



Ambystoma taylori Brandon, Maruska, and Rumph, 1982. Taylor's Salamander is a state endemic species known only from Laguna Alchichica, a saline crater lake in eastern Puebla (Frost, 2016). The IUCN SSC Amphibian Specialist Group (2015) noted water extraction and diversion as the most serious threats to this species, and that pollution and the continued transformation of the lake would result in its disappearance. Wilson et al. (2013a) determined the Environmental Vulnerability Score (EVS) of this salamander as 15, placing it in the lower portion of the high vulnerability category, and the IUCN has assessed its conservation status as Critically Endangered. In the following article the authors provide details on the distribution and conservation status of the herpetofauna of the state of Puebla, Mexico. 📷 © Valeria Mas



The herpetofauna of Puebla, Mexico: composition, distribution, and conservation status

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ABSTRACT: The herpetofauna of the state of Puebla, Mexico, is composed of 267 species, including 64 anurans, 25 salamanders, 174 squamates, and four turtles. We document the distribution of the herpetofaunal members among the six physiographic regions we recognize. The number of species ranges from 41 in the Sierra Madre del Sur to 185 in the Sierra Madre Oriental. The individual species occupy from one to six regions ($\bar{x} = 2.4$). The largest number of single-region species occurs in the Sierra Madre Oriental (50), followed by the Upper Balsas Basin (26), the Trans-Mexican Volcanic Belt (20), the Gulf Coastal Lowlands (four), the Valley of Tehuacán (four), and the Sierra Madre del Sur (one). A Coefficient of Biogeographic Resemblance (CBR) matrix demonstrates that the number of shared species ranges from five between the Gulf Coastal Lowlands and the Sierra Madre del Sur to 98 between the Sierra Madre Oriental and the Trans-Mexican Volcanic Belt. A similarity dendrogram based on the Unweighted Pair Group Method with Arithmetic Averages (UPGMA) reveals two well-defined clusters, one associated with three physiographic regions on the Pacific versant of Mexico (Sierra Madre del Sur, Valley of Tehuacán, and Upper Balsas Basin), and the other associated with three regions on the Atlantic versant (Trans-Mexican Volcanic Belt, Sierra Madre Occidental, and Gulf Coastal Lowlands). About 79% of the herpetofauna is distributed in one or two of the six regions, indicating the relatively narrow distribution of many species in the state. We allocated the largest number of herpetofaunal species (154 of 259) to the Mexican endemic category, followed by the non-endemic category (98), the Puebla endemic category (four), and the non-native category (three). The principal environmental threats to the herpetofauna are deforestation, livestock ranching, the construction of infrastructure, extractive industries (hydroelectric dams and mines), the desiccation and contamination of water bodies, diseases, and global warming. We evaluated the conservation status of the native species by using the SEMARNAT (NOM-059), IUCN, and EVS systems, of which the EVS proved to be the most helpful. We also employed the Relative Herpetofaunal Priority (RHP) methodology to determine the rank order importance of the physiographic areas, and found the highest values for the Sierra Madre Oriental, followed by the Trans-Mexican Volcanic Belt, the Sierra Madre del Sur, and the

Gulf Coastal Lowlands. An analysis of the features for the 14 protected areas in the state reveals their relative capability for providing protection to the members of the herpetofauna. Finally, we develop a set of conclusions and recommendations for the future protection of the Pueblan herpetofauna.

Key Words: Anurans, caudates, physiographic regions, protected areas, protection recommendations, squamates, turtles

RESUMEN: La herpetofauna del estado de Puebla, México, está conformada por 267 especies, incluyendo 64 anuros, 25 salamandras, 174 escamosos y cuatro tortugas. Documentamos la distribución de la herpetofauna entre seis regiones fisiográficas que aquí reconocemos. El número de especies varía de 41 en la Sierra Madre del Sur a 185 en la Sierra Madre Oriental. Cada una de las especies ocupa desde una hasta seis regiones ($\bar{x} = 2.4$). El mayor número de especies distribuidas en una sola región ocurre en la Sierra Madre Oriental (50), seguido por la Cuenca Alta del Balsas (26), la Faja Volcánica Transmexicana (20), Tierras Costeras del Golfo (cuatro), Valle de Tehuacán (cuatro) y la Sierra Madre del Sur (una). Una matriz con un coeficiente de similitud biogeográfica (CSB) demuestra que el número de especies compartidas varía de cinco entre la Tierras Costeras del Golfo y la Sierra Madre del Sur a 98 entre la Sierra Madre Oriental y la Faja Volcánica Transmexicana. Un dendrograma de similitud basado en el Método por Agrupamiento de Pares no Ponderado con Media Aritmética (MAPMA) revela dos grupos bien definidos, uno asociado con tres regiones fisiográficas en la vertiente del pacífico (Sierra Madre del Sur, Valle de Tehuacán y Cuenca Alta del Balsas) y el otro asociado con tres regiones en la vertiente del atlántico (Faja Volcánica Transmexicana, Sierra Madre Occidental y Tierras Costeras del Golfo). Cerca del 79% de la herpetofauna está distribuida en una o dos de las seis regiones, indicando una relativa distribución restringida de muchas de las especies en el estado. Ubicamos a la mayoría de los miembros de la herpetofauna (154 de 259) en la categoría de endémicas a México, seguido de las especies no endémicas (98); endémicas a Puebla (cuatro) y la categoría de especies no nativas (tres). Las principales amenazas son la deforestación, ganadería, construcción de infraestructura, industria extractiva (presas hidroeléctricas y minas), desecación y contaminación de cuerpos de agua, enfermedades, y el calentamiento global. Evaluamos el estatus de conservación de las especies nativas con los sistemas de SEMARNAT (NOM-059), IUCN y EVS, del cual, el EVS fue más útil. También empleamos la metodología para establecer la Prioridad Herpetofaunística Relativa (PHR) para determinar la categoría del orden de importancia de las áreas fisiográficas, encontrando los valores más altos para la Sierra Madre Oriental, seguida por la Faja Volcánica Transmexicana, Sierra Madre del Sur y Tierras Costeras del Golfo. Un análisis de las características de las 14 áreas protegidas en el estado revela su capacidad relativa para brindar protección a los miembros de la herpetofauna. Finalmente, desarrollamos una serie de conclusiones y recomendaciones para la futura protección de la herpetofauna poblana.

Palabras Claves: Anuros, caudados, escamosos, recomendaciones para protección, regiones fisiográficas, tortugas

Citation: Woolrich-Piña, G. A., E. García-Padilla, D. L. DeSantis, J. D. Johnson, V. Mata-Silva, and L. D. Wilson. 2017. The herpetofauna of Puebla, Mexico: composition, distribution, and conservation. *Mesoamerican Herpetology* 4: 791–884.

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Received: 16 November 2017; **Accepted:** 12 December 2017; **Published:** 30 December 2017.

“... If you are lucky enough to live among threatened species...your job, if you want to make a difference, is to protect them. Those species really don't live anywhere else...and if you don't keep them alive, no one else can.”

—ANTHONY D. BARNOSKY (2014)

INTRODUCTION

The state of Puebla, located in east-central Mexico, encompasses portions of three significant mountain ranges, the Sierra Madre Oriental (SMO), the Trans-Mexican Volcanic Belt (TMV), and the Sierra Madre del Sur (SMS); three other physiographic regions include the Upper Balsas Basin (UBB), small segments of the Gulf Coastal Lowlands (GCL), and the Valley of Tehuacán (VOT) (Fig. 1). Puebla is bounded to the east by Veracruz, to the southeast by Oaxaca, to the south and southwest by Guerrero, to the west by Morelos, México, and Tlaxcala, and to the northwest by Hidalgo. The surface area of Puebla consists of 34,306 km², which ranks it 21st among the 31 states of Mexico (www.wikipedia.org; accessed 15 May 2017). In 2015 the population of Puebla was estimated as 6,168,883, which ranked 5th in the country, as well as 6th in population density, with 180 people/km² (www.wikipedia.org; accessed 15 May 2017).



Fig. 1. Physiographic regions of the state of Puebla, Mexico. Abbreviations are as follows: GCL = Gulf Coastal Lowlands; SMO = Sierra Madre Oriental; TMV = Trans-Mexican Volcanic Belt; SMS = Sierra Madre del Sur; UBB = Upper Balsas Basin; and VOT = Valley of Tehuacán.

Puebla contains the three highest mountains in Mexico, the volcanoes Pico de Orizaba (or Citlaltépetl) at an elevation of 5,747 m, Popocatepetl at 5,452 m, and Iztaccíhuatl (or Ixtaccíhuatl) at 5,286 m, which are shared with adjacent states (i.e., Pico de Orizaba with Veracruz, Popocatepetl with the state of México, and Iztaccíhuatl with the state of México); they also lie along the eastern boundary of the TMV, are snow-capped, and contain (or used to contain) glaciers, and Popocatepetl is active and the other two are dormant (www.wikipedia.org; accessed 15 May 2017). The TMV is considered the southern edge of the Central Plateau, and Campbell (1999) and Wilson and Johnson (2010) primarily regarded the UBB and VOT as part of the Pacific Lowlands from Sinaloa to Western Chiapas (SC), a region that also includes inland intrusions associated with the Balsas Basin and Central Depression of Chiapas.

Given the confluence of three species-rich montane centers of endemism in east-central Mexico, the state of Puebla would be expected to contain a relatively species rich herpetofauna, with many endemic species. Still, herpetological undertakings in Puebla have not rivaled many contemporary investigations conducted in some adjoining states, such as in Hidalgo (Ramírez-Bautista, 2014), Veracruz (Pérez-Higareda and Smith, 1991 [snakes only]),

Guerrero (Pérez-Ramos et al., 2000), and Oaxaca (Casas-Andreu, et al., 2004; Mata-Silva et al., 2015). Based on some of these papers, the state species richness values range from a high of 442 species in Oaxaca to a low of 136 species in Guerrero. The low figure for Guerrero probably is due to collecting bias, as the surface of that state is relatively large and mountainous and thus potentially contains more endemic species. Hidalgo, with 183 reported species, is somewhat smaller in area than Guerrero, but more herpetological investigations have been conducted in this state because of the efforts of an active group of local university professors and students. The states of Tlaxcala and Morelos are small in area, and to date their herpetofaunal species richness has not been fully determined. Similarly, the species richness of the herpetofauna of Veracruz has not been fully established.

Conversely, García-Vázquez et al. (2009) provided the most recent herpetofaunal list for Puebla, which at 246 species included numerous state records derived from previous sources. Subsequently, Canseco-Marquez and Gutiérrez-Mayén (2010) added two more species to the state's list, in their study of the VOT. In this study, we recompiled the species list for Puebla and updated taxonomic and nomenclatural information, and also provide an analysis of the conservation status of each species. We also compare our information to that of other known herpetofaunas of selected states in Mexico.

MATERIALS AND METHODS

Our Taxonomic Position

Herein we adopt the same taxonomic position as explained in previous papers on other portions of Mesoamerica (Johnson, et al., 2015a, b; Mata-Silva et al., 2015). Johnson (2015b) can be consulted for a statement on this position, with special reference to the subspecies concept.

Updating the Herpetofaunal List

We assembled our list for the herpetofauna of Puebla primarily based on the information in the following publications: Vega-López and Álvarez-Solórzano (1992), Canseco-Márquez et al. (2000), Canseco-Márquez et al. (2004), Parra-Olea et al. (2004), Woolrich-Piña et al. (2005), Flores-Villela and Canseco-Márquez (2007), García-Vázquez et al. (2006, 2009), Garza Castro et al. (2006), Canseco-Márquez and Gutiérrez Mayén (2006), Gutiérrez Mayén and Salazar Arenas (2006), Canseco-Márquez and Gutiérrez-Mayén (2010), García-Vázquez et al. (2010), Gutiérrez-Mayén et al. (2011), Mendoza-Hernández et al. (2012), Pavón-Vázquez et al. (2013), Solano-Zavaleta et al. (2013), and Rovito et al. (2015).

System for Determining Distribution Status

We used the same system originated by Alvarado-Díaz et al. (2013) for determining the distribution status of members of the herpetofauna of Michoacán for that of Puebla. This system also has been used for other areas of Mexico (see Mexican Conservation Series, below). We used the following distributional categories for the state of Puebla: SE = endemic to Puebla; CE = endemic to Mexico; NE = not endemic to Mexico; and NN = non-native in Mexico.

Systems for Determining Conservation Status

To evaluate the conservation status of the herpetofauna of Puebla, we used the same systems (i.e., SEMARNAT, IUCN, and EVS) employed in papers detailed in the following paragraph. These papers contain detailed descriptions of the three systems.

THE MEXICAN CONSERVATION SERIES

The Mexican Conservation Series (MCS) was initiated in 2013 with a study on the herpetofauna of Michoacán (Alvarado-Díaz et al., 2013), as a part of a set of five papers designated as the Special Mexico Issue in the journal *Amphibian & Reptile Conservation*. The basic format of the MCS was established in that paper (i.e., to examine the composition, physiographic distribution, and conservation status of the herpetofauna of a given Mexican state or group of states). Two years later, the MCS was resumed with a paper on the herpetofauna of Oaxaca (Mata-Silva et al., 2015), followed by one on the herpetofauna of Chiapas (Johnson et al., 2015a). The following year three more entries were published, on Tamaulipas (Terán-Juárez et al., 2016), Nayarit (Woolrich-Piña et al., 2016), and Nuevo León (Nevárez-de los Reyes et al., 2016), and this year two more, on Jalisco (Cruz-Sáenz et al., 2017) and

the Mexican Yucatán Peninsula (González-Sánchez et al., 2017). Thus, this paper on the herpetofauna of Puebla is the ninth entry in this series. Carbajal-Márquez and Quintero-Díaz (2016), who were not directly part of the MCS team, used a similar format for their paper on the herpetofauna of Aguascalientes.

PHYSIOGRAPHY AND CLIMATE

Physiographic Regions

We recognize six physiographic regions within the state of Puebla, based on modifications of the schemes in Campbell (1999) and INEGI (2013), which we briefly describe below.

Gulf Coastal Lowlands (GCL).—This region is the smallest in the state, occupying an area of ca. 176 km² (0.54% of Puebla's land surface; Fig. 1). The GCL (Fig. 2) is bordered to the northwest by the GCL of northern Veracruz, to the west by the SMO, and to the east by the Gulf Coastal Plain of central Veracruz. The geomorphology of the GCL contains characteristics of an emerged coastal plain that is interrupted by some isolated mounts, especially near the SMO. Most of the rocks in this region are sandstones, limestones, and shales dating from the Cretaceous and Tertiary. The municipalities located in this region are: Acateno, Ayotoxco de Guerrero, Cuetzalan del Progreso, Francisco Z. Mena, Hueytamalco, Jonotla, Tenampulco, Tuzamapan de Galeana, Venustiano Carranza, and Zoquiapan. The elevations lie between 150 and 550 m, so the uplifted areas between about 200 m and 550 m are those connected to the lower border of the SMO. In this case, we consider a coastal plain as the essentially flat areas associated with the adjacent Gulf of Mexico (Fig. 2). The same system was used by Johnson et al. (2010, 2015a) for the Pacific Coastal Plain in Chiapas and by Cruz-Sáenz et al. (2017) for Jalisco, where the coastal plain attained a maximum elevation of around 200 m.




Fig. 2. *Gulf Coastal Lowlands.* Rancho Las Margaritas, Km 9 marker on the Hueytamalco–Tenampulco road, at an elevation of 400 m. The vegetation consists of patches of tropical forest that still exist in this region. © J. Guillermo Ortega-Vázquez

The main vegetation of the GCL is evergreen forest with secondary formations. Rainforest also is represented, and occurs in transitional areas with evergreen forest. Plant species distributed in this region include *Alnus jorullensis*, *Liquidambar styraciflua*, *Trema micrantha*, *Conostegia xalapensis*, *Clethra* sp., *Cyathea* sp., *Bocconia frutescens*, and *Pteridium aquilinum* (www.wikipedia.org; accessed 27 May 2017).

Sierra Madre Oriental (SMO).—The SMO (Fig. 1) is characterized by a series of mountain ranges dating from the Lower Jurassic to the Late Cretaceous-Tertiary, as well as by volcanic intrusive rocks. The SMO (Fig. 3) is located

in the northern and eastern portions of the state and is positioned between sections of the GCL and TMV, forming what also is called the Sierra Nororiental of Puebla, which comprises the Sierras of Zacapoaxtla, Huauchinango, Teziutlán, Tetela de Ocampo, Chignahuapan, and Zacatlán. The highest peaks in this area are Apulco, Chichat, Chignahuapan, Soltepec and Tlatlauquitepec, whose elevations lie between 1,500 m (at La Cumbre, Apulco) and 2,200 m (at Cerro Cabezón, Tlatlauquitepec). The southern Sierra Nororiental of Puebla is a geologic transitional zone between the SMO and TMV. This region occupies an area of ca. 4,489 km² (13% of the state's surface), and the elevations are between 600 and 1,900 m. The vegetation of the SMO is composed of pine forest, pine-oak forest, rainforest, and sub-deciduous lowland forest. Species distributed in this region include *Ceiba parviflora*, *Bursera simaruba*, *Cedrela odorata*, *Swietenia macrophylla*, *Spondias mombin*, *Brosimum alicastrum*, *Coccoloba barbadens*, *Pithecellobium arboreum*, *Lysiloma divaricata*, *Phoeba tampicensis*, *Bursera simaruba*, *Acacia coulteri*, and *Ficus* spp. (Luna et al., 2004).



