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Herpetofauna of Parque Nacional Cumbres de Monterrey, natural protected area in Nuevo Leon, Mexico

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A B S T R A C T

The study was conducted at Parque Nacional Cumbres de Monterrey, located on the Sierra Madre Oriental in Northeastern Mexico. The objectives: determine the status of the herpetofauna and determine the plant community and altitudinal distribution of each species. The study area was divided into 9 zones: submontane scrubland, oak forest, oak-pine forest, pine-oak forest, gallery forest, temperate forest of *Abies* and *Juniperus*, pine forest, and crop-impacted areas. We performed 17 field trips from May 2009 to January 2011 using transects. We registered 725 individuals belonging to 50 different species: ten species of toads and frogs, one species of salamander, 21 species of lizards, 17 species of snakes, and one species of tortoise. A literature search increase the number of species/subspecies to 110, 18 are under special concern and 20 are threatened, in accordance to the NOM-059-SEMARNAT-2010. We expect to add to our species list by surveying in other areas, in different seasons, and at different times of the day, by increasing the number of registered species will help us determine more specifically the species parameters, as well as establish better management and conservation strategies for reptiles and amphibians.

Introduction

The Sierra Madre Oriental is a mountain range running North-South throughout eastern Mexico. This mountain system occupies an area of 160,220.4km^2, equivalent to about 8.2% of the country's territory (Mexico territorial extension=

1,964,375 km^2), and its altitude ranges between 200 and 3,600 meters above sea level (m.a.s.l.) (Luna *et al.*, 2004). Several regionalization systems of Mexico, based on both physical and biotic criteria, show the Sierra Madre Oriental to have unique geographical and biological diversity (Lazcano *et al.*, 2009). According Canseco-Marquez *et al.* (2004) reported for the Sierra Madre Oriental 207 species of amphibians and reptiles, distributed as follows: 44 anuran, 20 salamanders, 49 saurian, 88 snakes and 6 turtles.

Parque Nacional Cumbres de Monterrey is located on the Sierra Madre Oriental. This 177,395 ha study area, shows different topographical variation, a range of habitats, from submontane shrub to pine forests, and has an altitudinal gradient that ranges from 450 to 3,240 masl. These characteristics give to this park with unique climatic conditions suitable for observing an important number of species in this federal protected area (CONANP, 2006).

Mexican president Lázaro Cárdenas del Rio created the park "Parque Nacional Cumbres de Monterrey" on November 24, 1939 with an area of 246,500 ha; it was delimited again in the year 2000 and its size was reduced to 177,395ha. It was designated as a National Park on November 17, 2000 (CONANP, 2006). Because of its status as a national park, it is important to determine the number of amphibian and reptilian species in the protected natural area, as well as their altitudinal distribution, and associated plant communities.

Herpetological works have been performed near the study site, Martín del Campo (1953), Aseff-Martinez (1967)and Velasco-Torres (1970) the three authors studied the North, Center and South of Nuevo Leon and registered 93 species; Treviño-Saldaña (1978) registered 57 species in the South of Nuevo Leon; Vallejo-Gamero (1981) documents the distribution of rattlesnakes in the state. Inside "Parque Nacional Cumbres de Monterrey", Benavides-Ruiz (1987) registered 40 species in the municipality of Santiago, and Banda-Leal (2002) reported 44 species after the fire in the Chipinque Ecological. Today, Parque Nacional Cumbres de Monterrey is under strong anthropogenic impacts, such as changes in soil use for agriculture, water shortages, landscape deterioration, trash, urbanization, uncontrolled logging, livestock and forest fires (CONANP, 2006). Due to these impacts, it is important to understand how the herpetological composition of this natural protected area has changed throughout the years, even though there is a lack of historical records for the national park. Our main objective was to establish the present status of the herpetofauna and identify changes caused by anthropogenic that influence the relationship between the herpetofauna and a particular plant communities.

