VERTEBRATES THAT SHARE ITS HABITAT WITH *Lepus flavigularis*, AN ENDANGERED LEPORID

VERTEBRADOS QUE COHABITAN CON *Lepus flavigularis*, UN LEPÓRIDO EN PELIGRO DE EXTINCIÓN

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RESUMEN

Se registró la diversidad estacional y anual de vertebrados en el pastizal abierto (hábitat de *Lepus flavigularis*) en Santa María del Mar, Juchitán de Zaragoza, Oaxaca. El estudio se realizó entre octubre del 2015 y mayo del 2016 mediante dos muestreos en estación húmeda y dos en seca. Se utilizaron transectos de ancho fijo para monitoreo de herpetofauna; transectos lineales de ancho variable para aves; cámaras trampa para mamíferos medianos y grandes; redes de niebla para quirópteros, y trampas Sherman para mamíferos pequeños. La diversidad alfa estacional y anual se analizó utilizando los índices de Shannon (H') y Simpson (1/D), la diversidad beta con coeficiente de disimilitud de Jaccard (J), y la comparación estacional mediante la prueba U Mann-Whitney (W). Se registraron 77 especies de vertebrados. Para reptiles, la diversidad alfa anual fue de H´=1.2640 y 1/D=2.5905; para aves de H´= 2.7597 y 1/D=9.8032; y para mamíferos medianos y grandes de H´= 1.3100 y 1/D=2.6702. No se encontraron diferencias estacionales para la diversidad de reptiles (W = 94, p= 0.2052) y mamíferos (W = 14, p= 0.5584), pero sí para aves (W = 801, p= 0.0202). Para reptiles (cualitativo J=0.6666: cuantitativo J= 0.4433) y mamíferos (cualitativo J= 0.6666; cuantitativo J=0.6352), se comparten pocas especies estacionalmente, no así para aves (cualitativo J= 0.3829; cuantitativo J= 0.6430). Probablemente la presencia del fenómeno climático El Niño, que acentuó la sequía en el área de estudio, haya contribuido a que la diversidad de anfibios, reptiles y mamíferos fuera menor a la esperada.

ABSTRACT

Seasonal and annual vertebrate diversity that cohabit with the Tehuantepec jackrabbit (*Lepus flavigularis*) in Santa Maria del Mar, Juchitán de Zaragoza, Oaxaca, were recorded. The study was carried out between October of 2015 and May of 2016 (two samplings in the wet season and two in the dry season). Fixed-width transects were used to monitor amphibians and reptiles; variable width transects for birds; camera trapping for medium and large mammals; fog networks for flying mammals and Sherman traps for small mammals. Seasonal and annual alpha diversity were analyzed using Shannon (H') and Simpson (1/D) indices, beta diversity with Jaccard dissimilarity índices (J), and the seasonal comparison with Mann-Whitney U test (W). We recorded 77 vertebrate species. For reptiles, annual alpha diversity was H'= 1.2640 and 1/D = 2.5905; for birds was H'= 2.7597 and 1/D = 9.8032; and for medium and large mammals was H'= 1.3100 and 1/D = 2.6702. No significant seasonal differences were found for reptiles (W = 94, p = 0.2052) and mammals (W = 14, p = 0.5584) diversity, but it was found for birds (W = 801, p = 0.0202). For reptiles (qualitative J = 0.6666: quantitative J = 0.4433) and mammals (qualitative J = 0.6666, quantitative J = 0.6352), few species are seasonally shared, but not for birds (qualitative J = 0.3829, quantitative J = 0.6430). It is likely that the presence of the El Niño climatic phenomenon, which accentuated the drought in the study area, has contributed to the diversity of some groups was less than expected.

INTRODUCTION

Mexico is one of the five megadiverse worldwide countries (CONABIO, 2008; Navarro-Sigüenza et al., 2014) and the Tehuantepec Isthmus is one of the richest regions in this country (Casas-Andrew et al., 2004). Its biological diversity is because it is a biogeographical barrier for incapable species to cross lands with abrupt altitudinal changes, and because the Tehuantepec Isthmus is located in the contact zone of the Neotropical and Nearctic biogeographic regions (Pérez-García et al., 2001). Also, it is a center of endemism for terrestrial vertebrates (Casas-Andrew et al., 2004; González et al., 2004), such as the Tehuantepec jackrabbit (*Lepus flavigularis*), a species catalogued as Endangered (EN) by the IUCN Red List of Threatened Species (Cervantes et al., 2016) and currently considered the most endangered lagomorph species worldwide due to anthropogenic activities such as agriculture, urban development and illegal hunting (Lorenzo et al., 2015). These species populations are currently genetically isolated from each other, making *L. flavigularis* more susceptible to extinction which would mean a significant change in the structure of the grassland community as it plays an important ecological role being part of the trophic networks, and regulating the botanical composition of its habitat (Lorenzo et al. 2015). Different studies have been carried out with the purpose of contributing to the knowledge and conservation of the Tehuantepec jackrabbit (*L. flavigularis*) recording its distribution, population density, reproductive behavior, home range, habitat use, diet, its morphological and genetic characteristics, as well as the effect of anthropogenic activities (extense livestock farming) on its ecology (Rico et al., 2007; Lorenzo et al., 2008; Rioja et al., 2008; Carrillo-Reyes et al., 2010; Rioja et al., 2011; Carrillo-Reyes et al., 2012; Sántiz et al., 2012; Rioja and Carrillo Reyes, 2014; Lorenzo et al., 2015; Luna et al., 2016; Rioja et al., 2016). However, no studies have been focused on the diversity of vertebrates that cohabitate with *L. flavigularis*. Inventories are of great importance because they serve as a repository of data on species residing in a place (Dirzo and Raven 1994). Also, through these studies it is possible to know the distribution of species in different ecosystems, and therefore to develope management and conservation plans in a given region. It is important to consider that the information obtained from the inventories constitutes the basic unit of biosystematic research, so that derived information of these inventories is essential for the advancement of other academic areas such as evolutionary biology, biogeography, comparative anatomy, ecology, among others (Casas-Andrew et al., 2004). The purpose of this study is for the first time to record the diversity of terrestrial vertebrates in the Tehuantepec jackrabbit (*L. flavigularis*) habitat at Santa Maria del Mar, municipality of Juchitán de Zaragoza, Oaxaca. The anterior is key information to develop conservation and management protocols of this lagomorph and its habitat.