Fig. 3. *Sierra Madre Oriental*. Pine-oak forest at Xochititán, 25 km W of Tetela de Ocampo, in the municipality of Tetela de Ocampo, at an elevation of 1,800 m.  © Guillermo A. Woolrich-Piña

Trans-Mexican Volcanic Belt (TMV).—The TMV (Fig. 1) is characterized as a mass of volcanic rock resulting from successive volcanic episodes dating from the late Miocene and Pliocene (≈ 7 –3.5 million years ago). In Puebla, this physiographic region is the largest, covering an area of ca. 15,454 km² (45% of the entire state). This region is composed of the Sierra Nevada and Serranías de los Frailes, Temixco, Amozoc, Tepeaca, and Soltepec. The highest elevations are the volcanoes Pico de Orizaba (Citlaltépetl; 5,747 m), Popocatepetl (5,452 m), Iztaccíhuatl (5,286 m), and Malinche (Malintzin; 4,461 m), the highest mountains in Mexico. The elevations in Puebla generally range between 2,200 and 3,500 m. In this region there is a transition zone with the SMO, called Axalapazcos, in which the crater lakes Tecuila, Quechulac, Alchichica (Fig. 4), Atexcac, Aljojuca, and La Preciosa are located; these lakes contain brackish water due to underground erosion caused by the groundwater on the limestone rocks of the subsoil. The vegetation in this region is composed of pine, pine-oak, and oak forests, as well as grassland (*Abies religiosa*, *Pinus pseudostrobus*, *P. hartwegii*, *P. attenuata*, *P. ayacahuite*, *P. leiophylla*, *P. patula*, *P. teocote*, *Quercus* spp., *Q. rugosa*, *Alnus* spp., *Arbutus* spp., *Cupressus* spp., *Juniperus* spp., and *Festuca tolucensis*; Luna et al., 2009).

Sierra Madre del Sur (SMS).—The Sierra Madre del Sur (Fig. 1) is the result of complex geological processes. The basement is formed of metamorphic rocks (shale, gneiss, quartzite and marble) that date from the Paleozoic; above these rocks are sandstones, limestones, and shales from the Jurassic and Cretaceous, and finally conglomerate, volcanic rocks and alluvium from the Tertiary and Quaternary. In Puebla, this physiographic region (Fig. 5) contains

only a small section sandwiched between the UBB and VOT in the southeastern part of the state, which is an extension of the Mixteca region of Oaxaca, covering an area of ca. 1,300 km². The elevations of the SMS in Puebla are between 1,400 and 2,500 m. The vegetation in this region is composed of thorny xeric scrub forest and tropical dry forest, including cacti (*Neobouxbamia tetetzo*, *Cephalocereus* spp.), mesquite trees (*Prosopis laevigata*), “pata de elefante” trees (*Beucarnea gracilis*), and other plants (*Myrtillocactus geometrizans*, *Echinocactus viznaga*, *Fouquieria formosa*, and *Holocantha stewartii*), among others (Valiente-Banuet et al., 2009).




Fig. 4. *Trans-Mexican Volcanic Belt.* View of the saline Lago de Alchichica, in the municipality of Alchichica, at an elevation of 2,300 m. The lake lies in a volcanic crater, and is the only known locality for the Pueblan endemic salamander *Ambystoma taylori*. 📷 © Enrique Barquet




Fig. 5. *Sierra Madre del Sur.* Thorn scrub forest near Ixcaquixtla, in the municipality of Ixcaquixtla, 18 km S of Tepexi de Rodríguez, at an elevation of 2,000 m. 📷 © Guillermo A. Woolrich-Piña



Incilius cristatus (Wiegmann, 1833). The Large-crested Toad occurs in “central-western Veracruz and adjacent Puebla, Mexico” (Frost, 2016). This individual was found near the Barranca of Xocoyolo, in the municipality of Cuetzalan del Progreso, Puebla. Wilson et al. (2013a) determined its EVS as 14, placing it at the lower portion of the high vulnerability category, the IUCN has assessed it as Critically Endangered, and SEMARNAT lists this toad under the category of special concern (Pr).  © José Alfredo Hernández-Díaz



Dryophytes plicatus (Brocchi, 1877). The Ridged Treefrog is distributed in the Sierra Madre Oriental and the Cordillera Volcanica along the southern edge of the Mexican Plateau (in Michoacán, Morelos, México, D.F., Tlaxcala, Puebla, Veracruz, and Hidalgo) (Frost, 2016). This individual was found in San Andrés Cholula, in the municipality of San Andrés Cholula, Puebla. Wilson et al. (2013a) calculated its EVS as 11, placing it in the lower portion of the medium vulnerability category, the IUCN has assessed it as Least Concern, and SEMARNAT lists this treefrog as threatened (A).  © Elí García-Padilla

Upper Balsas Basin (UBB).—The UBB (Fig. 1) is directed transversely from east to west and is located immediately south of the TMV region, covering an area of ca. 9,000 km² and extending in an arc by the highlands that lie to the west of the VOT, and end by joining north of Ixcaquitla and southeast of the city of Puebla, at the edge of the Mesa de Anáhuac (Fernández-Nava et al., 1998). The southern border of the UBB is formed by the higher areas of the SMS in Guerrero, and the northern border by sections of the TMV, VOT, and the Mixteca area of the SMS. The southeastern boundary of the UBB also is aligned with the SMS. The elevational gradient of the UBB in Puebla

mostly lies between 1,500 and about 2,000 m, but also contains a few peaks with elevations above 2,000 m, such as Cerro Tecorral at 2,060 m, in which the Río Atoyac formed a canyon.


Geologically, the UBB is structured by heterogeneous Cenozoic rocks consisting mainly of clastics, including gypsum and limestone, and by volcanic rock overlapping the Mesozoic rocks. Several lithologic formations are recognized (Pie de Vaca Formation, Cuayuca Formation, Oapan Formation, and Jolalpan gypsum), which have been assigned to a late Eocene-Early Oligocene age (Carranza-Sierra, 2001).

Tropical deciduous forest is distributed in the higher portions of the UBB of Puebla, which consists of *Bursera aptera*, *B. fagaroides*, *B. lancifolia*, *B. morelensis*, *B. schlechtendalii*, *Actinocheita filicina*, *Euphorbia fulva*, *Acacia bilimekii*, *A. coulteri*, *A. pennatula*, *Conzattia multiflora*, *Croton rzedowskii*, *Pithecellobium acatlense*, *Tecoma stans*, and *Wimmeria pubescens*. Floristic elements such as *Hauya elegans*, *Euphorbia fulva*, *Cedrela salvadorensis*, *Bursera grandifolia*, *B. vejar-vazquezi*, *Sideroxylon capari*, *Lasiacis divaricata*, *Dorstenia drakeana*, *Euphorbia antisiphylitica*, *Cyrtocarpa procerca*, *Thevetia thevetioides*, and *Ceiba parviflora* are found in the lower parts and along rivers and streams (Guízar, 1991). Xerophilous scrub vegetation also occurs within the UBB of Puebla, primarily in the municipalities of Acatlán and Petlalcingo. In this region, the slopes are covered with dense xerophilous scrub composed of *Castela tortuosa*, *Schaefferia stenophylla*, *Gochnatia obtusa*, and *Fouquieria formosa*, as well as the shrub *Cercidium praecox*; associations of *Escontria chiotilla* and large aggregates of the thorn scrubs *Celtis pallida*, *Randia armata*, and *Schaefferia pilosa* also are common (Fernández-Nava et al., 1998).

Valley of Tehuacán (VOT).—The VOT (Fig. 1) encompasses an area of ca. 3,900 km², at elevations ranging from 1,400 to about 3,000 m (Miguel-Talonia et al., 2014); the Sierra de Zapotitlán is representative of this region, and the highest peaks in the valley are Cerro Pajarito at an elevation of 2,700 m, and Cerro Chacatecas at 2,500 m (Woolrich-Piña et al., 2010). The arid conditions of the VOT (Fig. 6) are the result of a rain shadow effect caused by the Sierra de Zongolica. Geologically, the VOT originated from an event caused by the progressive deformation of the Earth's crust during the Cenozoic, after the Laramide orogeny, which involved four phases.

In the northern portions of the valley the predominant vegetation consists of tropical deciduous forest and xerophytic scrub, but the southern portions contain pine-oak forest and small patches of cloud forest (Villaseñor et al., 1990). Valiente-Banuet et al. (2000) recognized 29 plant associations, of which nine are physiognomically dominated by such columnar cacti as *Cephalocereus columna-trajani*, *Escontria chiotilla*, *Neobuxbaumia macrocephala*, *N. mezcalaensis*, *N. tetetzo*, *Pachycereus fulviceps*, *P. weberi*, *Polaskia chichipe*, *Stenocereus stellatus*, and *S. dumortieri*. According to Arias et al. (2012), 86 species of cacti are found in the VOT.



Fig. 6. *Valley of Tehuacán.* Xeric vegetation in the Jardín Botánico Helia Bravo Hollis in Zapotitlán de las Salinas, municipality of Zapotitlán de las Salinas, at an elevation of 1,700 m.  © Elí García-Padilla



Ambystoma subsalsum Taylor, 1943. The Alchichica Salamander is distributed in the “high elevations of Durango and Zacatecas, presumably to Puebla” (Frost, 2016). This individual came from the Axalapazcos region, in central Puebla. Wilson et al. (2013a) determined its EVS as 14, placing it at the lower portion of the high vulnerability category, the IUCN has not evaluated this species, and this salamander is not listed by SEMARNAT. 📷 © Peter Heimes



Aquiloerycea quetzalanensis (Parra-Olea, Canseco-Márquez, and García-París, 2004). The Cuetzalan Salamander is endemic to Puebla, where it is distributed in pine-oak and cloud forests at elevations from 830 to 1,900 m (Amphibia Species of the World; accessed 7 July 2017; Mociño-Deloya et al., 2007). This individual was found near Xocoyolo, Puebla. Wilson et al. (2013a) calculated its EVS as 17, placing it in the middle portion of the high vulnerability category, the IUCN has assessed it as Critically Endangered, and this species is not listed by SEMARNAT. 📷 © Sean Rovito

Climate

Temperature.—We indicate the monthly minimum, mean, and maximum temperatures for a single locality for each of the six physiographic regions we recognize in Puebla (Table 1). The elevations for these localities range from 133 m in the GCL at Venustiano Carranza to 3,393 m in the TMV at Chiautzingo.

Table 1. Monthly minimum, mean (in parentheses), maximum, and annual temperature data (in °C) for the physiographic regions of Puebla, Mexico. Localities and their elevation for each of the regions are as follows: Gulf Coastal Lowlands—Venustiano Carranza (133 m); Sierra Madre Oriental—Zacapoaxtla (1,733 m); Trans-Mexican Volcanic Belt—Chiautzingo (3,393 m); Sierra Madre del Sur—Tepexi de Rodríguez (2,171 m); Upper Balsas Basin—Chiautla (991 m); and Valley of Tehuacán—Zapotitlán Salinas (1,500 m). Data taken from <http://smn.cna.gob.mx/es/informacion-climatologica-ver-estado?estado=pue> (accessed 12 Oct 2017).

Physiographic Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Gulf Coastal Lowlands	13.7 (18.9) 24.1	14.8 (20.2) 25.7	16.9 (22.6) 28.3	20.0 (25.9) 31.9	21.5 (27.3) 33.2	22.6 (28.0) 33.5	22.2 (27.4) 32.6	22.1 (27.5) 33.0	21.7 (26.7) 31.8	19.8 (25.0) 30.2	16.6 (21.8) 27.1	14.7 (19.7) 24.7	18.8 (24.3) 29.6
Sierra Madre Oriental	3.8 (12.8) 24.0	3.5 (13.5) 24.8	5.5 (16.3) 28.1	6.7 (18.1) 28.4	8.8 (19.0) 32.2	9.0 (18.0) 29.0	7.6 (16.9) 25.3	6.5 (16.9) 25.7	9.1 (16.5) 24.1	7.9 (15.4) 25.2	5.3 (14.5) 27.6	3.7 (13.6) 25.1	6.5 (16.0) 26.6
Trans Mexican Volcanic Belt	-0.4 (7.9) 17.0	0.3 (9.1) 18.7	0.6 (10.9) 24.3	2.5 (11.8) 22.2	3.4 (13.2) 32.0	5.4 (12.3) 21.4	4.6 (12.3) 31.7	3.9 (12.3) 31.2	4.5 (12.2) 31.5	1.8 (11.0) 31.5	1.7 (10.5) 31.7	0.2 (9.4) 31.3	2.4 (11.1) 27.0
Sierra Madre del Sur	2.5 (15.7) 30.4	4.4 (17.5) 32.2	6.6 (20.6) 34.0	9.6 (22.3) 35.0	7.6 (22.5) 36.4	10.8 (21.4) 33.4	10.0 (20.3) 32.4	10.0 (20.2) 33.5	9.6 (19.4) 30.4	5.3 (18.4) 32.3	4.3 (17.1) 31.7	3.0 (15.6) 30.0	10.3 (19.3) 28.2
Upper Balsas Basin	11.6 (27.2) 32.5	10.9 (22.1) 37.1	12.0 (23.5) 37.6	16.7 (25.8) 40.3	16.7 (28.5) 40.5	2.0 (28.7) 38.3	1.9 (26.0) 41.9	1.9 (25.9) 41.5	1.9 (24.9) 43.9	15.6 (25.7) 40.0	13.7 (23.3) 33.9	11.5 (22.2) 33.0	17.2 (25.3) 33.4
Valley of Tehuacán	5.5 (17.5) 30.6	7.5 (19.4) 34.5	9.4 (21.9) 35.4	11.9 (23.9) 39.3	13.8 (24.5) 38.3	14.9 (23.8) 37.8	14.0 (22.7) 35.5	14.4 (23.0) 35.4	14.1 (22.5) 32.9	11.6 (21.5) 33.1	7.3 (19.7) 31.7	7.0 (17.9) 30.7	10.9 (21.5) 34.6

The mean annual temperature (MAT) for Chiautla (elevation 991 m) in the UBB, is 25.3°C, followed by that of Venustiano Carranza (133 m) in the GCL with 24.3°C. The next lowest MAT is 21.5°C at Zapotitlán Salinas (1,500 m) in the VOT, followed by 19.3°C reported at Tepexi de Rodríguez (2,171 m), in the SMS. The MAT for Zacapoaxtla (1,733 m) in the SMO is 16.0°C, and that for Chiautzingo (3,393 m) in the TMV is 11.1°C (Table 1).

The minimum annual temperatures range from 2.4°C in the TMV to 18.8°C in the GCL. The maximum annual temperatures range from 26.6°C in the SMO and 27.0°C in the TMV to 34.6°C in the VOT. Among the six physiographic regions in Puebla, the minimum annual temperatures are 10.8–24.6°C lower than the maximum annual temperatures (Table 1). The mean monthly temperatures peak during May or June, most often in May, and reach their low point during December, January, or February, but usually in January (Table 1).

Precipitation.—The monthly precipitation is lowest during the dry season, in December, February or March, and highest during the rainy season, in July or September, but usually in September (Table 2). The data in Table 2 demonstrate that 76–90% (\bar{x} = 0.83) of the annual rainfall is deposited during the rainy season, which extends from May to October (Table 2). The annual rainfall ranges from 408 mm in the VOT to 1,575 mm in the GCL, with the larger value 3.9 times greater than the smaller one (Table 2).

Table 2. Monthly and annual precipitation data (in mm) for the physiographic regions of Puebla, Mexico. Localities and their elevation for each of the regions are as follows: Gulf Coastal Lowlands—Venustiano Carranza (133 m); Sierra Madre Oriental—Zacapoaxtla (1,733 m); Trans Mexican Volcanic Belt—Chiautzingo (3,393 m); Sierra Madre del Sur—Tepexi de Rodríguez (2,171 m); Upper Balsas Basin—Chiautla (991 m); Valley of Tehuacán—Zapotitlán Salinas (1,500 m). The shaded area indicates the months of the rainy season. Data taken from <http://smn.cna.gob.mx/es/informacion-climatologica-ver-estado?estado=pue> (accessed 12 Oct 2017).

Physiographic Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Gulf Coastal Lowlands	48	46	46	81	107	233	229	216	256	160	81	72	1,575
Sierra Madre Oriental	40	33	26	38	54	167	114	110	268	168	86	53	1,156
Trans Mexican Volcanic Belt	16	8	10	48	87	153	168	164	145	71	15	3	888
Sierra Madre del Sur	37.1	5.9	11.8	23.6	57.8	149.2	104.6	133.8	132.0	61.9	9.9	6.2	733.8
Upper Balsas Basin	28.4	7.2	1.4	11.9	55.2	120.3	128.8	141.1	173.9	68.0	10.7	2.4	749.3
Valley of Tehuacán	6	4	5	17	47	92	57	58	83	30	5	4	408

COMPOSITION OF THE HERPETOFAUNA

Families

The herpetofauna of Puebla contains representatives of 41 families (Table 3) of the 59 known from Mexico (69.5%), including 10 of anurans (of a total of 11; 90.9%), three of salamanders (four; 75.0%), 25 of squamates (31; 80.6%), and three of turtles (10; 30.0%). No caecilian or crocodylian families are represented in the state (Wilson et al., 2013a, b; J. Johnson, unpublished). Of the amphibian families, 71.9% of the species are classified in the Craugastoridae, Hylidae, Ranidae, and Plethodontidae, whereas for those in the remainder of the herpetofauna 64.6% of the species are in the Phrynosomatidae, Colubridae, Dipsadidae, Natricidae, and Viperidae (Tables 4, 5).

Table 3. Composition of the native and non-native herpetofauna of Puebla, Mexico.

Orders	Families	Genera	Species
Anura	10	25	64
Caudata	3	9	25
Subtotals	13	34	89
Squamata	25	75	174
Testudines	3	3	4
Subtotals	28	78	178
Totals	41	112	267

Table 4. Distribution of the amphibians, crocodylians, squamates, and turtles of Puebla, Mexico, by physiographic region. Abbreviations are as follows: GCL = Gulf Coastal Lowlands; SMO = Sierra Madre Oriental; TMV = Trans- Mexican Volcanic Belt; SMS = Sierra Madre del Sur. UBB = Upper Balsas Basin; and VOT = Valley of Tehuacán. See text for descriptions of these regions. * = species endemic to Mexico; ** = species endemic to Puebla; and *** = non-native species.

