THE HERPETOFAUNA OF AGUASCALIENTES, MÉXICO

RUBÉN ALONSO CARBAJAL-MÁRQUEZ[1, 3] AND GUSTAVO E. QUINTERO-DÍAZ[2, 3*]

[1]*Departamento de Conservación de la Biodiversidad. El Colegio de la Frontera Sur, Unidad Chetumal, Quintana Roo, México*
[2]*Departamento de Biología, Centro de Ciencias Básicas, Universidad Autónoma de Aguascalientes. México*
[3]*Conservación de la Biodiversidad del Centro de México, A.C. Aguascalientes, Aguascalientes, México.*
**Correspondent:gequintmxags@hotmail.com*

Abstract.—Aguascalientes is the state located in the center of Mexico, where different physiographic regions coincide, and contains 90 species of amphibians and reptiles with the inclusion of non-native species: 18 anurans, 3 salamanders, 3 turtles, 25 lizards and 41 snakes. In this study, we recognize six physiographic regions: *Semiarid Zone* containing 47 species, *Southern Grasslands* with 46 species, *Sierra El Laurel* with 56 species, *Calvillo Valley* with 44 species, *Sierra Fría* with 51 species, and *Northern Grasslands* with 29 species. We constructed a Coefficient of Biogeographic Resemblance (CBR) matrix in which the number of shared species ranges from 21 to 40. We used this CBR matrix to build a UPGMA dendrogram, which illustrates a higher resemblance between *Sierra El Laurel* and *Calvillo Valley*, which cluster with *Sierra Fría*. We allocated the Aguascalientes herpetofauna into four distributional categories, of which, the largest is comprised of the country endemics (44), followed by the non-endemics (40), non-natives (6), and finally, the state endemics (0). We examined the conservation status of native species by utilizing the SEMARNAT, IUCN, and EVS systems. The EVS proved to be the most useful system for assessing the conservation status of the herpetofauna of the state. The native species we placed in three vulnerability categories from low (24 species) to medium (38) to high (22). We applied the Relative Herpetofaunal Priority (RHP) method to determine the rank order based on endemic species and the number of EVS species assessed with high vulnerability. The two mountainous regions, the *Sierra Fría* and *Sierra El Laurel*, were determined to have the highest conservation priorities.

Keywords.—Conservation status; protected areas; amphibians; reptiles; Aguascalientes.

Resumen.— El estado de Aguascalientes está localizado en el centro de México, donde distintas regiones biogeográficas coinciden, y posee 90 especies de herpetofauna, incluyendo 18 anuros, 3 salamandras, 3 tortugas, 25 lagartijas y 41 serpientes, incluyendo las especies no nativas. Se reconocen seis regiones fisiográficas: *Zona Semiárida* con 47 especies, *Pastizales del Sur* 46 especies, *Sierra El Laurel* 56 especies, *Valle de Clavillo* 44 especies, *Sierra Fría* 51 especies y *Pastizales del Norte* con 29 especies. Se construyó una matriz de Coeficiente de Similitud Biogeográfica (CBR) en la cual el número de especies compartidas va de 21 a 40. Usamos estos datos para construir un dendrograma de UPGMA, el cual ilustra la mayor similitud entre la *Sierra El Laurel* y el *Valle de Calvillo* y los agrupa junto con *Sierra Fría*. Se ubicaron los miembros de la herpetofauna de Aguascalientes en cuatro categorías de distribución, y se obtuvo que el mayor número de especies consiste de especies endémicas a México (44), seguido por especies no endémicas (40), especies no nativas (seis) y endémicas al estado (0). Se examinó el *status* de conservación de las especies nativas utilizando tres sistemas: SEMARNAT, IUCN y EVS. El sistema EVS demostró ser el más útil para evaluar el *status* de conservación de la herpetofauna del estado, ya que incluye todas las especies en tres categorías de vulnerabilidad que incrementan de baja (24) a media (38) y disminuye en

la categoría alta (22). Se aplicó el método de Prioridad Relativa de Herpetofauna (RHP) para determinar el orden de rango de la herpetofauna regional dependiendo del número de especies endémicas a nivel estatal y nacional, y el número de especies en la categoría de alta vulnerabilidad en el sistema EVS, y se obtuvo que la *Sierra Fría* y *Sierra El Laurel* ocupan el lugar número uno en cada categoría, respectivamente.

Palabras clave.—Estado de conservación; áreas protegidas; anfibios; reptiles; Aguascalientes.

Introduction

Mexico is considered a mega-diverse country, which is especially true for its herpetofauna. There are as many as 1,240 species of amphibian and reptiles and well over half of them are endemic to the country (Wilson et al. 2013a, b). To date, the documented amphibian fauna of Mexico consists of 376 species (67% endemic), including 237 anurans, 2 caecilians, and 137 salamanders, which places Mexico with the 5th largest number of amphibians in the world after Brazil, Colombia, Ecuador and Peru (Alvarado-Díaz et al. 2013; Wilson et al. 2013b; Parra-Olea et al. 2014). Respect to the reptiles, contain 864 species (57% endemic), including 813 squamates, 48 turtles, and 3 crocodylians, placing Mexico as the second largest reptile fauna, after Australia (Wilson et al. 2013a; Flores-Villela and García-Vázquez 2014).

Aguascalientes is the fifth smallest state in Mexico, with an area of 5,680.33 km², which represents 0.3% of the country´s land surface. The state is located in the center of the country between latitudes 22°27′ and 21°28′ N, and longitudes 101°53′ and102°52′ W. It borders the state of Zacatecas to the north, east and west and Jalisco to the south and east. The state of Aguascalientes exhibits a wide variety of landscapes within its territory with major influences from the southern Sierra Madre Occidental and Central Mexican Plateau. In the northwest portion of the state is the Sierra Fría, which has the highest elevation in the state at 3,050 m. In the southwest of the state is the valley of the Calvillo River containing the lowest elevation of the state at 1,540 m. The eastern half of the state is dominated by semiarid grasslands and the agricultural activities on the Mesa Central. In the central part of the state is Aguascalientes Valley, which is 92 km long, runs the length of the state in a north-south direction, ranges from 1,860 to 2,000 m in elevation, and is home to the Aguascalientes City (Esparza-Juarez 2008).

In order to make an assessment of the conservation status of the herpetofauna of Aguascalientes, an effort has been made to complete an accurate accounting of the distribution and species composition (species richness) of the state (see below). In this study, we update the list of amphibians and reptiles in Aguascalientes, analyze their distribution between the different physiographic regions, and use various measures to assess their conservation status in order to provide recommendations to assist the current conservation efforts in the state.

Material and Methods

Sampling Procedures

We conducted fieldwork in all 11 municipalities of Aguascalientes from 2004 to 2015, representing all of the state's physiographic provinces, with significant attention paid to poorly sampled areas. This effort was part of the "Anfibios y Reptiles del Altiplano Mexicano" project undertaken by the Biology Laboratory of the Universidad Autónoma de Aguascalientes (UAA) and the "Herpetofauna del Estado de Aguascalientes" project undertaken by the non-governmental organization Conservación de la Biodiversidad del Centro de México (BIODIVERSIDAD A.C.) and the Biology Laboratory of the Universidad Autónoma de Aguascalientes (UAA). During each visit, we used visual encounter surveys to locate amphibians and reptiles during the day and night, which included road surveys at sunset and early evening hours. This work was conducted under scientific collecting permits (SEMARNAT- SGPA/DGVS/05143/14 and SGPA/DGVS/03079/16) and used the collection techniques described by Casas et al. (1991). In cases where we could not identify individuals directly in the field, they were collected and subsequently deposited in the herpetological collections of UAA. We identified specimens using taxonomic keys and other information provided in Duellman (2001) and Flores-Villela et al. (1995), and updated scientific names following Wilson et al. (2013 a, b).

Updating the Herpetofauna List

In addition to specimens recorded during fieldwork, we used records from several scientific collections available on VertNet. Additionally, we included records for Aguascalientes from McCranie and Wilson (2001), Vázquez-Díaz and Quintero-Díaz (1997; 2005), Quintero-Díaz et al. (2008a, b), the journals *Check List, Herpetological Review, Herpetology Notes, Revista Mexicana de Biodiversidad* (Carbajal-Márquez et al. 2011; Arenas-Monroy et al. 2014; Quintero-Díaz et al. 2014a, b; Carbajal-Márquez and Quintero-Díaz 2015; Carbajal-Márquez et al. 2015a, b; Carbajal-Márquez and Quintero-Díaz In Press; Quintero-Díaz et al. 2015; Quintero-Díaz and Carbajal-Márquez In Press; Quintero-Díaz et al. 2016) and otherwise posted at the IUCN Red List website. We follow the taxonomy used in Wilson (2013a, b), with the exception of the recently described *Sceloporus aurantius* and the taxonomic change of *S. scalaris brownorum* to *S. brownorum* (Bryson et al. 2012; Grummer and Bryson 2014), *Lampropeltis triangulum* to *Lampropeltis polyzona* (Ruane et al. 2014), *Pseudoeurycea bellii* to *Isthmura bellii* (Rovito et al. 2015).

