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A Comparison of Amphibian and Reptile Diversity Between Disturbed and Undisturbed Environments of Salvatierra, Guanajuato, Mexico

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Abstract

Amphibians and reptiles are two groups of vertebrates that are sensitive to changes in their environment. These changes are mostly caused by human activities, which affect the abundance, composition, and distribution of these vertebrates. In this study, we compare the richness and taxonomic diversity of herpetofauna between undisturbed environments (tropical deciduous forest = TDF) and disturbed environments (corn fields = CF) near the towns of Urireo (URI) and San Nicolas de los Agustinos (SNA) in Salvatierra, Guanajuato. We recorded a total of 19 species in the two locations (4 amphibian and 15 reptile species). At the URI locality, 12 species were recorded in CF and 10 in TDF. At the SNA locality, eight species were recorded in CF and seven species in TDF. In addition, we found that overall taxonomic distinctness was greater at URI than SNA across both types of vegetation, with the highest diversity found in TDF of URI. Seven of the 19 species recorded are current allocated to some protection category of NOM-059-SEMARNAT-2010: *Lithobates neovolcanicus*, *Kinosternon integrum*, *Sceloporus grammicus*, *Lampropeltis polyzona*, *Masticophis mentovarius*, *Salvadora bairdi*, and *Thamnophis melanogaster* differing from other mechanisms such as the International Union for Conservation of Nature and Environmental Vulnerability Score. Our results suggest that carrying out long-term studies that include diversity and taxonomic distinctness in environments with different levels of disturbance, in addition to including characteristics of natural history, might enhance the development of more efficient conservation strategies for these vertebrates.

Keywords

herpetofauna, richness, undisturbed, disturbed environment, Guanajuato, Mexico

Introduction

The ecosystems of the Earth today constitute a matrix of fragmented landscapes (Fischer & Lindenmayer, 2007), particularly in tropical areas (Ndriantsoa, Riemann, Raminosoa, Rödel, & Glos, 2017; Wisser, Peet, & White, 1996). Consequently, it is of great interest to evaluate the structure and functionality of plant and animal communities in systems that are disturbed as a result of agricultural, livestock or forestry activity (Gardner, Barlow, & Peres, 2007; Hernández-Ordoñez & Suazo-Ortuño, 2016; Ramírez-Bautista & Pineda-López, 2016). For example, cattle grazing has been shown to have negative effects on natural vegetation because it compacts the soil and impedes the removal and recycling

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of nutrients (Thompson, Nowakowski, & Donnelly, 2015).

Modification of habitats by human beings can have serious effects on the ecological, reproductive, and physiological attributes of the amphibians and reptiles that inhabit them (Berriozabal-Islas, Badillo-Saldaña, Ramírez-Bautista, & Moreno, 2017; Huey, 1991; Thompson et al., 2015; Vitt & Caldwell, 2014; Zug, Vitt, & Caldwell, 2001). Primarily, when plant cover is eliminated, changes in photoperiod, humidity, and temperature can influence the viability of the organisms that inhabiting the disturbed environment, so it may affect their richness and abundance (Cruz-Elizalde et al., 2016). Therefore, it is necessary to assess the diversity and composition of the amphibian and reptile communities in human-disturbed environments of Mexico (Magno-Benítez, Ramírez-Bautista, & Cruz-Elizalde, 2016).

Studies conducted in disturbed environments have focused on understanding and estimating the composition of amphibian and reptile communities as well as the underlying causes of their decline, such as fragmentation of native plant components and transition zones (Berriozabal-Islas et al., 2017; Hernández-Ordoñez & Suazo-Ortuño, 2016). However, Suazo-Ortuño, Alvarado-Díaz, and Martínez-Ramos (2008) and Ndriantsoa et al. (2017) note that some tropical ecosystems modified by human beings contain higher amphibian and reptile species richness and diversity than undisturbed environments, due to two factors: (a) the presence of patches of original vegetation that maintain shelter and food for the herpetofauna and (b) some species have greater plasticity and adaptation in environments that are undergoing transformation processes.

Other farming systems, such as coffee plantations, promote greater diversity of amphibians and reptiles compared to the surrounding undisturbed areas (Macip-Ríos & Casas-Andreu, 2008). Thus, other authors such as Moguel and Toledo (1996), Heinen (1992), and Pineda and Halfpter (2004) consider coffee plantations to be strategic zones for the conservation of native herpetofauna, given the high structural complexity of this habitat. In the case of forests with commercial use and neighboring cultivation areas, Illescas-Aparicio et al. (2016) evaluated the effect of management on the diversity and richness of amphibians and reptiles in Ixtlan de Juárez, Oaxaca, finding that the zones for cultivation protected the greatest species diversity and richness in comparison with native forest.

