2002*) and internationally known for its importance for

76   shorebird conservation (*WHSRN, 2004*). It is also part of an important bird area "Pradera de

77   Tokio" (AICA-NE-36; *Del Coro & Márquez, 2000*) that harbors vulnerable bird species both

78   endemic and migratory, such as Golden Eagle (*Aquila chrysaetos)*, Long-billed Curlew

79   (*Numenius americanus)*, Mountain Plover (*Charadrius montanus)* and Worthen's Sparrow

80   (*Spizella wortheni*) (*Macias et al., 2011*). The Llano La Soledad also contains the largest colony

81   of Mexican Prairie Dogs (*Cynomys mexicanus)* (*Treviño & Grant, 1998*) and therefore represents

82   the most extensive and continuous habitat in terms of burrow and food availability for the

83   Burrowing Owl in northeastern Mexico.

84   The area is dominated by open grasslands with 80% bare ground and 20% plant cover: 3% of

85   grass and 17% of forbs and shrubs. The most common species are: Spear Globemallow

86   (*Sphaeralcea hastulata*), Four Wing Saltbush (*Atriplex canescens*), Three Awn (*Aristida ssp.*)

87   and Burrograss (*Scleropogon brevifolius*), Creeping Muhly (*Muhlenbergia repens*), Sand Muhly

88   (*M. arenicola*) and Grama (*Bouteloua karwinskii*) (*Cruz-Nieto, 2006*). The semi-arid climate

89   features temperatures ranging from 6 to 25 °C with an annual average of 16 °C (*CONAGUA,*

90   *2019*). Average annual precipitation is 427mm (*INEGI, 2005*). Annual rainfall for 2002-2004

91   years, was obtained from the closest (~6 km) meteorological station in La Carbonera (19032;

92   *CONAGUA, 2019*).

93   **Pellet Collection and Analyses**

94   Pellets were collected at the entrances of burrows, from the first week of October through the

95   first week of March over three winter seasons: 2002-2003, 2003-2004, and 2004-2005. We

96   Collected pellets from burrows every third day. We analyzed and quantified the remains of each

97   pellet according to the methods of *Errington*, (*1930; 1932*) and *Marti*, (*1987*). We identified

98   mammals according to *Anderson*, (*1972*) and *Roest*, (*1991*), herpetofauna following *Smith &*

99   *Taylor*, (*1950)* and *Smith & Smith,* (*1993*), birds following *Howell & Webb,* (*2004*) and *Dunn*,

100 (*2006*), and invertebrates according to *Borror et al.*, (*1989*). All vertebrate prey items that could

101 not be determined to the species level were included in the unidentified category.

102 We estimated biomass multiplying weight for the frequency of occurrence of each type of prey,

103 assuming there was one individual per pellet. For mammals we used the median of the weight for

104 each species to avoid overestimation (*Holt & Childs,* 1991). Medians were obtained from data

105 given for Mexico by *Ceballos & Oliva,* (*2005*). For reptiles, we used specimens from the

106 Herpetology Laboratory collection at the Universidad Autonoma de Nuevo Leon/Facultad de

107 Ciencias Biologicas; for insects, data reported by *Olalla* (*2014*); and for spider, median weights

108 were obtained from live specimens of the Arachnology collection at the Facultad de Ciencias

109 Biologicas/Universidad Autonoma de Nuevo Leon.

110 **Statistical Analyses**

111 We estimated niche breadth and their 95% confidence intervals for each season using Smith's

112 measure (1982), and their overlap using Horn's index (1966) with Ecological Methodology 7.2

113   (*Krebs, 2011*) software. We considered niche breadth estimates with non-overlapping 95%

114   confidence intervals as statistically different.

115   To test for an association (α = 0.05) of prey frequency and biomass among taxonomic levels and

116   years we used X^2 contingency tests (*Zar, 1998*). We also calculated and interpreted Cramér's phi

117   coefficient (ϕ_c) as a measure of the effect size of the association (Cohen 1988). These analyses

118   were conducted using PAST 3.14 (*Hammer et al., 2001*).

119   **RESULTS**

120   We analyzed 358 pellets, and found 821 items from 26 taxa. We recorded 7 orders and 17

121   families of invertebrates, 6 genera of small mammals, 2 genera of reptiles, and 1 avian genus.

