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Population parameters of two Sympatric Kangaroo Rats: *Dipodomys merriami* and *Dipodomys nelsoni*

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The dynamics of climatic conditions cause diverse changes in organisms' populations. Species as the kangaroo rats (*Dipodomys*) have shown sensitivity to some climatic conditions variables such as the precipitation and temperature. For this reason, it is important to understand the relationship between these conditions and species, especially when *Dipodomys* species are considered keystone species and ecosystem engineers. The capture-recapture technique was performed monthly from 2012 to 2016. Total individual counts, age, reproductive condition, weight, and sex of *Dipodomys merriami* and *D. nelsoni* were determined and recorded. We analyzed the frequencies, age, reproductive status, sex ratio, and weight of sampled species. Daily temperature and precipitation data of the study area were analyzed with population parameters and frequency data. Further, temperature and precipitation from 2012 to 2016 in the study area were analyzed in regard with studied species frequencies. The research was conducted in two environments: shrubland and grassland in the Chihuahuan desert. The results showed that *D. merriami* was the most abundant species; however, the frequencies from the two species were higher in the shrubland. Moreover, there was no statistic relationship between species' frequencies and temperature, but there was a tendency with precipitation. Overall, the number of males and females of the two species was similar. The most found age category individuals was adults, most frequent reproductive status were non-pregnant females and males with abdominal testicles. Weight of individuals was different between species and age categories sub-adults and adults. The patterns are comparable to those found in other species of this genus. Results from this research provide information needed to take the required actions regarding the management and conservation of species with restricted distribution, such as *D. nelsoni*.

El dinamismo de las variables climáticas provoca diversos cambios en las poblaciones de los organismos. Algunas especies como las ratas canguro (*Dipodomys*), han demostrado sensibilidad ante los cambios de algunas variables climáticas. Por ello la relevancia de conocer la relación de estas variables con las especies del género *Dipodomys*, más aún cuando son consideradas como especies clave, ingenieras del sistema e indicadoras de salud de los ecosistemas. Esta investigación se planteó analizar las frecuencias, edades, estados reproductivos, proporciones de sexos y pesos de dos especies de ratas canguro (*D. merriami* y *D. nelsoni)*, así como analizar los datos de temperatura y precipitación de la zona de estudio con las frecuencias de las ratas canguro. Se utilizó la técnica de captura-recaptura durante los años 2012 al 2016 en dos tipos de ambientes matorral y pastizal del desierto Chihuahuense. Además, se obtuvieron y analizaron las temperaturas y precipitaciones de la zona de estudio durante los años estudiados con las frecuencias de las dos especies de ratas canguro. Los resultados obtenidos mostraron que *D. merriami* fue la especie con mayor abundancia; no obstante, las frecuencias de las dos especies fueron más altas en el matorral. Además, no existió relación estadística de las frecuencias de las especies con la temperatura, pero sí existió cercanía a la diferencia estadística con la precipitación. En general, el número de hembras y machos de ambas especies fue similar durante los muestreos, así como la categoría de edad más abundante fueron los adultos; mientras que los estados reproductivos más frecuentes fueron las hembras no preñadas y los machos con testículos abdominales. El peso de los organismos fue diferente entre las dos especies y entre los subadultos y adultos. Estos patrones fueron similares a los reportados para otras especies del género *Dipodomys*. Los resultados de esta investigación brindan información necesaria para tomar acciones requeridas acerca del manejo y conservación de especies con distribución restringida como *D. nelsoni*.

Keywords: Chihuahuan desert; density; desert rodents; Heteromyidae; precipitation; temperature

Introduction

The natural dynamics of climatic variables promote various changes in living beings, which can be behavioral, endocrine, metabolic, among others and which in turn lead to a series of responses that affect different trophic levels (Selwood *et al.* 2015). For example, temperature is a signal for some mammals indicating the entrance or exit of hibernation (Lane *et al.* 2012). On the other hand, precipitation is used by plant species for the production and germination of seeds, besides the emergence of seedlings. Precipitation is then used by rodents, who deploy their reproductive period during the rainy season, since they can meet the high energy demands of reproductive states such as pregnancy and lactation (Brown and Ernest 2002; Lima *et al.* 2008).

This is particularly important in semiarid environments, since precipitation pulses determine plant production, and the resource availability to organisms (Hernández *et al.* 2011; Polyakov *et al.* 2021), as well as it influences to population rates (*e.g.* density) of small mammals (Lima *et al.* 2008; Hernández *et al.* 2011). However, the exacerbated changes in climatic variables, caused by global warming, have affected ecosystems and their species (Lane *et al.* 2012; Selwood *et al.* 2015; Ward 2016). In arid systems the extension of the dry seasons has delayed the emergence and development of plant species, which in turn affects those species depending on them, either for feeding, the deployment of reproductive or hibernation behavior (Selwood *et al.* 2015).

Kangaroo rats (*Dipodomys* spp.) are usually abundant species of the North American arid systems, thus it is common for them to be the dominant species within their rodent communities (Reichman and Van De Graaff 1975; Hernández *et al.* 2005; 2011; Lightfoot *et al.* 2012). Since kangaroo rats are considered keystone species, ecosystem engineers, and indicators of the health status of their habitats (Valone *et al.*, 1995; Fernández *et al.* 2014; Hafner 2016; Longland and Dimitri 2021), several investigations have been carried out addressing their distribution, behavior, population parameters and structure (Price and Kelly 1994; Morrison *et al.* 1996; Daskalova *et al.* 2020). Furthermore, their population responses to climatic variables such as precipitation have been investigated (Hernández *et al.* 2005; Lima *et al.* 2008). Intense precipitation has caused flooding, resulting in the deaths of many kangaroo rats and, thus severe population declines (Thibault and Brown 2008). The local extinction of these species results in the loss of crucial ecological processes, including seed dispersal and soil aeration, as well as a protein source for other organisms (Valone *et al.* 1995; Goldingay *et al.* 1997; Ward 2016; Germano and Saslaw 2017).

