Diversity and relative abundance of rodent species under three habitat conditions in the Altiplano Potosino Oeste, Mexico

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ABSTRACT

Objective: To evaluate the diversity and abundance of rodent species, as well as vegetation cover, under three habitat conditions in the Altiplano Potosino Oeste.

Design/Methodology/Approach: The work was carried out in eight sites with good (3), regular (2), and poor (3) vegetation cover conditions. Frequency, basal, and aerial cover data were collected in three plot sizes to obtain the results for the three types of vegetation: arborescent stratum (20×20 m), shrubs (3 plots of 5×5 m), and herbaceous stratum (2 plots of 1×1m). In order to collect the rodent data, three sampling nets with 100 Sherman traps were used. Rodent species diversity was determined using the Shannon-Whinner index (SWI), while abundance was obtained using the Relative Density Index (RDI). Differences were determined using ANOVA.

Results: Grass cover decreased depending on the condition; however, this was not the case of the shrub cover. The overall diversity of rodent species was 21 (16 in fair, 15 in good, and 14 in poor condition). The total SWI and RDI decreased depending on the condition. *Dipodomys ornatus*, *D. merriami*, and *Chaetodipus nelsoni* were the most abundant and most widespread species.

Study Limitations/Implications: The study was conducted during the most restrictive season and under drought conditions. This situation impacted cattle, but not rodents. However, although their plasticity maintained relatively stable RDI values, the indices decreased depending on the condition.

Findings/Conclusions: Despite their habitat conditions, the rodents found in the area are more diverse and abundant than those reported in reference works. Therefore, further studies about this subject should be carried out using rodents as bioindicators.

Keywords: *Dipodomys ornatus*, *D. merriami*, *Chaetodipus nelsoni*, Relative Density Index, Shannon-Wiener Index.

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INTRODUCTION

Livestock practices in arid and semi-arid areas are usually inadequate and lead to vegetation cover degradation, which increases under adverse weather conditions (Holechek and Valdez, 2018; Weber-Grullon *et al.*, 2022). Such is the case of the Altiplano Potosino in Mexico, where 73% of the

surface is used for an extensive cow-calf production system (INEGI, 2022). In this area, the livestock density and the erosion rate are high; additionally, there is a forage deficiency. These conditions lead to an increase in shrub species with low forage value (Li *et al.*, 2022), low productivity, a poor nutrient value, and a poor body condition of the livestock (Chen *et al.*, 2022). In addition to livestock practices, the herbivory of wild rodents can impact the structure and regeneration of vegetation (Lucero and Callaway, 2018; Zhong *et al.*, 2022), which can be worsened by weather conditions (Peterson *et al.*, 2021).

In arid areas of North America, 50% of the wild rodent species are granivorous (Fox, 2011). Rodents have an important ecological role as seed dispersers, they establish vegetation patches (Godó *et al.*, 2022), turn over the soil (Eldridge *et al.*, 2012), and are a key link in the food chain (Fox, 2011). In semi-arid and arid ecosystems, the specific composition of rodent communities includes a great number of individuals of one or several predominant species, while other species are hardly included in this type of communities (Hernández *et al.*, 2011; Lightfoot *et al.*, 2012). This structure can be maintained in a relatively regular state through time; however, its abundance and activity areas fluctuate depending on precipitation and, therefore, on vegetation biomass and cover (Lightfoot *et al.*, 2012; Bai *et al.*, 2022).

In addition to overgrazing and its consequences on natural resources, drought impacted the Altiplano Potosino Oeste (APO) in 2010 and 2011, causing weight loss and mortality among livestock (Servicio Meteorológico Nacional (México), n.d.). Overall, body condition and survival of livestock are easily noticed, unlike other users of the ecosystem (*e.g.*, rodents). Therefore, the objective of this study was to evaluate the diversity and the relative abundance of rodent species, under three vegetation cover conditions of the APO during droughts.

MATERIALS AND METHODS

The APO includes the municipalities of Salinas, Villa de Ramos, and Santo Domingo, in the NW portion of San Luis Potosí. APO is located between the following coordinates: 22° 46' - 23° 80' N and 101° 0' - 102° 25' W. The climate is dry semi-warm with summer rains (BS_0kw); the mean annual temperature ranges from 12 to18 °C, while the mean annual precipitation fluctuates between 300 to >400 mm. The 2010 mean annual precipitation reached 270 mm; however, in 2011 only 83 mm were recorded (SMN, 2022). The microphyllous desert scrub prevails in the area, with various degrees of grass cover (INEGI, 2022). Eight livestock sites from the APO area were selected to conduct the sampling field work. They were at least 10 km apart from each other. The sites were classified as follows: three had a good vegetation cover (G), two had a regular vegetation cover (R), and three had a poor vegetation cover (P). Additionally, each site was qualified according to the body condition of the livestock, based on the following scale: 1 (skinny); 2 (thin); 3 (moderate); 4 (good); and 5 (fleshy) (Houghton *et al.*, 1990).