In this context, it is observed that recent studies of disturbed environments in different parts of Mexico reflect a consistent pattern of greater or equal richness and diversity for amphibians and reptiles (Macip-Ríos & Casas-Andreu, 2008; Macip-Ríos & Muñoz-Alonso, 2008; Magno-Benítez et al., 2016; Roth-Monzón, Mendoza-Hernández, & Flores-Villela, 2017). The state

of Guanajuato suffers from some of the greatest loss of vegetation cover due to activities such as industry and agriculture (Leyte-Manrique, Morales-Castorena, & Escobedo-Morales, 2016; Mendoza-Quijano et al., 2001). Few studies have been conducted in agricultural areas, nor have richness and diversity of amphibians and reptiles been compared between disturbed and conserved environments. For example, Sánchez-Luna and Reynoso (2012) analyzed the herpetofauna of the Lago Crater Protected Natural Area (PNA), a highly disturbed area, and they found low species richness in comparison with Cerro de Amoles and Laguna de Yuriria PNAs, where they recorded 13 and 15 species, respectively.

Therefore, the aims of this study are as follows: (a) to understand and compare the diversity and composition of amphibian and reptile species between undisturbed areas (tropical deciduous forest) and disturbed areas (corn fields); (b) to evaluate the taxonomic diversity of each of these areas; and (c) to identify the species at risk in each locality and vegetation type, based on NOM-059-SEMARNAT-2010, the International Union for Conservation of Nature (IUCN) Red List (2017), and Environmental Vulnerability Score (Wilson, Johnson, & Mata-Silva, 2013a, 2013b).

Methods

Study Area

The study area includes the localities of San Nicolas de los Agustinos (SNA, 20° 12' 52.89" N and 100° 50' 33.60" W) and Urireo (URI, 20° 14' 38.92" N and 100° 57' 48.3212" W), both in the municipality of Salvatierra, Guanajuato (Figure 1). SNA is located 7.72 km northwest of the city of Salvatierra at an elevation of 1,889 m. It has a semi-tropical climate with average summer rains of 800 mm and an annual average temperature of 18°C. The vegetation types are tropical deciduous forest, xerophilous scrub, and the agricultural crops (Comité de Planeación para el Desarrollo Municipal [COPLADEM], 2004; Rzedowski, 2006). URI is located 2.79 km east of the city of Salvatierra at an elevation of 1,786 m. The average annual temperature is 18.2°C and the average precipitation is 830 mm per year. The vegetation is composed of xerophilous scrub, tropical deciduous forest, and agricultural crops (COPLADEM, 2004; Rzedowski, 2006). The main body of water at the site is the Lerma River, which crosses the municipality of Salvatierra. At SNA, irrigation channels are the main sources of water, while URI contains scarce seasonal water pools (COPLADEM, 2004; Walter & Brooks, 2009).

Prior to sampling, the study sites were delimited according to their plant components and types of water bodies. The vegetation selected for both localities consisted of patches of native vegetation formed by

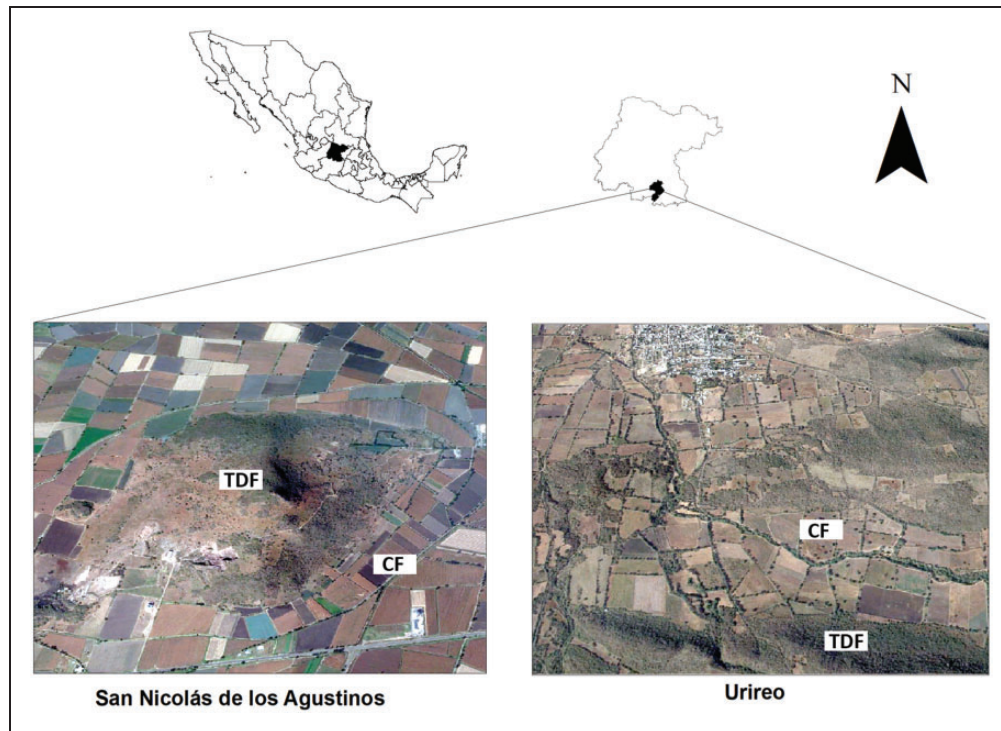


Figure 1. Location of the communities of San Nicolás de los Agustinos (SNA) and Urireo (URI) in municipality of Salvatierra, Guanajuato. Vegetation types: tropical deciduous forest (TDF) and corn fields (CF).

elements of tropical deciduous forest (TDF; undisturbed) and corn farms (CF; disturbed). The water pools were characterized as natural pools for the TDF and irrigation water channels for CF.