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
Anura (64 species)							
Bufonidae (8 species)							
<i>Anaxyrus compactilis</i> *			+		+		2
<i>Incilius cristatus</i> *		+					1
<i>Incilius marmoreus</i> *		+			+		2
<i>Incilius nebulifer</i>	+	+	+				3
<i>Incilius occidentalis</i> *		+	+	+	+	+	5
<i>Incilius perplexus</i> *					+		1
<i>Incilius valliceps</i>	+	+					2
<i>Rhinella horribilis</i>	+	+	+		+	+	5
Centrolenidae (1 species)							
<i>Hyalinobatrachium fleischmanni</i>	+	+	+				3
Craugastoridae (10 species)							
<i>Craugastor alfredi</i>	+	+					2
<i>Craugastor augusti</i>		+	+	+	+	+	5
<i>Craugastor berkenbuschii</i> *	+	+					2
<i>Craugastor decoratus</i> *	+	+	+				3
<i>Craugastor galacticorhinus</i> *		+					1
<i>Craugastor loki</i>	+	+	+				3
<i>Craugastor mexicanus</i> *		+	+				2
<i>Craugastor pygmaeus</i>		+	+				2
<i>Craugastor rhodopis</i> *		+	+				2
<i>Craugastor rugulosus</i> *					+		1
Eleutherodactylidae (4 species)							
<i>Eleutherodactylus leprus</i>	+	+	+				3
<i>Eleutherodactylus nitidus</i> *		+	+	+	+	+	5
<i>Eleutherodactylus verrucipes</i> *		+	+	+			3
<i>Eleutherodactylus verruculatus</i> *		+					1
Hylidae (24 species)							
<i>Anotheca spinosa</i>		+					1
<i>Bromeliohyala dendroscarta</i> *		+					1
<i>Charadrahyla taeniopus</i> *		+	+				2
<i>Dendropsophus microcephalus</i>		+					1
<i>Dryophytes arenicolor</i>				+	+		2
<i>Dryophytes euphorbiaceus</i> *		+	+				2

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
<i>Dryophytes eximius</i> *		+	+				2
<i>Dryophytes plicatus</i> *			+				1
<i>Exerodonta smaragdina</i> *					+		1
<i>Exerodonta xera</i> *						+	1
<i>Megastomatohyla mixomaculata</i> *		+					1
<i>Ptychohyla zophodes</i> *		+					1
<i>Rheohyla miotypanum</i> *	+	+	+				3
<i>Sarcohyla arborescendens</i> *		+	+				2
<i>Sarcohyla bistincta</i> *		+					1
<i>Sarcohyla charadricola</i> *		+					1
<i>Sarcohyla robertsorum</i> *		+	+				2
<i>Scinax staufferi</i>	+	+	+				3
<i>Smilisca baudinii</i>	+	+	+		+	+	5
<i>Smilisca cyanosticta</i>		+					1
<i>Tlalocohyla godmani</i> *	+	+					2
<i>Tlalocohyla picta</i>	+	+					2
<i>Tlalocohyla smithii</i> *					+		1
<i>Trachycephalus vermiculatus</i>	+	+					2
Leptodactylidae (2 species)							
<i>Leptodactylus fragilis</i>	+	+					2
<i>Leptodactylus melanonotus</i>	+	+	+				3
Microhylidae (2 species)							
<i>Hypopachus ustus</i>	+		+	+			3
<i>Hypopachus variolosus</i>		+		+	+		3
Phyllomedusidae (3 species)							
<i>Agalychnis callidryas</i>	+	+					2
<i>Agalychnis dacnicolor</i> *					+		1
<i>Agalychnis moreletii</i>	+	+					2
Ranidae (9 species)							
<i>Lithobates berlandieri</i>	+	+	+				3
<i>Lithobates catesbeianus</i> ***	+			+			2
<i>Lithobates chichicuahutla</i> *			+				1
<i>Lithobates johni</i> *	+	+					2
<i>Lithobates montezumae</i> *			+				1
<i>Lithobates pueblae</i> *		+					1
<i>Lithobates spectabilis</i> *		+	+	+	+	+	5
<i>Lithobates vaillanti</i>		+					1
<i>Lithobates zweifeli</i> *					+		1

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
Scaphiropodidae (1 species)							
<i>Spea multiplicata</i>	+	+	+	+	+	+	6
Caudata (25 species)							
Ambystomatidae (3 species)							
<i>Ambystoma leorae</i> *			+				1
<i>Ambystoma taylori</i> **			+				1
<i>Ambystoma subsalsum</i> *		+	+		+	+	4
Plethodontidae (21 species)							
<i>Aquiloerycea cafetalera</i> *		+					1
<i>Aquiloerycea cephalica</i> *			+				1
<i>Aquiloerycea quetzalanensis</i> **		+	+				2
<i>Bolitoglossa platydactyla</i> *	+	+	+				3
<i>Chiropterotriton arboreus</i> *		+					1
<i>Chiropterotriton orculus</i> *		+	+				2
<i>Isthmura bellii</i> *		+	+				2
<i>Isthmura gigantea</i> *		+	+				2
<i>Parvimolge townsendi</i> *		+	+				2
<i>Pseudoeurycea firscheini</i> *		+					1
<i>Pseudoeurycea gadovii</i> *			+				1
<i>Pseudoeurycea leprosa</i> *		+	+				2
<i>Pseudoeurycea lineola</i> *		+					1
<i>Pseudoeurycea lynchi</i> *		+	+				2
<i>Pseudoeurycea melanomolga</i> *			+				1
<i>Pseudoeurycea mixteca</i> *				+			1
<i>Thorius dubitus</i> *		+					1
<i>Thorius magnipes</i> *		+					1
<i>Thorius maxillabrochus</i> *						+	1
<i>Thorius schmidti</i> *		+					1
<i>Thorius troglodytes</i> *		+					1
Salamandridae (1 species)							
<i>Notophthalmus meridionalis</i>	+						1
Squamata (174 species)							
Anguidae (7 species)							
<i>Abronia graminea</i> *		+	+				2
<i>Abronia taeniata</i> *		+	+				2
<i>Barisia imbricata</i> *		+	+		+	+	4
<i>Celestus enneagrammus</i> *		+					1
<i>Celestus legnotus</i> *		+	+				2

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
<i>Gerrhonotus liocephalus</i>		+	+	+		+	4
<i>Gerrhonotus ophiurus</i> *		+	+				2
Corytophanidae (3 species)							
<i>Basiliscus vittatus</i>	+	+				+	3
<i>Corytophanes hernandesii</i>	+	+					2
<i>Laemanctus serratus</i>		+					1
Dactyloidae (8 species)							
<i>Norops carlliebi</i> *		+	+	+		+	4
<i>Norops cymbops</i> *		+					1
<i>Norops laeviventris</i>	+	+	+				3
<i>Norops microlepidotus</i> *					+		1
<i>Norops naufragus</i> *		+					1
<i>Norops petersii</i>		+					1
<i>Norops sericeus</i>	+	+	+				3
<i>Norops tropidonotus</i>		+					1
Eublepharidae (1 species)							
<i>Coleonyx elegans</i>		+			+		2
Gekkonidae (1 species)							
<i>Hemidactylus frenatus</i> ***		+			+		2
Helodermatidae (1 species)							
<i>Heloderma horridum</i> *					+		1
Iguanidae (3 species)							
<i>Ctenosaura acanthura</i>		+		+		+	3
<i>Ctenosaura pectinata</i> *					+	+	2
<i>Iguana iguana</i>		+			+		2
Mabuyidae (1 species)							
<i>Marisora brachypoda</i>					+		1
Phrynosomatidae (22 species)							
<i>Phrynosoma asio</i>					+		1
<i>Phrynosoma braconnieri</i> *				+	+	+	3
<i>Phrynosoma orbiculare</i> *		+	+		+		3
<i>Phrynosoma taurus</i> *				+	+	+	3
<i>Sceloporus aeneus</i> *			+				1
<i>Sceloporus aureolus</i> *		+	+	+		+	4
<i>Sceloporus bicanthalis</i> *			+				1
<i>Sceloporus formosus</i> *		+					1
<i>Sceloporus gadoviae</i> *				+	+	+	3
<i>Sceloporus grammicus</i>		+	+	+		+	4

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
<i>Sceloporus horridus</i> *			+	+	+	+	4
<i>Sceloporus jalapae</i> *		+	+	+		+	4
<i>Sceloporus megalepidurus</i> *		+	+	+		+	4
<i>Sceloporus melanorhinus</i>					+		1
<i>Sceloporus mucronatus</i> *		+	+				2
<i>Sceloporus ochoteranae</i> *					+		1
<i>Sceloporus palaciosi</i> *			+				1
<i>Sceloporus scalaris</i> *			+				1
<i>Sceloporus spinosus</i> *		+	+	+		+	4
<i>Sceloporus torquatus</i> *		+	+				2
<i>Sceloporus variabilis</i>	+	+	+				3
<i>Urosaurus bicarinatus</i> *				+	+	+	3
Phyllodactylidae (1 species)							
<i>Phyllodactylus bordai</i> *				+		+	2
Scincidae (3 species)							
<i>Plestiodon brevisrostris</i> *		+	+				2
<i>Plestiodon copei</i> *		+	+				2
<i>Plestiodon lynxe</i> *		+	+				2
Sphaerodactylidae (1 species)							
<i>Sphaerodactylus glaucus</i>		+					1
Sphenomorphidae (3 species)							
<i>Scincella cherriei</i>		+					1
<i>Scincella gemmingeri</i> *	+	+	+				3
<i>Scincella silvicola</i> *	+	+	+				3
Teiidae (6 species)							
<i>Aspidoscelis costata</i> *		+	+		+	+	4
<i>Aspidoscelis deppii</i>					+		1
<i>Aspidoscelis parvisocia</i> *				+		+	2
<i>Aspidoscelis sackii</i> *					+	+	2
<i>Holcosus amphigrammus</i> *	+	+					2
<i>Holcosus sinister</i> *					+		1
Xantusiidae (3 species)							
<i>Lepidophyma sylvaticum</i> *	+	+	+				3
<i>Lepidophyma tuxtlae</i> *	+	+					2
<i>Lepidophyma zongolica</i> **	+						1
Xenosauridae (3 species)							
<i>Xenosaurus grandis</i> *		+					1
<i>Xenosaurus rectocollaris</i> *		+		+		+	3

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
<i>Xenosaurus tzacualtipantecus</i> *		+					1
Boidae (2 species)							
<i>Boa imperator</i>	+	+	+			+	4
<i>Boa sigma</i> *					+	+	2
Colubridae (31 species)							
<i>Conopsis acuta</i> *		+	+	+		+	4
<i>Conopsis biserialis</i> *		+		+			2
<i>Conopsis lineata</i> *		+	+			+	3
<i>Conopsis nasus</i> *			+				1
<i>Drymarchon melanurus</i>	+	+	+		+	+	5
<i>Drymobius margaritiferus</i>	+	+	+		+		4
<i>Ficimia olivacea</i> *		+			+		2
<i>Ficimia publia</i>		+			+	+	3
<i>Ficimia streckeri</i>	+	+					2
<i>Lampropeltis polyzona</i> *	+	+	+	+	+	+	6
<i>Leptophis diplotropis</i> *			+		+		2
<i>Leptophis mexicanus</i>	+	+	+				3
<i>Masticophis mentovarius</i>		+	+		+	+	4
<i>Mastigodryas melanolomus</i>	+	+	+				3
<i>Oxybelis aeneus</i>	+	+	+	+	+	+	6
<i>Pituophis deppei</i> *		+	+			+	3
<i>Pituophis lineaticollis</i>		+		+		+	3
<i>Pseudelaphe flavirufa</i>	+	+					2
<i>Pseudoficimia frontalis</i> *		+			+		2
<i>Salvadora bairdi</i> *			+			+	2
<i>Salvadora intermedia</i> *				+		+	2
<i>Salvadora mexicana</i> *					+		1
<i>Senticolis triaspis</i>		+	+	+	+	+	5
<i>Sonora michoacanensis</i> *					+		1
<i>Spilotes pullatus</i>	+	+					2
<i>Tantilla bocourti</i> *					+	+	2
<i>Tantilla calamarina</i> *					+		1
<i>Tantilla robusta</i> **	+	+					2
<i>Tantilla rubra</i>	+	+			+		3
<i>Trimorphodon biscutatus</i>					+		1
<i>Trimorphodon tau</i> *			+	+	+	+	4
Dipsadidae (37 species)							
<i>Adelphicos quadrivirgatum</i>	+	+	+				3

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
<i>Amastridium sapperi</i>	+	+					2
<i>Chersodromus liebmanni</i> *		+					1
<i>Coniophanes bipunctatus</i>	+	+					2
<i>Coniophanes fissidens</i>	+	+	+				3
<i>Coniophanes imperialis</i>	+	+	+				3
<i>Coniophanes melanocephalus</i> *					+		1
<i>Coniophanes piceivittis</i>	+	+					2
<i>Conophis vittatus</i>					+		1
<i>Enulius flavitorques</i>					+		1
<i>Geophis blanchardi</i> *		+					1
<i>Geophis dubius</i> *		+					1
<i>Geophis lorancai</i> *		+					1
<i>Geophis mutitorques</i> *		+	+				2
<i>Geophis semidoliatus</i> *	+	+					2
<i>Geophis turbidus</i> *		+					1
<i>Hypsiglena torquata</i> *					+		1
<i>Imantodes cenchoa</i>	+	+	+				3
<i>Imantodes gemmistratus</i>				+	+	+	3
<i>Leptodeira maculata</i>		+	+				2
<i>Leptodeira septentrionalis</i>	+	+	+				3
<i>Leptodeira splendida</i> *					+		1
<i>Ninia diademata</i>	+	+					2
<i>Ninia sebae</i>	+						1
<i>Oxyrhopus petolarius</i>		+					1
<i>Pliocercus elapoides</i>	+	+					2
<i>Pseudoleptodeira latifasciata</i> *					+		1
<i>Rhadinaea cuneata</i> *		+					1
<i>Rhadinaea decorata</i>	+	+	+				3
<i>Rhadinaea fulvivittis</i> *		+					1
<i>Rhadinaea hesperia</i> *					+	+	2
<i>Rhadinaea marcellae</i> *	+	+					2
<i>Rhadinaea quinquelineata</i> *		+	+				2
<i>Sibon dimidiatus</i>		+					1
<i>Sibon nebulatus</i>		+	+				2
<i>Tropidodipsas sartorii</i>	+	+	+				3
<i>Tropidodipsas zweifeli</i> *						+	1
Elapidae (7 species)							
<i>Micrurus bernadi</i> *	+	+	+				3

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
<i>Micrurus diastema</i>		+					1
<i>Micrurus elegans</i>		+					1
<i>Micrurus laticollaris</i> *					+	+	2
<i>Micrurus nebularis</i> *		+					1
<i>Micrurus pachecogili</i> *						+	1
<i>Micrurus tener</i>		+					1
Leptotyphlopidae (2 species)							
<i>Rena maxima</i> *				+	+	+	3
<i>Rena myopica</i> *			+				1
Natricidae (12 species)							
<i>Nerodia rhombifer</i>	+	+	+				3
<i>Storeria dekayi</i>	+	+	+				3
<i>Storeria storerioides</i> *			+				1
<i>Thamnophis chrysocephalus</i> *		+					1
<i>Thamnophis conanti</i> *		+					1
<i>Thamnophis cyrtopsis</i>					+	+	2
<i>Thamnophis eques</i>			+				1
<i>Thamnophis proximus</i>	+	+	+				3
<i>Thamnophis pulchrilatus</i> *			+				1
<i>Thamnophis scalaris</i> *			+				1
<i>Thamnophis scaliger</i> *			+				1
<i>Thamnophis sumichrasti</i> *	+	+	+				3
Sibynophiidae (1 species)							
<i>Scaphiodontophis annulatus</i>	+	+	+				3
Typhlopidae (2 species)							
<i>Amerotyphlops tenuis</i>		+					1
<i>Indotyphlops braminus</i> ***	+						1
Viperidae (13 species)							
<i>Agkistrodon bilineatus</i>					+		1
<i>Atropoides nummifer</i> *	+	+	+				3
<i>Bothrops asper</i>	+	+	+				3
<i>Crotalus culminatus</i> *					+		1
<i>Crotalus intermedius</i> *		+	+	+		+	4
<i>Crotalus molossus</i>		+	+	+		+	4
<i>Crotalus polystictus</i> *			+				1
<i>Crotalus ravus</i> *		+	+	+		+	4
<i>Crotalus scutulatus</i>		+	+			+	3
<i>Crotalus triseriatus</i> *		+	+				2

Taxa	Physiographic Regions of Puebla						Number of Regions Occupied
	GCL	SMO	TMV	SMS	UBB	VOT	
<i>Mixcoatlus melanurus</i> *				+		+	2
<i>Ophryacus smaragdinus</i> *		+					1
<i>Ophryacus undulatus</i> *		+	+				2
Testudines (4 species)							
Emydidae (1 species)							
<i>Trachemys venusta</i>		+	+				2
Kinosternidae (2 species)							
<i>Kinosternon herrerai</i> *	+	+	+				3
<i>Kinosternon integrum</i> *			+		+	+	3
Trionychidae (1 species)							
<i>Apalone spinifera</i> ***		+					1

Table 5. Summary of the distributional occurrence of herpetofaunal families in Puebla, Mexico, by physiographic province. Abbreviation are as follows: GCL = Gulf Coastal Lowlands; SMO = Sierra Madre Oriental; TMV = Trans- Mexican Volcanic Belt; SMS = Sierra Madre del Sur; UBB = Upper Balsas Basin; and VOT = Valley of Tehuacán.