The number of possible species to be included in the sampling was determined by the non-parametric estimators Chao1, Jacknife 1 y ACE (Gotelli and Colwell, 2001), based on a field survey developed and represented in curves of species accumulation.

Material and Methods

Study sites

Parque Nacional Cumbres de Monterrey is located in the northern part of the Sierra Madre Oriental. It includes the municipalities of Allende, Monterrey, García, Montemorelos, Rayones, San Pedro Garza Garcia, Santa Catarina, and Santiago. The park is located between (25°37'55''N,

100°44'50''W) and (25°01'05''N, 99°56'05''W) with an elevation range of 520-3420masl (Ramirez-Hernandez and Masuch-Oesterreich, 2013). The park is located on the west-center zone of the state of Nuevo Leon, adjacent to the state of Coahuila. "Parque Nacional Cumbres de Monterrey" has a surface area of 177,395ha, and is composed mostly of mountains and mesetas (plateaus). The region contains a rich biodiversity from dry zones with species characteristic from desert areas, to scrublands and forests comprised mainly of pines and oaks in the highest parts (Fig. 1).

The area is divided into nine plant communities: submontaine scrubland, oak forest, oak-pine forest, pine-oak forest, pine forest, template *Abies* forest and *Juniperus* forest, gallery forest and crop-impacted areas (CONANP, 2006).

The representative species sampled for the submountainous scrubland community are Barreta (*Helietta parvifolia*), Texas Olive (*Cordia boissieri*), Ocotillo (*Fouquieria splendens*), Blackbrush (*Acacia rigidula*), Sweet Acacia (*Acacia farnesiana*), Honey Mesquite (*Prosopis glandulosa*), Giant Desert Palm (*Yucca filifera*), Carneros Yucca (*Yucca carnerosana*), Tree Choya (*Opuntia imbricata*), Tasajillo (*Opuntialepto caulis*), Lechuguilla (*Agave lechuguilla*) and Leatherstem (*Jatrophadioica*).

The oak forest's representative species are: Compton Mexican Loquat-leaf Oak (*Quercus rysophylla*), Live Oak (*Quercus virginiana*), Mexican White Oak (*Quercus polymorpha*), Lacey Oak (*Quercus laceyi*) and Canby Oak (*Quercu scanby*).

The species most abundant in the Pine forest are: Twisted-leaf Pine (*Pinus teocote*), White Pine (*Pinus pseudostrobus*), Mexican White Pine (*Pinus ayacahuite*), Garabatillo Pine (*Pinus greggii*), and Mexican Pinyon (*Pinus cembroides*). The area most impacted by agriculture, stockbreeding and settlements are inside this vegetal community.

Juniperus temperate forest is represented by species like the One-seed Juniper (*Juniperus monosperma*) and Alligator Juniper (*Juniperus. deppeana*).The *Abies* temperate forest is mainly composed of Vejar's Fir (*Abiesvejari*).

Gallery forests are located near rivers with permanent or semi-permanent flow. Some species in this area are: Willow (*Salix nigra*), Trembling Aspen (*Populus tremuloides*), Mexican Walnut (*Juglansmollis*), Mesquite (*Prosopis glandulosa*) and Oaks (*Quercus ssp*.).

Crop-impacted areas are included the areas with human interactions, like grazing areas, induced grasslands and burned-down areas.

The plant communities was determined at Parque Nacional Cumbres de Monterrey by their covering across the 450-3240 masl altitude gradients according to CONANP (2006) and corroborated by the field trips. Once these communities limits were established, were determined the transects which present a length of 1000m and 6m width using the sampling method described by Campbell and Christman (1982) which consists of walking through determining transect localizing, capturing and registering specimens. No specialized method was used to locate or collect herpetofauna (pitfall traps, funnel traps and drift fence), because soil was very shallow, instead specimens were captured using professional snake hooks and reptile tongs.