These studies were mainly focused on species such as *Dipodomys merriami* Mearns, 1890, which has a wide distribution, ranging from the Southeastern of the U.S.A to central Mexico. Within the Chihuahuan Desert, *D. merriami*, converges with *Dipodomys nelsoni*, which is restricted only to the north of Mexico and has been studied to a lesser extent (Hafner 2016). The distributions of both species overlap with *Dipodomys ordii*, which, unlike *D. merriami* and *D. nelsoni*, specializes in sandy soils such as dunes. Therefore, these three *Dipodomys* species do not share home range (Schroder 1987). *Dipodomys merriami* and *D. nelsoni* have similar ecological and morphological characteristics, although *D. nelsoni* is larger, heavier, and has a distinctive white hair tip on the tail (Best, 1988). Both *D. merriami* and *D. nelsoni* inhabit ecosystems affected by human development activities (Lane *et al.*, 2012; Selwood *et al.*, 2015). Given their ecological importance, continuous monitoring of long-term population changes is essential. Additionally, understanding the impact of environmental variables, especially those that limit population growth, such as precipitation and temperature on their population dynamics is crucial (Hernández *et al.*, 2005; Lima *et al.*, 2008; Montero-Bagatella *et al.*, 2023). These environmental variables influence can be detected though the study of population parameters (Greenville *et al.* 2017), and provide information on their population sizes and cycles, therefore the information can be used for the management and conservation of species (Germano and Saslaw 2017). In addition, the use of biological data from organisms such as body weight, provides information on their life stage and health status (Zeng and Brown 1987; Price and Kelly 1994), along with their habitat conditions (Hernández *et al.* 2005). For these reasons, the goal of this research is to obtain the densities, population parameters and body weight of *D. nelsoni* and *D. merriami* in two environments from the Chihuahuan Desert. Further, we aim to analyze the relationship between the densities of the two species with temperature and precipitation.

Materials and methods

Study area: This research was carried out in the central region of the Chihuahuan Desert, in the Mapimí Biosphere Reserve (Reserva de la Biosfera de Mapimí), Mexico (Figure 1). The Reserve is located between the states of Durango, Chihuahua, and Coahuila (CONANP 2006). The weather is semi-warm with precipitations in summer and extreme thermal amplitude. The average annual temperature is 20.8 Celsius and mean annual precipitation is 264 mm. The rainy season is from July to January, while the dry season is from February to June. Summer precipitation (July-September) represents over 75% of annual precipitation (Cornet 1988; CONANP 2006).

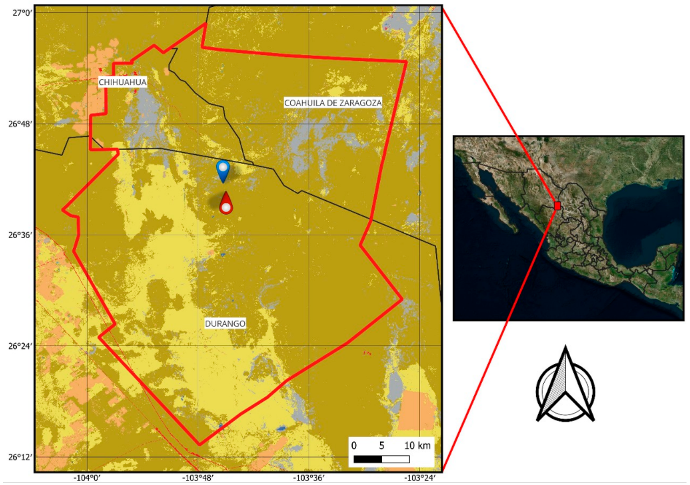

Figure 1. Map of the Mapimí Biosphere Reserve in Mexico. Blue point = shrubland site, red point = grassland site.

The main plant communities in the area are xeric shrublands (*Larrea tridentata, Fouquieria splendens* and *Opuntia rastrera*) and shrubby grasslands (*Hilaria mutica, Sporobolus airoides, Prosopis glandulosa*) (CONANP 2006; Hernández *et al.* 2011).