MATERIALS AND METHODS

Study site. The study site covers an area of 14 km^2 of the locality of Santa María del Mar (16°14’7” - 16º12’46” N and 94°53’9” - 94º48’15” W) in the municipality of Juchitán de Zaragoza, in Oaxaca state, Mexico. It is located in the south of the semi-arid region of the Tehuantepec Isthmus, between a coastal lake (Mar Tileme) and the Pacific Ocean. The town is inhabited by 862 people of indigenous (Huave) origin (Instituto Nacional de Estadística y Geografía, 2014). The main productive activities in the area are fishing, livestock production and, occasionally seasonal agriculture and subsistence hunting (Carrillo-Reyes et al., 2010). The local climate type is Awo, tropical wet with a pronounced dry season, the driest month has a precipitation less than 60mm and an average annual temperature of 25°C and average annual precipitation of 800mm; the wet season occurs between May and October with a short dry period in August, while the dry season begins in November and ends in April (García and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO], 1998). The habitat of *L. flavigularis* never exceeds 4 or 5 km wide on the shores of salt lagoons and is characterized by extensive zones of grassland, dominated by *Eragrostis prolifera* Steud with an importance value of 64.48, *Jouvea pilos*a J. Presl with an importance value of 49.56, and *Whalteria preslii* Walp with an importance value of 41.15 and isolated elements of species such as *Opuntia tehuantepecana* Bravo and *Opuntia decumbens* Salm-Dyckes; these areas are utilized for cattle husbandry (Pérez-García et al., 2001; Rzedowski, 2006; Carrillo-Reyes et al., 2010).

Monitoring. A total of four visits were made to the site between October 2015 and May 2016 (two in each season of the year). Each visit lasted a minimum of five consecutive days. The monitoring area corresponded only to the Tehuantepec jackrabbit (*L. flavigularis*) habitat (open grasslands; Carrillo-Reyes et al., 2010). Herpetofauna (amphibians and reptiles) monitoring was made through fixed-width line transects (500 m length and fixed width of 10 m) according to Muñoz-Alonso, 2012. A total of four transects were established at random across the jackrabbit habitat, and each transect was covered three consecutive days per visit. The observations were made from 9:00 h to 12:00 h and from 19:00 h to 00:00 h, during the greater activity of amphibians and reptiles (Jones, 1986). Reptiles and amphibians were located on both sides of the transect; once located, the individuals were georeferenced using a manual receiver of the geolocation system (GPS, Garmin ™ etrex Vista) and recorded the number and the type of plant association where these were captured; photographs of each specimen were taken whenever it was possible. In the case of amphibians the capture was carried out manually; for reptiles, the techniques of capture varied, using rods with sliding ties of hemp thread and manual collection for lacertilians, non-venomous snakes and terrestrial and freshwater turtles, and for the case of venomous snakes were used herpetological tongs 44" length (Karns, 1986; Casas-Andrew et al., 2004). Once the identification of the specimens was carried out, individuals were released at the site where they were found. Taxonomic determination of the individuals was carried out with aid of specialized literature: Campbell and Lamar (1989); Flores-Villela et al. (1995); Conant and Collins (1998); Powell et al. (1998) and Lee (2000). The nomenclatural information was based on the work of Casas-Andrew et al. (2004); Flores-Villela, Canseco-Márquez (2004), Frost et al. (2006) and a review of the works of Köhler (2003) and Köhler (2011) on reptiles and amphibians from Central America, respectively.