Fieldwork and Specimen Collection

From June to November 2016 and January to May 2017, systematic monthly surveys of the herpetofauna were carried out in both environments at the two localities, amounting to a total of 528 man-hours.

Sites—SNA and URI

For both the CF and TDF sites at SNA, six transects of 10×500 m were delimited, located 50 m apart to ensure independence of the data (Berriozabal-Islas et al., 2017). The transects at CF included the irrigation channels and surrounding vegetation. During the monthly samplings, two replicates per transect were performed for each habitat.

Specimen Collection

The organisms were collected according to the monitoring and capture techniques for amphibians and reptiles proposed by Casas-Andreu, Valenzuela-López, and Ramírez-Bautista (1991). Amphibians were collected through the use of entomological nets and by hand

from 9:00 to 14:00 and 16:00 to 22:00 in order to maximize the chances of observing both diurnal and crepuscular/nocturnal species. Turtles were searched for in water pools and irrigation channels of both localities and in both types of vegetation and were collected with entomological nets and by hand. For snakes of semiaquatic habit, entomological nets were used, while herpetological hooks (or snake hooks) were used to catch terrestrial snakes. Lizards were collected by hand or with the help of plastic bands. In addition to the collection of specimens, data on the vegetation types were recorded and the habitats of each species were characterized as: aquatic, terrestrial, saxicolous, arboreal, or fossorial. Geographic location data were taken from each record using a Garmin GPS, model e-Trex, and the elevation in meters.

The organisms were identified at species level through the use of dichotomous keys (Ramírez-Bautista, Hernández-Salinas, García-Vázquez, Leyte-Manrique, & Canseco-Márquez, 2009; Vázquez-Díaz & Quintero-Díaz, 2005). Once the individuals were identified, they were marked with epoxy paint, and an identification code was assigned to avoid counting the same individuals. Subsequently, the organisms were released at the site where they were collected. If the species could not be identified in the field, the specimens were transferred to the Biology Laboratory of the Instituto Tecnológico Superior de Salvatierra, and they were later returned to

the site where they were collected. The collection permit (SGPA/DGSV/06622/13) was issued to ALM by Dirección General de Vida Silvestre de la Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT).

Data Analysis

Species richness was defined as the number of species recorded during the entire study period and abundance was the number of individuals of each species. To assess the diversity for each community was determined with the Shannon-Wiener index (Krebs, 1999; Moreno, 2001). And to detect possible differences between localities and vegetation types, we applied a nonparametric Mann–Whitney U test, using the number of species in each type of vegetation as a response variable. This analysis was calculated with the PAST program.

The taxonomic diversity between the undisturbed vegetation sites and the disturbed sites was compared for the two localities, using the average taxonomic distinctness index (Clarke & Warwick, 2001; Clarke & Warwick, 1998) in the PRIMER 5 (PRIMER-E Ltd, 2001) program. For this analysis, a matrix of species presence/absence by site, and a table with the different levels of taxonomic classification was used (Gotelli & Colwell, 2001). The null hypothesis assumes that each sample (sites in this case) contains species chosen at random from the total set of species and that they should also be within a confidence limit of 95%. Since the theoretical mean remains constant while the variance decreases as (m) increases, the 95% confidence interval assumes a “funnel” shape (Clarke & Warwick, 1998); this means that the sample data inside this interval have values of taxonomic diversity significantly different than expected at random. We calculated rarefaction curves in order to avoid biases associated with the sampling intensity and the species abundance distribution. Rarefaction and extrapolation curves based on the Hill numbers were used to compare species richness between the two vegetation types by each site. We followed the methods developed by Colwell et al. (2012) implemented in the online package iNEXT (Chao et al., 2014). For estimation and comparison of the rarefaction curves, the Hills number $q = 0$ (Richness) was used, using 100 randomizations with 95% confidence intervals. Significant differences between samples were identified by the lack of overlapping confidence intervals of the graph obtained. Finally, to determine the composition of the herpetofauna between sites, rank abundance curves or Whittaker curves were calculated (Feinsinger, 2003; Magurran, 2004). To plot the rank abundance curves, the logarithm of the proportion of each species p_i (n_i/N) was calculated. The species were ordered from most to least abundant (Feinsinger, 2003).

Species at Risk

To determine which species were at risk in both locations and vegetation types, we referred to the Official Mexican Standard NOM-059-SEMARNAT-2010 (Diario Oficial, 2010), the IUCN Red List (2017), and Environmental Vulnerability Score (Wilson et al., 2013a, 2013b). The NOM-059 recognizes the following categories: Endangered (P), Threatened (A), Subject to Special Protection (Pr), Probably Extinct in the Wild (E), and Not Considered (Nc). The IUCN Red List utilizes the following categories: Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Not Evaluated (NE), and Data Deficient (DD). And the Environmental Vulnerability Score that considers three risk categories: low (3–9 points), medium (10–13 points), and high (14–20 points). Species features based on (a) extent of geographic distribution, (b) extent of ecological distribution (vegetation types used), and (c) type of reproductive mode for amphibians and degree of human persecution for reptiles (for details, see Wilson et al., 2013a, 2013b).