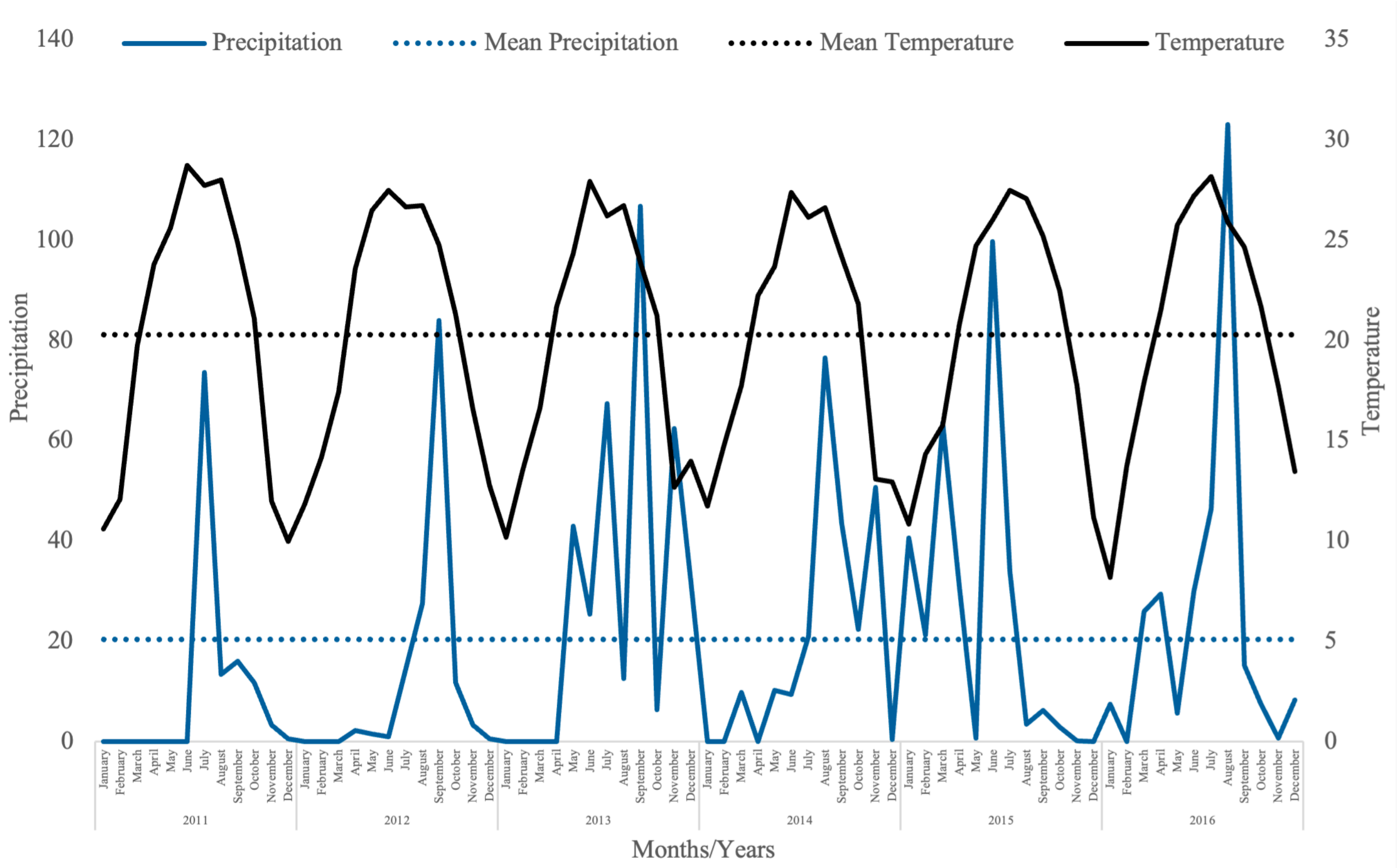

Figure 2. Mean temperature and precipitation registered during the study at Mapimí Biosphere Reserve. Black line = temperature, point black line = mean precipitation, blue line = precipitation, point blue line = mean precipitation.

Rodent trapping: We used databases from the Long-Term Ecological Research project (since 1996) from the 2012 to 2016 years to obtain the frequencies and population parameters of *D. nelsoni* and *D. merriami* in two environments from the Chihuahuan Desert. The data bases collect information from the captures of rodents in the areas of grassland and shrubland during spring and autumn (Hernández *et al.* 2005; 2011). To gather this information, at each site (3.1 ha) three established radial networks were set with 145 Sherman traps (30x10x8 cm), disposed in twelve lines (100 m each line), each radiating from a central point. 12 traps were set along each line, the first 4 at 5 m intervals and the rest at 10 m intervals, plus 1 in the center, including a 5-m peripheral buffer. Traps were baited with oat flakes and were active during three consecutive nights per season (Hernández *et al.* 2011). Traps were checked and baited each day at 7:00 and 16:00 h. From each captured individual, its species, sex, age, weight, and reproductive status (scrotal testicles in males or signs of pregnancy in females) were recorded (Zeng and Brown 1987; Hernández *et al.* 2005; Lima *et al.* 2008; Germano and Saslaw 2017). Age was determined by the size, fur coloration and reproductive status (Zeng and Brown 1987; Price and Kelly 1994; Hernández *et al.* 2005; 2011; Germano and Saslaw 2017). Captured individuals were marked in the ventral region with a semi-permanent marker and later released *in situ* (Hernández *et al.* 2011; Sikes and Gannon 2011). Due to intense precipitations in November 2013 and 2014, no sampling was carried out in those periods.

Climatic variables: Data on temperature and precipitation from the study sites and years of sampling were obtained from the Meteorological Station from the Desert Laboratory, Instituto de Ecología A.C.

Statistical analyses: To carry out the statistical analyses, based on the reported frequencies of the kangaroo rats, the total number of captures per species at each site was used. The percentages of capture with their 95% confidence intervals (CI) were obtained (O'Brien and Yi, 2016). In addition, lineal regressions between the frequencies of captures from both species with temperature, precipitation from the previous year, and from the sampling year were performed (Hernández *et al.* 2005).

Age population structure was analyzed by species with X^2 and exact Fisher tests. For the analyses of reproductive status and sex for both species, squared Chi and exact Fisher tests were carried out. Body weight for captured individuals was analyzed with ANOVAs s by species, site, sex, and age, and the respective *post hoc* Tukey tests were performed (Hernández *et al.* 2011). Analyses were carried out with the software Minitab 21.1.1.0.

Results

Temperatures at sampling sites presented marked and similar cycles in the years of study; maximum peaks were registered from June to August (summer) and descended reaching the lowest values between December and January (winter). The highest temperatures were reported in June and August, while the lowest were presented in December and January (Figure 2). The average temperature in the study site was 20.3 Celsius. There were statistical differences of temperatures among seasons (*F* = 281.38, *d. f* = 3, *P* = < 0.001); *post hoc* test indicated differences between summer and spring on the one hand and winter and autumn on the other (*P* = 0.05).

On the other hand, precipitation presented similar cycles during years 2011 and 2012, in which there were pronounced periods of drought that lasted from January to May (winter and spring). Precipitations began in June reaching its highest values in July and September (summer), decreasing in the subsequent months (autumn). From 2013 to 2015 there were constant monthly precipitations that included the winter months; the highest values of the precipitations of these years were reported from June to September. The year 2015 was the rainiest, with a total of 613.4 mm recorded annually, contrasting with 107.2 mm in 2011. There were statistically significant differences of precipitations among seasons of the years (*F* = 10.10, *d. f* = 3, *P* = < 0.001); the *post hoc* test indicated differences between summer and the other seasons (*P* = 0.05).