System for Determining Conservation Status

We used the same systems as Alvarado-Díaz et al. (2013) and Mata-Silva et al. (2015) to assess the conservation status of the herpetofauna of Aguascalientes (SEMARNAT, IUCN and EVS).

The SEMARNAT system, established by the Secretaría de Medio Ambiente y Recursos Naturales, employs three categories: Endangered (P), Threatened (A), and Subject to Special Protection (Pr) (Diario Oficial de la Federación 2010). For species not assessed by this system, we use the designation "No Status."

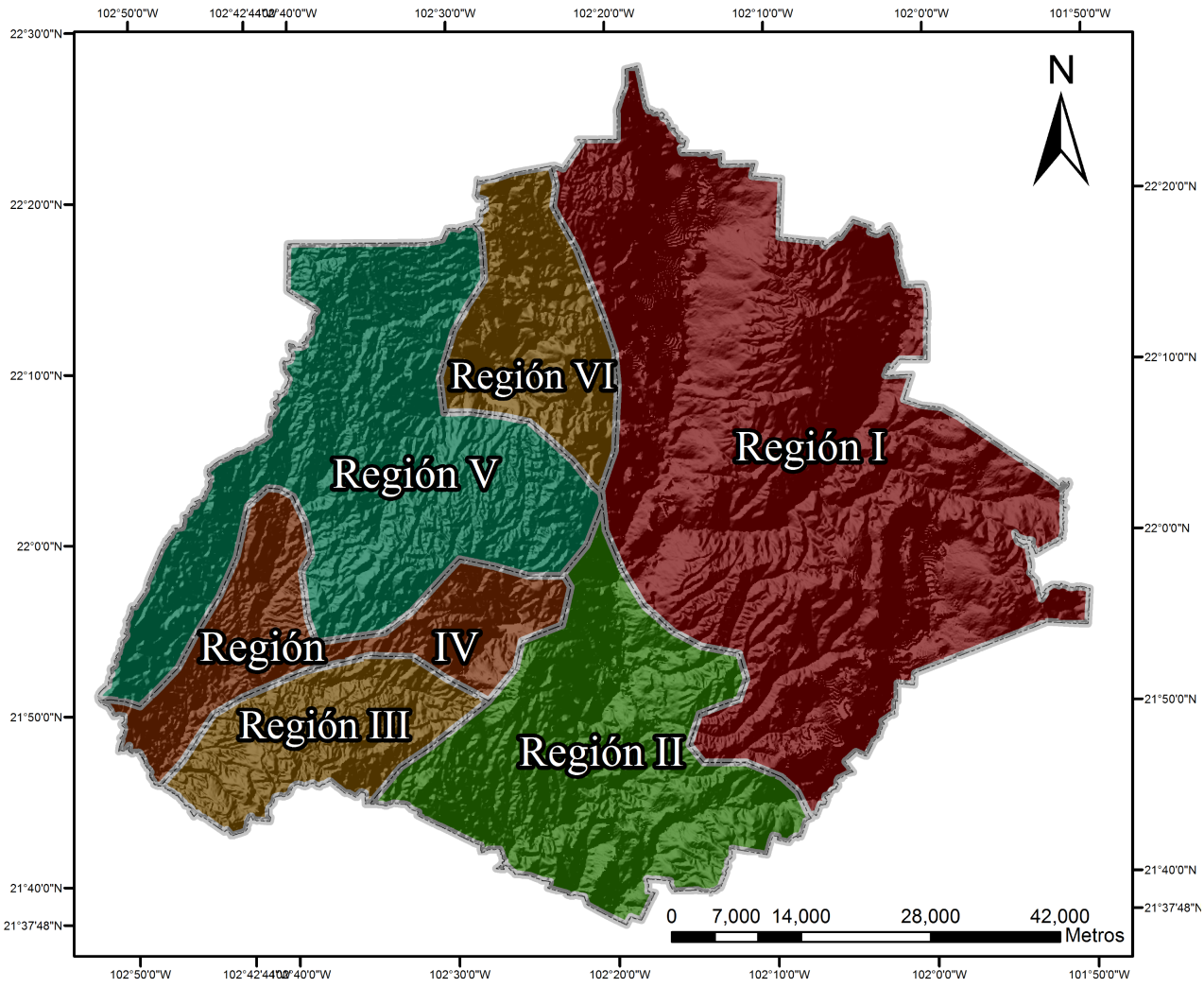

Figure. 1. Physiographic regions in Aguascalientes, Mexico, from Vázquez-Díaz and Quintero-Díaz (2005).

The IUCN system is utilized widely to assess the conservation status of species on a global basis. The categories used are: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE). The categories Critically Endangered, Endangered, and Vulnerable collectively are termed "threat categories," to distinguish them from the other six.

The EVS system was developed initially for use in Honduras by Wilson and McCranie (2004), and subsequently was used in several chapters on Central American countries (Wilson et al. 2010). Wilson et al. (2013a, b) modified this system and explained its use for the amphibians and reptiles of Mexico, and we follow their prescriptions. The EVS measure is not designed for use with marine species (e.g., marine turtles and sea snakes), and generally is not applied to non-native species.

System for Determining Distributional Status

For establishing the distributional ranges of the members of the Aguascalientes herpetofauna, we used the system developed for the herpetofauna of Michoacán by Alvarado-Diaz et al. (2013), which was subsequently used by Mata-Silva et al. (2015), Johnson et al. (2015) and Terán-Juárez et al. (2016). This system is composed of the following four categories: SE = endemic to state; CE = endemic to Mexico; NE = not endemic to Mexico; NN = non-native in Mexico.

Coefficient of Biogeographic Resemblance

To examine the herpetofaunal relationships among the six physiographic provinces in Aguascalientes, we constructed a Coefficient of Biogeographic Resemblance (CBR) matrix (Duellman 1990). The formula for this algorithm is CBR = 2C/N1 + N2, where C is the number of species in common to both provinces, N1 is the number of species in the first province, and N2 is the number of species in the second province.

Relative Herpetofaunal Priority

We determine the Relative Herpetofaunal Priority (RHP) for Aguascalientes by constructed two informative matrix, one for the endemicity values and the other for the EVS values. For a detailed description of the RHP see Johnson et al. (2015).

Physiographic Regions

The physiography of the state is composed of three main provinces: Sierra Madre Occidental, Mesa Central, and Faja Volcánica Transmexicana. Overall, approximately 80% of the state contains a homogenous landscape, however, under a closer examination, one discovers a more subtle mosaic of landscapes, particularly in its western portion, where the main mountain ranges are located. Based on the publications of SPP (1981), De la Cerda (1999a, b); De la Cerda-Lemus (2008), García-Regalado (2008), Rosales-Carrillo (2008), Siqueiros-Delgado (1999; 2008) and Vázquez-Díaz and Quintero-Díaz (2005), the state has been divided in six main regions, based on the types of dominant vegetation and physiographic features. The regions are: *Region 1–Semiarid Zone; Region 2–Southern Grasslands; Region 3–Sierra El Laurel; Region 4–Calvillo Valley; Region 5–Sierra Fría;* and *Region 6–Northern Grasslands* (Fig. 1). For a detailed description of the six regions see Vázquez-Díaz and Quintero-Díaz (2005).

Climate

Aguascalientes is located at the northern tropical zone of Mexico, where twice a year the sun's rays are directly overhead and temperatures are high. The annual mean high temperature is 26.3°C compared to the annual mean low temperature of 10.6°C (INEGI 2008). Annual mean rainfall is between 400-800mm. Because the altitude of the state ranges from 1540 to 3050 m, there is variation in the climate. For instance, in the lower elevations of the municipality of Calvillo, annual average temperatures range between 20°C and 22°C, while in the peaks of the Sierra Fría, the annual average temperatures range between 16°C and 18°C. Moreover, the remoteness of Aguascalientes from large water bodies influences the amplitude of the daily and seasonal temperature variation, so

Table 1. Range of annual average temperature (°C), precipitation (mm), and climate (Köppen modified by García 2004) for the physiographic regions of Aguascalientes, Mexico. Data taken from INEGI (2008).

Physiographic Region	Temperature	Precipitation	Climate
1	14-18	400-500	BS1kw
2	16-20	500-600	BS1hw(w), BS1kw(w)
3	14-18	700-800	C(w0), C(w1)
4	18-22	600-700	BS1hw(w)
5	12-16	700-800	C(w0), C(w1)
6	16-18	500-600	BS1kw

in general, the climate fluctuates more greatly compared to coastal states (Table 1), (INEGI 2008).