Families	Number of Species	Distributional Occurrence					
		GCL	SMO	TMV	SMS	UBB	VOT
Bufonidae	8	3	6	4	1	5	2
Centrolenidae	1	1	1	1	—	—	—
Craugastoridae	10	4	9	6	1	2	1
Eleutherodactylidae	4	1	4	3	2	1	1
Hylidae	24	6	19	9	1	4	2
Leptodactylidae	2	2	2	1	—	—	—
Microhylidae	2	1	1	1	2	1	—
Phyllomedusidae	3	2	2	—	—	1	—
Ranidae	9	3	5	4	2	2	1
Scaphiopodidae	1	1	1	1	1	1	1
Subtotals	64	24	50	30	10	17	8
Ambystomatidae	3	—	1	3	—	1	1
Plethodontidae	21	1	15	11	1	—	—
Salamandridae	1	1	—	—	—	—	—
Subtotals	25	2	16	14	1	1	1
Totals	89	26	66	44	11	18	9
Anguidae	7	—	7	6	1	1	2
Corytophanidae	3	2	3	—	—	—	1
Dactyloidae	8	2	7	3	1	1	1
Eublepharidae	1	—	1	—	—	1	—
Gekkonidae	1	—	1	—	—	1	—

Families	Number of Species	Distributional Occurrence					
Helodermatidae	1	—	—	—	—	1	—
Iguanidae	3	—	2	—	1	2	2
Mabuyidae	1	—	—	—	—	1	—
Phrynosomatidae	22	1	10	14	10	9	10
Phyllodactylidae	1	—	—	—	1	—	1
Scincidae	3	—	3	3	—	—	—
Sphaerodactylidae	1	—	1	—	—	—	—
Sphenomorphidae	3	2	3	2	—	—	—
Teiidae	6	1	2	1	1	4	3
Xantusiidae	3	3	2	1	—	—	—
Xenosauridae	3	—	3	—	1	—	1
Subtotals	67	11	45	30	16	21	21
Boidae	2	1	1	1	—	1	2
Colubridae	31	11	21	15	8	17	14
Dipsadidae	37	15	27	11	1	8	3
Elapidae	7	1	5	1	—	1	2
Leptotyphlopidae	2	—	—	1	1	1	1
Natricidae	12	4	6	9	—	1	1
Sibynophiidae	1	1	1	1	—	—	—
Typhlopidae	2	1	1	—	—	—	—
Viperidae	13	2	9	9	4	2	5
Subtotals	107	36	71	48	14	31	28
Emydidae	1	—	1	1	—	—	—
Kinosternidae	2	1	1	2	—	1	1
Trionychidae	1	—	1	—	—	—	—
Subtotals	4	1	3	3	—	1	1
Totals	178	48	119	81	30	53	50
Sum Totals	267	74	185	125	41	71	59

Genera

Of the 210 genera known to occur in Mexico (J. Johnson, unpublished), 112 (53.3%) have been recorded in Puebla. This number includes 25 genera of anurans (of a total of 38 in Mexico; 65.8%), nine of caudates (19; 47.4%), 75 of squamates (137; 54.7%), and three of turtles (18; 16.7%). Among the amphibians, the most speciose genera are *Incilius* (six species), *Craugastor* (10), *Lithobates* (eight native species), and *Pseudoeurycea* (seven); among the remainder of the herpetofauna, the genera are *Norops* (eight species), *Sceloporus* (17), *Geophis* (six), *Micrurus* (seven), *Thamnophis* (nine), and *Crotalus* (seven).

Species

The herpetofauna of Puebla currently consists of 267 species, including 64 anurans, 25 salamanders, 174 squamates, and four turtles (Table 3). Wilson et al. (2013a) reported 378 native amphibians from Mexico; the present number is 394 (J. Johnson, unpublished). The number of native amphibian species in Puebla is 88, 22.3% of those currently known from Mexico. Wilson et al. (2013b) calculated the total number of species for the remainder of the

herpetofauna as 849; the current number is 899 (J. Johnson, unpublished). The figure for native species in Puebla is 175, 19.5% of the total. In summary, the 263 native herpetofaunal species known from Puebla represent 20.3% of the total recorded for Mexico (1,293 species; J. Johnson, unpublished). Of the states thus far studied in the MCS, only Oaxaca shares a common border with Puebla; the herpetofauna reported for Oaxaca by Mata-Silva et al. (2015) consisted of 442 species, 1.7 times the number we are reporting for Puebla.

COMMENTS ON THE SPECIES LIST

Comments on a few species relative to our species list are necessary, as follows:

Trachycephalus “*vermiculatus*.” Ron et al. (2016) partially analyzed the taxonomy of *T. typhonius*, but left populations west of the Andes to southern and eastern Mexico without a name. Based on priority, *T. “vermiculatus”* would be the name assigned to populations found in Mexico, Central America, and the rest of South America (Frost, 2017).

Pseudoeurycea altamontana. The Morelos False Brook Salamander (or Morelos Salamander) is a poorly known species indicated by Frost (2017) as known “only from the type locality (Lake Zempoala) and the west slope of Mount Popocatepetl [sic], Morelos, southern Distrito Federal, and México, México, ca. 3000 m elevation.” The western slope of Popocatepetl, the second highest mountain in Mexico, encompasses a tripoint where the bordering states of México, Morelos, and Puebla converge. Taylor (1944) reported this species as occurring on Popocatepetl, but did not specify a locality. The type locality given by Taylor (1939: 272) is Lake Zempoala, Morelos, Mexico, at 10,500 feet elevation (3,201 m), so presumably this is the data supporting the “ca. 3000 m” figure provided by Frost (2017). Some photos, ostensibly of this species, are posted at the CalPhotos website (and at the AmphibiaWeb site), but are indicated to be of individuals from either Morelos or México. Thus, no records of *P. altamontana* are known from Puebla (Vega-López and Álvarez-Solórzano (1992), although this species eventually might be found in this state.

Chiropterotriton chiropterus. Smith and Taylor (1948) indicated that the holotype of “*Chiropterotriton chiroptera*” is unknown, but that it ranges from near the Río Frío, in the vicinity of the Iztaccíhuatl-Popocatepetl volcanoes, which is the “Mirador,” Veracruz, type locality. Vega-López and Álvarez-Solórzano (1992) indicated two specimens from 4 km NE of Río Frío at 3,200 m. Parra-Olea et al. (2006), however, concluded that this species is known only from central Veracruz, near Huatusco, Mexico, at elevations from 1,000 to 1,200 m. Nevertheless, *C. chiropterus* probably occurs in the SMO and TMV regions of Puebla (www.amphibiaweb.org; accessed 14 November 2017).

PATTERNS OF PHYSIOGRAPHIC DISTRIBUTION

We employed a system of six physiographic regions (Fig. 1) to analyze the distributional patterns for the herpetofauna of Puebla. We tabulated the physiographic distribution of these species in Table 4, and summarize these data in Table 5.

The total number of species in the six regions ranges from a low of 41 in the SMS to a high of 185 in the SMO. The values for the other four regions are 59 (VOT), 71 (UBB), 74 (GCL), and 125 (TMV). The low value of 41 represents 22.2% of the high value of 185. The reason for the low value of 41, relative to that for the other five regions, is because the SMS is one of the two smallest of the six regions in Puebla.

Four herpetofaunal groups are represented in Puebla, i.e., anurans, salamanders, squamates, and turtles. The largest number of species in three of the four groups (anurans, salamanders, and squamates) occurs in the SMO (Table 5), with the same number of turtle species occupying the SMO and TMV (Table 5). Interestingly, the number of herpetofaunal species occupying five of the six physiographic regions is relatively low (< 50%) compared to the total of 267 species in the state (Table 5), as follows: SMS (41; 15.4%); VOT (59; 22.1%); UBB (71; 26.6%); GCL (74; 27.7%); and TMO (125; 46.8%). The exception is the SMO, with 185 species (69.3% of the total). These figures generally point to a relatively low level of herpetofaunal species sharing among the six regions (see below). The figures also specify that species richness in Puebla generally increases with the size of the region, and the quantities of humid and semihumid ecosystems found within them. An exception for size is the UBB, which is the second largest region in Puebla but only contains 71 herpetofaunal species; the lower value likely is because most of the region’s landscape is covered by subhumid plant formations.



Isthmura gigantea (Taylor, 1939). The Giant False Brook Salamander occurs “in the La Joya-Jalapa region of Veracruz and into northeastern Hidalgo, Mexico” (Frost, 2016); the IUCN Red List of Threatened Species, however, indicates its range as “the eastern margins Sierra Madre Oriental of Hidalgo, Mexico, where it has been recorded from northern Puebla and Veracruz.” This individual is from Chignautla, in the municipality of Chignautla. Wilson et al. (2013a) indicated its EVS as 16, placing it in the middle portion of the high vulnerability category, the IUCN has judged it as Critically Endangered, and this salamander is not listed by SEMARNAT. 📷 © Sean Rovito



Abronia graminea (Cope, 1864). The Tehuacán Arboreal Alligator Lizard is distributed in the “highlands of the States of Veracruz and adjacent Puebla, Mexico” (Flores and Santos-Barrera, 2007). This individual was found in a region along the states of Puebla and Veracruz. Wilson et al. (2013b) calculated its EVS as 15, placing it in the lower portion of the high vulnerability category, the IUCN has assessed this species as Endangered, and SEMARNAT lists this lizard as threatened (A). 📷 © Cesar Barrio-Amorós

The members of the Pueblan herpetofauna inhabit from one to six physiographic regions, as follows: one (105 of 267 species; 39.3%); two (78; 29.2%); three (54; 20.2%); four (19; 7.1%); five (eight; 3.0%); and six (three; 1.1%). The three species distributed in all six regions are *Spea multiplicata*, *Lampropeltis polyzona*, and *Oxybelis aeneus*. Two of these three species range outside of Mexico; the other (*Lampropeltis polyzona*) is endemic to the country.

A sizable proportion of the 267 species in Puebla occupy only one or two physiographic regions (183; 68.5%), which is significant for conservation. The mean regional occupancy is 2.4, which lies within the range for the other states thus far examined in the MCS (1.9 to 3.7; Alvarado-Díaz et al., 2013; Mata-Silva et al., 2015; Johnson et al., 2015a; Terán-Juárez et al., 2016; Woolrich-Piña et al., 2016; Nevárez-de los Reyes et al., 2016; Cruz-Sáenz et al., 2017; González-Sánchez et al., 2017).

The number of species distributed in a single region range from one (in the SMS) to 50 (in the SMO).

The 50 single-region species in the SMO are as follows:

<i>Incilius cristatus</i> *	<i>Norops petersii</i>
<i>Craugastor galacticorhinus</i> *	<i>Norops tropidonotus</i>
<i>Eleutherodactylus verruculatus</i> *	<i>Sceloporus formosus</i> *
<i>Anothea spinosa</i>	<i>Sphaerodactylus glaucus</i>
<i>Bromeliohyla dendroscarta</i> *	<i>Scincella cherriei</i>
<i>Dendropsophus microcephalus</i>	<i>Xenosaurus grandis</i> *
<i>Megastomatohyla mixomaculata</i> *	<i>Xenosaurus tzacualtipantecus</i> *
<i>Ptychohyla zophodes</i> *	<i>Chersodromus liebmanni</i> *
<i>Sarcohyla bistincta</i> *	<i>Geophis blanchardi</i> *
<i>Sarcohyla charadricola</i> *	<i>Geophis dubius</i> *
<i>Smilisca cyanosticta</i>	<i>Geophis lorancai</i> *
<i>Lithobates pueblae</i> *	<i>Geophis turbidus</i> *
<i>Lithobates vaillanti</i>	<i>Oxyrhopus petolarius</i>
<i>Aquiloerycea cafetalera</i> *	<i>Rhadinaea cuneata</i> *
<i>Chiropterotriton arboreus</i> *	<i>Rhadinaea fulvivittis</i> *
<i>Pseudoeurycea firscheini</i> *	<i>Sibon dimidiatus</i>
<i>Pseudoeurycea lineola</i> *	<i>Micrurus diastema</i>
<i>Thorius dubitus</i> *	<i>Micrurus elegans</i>
<i>Thorius magnipes</i> *	<i>Micrurus nebularis</i> *
<i>Thorius schmidti</i> *	<i>Micrurus tener</i>
<i>Thorius troglodytes</i> *	<i>Thamnophis chrysocephalus</i> *
<i>Celestus enneagrammus</i> *	<i>Thamnophis conanti</i> *
<i>Laemanctus serratus</i>	<i>Amerotyphlops tenuis</i>
<i>Norops cymbops</i> *	<i>Ophryacus smaragdinus</i> *
<i>Norops naufragus</i> *	<i>Apalone spinifera</i> ***

Thirty-four of these 50 species (68.0%) are country endemics, and the remaining 16 are non-endemics, except for the non-native *Apalone spinifera*. Most of the non-endemic species also range varying distances to the south in Central America, with the exception of *Micrurus tener*, which also ranges to the north into the south-central United States.

Twenty-six species are limited to the UBB in Puebla, as follows:

<i>Incilius perplexus</i> *	<i>Holcosus sinister</i> *
<i>Craugastor rugulosus</i> *	<i>Salvadora mexicana</i> *
<i>Exerodonta smaragdina</i> *	<i>Sonora michoacanensis</i> *
<i>Tlalocohyla smithi</i> *	<i>Tantilla calamarina</i> *
<i>Agalychnis dacnicolor</i> *	<i>Trimorphodon biscutatus</i>
<i>Lithobates zweifeli</i> *	<i>Coniophanes melanocephalus</i> *
<i>Norops microlepidotus</i> *	<i>Conophis vittatus</i>
<i>Heloderma horridum</i> *	<i>Enulius flavitorques</i>
<i>Marisora brachypoda</i>	<i>Hypsiglena torquata</i> *
<i>Phrynosoma asio</i>	<i>Leptodeira splendida</i> *
<i>Sceloporus melanorhinus</i>	<i>Pseudoleptodeira latifasciata</i> *
<i>Sceloporus ochoterena</i> *	<i>Agkistrodon bilineatus</i>
<i>Aspidoscelis deppii</i>	<i>Crotalus culminatus</i> *

Eighteen of these 26 species (69.2%) are country endemics, and the remaining eight are non-endemics that occur farther south into Central America.

The 20 single-region species in the TMV are as follows:

<i>Dryophytes plicatus</i> *	<i>Sceloporus palaciosi</i> *
<i>Lithobates chichicuahutla</i> *	<i>Sceloporus scalaris</i> *
<i>Lithobates montezumae</i> *	<i>Conopsis nasus</i> *
<i>Ambystoma leorae</i> *	<i>Rena myopica</i> *
<i>Ambystoma taylori</i> **	<i>Storeria storerioides</i> *
<i>Aquiloerycea cephalica</i> *	<i>Thamnophis eques</i>
<i>Pseudoeurycea gadovii</i> *	<i>Thamnophis pulchrilatus</i> *
<i>Pseudoeurycea melanomolga</i> *	<i>Thamnophis scalaris</i> *
<i>Sceloporus aeneus</i> *	<i>Thamnophis scaliger</i> *
<i>Sceloporus bicanthalis</i> *	<i>Crotalus polystictus</i> *

Eighteen of these 20 species (90.0%) are country endemics, and one is a state endemic. The remaining species (*T. eques*) ranges to the north into the southwestern United States.

Four species are restricted to the GCL region in Puebla, including:

<i>Notophthalmus meridionalis</i>	<i>Ninia sebae</i>
<i>Lepidophyma zongolica</i> **	<i>Indotyphlops braminus</i> ***

Of these four species, two are non-endemics (the salamander distributed to the north in the United States and the snake to the south in Central America), one is a state endemic, and one is a non-native.

Four species also are restricted to the VOT in Puebla, including:

<i>Exerodonta xera</i> *	<i>Tropidodipsas zweifeli</i> *
<i>Thorius maxillabrochus</i> *	<i>Micrurus pachecogili</i> *

All of these species are country endemics.

A single species, the country endemic salamander *Pseudoeurycea mixteca*, is restricted to the SMS.

In summary, of the 105 single-region species occurring in Puebla, 75 (71.4%) are country endemics, 26 are non-endemics (24.8%), two are state endemics (1.9%), and two are non-natives (1.9%). Of the six physiographic regions, the SMO is of greatest conservation significance because it houses the largest overall number of species (185), the largest number of single-region species (50), and the largest number of country endemics (34).

We constructed a Coefficient of Biogeographic Resemblance (CBR) matrix for examining the herpetofaunal similarity relationships among the six physiographic regions in Puebla (Table 6). The SMO contains the most species richness (185 species) and the SMS contains the least (41). The mean species richness value from all six regions is 92.5. The number of shared species between all the regional pairs ranged from a high of 98 between the TMV and SMO, to the lowest number of five between the SMS and GCL; the mean value of shared species among all six regions is 31.9.

Table 6. Pair-wise comparison matrix of Coefficient of Biogeographic Resemblance (CBR) data of herpetofaunal relationships for the six physiographic regions in Puebla, Mexico. Underlined values = number of species in each region; upper triangular matrix values = species in common between two regions; and lower triangular matrix values = CBR values. The formula for this algorithm is $CBR = 2C/N1 + N2$ (Duellman, 1990), where C is the number of species in common to both regions, N1 is the number of species in the first region, and N2 is the number of species in the second region. See Fig 8 for the UPGMA dendrogram produced from the CBR data.

	Gulf Coastal Lowlands	Sierra Madre Oriental	Trans-Mexican Volcanic Belt	Sierra Madre del Sur	Upper Balsas Basin	Valle de Tehuacán
Gulf Coastal Lowlands	<u>74</u>	68	43	5	8	8
Sierra Madre Oriental	0.53	<u>185</u>	98	25	26	35
Trans-Mexican Volcanic Belt	0.43	0.64	<u>125</u>	23	22	34
Sierra Madre del Sur	0.09	0.22	0.28	<u>41</u>	18	34
Upper Balsas Basin	0.11	0.20	0.22	0.32	<u>71</u>	32
Valle de Tehuacán	0.12	0.29	0.37	0.68	0.49	<u>59</u>

The CBR data in Table 6 demonstrate similarity values ranging from a low of 0.09 between the GCL and SMS, and a high of 0.68 between the VOT and SMS. The GCL and SMS in Puebla are situated at opposite extremes in their environmental physiognomies, respectively (tropical humid to semihumid lowlands vs. more temperate semihumid to subhumid highland habitats), as well as by their separation from each other by the adjacent VOT, and by the rugged SMO and TMV montane regions, whose herpetofaunal relationships are more aligned with the GCL region (0.53 and 0.43, respectively). Conversely, the SMS is more associated with the southern Pacific versant regions of Puebla, specifically with the VOT (0.68) and UBB (0.33); only a very small portion of a geographically widespread SMS actually is found in Puebla. The SMS, UBB, and VOT all contact each other to varying degrees and their herpetofaunal affinities are with the Pacific lowlands of Mexico (Campbell, 1999; Wilson and Johnson, 2010) via the lower Río Balsas Basin, and eastward along the Pacific Coastal Plain where it abuts the SMS in southern Guerrero and Oaxaca. The highest CRB value of any pair of the Atlantic and Pacific groups in Puebla is between Pacific versant members, the SMS and VOT, which cluster at 0.68. In Puebla, these two small regions lie adjacent to one another and share subhumid environmental regimes in their neighboring areas.