We performed 17 field trips in the study site in different location, with duration between

two and four days, between May 2009 and January 2011. The samples were taken between 700–1300 hours and 1400–1900, involving 11 man-hours of effort. The specimens were captured using halters, leather gloves and forceps and were carried in tagged cloth bags. We tried to inflict minimum harm to the microhabitat of the studied organisms, and we tried to return the objects providing coverage to their original positions. We identified the collected specimens according to the criteria established by Smith and Taylor (1966), Conant and Collins (1998), and according to the catalog published by The Society for the Study of Amphibian and Reptiles (SSAR). Common and scientific names are based on Liner and Casas-Andreu (2008).

We used non parametric estimators of diversity (Chao1 and Jacknife1) based on the Estimates program Ver. 7 (Colwell, 2004). These estimators determine the number of possible species in a sampled universe, based on the collecting effort and the species accumulation curves plotted (Gotelli and Colwell, 2001).

The wealth of species for every type of plant community was evaluated using the Shannon-Weiner index. This index considers the community as a finite sample and is sensitive to a change in the number of species (Halffter *et al.,* 2001). The Shannon-Weiner index acts under the assumption that samples are taken randomly from an immense population and all the populations are present in a single sample (Magurran, 2004).

Results and Discussion

Our herpetofaunistic inventory of the studied area found 50 species in 725 observed specimens and distributed as follows Amphibia: Anura, six families, nine genus, ten species; Caudata, one family, onegenus, one species; Reptiles: Sauria, six families, nine genus, 21 species; Serpentes, four families, 13 genus, 17 species and Testudines, one family, one genus, one species.

Using the not parametric estimators of variety of species (Jacknife 1 and Bootstrap) (Fig. 2), we obtained the expected wealth of species, giving the results for Jacknife 1= 69.65 and Bootstrap= 57.35. This suggests that the not parametric indicators have not yet reached the asymptote, and more samplings are required to achieve curve stability. A stable curve means that the sampling is representative and it is not possible to add more species.

The plant community with the greatest number of species was the pine forest, with 29, followed by the submountain shrub, with 21. Oak and pine-oak forest presented 17 species each. The community with the lowest number of species was the oak-pine forest with ten species, followed by human-impacted areas and *Abies* forest with five species each, and finally, the gallery forest and *Juniperus* forest presented only three species each. The diversity calculated by the Shannon-Weiner index for every plant community showed that the pine-oak forest presented the higher diversity index (H' 2.421), while the gallery forest presented the lowest index (H'1.04). The pine forest presented the largest number of rare species, with *Craugasto raugustiaugusti, Chiroptero tritonpriscus, Lepidophyma sylvaticum, Panthero phisbairdi, Thamno phisexsul,* and *Tropidodipsas sartoriisartorii;* and the submountainous shrub with four species: *Plestiodono bsoletus, Coluberschot tiruthveni, Gyalopioncanum* and *Micrurus tener*. The species with higher richness were *Sceloporus grammicus disparilis* (127 individuals) and *Sceloporus parvus* (76

individuals). The impacted area includes the agriculture lands we observed *Speamultiplicata, Sceloporus grammicus disparilis, S. goldmani, S. parvus* and *Thamnophis proximus diabolicus.*

The herpetofauna of the state of Nuevo Leon, based on literature and preserved collections, is comprised of 136 species (Lazcano *et al.*, 2010). In this study we registered 50 species for Parque Nacional Cumbres de Monterrey, which represents 36.76% of the total herpetofauna known for the state.

Of the 50 species registered during field trips, we add 60 species from scientific collections and previous papers by Martín del Campo (1953), Aseff-Martinez (1967), Velasco-Torres (1970), Treviño-Saldaña (1978), Vallejo-Gamero (1981), Benavides-Ruiz (1987), Banda-Leal (2002), Lazcano *et al.* (2010),thus increasing the number of species in the park to 110. It is worth mentioning that this research corroborates the presence of *Chiropterotriton priscus* in the park, having been previously recorded in San Antonio Peña Nevada (Lazcano *et al.*, 2004), Cerro El Potosí (Contreras-Lozano *et al.*, 2010) and in between these two localities.