Results

Herpetofauna

The list reported here includes 90 species of amphibians and reptiles for the Aguascalientes State (21 amphibians and 69 reptiles). This increases the list of species by 13 (16.8%) over the number reported by Quintero-Díaz et al. (2008a, b). The number of species occurring in Aguascalientes is 7.2% of the total herpetofauna in Mexico base on the most updated accounts (Flores-Villela and García-Vázquez 2014; Parra-Olea et al. 2014; Table 2). Of the amphibians, 18 are anurans (85.7%), including the non-native *Rhinella marina* and *Lithobates catesbeianus*, and three are salamanders (14.3%). Of the reptiles, 66 are squamates (95.6%), including the non-native *Hemidactylus frenatus*, *H. turcicus* and *Indotyphlops braminus*, and three are turtles (4.4%), including the non-native *Trachemys scripta*.

Families

The herpetofauna of Aguascalientes (90 species) is classified into 24 families (42.8% of the number in Mexico). For the amphibians, 21 species are classified in nine (56.2%) of the 16 families known that occur in Mexico (Parra-Olea et al. 2014; Table 2). The 69 species of reptiles are classified in 15 (37.5%) of the 40 families known that occur in Mexico (Flores-Villela and García-Vázquez 2014; Table 2).

Genera

The herpetofauna of Aguascalientes is represented by 50 genera (23.6% of the 212 known from Mexico; Table 2) with amphibians classified into 12 genera (22.6% of the 53 known from Mexico) and reptiles in 38 genera (23.9% of 159 known from the country). The largest amphibian genus is *Lithobates* (four native species and one non-native). The largest reptile genus is *Sceloporus* (11 species).

Species

The state of Aguascalientes is home of 21 species of amphibians which represents 5.5% of the total amphibians of Mexico (Table 2). Anurans are represented in the state by 18 species

Table 2. Taxonomic composition of the amphibians and reptiles of Mexico and the state of Aguascalientes. In each column, the number to the left is that indicated in Flores-Villela and García-Vázquez (2014) and Parra-Olea et al. (2014) for the country of Mexico; the number to the right is that recorded in this study for the state of Aguascalientes. These numbers include the non-native taxa.

Taxa	Families	Genera	Species
Anura	11/7	36/10	237/18
Caudata	4/2	16/2	137/3
Gymnophiona	1/0	1/0	2/0
Subtotal	16/9	53/12	376/21
Squamata	28/13	138/36	813/66
Testudines	10/2	19/2	48/3
Crocodylia	2/0	2/0	3/0
Subtotal	40/15	159/38	864/69
Total	**56/24**	**212/50**	**1240/90**

(7.6% of total anurans of Mexico), while salamanders are represented by 3 species (2.2% of total salamanders of Mexico). México is inhabited by 864 species of reptiles, of which, 69 (7.9%) occur in Aguascalientes. Of these, squamates (8.1% of 813 Mexican species) are proportionately better represented than turtles (6.2% of 48 species) including the non-native species.

Patterns of Physiographic Distribution

Of the 90 species recorded for the state, 25 (27.7%, 5 amphibians and 20 reptiles) are limited to a single physiographic region. Of the species found in two or more regions, 20 (22.2 %, 4 amphibians and 16 reptiles) are known from two regions, 11 (12.2%, 3 amphibians and 8 reptiles) from three, 11 (12.2%, 2 amphibians and 9 reptiles) from four, 7 (7.7 %, 2 amphibians and 5 reptiles) from five, and 16 (17.7%, 5 amphibians and 11 reptiles) from all six regions. In both amphibians and reptiles, the number of species from one or more region decreases as more regions are occupied, with the exception of their presence in all six regions. The species found across all the physiographic regions tend to be widely distributed across Mexico (*Anaxyrus punctatus, Hyla arenicolor, H. eximia, Lithobates montezumae, Spea multiplicata, Sceloporus grammicus, S. torquatus, Aspidoscelis gularis, Conopsis nasus, Pituophis deppei, Trimorphodon tau, Diadophis punctatus, Thamnophis eques, Thamnophis melanogaster, Crotalus*

Figure 2. *Kinosternon integrum* (Mexican Mud Turtle) is endemic to México, its EVS is 11 (medium vulnerability category). Its conservation status has been assessed as Least Concern (LC) by IUCN, and Special Protection (Pr) species by SEMARNAT. Photo by Gustavo E. Quintero-Díaz.

molossus and *Kinosternon integrum*; Fig. 2) (Table 3).

The total number of species among the six regions ranges from 29 in the Northern Grasslands (Region 6) to 56 in the Sierra El Laurel (Region 3), but variations in the number of species between regions are not drastic. For instance, the Sierra Fría (Region 5) possesses 51 species, so both *Sierras* have a high number of species and deserve conservation attention (Table 4). Of considerable conservation significance is that almost 50% of the species in the state are confined to one or two of the six physiographic provinces. Anurans are best represented in both the Sierra El Laurel (Region 3; 13 species) and the Southern Grasslands (Region 2; 13 species). The Southern Grasslands and Semiarid Zone (Region 1) are home of *Smilisca dentata* (Upland Burrowing Tree-frog) (Fig. 3), a species almost endemic to these portions of the state, so these regions are deserving of conservation attention. Salamanders are best represented in both the Sierra El Laurel (Region 3; 2 species) and the Sierra Fría (Region 5; 2 species).

Reptiles are best represented in the Sierra El Laurel (Region 3; 41 species) and the Sierra Fría (Region 5; 39 species). This same pattern follows for lizards, which are also best represented in both the Sierra El Laurel (Region 3; 15 species) and the Sierra Fría (Region 5; 14 species). The Sierra El Laurel is home to *Sceloporus aurantius*, a species endemic to a small area, with only three known localities: one located at the Aguascalientes and Jalisco border and two in Zacatecas (Grummer and Bryson 2014; Carbajal-Márquez and Quintero-Díaz 2015; Fig. 4). The representation of snakes is more homogeneous, with four regions with high numbers of species: the Semiarid Zone (Region 1; 24 species), the Sierra El Laurel (Region 3; 24 species), the Calvillo Valley (Region 4; 24 species) and the Sierra Fría (Region 5; 24 species). Finally, turtles are best represented in the Southern Grasslands (Region 2; 3 species),

Figure 3. *Smilisca dentata* (Upland Burrowing Tree-Frog) is a near endemic to the state and endemic to México, its EVS is 14, placing it in the high vulnerability category. Its conservation status has been assessed as Endangered (EN) by IUCN, and threatened (A) species by SEMARNAT. Photo by Gustavo E. Quintero-Díaz.

Figure 4. *Sceloporus aurantius* (Southern Occidental Bunchgrass Lizard) is endemic to the region and endemic to México, its EVS is 14, placing it in the high vulnerability category. Its conservation status has not been evaluated (NE) by IUCN, and not assessed (NS) by SEMARNAT. Photo by Gustavo E. Quintero-Díaz.

Table 3. Distribution of the native and non-native amphibians and reptiles of Aguascalientes, Mexico, by physiographic region. Abbreviations: RA = Rare; AB = Abundant and CO = Common. * = non-native to Aguascalientes and ** = non-native to Mexico. In parentheses, number of species by taxon.

Taxa	Physiographic Regions					
	1	2	3	4	5	6
Amphibia (21)						
Anura (18)						
Bufonidae (5)						
Anaxyrus cognatus	RA	RA				RA
Anaxyrus compactilis	RA	AB				
Anaxyrus punctatus	RA	RA	CO	CO	CO	AB
Incilius occidentalis		RA	CO	CO	RA	
*Rhinella marina**	RA					
Craugastoridae (2)						
Craugastor augusti	RA	RA	RA	RA	RA	
Craugastor occidentalis			RA			
Eleutherodactylidae (1)						
Eleutherodactylus nitidus			RA	RA	RA	RA
Hylidae(3)						
Hyla arenicolor	CO	AB	AB	AB	AB	AB
Hyla eximia	AB	AB	AB	AB	AB	AB
Smilisca dentata	RA	RA				
Microhylidae (1)						
Hypopachus variolosus		AB	AB	CO	RA	RA
Ranidae (5)						
*Lithobates catesbeianus**					AB	
Lithobates magnaocularis			RA			
Lithobates montezumae	AB	AB	AB	AB	AB	AB
Lithobates neovolcanicus		RA	RA	RA		
Lithobates psilonota		RA	RA			
Scaphiopodidae (1)						
Spea multiplicata	AB	AB	RA	CO	RA	RA
Caudata (3)						
Ambystomatidae (2)						
Ambystoma rosaceum					RA	
Ambystoma velasci	RA	RA	RA			
Plethodontidae (1)						
Isthmura bellii			RA		RA	