Bird monitoring was made through variable-width linear transects (2 km length; Sutherland, 2006; Rioja et al., 2013). A total of three fixed transects were established across the jackrabbit habitat, and each transect was surveyed simultaneously by two observers by walking twice a day: 06:00-10:00 h and 15:00-19:00 h. The starting point of the transect was alternated for every survey to reduce the effect of time of the day on the recordings. Visual observations of the bird species were recorded during a total of 96 observation hours in 12 days of field monitoring. Observations were carried out using binoculars (Konus®, 10x50). Bird species were identified using the field guides of Peterson and Chalif (1989); Howell and Webb (1995) and Sibley (2000). Scientific taxonomic arrangement nomenclature and common names were described according to the American Ornithologists' Union [AOU] (2016). The birds were photographed to obtain an illustrative collection of the species recorded when possible. The following parameters were recorded for each observed individual or group: transect, habitat type, coordinates, perpendicular distance to transect (using a Bushnell® Laser Legend 1200ARC rangefinder), species and number of individuals (Bibby et al., 2000; Gregory et al., 2004). Large and medium mammals monitoring was made using trail cameras, placing 20 simple monitoring stations (CuddebackTM, Ambush IR, model 1187, resolution 5 Megapixels). These were placed along two transects, with five trail cameras within each, located at approximately 150 meters between each one (Chávez et al., 2013). The trail cameras were active for a total of 12 days of field monitoring. Each trail camera was programmed to remain active throughout the night, with a maximum delay of five seconds between each shot, recording still images and video. Small mammals (rodents) monitoring was made through 24 Sherman traps distributed into two linear transects, each placed 50 meters apart across the jackrabbit habitat for four consecutive nights for each field visit (20 days of field monitoring), and barley with oats, vanilla and peanut butter (Becerril-Tesillo, 2006); transects were randomly placed and east-west oriented; finally, for bat monitoring, two mist nets were placed for three consecutive nights in every visit to study area, starting at 19:00 h and remained open until 12:00 h nets were placed in two sites previously selected in which the movement of bats was observed due to the presence of small puddles. The captured individuals were placed in cloth sacks and released after identification (Saldaña-Vázquez, 2010). In order to identify species, the Mammalian Guides of Central America and Southeastern Mexico (Reid, 2009) and the field identification code of Mexican Bats were used (Medellín and Sánchez, 1997). Priority vertebrate species were identified according to the Standard Mexican Official NOM-059-SEMARNAT-2010 (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2010). In addition, the presence of species on the International Union Conservation of Nature's Red List (IUCN, 2017), as well as listed species in one of the appendices of the Convention on International Trade in Threatened Species of Wild Fauna and Flora (CITES, 2017) was registered.

Analysis of Data. The species accumulation curve was obtained to determine the estimated precision of the sampling effort of each of the monitoring methods. The curve was constructed using the method of random species accumulation (Gotelli and Colwell, 2001). Species richness was plotted using the Bootstrap estimator (Smith and Van Belle, 1984). Seasonal and annual specific richness was estimated for each of group using the number of species recorded during the four field visits, two in the wet season and two in the dry season (Santizo, 2016). The seasonal and annual relative abundance by taxonomic group was also calculated; for herpetofauna it was based on the total abundance of individuals relative to the total number of individuals of all species recorded (Franco-Lopez et al., 1985; Naranjo and Bolaños, 2003); for birds with the Horvitz-Thompson transect variable-width estimator (Miller, 2016); for medium and large mammals by means of the number of independent photographic events between the number of effective days for each monitored season; for small mammals by the capture effort (López et al., 2009) and for bats by the number of individuals/meters net * hours of sampling (Medellín, 1993). The seasonal and annual alpha diversity were calculated using Simpson (1/D) and Shannon (H') indices (Rioja et al., 2013; Rioja and Carrillo-Reyes , 2014). The similarity between seasons (beta diversity) was calculated using quantitative and qualitative

Jaccard indices (J) (Moreno, 2001). The nonparametric Mann-Whitney U test (W) was used to compare the diversity of each group seasonally (Badii et al., 2012; Rioja et al., 2013; Rioja and Carrillo-Reyes, 2014). All statistical analyses were performed using R software (R Development Core Team, 2015), and vegan Packages (Oksanen et al., 2017), fossil (Vavrek, 2011), distance (Miller, 2016) and BiodiversityR (Kindt and Coe, 2005).

RESULTS

Species accumulation curve. According to the Bootstrap estimator (1979), the sampling effort was satisfactory for reptiles (12 species or 87.46%, N = 13.72), birds (49 species or 95.20%, n = 51.47) and medium and large mammals (6 species or 85.71%., n = 7), whereas not sufficient records were obtained for amphibians, bats and rodents to perform the accumulation curve.