122   Vertebrates represented 10% and invertebrates 90% of prey items consumed during the three

123   winter seasons, but the proportions were inversed for biomass, with vertebrates composing 84%

124   and invertebrates 16% of biomass consumed. Rodents composed 7% of the prey items eaten, but

125   82% of the biomass particularly Cricetid rodents. Insects, primarily from the orders Coleoptera

126   (55%) and Orthoptera (27%) represented 84% of consumed items but contributed only to 12% of

127   the biomass (Fig. 3; Tables 1, 2).

128   Niche breadth measures were wide, indicating, as expected, a generalist species, with consistent

129   overall estimates for both frequency of occurrence (FT= 0.77; 95%CI=0.74-0.80) and biomass

130   (FT=0.74; 95%CI=0.70-0.77). However, the niche breadth based on biomass was significantly

131   smaller for the winter of 2003-04 (Table 3, Fig. 4). This also coincided with above average (395

132   mm; 1956-2014) annual precipitation of 505 mm during 2003, compared with drier years: 288

133   mm (2002) and 304 mm (2004).

134   There was a highly significant and small correlation between yearly parameters and prey items of

135   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,

136 ϕ_c =0.18), and moderate with families (X^2=215.2, *df*=32, p<0.0001, ϕ_c =0.38). There were weak

137 to strong associations between biomass and year at every taxonomic level (Table 4). Year

138 associations with vertebrate taxonomic levels were primarily caused by a greater consumption of

139 mammal (rodents) biomass, particularly, Spotted Ground Squirrel (*Xerospermophilus spilosoma*)

140 and Mexican Woodrats (*Neotoma Mexicana*). During the second (wet) year, Merriam´s

141 Kangaroo Rat (*Dipodomys merriami*) consumption decreased during the same period (Table 2).

142 Changes in prey composition and relative biomass during the second season were also evident

143 from niche overlap indices, which show the smallest values when compared to the first and third

144 seasons (0.45 and 0.47), and greater frequency of occurrence, ranging from 0.78 to 0.87 (Table

145 5). Birds on the contrary, were very stable among years with a relative biomass between 11 and

146 13% (Table 2).

147 **DISCUSSION**

148 Our findings provide additional evidence that the burrowing owl is a generalist and opportunistic

149 predator. Invertebrates (mainly arthropods) were the most frequent food items, corroborating

150 previous studies that have shown that overwintering Burrowing Owls feed mainly on arthropods

151 and small mammals (*Ross & Smith, 1970; Coulombe, 1971; Butts, 1976; Tyler, 1983; York et*

152 *al., 200; Valdez- Gómez, 2003; Littles et al., 2007; Hall et al., 2009*).

153 Invertebrates represented 90% of prey items consumed, which is similar to results from other

154 studies (*Littles et al., 2007; Caveric et al., 2013; Cavalli et al., 2014*) as they report values

155 ranging from 93% to 98%, but higher than the 78% reported by *Valdez- Gómez* for Mexico

156 (*2003*).

157   Insects represented 84% of the items in the diet, which was very similar among the seasons,

158   varying between 83 and 87%, which is greater than the 63% reported in México (*Valdez- Gómez,*

159   *2003*) and less than the 91% reported in southern Texas (*Littles et al., 2007*).

160   Beetles were the most-frequently consumed insects overall with 55%, and a maximum variation

161   of 10% between years. Beetles have been observed as a consumed insect order, which is not

162   common in North America and has only been observed during the breeding season (39%-54%;

163   e.g. *Haug, 1985; Green et al., 1993; Floate et al., 2008*) and more prevailing in South America

164   (e.g. *Andrade et al., 2010; Cavalli et al., 2013*). In most studies in North America, crickets

165   (Gryllidae) were the most frequently ingested insects (*York et al., 2002; Valdez- Gómez, 2003;*

166   *Littles et al., 2007; Hall et al., 2009*). At the family level, Carabid beetles were the most

167   frequently consumed (25%) in our study, while other authors report Gryllidae (crickets; *Valdez-*

168   *Gómez, 2003; Littles et al., 2007*). *Jonas et al.,* (*2002*) observed a positive correlation between

169   native vegetation and beetles, whose consumption by Burrowing Owls in our study was likely

170   related to the high proportion of native vegetation in Llano La Soledad. Beetles have an affinity

171   for native vegetation (*Crisp et al., 1998; Jonas et al., 2002; Littles et al., 2007*) whereas crickets

172   are common in disturbed areas (*Smith, 1940; Jonas et al., 2002*) in North America, especially in

173   grazed and overgrazed pastures, abandoned pastures (*Jonas et al., 2002*), abandoned crop fields,

174   lawns, old fields and other grassy areas (*Cade & Otte, 2000; Moulton et al., 2005*), as well as in

175   tilled and plowed fields (*Carmona, 1998*); however, these types of fields were not common in

176   our study area, and the closest were around 10 km away.