Taxa	Physiographic Regions					
	1	2	3	4	5	6
Reptilia (69)						
Squamata (66)						
Anguidae (3)						
Barisia ciliaris					CO	
Elgaria kingii			CO			
Gerrhonotus liocephalus		RA	RA	RA	RA	
Dactyloidae (1)						
Anolis nebulosus		RA	CO	CO	CO	RA
Gekkonidae (2)						
*Hemidactylus frenatus***		RA				
*Hemidactylus turcicus***		RA				
Iguanidae (1)						
Ctenosaura pectinata			AB	AB	RA	
Phrynosomatidae (16)						
Holbrookia approximans	RA					RA
Phrynosoma cornutum	RA					RA
Phrynosoma modestum	RA					
Phrynosoma orbiculare	RA	RA	CO		CO	
Sceloporus aurantius			AB			
Sceloporus brownorum					AB	
Sceloporus clarkii			RA	RA		
Sceloporus goldmani	AB					
Sceloporus grammicus	RA	RA	AB	RA	AB	AB
Sceloporus horridus			AB	AB	AB	
Sceloporus jarrovii			AB		AB	RA
Sceloporus minor	AB					
Sceloporus scalaris					CO	
Sceloporus spinosus	CO	CO	RA			AB
Sceloporus torquatus	RA	CO	AB	AB	AB	AB
Urosaurus bicarinatus			CO	CO	CO	
Scincidae (1)						
Plestiodon lynxe	RA		CO		CO	CO
Teiidae (1)						
Aspidoscelis gularis	AB	AB	CO	AB	RA	AB

Taxa	Physiographic Regions					
	1	2	3	4	5	6
Colubridae (20)						
Arizona elegans	RA					
Coluber bilineatus		RA	RA	RA	RA	RA
Coluber flagellum	RA	RA				
Coluber mentovarius	RA	RA	RA	RA	RA	RA
Coluber taeniatus	RA					
Conopsis nasus	CO	CO	AB	RA	AB	RA
Drymarchon melanurus		RA	RA	RA	RA	
Lampropeltis mexicana	RA		RA		RA	
Lampropeltis polyzona		RA		RA		
Oxybelis aeneus			RA	RA		
Pantherophis emoryi	RA					
Pituophis catenifer	RA					
Pituophis deppei	CO	RA	RA	RA	RA	RA
Rhinocheilus lecontei				RA		
Salvadora bairdi	RA		RA	RA	CO	
Senticolis triaspis			CO	CO	RA	
Sonora mutabilis				RA		
Tantilla bocourti			RA		RA	
Tantilla wilcoxi	RA	RA				
Trimorphodon tau	RA	RA	RA	RA	RA	RA
Dipsadidae (5)						
Diadophis punctatus	RA	RA	RA	RA	RA	RA
Geophis dugesii			RA	RA	RA	
Heterodon kennerlyi	RA	RA				
Hypsiglena jani	RA	RA		RA	RA	RA
Rhadinaea hesperia			RA			
Elapidae (1)						
Micrurus distans			RA	RA		
Natricidae (6)						
Storeria storerioides	RA		RA			
Thamnophis cyrtopsis	RA	RA	CO	CO	CO	
Thamnophis eques	CO	CO	CO	CO	CO	CO
Thamnophis melanogaster	RA	RA	RA	RA	RA	RA
Thamnophis pulchrilatus			CO		CO	
Thamnophis scaliger	RA				RA	
Typhlopidae (1)						
Indotyphlops braminus **		RA	RA	RA		

Taxa	Physiographic Regions					
	1	2	3	4	5	6
Viperidae (8)						
Crotalus aquilus	RA	RA	RA			
Crotalus atrox	RA					
Crotalus basiliscus				RA	RA	
Crotalus lepidus					AB	
Crotalus molossus	CO	CO	CO	CO	CO	CO
Crotalus polystictus		RA	RA	RA	RA	
Crotalus pricei					RA	
Crotalus scutulatus	RA	RA		RA	RA	
Testudines (3)						
Kinosternidae (2)						
Kinosternon hirtipes		RA				RA
Kinosternon integrum	AB	AB	AB	AB	AB	AB
Emydidae (1)						
*Trachemys scripta**		RA	RA			

although *Trachemys scripta* is a non-native species in Aguascalientes.

The distribution of the 21 native species confined to a single region (Table 3), are all more broadly distributed outside the state where that region borders adjacent states. Within Aguascalientes, the following eight species occur only within the Semiarid Zone (Region 1): *Phrynosoma modestum*, *Sceloporus goldmani*, *Sceloporus minor*, *Arizona elegans*, *Coluber taeniatus*, *Pantherophis emoryi*, *Pituophis catenifer* and *Crotalus atrox*. There are five species limited to the Sierra El Laurel (Region 3): *Craugastor occidentalis*, *Lithobates magnaocularis* (Fig. 5), *Elgaria kingii*, *Sceloporus aurantius* and *Rhadinaea hesperia*. In the Calvillo Valley (Region 4), two species are confined to this region: *Rhinocheilus lecontei* (Fig. 6) and *Sonora mutabilis*. And in the Sierra Fría (Region 5), there are six species: *Ambystoma rosaceum* (Fig. 7), *Barisia ciliaris*, *Sceloporus brownorum*, *Sceloporus scalaris*, *Crotalus lepidus* and *Crotalus pricei*. Finally, there are no species limited to the Southern Grasslands (Region 2) and Northern Grasslands (Region 6).

Figure 5. *Lithobates magnaocularis* (Northwest Mexico Leopard Frog) is endemic to México, its EVS is 12, placing it in the medium vulnerability category. Its conservation status has been evaluated as Least Concern (LC) by IUCN, and not assessed (NS) species by SEMARNAT. Photo by Gustavo E. Quintero-Díaz.

Table 4. Summary of the distributional occurrence of families of amphibians and reptiles in Aguascalientes by physiographic region.

Families	Number of Species	Distributional Occurrence					
		1	2	3	4	5	6
Bufonidae	5	4	4	2	2	2	2
Craugastoridae	2	1	1	2	1	1	—
Eleutherodactylidae	1	—	—	1	1	1	1
Hylidae	3	3	3	2	2	2	2
Microhylidae	1	—	1	1	1	1	1
Ranidae	5	1	3	4	2	2	1
Scaphiopodidae	1	1	1	1	1	1	1
Subtotals	**18**	**10**	**13**	**13**	**10**	**10**	**8**
Ambystomatidae	2	1	1	1	—	1	—
Plethodontidae	1	—	—	1	—	1	—
Subtotals	**3**	**1**	**1**	**2**	—	**2**	—
Totals	**21**	**11**	**14**	**15**	**10**	**12**	**8**
Emydidae	1	—	1	1	—	—	—
Kinosternidae	2	1	2	1	1	1	2
Subtotals	**3**	**1**	**3**	**2**	**1**	**1**	**2**
Anguidae	3	—	1	2	1	2	—
Dactyloidae	1	—	1	1	1	1	1
Gekkonidae	2	—	2	—	—	—	—
Iguanidae	1	—	—	1	1	1	—
Phrynosomatidae	16	9	4	9	5	8	6
Scincidae	1	1	—	1	—	1	1
Teiidae	1	1	1	1	1	1	1
Subtotals	**25**	**11**	**9**	**15**	**9**	**14**	**9**
Colubridae	20	12	9	11	12	10	5
Dipsadidae	5	3	3	3	3	3	2
Elapidae	1	—	—	1	1	—	—
Natricidae	6	5	3	5	3	5	2
Typhlopidae	1	—	1	1	1	—	—
Viperidae	8	4	4	3	4	6	1
Subtotals	41	24	20	24	24	24	10
Totals	69	36	32	41	34	39	21
Sum Totals	90	47	46	56	44	51	29

The greatest degree of resemblance occurs between the adjacent Sierra El Laurel (Region 3) and Calvillo Valley (Region 4), with 38 species shared and a CBR value of 0.76 (Table 5). While there is a distinct elevation difference between the two regions, the contact favors an altitudinal gradient distribution of species (Fig 1). Similarly, the adjacent Sierra Fría (Region 5) and Calvillo Valley (Region 4) share 36 species and a CBR value of 0.75. The two mountainous regions (Regions 3 and 5) share 40 species with a CBR value of 0.74. As expected, there is a large of degree of resemblance between the Semiarid Zone (Region 1) and Southern Grasslands (Region 2) (31 species; CBR value of 0.67), due to their wide contact area, which forms a gradient from a semiarid to more humid area. Similarly, there is a large degree of resemblance between the Southern Grasslands (Region 2) and Calvillo Valley (Region 4), which share 30 species and a CBR value of 0.66. The lowest degree of resemblance occurs between Semiarid Zone (Region 1) and Calvillo Valley (Region 4), with 21 shared species and CBR value of 0.46 (Table 5).