The amphibian group *Chiropterotriton priscus* was only observed once in the pine forest at 2441 masl This species is only found in high elevations, between 1800–3400 masl (Lazcano *et al.*, 2004), and is highly dependent on the humidity generated by precipitation, hiding in crevices during the hot season, awaiting the rain (Lemos-Espinal and Smith, 2007). *Lithobates berlandieri*, on the other hand, was found in almost all the plant communities, from submountainous shrub to pine forest, which makes it likely that the conditions of humidity, temperature, food availability and altitude favor the success of this species. Contreras-Lozano *et al.* (2007) also report the presence of this species in different plant communities, from submountain shrub to oak forest in the Sierra de Picachos.

The reptilian group is the most widely represented, and species of the genus *Sceloporus* (*S. grammicus disparilis, S. torquatus binocularis and S.parvus*) were observed in most of the vegetable communities. This could be because the factors such as temperature, precipitation, and photoperiod during the dry and rainy seasons could favor the presence of this species in different environments (Ramírez-Bautista *et al.*, 2006; Lazcano *et al.*, 2009). Small species such as *Sceloporus goldmani, S. grammicus disparilis* and *S. parvus* were found in impacted areas. Their abundance here happens because open areas are favorable for ectothermic reptiles (Pianka, 1996), and the conditions favor species that prefer open areas and limit the populations of species that prefer dense vegetation (Lyon *et al.*, 2000).

The diversity presented by the Jacknife and Bootstrap nonparametric estimators showed that the cumulative curve did not attain stability by reaching the asymptote, so it is possible that, as more samplings are carried out, the list of species present in the "Parque Nacional Cumbres de Monterrey" would increase (Colwell and Coddington, 1994). The represented biodiversity parametric indexes were 71.78 % and 87.18 %. Not reaching the asymptote can be due to some species being rare, only observed once or twice. This fact is directly related to most of the estimator curves. Since the cumulative species curve does not reach the asymptote (Toti *et al.*, 2000) and so, more sampling is required.

Table.1 Species found in the different plant communities, altitudinal gradient and status of the species according to the Norma Oficial Mexicana of Parque Nacional Cumbres de Monterrey. Abbreviations: SC= Submontane scrubland, OF= Oak forest, OPF= Oak-pine forest, POF= Pine-oak forest, PF= Pine forest, FJ= Template forest *Juniperus*, FA= Template forest *Abies*, GF= Gallery forest, IA= Crop impacted areas. S= Status, Pr= Under concern, A= Threatened, E= Endemic to Mexico, Listed in literature= ○

	Plant community										
Species	SC	OF	OPF	POF	PF	FJ	FA	GF	IA	Altitude	S
Amphibia: Anura											
Bufonidae											
Anaxyrus cognatus○											
Anaxyrus debilis○											Pr
Anaxyrus punctatus○	X				X					778-2139	
Anaxyrus speciosus○											
Incilus nebulifer○				X						705-783	
Rhinella marina ○				X						717	
Craugastoridae											
Craugastor augusti○					X					2042	
Eleutherodactylidae											
Eleutherodactylus cystignathoides campi		X			X					1247-2212	
Eleutherodactylus guttilatus○											
Eleutherodactylus longipes					X		X			2209-2216	
Hylidae											
Ecnomiohyla miotympanum	X	X	X							1065-1076	
Smilisca baudinii		X	X							1867	
Leptodactylidae											
Leptodactylus fragilis○											
Microhylidae											
Gastrophryne olivácea○											Pr
Hypopachus variolosus○											
Ranidae											
Lithobates berlandieri○	X	X	X	X	X					759-2291	Pr
Scaphiopodidae											
Scaphiopus couchi○											
Spea multiplicata					X				X	1877-2134	
Amphibia: Caudata											
Plethodontidae											
Chiropterotriton priscus					X					2441	Pr
Reptilia: Squamata: Sauria											
Anguidae											
Barisia ciliaris											
Gerrhonotus infernalis○		X			X		X			2072-2256	Pr
Gerrhonotus parvus○		X								1640	Pr
Crotaphytidae											
Crotaphytus collaris○	X									836-957	A
Eublepharidae											