Species composition and richness. For amphibians, small mammals (rodents) and bats, statistical analyzes could not be performed, since only one species of amphibian (*Scinax staufferi* Cope, 1865), one species of rodent (*Liomys pictus* Thomas, 1893), and two species of bats (*Artibeus Jamaicensis* Leach, 1821 and *Myotis thysanodes* Miller, 1897) were recorded during the wet season. It should be mentioned that none of these species are within a category of risk according to the Red List (IUCN, 2017), and do not appear within any category according to NOM-059-SEMARNAT-2010 (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2010) or within none of the CITES Appendices (CITES, 2017). For reptiles, the annual richness was 15 species. During the dry season, a richness of eight species was registered and during the wet season a richness of 15 species was registered. The scorpion turtle (*Kinosternon scorpiodes*) and the brown coral (*M. browni*) are listed under Special Protection according to the NOM-059-SEMARNAT-2010 (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2010), the green iguana (*Iguana iguana*) as Endangered Species, meanwhile the boa (*Boa constrictor*), the spotted striped snake (*Thamnophis marcianus*), the striped iguana (*Ctenosaura similis*) and the mexican spiny iguana (*C. pectinata*) are Threatened according to the NOM-059-SEMARNAT-2010 (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2010). It should be mentioned that only the boa (*B. constrictor*) appears within Appendix II of CITES (CITES, 2017) (Table 1). For birds, the annual richness was 49 species, registering 41 species for the wet season and 36 species for the dry season. Ony two species (*Colinus virginianus* and *Thalasseus elegans*) are found to be Almost Threatened according to BLI (BirdLife International, 2016) and IUCN (2017) (Table 2). Finally, for medium and large mammals there was an annual richness of nine species; five species in wet season and four species in dry season. All mammals species are classified as a Minor Concern according to the IUCN Red List of Threatened Species (IUCN, 2017), and only the Tehuantepec jackrabbit (*L. flavigularis*) is in danger of extinction according to this list and with the NOM-SEMARNAT-2010 (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2010). No mammal species appears in CITES (2016) (Table 3).

Relative abundance. Throughout the study, the most abundant reptile species were the seven-line huico (*A. deppii*) followed by the pink-bellied squamish gecko (*S.variabilis*) and the common home gecko (*Hemidactylus frenatus*), and the less abundant were the striped guinea pig (*Conophis vittatus vittatus*), followed by the brown bass (*Basiliscus vittatus*) and the petalillos (*Drymobius margaritiferus*) (Table 1). The most abundant bird species were the major zanate (*Quiscalus mexicanus*), the common ground-dove (*Columbina passerina*), and the white winged pigeon (*Zenaida asiática*), while the less abundant were the teal (*Spatula discors*), the green egret (*Butorides virescens*) and the collared plover (*Charadrius*) with a single record throughout the monitoring to name some (Table 2). Finally, the most abundant medium and large mammals species were the Tehuantepec jackrabbit (*L. flavigularis*), the gray fox (*Urocyon cinereoargenteus*) and the coyote (*Canis*), while the least abundant species were the white back skunk (*Mephitis macroura*) and the armadillo (*Dasypus novemcinctus*) (Table 3).

Alpha diversity. The Shannon and Simpson indices indicated that the study area showed a reptiles diversity of H ‘= 1.2640 and 1/D=2.5905 throughout the year, for the wet season the alpha diversity was H‘=1.3434 and 1/D=2.8843 and for the dry season was H‘=1.0008 and 1/D=2.1258. The alpha diversity of birds throughout the year was H=2.7597 and 1/D=9.8032, for the wet season was H`=2.6962 and 1/D=10.4400 and for the dry season was H‘= 2.3426 and 1/D=6.1572. Finally, for medium and large mammals the alpha annual diversity was H’=1.2100 and 1/D=2.6702, for the wet season was H`=1.295 1/D=3.3602 and for the dry season was H’=0.8369 and 1/D=1.7142.

Beta diversity. According to Jaccard qualitative and quantitative dissimilarity indices, few reptile species are shared between the wet and dry seasons, with homogeneous abundances (J=0.6666 and J=0.4433, qualitative and quantitative respectively). In the case of birds, the Jaccard dissimilarity indices presented values of J=0.3829 and J=0.6430 (qualitative and quantitative respectively), indicating that the composition of species in the wet season is very similar to dry season, with abundances that behave differently between the two seasons. Finally, the Jaccard qualitative and quantitative dissimilarity indices showed that medium and large mammals composition and their abundances are dissimilar between seasons (J=0.6666 and J=0.6352, qualitative and quantitative respectively).

Seasonal comparison of diversity. The U Mann-Whitney test revealed that reptile diversity ($W = 94$, $p = 0.2052$) and medium and large mammals diversity ($W = 14$, $p = 0.5584$) show no statistically significant difference between the dry and wet seasons. For birds, there was a statistically significant difference ($W = 801$, $p = 0.0202$), with a higher diversity during the wet season.