Results

A total of 19 species were recorded jointly for both communities. Amphibians were represented by four species from three families and three genera (Craugastoridae, Hylidae, and Ranidae). Reptiles were represented by six families (Colubridae, Teiidae, Natricidae, Dactyloidae, Kinosternidae, and Phrynosomatidae), constituting 11 genera and 15 species. Comparing the total richness of species recorded in the two locations, we observed that the highest value was recorded for the URI locality with 16, while 10 species were encountered at SNA. By vegetation type, URI had 12 species in CF and nine species in TDF. In the case of SNA, eight species were recorded in CF and six species in TDF (Table 1).

Diversity calculated by the Shannon-Wiener richness index (H') was 1.69 for SNA and 1.4 for URI. The Mann–Whitney U test did not show significant differences between localities ($U = 0.12$, $p = .1$). At the SNA site, the CF vegetation had a value of 1.6, while the TDF site recorded a value of 1.2; however, there were no significant differences between them ($U = 0.23$, $p = .03$). For the URI location, the CF had a value of 1.1 while the TDF habitat had a value of 1.4, once again showing no significant differences between vegetation types based on the Mann–Whitney U test ($U = 0.65$, $p = .95$).

Rarefaction analysis showed that species richness was higher in cultivation zones than in the tropical deciduous forest at both the SNA (Figure 2(a)) and URI (Figure 2(b)) locations. Nevertheless, confidence

Table 1. Inventory of Amphibian and Reptile Species in SNA and URI.

Species	SNA		URI		Habitat	Acronym
	CF	TDF	CF	TDF		
Amphibian						
<i>Dryophytes arenicolor</i>			1	2	Aqua-Sax	Da
<i>Dryophytes eximius</i>			1		Arb-Terr	De
<i>Craugastor augusti</i>				2	Arb-Terr	Ca
<i>Lithobates neovolcanicus</i>	33		21	19	Aqua	Ln
Reptilia						
<i>Kinosternon integrum</i>	6		5	38	Aqua-Terr	Ki
<i>Norops nebulosus</i>			1		Arb-Terr	Nn
<i>Sceloporus aeneus</i>				1	Sax	Sa
<i>Sceloporus dugesii</i>	60	27	19	2	Sax	Sd
<i>Sceloporus grammicus</i>	2	3			Sax-Arb	Sg
<i>Sceloporus spinosus</i>			1		Sax	Ss
<i>Sceloporus torquatus</i>	7	1	163	13	Sax-Arb	St
<i>Aspidoscelis gularis</i>	20	30	7		Terr	Ag
<i>Conopsis lineata</i>	3				Sax-Terr	Cl
<i>Drymarchon melanurus</i>		1		1	Aqua-Terr	Dm
<i>Lampropeltis polyzona</i>			6		Sax-Terr	Lp
<i>Masticophis mentovarius</i>		2		1	Terr	Mm
<i>Salvadora bairdi</i>			1		Terr	Sb
<i>Thamnophis melanogaster</i>	12				Aqua-Terr	Tm
<i>Indotyphlops braminus</i>			3		Foss-Terr	Ib
	143	64	229	79		N = 515

Note. The abundance for each type of plant community in both sites and the acronym for each species are also shown. Habits: Aquatics = Aqua, Saxicolous = Sax, Arboreal = Arb, Terrestrial = Terr, Fossorial = Foss. SNA = San Nicolas de los Agustinos; URI = Urireo; CF = corn field; TDF = tropical deciduous forest.

intervals for both sites are overlapping, suggesting a lack of significance.

It was found that the values for the average taxonomic differentiation index ($\Delta+$) ranged between 47.62 (TDF at SNA) and 68.52 (TDF at URI). The site with the highest taxonomic diversity was TDF at URI ($\Delta+$ = 68.52), followed by CF for URI ($\Delta+$ = 66.88), and CF at SNA ($\Delta+$ = 62.50), while the site with the lowest taxonomic diversity was TDF at SNA ($\Delta+$ = 47.62; Figure 3).

The rank abundance curves by locality showed that at the SNA site, *Sceloporus dugesii* was the most abundant species in the CF, while *A. gularis* was most abundant in the TDF. Likewise for the URI locality, *Sceloporus torquatus* and *K. integrum* were the most abundant species in the CF and TDF, respectively (Figure 4).

Species at Risk

According to NOM-059-SEMARNAT-2010, four species were found to be in the Threatened category and three species in the Special Protection category (Table 2). In the IUCN Red List, only *Lithobates neovolcanicus* is under the category of Near Threatened and *Thamnophis melanogaster* as Endangered (Table 2;