The overall CBR coefficient values among the six physiographic regions of Puebla are as follows (arranged from highest to lowest values, with species richness values in parentheses):

- Sierra Madre del Sur (41)—0.68—Valley of Tehuacán (59)
- Sierra Madre Oriental (185)—0.64—Trans-Mexican Volcanic Belt (125)
- Gulf Coastal Lowlands (74)—0.53—Sierra Madre Oriental (185)
- Upper Balsas Basin (71)—0.49—Valley of Tehuacán (59)
- Gulf Coastal Lowlands (74)—0.43—Trans-Mexican Volcanic Belt (125)
- Trans-Mexican Volcanic Belt (125)—0.37—Valley of Tehuacán (59)

- Sierra Madre del Sur (41)—0.32—Upper Balsas Basin (71)
- Sierra Madre Oriental (185)—0.29—Valley of Tehuacán (59)
- Trans-Mexican Volcanic Belt (125)—0.28—Sierra Madre del Sur (41)
- Trans-Mexican Volcanic Belt (125)—0.22—Upper Balsas Basin (71)
- Sierra Madre Oriental (185)—0.22—Sierra Madre del Sur (41)
- Sierra Madre Oriental (185)—0.20—Upper Balsas Basin (71)
- Gulf Coastal Lowlands (74)—0.12—Valley of Tehuacán (59)
- Gulf Coastal Lowlands (74)—0.11—Upper Balsas Basin (71)
- Gulf Coastal Lowlands (74)—0.09—Sierra Madre del Sur (41).

Based on the data in Table 6, we created a UPGMA dendrogram (Fig. 7) to illustrate the herpetofaunal resemblance patterns in a hierarchical fashion among the six physiographic regions of Puebla (see map, Fig. 1). The dendrogram indicates two clusters of three pairwise groupings, which primarily are associated with either the Atlantic (TMV, SMO, GCL) or Pacific drainages (SMS, VOT, UBB) of Mexico. None of the six regions show particularly high resemblance patterns with the other regions, as the highest shared value only is 0.68 between the Pacific versant’s SMS and VOT, two of the smaller regions in Puebla located adjacent to each other in the southeastern portion of the state; together, these two regions cluster with the UBB at a value of 0.41. The landscape of the Pacific cluster contains an overall higher coverage of subhumid vegetation than the Atlantic cluster, as well as the lowest species richness values for all six regions in Puebla.

The Atlantic slope regions showed the highest pairwise similarity value of 0.64 between the SMO and TMV, which also are the regions with the highest species richness values, 185 and 125 species, respectively. These two regions cluster with the third highest region for species richness (74 species in the GCL) at a value of 0.48. Based on

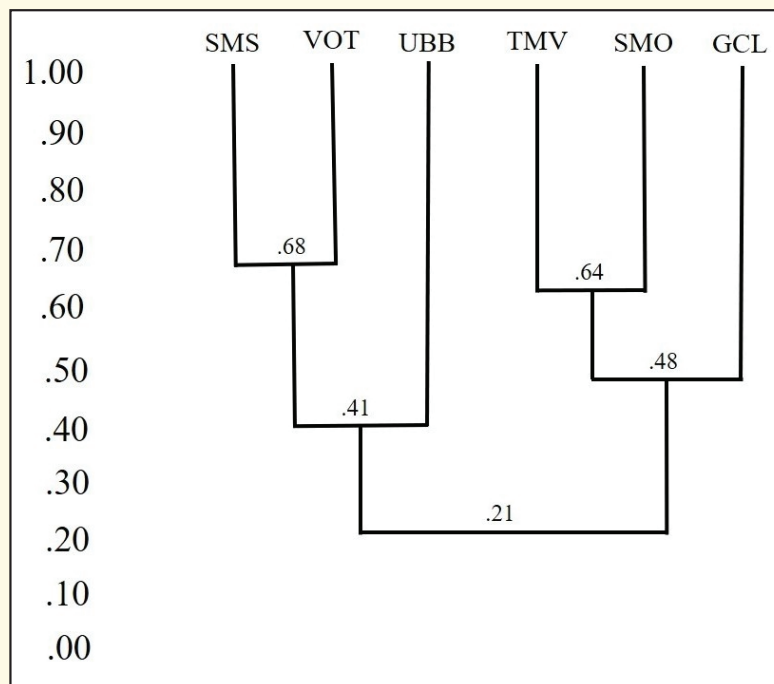


Fig. 7. A UPGMA generated dendrogram illustrating names identified in the introduction section and the similarity relationships of species richness among the herpetofauna in the six physiographic regions of Puebla (based on the data in Table 6). We calculated the similarity values using Duellman’s (1990) Coefficient of Biogeographic Resemblance (CBR).



Abronia taeniata (Wiegmann, 1828). The Banded Arboreal Alligator Lizard ranges in the highland areas primarily along the eastern slopes of the Sierra Madre Oriental in the states of Tamaulipas, San Luis Potosí, Hidalgo, and Querétaro (Lemos-Espinal and Dixon, 2013). This individual was encountered at La Cumbre, 9 km north of Zacapoaxtla, in the municipality of Zacapoaxtla, Puebla. Wilson et al. (2013b) estimated its EVS as 15, placing it in the lower portion of the high vulnerability category, the IUCN has assessed it as Vulnerable, and SEMARNAT lists this lizard under the category of special protection (Pr). 📷 © Guillermo Woolrich-Piña



Gerrhonotus liocephalus Wiegmann, 1828. The Smooth-headed Alligator Lizard “is endemic to southern Mexico, where it has been recorded from the States of Puebla, Oaxaca, Hidalgo and central Chiapas” (Vazquez Díaz and Quintero Díaz, 2007). This individual is from Parque Estatal Flor del Bosque, in the municipality of Amozoc de Mota, Puebla. Wilson et al. (2013b) calculated its EVS as 6, placing it in the middle of the low vulnerability category, the IUCN has assessed it as Least Concern, and SEMARNAT lists this lizard under the category of special protection (Pr). 📷 © Fernando Martínez-Belmar

elevation, the GCL is the lowest region in Puebla, even though it clusters with the adjacent and much more elevated SMO and TMV regions. This result likely is due to the sharing of herpetofaunal species that to some degree are restricted to humid vegetation formations, which numerically dominate the landscape in much of the three regions. The GCL also showed the lowest CBR value when compared to the three primarily Pacific regions (SMS, UBB, VOT) in Puebla, with an average CBR value of 0.11 (calculated from the data in Table 6). Therefore, the GCL's influence lowers the level of average similarity that affectedly reduces the UPGMA similarity value in Puebla to 0.21 between the Pacific and Atlantic clusters. The 0.21 value also is the third lowest known from UPGMA dendrograms aligning all cluster values on our previous MCS papers (i.e., Mata-Silva et al., 2015 for Oaxaca = 0.07; Alvarado-Díaz et al., 2013 calculated from CBR matrix for Michoacan = 0.20; Terán-Juárez et al., 2016 for Tamaulipas = 0.23; Johnson et al., 2015 for Chiapas, Woolrich-Piña et al., 2016 for Nayarit, and Cruz-Sáenz et al., 2017 for Jalisco = 0.35; Woolrich-Piña et al., 2016 for Nayarit and Cruz-Saenz et al., 2017 for Jalisco = 0.35; Johnson et al., 2015a for Chiapas and Nevárez-de los Reyes et al., 2016 for Nuevo León = 0.37; and González-Sánchez et al. 2017 for the Yucatan Peninsula of Mexico = 0.51. To this list, we also added a paper by Carbajal-Márquez and Quintero-Díaz (2016) on the herpetofauna of Aguascalientes, who used our MCS template to analyze their data; the UPGMA value connecting their two major clusters is 0.51. The average value for connecting all the clusters in the UPGMA dendrograms of the above 10 papers is 0.32.

In summary, the CBR data and the resulting UPGMA dendrogram for this study was expected, as it revealed the biogeographic affiliation patterns of Puebla's herpetofauna with either the Pacific or Atlantic versants of Mexico. The generally lower CBR coefficient values imply that most of the six regions contain significant numbers of species found only within their respective borders. We also assume that future additions of other species to the datasets will not significantly change our results.

DISTRIBUTION STATUS

As in other papers in the MCS series, we used the following categories to determine the distribution status of the herpetofauna of Puebla: non-endemic, country endemic, state endemic, and non-native. We present these categories in Table 7, and summarize them in Table 8.

Table 7. Distribution and conservation status measures for members of the herpetofauna of Puebla, Mexico. Distribution Status: RE = endemic to Mexican portion of Yucatan Peninsula; CE = endemic to country of Mexico; NE = not endemic to state or country; and NN = non-native. Environmental Vulnerability Score (taken from Wilson et al. 2013a,b): low (L) vulnerability species (EVS of 3–9); medium (M) vulnerability species (EVS of 10–13); and high (H) vulnerability species (EVS of 14–20). IUCN Categorization: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; NE = Not Evaluated (no DD species are identified). SEMARNAT Status: A = Threatened; P = Endangered; Pr = Special Protection; and NS = No Status. See text for explanations of the EVS, IUCN, and SEMARNAT rating systems.

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Anaxyrus compactilis</i> *	CE	H (14)	LC	NS
<i>Incilius cristatus</i> *	CE	H (14)	CR	Pr
<i>Incilius marmoreus</i> *	CE	M (11)	LC	NS
<i>Incilius nebulifer</i>	NE	L (6)	LC	NS
<i>Incilius occidentalis</i> *	CE	M (11)	LC	NS
<i>Incilius perplexus</i> *	CE	M (11)	EN	NS
<i>Incilius valliceps</i>	NE	L (6)	LC	NS
<i>Rhinella horribilis</i>	NE	L (3)	NE	NS
<i>Hyalinobatrachium fleischmanni</i>	NE	M (10)	LC	NS
<i>Craugastor alfredi</i>	NE	M (11)	VU	NS

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Craugastor augusti</i>	NE	L (8)	LC	NS
<i>Craugastor berkenbuschi</i> *	CE	H (14)	NT	Pr
<i>Craugastor decoratus</i> *	CE	H (15)	VU	Pr
<i>Craugastor galacticorhinus</i> *	CE	H (15)	NE	NS
<i>Craugastor loki</i>	NE	M (10)	LC	NS
<i>Craugastor mexicanus</i> *	CE	M (10)	LC	NS
<i>Craugastor pygmaeus</i>	NE	L (9)	VU	NS
<i>Craugastor rhodopis</i> *	CE	H (14)	VU	NS
<i>Craugastor rugulosus</i> *	CE	M (13)	LC	NS
<i>Eleutherodactylus leprus</i>	NE	M (12)	VU	NS
<i>Eleutherodactylus nitidus</i> *	CE	M (12)	LC	NS
<i>Eleutherodactylus verrucipes</i> *	CE	H (16)	VU	Pr
<i>Eleutherodactylus verruculatus</i> *	CE	H (18)	DD	NS
<i>Anothea spinosa</i>	NE	H (14)	LC	NS
<i>Bromeliohyla dendroscarta</i> *	CE	H (17)	CR	Pr
<i>Charadrahyla taeniopus</i> *	CE	M (13)	VU	A
<i>Dendropsophus microcephalus</i>	NE	L (7)	LC	NS
<i>Dryophytes arenicolor</i>	NE	L (7)	LC	NS
<i>Dryophytes euphorbiaceus</i> *	CE	M (13)	NT	NS
<i>Dryophytes eximius</i> *	CE	M (10)	LC	NS
<i>Dryophytes plicatus</i> *	CE	M (11)	LC	A
<i>Exerodonta smaragdina</i> *	CE	M (12)	LC	Pr
<i>Exerodonta xera</i> *	CE	H (14)	VU	NS
<i>Megastomatohyla mixomaculata</i> *	CE	H (14)	EN	A
<i>Ptychohyla zophodes</i> *	CE	M (13)	DD	NS
<i>Rheohyla miotypanum</i> *	CE	L (9)	NT	NS
<i>Sarcohyla arborescandens</i> *	CE	M (11)	EN	Pr
<i>Sarcohyla bistincta</i> *	CE	L (9)	LC	Pr
<i>Sarcohyla charadricola</i> *	CE	H (14)	EN	A
<i>Sarcohyla robertsorum</i> *	CE	M (13)	EN	A
<i>Scinax staufferi</i>	NE	L (4)	LC	NS
<i>Smilisca baudinii</i>	NE	L (3)	LC	NS
<i>Smilisca cyanosticta</i>	NE	M (12)	NT	NS
<i>Tlalocohyla godmani</i> *	CE	M (13)	VU	A
<i>Tlalocohyla picta</i>	NE	L (8)	LC	NS
<i>Tlalocohyla smithii</i> *	CE	M (11)	LC	NS
<i>Trachycephalus vermiculatus</i>	NE	L (4)	LC	NS
<i>Leptodactylus fragilis</i>	NE	L (5)	LC	NS
<i>Leptodactylus melanonotus</i>	NE	L (6)	LC	NS

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Hypopachus ustus</i>	NE	L (7)	LC	Pr
<i>Hypopachus variolosus</i>	NE	L (4)	LC	NS
<i>Agalychnis callidryas</i>	NE	M (11)	LC	NS
<i>Agalychnis dacnicolor</i> *	CE	M (13)	LC	NS
<i>Agalychnis moreletii</i>	NE	L (7)	CR	NS
<i>Lithobates berlandieri</i>	NE	L (7)	LC	Pr
<i>Lithobates catesbeianus</i> ***	NN	—	—	—
<i>Lithobates chichicuaula</i> *	CE	H (15)	CR	NS
<i>Lithobates johni</i> *	CE	H (14)	EN	P
<i>Lithobates montezumae</i> *	CE	M (13)	LC	Pr
<i>Lithobates pueblae</i> *	CE	H (15)	CR	P
<i>Lithobates spectabilis</i> *	CE	M (12)	LC	NS
<i>Lithobates vaillanti</i>	NE	L (9)	LC	NS
<i>Lithobates zweifeli</i> *	CE	M (11)	LC	NS
<i>Spea multiplicata</i>	NE	L (6)	LC	NS
<i>Ambystoma leorae</i> *	CE	H (15)	CR	A
<i>Ambystoma taylori</i> **	SE	H (15)	CR	Pr
<i>Ambystoma subsalsum</i> *	CE	H (14)	NE	NS
<i>Aquiloerycea cafetalera</i> *	CE	H (17)	NE	NS
<i>Aquiloerycea cephalica</i> *	CE	H (14)	NT	A
<i>Aquiloerycea quetzalanensis</i> **	SE	H (17)	DD	NS
<i>Bolitoglossa platydactyla</i> *	NE	H (15)	NT	Pr
<i>Chiropterotriton arboreus</i> *	CE	H (18)	CR	Pr
<i>Chiropterotriton orculus</i> *	CE	H (18)	VU	NS
<i>Isthmura bellii</i> *	CE	M (12)	VU	A
<i>Isthmura gigantea</i> *	CE	H (16)	CR	NS
<i>Parvimolge townsendi</i> *	CE	H (16)	CR	A
<i>Pseudoeurycea firscheini</i> *	CE	H (18)	EN	Pr
<i>Pseudoeurycea gadovii</i> *	CE	M (13)	EN	Pr
<i>Pseudoeurycea leprosa</i> *	CE	H (16)	VU	A
<i>Pseudoeurycea lineola</i> *	CE	H (14)	EN	Pr
<i>Pseudoeurycea lynchi</i> *	CE	H (17)	CR	NS
<i>Pseudoeurycea melanomolga</i> *	CE	H (16)	EN	Pr
<i>Pseudoeurycea mixteca</i> *	CE	H (17)	LC	NS
<i>Thorius dubitus</i> *	CE	H (16)	EN	Pr
<i>Thorius magnipes</i> *	CE	H (17)	CR	NS
<i>Thorius maxillabrochus</i> *	CE	H (18)	NE	NS
<i>Thorius schmidtii</i> *	CE	H (17)	EN	Pr
<i>Thorius troglodytes</i> *	CE	H (16)	EN	Pr

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Notophthalmus meridionalis</i>	NE	M (12)	EN	P
<i>Abronia graminea</i> *	CE	H (15)	EN	A
<i>Abronia taeniata</i> *	CE	H (15)	VU	Pr
<i>Barisia imbricata</i> *	CE	H (14)	LC	Pr
<i>Celestus enneagrammus</i> *	CE	H (14)	LC	Pr
<i>Celestus legnotus</i> *	CE	H (14)	LC	NS
<i>Gerrhonotus liocephalus</i>	NE	L (6)	LC	Pr
<i>Gerrhonotus ophiurus</i> *	CE	M (12)	LC	NS
<i>Basiliscus vittatus</i>	NE	L (7)	LC	NS
<i>Corytophanes hernandesii</i>	NE	M (13)	LC	Pr
<i>Laemanctus serratus</i>	NE	L (8)	LC	Pr
<i>Norops carlliebi</i> *	CE	H (15)	NE	NS
<i>Norops cymbops</i> *	CE	H (17)	DD	A
<i>Norops laevis</i>	NE	L (9)	NE	NS
<i>Norops microlepidotus</i> *	CE	H (15)	LC	Pr
<i>Norops naufragus</i> *	CE	M (13)	VU	Pr
<i>Norops petersii</i>	NE	L (9)	NE	NS
<i>Norops sericeus</i>	NE	L (8)	NE	NS
<i>Norops tropidonotus</i>	NE	L (9)	NE	NS
<i>Coleonyx elegans</i>	NE	L (9)	LC	A
<i>Hemidactylus frenatus</i> ***	NN	—	—	—
<i>Heloderma horridum</i> *	CE	H (14)	LC	A
<i>Ctenosaura acanthura</i>	NE	M (12)	NE	Pr
<i>Ctenosaura pectinata</i> *	CE	H (15)	NE	A
<i>Iguana iguana</i>	NE	M (12)	NE	Pr
<i>Marisora brachypoda</i>	NE	L (6)	LC	NS
<i>Phrynosoma asio</i>	NE	M (11)	LC	Pr
<i>Phrynosoma braconneri</i> *	CE	H (15)	LC	Pr
<i>Phrynosoma orbiculare</i> *	CE	M (12)	LC	A
<i>Phrynosoma taurus</i> *	CE	M (12)	LC	A
<i>Sceloporus aeneus</i> *	CE	M (13)	LC	NS
<i>Sceloporus aureolus</i> *	CE	H (15)	NE	NS
<i>Sceloporus bicanthalis</i> *	CE	M (13)	LC	NS
<i>Sceloporus formosus</i> *	CE	H (15)	LC	NS
<i>Sceloporus gadoviae</i> *	CE	M (11)	LC	NS
<i>Sceloporus grammicus</i>	NE	L (9)	LC	Pr
<i>Sceloporus horridus</i> *	CE	M (11)	LC	NS
<i>Sceloporus jalapae</i> *	CE	M (13)	LC	NS
<i>Sceloporus megalepidurus</i> *	CE	H (14)	VU	Pr