Field work was carried out from March to May 2011, when rodents faced the most restrictive availability of resources (Lightfoot *et al.*, 2012). Vegetation cover was evaluated using 20×20 m plots nested at random, with two replicates per site. Frequency, basal cover, and area of the arborescent species were determined. The same variables were used

to measure shrub species in three 5×5 m plots, located within the abovementioned plots. Perennial grasses and herbs were established in two 1.0 m^2 plots (Stohlgren *et al.*, 1999). Cover differences were calculated with an ANOVA, while a Tukey's Test (Statistical Analysis System [SAS], 2004) was used for the comparison of means. Arborescent stratum was recorded only in P and it was not used in the comparisons. Rodents' population sampling was carried out using three trapping nets per site. Each net contained 100 Sherman traps (10×10 lines, placing a trap every 10 m) (Krebs, 1989), which remained active for 72 h. The bait consisted of oat flakes and the traps were checked at dawn and dusk. The sampling effort was carried out during 7,200 days $trap^{-1}$. The identification keys developed by Mellink (1984) and Álvarez-Castañeda *et al.* (2017) were used to determine the rodent species. The Shannon-Whinner (H') index was used to determine the abundance of species per condition, using the Ecological Methodology 6.0 software (Kenney and Krebs, 2001). The abundance of the rodent population was evaluated using the Relative Density Index (RDI), following the methodology proposed by Calhoun (1959). This methodology compares the number of captures with the number of night traps and the sampling area. The result is set forth as individuals per hectare (Ind ha^{-1}).

RESULTS AND DISCUSSION

The basal and aerial covers of grasses and herbs were higher (Table 1) with the highest values of G (P=0.0007), where livestock had a regular body condition. In R and P, a lower vegetation cover, livestock with thin body condition, and livestock mortality were observed. According to White (2008), these results can be the consequence of drought and overgrazing. The basal cover in the shrub stratum was higher in inverse proportion to habitat quality. There were no differences between the aerial covers (P=0.0005). The arborescent stratum was scarce. None of the conditions recorded an optimum grass cover. G had a regular condition, while in the others, according to Holechek *et al.* (1989) and Ahumada-Hernández *et al.* (2022), the condition was poor.

Table 1. Cover (%) of the vegetation strata (basal and aerial covers), per habitat condition in the Altiplano Potosino Oeste (G=Good, R=Regular, P=Poor).

Category	Layer	Vegetation coverage (%)	
		Basal	Aerial
G	Grasses and herbs	33.36[a]	55.34[a]
R		11.67[b]	22.68[b]
P		7.62[b]	18.54[b]
G	Shrub	0.06[c]	3.85[c]
R		0.07[c]	2.73[c]
P		0.28[c]	6.05[c]
G	Arborescent	<0.01[c]	<0.10[c]
R		<0.01[c]	<0.10[c]
P		0.04[c]	0.16[c]

a,b,c Values in the same column with different letter are different (P>0.05).

In the arid areas, regardless of their combination, approximately 11 rodent species can usually be found in a community (Brown and Kurzius, 1987). For this work, we captured 21 species. This number is higher than the 15 rodent species recorded by Mellink and Valenzuela (1995) for the Altiplano Potosino. It is also higher than the results of Hernández *et al.* (2011) for the Mapimí region (Durango, México), the 14 rodent species found by Lightfoot *et al.* (2012) in La Jornada (New Mexico), and the 10 species registered by Ahumada-Hernández *et al.* (2022) in southwestern Zacatecas. However, as a result of the habitat condition, the abundance of rodents was similar to the number recorded by the abovementioned authors: 16 species in R, 15 in G, and 14 in P (Table 2). Based on the Shannon-Wiener index, the diversity of the species depended on the habitat condition (H': G=3.69; R=3.31; P=2.53), because this index weights up the number of species and their abundance (Krebs, 1989).

Regarding the RDI (Table 2), there was no significant differences between basal cover (P=0.606) and aerial cover (P=0.293); however, there was a weak relation between the habitat condition and the population density (R^2=4.99). For their part, Ahumada-Hernández *et al.* (2022) reported lower values in the Tula ranch and mentioned a relation between the abundance of rodents and the grass cover; however, no positive correlation was recorded. The following RDI values were obtained: 50.7, 40.9, and 26.7 ind ha^{-1}, for G, P, and R, respectively. Shrub was the predominant type of vegetation in all the conditions; shrubs protect rodents against predators (Lightfoot *et al.*, 2012; Szymañski *et al.*, 2020).