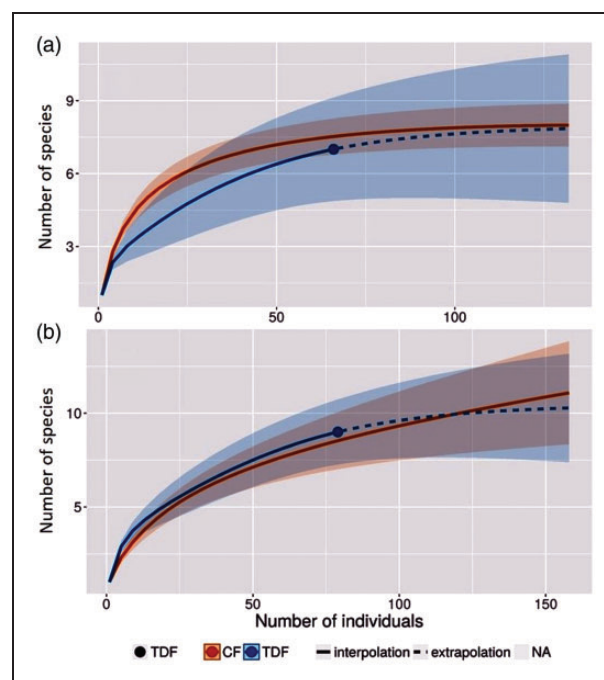


Figure 2. Rarefaction/extrapolation curves for (a) SNA and (b) URI. CF = corn fields; TDF = tropical deciduous forest. The shaded area represents the 95% confidence interval of each curve.

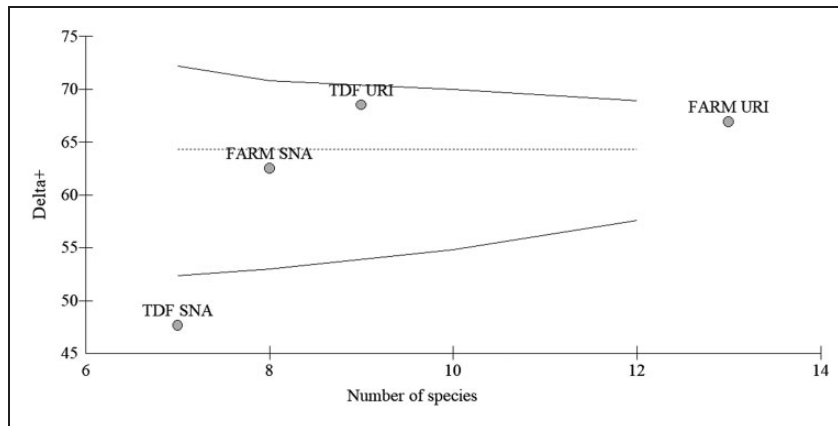


Figure 3. Taxonomic diversity for the herpetofauna of San Nicolas de los Agustinos (SNA) and Urireo (URI). The funnel plot is shown with the values of the taxonomic diversity index ($\Delta+$) of the two sites and vegetation types, with 95% confidence limits (solid line) and the values expected by chance (dotted line). The X-axis corresponds to the species richness values, while the Y-axis corresponds to the values of $\Delta+$. The points represent the locations of the different sites within the graph. Tropical deciduous forest (TDF) and CF in SNA and TDF and CF in URI.

Figure 5). Finally, considering the environmental vulnerability index proposed by Wilson et al. (2013a, 2013b), three species of amphibians are in medium environmental vulnerability: *Craugastor augusti*, *Dryophytes arenicolor*, and *L. neovolcanicus* (Table 2; Figure 5). And in reptiles, five species have high vulnerability, and three with medium vulnerability. Finally, in the case of the snake, *Indotyphlops braminus* (given that it is an invasive alien species) is not considered in any category of risk in the NOM-059 and the red list but the EVS catalogs it as low risk (L).

Discussion

The species richness found in this study revealed that species in the analyzed environments were different from each other, as well as diversity caused by disturbance of the tropical deciduous forest. However, the tropical deciduous forest appears to present higher values of taxonomic diversity than areas with corn fields. These responses may be explained by several factors, including the patterns of temporal and spatial distribution of species in different ecosystems and availability of resources such as food, shelter, and space (Parker, 1994; Vitt & Caldwell, 2014). When comparing the results of the rarefaction analysis, we found that there are no significant differences in species richness between the vegetation types of the two sites.

In other cases, it has been documented that when an environment is transformed such that there is significant simplification of the native vegetation, the original composition of the biota also is modified, so that only some species have a favorable response to the transformation (Berriozabal-Islas et al., 2017; Burgos & Mass, 2004). This response may include greater plasticity and

adaptation, which may be reflected in an increase in reproduction rates, thermoregulation, and survival, and consequently a successful occupation of the modified environments (Germaine & Wakeling, 2001). Compared to amphibians, reptile species are more favored in modified environments, likely due to their tolerance to seasonal variations in temperature, precipitation, and humidity, which results in greater exploitation of available microhabitats and food (Macip-Ríos & Casas-Andreu, 2008; Macip-Ríos & Muñoz-Alonso, 2008). Furthermore, this composition was reflected in the low abundance and representativeness of some species, particularly amphibians, which may be due to the fact that the habitat is already highly disturbed. Some authors, such as Moguel and Toledo (1996), Macip-Ríos and Muñoz-Alonso (2008), Suazo-Ortuño et al. (2008) and Chamberlain et al. (2009), indicate that average alterations to the environment can promote an increase in the abundance, richness, and diversity of some taxonomic groups. This was the case in this study, in which there was greater taxonomic diversity of reptiles such as snakes and lizards.