Total sampling effort was of 20, 880 night-traps or in other words 10,440 night-traps per site. *Dipodomys merriami* was the most abundant species, with its highest frequency recorded in the shrubland in 2015 with 110 captures (Figure 3). At the same site, there were declines in the species during March 2013 and 2014, from which they recovered in March 2015. In November 2016 the highest frequency of *D. nelsoni* was reported with 29 captures in the grassland. The percentage of captures from *D. merriami* in the grassland was 1.34 % (95 % *CI* 1.17 - 1.54), while it was of 2.80% (95% *CI* 2.54 - 3.07) in the shrubland, hence being statistically different. While the percentage of captures of *D. nelsoni* in the grassland was 0.37 % (95 % *CI* 0.29-0.49) and 0.48 % (95 % *CI* 0.38-0.61) in the shrubland, with no statistical difference.

There was no statistical relation between the densities of *D. merriami* and the precipitations from the sampling year (*F* = 0.01, *d. f.* = 1, *P* = 0.92), but there was a tendency with precipitation from the previous year (*F* = 4.9, *d. f.* = 1, *P* = 0.06). *D. nelsoni* did not present a statistical relation with precipitation from the sampling year (*F* = 0.01, *d. f.* = 1, *P* = 0.94), nor with precipitation from the previous year (*F* = 2.9, *d. f.* = 1, *P* = 0.13). Just as there was no statistical relation between temperature and the densities of *D. merriami* (*F* = 0.02, *d. f.* = 1, *P* = 0.89), nor *D. nelsoni* (*F* = 1.16, *d. f* = 1, *P* = 0.32).

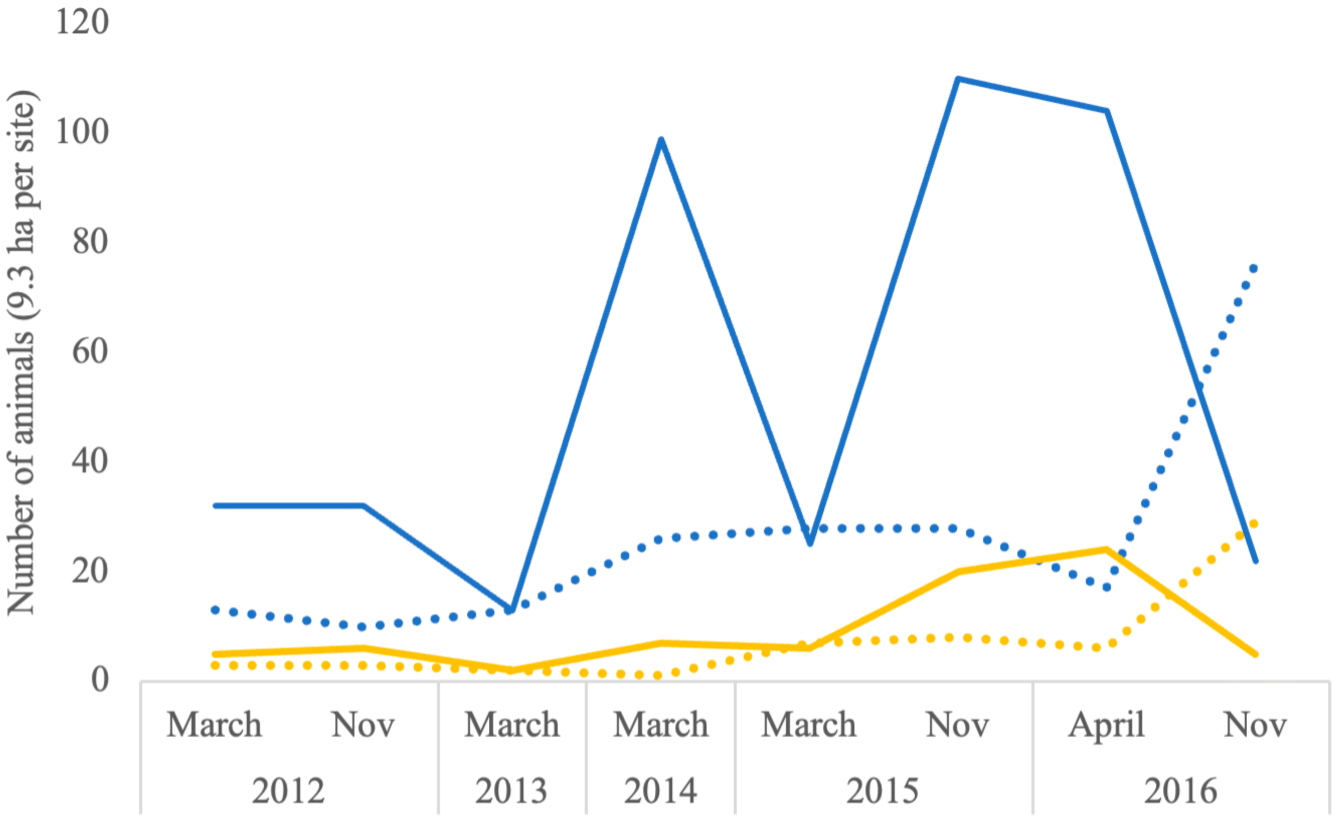

Figure 3. Number of captures of *Dipodomys merriami* and *D. nelsoni* by environment type. Blue line = *Dipodomys merriami* in shrubland, point blue line = *Dipodomys merriami* in grassland, yellow line = *D. nelsoni* in shrubland, point yellow line = *D. nelsoni* in grassland.