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Sceloporus melanorhinus</i>	NE	L (9)	LC	NS
<i>Sceloporus mucronatus</i> *	CE	M (13)	LC	NS
<i>Sceloporus ochoterenae</i> *	CE	M (12)	LC	NS
<i>Sceloporus palaciosi</i> *	CE	H (15)	LC	NS
<i>Sceloporus scalaris</i> *	CE	M (12)	LC	NS
<i>Sceloporus spinosus</i> *	CE	M (12)	LC	NS
<i>Sceloporus torquatus</i> *	CE	M (11)	LC	NS
<i>Sceloporus variabilis</i>	NE	L (5)	LC	NS
<i>Urosaurus bicarinatus</i> *	CE	M (12)	LC	NS
<i>Phyllodactylus bordai</i> *	CE	M (13)	LC	Pr
<i>Plestiodon brevisrostris</i> *	CE	M (11)	LC	NS
<i>Plestiodon copei</i> *	CE	H (14)	LC	Pr
<i>Plestiodon lynxe</i> *	CE	M (10)	LC	Pr
<i>Sphaerodactylus glaucus</i>	NE	M (12)	LC	Pr
<i>Scincella cherriei</i>	NE	L (8)	NE	NS
<i>Scincella gemmingeri</i> *	CE	M (11)	LC	Pr
<i>Scincella silvicola</i> *	CE	M (12)	LC	A
<i>Aspidoscelis costata</i> *	CE	M (11)	LC	Pr
<i>Aspidoscelis deppii</i>	NE	L (8)	LC	NS
<i>Aspidoscelis parvisocia</i> *	CE	H (15)	LC	Pr
<i>Aspidoscelis sacki</i> *	CE	H (14)	LC	NS
<i>Holcosus amphigrammus</i> *	CE	M (11)	NE	NS
<i>Holcosus sinister</i> *	CE	M (13)	NE	NS
<i>Lepidophyma sylvaticum</i> *	CE	M (11)	LC	Pr
<i>Lepidophyma tuxtlae</i> *	CE	M (11)	DD	A
<i>Lepidophyma zongolica</i> **	SE	H (16)	NE	NS
<i>Xenosaurus grandis</i> *	CE	L (9)	VU	Pr
<i>Xenosaurus rectocollaris</i> *	CE	H (16)	LC	NS
<i>Xenosaurus tzacualtipantecus</i> *	CE	H (16)	NE	NS
<i>Boa imperator</i>	NE	M (10)	NE	NS
<i>Boa sigma</i> *	CE	H (15)	NE	NS
<i>Conopsis acuta</i> *	CE	H (14)	NE	NS
<i>Conopsis biserialis</i> *	CE	M (13)	LC	A
<i>Conopsis lineata</i> *	CE	M (13)	LC	NS
<i>Conopsis nasus</i> *	CE	M (11)	LC	NS
<i>Drymarchon melanurus</i>	NE	L (6)	LC	NS
<i>Drymobius margaritiferus</i>	NE	L (6)	NE	NS
<i>Ficimia olivacea</i> *	CE	L (9)	NE	NS
<i>Ficimia publia</i>	NE	L (9)	LC	NS

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Ficimia streckeri</i>	NE	M (12)	LC	NS
<i>Lampropeltis polyzona</i> *	CE	M (11)	NE	NS
<i>Leptophis diplotropis</i> *	CE	H (14)	LC	A
<i>Leptophis mexicanus</i>	NE	L (6)	LC	A
<i>Masticophis mentovarius</i>	NE	L (6)	LC	A
<i>Mastigodryas melanolomus</i>	NE	L (6)	LC	NS
<i>Oxybelis aeneus</i>	NE	L (5)	NE	NS
<i>Pituophis deppei</i> *	CE	H (14)	LC	A
<i>Pituophis lineaticollis</i>	NE	L (8)	LC	NS
<i>Pseudelaphe flavirufa</i>	NE	M (10)	LC	NS
<i>Pseudoficimia frontalis</i> *	CE	M (13)	LC	NS
<i>Salvadora bairdi</i> *	CE	H (15)	LC	Pr
<i>Salvadora intermedia</i> *	CE	H (16)	LC	Pr
<i>Salvadora mexicana</i> *	CE	H (15)	LC	Pr
<i>Senticolis triaspis</i>	NE	L (6)	LC	NS
<i>Sonora michoacanensis</i> *	CE	H (14)	LC	NS
<i>Spilotes pullatus</i>	NE	L (6)	NE	NS
<i>Tantilla bocourti</i> *	CE	L (9)	LC	NS
<i>Tantilla calamarina</i> *	CE	M (12)	LC	Pr
<i>Tantilla robusta</i> **	SE	H (16)	DD	NS
<i>Tantilla rubra</i>	NE	L (5)	LC	Pr
<i>Trimorphodon biscutatus</i>	NE	L (7)	NE	NS
<i>Trimorphodon tau</i> *	CE	M (13)	LC	NS
<i>Adelphicos quadrivirgatum</i>	NE	M (10)	LC	Pr
<i>Amastridium sapperi</i>	NE	M (10)	LC	NS
<i>Chersodromus liebmanni</i> *	CE	M (12)	LC	Pr
<i>Coniophanes bipunctatus</i>	NE	M (10)	LC	NS
<i>Coniophanes fissidens</i>	NE	L (7)	NE	NS
<i>Coniophanes imperialis</i>	NE	L (8)	LC	NS
<i>Coniophanes melanocephalus</i> *	CE	H (14)	DD	NS
<i>Coniophanes piceivittis</i>	NE	L (7)	LC	NS
<i>Conophis vittatus</i>	NE	M (11)	LC	NS
<i>Enulius flavitorques</i>	NE	L (5)	NE	NS
<i>Geophis blanchardi</i> *	CE	H (15)	DD	Pr
<i>Geophis dubius</i> *	CE	M (13)	LC	NS
<i>Geophis lorancai</i> *	CE	H (14)	NE	NS
<i>Geophis mutitorques</i> *	CE	M (13)	LC	Pr
<i>Geophis semidoliatus</i> *	CE	M (13)	LC	NS
<i>Geophis turbidus</i> *	CE	H (15)	NE	NS

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Hypsiglena torquata</i> *	CE	L (8)	LC	Pr
<i>Imantodes cenchoa</i>	NE	L (6)	NE	Pr
<i>Imantodes gemmistratus</i>	NE	L (6)	NE	Pr
<i>Leptodeira maculata</i>	NE	L (7)	LC	Pr
<i>Leptodeira septentrionalis</i>	NE	L (8)	NE	NS
<i>Leptodeira splendida</i> *	CE	H (14)	LC	NS
<i>Ninia diademata</i>	NE	L (9)	LC	NS
<i>Ninia sebae</i>	NE	L (5)	LC	NS
<i>Oxyrhopus petolarius</i>	NE	H (14)	NE	NS
<i>Pliocercus elapoides</i>	NE	M (10)	LC	NS
<i>Pseudoleptodeira latifasciata</i> *	CE	H (14)	LC	Pr
<i>Rhadinaea cuneata</i> *	CE	H (15)	DD	Pr
<i>Rhadinaea decorata</i>	NE	L (9)	NE	NS
<i>Rhadinaea fulvivittis</i> *	CE	M (11)	VU	NS
<i>Rhadinaea hesperia</i> *	CE	M (10)	LC	Pr
<i>Rhadinaea marcellae</i> *	CE	M (12)	EN	Pr
<i>Rhadinaea quinquelineata</i> *	CE	H (15)	DD	Pr
<i>Sibon dimidiatus</i>	NE	M (10)	LC	NS
<i>Sibon nebulatus</i>	NE	L (5)	NE	NS
<i>Tropidodipsas sartorii</i>	NE	L (9)	LC	Pr
<i>Tropidodipsas zweifeli</i> *	CE	H (16)	NE	Pr
<i>Micrurus bernadi</i> *	CE	H (15)	LC	NS
<i>Micrurus diastema</i>	NE	L (8)	LC	Pr
<i>Micrurus elegans</i>	NE	M (13)	LC	Pr
<i>Micrurus laticollaris</i> *	CE	H (14)	LC	Pr
<i>Micrurus nebularis</i> *	CE	H (18)	DD	Pr
<i>Micrurus pachecoglii</i> *	CE	H (18)	DD	NS
<i>Micrurus tener</i>	NE	M (11)	LC	NS
<i>Rena maxima</i> *	CE	M (11)	LC	NS
<i>Rena myopica</i> *	CE	M (13)	LC	NS
<i>Nerodia rhombifer</i>	NE	M (10)	LC	NS
<i>Storeria dekayi</i>	NE	L (7)	LC	NS
<i>Storeria storerioides</i> *	CE	M (11)	LC	NS
<i>Thamnophis chrysocephalus</i> *	CE	H (14)	LC	A
<i>Thamnophis conanti</i> *	CE	H (17)	NE	NS
<i>Thamnophis cyrtopsis</i>	NE	L (7)	LC	A
<i>Thamnophis eques</i>	NE	L (8)	LC	A
<i>Thamnophis proximus</i>	NE	L (7)	LC	A
<i>Thamnophis pulchrilatus</i> *	CE	H (15)	LC	NS

Taxa	Distribution Status	Environmental Vulnerability Category (Score)	IUCN Categorization	SEMARNAT Status
<i>Thamnophis scalaris</i> *	CE	H (14)	LC	A
<i>Thamnophis scaliger</i> *	CE	H (15)	VU	A
<i>Thamnophis sumichrasti</i> *	CE	H (15)	LC	A
<i>Scaphiodontophis annulatus</i>	NE	M (11)	LC	NS
<i>Amerityphlops tenuis</i>	NE	M (11)	LC	NS
<i>Indotyphlops braminus</i> ***	NN	—	—	—
<i>Agkistrodon bilineatus</i>	NE	M (11)	NT	Pr
<i>Atropoides nummifer</i> *	CE	M (13)	LC	A
<i>Bothrops asper</i>	NE	M (12)	NE	NS
<i>Crotalus culminatus</i> *	CE	H (15)	NE	NS
<i>Crotalus intermedius</i> *	CE	H (15)	LC	A
<i>Crotalus molossus</i>	NE	L (8)	LC	Pr
<i>Crotalus polystictus</i> *	CE	H (16)	LC	Pr
<i>Crotalus ravus</i> *	CE	H (14)	LC	A
<i>Crotalus scutulatus</i>	NE	M (11)	LC	Pr
<i>Crotalus triseriatus</i> *	CE	H (16)	LC	NS
<i>Mixcoatlus melanurus</i> *	CE	H (17)	EN	Pr
<i>Ophryacus smaragdinus</i> *	CE	H (14)	NE	NS
<i>Ophryacus undulatus</i> *	CE	H (15)	VU	Pr
<i>Trachemys venusta</i>	NE	H (19)	VU	NS
<i>Kinosternon herrerai</i> *	CE	H (14)	NT	Pr
<i>Kinosternon integrum</i> *	CE	M (11)	LC	Pr
<i>Apalone spinifera</i> ***	NN	—	—	—

Table 8. Summary of the distribution status of herpetofaunal families in Puebla, Mexico.

Families	Number of Species	Distribution Status			
		Non-endemic (NE)	Country Endemic (CE)	State Endemic (SE)	Non-native (NN)
Bufo	8	3	5	—	—
Centrolenidae	1	1	—	—	—
Craugastoridae	10	4	6	—	—
Eleutherodactylidae	4	1	3	—	—
Hylidae	24	8	16	—	—
Leptodactylidae	2	2	—	—	—
Microhylidae	2	2	—	—	—
Phyllomedusidae	3	2	1	—	—
Ranidae	9	2	6	—	1
Scaphiopodidae	1	1	—	—	—

Families	Number of Species	Distribution Status			
		Non-endemic (NE)	Country Endemic (CE)	State Endemic (SE)	Non-native (NN)
Subtotals	64	26	37	—	1
Ambystomatidae	3	—	2	1	—
Plethodontidae	21	1	19	1	—
Salamandridae	1	1	—	—	—
Subtotals	25	2	21	2	—
Totals	89	28	58	2	1
Anguidae	7	1	6	—	—
Corytophanidae	3	3	—	—	—
Dactyloidae	8	4	4	—	—
Eublepharidae	1	1	—	—	—
Gekkonidae	1	—	—	—	1
Helodermatidae	1	—	1	—	—
Iguanidae	3	2	1	—	—
Mabuyidae	1	1	—	—	—
Phrynosomatidae	22	4	18	—	—
Phyllodactylidae	1	—	1	—	—
Scincidae	3	—	3	—	—
Sphaerodactylidae	1	1	—	—	—
Sphenomorphidae	3	1	2	—	—
Teiidae	6	1	5	—	—
Xantusiidae	3	—	2	1	—
Xenosauridae	3	—	3	—	—
Subtotals	67	19	46	1	1
Boidae	2	1	1	—	—
Colubridae	31	14	16	1	—
Dipsadidae	37	20	17	—	—
Elapidae	7	3	4	—	—
Leptotyphlopidae	2	—	2	—	—
Natricidae	12	5	7	—	—
Sibynophiidae	1	1	—	—	—
Typhlopidae	2	1	—	—	1
Viperidae	13	4	9	—	—
Subtotals	107	49	56	1	1
Emydidae	1	1	—	—	—
Kinosternidae	2	—	2	—	—
Trionychidae	1	—	—	—	1
Subtotals	4	1	2	—	1
Totals	178	69	104	2	3
Sum Totals	267	97	162	4	4

The numbers of species in each of these four categories, in decreasing order of size, are as follows: country endemics, 162 (60.7%); non-endemics, 97 (36.3%); state endemics, 4 (1.5%); and non-natives, 4 (1.5%). As with the states of Michoacán (Alvarado-Díaz et al., 2013), Nayarit (Woolrich-Piña et al., 2016), and Jalisco (Cruz-Sáenz et al., 2017), the largest number of herpetofaunal species in Puebla falls within the country endemic category. The proportional representation in the three other states is, respectively, 56.7%, 57.1%, and 63.7%. In other cases, the greatest number lies within the non-endemic category, as follows: Oaxaca (41.4%; Mata-Silva et al., 2015); Tamaulipas (64.7%; Terán-Juárez et al., 2016); Nuevo León (68.3%; Nevárez-de los Reyes et al., 2016); and Chiapas (81.2%; Johnson et al., 2015a). Interestingly, in the tri-state Mexican Yucatan Peninsula (González-Sánchez et al., 2017), only one country endemic and 11 regional endemics were reported, compared to 127 non-endemics (87.6% of 145 species).

In the seven previous individual-state entries in the MCS, the number of state endemics varies greatly, as does the proportion of these species compared to the herpetofauna as a whole. The numbers range from one in Nayarit and Nuevo León (Woolrich-Piña et al., 2016; Nevárez-de los Reyes et al., 2016) to 93 in Oaxaca (Mata-Silva et al., 2015). The proportion of these species also ranges greatly, from 0.6% in Nayarit (Woolrich-Piña et al., 2016) to 21.0% in Oaxaca (Mata-Silva et al., 2015). The percentage in Puebla, as previously noted, is near the low end of the overall range (1.5%). The four state endemics in Puebla include the ambystomatid salamander *Ambystoma taylori*, the plethodontid salamander *Aquiloerycea quetzalanensis*, the xantusiid lizard *Lepidophyma zongolica*, and the colubrid snake *Tantilla robusta* (Table 4).

The number of non-native species in Puebla is four, including the ranid frog *Lithobates catesbeianus*, the gekkonid lizard *Hemidactylus frenatus*, the typhlopoid snake *Indotyphlops braminus*, and the trionychid turtle *Apalone spinifera*. The proportion is rather typical for that seen in the other MCS treatments. In sum total, the non-native species reported in these other treatments are as follows:

Eleutherodactylus planirostris (Quintana Roo, Yucatán)

Lithobates catesbeianus (Michoacán, Nayarit, Nuevo León)

Anolis carolinensis (Tamaulipas)

Norops sagrei (Campeche, Quintana Roo, Tamaulipas, Yucatán)

Gehyra mutilata (Chiapas, Jalisco, Nayarit)

Hemidactylus frenatus (Campeche, Chiapas, Jalisco, Michoacán, Nayarit, Oaxaca, Quintana Roo, Tamaulipas, Yucatán)

Hemidactylus turcicus (Campeche, Chiapas, Jalisco, Nuevo León, Tamaulipas, Yucatán)

Sphaerodactylus argus (Yucatán)

Indotyphlops braminus (Campeche, Chiapas, Jalisco, Michoacán, Nayarit, Nuevo León, Oaxaca, Quintana Roo, Tamaulipas, Yucatán)

Trachemys scripta (Nuevo León)

Not surprisingly, the most widespread of the non-native species among these states is the uniparental typhlopoid snake *Indotyphlops braminus*; it also is the most widely distributed snake species in the world, primarily given its ease of introduction (Vitt and Caldwell, 2009). The gecko *Hemidactylus frenatus* is the next most widespread.