For amphibians, this pattern was not observed given that there was low taxonomic representation with only four species (*Dryophytes arenicolor*, *Dryophytes eximius*, *Craugastor augusti*, and *Lithobates neovolcanicus*, the latter being the most abundant). It has been suggested that some species are not strictly dependent on the complexity of the plant structure, so if new environments can provide different environmental conditions, such as microclimates, the presence of some species will be favored, as in the case of reptiles in crop farms, while others, such as amphibians, will have low diversity and occurrence (*C. augusti*, *D. arenicolor*, and *D. eximius*) in modified systems. This is because changes to the

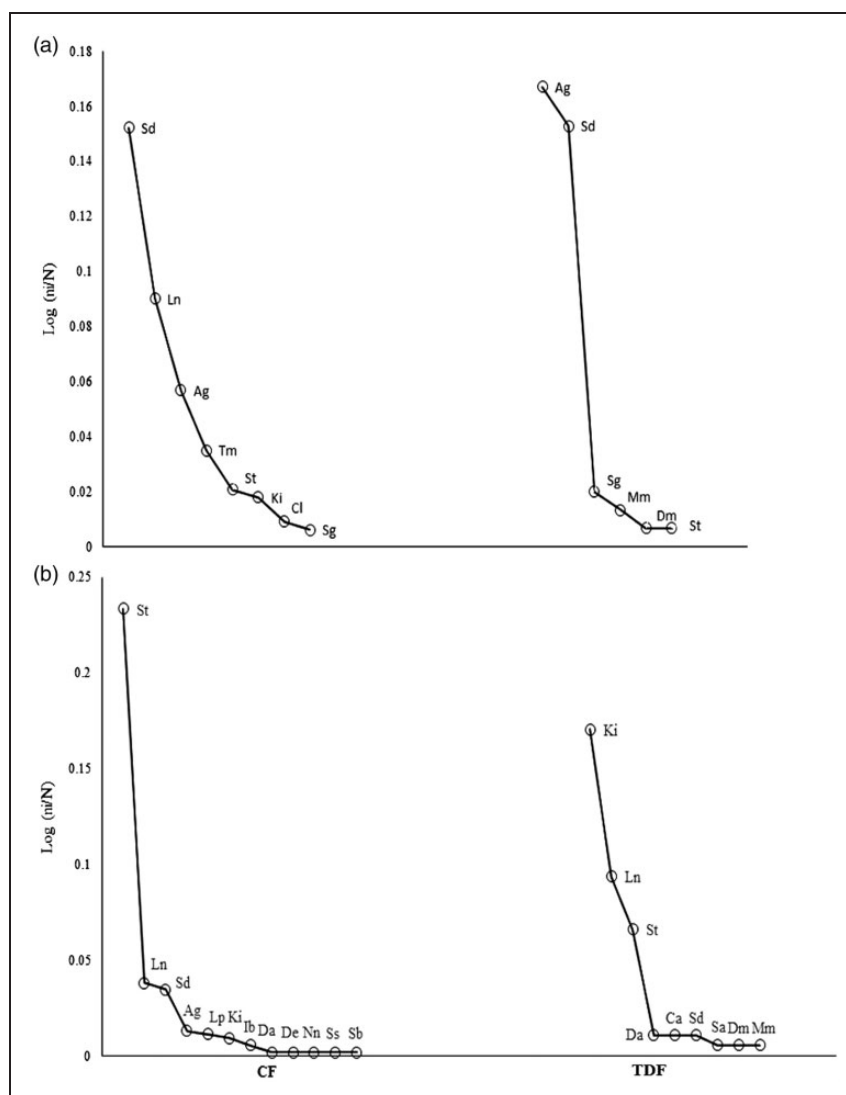


Figure 4. Rank abundance curves that represent the composition of species between localities and vegetation types: (a) SNA and (b) URI. Sd = *Sceloporus dugesii*, Ln = *Lithobates neovolcanicus*, Ag = *Aspidoscelis gularis*, Tm = *Thamnophis melanogaster*, St = *Sceloporus torquatus*, Ki = *Kinosternon integrum*, Cl = *Conopsis lineata*, Sg = *Sceloporus grammicus*, Ss = *Sceloporus spinosus*, Mm = *Masticophis mentovarius*, Dm = *Drymarchon melanurus*, Lp = *Lampropeltis polyzona*, Ib = *Indotyphlops braminus*, Nn = *Norops nebulosus*, Da = *Dryophytes arenicolor*, De = *Dryophytes eximius*, Sb = *Salvadora bairdi*, Ca = *Craugastor augusti*, and Sa = *Sceloporus aeneus*.

environment (habitat) do not favor this group, except for species with greater tolerance and adaptability to disturbed environments (Ndriantsoa et al., 2017; Vitt & Caldwell, 2014), as in the case of *Lithobates neovolcanicus* which was the most abundant species, being found even in areas with significant livestock activity and water channels in SNA.