Figure 6. *Rhinocheilus lecontei* (Long-Nosed Snake) is not endemic to México, its EVS is 8, placing it in the low vulnerability category. Its conservation status has been evaluated as Least Concern (LC) by IUCN, and not assessed (NS) species by SEMARNAT. Photo by Gustavo E. Quintero-Díaz.

Figure 7. *Ambystoma rosaceum* (Tarahumara Salamander) is endemic to México, its EVS is 14, placing it in the high vulnerability category. Its conservation status has been evaluated as Least Concern (LC) by IUCN, and assessed as Special protection (Pr) species by SEMARNAT. Photo by Gustavo E. Quintero-Díaz.

Based on the data in Table 5, we constructed a UPGMA dendrogram to easily visualize the overall herpetofaunal resemblance patterns among the six physiographic regions in hierarchical manner (Fig. 8). The general patterns from the UPGMA data indicate that the higher elevation habitats (SL and SF), and the elevational gradient formed with the Calvillo Valley, contains more species than the regions containing lower elevations and drier habitats. In addition, the heterogeneity of habitat in these three regions influences species richness.

Distributional Status

Including all amphibians and reptiles (90 species) from Aguascalientes, the largest category (44, 48.8%) are those endemic to Mexico, followed by the non-endemics to the country (40, 44.4%), and the non-natives

Table 5. CBR matrix of the native herpetofaunal relationships for the six physiographic regions in Aguascalientes, Mexico. Above the diagonal, values represent the shared species. Below the diagonal, values represent the CBR index. Total species in bold. See *Physiographic regions* for a more detailed explanation.

Physiographic Regions	1	2	3	4	5	6
1	**47**	31	27	21	25	23
2	*0.67*	**46**	32	30	29	24
3	*0.52*	*0.63*	**56**	38	40	24
4	*0.46*	*0.66*	*0.76*	**44**	36	22
5	*0.51*	*0.59*	*0.74*	*0.75*	**51**	24
6	*0.6*	*0.64*	*0.56*	*0.6*	*0.6*	**29**

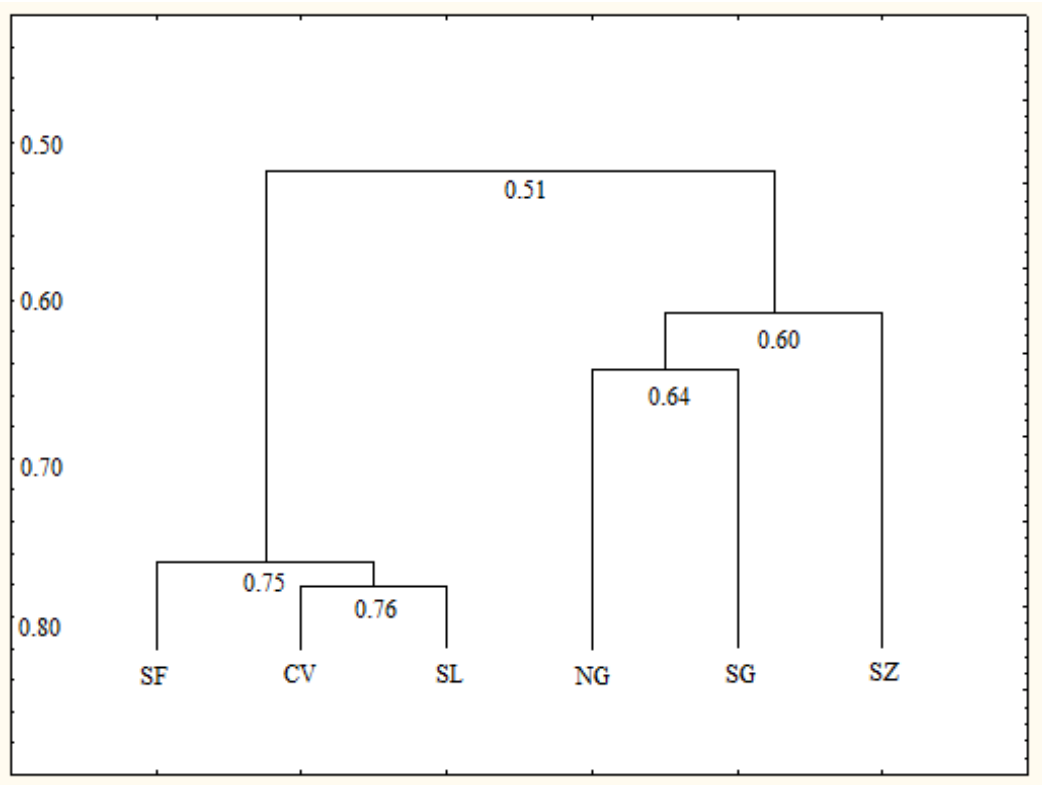

Figure 8. A UPGMA generated dendrogram illustrating the relationships of species richness among the herpetofauna of the six physiographic regions of Aguascalientes (based on data in Table 5).

to the state (6, 6.6%). The non-native species include the amphibians *Rhinella marina* and *Lithobates catesbeianus* and the reptiles *Hemidactylus frenatus, H. turcicus, Indotyphlops braminus* and *Trachemys scripta* (Table 6).

The non-endemic species category is comprised of seven anurans (17.5% of 40), one salamander (2.5%), nine lizards (22.5%), 21 snakes (55%) and one turtle (2.5%). The country endemic species category consists of nine anurans

(20.4% of 44), two salamanders (4.5%), 14 lizards (31.8%), 18 snakes (40.9%) and one turtle (2.3%) (Table 7). Only one species, the Upland Burrowing Tree-frog (*Smilisca dentata*), is a near endemic to the state. In the latest updates of the herpetofauna of Mexico, it is reported that there are 745 (252 amphibians and 493 reptiles) endemic species to the country, so of the species endemic to Mexico, 5.9% occur in Aguascalientes (Flores-Villela and García-Vázquez 2014; Parra-Olea et al. 2014).

Conservation Status

The SEMARNAT system.—In the SEMARNAT system for assessing the conservation status of Mexican species (NOM-059, 2010), of the 84 native species to Aguascalientes, 54 (64.2%) are not included on the list, while 30 have a conservation ranking (Table 8). For the 30 species with a conservation designation, none are endangered (P), 11 are threatened (A), and 19 have special protections (Pr). Of the 11 threatened (A) species, there are two anurans, one salamander, one lizard and seven snakes. Of the 19 species under special protection (Pr), there is one anuran, two salamanders, two turtles, four lizards and 10 snakes.

The purpose of the SEMARNAT system is to identify species that require conservation attention, however it is hard to evaluate its effectiveness since it is unknown whether species not on the list have been evaluated. Since there are many species that are endemic to the country without an evaluation, we feel the system is not a complete assessment and suffers from the lack of being regularly updated. The SEMARNAT system is the method most used by Mexican researchers to evaluate the conservation status of species of amphibians and reptiles, however with its four categories of risk to the extinction, we conclude that it is not a good tool for the conservation of these groups.

The IUCN system.—The data indicates that 76 (90.4%) of the 84 native species in Aguascalientes have been allocated to one of the eight IUCN categories; only six of the eight categories have been applied to members of the Mexican herpetofauna, since the Extinct and Extinct in the Wild categories have not been used.

In Aguascalientes, there are no species allocated to the critically endangered (CR) category, three (3.5%) listed in the endangered (E) category (one anuran, one lizard and one snake), two (2.3%) in the vulnerable (V) category (one salamander and one snake), one (1.2%) in the near threatened (NT) category (anuran), 68 (80.9%) in the least concern (LC) category (12 anurans, two salamanders, two turtles, 18 lizards and 34 snakes), and two (2.3%) as data deficient (DD) (two anurans). Finally, eight (9.5%) species are not evaluated (NE), which includes four lizards and four snakes (Table 9).

The largest number and proportion of species in the IUCN herpetofaunal assessments are allocated to the LC category. As mentioned by Alvarado-Díaz et al. (2013), Mata-Silva et al. (2015), and noted by Wilson et al. (2013a, b), this category is "a dumping ground" and a more discerning look at LC species might reveal that many should be partitioned into other categories, instead of LC. The IUCN red

Table 6. Distributional status and conservation categories for members of the herpetofauna of Aguascalientes, Mexico. Distributional Status: SE = endemic to Aguascalientes; CE = endemic to Mexico; NE = not endemic to Mexico; NN = non-native in Mexico. Environmental Vulnerability Score (taken from Wilson et al. 2013a, b): low vulnerability species (EVS of 3–9); medium vulnerability species (EVS of 10–13); high vulnerability species (EVS of 14–20). IUCN Categorization: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = Not Evaluated. SEMARNAT Status: A = Threatened; P = Endangered; Pr = Special Protection; NS = No Status. See text for explanations of the EVS, IUCN, and SEMARNAT rating systems.