PRINCIPAL ENVIRONMENTAL THREATS

The threats facing the herpetofauna of Puebla are similar to those indicated for other areas studied in the MCS series, as well as in González-Sánchez et al. (2017), and have been observed since the late 20th and early 21st centuries (Gibbons et al., 2000; Collins and Storfer, 2003). Several of the threats, however, tend to be highly targeted throughout the state.



Corytophanes hernandesii (Wiegmann, 1831). Hernandez’s Helmeted Basilisk ranges from southeastern San Luis Potosí, Mexico, and along the Atlantic versant to northwestern Honduras” (Lemos-Espinal and Dixon, 2013: 102). This individual came from near Tuzamapan, in the municipality of Tuzamapan de Galeana, Puebla. Wilson et al. (2013b) determined its EVS as 13, placing it at the upper limit of the medium vulnerability category, the IUCN has not evaluated this species, and SEMARNAT lists this lizard under the category of special protection (Pr). 📷 © Guillermo Woolrich-Piña



Phrynosoma braconneri Duméril and Bocourt, 1870. The Short-tailed Horned Lizard occurs on the “extreme southern edge of the central Mexican plateau... [in] semiarid portions of Puebla and Oaxaca” (Reptile Database; accessed 17 December 2017). This individual is from Parque Estatal Flor del Bosque, in the municipality of Amozoc de Mota, Puebla. Wilson et al (2013b) determined its EVS as 15, placing it in the lower portion of the high vulnerability category, the IUCN has evaluated it as Least Concern, and SEMARNAT lists this lizard under the category of special protection (Pr). 📷 © Fernando Martínez-Belmar

Deforestation

An average of 15,000 ha is deforested each year in Puebla as a result of forest fires and clandestine logging (Fig. 8). Among the most affected areas are the Sierra Norte, Sierra Negra, and around the volcanoes (CONAFOR, 2013), which are located within the SMO and TMV physiographic regions; these regions contain the largest number of herpetofaunal species in the state.

Livestock

Land use change resulting from livestock activity is a common occurrence (Fig. 9). In the GCL and SMO regions, vast areas of grassland that originally were cloud forest and/or tropical forest have been developed for raising cattle and pigs (INEGI, 2013). In southern Puebla (SMS), goats (*Capra hircus*) frequently are observed foraging on cacti (Reséndiz-Melgar et al., 2005), which serve as microhabitats for species such as *Craugastor augusti*, *Eleutherodactylus nitidus*, and *Sceloporus jalapae*, among others.



Fig. 8. Deforestation. Deforested area 3.2 km NE of Tacotalpan, in the municipality of Tenampulco, at an elevation of 200 m.

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Construction of Infrastructure and Extractive Industry (Hydroelectric Dams and Mines)

The construction of a hydroelectric dam in the Sierra Norte de Puebla (SMO), along the Apulco River Basin, presents another threat (Fig. 10). The purpose of this project is to flood a vast area of the river basin (El Economista, 2015), which to varying degrees will destroy the habitats used by resident organisms. Among the most affected groups are vulnerable species such as *Incilius cristatus* and *Xenosaurus tzacualtipantecus*.

Another threat is presented by the extractive industry (mining), which affects much of the lithological and mineral material in the hills and mountains where vegetation and rocky substrates serve as microhabitats and refuges for the native herpetofauna. These processes are observed in parts of the Sierra Norte de Puebla, the eastern end of the TMV, as well as in the VOT, where several mountains have been exploited for construction materials (G. Woolrich-Piña, pers. observ.), and in sections of the Río Salado (VOT) where salt production has changed the physicochemical characteristics of the water, primarily affecting such species as *Exerodonta xera*, *Incilius occidentalis*, *Lithobates spectabilis*, and *Dryophytes arenicolor* (Woolrich-Piña et al., 2010, 2011, 2015, 2017).



Fig. 9. *Livestock.* A field with cattle 1.3 km N of La Lima, in the municipality of Tenampulco, at an elevation of 200 m.

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Fig. 10. *Construction of infrastructure and extractive industry (hydroelectric dams and mines).* A dam in the municipality of Tlatauquitepec, at an elevation of 1,900 m.

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Desiccation and Contamination of Bodies of Water

Continued population growth in rural Puebla has increased the number and size of human settlements that require basic services to subsist. Poor planning has caused the contamination of many aquifers caused by sediments, or their water has been depleted through the process of irrigating crops (Fig. 11). An example of this impact involves Laguna de Alchichica (TMV), where discharging wastewater into the lake and lowering the water table has modified the physicochemical characteristics by increasing the salinity levels (Woolrich-Piña et al., 2012). *Ambystoma taylori*, a salamander endemic to this lake, has been directly exposed to this threat (www.vwporamoramexico.mx), in addition to several other species of amphibians.

Diseases

Chytridiomycosis is an exclusive amphibian disease caused by the pathogenic fungus *Batrachochytrium dendrobatidis*. This disease initially was reported in Mexico in the 1970s (Mendoza-Almeralla, 2015). In Puebla, the presence of this pathogen has been identified from two amphibian populations: *Ambystoma subsalsum* at an elevation of 2,350 m, and *Pseudoeurycea leprosa* at an elevation of 3,079 m (Frias-Álvarez et al., 2008). Climate change and the introduction of the Bullfrog, *Lithobates catesbeianus*, have been suggested as relevant factors for the spread of this fungus in Mexico (Mendoza-Almeralla, 2015). Thus, populations of both species should be monitored continually for this disease, as well as its spread to other populations.



Fig. 11. *Desiccation and contamination of bodies of water:* The Río Apulco in the municipality of Zacapoaxtla, at an elevation of 1,400 m.  © José Edgar Valera-Sánchez

Global Warming

A gradual increase in environmental temperatures directly influences the biological activities of ectotherms (in this case, amphibians and reptiles). The effect of global warming may increase the amount of time organisms should spend in their shelters to avoid dangerous temperatures that can affect their physiological processes and behavior. This cascading effect, therefore, might increase their exposure to diseases, and reduce their time for social interactions and reproductive activities, feeding periods, and exploring home ranges and movement rates. These disruptions eventually can lead to reducing population sizes, and possibly result in local extirpations (Sinervo et al., 2010; Huey et al., 2012).

CONSERVATION STATUS

As in other papers in the MCS, we used the SEMARNAT, IUCN, and EVS systems to assess the conservation status of the herpetofauna of Puebla.

The SEMARNAT System

Mexican herpetologists often use the SEMARNAT system (an acronym for Secretaría de Medio Ambiente y Recursos Naturales, the Mexican governmental agency that developed it) to assess the conservation status of various elements of the country's herpetofauna. We placed the ratings available for some members of the Pueblan herpetofauna in Table 7 and summarize them in Table 9.

Table 9. SEMARNAT categorizations for herpetofaunal species in Puebla, Mexico, arranged by families. Non-native species are excluded.

Families	Number of Species	SEMARNAT Categorizations			
		Endangered (P)	Threatened (A)	Special Protection (Pr)	No Status (NS)
Bufonidae	8	—	—	1	7
Centrolenidae	1	—	—	—	1
Craugastoridae	10	—	—	2	8
Eleutherodactylidae	4	—	—	1	3
Hylidae	24	—	6	4	14
Leptodactylidae	2	—	—	—	2
Microhylidae	2	—	—	1	1
Phyllomedusidae	3	—	—	—	3
Ranidae	8	2	—	2	4
Scaphiopodidae	1	—	—	—	1
Subtotals	63	2	6	11	44
Ambystomatidae	3	—	1	1	1
Plethodontidae	21	—	4	9	8
Salamandridae	1	1	—	—	—
Subtotals	25	1	5	10	9
Totals	88	3	11	21	53
Anguidae	7	—	1	4	2
Corytophanidae	3	—	—	2	1
Dactyloidae	8	—	1	2	5
Eublepharidae	1	—	1	—	—
Helodermatidae	1	—	1	—	—
Iguanidae	3	—	1	2	—
Mabuyidae	1	—	—	—	1
Phrynosomatidae	22	—	2	4	16
Phyllodactylidae	1	—	—	1	—
Scincidae	3	—	—	2	1
Sphaerodactylidae	1	—	—	1	—
Sphenomorphidae	3	—	1	1	1
Teiidae	6	—	—	2	4
Xantusiidae	3	—	1	1	1
Xenosauridae	3	—	—	1	2
Subtotals	66	—	9	23	34
Boidae	2	—	—	—	2
Colubridae	31	—	5	5	21
Dipsadidae	37	—	—	15	22
Elapidae	7	—	—	4	3

Leptotyphlopidae	2	—	—	—	2
Natricidae	12	—	7	—	5
Sibynophiidae	1	—	—	—	1
Typhlopidae	1	—	—	—	1
Viperidae	13	—	3	6	4
Subtotals	106	—	15	30	61
Emydidae	1	—	—	—	1
Kinosternidae	2	—	—	2	—
Subtotals	3	—	—	2	1
Totals	175	—	24	55	96
Sum Totals	263	3	35	76	149

The SEMARNAT system is comprised of three categories, i.e., endangered (P), threatened (A), and under special protection (Pr). We placed species that remain unevaluated in this system in a “no status” (NS) category.

An examination of the data in Table 9 demonstrates that of 263 native herpetofaunal species in Puebla, 149 (56.7%) have not been evaluated, including 53 of 88 species of amphibians (60.2%), 95 of 172 species of squamates (55.2%), and one of three species of turtles (33.3%). Of the remaining 114 (43.3%), only three (1.1% of the total of 263) are placed in the endangered category (P), 35 in the threatened category (13.3%), and 76 in the special protection category (28.9%). The four endangered species are two country endemic anurans (*Lithobates johni* and *L. pueblae*) and one non-endemic salamander (*Notophthalmus meridionalis*). The threatened species include six anurans, five salamanders, and 24 squamates. Finally, the 76 special concern species include 11 anurans, 10 salamanders, 53 squamates, and two turtles.



Phrynosoma taurus Dugès, 1873. The Mexican Horned Lizard is distributed in “Morelos, Puebla, Oaxaca, [and] Guerrero” (Reptile Database; accessed 17 December 2017). This individual was found in the Jardín Botánico Helia Bravo Hollis, Zapotitlán Salinas. Wilson et al. (2013b) calculated its EVS as 12, placing it in the upper portion of the medium vulnerability category, the IUCN has assessed it as Least Concern, and SEMARNAT lists this lizard as threatened (A). © Elí García-Padilla

As with all but the Michoacán herpetofaunal surveys conducted in the MCS, more than one-half of the native species in Puebla remain unevaluated by the SEMARNAT system. As in the other MCS studies, we conclude that this system offers little value in assessing the overall conservation status of the Pueblan herpetofauna. This conclusion is especially defensible given that of the 149 unevaluated species, 78 are country endemics and three are state endemics (54.4% of the unevaluated species). This system of assessment likely will continue to be found deficient until all members of the Mexican herpetofauna somehow are included and their status appropriately updated as necessary.

The IUCN System

The International Union for Conservation of Nature (IUCN) is a well-known conservation organization established in 1948 and headquartered in Gland, Switzerland. Julian Huxley, the eminent British biologist, established the IUCN (originally as the International Union for Protection of Nature or IUPN) during his time as the first Director General of UNESCO (www.wikipedia.org; accessed 21 May 2017). Perhaps the most widely known accomplishment of this organization was the 1964 introduction of its IUCN Red List of Threatened Species, commonly known as the IUCN Red List. One of the major benefits of this listing is that it is based upon “precise criteria to evaluate the extinction risk of...species...that are “relevant to all species and all regions of the world” (www.wikipedia.org; accessed 21 May 2017). Extinction risk is categorized by the use of nine categories, including 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).

In previous entries of the MCS, the authors have been critical of the IUCN system. Johnson et al. (2015b) provided an outline of these reasons, and especially in how the EVS system (on which the MCS is based) compares with that of the IUCN. Nonetheless, because the IUCN system is used broadly to assess the conservation status of the Mesoamerican herpetofauna, herein we use it for the Mexican state of Puebla. Thus, we documented the IUCN ratings for this herpetofauna in Table 7, and summarize them in Table 10.

Table 10. IUCN Red List categorizations for herpetofaunal families in Puebla, Mexico. Non-native species are excluded. The shaded columns to the left are the “threat categories,” and those to the right the categories for which too little information on conservation status exists to allow the taxa to be placed in any other IUCN category, or they have not been evaluated.

Families	Number of Species	IUCN Red List Categorizations						
		Critically Endangered	Endangered	Vulnerable	Near Threatened	Least Concern	Data Deficient	Not Evaluated
Bufo	8	1	1	—	—	5	—	1
Centrolenidae	1	—	—	—	—	1	—	—
Craugastoridae	10	—	—	4	1	4	—	1
Eleutherodactylidae	4	—	—	2	—	1	1	—
Hylidae	24	1	4	3	3	12	1	—
Leptodactylidae	2	—	—	—	—	2	—	—
Microhylidae	2	—	—	—	—	2	—	—
Phyllomedusidae	3	1	—	—	—	2	—	—
Ranidae	8	2	1	—	—	5	—	—
Scaphiopodidae	1	—	—	—	—	1	—	—
Subtotals	63	5	6	9	4	35	2	2
Ambystomatidae	3	2	—	—	—	—	—	1
Plethodontidae	21	5	7	3	2	1	1	2

Families	Number of Species	IUCN Red List Categorizations						
		Critically Endangered	Endangered	Vulnerable	Near Threatened	Least Concern	Data Deficient	Not Evaluated
Salamandridae	1	—	1	—	—	—	—	—
Subtotals	25	7	8	3	2	1	1	3
Totals	88	12	14	12	6	36	3	5
Anguidae	7	—	1	1	—	5	—	—
Corytophanidae	3	—	—	—	—	3	—	—
Dactyloidae	8	—	—	1	—	1	1	5
Eublepharidae	1	—	—	—	—	1	—	—
Helodermatidae	1	—	—	—	—	1	—	—
Iguanidae	3	—	—	—	—	—	—	3
Mabuyidae	1	—	—	—	—	1	—	—
Phrynosomatidae	22	—	—	1	—	20	—	1
Phyllodactylidae	1	—	—	—	—	1	—	—
Scincidae	3	—	—	—	—	3	—	—
Sphaerodactylidae	1	—	—	—	—	1	—	—
Sphenomorphidae	3	—	—	—	—	2	—	1
Teiidae	6	—	—	—	—	4	—	2
Xantusiidae	3	—	—	—	—	1	1	1
Xenosauridae	3	—	—	1	—	1	—	1
Subtotals	66	—	1	4	—	45	2	14
Boidae	2	—	—	—	—	—	—	2
Colubridae	31	—	—	—	—	23	1	7
Dipsadidae	37	—	1	1	—	20	4	11
Elapidae	7	—	—	—	—	5	2	—
Leptotyphlopidae	2	—	—	—	—	2	—	—
Natricidae	12	—	—	1	—	10	—	1
Sibynophiidae	1	—	—	—	—	1	—	—
Typhlopidae	1	—	—	—	—	1	—	—
Viperidae	13	—	1	1	1	7	—	3
Subtotals	106	—	2	3	1	69	7	24
Emydidae	1	—	—	1	—	—	—	—
Kinosternidae	2	—	—	—	1	1	—	—
Subtotals	3	—	—	1	1	1	—	—
Totals	175	—	3	8	2	115	9	38
Sum Totals	263	12	17	20	8	151	12	43
Category Totals	263	49			159		55	



Xenosaurus rectocollaris Smith and Iverson, 1993. The Pallid Knob-scaled Lizard is distributed in southeastern Puebla in the Desierto de Tehuacán (Lemos-Espinal et al., 2012) and the Montañas y Valles del Occidente region of western Oaxaca (Mata-Silva et al., 2015). This individual came from near Tehuacán, Puebla. Wilson et al. (2013b) determined its EVS as 16, placing it in the middle of the high vulnerability category, the IUCN has judged it as Least Concern, and this lizard is not listed by SEMARNAT. © Cesar Barrio-Amorós

Of the 263 native members of the Pueblan herpetofauna, 209 (79.5%) of these species have been assessed by the IUCN. Of these 209 species, 49 have been allocated to one of the “threat categories,” including 12 as CR, 17 as EN, and 20 as VU. The 12 CR species include *Incilius cristatus*, *Bromeliohyala dendroscarta*, *Agalychnis moreletii*, *Lithobates chichicuahutla*, *Lithobates pueblae*, *Ambystoma leorae*, *A. taylori*, *Chiropterotriton arbores*, *Isthmura gigantea*, *Parvimolge townsendi*, *Pseudoeurycea lynchi*, and *Thorius magnipes*. Interestingly, all of these species are amphibians (five anurans, seven salamanders). In addition, 10 of the 12 are Mexican endemics and one is a state endemic, except for the phyllomedusid frog *A. moreletii*. The 17 EN species are *Incilius perplexus*, *Megastomatohyala mixomaculata*, *Sarcophyla arborescandens*, *S. charadricola*, *S. robertorum*, *Lithobates johni*, *Pseudoeurycea firscheini*, *P. gadovii*, *P. lineola*, *P. melanomolga*, *Thorius dubitus*, *T. schmidti*, *T. troglodytes*, *Notophthalmus meridionalis*, *Abronia graminea*, *Rhadinaea marcellae*, and *Mixcoatlus melanurus*. All of these species are amphibians, except for one lizard and two snakes. Also, all are Mexican endemics, except for the salamander *Notophthalmus meridionalis*. The 20 VU species include *Craugastor alfredi*, *C. decoratus*, *C. pygmaeus*, *C. rhodopsis*, *Eleutherodactylus leprus*, *E. verrucipes*, *Charadrahyla taeniopus*, *Exerodonta xera*, *Tlalocohyla godmani*, *Chiropterotriton orculus*, *Isthmura bellii*, *Pseudoeurycea leprosa*, *Abronia taeniata*, *Norops naufragus*, *Sceloporus megalepidurus*, *Xenosaurus grandis*, *Rhadinaea fulvivittis*, *Thamnophis scaliger*, *Ophryacus undulatus*, and *Trachemys venusta*. Twelve of these species are amphibians, seven are squamates, and one is a turtle. Fifteen of the 20 species are Mexican endemics, and the rest are non-endemics. In total, of the 49 species in the “threat categories,” 38 (77.6%) are amphibians and 44 (89.8%) are Mexican endemics.