Table I. List of reptiles species found in Santa María del Mar, Oaxaca, México

Species	Common name	NOM[1]	IUCN[2]	CITES[3]	AR-WET[4]	AR-DRY[5]	AR-ANUAL[6]
SQUAMATA							
Corytophanidae							
Basiliscus vittatus	Brown Basilisk				0.0208	0.0	0.0104
Gekkonidae							
Hemidactylus frenatus	Common House Gecko		LC		0.4166	0.125	0.2708
Iguanidae							
Iguana iguana	Common Green Iguana	P	LC		s/d	s/d	s/d
Ctenosaura pectinata	Western Spiny-tailed Iguana	A			s/d	s/d	s/d
Ctenosaura similis	Common Spiny-tailed Iguana, Black Iguana, Black Spiny-tailed Iguana	A	LC		0.0	0.1041	0.0520
Prynosomatidae							
Sceloporus siniferus	Longtail Spiny Lizard		LC		0.0416	0.0	0.0208
Sceloporus variabilis	Rosebelly Lizard				1.3333	0.6666	1
Teiidae							
Aspidoscelis deppii	Blackbelly Racerunner		LC		1.9791	1.5416	1.7604
Colubridae							
Drymobius margaritiferus	Speckled Racer		LC		0.0416	0.0	0.0208
Masticophis mentovarius	Neotropical Whip Snake				0.125	0.0	0.0625
Natricidae							
Thamnophis marcianus	Checkered Garter Snake	A			0.0833	0.0208	0.0520
Boidae							
Boa constrictor	Boa	A		II	s/d	s/d	s/d
Dipsadidae							
Conophis vittatus vittatus	Striped Road Guarder		LC		0.0208	0.0	0.0104
Elapidae							
Micrurus browni	Brown's Coral Snake	Pr	LC		s/d	s/d	s/d
TESTUDINES							
Kinosternidae							
Kinosternon scorpiodes	Scorpion Mud Turtle	Pr			0.0625	0.0	0.0312

[1]Mexican legislation category according to SEMARNAT (2010), Pr=Special protection, A=Threatened, P=Extinction risk. [2]Red list category (IUCN, 2017; LC=Least concern). [3]Appendices of CITES (2017). [4]Relative abundance for wet season. [5]Relative abundance for dry season. [6]Anual relative abundance.

Table II. List of bird species found in Santa María del Mar, Oaxaca, México. Species arrangement according to AOU (2016).

Species	Common name	MS[1]	NOM[2]	IUCN[3]	BLI[4]	CITES[5]	AR-WET[6]	AR-DRY[7]	ARANUAL[8]
ANSERIFORMES									
Anatidae									
Dendrocygna autumnalis	Black-bellied Whistling-duck	R		LC	LC		6.1800	0.0	3.0009
Spatula discors	Blue-winged teal	Nb		LC	LC		0.25	0.0	0.1250
GALLIFORMES									
Odontophoridae									
Colinus virginianus	Northern Bobwhite	R		NT	NT		0.7500	0.5	0.6250
SULIFORMES									
Fragatidae									
Fregata magnificens	Magnificent Frigatebird	Nb		LC	LC		0.5	0.0	0.25
Phalacrocoracidae									
Phalacrocorax brasilianus	Neotropic Cormorant	R		LC	LC		0.75	2.2850	1.5175
PELECANIFORMES									
Pelecanidae									
Pelecanus occidentalis	Brown Pelican	Nb		LC	LC		5.4575	0.0	2.7287
Ardeidae									
Ardea herodias	Great Blue Heron	Wv		LC	LC		0.25	2.5025	1.3762
Ardea alba	Great Egret	R		LC	LC		2.3325	3.1275	2.73
Egretta thula	Snowy Egret	R		LC	LC		0.25	0.0	0.125
Bubulcus ibis	Cattle Egret	R		LC	LC		3.305	2.7525	3.0287
Butorides virescens	Green Heron	R		LC	LC		0.25	0.0	0.125
CATHARIFORMES									
Cathartidae									
Coragyps atratus	Black Vulture	R		LC	LC		2.1275	6.1125	4.12
Cathartes aura	Turkey Vulture	R		LC	LC		2.3475	15.83	9.0887
ACCIPITRIFORMES									
Accipitridae									
Rupornis magnirostris	Roadside Hawk	R		LC	LC		0.0	0.5	0.25
GRUIFORMES									
Rallidae									
Fulica americana	American Coot	Wv		LC	LC		0.5	0	0.25
CHARADRIIFORMES									
Burhinidae									
Burhinus bistriatus	Double-striped Thick-knee	R		LC	LC		0.75	0	0.375
Charadriidae									
Pluvialis squatarola	Black-bellied Plover	Wv		LC	LC		0.75	7.0775	3.9137