Regarding the three habitat conditions, population density was higher than the 17.8 ind ha^{-1} recorded by Hernández *et al.* (2005) in the Mapimí shrub and the 11.9 ind ha^{-1} obtained by Lightfoot *et al.* (2012) in La Jornada Basin. Concerning the RDI per species, *D. ornatus* recorded the highest population density in G, followed by *D. ordii*, and *Chaetodipus nelsoni*. In R, the highest population density was obtained by *D. merriami* and *D. phillipsi*, while for P, *D. phillipsi* recorded the highest population density. The species with the lowest RDI in G were: *Peromyscus eremicus* and *Perognathus flavus*. Meanwhile, the lowest population densities in R were registered by: *Ictidomys mexicanus*, *D. nelsoni*, *Peromiscus melanophrys*, *P. maniculatus*, and *P. difficilis*. Finally, the lowest population densities in P were recorded by: *Neotoma leucodon*, *P. eremicus* and *Onychomys torridus*.

Dypodomys merriami and *C. nelsoni* were the most abundant species, in pastures and in shrub, respectively. Meanwhile, *X. spilosoma*, *C. nelsoni*, *D. merriami*, *D. ordii*, *D. ornatus*, *P. maniculatus*, *P. eremicus* and *P. difficilis* were found in the three conditions. However, some of these species had a low population density, particularly *C. nelsoni*, *D. merriami*, *D. ordii* and *D. ornatus*, which were generalist and abundant. These results matched the reports of Hernández *et al.* (2011) and Lightfoot *et al.* (2012), but not the reports of Ahumada-Hernández *et al.* (2022). The species with the lowest presence, found only in one condition and with a low population density, were *L. mexicanus*, *D. nelsoni*, *D. stephensi*, *N. mexicana*, *Peromyscus melanophrys* and *R. megalotis*.

Overall, the species found in the APO seem to be adapted to the conditions of their habitat, where drought is a frequent event. In fact, this work found higher values both for diversity and for population density. The prevailing species were granivorous rodents

Table 2. Rodent species and Relative Density Index (RDI) per habitat condition (Good=G, Regular=R, and Poor=P) in the Altiplano Potosino Oeste.

Family	Species	RDI mean (Ind ha^{-1})		
		G	R	P
Sciuridae	*Ictidomys mexicanus*	-	0.44	-
	Xerospermophilus spilosoma	2.22	2.22	1.78
Heteromyidae	*Chaetodipus eremicus*	4.00	0.89	-
	C. nelsoni	6.22	1.33	2.67
	Perognathus flavus	0.44	-	0.89
	Dipodomys merriami	4.44	9.78	0.89
	D. nelsoni	-	0.44	-
	D. ordii	7.56	1.78	4.00
	D. ornatus	13.78	2.67	22.22
	D. stephensi	-	1.33	-
Muridae	*Neotoma leucodon*	0.89	0.89	0.44
	N. mexicana	-	1.33	-
	Peromyscus melanophrys	-	0.44	-
	P. gratus	2.67	-	1.78
	P. eremicus	0.44	1.33	0.44
	P. maniculatus	1.33	0.44	0.89
	P. difficilis	2.22	0.44	2.22
	Reithrodontomys fulvescens	-	0.89	1.33
	R. megalotis	0.89	-	-
	Onychomys arenícola	1.33	-	0.89
	O. torridus	2.22	-	0.44
Total		50.67	26.67	40.89

that store food, mainly *D. ornatus*, *C. nelsoni* and *D. merriami*, as a consequence of the desertification promoted by livestock practices (Graham and Whitford, 2000). Altogether, the composition and the abundance of rodent species in the APO were related to the quality of the habitat and, unlike cattle, rodents do not seem to have been impacted by droughts. Therefore, we recommend considering rodents as bioindicators, carrying out further studies, and extending the sampling collection, both in space and time.

CONCLUSIONS

A higher diversity of rodents and a higher RDI were recorded in this study, both in this region and other regions with similar characteristics. A low body condition and even mortality were recorded among cattle, as a consequence of droughts; however, there was no proof of impact on rodents. Compared with other research, rodent populations were stable; nevertheless, the species diversity depended on their habitat conditions, fluctuating between the highest (good condition) and the lowest values (poor condition). Overgrazing

can pose a risk to the permanence of healthy rodent populations within an ecosystem where the microphyllous shrub prevails.

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