177   Conversely, in South America, although coleopterans have been found to be highly consumed

178   and preferred by the burrowing owl, their relative abundance was higher in agricultural areas

179   than in vegetated sand-dunes (*Cavalli et al., 2013*). These authors suggested that coleopterans

180 may also have been common in owls' diet because they require little effort to capture,

181 particularly when they are abundant near burrows. *Littles et al., (2007)* reported that beetles were

182 the second most consumed item (32%) of all prey items on a barrier island, where vast expanses

183 of the native vegetation occur in comparison to agricultural and grassland, in grasslands, fire

184 suppression has allowed brush species such as Honey Mesquite (*Prosopis glandulosa*) to invade

185 the remaining native pastures and most remaining grasslands are dominated by exotic grass

186 species that were introduced for cattle.

187 The second-most frequently consumed prey items in our study were the grasshoppers (22%),

188 while *Valdez- Gómez, 2003* reported to this same group (15%) and *Littles et al., 2007*, mentioned

189 Lepidoptera (13%). Our data showed variation in relative frequency of consumption among

190 arthropod groups, with the greatest frequency of occurrence of spiders during the first season

191 (<10%); and a decrease in the presence of Scarabeidae and an increase of Tenebrionidae and

192 Gryllidae occurrence in the third year (Table 1).

193 In addition, the Burrowing Owls' consumption at Llano de la Soledad showed more variation,

194 which is an indicator of a natural habitat and typical of an opportunistic predator that feeds on

195 what is available (*Jaksic & Martí, 1981; Jaksic, 1988; Green et al., 1993; Haug et al., 1993;*

196 *Littles, 2007*).

197 Vertebrates represented 10% of the remaining prey items consumed by the Burrowing Owls,

198 which was less than the 21% recorded in Guanajuato, Mexico (*Valdez- Gómez, 2003*), and

199 greater than the 2% recorded in southern Texas (*Littles et al., 2007*). However, rodents were

200 consistent as the most frequently vertebrate with 74%, in comparison with 70% reported by

201 *Littles et al., (2007)* and 86% by *Valdez- Gómez (2003)*.

202 We found that Silky Pocket mice were the most common rodent prey (19%), followed by the

203 Western Harvest Mouse (15%), the Deer Mice and Merriam's Kangaroo Rats (14% each). In

204 contrast, the most commonly found rodents in Guanajuato were deer (39%) and Silky Pocket

205 Mice (35%; *Valdez- Gómez, 2003*); while in Texas the most common were Northern Pigmy

206 (23%) and Fulvous Harvest Mice (19%; *Littles et al., 2007*). All of these rodent species are

207 distributed in U. S. and Mexico, mostly within arid areas of both countries, and their variation as

208 the most consumed prey per region is consistent with the capacity of the Burrowing Owl to use

209 what is likely most available on each region.

210 Even though vertebrates only represent 10% of prey items, they accounted for 87% of the total

211 biomass consumed, which is similar to other authors' findings (*Littles et al., 2007; Nabte et al.,*

212 *2008; Carevic et al., 2013*). Mammals biomass was of 74% varied between 62 and 82% between

213 years, which is higher than what has been reported for Texas (52%) (*Littles et al., 2007*) and

214 Mexico (25%; *Valdéz-Gómez et al., 2009*), but within the 25 to 95% reported in Argentina and

215 Chile (*Andrade et al., 2004; Nabte et al., 2008; De Tomasso et al., 2009; Andrade et al., 2010;*

216 *Carevic et al., 2013*). Cricetid rodents composed 58% of the biomass, which falls within the

217 range of 37 to 95% found in other studies (*Littles et al., 2007; Nabte et al., 2008; Andrade et al.,*

218 *2010*).