Table II. Continuation

Charadrius collaris	Collared Plover	R	LC	LC	0.25	0	0.1250
Charadrius semipalmatus	Semipalmated Plover	Wv	LC	LC	0.5	0.25	0.3750
Charadrius vociferus	Killdeer	Wv	LC	LC	0.25	0	0.1250
Scolopacidae							
Tringa semipalmata	Willet	Nb	LC	LC	0.25	0.0	0.125
Bartramia longicauda	Upland Sandpiper	Nb	LC	LC	0.25	0.0	0.125
Numenius phaeopus	Whimbrel	Wv	LC	LC	9.22	4.385	6.8025
Arenaria interpres	Ruddy Turnstone	Nb	LC	LC	1.665	0.0	0.8325
Laridae							
Larus atricilla	Laughing Gull	Nb	LC	LC	1.00	0.5	0.75
Larus pipixcan	Franklin's Gull	T	LC	LC	0.5	4.005	2.2525
Thalasseus elegans	Elegant tern	T	NT	NT	1.00	1.00	1.00
COLUMBIFORMES							
Columbidae							
Columbina inca	Inca dove	R	LC	LC	0.5	0.0	0.375
Columbina passerina	Common Ground-dove	R	LC	LC	47.0575	13.8125	30.435
Zenaida asiatica	White-winged Dove	Wv	LC	LC	34.3875	0.75	17.568
Zenaida macroura	Mourning Dove	R	LC	LC	14.2375	0.25	7.2437
CUCULIFORMES							
Cuculidae							
Crotophaga sulcirostris	Groove-billed Ani	R	LC	LC	0.5	0.75	0.625
CAPRIMULGIFORMES							
Trochilidae							
Archilochus colubris	Ruby-throated Hummingbird	Nb	LC	LC	0.945	0	0.4725
Caprimulgidae							
Chordeiles minor	Common Nighthawk	R	LC	LC	31.8825	0	15.941
PICIFORMES							
Picidae							
Melanerpes aurifrons	Golden-fronted Woodpecker	R	LC	LC	0.0	0.25	0.125
FALCONIFORMES							
Falconidae							
Caracara cheriway	Crested Caracara	R	LC	LC	0.0	0.5	0.25
Falco sparverius	American Kestrel	Nb	LC	LC	13.925	12.8075	13.3662
PASSERIFORMES							
Tyrannidae							
Pitangus sulphuratus	Great-tailed Grackle	R	LC	LC	3.63	0.5	2.065
Tyrannus verticalis	Western Kingbird	Wv	LC	LC	0.25	0.0	0.125
Tyrannus forficatus	Scissor-tailed Flycatcher	Wv	LC	LC	30.7525	0.25	15.5012
Corvidae							
Calocitta formosa	White-throated Magpie-jay	R	LC	LC	0.25	0.25	0.25
Alaudidae							
Eremophila alpestris	Horned lark	R	LC	LC	1.0	0.5	0.75
Mimidae							
Mimus gilvus	Tropical Mockingbird	R	LC	LC	22.4	11.205	16.8025
Parulidae							
Geothlypis trichas	Common Yellowthroat	Nb	LC	LC	0.25	0.0	0.125
Peucaea ruficauda	Stripe-headed Sparrow	R	LC	LC	3.38	0.25	1.815

Pooecetes gramineus	Vesper Sparrow	R	LC	LC	15.9	0.5	8.2
Chondestes grammacus	Lark sparrow	R	LC	LC	0.0	0.25	0.125
Quiscalus mexicanus	Great Kiskadee	R	LC	LC	66.4125	62.0975	64.255
Icterus gularis	Altamira oriole	R	LC	LC	0.5	0.25	0.375

[1]Migratory status (Sr=Summer resident, R=Resident breeder, T=Transient migrant, Wr=Winter visitor, and Nb=Non- breeding visitor). [2]Mexican legislation category according to SEMARNAT (2010). [3]Red list category (IUCN, 2017; LC=Least concern, NT=Near threatened). [4]BirdLife international category (LC=Least concern, Nt=Near threatened). [5]Appendices of CITES (2017). [6]Relative abundance for wet season. [7]Relative abundance for dry season. [8]Anual relative abundance.

Table III.- List of mammal species found in Santa María del Mar, Oaxaca, México.

Species	Common name	NOM[1]	CITES[2]	IUCN[3]	AR-WET[4]	AR-DRY[5]	ARANUAL[6]
CARNIVORA							
Canidae							
Canis latrans	Coyote			LC	10.52631	5.26315	7.8947
Urocyon cinereoargenteus	Gray Fox			LC	15.7894	0.0	7.8947
Procyonidae							
Procyon lotor	Northern Raccoon			LC	10.5263	0.0	5.2631
Mephitidae							
Mephitis macroura	Hooded Skunk			LC	0.0	5.2631	2.6315
Spylogale gracilis	Western Spotted Skunk			LC	s/d	s/d	s/d
CINGULATA							
Dasypodidae							
Dasypus novemcinctus	Nine-Banded Armadillo			LC	s/d	s/d	s/d
DIDELPHIMORPHIA							
Didelphidae							
Didelphis marsupialis	Common oposum			LC	0.0	5.2631	2.6315
LAGOMORPHA							
Leporidae							
Lepus flavigularis	Tehuantepec jackrabbit	P		EN	31.5789	47.3684	39.4736
Sylvilagus floridanus	Eastern Cottontail			LC	s/d	s/d	s/d

[1]Mexican legislation category according to SEMARNAT (2010; P=Endangered risk). [2]Appendices of CITES (2017). [3]Red list category (IUCN, 2017; LC=Least concern, EN=Endangered). [4]Relative abundance for wet season. [5]Relative abundance for dry season. [6]Anual relative abundance.