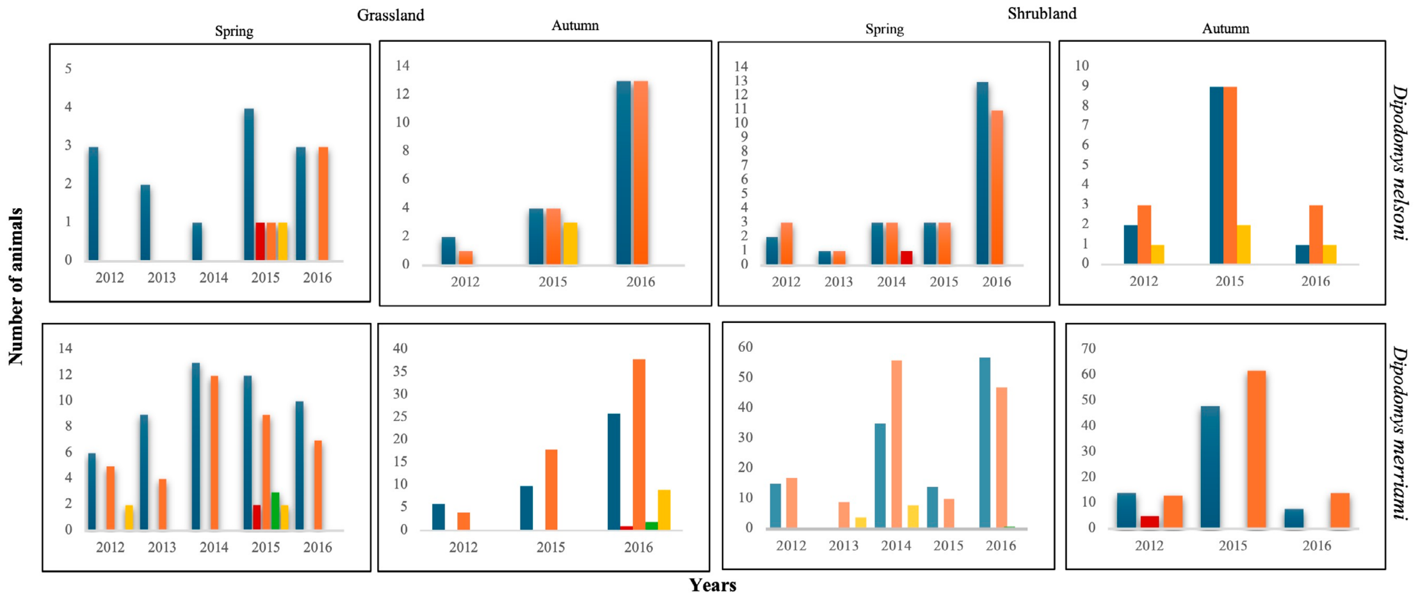

Figure 4. *Dipodomys nelsoni* and *merriami* reproductive status in the two studied environments. Blue bars = abdominal testes, yellow bars = scrotal testes orange bars = not pregnant, green bars = pregnant, red bars = lacting.

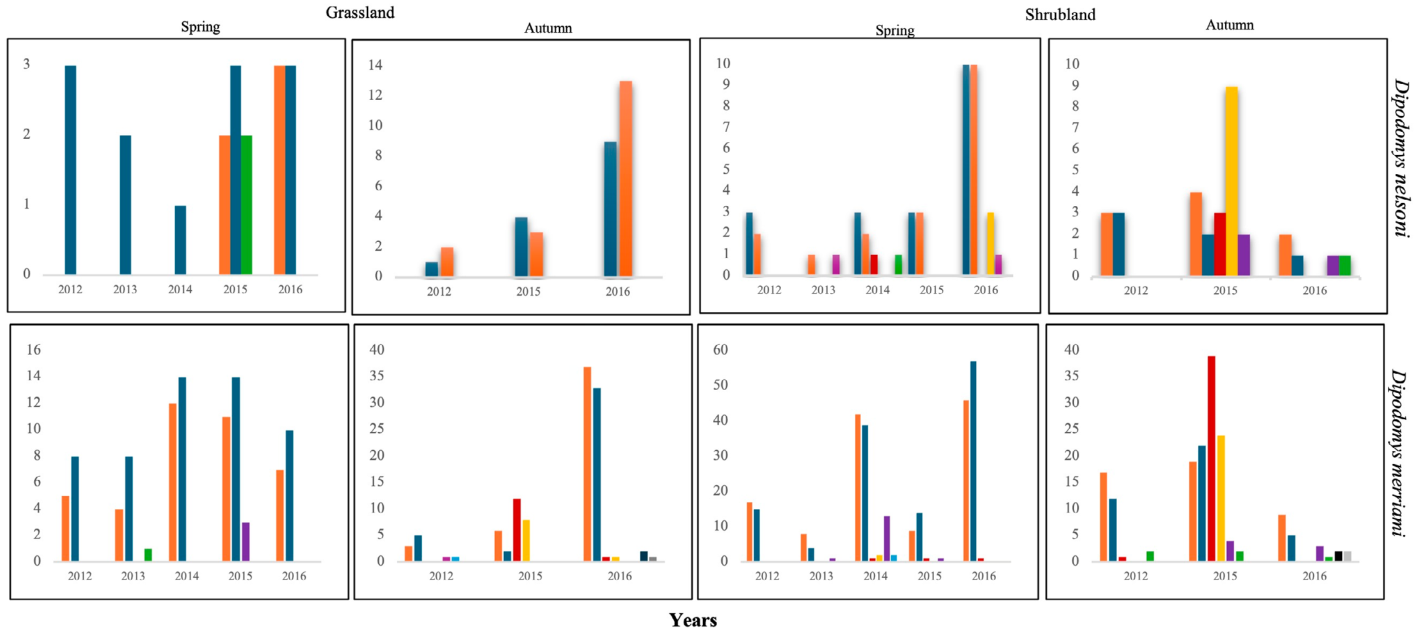

Figure 5. *Dipodomys D. nelsoni* and *D. merriami* registered by age categories and environment type. Orange bars = adult female, blue pale bars = adult male, red bars = subadult female, yellow bars = subadult male, purple bars = juvenile female, green bars = juvenile male, , black bars = young female, grey bars = young male.

In general, the number of females and males was similar during sampling. Nevertheless, the 1:1 ratio occurred only on few occasions. Females were captured slightly more often in the shrubland and males in the grassland. However, there were no statistical differences at the work sites between females and males from *D. merriami* (X^2 = 0.8, *d. f.* = 1, *P* = 0.36), though there was a tendency with *D. nelsoni* (*P* = 0.06).