219 As previously stated, within vertebrates, changes in rodent species biomass use during the

220 second season drove the main differences in niche breadth and composition among years. This

221 difference coincides with a high annual rainfall that may have produced irruptive population

222 events (*Greenville et al., 2012*), or caused changes in rodent species' population densities, which

223 would affect their availability and their selection as prey by the Burrowing Owl (*Silva et al.,*

224 *1995*). Although this was not measured, temporal variation in populations of all the prey species

225   in our study have been associated with rainfall, more strongly for the species we found changed

226   the most, such as Merriam's Kangaroo Rat, Silky Pocket Mice, Spotted Ground Squirrel and

227   Western Harvest Mouse (*Whitford, 1976; Brown & Zeng, 1989; Brown & Ernest, 2002*).

228   Temporal studies that include prey availability in disturbed and undisturbed areas of southern

229   Chihuahuan Desert would clarify the dynamics of prey use and preference for this vulnerable

230   owl species. Examining the effects of the variation in vertebrate biomass consumption on

231   survival of Burrowing Owls during wet and dry years would also be informative, especially

232   considering climate change scenarios. Another relevant aspect of the temporal framework for

233   diet studies is their relationship with pesticides and indirect exposure to contaminated prey,

234   which is likely, although with limited evidence at the moment (*Haug & Oliphant, 1987; James et*

235   *al., 1990*).

236   Finally, it is also important to highlight that Llano La Soledad grasslands are key to maintaining

237   healthy populations of the Burrowing Owl and other species. Management and conservation of

238   this population depends on the depth of our knowledge of this species, and one of the key

239   components is its feeding ecology.

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.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 (n=125)	2003-2004 (n=116)	2004-2005 (n=117)	Total (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

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

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 (N=125)	2003-2004 (N=116)	2004-2005 (N=117)	Total (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

2

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

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.
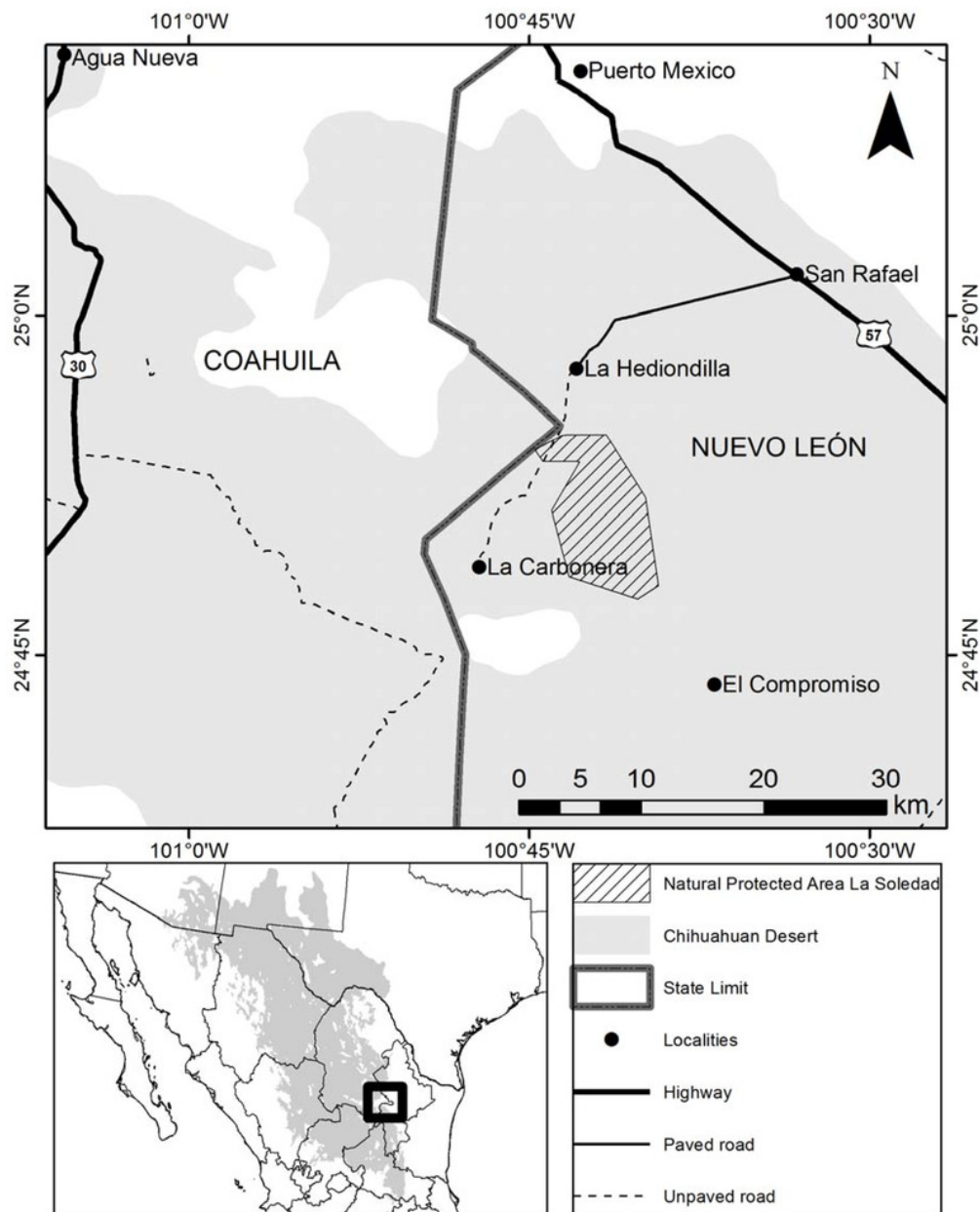
Figure 3