DISCUSSION

A complete inventory of the vertebrates that live in the Santa Maria del Mar grasslands was obtained. Regarding the accumulation of species, the monitoring was adequate for the different groups, registering 87.46% of reptiles, 95.20% of birds and 85.71% of mammals expected. According to the literature, when the percentage of species found is greater than 70% of the total estimated richness, monitoring is satisfactory (Soberón and Llorente ,1993; Jiménez-Valverde and Hortal, 2003; Pineda-López and Verdú-Faraco, 2013).
During the monitoring period, only amphibian species *S. staufferi* was recorded, which was observed only during the wet season; this species was located near to a water source, which is in agreement with its natural history, indicating it can be found in temporary ponds in pastures (Cedeño-Vázquez et al., 2001). We registered only one species of rodent, the spiny mouse (*L. pictus*), that can inhabit a wide variety of habitats, however, it prefers places with seed availability (López et al., 2009). Finally, only two species of bats (*M. thysanodes* and *A. jamaicensis*) were found, which were captured during the wet season; the first is an insectivorous bat that may have foraging sites in open areas with artificial lighting and artificial dikes according to the literature (Fenton et al., 1992; Gehrt and Chelsvig, 2003, Avila-Flores and Fenton, 2005), which probably allowed it to be in the area despite the fact that it did not have an arboreal stratum. It is important to mention that this bat was captured in the net placed near a small puddle with the presence of insects, which surely is related to the capture of this species. *A. jamaicensis* is a frugivorous bat that can live in a large number of plant communities such as low deciduous forests, savannas, among others (Orozco-Segovia and Vázquez-Yanes, 1982; Fenton et al., 1992; Bredt and Uieda, 1996).

The richness of reptile species recorded in the study site (14 km^2) corresponds to 2.82% of the herpetofauna for the entire state of Oaxaca (Casas-Andrew et al., 2004); this result differs from Rioja et al. (2013) who recorded it an area of 20 km^2 (Montecillo Santa Cruz, municipality of San Francisco del Mar), 49 species of reptiles corresponding to 11.47% of the oaxacan herpetofauna, and from Martín-Regalado et al. (2011), who recorded 36 reptiles at Cerro Guiengola, near Tehuantepec in an area of 4,530 ha (the monitoring took place in a 50% lower area). It should be mentioned that both studies carried out a greater sampling effort, since they comprised 48 and 60 days, respectively, and included different and complex vegetal associations, which could influence the differences of richness recorded between the present study and those. These factors also influenced the different results obtained for birds and mammals; in a previous study in same locality, on a similar surface, but with a monitoring in four different vegetal associations that were sampled during 98 days, Rioja and Carrillo-Reyes (2014) found 75 bird species (10.1% of the total avifauna reported for Oaxaca), while in the present study we recorded 49 species, corresponding to 6.59% of oaxacan birds. Finally, the mammalian richness recorded in the study area corresponded to 4.05% of the state's mastofauna Santos-Moreno (2014); López et al. (2009) recorded 33 species of mammals (14.86% of the oaxacan mastofauna) in a study carried out at the lagoon area of Tehuantepec Isthmus with different plant associations.

The greatest seasonal and annual diversity was presented in the group of birds (annual: H`=2.7597 and 1/D= 9.8032; wet season: H`=2.6962 and 1/D=10.4400), while the mammal group presented the lowest seasonal and annual diversity (annual: H'= 1.2100 and 1/D = 2.6702; dry season: H'=0.8369 and 1/D=1.7142). No significant seasonal differences were found for reptiles (W = 94, p=0.2052) and mammals (W = 14, p = 0.5584) diversity, but it was found for birds (W=801, p = 0.0202). Finally, for reptiles (qualitative J=0.6666: quantitative J=0.4433) and mammals (qualitative J=0.6666, quantitative J = 0.6352), few species are seasonally shared, but not for birds (qualitative J = 0.3829, quantitative J = 0.6430). For reptiles, only the seven lines lizard (*A. deppii*), the pink panza squat lizard (*S. variabilis*) and the common home gecko (*H. frenatus*) were seasonal shared, possibly due to the fact that these species are generalists and have successful thermal characteristics in sites with high solar radiation, such as wooded savannahs or cleared sites, in addition to being tolerant to the disturbance (Vitt et al., 1997; Vitt and Pianka, 2004; Medina-Rangel, 2011), while most of the registered reptiles are specialists, like *D. margaritiferus* and *C. vittatus vittatus* which largely feed on amphibians (García and Ceballos, 1994; Lee, 2000) or with life cycles closely linked to humidity and water bodies (*T. marcianus, K. scorpiodes* and *B. vittatus*) (Berry e Iverson, 2001; Cadeño-Vázquez et al., 2001), so they were only recorded at one season or another. Also for mammals, few species were seasonally shared, the coyote (*C. latrans*) a generalist and tolerant mammal to habitat disturbance (Leopold, 1977; Pacheco et al., 2006) and the Tehuantepec jackrabbit (*L. flavigularis*); because the study was carried out in *L. flavigularis* habitat, so it is natural to have recorded it throughout the sampling (Rioja et al., 2011; Carrillo-Reyes et al., 2012). In contrast, most of the registered mammals are specialists like the raccoon (*P. lotor*) which presents a diet that varies between seasons; during the dry season approximately 50% of the components of its diet are of vegetal type, whereas in the wet season 70% are of animal type (Guerrero et al., 2000). This may help to explain why the raccoon did not appear in the grassland in the dry season because this plant association does not offer great variety of food resources for this species, in contrast, in the wet season it is possible that this species feeds mainly on animals and it finds them in the grasslands, where mammals, reptiles, and birds are part of its diet (Guerrero et al., 2000). In the case of birds, the species present all year were the most abundant like the zanate (*Q. mexicanus*), white pigeon (*Z. asiatica*), buzzard (*C. aura*), among many others; these species have general habits and are tolerant to the disturbance, developing well in grasslands and open zones (CONABIO 2010; Medina-Rangel, 2011), causing these species were present all year; in contrast, few species not shared were Anseriformes, Pelecaniformes, Charadriiformes and Passeriformes; many of them are migratory species, which during a determined season migrate to other places (Navarro-Sigüenza et al., 2014) and therefore they were registered in one season, or related with water bodies, finally, it is possible that many of the species of Passeriformes may not have been found during both seasons, because some nesting species are looking for higher strata (canopy) to make their nests in spring (CONABIO, 2010).