Regarding the reproductive status of the two species, non-pregnant females and males with abdominal testicles were more common (Figure 4), whereas scrotal males, as well as pregnant and lactating females, were less frequently observed. In March 2015 and November 2016 all reproductively active individuals' status of *D. merriami* were registered in the grassland. There was a significant difference between reproductive status of *D. merriami* between shrubland and grassland sites (X^2 = 13.5, *d. f.* = 4, *P* = 0.009). In contrast for *D. nelsoni* presented a statistical difference at the study sites between males with abdominal testicles and scrotated males (*P* = 0.05), being males with abdominal testicles more frequent; between pregnant and non-pregnant females (*P* = 0.001), being pregnant more frequent but not between lactating and non-pregnant females (*P* = 1).

The most frequent age category for both species was adults, followed by subadults, juveniles, and finally young

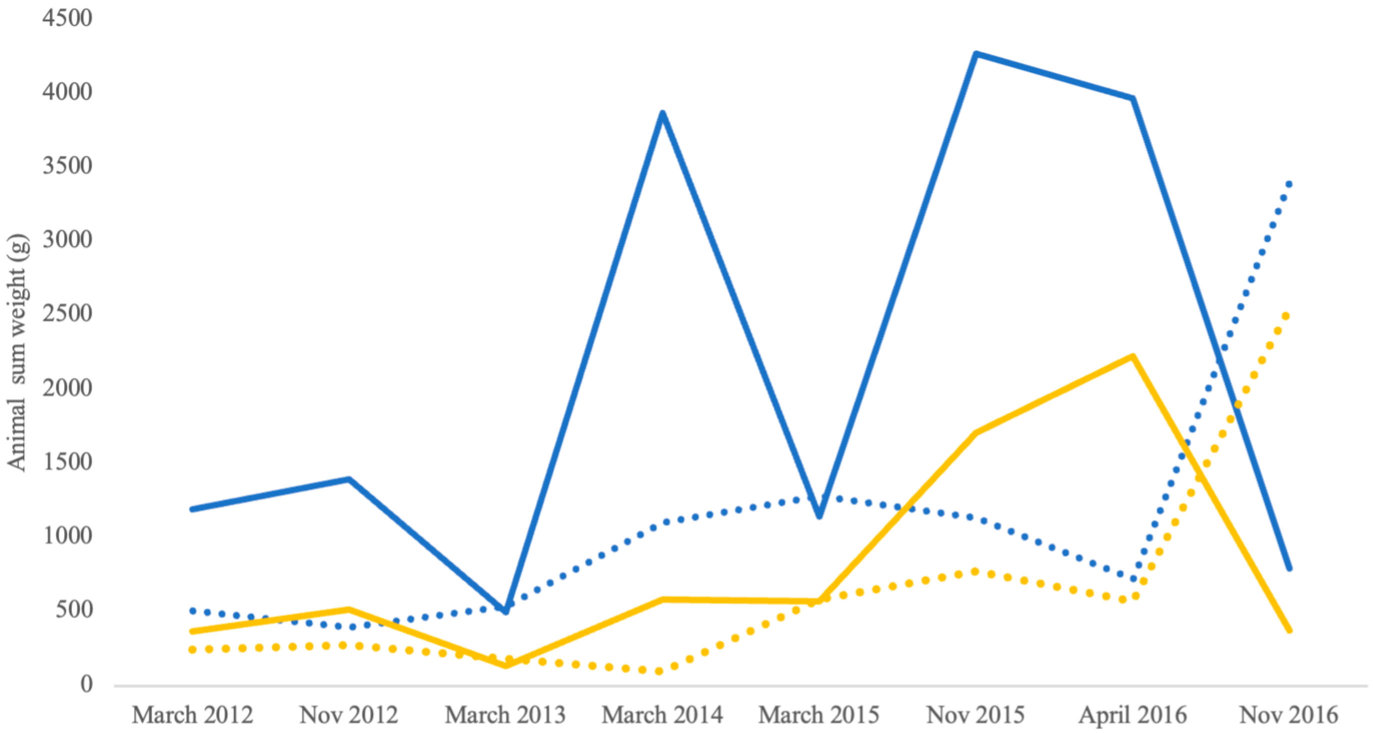

Figure 6. *Dipodomys merriami* and *D. nelsoni* total sum weights at the two studied environments. Blue line = *Dipodomys merriami* in Shrubland, point blue line = *Dipodomys merriami* in grassland, yellow line = *D. nelsoni* in Shrubland, point yellow line = *D. nelsoni* in grassland.

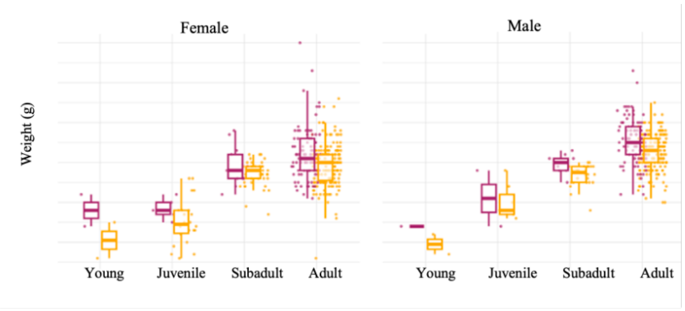

Figure 7. *Dipodomys merriami* weights by sex, age category and environment. Purple box and plots = grassland, yellow box and plots = shrubland

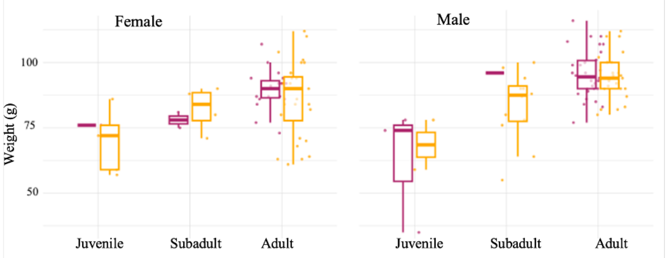

Figure 8. *Dipodomys nelsoni* weights by sex, age category and environment. Purple box and plots = grassland, yellow box and plots = shrubland

individuals which were only reported for *D. merriami* in November 2016 (Figure 5). Age categories from this species were close to a statistical difference for both study sites ($X^2 = 7.2$, *d. f.* = 3, $P = 0.06$), while there were significant differences for *D. nelsoni* at the study sites ($X^2 = 11.0$, *d. f.* = 3, $P = 0.01$).