For the crop fields farm (CF) localities, the availability of sites, including abandoned buildings, poles, debris, fences, and open areas (Figure 5(b)), offers various sites of perches for lizards (reptiles) to bask and thermoregulate to carry out their physiological and metabolic processes (Cruz-Elizalde & Ramírez-Bautista, 2012). In this

way, the heterogeneity found in the environments will be a factor that ultimately determines the degree of species turnover among them (Melo, Rangel, & Didiz-Filho, 2009; Svenning, Fiørgaard, & Baselga, 2011).

Regarding the structure of the communities (Figure 4), dominant and rare species can be discerned according to what is expected to be found within the undisturbed and disturbed environments. For example, few species are very abundant and most species are very rare in undisturbed sites (Magurran, 2004). This pattern was also observed in this study; however, for disturbed sites, in both locations, the dominant group recorded was the lizards. This is likely the result of an increase

Table 2. List of Species in the Localities of SNA and URI in the Municipality of Salvatierra, Guanajuato.

Species	Protection category			SNA		URI	
	NOM-059	IUCN	EVS	CF	TDF	CF	TDF
Amphibia							
<i>Craugastor augusti</i>	Nc	LC	12-M		X		
<i>Dryophytes arenicolor</i>	Nc	LC	11-M			X	X
<i>Dryophytes eximius</i>	Nc	LC	9-L			X	
<i>Lithobates neovolcanicus</i>	A	NT	13-M	X		X	X
Reptilia							
<i>Kinosternon integrum</i>	Pr	LC	6-L	X		X	X
<i>Norops nebulosus</i>	Nc	LC	7-L			X	
<i>Sceloporus aeneus</i>	Nc	LC	6-L				X
<i>Sceloporus dugesii</i>	Nc	LC	15-H	X	X	X	X
<i>Sceloporus grammicus</i>	Pr	LC	15-H	X	X		
<i>Sceloporus spinosus</i>	Nc	LC	12-M			X	
<i>Sceloporus torquatus</i>	Nc	LC	11-M	X	X	X	X
<i>Aspidoscelis gularis</i>	Nc	LC	9-L	X	X	X	
<i>Conopsis lineata</i>	Nc	LC	13-M	X			
<i>Drymarchon melanurus</i>	Nc	LC	13-L		X		X
<i>Lampropeltis polyzona</i>	A	NE	14-H			X	
<i>Masticophis mentovarius</i>	A	LC	10-L		X		X
<i>Salvadora bairdi</i>	Pr	LC	15-H			X	
<i>Thamnophis melanogaster</i>	A	EN	15-H	X			
<i>Indotyphlops braminus</i>	Nc	NE	6-L			X	

Note. Protection category according to both the Normative Official Mexican; NOM-059-SEMARNAT-2010 (Diario Oficial, 2010), the IUCN; Red list (IUCN, 2017), and EVS; Environmental Vulnerability Score (Wilson et al., 2013a, 2013b). Low = L, values of 3 to 9; Medium = M, values of 10 to 13, and High = H, with values of 14 to 20. The species that are considered in some protection status are indicated, as well as the types of vegetation in which they occur in both localities. Conservation status categories are as follows: SEMARNAT (2010): A = Threatened, Pr = Special Protection, and Nc = Not evaluated. IUCN (2017): LC = Least Concern, NT = Near Threatened, EN = Endangered, and NE = Not Evaluated. SNA = San Nicolas de los Agustinos; URI = Urireo; IUCN = International Union for Conservation of Nature; EVS = Environmental Vulnerability Score; CF = corn field; TDF = tropical deciduous forest.

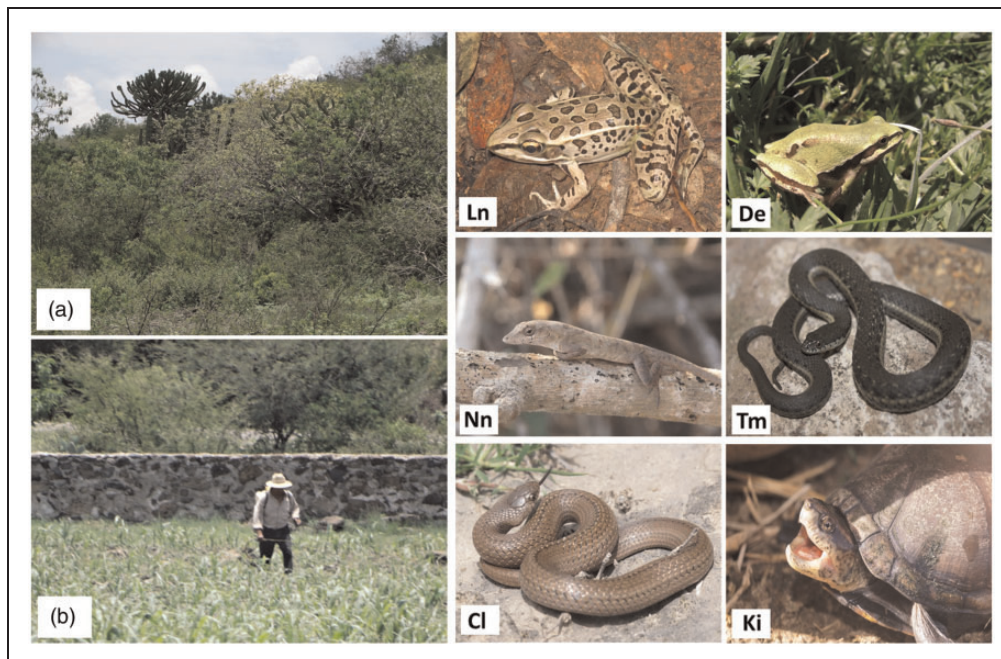


Figure 5. Photographs of the sites analyzed: (a) = tropical deciduous forest and (b) corn fields. Also shown are species risk categories in the NOM-059 and red list IUCN. *Lithobates neovolcanicus* (Ln), *Dryophytes eximius* (De), *Norops nebulosus* (Nn), *Thamnophis melanogaster* (Tm), *Conopsis lineata* (Cl), and *Kinosternon integrum* (Ki). Credit of pictures: (a) and (b) ALM and species CBI.