Results of composition, richness, alpha and beta diversity are due to different factors, such as monitored area and the simple structure of the type of association sampled (open grassland). The open grassland presents only herbaceous stratum, which implies fewer microhabitats available with macro and microclimatic conditions that only allow the permanence of species with a broad spectrum of tolerance (Medina-Rangel, 2011). In addition, this type of vegetal association confers greater vulnerability to predators so that diversity and its components tend to be smaller (Martín-Regalado,2011; Medina-Rangel, 2011; Rioja-Paradela et al., 2013).

Another key factor in the composition, richness and diversity results that the study was carried out during an atypical year in terms of weather, related to the presence of El Niño phenomenon, which caused a precipitation deficit in the wet season, resulting in similar temperature and humidity conditions for both seasons, which, according to the literature, causes the weather to tend to warmer conditions all year round (Manson et al., 2009), thus affecting the environmental temperature, rainfall and the formation of temporary bodies of water that occur during the wet season in the grassland association of the study area (Rioja-Paradela et al., 2014), and that this year were not presented, thereby adversely affecting the diversity of amphibians, reptiles, birds and mammals. Weather is a very important factor, which can positively or negatively influence biodiversity. It has been observed that events such as global temperature increase during the last century have affected ecosystems and a wide range of taxa (Hughes, 2000; McCarty 2001; Walther et al., 2002), generating changes in the scheduling of seasonal events (Gilman et al., 2006). These events could be affecting the results of the present study, because between 2015-2016, the phenomenon El Niño was one of the strongest ever recorded, comparable to the episodes of 1982/1983 and 1997/1998 according to data obtained from the National Water Commission (CONAGUA, 2015; CONAGUA, 2016), the annual rainfall of the Tehuantepec Isthmus region was lower than the average (400 mm), being 2015 the driest year for the region, with an intense drought that occurred throughout the South Pacific, in addition to being the warmest year, according to records since 1971, registering temperature increases of up to 3 °C by the end of 2015 for the Pacific region, with El Niño that varied from moderate to strong intensity over the same year (CONAGUA, 2015), precisely where the study area is located.

CONCLUSIONS

The group that presented a greater diversity was birds, followed by mammals and finally reptiles, probably because the first one presents a greater mobility since much of the wealth of birds was composed by shorebirds that found all food and shelter resources in the habitat of Tehuantepec jackrabbit (*L. flavigulari*s).

El Niño is a phenomenon that significantly affects biological diversity, modifying through fluctuations in temperature and precipitation the spatial distribution of many species. It is probable that the fact that the study was carried out during an atypical year (the presence of the El Niño phenomenon that caused drought in the study area) was the reason for the diversity of amphibians, reptiles and mammals that cohabit with the Tehuantepec jackrabbit (*L. flavigularis*) was low compared to other studies carried out in previous years in neighboring localities; nevertheless, birds presented a high diversity of species compared to previous studies in the region where the study was located, which is probably due to the great capacity of mobility in this group.

It is considered necessary to continue monitoring these groups so that the structure of the community of vertebrates that cohabit with the Tehuantepec jackrabbit (*L. flavigularis*) can be known during typical and atypical climatic conditions.

All these vertebrate species form an integral part of the trophic networks present in the habitat of the Tehuantepec jackrabbit (*L. flavigularis*), an endemic and endangered species; these vertebrate species are part of the ecosystem of the open grassland, so measures that allow them to remain must be taken, emphasizing those under some category of risk, because in the area activities such as extensive cattle ranching and poaching of species such as the green iguana (*I. iguana*), the striped iguana (*C. similis*) and the boa (*B. constrictor*), and the Tehuantepec jackrabbit (*L. flavigularis*) were carried out. In addition, it should be taken into account that the Isthmus of Tehuantepec is a vertebrate endemism center, and has been classified as IBA (Important Area for the Conservation of Birds) of international BirdLife. The area comprises a range of possible microhabitats for different species of amphibians, reptiles, birds and mammals, making it an important area in which management measures for the conservation of biodiversity should be promoted.

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