Taxa	Distributional Status	EVS	SEMARNAT	IUCN
Amphibia (21)				
Anura (18)				
Bufonidae (5)				
Anaxyrus cognatus	NE	9	NS	LC
Anaxyrus compactilis	CE	14	NS	LC
Anaxyrus punctatus	NE	5	NS	LC
Incilius occidentalis	CE	11	NS	LC
Rhinella marina	NN	3	NS	LC
Craugastoridae (2)				
Craugastor augusti	NE	8	NS	LC
Craugastor occidentalis	CE	13	NS	DD
Eleutherodactylidae (1)				
Eleutherodactylus nitidus	CE	12	NS	LC
Hylidae(3)				
Hyla arenicolor	NE	7	NS	LC
Hyla eximia	NE	10	NS	LC
Smilisca dentata	CE	14	A	EN
Microhylidae (1)				
Hypopachus variolosus	NE	4	NS	LC
Ranidae (5)				
Lithobates catesbeianus	NN	10	NS	LC
Lithobates magnaocularis	CE	12	NS	LC
Lithobates montezumae	CE	13	Pr	LC
Lithobates neovolcanicus	CE	13	A	NT
Lithobates psilonota	CE	14	NS	DD
Scaphiopodidae (1)				
Spea multiplicata	NE	6	NS	LC
Caudata (3)				
Ambystomatidae (2)				
Ambystoma rosaceum	CE	14	Pr	LC
Ambystoma velasci	NE	10	Pr	LC
Plethodontidae (1)				
Isthmura bellii	CE	12	A	VU

Taxa	Distributional Status	EVS	SEMARNAT	IUCN
Reptilia (69)				
Squamata (66)				
Anguidae (3)				
Barisia ciliaris	CE	15	NS	NE
Elgaria kingii	NE	10	Pr	LC
Gerrhonotus liocephalus	NE	6	Pr	LC
Dactyloidae (1)				
Anolis nebulosus	CE	13	NS	LC
Gekkonidae (2)				
Hemidactylus frenatus	NN	—	NS	LC
Hemidactylus turcicus	NN	—	NS	LC
Iguanidae (1)				
Ctenosaura pectinata	CE	15	A	NE
Phrynosomatidae (16)				
Holbrookia approximans	NE	14	NS	LC
Phrynosoma cornutum	NE	11	NS	LC
Phrynosoma modestum	NE	12	NS	LC
Phrynosoma orbiculare	CE	12	NS	LC
Sceloporus aurantius	CE	14	NS	NE
Sceloporus brownorum	CE	14	NS	NE
Sceloporus clarkii	NE	10	NS	LC
Sceloporus goldmani	CE	15	NS	EN
Sceloporus grammicus	NE	9	Pr	LC
Sceloporus horridus	CE	11	NS	LC
Sceloporus jarrovii	NE	11	NS	LC
Sceloporus minor	CE	14	NS	LC
Sceloporus scalaris	CE	12	NS	LC
Sceloporus spinosus	CE	12	NS	LC
Sceloporus torquatus	CE	11	NS	LC
Urosaurus bicarinatus	CE	12	NS	LC
Scincidae (1)				
Plestiodon lynxe	CE	10	Pr	LC
Teiidae (1)				
Aspidoscelis gularis	NE	9	NS	LC
Colubridae (20)				
Arizona elegans	NE	5	NS	LC
Coluber bilineatus	NE	11	NS	LC
Coluber flagellum	NE	8	A	LC
Coluber mentovarius	NE	6	NS	LC
Coluber taeniatus	NE	10	NS	LC
Conopsis nasus	CE	11	NS	LC
Drymarchon melanurus	NE	6	NS	LC

Taxa	Distributional Status	EVS	SEMARNAT	IUCN
Lampropeltis mexicana	CE	15	A	LC
Lampropeltis polyzona	CE	11	NS	NE
Oxybelis aeneus	NE	5	NS	NE
Pantherophis emoryi	NE	13	NS	LC
Pituophis catenifer	NE	9	NS	LC
Pituophis deppei	CE	14	A	LC
Rhinocheilus lecontei	NE	8	NS	LC
Salvadora bairdi	CE	15	Pr	LC
Senticolis triaspis	NE	6	NS	LC
Sonora mutabilis	CE	14	NS	LC
Tantilla bocourti	CE	9	NS	LC
Tantilla wilcoxi	NE	10	NS	LC
Trimorphodon tau	CE	13	NS	LC
Dipsadidae (5)				
Diadophis punctatus	NE	4	NS	LC
Geophis dugesii	CE	13	NS	LC
Heterodon kennerlyi	NE	11	NS	NE
Hypsiglena jani	NE	6	NS	NE
Rhadinaea hesperia	CE	10	NS	LC
Elapidae (1)				
Micrurus distans	CE	14	Pr	LC
Natricidae (6)				
Storeria storerioides	CE	11	NS	LC
Thamnophis cyrtopsis	NE	7	A	LC
Thamnophis eques	NE	8	A	LC
Thamnophis melanogaster	CE	15	A	EN
Thamnophis pulchrilatus	CE	15	NS	LC
Thamnophis scaliger	CE	15	A	VU
Typhlopidae (1)				
Indotyphlops braminus	NN	—	NS	NE
Viperidae (8)				
Crotalus aquilus	CE	16	Pr	LC
Crotalus atrox	NE	9	Pr	LC
Crotalus basiliscus	CE	16	Pr	LC
Crotalus lepidus	NE	12	Pr	LC
Crotalus molossus	NE	8	Pr	LC
Crotalus polystictus	CE	16	Pr	LC
Crotalus pricei	NE	14	Pr	LC
Crotalus scutulatus	NE	11	Pr	LC

Taxa	Distributional Status	EVS	SEMARNAT	IUCN
Testudines (3)				
Kinosternidae (2)				
Kinosternon hirtipes	NE	10	Pr	LC
Kinosternon integrum	CE	11	Pr	LC
Emydidae (1)				
Trachemys scripta	NN	16	Pr	LC

Table 7. Summary of the distributional status of herpetofaunal families in Aguascalientes (includes non-native species). CE = endemic to Mexico; NE = not endemic to Mexico; NN = non-native in Mexico. SE = state endemic omitted from the table, since there are none.

Families	Number of species	Distributional Status		
		CE	NE	NN
Bufonidae	5	2	2	1
Craugastoridae	2	1	1	—
Eleutherodactylidae	1	1	—	—
Hylidae	3	1	2	—
Microhylidae	1		1	—
Ranidae	5	4	—	1
Scaphiopodidae	1	—	1	—
Subtotals	**18**	**9**	**7**	**2**
Ambystomatidae	2	1	1	—
Plethodontidae	1	1	—	—
Subtotals	**3**	**2**	**1**	**—**
Totals	**21**	**11**	**8**	**2**
Emydidae	1	—	—	1
Kinosternidae	2	1	1	
Subtotals	**3**	**1**	**1**	**1**
Anguidae	3	1	2	—
Dactyloidae	1	1	—	—
Gekkonidae	2	—	—	2
Iguanidae	1	1	—	—
Phrynosomatidae	16	10	6	—
Scincidae	1	1	—	—
Teiidae	1	—	1	—
Subtotals	**25**	**14**	**9**	**2**
Colubridae	20	8	12	—
Dipsadidae	5	2	3	—
Elapidae	1	1	—	—
Natricidae	6	4	2	—
Typhlopidae	1	—	—	1
Viperidae	8	3	5	—
Subtotals	**41**	**18**	**22**	**1**
Totals	**69**	**33**	**32**	**4**
Sum Totals	**90**	**44**	**40**	**6**

Table 8. SEMARNAT categorization for herpetofauna native of Aguascalientes arranged by families (Diario Oficial de la Federación 2010).

Families	Number of species	SEMARNAT Categorization			
		Endangered	Threatened	Special	No Status
Bufonidae	4	—	—	—	4
Craugastoridae	2	—	—	—	2
Eleutherodactylidae	1	—	—	—	1
Hylidae	3	—	1	—	2
Microhylidae	1	—	—	—	1
Ranidae	4	—	1	1	2
Scaphiopodidae	1	—	—	—	1
Subtotals	**16**	—	**2**	**1**	**13**
Ambystomatidae	2	—	—	2	—
Plethodontidae	1	—	1	—	—
Subtotals	**3**	—	**1**	**2**	—
Totals	**19**	—	**3**	**3**	**13**
Kinosternidae	2	—	—	2	—
Subtotals	**2**	—	—	**2**	—
Anguidae	3	—	—	2	1
Dactyloidae	1	—	—	—	1
Iguanidae	1	—	1	—	—
Phrynosomatidae	16	—	—	1	15
Scincidae	1	—	—	1	—
Teiidae	1	—	—	—	1
Subtotals	**23**	—	**1**	**4**	**18**
Colubridae	20	—	3	1	16
Dipsadidae	5	—	—	—	5
Elapidae	1	—	—	1	—
Natricidae	6	—	4	—	2
Viperidae	8	—	—	8	—
Subtotals	**40**	—	**7**	**10**	**23**
Totals	**65**	—	**8**	**16**	**41**
Sum Totals	**84**	—	**11**	**19**	**54**

list also has a delay in which it is applied to newly described taxa. For species not evaluated (NE) from the state, *Barisia ciliaris*, *Ctenosaura pectinata*, *Sceloporus aurantius*, *S. brownorum*, and *Lampropeltis polyzona* are endemic to Mexico and most have recently experienced taxonomic changes (the exception is *C. pectinata*). *Heterodon kennerlyi* and *H. jani*, both

non-endemic to the country, have experienced taxonomic changes, as well as, *Oxybelis aeneus*, which is a widely distributed species and non-endemic to Mexico (Table 6).