Coleonyx brevis○											Pr
Gekkonidae											
Hemidactylus turcicus○											
Phrynosomatidae											
Cophosaurus texanus scitulus○	X									447-953	A
Phrynosoma cornotum○											
Phrynosoma modestum○											
Phrynosoma orbiculare orientale○					X					2134-2249	A
Sceloporus cautus○											
Sceloporus couchii○	X	X			X					832-1615	
Sceloporus goldmani○					X				X	2185-2309	
Sceloporus grammicus disparilis○	X	X	X	X	X	X	X		X	848-2476	Pr
Sceloporus marmoratus○	X			X				X		474-819	
Sceloporus minor○					X					1300	
Sceloporus oberon○	X	X	X	X	X					1450-2412	
Sceloporus olivaceus○		X		X						683-904	
Sceloporus parvus○	X	X	X	X	X		X		X	917-2236	
Sceloporus poinsettia poinsetti○	X	X	X		X	X				946-2215	
Sceloporus samcolemani○											
Sceloporus serrifer cyanogenys○											
Sceloporus spinosus spninosus○											
Sceloporus undulates consobrinus○											
Sceloporus torquatus binocularis○	X	X	X	X	X	X	X			1247-2465	
Scincidae											
Plestiodon brevirostris○	X	X		X	X					1101-2075	
Plestiodon obsoletus○	X									1172	
Plestiodon tetragrammus○				X						735	
Scincella silvicola caudaequinae○		X	X	X	X			X		500-1506	A
Teiidae											
Aspidocelis scalaris gularis○	X			X						689-1497	
Xantusidae											
Lepidophyma sylvaticum					X					1188	Pr
Reptilia: Squamata: Serpentes											
Colubridae											
Adelphicos quadrivirgatum mewmanorum○											Pr
Amastridium sapperi○											
Arizona elegans elegans											
Bogertophis subocularis○											
Coluber constrictor oaxaca○											A
Coluber flagellum testaceus○											A
Coluber schotti○	X										

Coluber taeneatus○							
Diadophys punctatus regalis○							
Drymarchon melanurus erebennus○							
Drymobius margaritiferus margaritiferus○							
Ficimia streckeri○							
Gyalopion canum○	X					885	
Heterodon kennerlyi○							
Hypsiglena jani texana○	X					952-966	Pr
Lampropeltis alterna○							A
Lampropeltis getula○							A
Lampropeltis mexicana○							A
Lampropeltis triangulum○							A
Leptodeira septentrionalis○			X		X	488-887	
Leptophis mexicanus○							A
Nerodia erythrogaster transversa○							A
Nerodia rombifer blanchardi○							
Opheodrys aestivus○							
Oxybelis aeneus○							
Pantherophis bairdi○				X		1222	
Pantheophis emoryi○							
Pithuophis catenifer sayi○							
Pithuophis deppei jani○							A
Rhadinaea montana○							Pr
Rinocheilus lecontei○							
Salvadora grahamiae○	X			X		941-2266	
Senticolis triaspis○							
Sonora semianulata○							
Storeria dekayi texana○							
Storeria hidalgoensis○		X	X	X		1983-2237	
Tantilla atriceps○		X				1449	A
Tantillani griceps○							
Tantilla rubra							Pr
Tantilla wilcoxi○							
Thamnophis cyrtopsis cyrtopsis○	X		X			1063-2286	A
Thamnophis exsul○				X		1840	A
Thamnophis marcianus○							A
Thamnophis proximus○				X	X	1877-1881	A
Trimorphodon tau○							
Tropidodipsas sartorii				X		1574	Pr
Elapidae							
Micrurus tener	X					1637	Pr