The total summed weights of *D. merriami* were generally greater than those from *D. nelsoni* (Figure 6). The latter only exceeded the weights of *D. merriami* in March 2015 and April 2016 within the shrubland habitat. *D. merriami* exhibited sharp declines in total summed weight in March 2013 and 2015, from which it recovered by November 2016. Both species showed a decrease in total summed weight in November 2016. There were no statistically significant differences in total summed weights between study sites for *D. merriami* ($F = 2.31$, *d.f* = 1, $P = 0.15$), or for *D. nelsoni* ($F = 0.16$, *d. f.* = 1, $P = 0.69$). However, there were statistically significant differences in total summed weights between the two species ($F = 29.7$, *d. f.* = 1, $P = < 0.001$).

The heaviest individuals from *D. merriami* were registered in the shrubland, and they were females (Figure 7). There was a statistically significant difference in body weights among organisms of this species at both study sites ($F = 35.6$, *d. f.* = 1, $P = < 0.001$), sexes ($F = 35.9$, *d. f.* = 1, $P = < 0.001$), and age categories ($F = 78.2$, *d. f.* = 3, $P = < 0.001$). The *post hoc* test indicated differences in weights from subadults and adults ($P = 0.05$), being adults heavier than subadult individuals. For the case of *D. nelsoni* there was no statistic difference between sites ($F = 0.75$, *d. f.* = 1, $P = 0.38$), but there was between sexes ($F = 8.47$, *d. f.* = 1, $P = 0.004$) and age categories ($F = 21.0$, *d. f.* = 3, $P = < 0.001$). The *post hoc* test indicated differences between weights between subadults and adults ($P = 0.05$) (Figure 8). Both species shared weight ranges at different age categories.

Discussion

The temperatures recorded in the study area during sampling years were similar to previous years and did not present statistical differences between annual seasons. In addition, there was no statistical relationship between frequencies from *D. merriami* nor *D. nelsoni*. Nevertheless, studies such as Koontz *et al.* (2001) and Montero-Bagatella *et al.* (2023) reported a relationship between temperature and frequencies of *D. merriami* and *D. phillipsii* , respectively. However, these studies involved monthly samplings throughout the study years, so increasing the sampling frequency in the current study area could help detect potential changes in species abundances in relation to temperature fluctuations.

On the other hand, precipitation from the sampling years exceeded 100 mm per year that were reported by Brown and Ernest (2002) as the annual average for desert zones. Similarly, more than 60 % of the total annual rainfall occurred in summer; in 2011 and 2012, it even exceeded 90%. Nonetheless, in 2014 and 2015 there were intense and continuous rains that generated an annual total six times greater than the average. These precipitations were caused by the complex meteorological phenomenon "El Niño", that began in 2014 and ended in the summer of 2016 (IRICS 2024). The presence of this climate pattern is common in arid systems, therefore it can have an impact on the species' frequencies (Brown and Ernest 2002; Lima *et al.* 2008; Thibault and Brown 2008; Lightfoot *et al.* 2012; Polyakov *et al.* 2021). Lightfoot *et al.* (2012) registered populations growth while "El Niño" was present, thus it could also be the case in the current study, given that the highest values of captures of *D. merriami* and *D. nelsoni* were recorded while "El Niño" was developing. Nevertheless, if precipitation is so intense that it causes floods, the destruction of food resources and burrows puts populations at risk, causing the death by drowning of individuals (Valone *et al.* 1995; Valone and Thornhill 2001; Brown and Ernest 2002; Kelt *et al.* 2008; Thibault and Brown 2008; Germano and Saslaw 2017).

Despite the highest values of number of captures of *D. merriami* and *D. nelsoni* coincided with maximum precipitations, no statistical relationship was found with precipitation of the sampling year, nor with the previous year. Contrasting with the response of rodent communities in the study from Hernández *et al.* (2005), that responded to precipitation from the previous year and two years before sampling. However, these authors used the data set of several rodent species in the area, hence the handling of the information and the choice of statistical tests, could have influenced the results (Lima *et al.* 2008). On the other hand, Lightfood *et al.* (2005) and Brown and Ernest (2002) did not report a response of the rodents to precipitation, so along with Cárdenas *et al.* (2021), they suggested the substitution of this variable by direct measures of vegetation such as plant production, given that it is a direct resource for rodents and they can show a greater response to it, even 24 months after precipitation occurs (Hernández *et al.* 2005; Lightfoot *et al.* 2012).

Frequencies were different between species, being higher for *D. merriami*. Similar results have been reported by Koontz *et al.* (2001) and Hernández *et al.* (2011) where *D. merriami* was also considered as a dominant species. Whereas *D. nelsoni* was classified as subdominant due to its lower abundances (Hernández *et al.* 2011); a pattern also present in this study. Coexistence and tolerance of these species is influenced by how the species use the resources (Bowers and Brown 1982; Frye 1983; Schroder 1987; Brown 1989; Bleich and Price 1995; Perri and Randall 1999), body size (Perri and Randall 1999), activity patterns (Brown 1989), microhabitat preferences (Schroder 1987), and community structure in which dominant species exclude subordinates (Blaustein and Risser 1976; Price *et al.* 1991).