The EVS system.—We divided the range of EVS scores into three categories following Wilson and McCranie (2004): low (EVS of 3–9), medium (10–13), and high (14–19). The category with the most species allocated to it is the medium category with 38 (45.2%), followed by the low category with 24 (28.5%), and finally the high category with 22 (26.2%). For the EVS system, the least vulnerable species scored four and included both *Hypopachus variolosus* and *Diadophis punctatus*, both are widely distributed, non-endemic species to Mexico. The most vulnerable species scored 16 and included the rattlesnakes *Crotalus aquilus* (Fig. 9), *C. basiliscus* and *C. polystictus*, all of which are endemic to the country and venomous, which makes them commonly killed on sight. We calculate the scores for three species with recent taxonomic changes that had not been evaluated in previous studies. *Sceloporus aurantius* and *S. brownorum* scored 14 in the low end of the high category, while *Lampropeltis polyzona* scored 11 in the medium category (Table 6).

The absolute and relative numbers for each of the three EVS categories (low, medium, high), arranged by major herpetofaunal group, are as follows: anurans 6 (37.5%), 7 (43.7%), and 3 (18.7%); salamanders 0 (0.0%), 2 (66.7), and 1 (33.3%); turtles 0 (0.0%), 2 (100%), and 0 (0.0%); lizards 3 (13%), 14 (60.9%), and 6 (26.1%); and snakes 15 (37.5%), 13 (32.5%), and 12 (30%). The highest absolute and relative numbers for each of the amphibian groups fall into the medium range, with the exception of snakes, which has the highest number of species in the low vulnerability category. For all amphibians grouped, the EVS rankings total 6 (31.6%), 9 (47.3%), and 4 (21.1%), while for all reptiles, they total 18 (27.7%), 29 (44.6%), and 18 (27.7%). This trend applies to the Aguascalientes herpetofauna as whole. Overall, the EVS scores place the most species in the medium category (Table 10). One advantage of the EVS system is that it considers all species that can be easily assessed with data that is generally available.

Figure 9. *Crotalus aquilus* (Queretaran Dusky Rattlesnake) is endemic to México, its EVS is 16, placing it in the high vulnerability category. Its conservation status has been evaluated as Least Concern (LC) by IUCN, and assessed as Special protection (Pr) species by SEMARNAT. Photo by Gustavo E. Quintero-Díaz.

Comparing the results of the three systems

When we compare the results of the three conservation ranking systems, only EVS could assess the entire herpetofauna of Aguascalientes. EVS also takes into account the status of

Table 9. IUCN Red List categorizations for herpetofaunal families in Aguascalientes, Mexico. Non-native species are excluded.

Families	Number of species	UICN Red List categorizations						
		CR	E	V	NT	LC	DD	NE
Bufonidae	4	—	—	—	—	4	—	—
Craugastoridae	2	—	—	—	—	1	1	—
Eleutherodactylidae	1	—	—	—	—	1	—	—
Hylidae	3	—	1	—	—	2	—	—
Microhylidae	1	—	—	—	—	1	—	—
Ranidae	4	—	—	—	1	2	1	—
Scaphiopodidae	1	—	—	—	—	1	—	—
Subtotals	**16**	**—**	**1**		**1**	**12**	**2**	**—**
Ambystomatidae	2	—	—	—	—	2	—	—
Plethodontidae	1	—	—	1	—	—	—	—
Subtotals	**3**	**—**	**—**	**1**	**—**	**2**	**—**	**—**
Totals	**19**	**—**	**1**	**1**	**1**	**14**	**2**	**—**
Kinosternidae	2	—	—	—	—	2	—	—
Subtotals	**2**	**—**	**—**	**—**	**—**	**2**	**—**	**—**
Anguidae	3	—	—	—	—	2	—	1
Dactyloidae	1	—	—	—	—	1	—	—
Iguanidae	1	—	—	—	—	—	—	1
Phrynosomatidae	16	—	1	—	—	13	—	2
Scincidae	1	—	—	—	—	1	—	—
Teiidae	1	—	—	—	—	1	—	—
Subtotals	**23**	**—**	**1**	**—**	**—**	**18**	**—**	**4**
Colubridae	20	—	—	—	—	18	—	2
Dipsadidae	5	—	—	—	—	3	—	2
Elapidae	1	—	—	—	—	1	—	—
Natricidae	6	—	1	1	—	4	—	—
Viperidae	8	—	—	—	—	8	—	—
Subtotals	**40**	**—**	**1**	**1**	**—**	**34**	**—**	**4**
Totals	**65**	**—**	**2**	**1**	**—**	**54**	**—**	**8**
Sum Totals	**84**	**—**	**3**	**2**	**1**	**68**	**2**	**8**

endemism. This system allows assessments to be made with information widely available, which allowed us to assess the EVS scores for three species that had not been evaluated. One disadvantage of EVS is that it does not apply to marine species, which is a problem not faced in this study, since there are no marine species in Aguascalientes. At present, the SEMARNAT system has no assessments for almost two-thirds of the native

amphibian and reptile species in the state, while the IUCN system designates over 80% of the species least concerned. In both the SEMARNAT and IUCN systems, only a portion of the herpetofauna is evaluated making it difficult to determine conservation priorities. Therefore, EVS is the only system that can be applied simply and economically to all species.

Relative Herpetofaunal Priority (RHP)

Since Aguascalientes has no state endemics, we used country endemics in its place, which total 44 of the 90 species in Aguascalientes. Within the six different regions, there are 31 of 44 (70.4%) country endemics found in the Sierra El Laurel, the highest for the state. This places the Sierra El Laurel in the first rank order. The rest of the regions (and the size of their respective endemic herpetofaunal components) in rank order, from highest to lowest, are as follows: Sierra Fría (27; 61.3%); Calvillo Valley (21; 47.7); Semiarid Zone (19; 43.1%); Southern Grasslands (18; 40.9%); and Northern Grasslands (11; 25%) (Table 11).

We summarized the number of native herpetofaunal species in each of the three EVS categories. On the basis of the number of high category species, the most significant physiographic region is the Sierra Fría, with 13 species of a total of 51 (25.4%). This region occupies the second rank based on the other RHP measures (Table 12). The rest of the regions in rank order, from highest to lowest, are as follows: Sierra El Laurel (12; 21.8% of 55); Semiarid Zone (10; 21.2% of 47); Calvillo Valley (eight; 19.5% of 41); Southern Grasslands (seven; 16.6% of 42) and Northern Grasslands (two; 6.9% of 29).

The rank orders demonstrated for the six physiographic regions in Table 11 and those in Table 12 are very similar but not the same: Sierra El Laurel (1, 2); Sierra Fría (2, 1); Calvillo Valley (3, 4); Semiarid Zone (4, 3); Southern Grasslands (5, 5) and Northern Grasslands (6, 6). Based on these measures, the RHP is highest for the both mountainous regions, followed by the Calvillo Valley and the Semiarid Zone. As demonstrated by Johnson et al. (2015) and Terán-Juárez et al. (2016), these measures might provide an easy and economical way of determining the best way to focus efforts and use conservation funds.

Conclusions

In total, 90 species of amphibian and reptiles are recorded for Aguascalientes, including six non-native species (*Rhinella marina, Lithobates catesbeianus, Hemidactylus frenatus, Hemidactylus turcicus, Indotyphlops braminus* and *Trachemys scripta*). The native amphibians comprise 16 anurans and three salamanders. The native reptiles comprise 23 lizards, 40 snakes and two turtles. Despite not having strictly endemic species to the state, nearly half of the species (44; 48.8%) found in Aguascalientes are endemic to Mexico, with a higher percentage of country endemics than Tamaulipas (32.1%) and Chiapas (17.6%), but fewer than Oaxaca (58.9%) and Hidalgo (59%).

The number of species in each of the six physiographic provinces in decreasing order is: Sierra El Laurel (56 species), Sierra Fría (51), Semiarid Zone (47), Southern Grasslands (46), Calvillo Valley (44) and Northern Grasslands (29). Among the six regions, the

Table 10. Environmental Vulnerability Scores (EVS) for herpetofaunal species in Aguascalientes, arranged by family. Shaded areas represent the vulnerability categories low, medium, and high. Non-native species are excluded.