Leptotyphlopidae						
Leptotyphlops dulcis○			X		689-691	
Leptotyphlops myopicus○						
Viperidae						
Agkistrodon taylori○						A
Crotalus atrox○						Pr
Crotalus lepidus lepidus○		X		X	1423-2314	Pr
Crotalus lepidus morulus○						Pr
Crotalus molossus molossus○						Pr
Crotalus molossus nigrescens		X		X	1800-2138	Pr
Crotalus pricei miquihuanus○						Pr
Crotalus scutulatus○						Pr
Crotalus totonacus○						Pr
Reptilia: Chelonia: Testudines						
Kinosternidae						
Kinosternon flavescens flavescens○						
Testudinidae						
Gopherus berlandieri	X				885	A

Figure.1 Study site of "Parque Nacional Cumbres de Monterrey", Nuevo Leon. Satellite Image of Nuevo León, Imagen of Parque Cumbres 2009 Cnes/Spot Imagen, Image 2009 DigitalGlobe, Image 2009 GeoEye

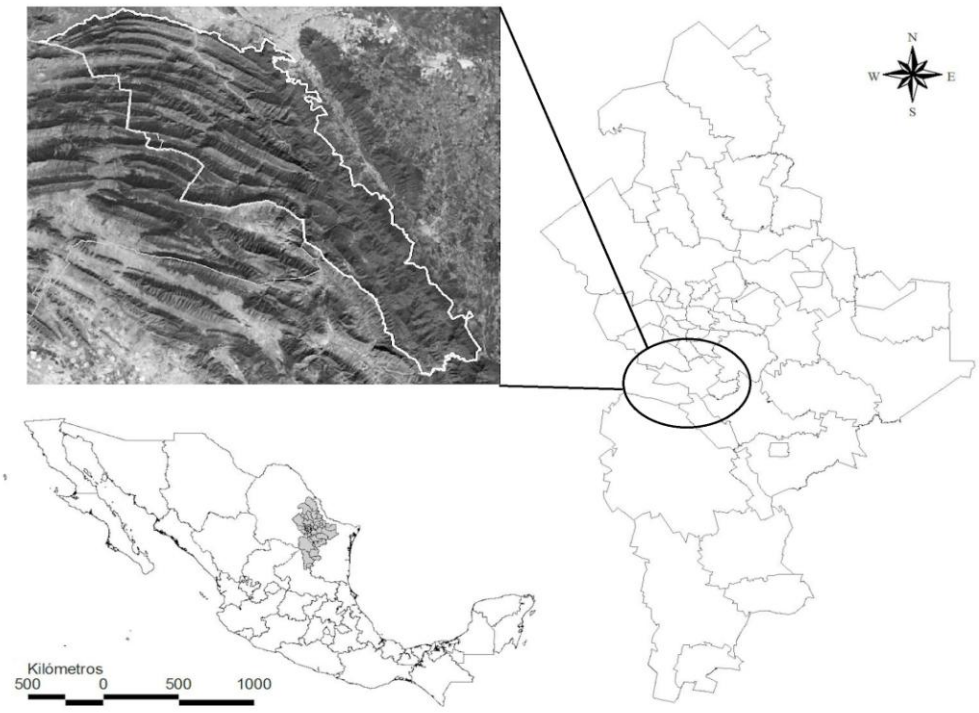
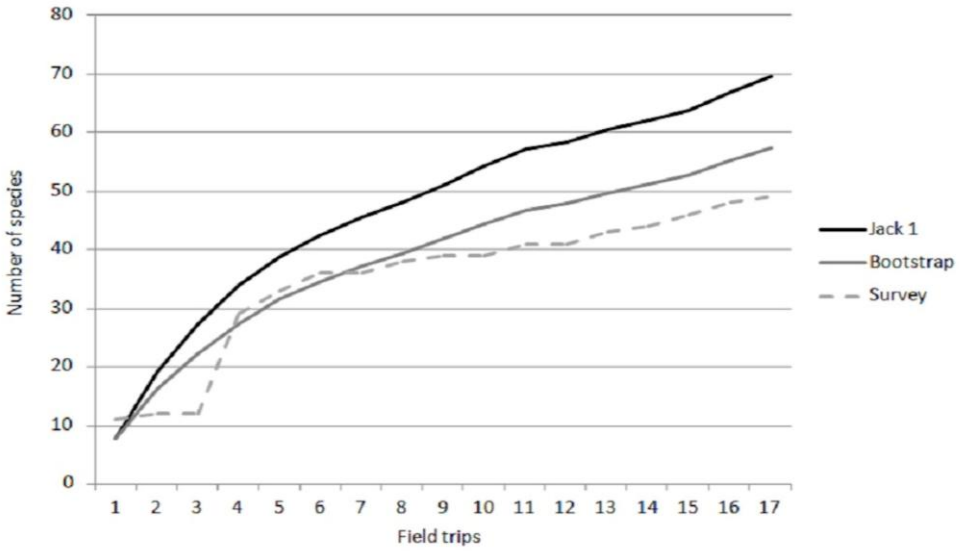