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.
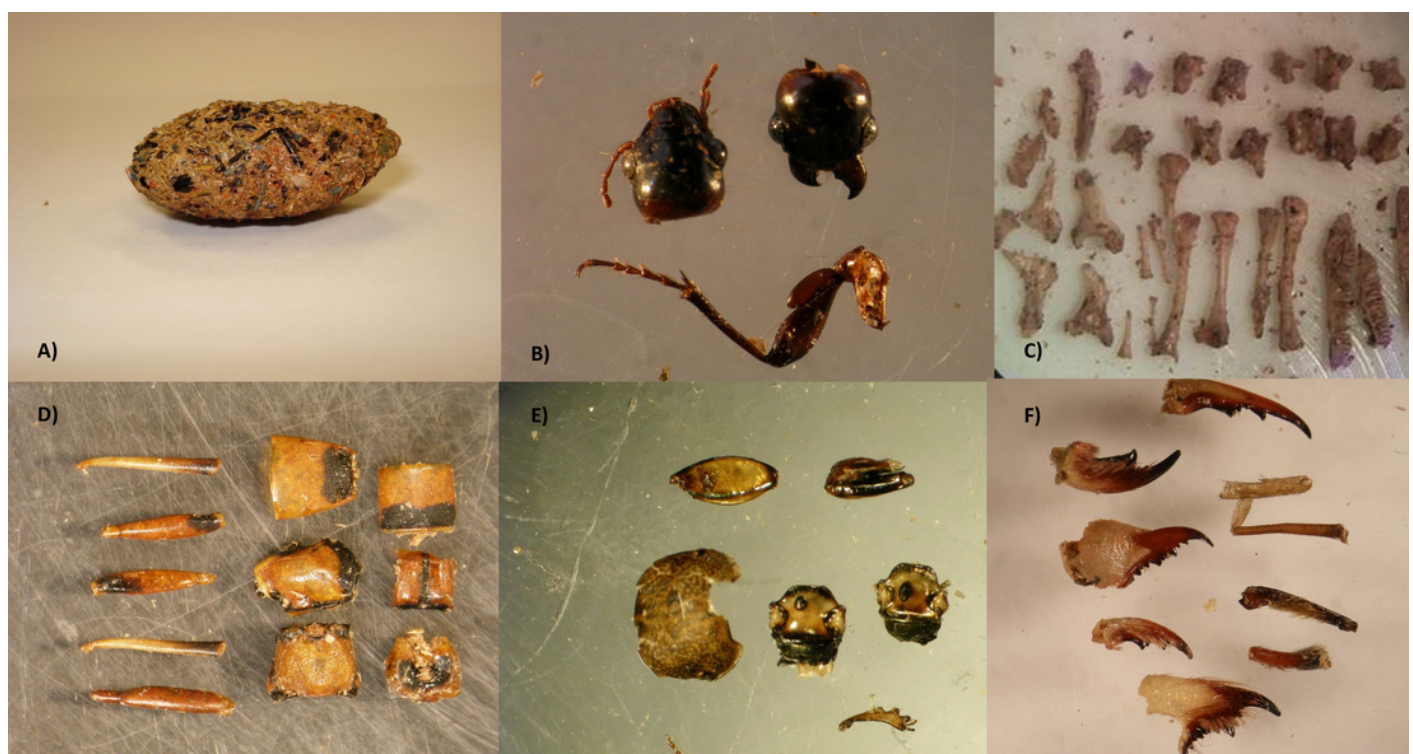
Figure 4

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.