Families	Number of species	Enviromental Vulnerability Score (EVS)																
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Bufonidae	4	—	—	1	—	—	—	1	—	1	—	—	1	—	—	—	—	—
Craugastoridae	2	—	—	—	—	—	1		—	—	—	1	—	—	—	—	—	—
Eleutherodactylidae	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Hylidae	3	—	—	—	—	1	—	—	1	—	—	—	1	—	—	—	—	—
Microhylidae	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ranidae	4	—	—	—	—	—	—	—	—	—	1	2	1	—	—	—	—	—
Scaphiopodidae	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotals	16	—	1	1	1	1	1	1	1	1	2	3	3	—	—	—	—	—
Subtotals %	—	—	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	12.5	18.7	18.7	—	—	—	—	—
Ambystomatidae	2	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—
Plethodontidae	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Subtotals	3	—	—	—	—	—	—	—	1	—	1	—	1	—	—	—	—	—
Subtotals %	—	—	—	—	—	—	—	—	33.3	—	33.3	—	33.3	—	—	—	—	—
Totals	19	—	1	1	1	1	1	1	2	1	3	3	4	—	—	—	—	—
Totals %		—	5.3	5.3	5.3	5.3	5.3	5.3	10.5	5.3	15.7	15.7	21	—	—	—	—	—
Kinosternidae	2	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—
Subtotals	2	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—
Subtotals %	—	—	—	—	—	—	—	—	50	50	—	—	—	—	—	—	—	—
Anguidae	3	—	—	—	1	—	—	—	1	1	1	1	1	1	—	—	—	—
Dactyloidae	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Iguanidae	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Phrynosomatidae	16	—	—	—	—	—	—	1	2	4	5	—	3	1	—	—	—	—
Scincidae	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Teiidae	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Subtotals	23	—	—	—	1	—	—	2	4	4	5	1	3	3	—	—	—	—
Subtotals %	—	—	—	—	4.3	—	—	8.7	17.3	17.3	21.7	4.3	13	13	—	—	—	—
Colubridae	20	—	—	2	3	—	2	2	2	3	—	2	2	2	—	—	—	—
Dipsadidae	5	—	1	—	1	—	—	—	1	1	—	1	—	—	—	—	—	—
Elapidae	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Natricidae	6	—	—	—	—	1	1	—	—	1	—	—	—	3	—	—	—	—
Viperidae	8	—	—	—	—	—	1	1	—	1	1	—	1	—	3	—	—	—
Subtotals	40	—	1	2	4	1	4	3	3	6	1	3	4	5	3	—	—	—
Subtotals %	—	—	2.5	5	10	2.5	10	7.5	7.5	15	2.5	7.5	10	12.5	7.5	—	—	—
Totals	65	—	1	2	5	1	4	5	8	11	6	4	7	8	3	—	—	—
Totals %	—	—	1.5	3	7.6	1.5	6.1	7.6	12.3	16.9	9.2	6.1	10.7	12.3	4.6	—	—	—
Sum Totals	84	—	2	3	6	2	5	6	10	12	9	7	11	8	3	—	—	—
Sum Totals %	—	—	2.3	3.5	7.1	2.3	5.9	7.1	11.9	14.2	10.7	8.3	13	9.5	3.5	—	—	—
Category Totals	84	Low = 24							Medium = 38				High = 22					

Table 11. Number of species in three distributional categories among the six physiographic regions of Aguascalientes, Mexico. Rank determined by Mexican endemics.

Physiographic Regions	Non-endemics	Mexican Endemics	Non-natives	Totals	Rank Order
Semiarid Zone	26	19	2	47	4
Southern Grasslands	24	18	3	45	5
Sierra El Laurel	22	31	2	55	1
Calvillo Valley	22	21	1	44	3
Sierra Fría	22	27	1	50	2
Northern Grasslands	18	11	—	29	6

Table 12. Number of species in the three EVS categories among the six physiographic regions in Aguascalientes, Mexico. Rank determined by the relative number of high EVS species.

Physiographic Regions	Low	Medium	High	Totals	Rank Order
Semiarid Zone	18	19	10	47	3
Southern Grasslands	17	18	7	42	5
Sierra El Laurel	17	26	12	55	2
Calvillo Valley	17	16	8	41	4
Sierra Fría	17	21	13	51	1
Northern Grasslands	12	15	2	29	6

representation of the major herpetofaunal grups is as follows: anurans = Sierra El Laurel and Southern Grasslands, salamanders = Sierra El Laurel and Sierra Fría, lizards = Sierra El Laurel, snakes = Calvillo Valley, Sierra El Laurel and Sierra Fría, and turtles = Southern Grasslands. The degree of herpetofaunal resemblance is greatest between Calvillo Valley and Sierra El Laurel. The UPGMA analysis demonstrates that the two mountainous regions cluster with the Calvillo Valley. Within Aguascalientes, the native amphibians and reptiles restricted to a single physiographic region, are in decreasing order: Semiarid Zone with eight species, Sierra Fría with six species, Sierra El Laurel with five species, Calvillo Valley with two species, and both the Southern Grasslands and Northern Grasslands with no species.

In order to assess the conservation status of the species of amphibians and reptiles within Aguascalientes, we used three conservation rating systems: SEMARNAT, IUCN and EVS. The SEMARNAT system proved incomplete, inasmuch that 64.2% of the native herpetofauna of Aguascalientes has not been assessed. SEMARNAT listed no species as endangered (P), 11 as threatened (A) and 19 with special protections (Pr). The IUCN system appears less suited for regional conservation assessments, focusing on global priorities. It assessed 76 (90.4%) of the native species, with 68 assigned

to the least concerned (LC) category. As such, the IUCN evaluation made it difficult to prioritize conservation needs across the state.

The EVS system addresses the deficiencies of the other two systems. Scores were assigned to the Aguascalientes native herpetofauna, with the majority of species falling into the medium category (38 species) for environmental vulnerability, with a similar number of species being assigned to the low (24) and high (22) categories. With this system, all species can be evaluated in the state, providing biologists working with the herpetofauna of Aguascalientes a better understanding what regions need the most attention and where to allocate the scarce funds available for conservation.

Employing the Relative Herpetofaunal Priority (RHP) method, we found the highest conservation importance of the regional herpetofauna to be for the two mountainous regions, the Sierra el Laurel and Sierra Fría, followed by the Calvillo Valley and the Semiarid Zone.

Recommendations

To protect the herpetofauna of Aguascalientes now and into the future, we need the establishment protected natural areas. The state currently has four protected areas: the "Cuenca Alimentadora del Distrito de Riego 001 Pabellón", which includes part of the Sierra Fría; the "Cuenca Alimentadora del Distrito de Riego 043 Nayarit" which includes parts of the Sierra Fría, Calvillo Valley and Sierra El Laurel (both at federal level); the "Área de protección del águila real" del Ejido Palo Alto, at El Llano (Semiarid Zone) at state level and the RAMSAR site "El Jagüey", Buenavista de Peñuelas (Southern Grasslands) at the international level (Lozano-Roman and Estrada Aguilera 2008). Therefore these areas play an essential role in securing the viability of populations of amphibians and reptiles in the face of human population growth.

An evaluation of the level of protection afforded to the Aguascalientes herpetofauna in each protected area is needed. It is also needed for neighboring states, which share a number of protected areas, to give a regional perspective, rather than one only focused at the state level.

The human-modified environments are the dominant landscapes in Aguascalientes, due to agriculture, logging, and cattle ranching, and industries to a lesser extent. Management plans that allow for the maximum number of herpetofaunal species to survive and avoid conflicts with human activities are lacking.

Conservation efforts for wild species in Aguascalientes are minimal, except those made by Upland Burrowing Treefrog (*Smilisca dentata*). However, it is well known that the primary strategy to prevent the extinction of wild species is habitat protection, avoiding with this action, fragmentation or alteration, difficult conditions to respect because of our human condition. If we continue with the opening of the agricultural frontier, road construction, earthworks and roads will be encouraged the fragmentation and thus altering the habitat and propitiates destruction. If we continue with the installation of infrastructure that only benefits the economy of a few, which today is limiting distribution of many wild

species, we will cause a high impact on their populations, as we are doing with *Smilisca dentata*.

Now, not only is the Upland Burrowing Treefrog, micro endemic to the center of Mexico, but also are the bunchgrass lizard *Sceloporus aurantius* in the Sierra El Laurel, *Sceloporus brownorum* in the Sierra Fria and *Sceloporus goldmani* in Sierra Juan Grande. Does the state economy will be more important that the protection of their biodiversity?

Finally, there is a need to increase environmental education to raise awareness, involve local communities in conservation, and instill a place-based awareness of the region's biodiversity in order to promote sustainable use of natural resources.

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