in the availability of trophic resources and space offering food and shelter throughout the year. In the crop farms at SNA, the presence of permanent water bodies, such as irrigation channels, provides an ideal environment for refuge and food sources for species such as *S. dugesii* and *S. torquatus* (Suazo-Ortuño et al., 2008; Vitt, Congdon, & Dickson, 1977). These few species are able to take advantage of and exploit the resources found at the modified sites consequently increasing their abundance, similar to the lizard community in tropical deciduous forests as mentioned by Berriozabal-Islas et al. (2017). It should also be noted that species diversity values may reflect the abundance of these species, as is the case with cropland in SNA. Examples are provided for the case of *Kinosternon integrum* specimens from the tropical forest at URI (Table 1), which were mainly concentrated in the scarce water pools. Pools were absent from the cultivation sites, leading to lower abundance (five individuals). For the case of SNA, individual species were only found in the crop farms. This is likely due to the availability and accessibility of water bodies, as the pools at URI are undisturbed, with no physical barriers to prevent the movement of individuals, while the irrigation channels at SNA are not favorable for turtles due to their dimensions and high banks. A detailed analysis of this observation was not done in this study; however, research by Macip-Ríos et al. (2009) mentions that *K. integrum*, like other species of that genus, seasonally moves and migrates locally to different water bodies often with individuals found together. This pattern was observed in this study, where a concentration of up to 15 individuals of this species was found in one of the water pools at URI.

The most abundant species in the low deciduous forest at the SNA locality was *Aspidoscelis gularis*, a species of lizard that is frequently associated with cactus plants that are characteristic of these seasonal environments (Pérez-Almazán et al., 2014). The turtle *Kinosternon integrum* was the most abundant in the deciduous lowland forest, followed by the frog *Lithobates neovolcanicus* for URI. This is likely due to the presence of large bodies of water, with carrying capacities of up to 20 or 30 individuals, as well as smaller bodies of water distributed throughout the tropical deciduous forest. Interestingly, the abundance of *K. integrum* decreased toward the crop farms in both locations despite the presence of permanent and seasonal pools, and irrigation channels. This may be due to the modification of their habitat that has caused water pools to decrease or as a result of collection for the pet trade or as a local food source (Cushman, 2006). This corroborates the research by Suazo-Ortuño et al. (2008), who mention that other species of the genus, such as *K. chimalhuaca*, are particularly sensitive to anthropic disturbances of their habitat.

The two sites with the greatest taxonomic diversity are the CF and TDF of URI. Together, they also had a higher number of species than the same types of vegetation in SNA. However, in the case of URI, although a smaller number of species was found (nine species) in TDF, its taxonomic diversity was higher than in crop farms, which had a higher number of species (12 species). The values found can be explained by a smaller number of crop farms at URI, and they are mostly seasonal and occupy a few hectares. Moreover, they are polycultures, which cause less disturbance and contain greater vegetation cover of TDF. In contrast, the production systems at SNA are irrigated and generally represented with sorghum and corn monocultures, with sparse native plant cover (TDF).

Implications for Conservation

One of the first steps on the biodiversity conservation is the identification of species vulnerability, in order to seek the best strategies aimed at mitigating this vulnerability. According to our results, the NOM-059-SEMARNAT-2010 contains seven species that are in a risk category and Red List IUCN (2017) has only two. However, in the EVS score, 11 species are at risk levels medium and high (Table 2).

In this context, although both the NOM-059 and the Red List propose categories of risk or conservation for the species, these do not reflect the true state of risk for the species in SNA and URI. Therefore, we consider that the EVS evaluates and measures the state of conservation in time and real scale, so it can be a useful tool to determine the conservation status of amphibians and reptiles in the areas of study. We conclude that despite their conservation status, these species have adapted to modified environments, such as agricultural areas that provide shelter and food. However, other species that are not included in NOM-059 or the Red List must also be considered, as they play an important ecological role within the CF and TDF. It is urgently needed to establish strategies aimed at the conservation of herpetofauna of the region, with emphasis on the turtle *Kinosternon integrum*, the snakes *Conopsis lineata*, *Masticophis mentovarius*, *Lampropeltis polyzona*, and the frogs *Dryophytes arenicolor*, *D. eximius*, and *Craugastor augusti*, as well as the bodies of water that surround them. Finally, this study contributes to the increase in knowledge of the diversity of amphibians and reptiles in disturbed environments in the state of Guanajuato.

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