Dipodomys merriami and *D. nelsoni* exhibited the lowest frequencies in grasslands characterized by dense vegetation composed of grasses and forbs exceeding one meter in height. Such vegetation may hinder the identification of escape routes and interfere with seed distribution and collection (Schroder 1987). This type of plant composition is associated with higher productivity (Hernández *et al.* 2005) and undergoes dynamic, contrasting seasonal changes during periods of high precipitation, resulting in greater seasonal variation in vegetation abundance and diversity, which in turn may contribute to increased variability in rodent populations in grasslands, as reported by Hernández *et al.* (2005). In contrast, shrublands exhibit less seasonal fluctuation (Goldingay and Price 1997), which contributes to more stable and higher rodent densities in these systems (Hernández *et al.* 2005). Additionally, shrublands are dominated by *Larrea* spp., a plant favored by *Dipodomys* species for burrow construction (Schroder 1987; Best 1988; Hernández *et al.* 2005). Kangaroo rats prefer open habitats due to their consumption of large grass seeds and burrowing behavior, which facilitate their daily and migratory movements (Goldingay and Price 1997). Furthermore, vegetation type is closely linked to specific soil characteristics that enhance plant richness and diversity (Hernández *et al.* 2005). Soil is a critical resource for *Dipodomys* species given its role in feeding, shelter, and reproduction (Schroder 1987; Best 1988;). Moreover, species of this genus require areas with bare soil for sandbathing, a behavior performed to clean and maintain their fur. Also, through these sandbaths, they also transmit olfactory signals to conspecifics related to dominance hierarchies and reproductive status (Randall 1991). Therefore, the vegetation and soil characteristics of grasslands may act as limiting factors for the development of these two species' populations, while on the other hand, they may favor other rodents like *Sigmodon hispidus* (Elizalde-Arellano *et al.* 2014), and even lagomorphs such as *Lepus californicus* (Marin *et al.* 2003).

Captures of *D. merriami* were more frequent in the shrubland, coinciding with studies of Schroder (1987), Hernández *et al.* (2005; 2011), Lightfood *et al.* (2012), Cárdenas *et al.* (2021), and García-Feria and González-

Romero (2021). This could be due to a higher diversity and plant productivity in the area (Hernández *et al.* 2005), besides *Dipodomys* species prefer to inhabit open sites with scarce plant cover, which allows them to freely visualize possible predators (Schroder 1987; Goldingay and Price 1997), as well as escape routes (Cárdenas *et al.* 2021). In contrast, the vegetation at the shrublands was high and dense as reported by Hernández *et al.* (2005), which prevented open environment conditions (Schroder 1987). Hernández *et al.* (2005) mentioned that in grassland, vegetation growth has a rapid response to precipitation, while shrubland vegetation does not significantly change with precipitation.

The number of captures from *D. nelsoni* did not statistically change between environments, as it was also reported by Eldridge and Whitford (2014). Nevertheless, it contrasted with results obtained by Hernández *et al.* (2005), who registered the highest captures in the shrubland. Hernández *et al.* (2005) attributed the results to the use by kangaroo rats to the base of shrubs, either as support for their burrows, as shelter for feeding (Schroder 1987; Eldridge and Whitford 2014), or as protection from predators (Svejcar *et al.* 2019). Furthermore, they pointed out that due to their digging habits, the type of soil influences their establishment, so further studies considering this variable could provide more ecological information on these species and their habitats.

Despite population declines that can be caused by dispersion, migration and predation (Eisenberg 1993; Orland and Kelt 2007), the number of males and females of *D. merriami* and *D. nelsoni* was similar during the sampling years. These results coincided with those of other *Dipodomys* species, such as *D. phillipsii* (Montero-Bagatella *et al.* 2023), *D. ingens, D. heermanni, D. nitratoides* (Germano and Saslaw 2017), and *D. merriami* (Zeng and Brown 1987). On the other hand, adults were more frequently captured as it was also reported by Zeng and Brown (1987), Germano and Saslaw (2017), and Montero-Bagatella *et al.* (2023). This could be due to the exploration and search of new territories by juveniles (Price and Kelly 1994; Orland and Kelt 2007); as well as the difficulty of capturing young individuals on account of the fact that they shelter inside burrows (Price and Kelly 1994; Eisenberg 1993).

The most abundant reproductive status for both species was non-pregnant females and males with abdominal testicles, while pregnant or lactating females presented the lowest frequencies. However, this abundance pattern of reproductive status were registered during different samplings, indicating a reproductive activity from both species year round, as is the case for other species from the same genus (Orland and Kelt 2007; Germano and Saslaw 2017; Montero-Bagatella *et al.* 2023). Nevertheless, such studies had monthly sampling that provided more detailed information. Therefore, carrying out samplings covering different seasons could complement the knowledge on the frequencies and the reproductive status of these species.

Body weight from organisms was different between species because of the natural distinction of their body sizes (Best 1988). However, due to the higher number of captures of *D. merriami*, the total weight of its individuals was greater than that of *D. nelsoni*., which coincided with results from Hernández *et al.* (2011). Moreover, there were individuals from both species that had the same weight regardless of their age categories; this could have been caused by the changes in weight that individuals present during the transitions in life stages (Zeng and Brown 1987), as well as the elevated energetic demands from reproductive stages such as pregnancy and lactation (Soholt 1977).

Dipodomys species represent an important component in the diet of mesocarnivores (Hernández *et al.* 2011). These predators have shown a preference in the consumption of *Dipodomys* species rather than rodents of smaller size such as *Chaetidopus* species (Laundré *et al.* 2009; Laundré and Hernández 2003). However, the difference between the body size of *D. merriami* and *D. nelsoni* does not represent a great difference in the energetic intake of mesocarnivores. Nonetheless, this difference in the energy contribution could differ from other consumers, such as birds or snakes. Therefore, the importance of studies on the predator-prey interactions, given the influence of predators in the population dynamics of the species (Price and Kelly 1994; Laundré and Hernández 2003; Polyakov *et al.* 2021).

Results from this study suggest that *D. merriami* and *D. nelsoni* present similar patterns to the other species from the same genus. Further, their population parameters (density, sex ratio, age and reproductive status) indicate that both populations were in development and growth. It is important to note that this research was carried out in a protected and destined to conservation area, where species are not subject to the constant anthropic pressures. Nevertheless, in Mexico there remain vast extensions of natural territories that do not present any protection for their conservation (Fernández *et al.* 2014), where urban development has led fragmented environments that have favored metapopulations. Therefore, it is necessary to supplement the information about the populations subject to such pressures (Hurtado and Mabry 2017), which would allow for greater knowledge of the species in order to take the necessary actions for their management and conservation (Christensen *et al.* 2019; 2023), specially of *D. nelsoni* that has a restricted distribution and low densities.

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