Figure.2 Species accumulation according estimators not parametric of Jacknife 1 and Bootstrap of Parque Nacional Cumbres de Monterrey



The Shannon-Wiener index showed that the pine-oak forest showed the greatest species diversity, while gallery forests where the least diverse. This difference in wealth of species can be explained by the fact that the pine forest represents a greater percentage of the park's area than gallery forests (CONABIO, 2006). It is worth mentioning that the oak forest and the submountane shrub presented high diversity values (H' 2.417 y H' 2.206 respectively). These types of plants communities are under a similar ecological focus as that shown by Contreras-Lozano *et al.* (2007), Lazcano *et al.* (2009) and Vite-Silva *et al.* (2010), indicating that the greatest species diversity from different groups is often found in submontane shrub communities and oak-pine forests. This shows that our findings agree with similar findings in these plant communities, as mentioned by Lazcano *et al.* (2006) and Contreras-Lozano *et al.* (2007).

Out of the 110 species, 38(35.2% of the registered herpetofauna) are listed on the Norma Oficial Mexicana, NOM-059-SEMARNAT-2010, (SEMARNAT, 2010) 18 species (16.36%) are under special protection (Pr) and 20species (18.18%) are considered threatened (A).

Twelve of the species listed in the NOM are considered endemic, but there should be 19 species add to this list, but were not consider in the NOM. In comparison, Canseco-Marquez *et al.* (2004) reported 59 endemic species in the entire extension of the Sierra Madre Oriental, and Lavin-Murcio and Lazcano (2009) reported 20 endemic species for the North Slope of the Sierra Madre. We registered 47.45% of the endemic species on the Sierra Madre Oriental's North Slope.

Nowadays the "Parque Nacional Cumbres de Monterrey" is subject to strong anthropocentric impacts, such as agriculture, water shortages, landscape deterioration, trash, urbanization, uncontrolled logging, cattle grazing, and forest fires (CONANP, 2006). These impacts particularly affect the snake population, because we only observed 17 of the 58 species (approximately 29.31%) previously reported by Lazcano *et al.* (2010). We learned, through personal

communication, that the people in the communities kill snakes whether they are poisonous or not, and so we think it is important to implement an education program focused on knowledge of reptiles and amphibians.

This work may hope to continue studying the herpetofauna at "Parque Nacional Cumbres de Monterrey". We expect to add to our species list by surveying in other areas, in different seasons, and at different times of the day, for example sampling at night to include nocturnal species, to increase the number of registered species. Increasing the number of registered species will help us determine more specifically the species parameters, as well as establish better management and conservation strategies for reptiles and amphibians.

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