Of 160 species in the “lower risk” categories, only eight are allocated to the NT category, whereas 152 are in the LC. The eight NT species consist of four anurans (*Craugastor berkenbuschii*, *Dryophytes euphorbiaceus*, *Rheohyla miotypanum*, and *Smilisca cyanosticta*), two salamanders (*Aquiloerycea cephalica* and *Bolitoglossa platydactyla*), one snake (*Agkistrodon bilineatus*), and one turtle (*Kinosternon herrerai*). Five of these eight species are Mexican endemics, and the rest are non-endemics.

The 152 LC species constitute 57.8% of the 263 native species. Whether such a sizable proportion of the Pueblan herpetofauna is of “least concern” should be examined more closely.

Fifty-four of the native species have not been evaluated, including 12 in the DD and 42 in the NE categories. Given that this number comprises 20.5% of the native herpetofauna in Puebla, these species also need to be examined in greater detail.

The EVS System

Although the EVS (Environmental Vulnerability Score) system was developed initially for application to the herpetofauna of Honduras (Wilson and McCranie, 2004), it has been expanded for use with the entire Mesoamerican herpetofauna (Wilson et al., 2013a, b; Johnson et al., 2015b). This system also has been used to evaluate the conservation status of a series of Mexican states and regions in the MCS, as well as by González-Sánchez et al. (2017). In this study, we employed this system to the herpetofauna of Puebla, and placed the values in Table 7 and summarize them in Table 11.

Table 11. Environmental Vulnerability Scores (EVS) for herpetofaunal species in Puebla, Mexico, arranged by family. Shaded area to the left encompasses low vulnerability scores, and the one to the right high vulnerability scores. Non-native species are excluded.

Families	Number of Species	Environmental Vulnerability Scores																
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Bufonidae	8	1			2					3			2					
Centrolenidae	1								1									
Craugastoridae	10						1	1	2	1		1	2	2				
Eleutheroactyludae	4										2				1		1	
Hylidae	24	1	2			2	1	2	1	3	2	5	4			1		
Leptodactylidae	2			1	1													
Microhylidae	2		1			1												
Phyllomedusidae	3					1				1		1						
Ranidae	8					1		1		1	1	1	1	2				
Scaphiopodidae	1				1													
Subtotals	63	2	3	1	4	5	2	4	4	9	5	8	9	4	1	1	1	
Ambystomatidae	3												1	2				
Plethodontidae	21										1	1	2	1	6	6	4	
Salamandridae	1										1							
Subtotals	25										2	1	3	3	6	6	4	
Totals	88	2	3	1	4	5	2	4	4	9	7	9	12	7	7	7	5	
Anguidae	7				1						1		3	2				
Corytophanidae	3					1	1					1						
Dactyloidae	8						1	3				1		2		1		
Eublepharidae	1							1										
Helodermatidae	1												1					
Iguanidae	3										2			1				
Mabuyidae	1				1													
Phrynosomatidae	22			1				2		4	6	4	1	4				
Phyllodactylidae	1											1						
Scincidae	3								1	1			1					
Sphaerodactylidae	1										1							
Sphenomorphidae	3						1			1	1							

Families	Number of Species	Environmental Vulnerability Scores																	
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Teiidae	6						1			2		1	1	1					
Xantusiidae	3								2					1					
Xenosauridae	3						1							2					
Subtotals	66			1	2	1	4	7	1	10	11	8	7	10	3	1			
Boidae	2								1					1					
Colubridae	31			2	7	1	1	3	1	2	2	4	4	2	2				
Dipsadidae	37			3	2	3	3	3	6	2	2	3	5	4	1				
Elapidae	7						1			1		1	1	1			2		
Leptotyphlopidae	2									1		1							
Natricidae	12					3	1		1	1			2	3		1			
Sibynophiidae	1									1									
Typhlopidae	1									1									
Viperidae	13						1			2	1	1	2	3	2	1			
Subtotals	106			5	9	7	7	6	9	11	5	10	14	14	5	2	2		
Emydidae	1																	1	
Kinosternidae	2									1			1						
Subtotals	3									1			1					1	
Totals	175			6	11	8	11	13	10	22	16	18	22	24	8	3	2	1	
Sum Totals	263	2	3	7	15	13	13	17	14	31	23	27	34	31	15	10	7	1	
Category Totals	263	70						95						98					

We applied EVS values to 263 of the 267 herpetofaunal species occurring in Puebla, excluding the four non-native forms (Table 11). The values range from 3 to 19, one short of the entire theoretical range of 3–20. The most frequent values (in 10 or more species) are 6 (15 species), 7 (13), 8 (13), 9 (17), 10 (14), 11 (31), 12 (23), 13 (27), 14 (34), 15 (30), 16 (16), and 17 (10). These 12 scores are provided to 243 of 263 species (92.4%) for which EVS could be determined. We calculated the lowest score of 3 for two species of anurans (*Rhinella horribilis* and *Smilisca baudinii*) and the highest score of 19 for one turtle (*Trachemys venusta*).

As in previous MCS studies, we placed the EVS into three categories of low, medium, and high vulnerability. As such, the summary numbers increase from low (70) through medium vulnerability (95), to high vulnerability (98). In general, this pattern is reflective of state herpetofaunas that contain more country and state endemics than non-endemic species.

In Table 12, we compared the results of the IUCN categories with those of the EVS system. Our comparison indicates that 49 of the 99 high vulnerability species (49.5%) are judged to occupy one of the three IUCN threat categories. This high proportion primarily results from the number of amphibians assessed as CR, EN, or VU. Twelve species (five anurans, seven salamanders) are judged as CR, 14 as EN (six anurans, eight salamanders), and 12 as VU (nine anurans, three salamanders). These 38 species comprise 43.2% of the 88 amphibian species recorded in Puebla. No squamates or turtles are assessed as CR, with only three judged as EN and eight as VU. These 11 species make up only 6.2% of the 178 species of squamates and turtles from Puebla. At the opposite extreme, the 70 low vulnerability species constitute 45.8% of the 153 LC species. As in other MCS studies, the results of the application between the IUCN and EVS systems do not complement one another.



Xenosaurus tzacualtipantecus Woolrich-Piña and Smith, 2012. The Zacualtipan Knob-scaled Lizard is known from the Sierra Madre Oriental in Hidalgo, Puebla, and Veracruz (Ramírez-Bautista et al., 2014). This individual was found near Tepehican, in the municipality of Tlatlauquitepec, Puebla. Wilson et al. (2013b) calculated its EVS as 17, placing it in the middle portion of the high vulnerability category, the IUCN has not assessed it, and this lizard is not listed by SEMARNAT. 📷 © Guillermo Woolrich-Piña



Lampropeltis polyzona Cope, 1861. The Mexican Milksnake “ranges on the Pacific side from southern Sonora south to Guerrero, and across the southern part of the Mexican Plateau eastward to Veracruz and northern Oaxaca” (Heimes, 2016: 89). This individual is from Atlixco, in the municipality of Atlixco, Puebla. Mata-Silva et al. (2015) judged its EVS as 11, placing it in the middle of the medium vulnerability category, the IUCN has not evaluated it, and this snake is not listed by SEMARNAT. 📷 © Peter Heimes

Table 12. Comparison of Environmental Vulnerability Scores (EVS) and IUCN categorizations for members of the herpetofauna of Puebla, Mexico. Non-native species are excluded. Shaded area at the top encompasses low vulnerability category scores, and the one at the bottom high vulnerability category scores.

EVS	IUCN Categories							Totals
	Critically Endangered	Endangered	Vulnerable	Near Threatened	Least Concern	Data Deficient	Not Evaluated	
3	—	—	—	—	1	—	1	2
4	—	—	—	—	3	—	—	3
5	—	—	—	—	4	—	3	7
6	—	—	—	—	11	—	4	15
7	1	—	—	—	10	—	2	13
8	—	—	—	—	10	—	3	13
9	—	—	2	1	9	—	5	17
10	—	—	—	—	13	—	1	14
11	—	2	2	1	23	1	2	31
12	—	2	2	1	15	—	3	23
13	—	2	3	1	19	1	1	27
14	1	4	3	3	17	1	5	34
15	4	1	4	1	11	3	7	31
16	2	3	2	—	4	1	3	15
17	3	2	—	—	1	2	2	10
18	1	1	1	—	—	3	1	7
19	—	—	1	—	—	—	—	1
Totals	12	17	20	8	151	12	43	263

The two principal reasons that these systems are not complementary is that a substantial proportion of the herpetofaunal species in Puebla have not been evaluated or have been placed in the DD category, and an even larger proportion has been allocated to the LC category. We placed the 12 species allocated to the DD category in Table 13, and interestingly, 10 of the species are country endemics and two are state endemics. Since all but two of these 12 species has been evaluated with an EVS in the high vulnerability category (the EVS of the others is 11 and 13, one or three points from the high category), we believe that allowing them to remain in the DD category indefinitely will not bring attention to the severity of their conservation needs. Furthermore, in our opinion the five species with an EVS of 17 or 18 probably should be allocated to the CR category, the four with an EVS of 15 or 16 to the EN category, and the remaining three species with an EVS of 13 or 14 to the VU or NT categories.

Table 13. Environmental Vulnerability Scores (EVS) for members of the herpetofauna of Puebla, Mexico, allocated to the IUCN Data Deficient category. * = country endemic; ** = state endemic.

Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Eleutherodactylus verruculatus</i> *	6	8	4	18
<i>Ptychohyla zophodes</i> *	5	7	1	13
<i>Aquiloerycea quetzalanensis</i> **	5	8	4	17
<i>Norops cymbops</i> *	6	8	3	17
<i>Lepidophyma tuxtlae</i> *	5	4	2	11
<i>Tantilla robusta</i> **	6	8	2	16
<i>Coniophanes melanocephalus</i> *	5	6	3	14
<i>Geophis blanchardi</i> *	5	8	2	15
<i>Rhadinaea cuneata</i> *	6	7	2	15
<i>Rhadinaea quinquelineata</i> *	5	8	2	15
<i>Micrurus nebularis</i> *	5	8	5	18
<i>Micrurus pachecoglii</i> *	6	7	5	18

A sizable number of herpetofaunal species in Puebla have not been evaluated by the IUCN. We placed these 42 species, along with their EVS calculations, in Table 14. Fifteen of the 42 species (35.7%) are country endemics, and one (*Lepidophyma zongolica*) is a state endemic. The remaining species are non-endemics, and perhaps have not been assessed for this or some other reason, even after their status was considered at a reptile assessment conference held in Palo Verde, Costa Rica, more than five years ago. Interestingly, the EVS for these 42 species ranges from 3 to 18 (of a theoretical range from 3 to 20). If the same assessment criteria were applied to this group as to the DD species in the above paragraph, then the four species with an EVS of 17 or 18 would be allocated to the CR category, the six with an EVS of 15 or 16 to the EN category, and the seven with EVS of 13 or 14 to the VU category. Perhaps the three species with an EVS of 12 should be placed in the NT category and the remaining 21 species in the LC category.

Table 14. Environmental Vulnerability Scores (EVS) for members of the herpetofauna of Puebla, Mexico, currently not evaluated (NE) by the IUCN. Non-native taxa are excluded. * = country endemic; ** = state endemic.

Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Rhinella horribilis</i>	1	1	1	3
<i>Craugastor galacticorhinus</i> *	6	8	4	18
<i>Ambystoma subsalsum</i> *	5	8	1	14
<i>Aquiloerycea cafetalera</i> *	6	7	4	17
<i>Thorius maxillabrochus</i>	6	8	4	18
<i>Norops carlliebi</i> *	5	7	3	15
<i>Norops laeiventris</i>	3	3	3	9
<i>Norops petersii</i>	2	4	3	9

Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Norops sericeus</i>	2	3	3	8
<i>Norops tropidonotus</i>	4	2	3	9
<i>Ctenosaura acanthura</i>	2	4	6	12
<i>Ctenosaura pectinata*</i>	5	4	6	15
<i>Iguana iguana</i>	3	3	6	12
<i>Sceloporus aureolus*</i>	5	7	3	15
<i>Scincella cherriei</i>	3	2	3	8
<i>Holcosus amphigrammus*</i>	5	3	3	11
<i>Holcosus sinister*</i>	5	5	3	13
<i>Lepidophyma zongolica**</i>	6	8	2	16
<i>Xenosaurus tzacualtipantecus*</i>	6	8	3	17
<i>Boa imperator</i>	3	1	6	10
<i>Boa sigma*</i>	5	4	6	15
<i>Conopsis acuta*</i>	5	7	2	14
<i>Drymobius margaritiferus</i>	1	1	4	6
<i>Ficimia olivacea*</i>	5	2	2	9
<i>Lampropeltis polyzona*</i>	1	3	5	9
<i>Oxybelis aeneus</i>	1	1	3	5
<i>Spilotes pullatus</i>	1	1	4	6
<i>Trimorphodon biscutatus</i>	2	1	4	7
<i>Coniophanes fissidens</i>	1	3	3	7
<i>Enulius flavitorques</i>	1	1	3	5
<i>Geophis lorancai*</i>	5	7	2	14
<i>Geophis turbidus*</i>	5	8	2	15
<i>Imantodes cenchoa</i>	1	3	2	6
<i>Imantodes gemmistratus</i>	1	3	2	6
<i>Leptodeira septentrionalis</i>	2	2	4	8
<i>Oxyrhopus petolarius</i>	3	6	5	14
<i>Rhadinaea decorata</i>	1	6	2	9
<i>Sibon nebulatus</i>	1	2	2	5
<i>Tropidodipsas zweifeli</i>	5	7	4	16
<i>Thamnopsis conanti*</i>	5	8	1	14
<i>Bothrops asper</i>	3	4	5	12
<i>Crotalus culminatus*</i>	5	5	5	15
<i>Ophryacus smaragdinus*</i>	3	6	5	14



Pituophis lineaticollis (Cope, 1861). The Middle American Gopher Snake occurs in the “highlands of southern Mexico and Guatemala” (Heimes, 2016: 134). This individual came from near Tehuacán, in the municipality of Tehuacán, Puebla. Wilson et al. (2013b) assessed its EVS as 8, placing it in the upper portion of the low vulnerability category, the IUCN has judged it as Least Concern, and this snake is not listed by SEMARNAT. © Ricardo Ramírez-Chaparro

Of the 263 native herpetofaunal species in Puebla, 152 (57.8%) are listed in the LC category by IUCN (Table 15). Based on these data, one might conclude that the herpetofauna of this state is in reasonably good environmental health. In our opinion, however, the LC category has been overused. When we placed the EVS for the 152 LC species in the three categories of low, medium, and high vulnerability, their respective numbers are 49, 69, and 34. In addition, 87 of the 152 species (57.2%) are country endemics. The EVS values for the 87 species range from 8 to 17. Following the same line of reasoning employed with the DD and NE species, it appears best to allocate the single species with an EVS of 17 to the CR category, the 16 species with an EVS of 15 or 16 to the EN category, and the 36 with an EVS of 13 or 14 to the VU category. The remaining 99 species should be allocated to either the NT or LC categories. In summary, of the 206 species placed in DD, NE, or LC categories, we suggest that 10 should be placed in the CR, 26 in the EN, and 46 in the VU categories. We suggest that 82 of the 206 species (38.9%) should be allocated to the three IUCN “threat categories.”

Table 15. Environmental Vulnerability Scores (EVS) for members of the herpetofauna of Puebla, Mexico, assigned to the IUCN Least Concern category. Non-native taxa are not included. * = country endemic.

Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Anaxyrus compactilis</i> *	5	8	1	14
<i>Incilius marmoratus</i> *	5	5	1	11
<i>Incilius nebulifer</i>	1	4	1	6
<i>Incilius occidentalis</i> *	5	5	1	11
<i>Incilius valliceps</i>	3	2	1	6
<i>Hyalinobatrachium fleischmanni</i>	3	4	3	10


Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Craugastor augusti</i>	2	2	4	8
<i>Craugastor loki</i>	2	4	4	10
<i>Craugastor mexicanus</i> *	5	7	4	16
<i>Craugastor rugulosus</i> *	5	4	4	13
<i>Eleutherodactylus nitidus</i> *	5	3	4	12
<i>Anotheca spinosa</i>	3	6	5	14
<i>Dendropsophus microcephalus</i>	3	3	1	7
<i>Dryophytes arenicolor</i>	2	4	1	7
<i>Dryophytes eximius</i> *	5	4	1	10
<i>Dryophytes plicatus</i> *	5	5	1	11
<i>Exerodonta smaragdina</i> *	5	6	1	12
<i>Sarcohyala bistincta</i> *	5	3	1	9
<i>Scinax staufferi</i>	2	1	1	4
<i>Smilisca baudinii</i>	1	1	1	3
<i>Tlalocohyla picta</i>	2	5	1	8
<i>Tlalocohyla smithii</i> *	5	5	1	11
<i>Trachycephalus vermiculatus</i>	1	2	1	4
<i>Leptodactylus fragilis</i>	1	2	2	5
<i>Leptodactylus melanonotus</i>	1	3	2	6
<i>Hypopachus ustus</i>	2	4	1	7
<i>Hypopachus variolosus</i>	2	1	1	4
<i>Agalychnis callidryas</i>	3	5	3	11
<i>Agalychnis dacnicolor</i> *	5	5	3	13
<i>Lithobates berlandieri</i>	4	2	1	7
<i>Lithobates montezumae</i> *	5	7	1	13
<i>Lithobates spectabilis</i> *	5	6	1	13
<i>Lithobates vaillanti</i>	3	5	1	9
<i>Lithobates zweifeli</i> *	5	5	1	11
<i>Spea multiplicata</i>	1	4	1	6
<i>Pseudoeurycea mixteca</i> *	5	8	4	17
<i>Barisia imbricata</i> *	5	6	3	14
<i>Celestus enneagrammus</i> *	5	6	3	14
<i>Celestus legnotus</i> *	5	6	3	14
<i>Gerrhonotus liocephalus</i>	2	1	3	6
<i>Gerrhonotus ophiurus</i> *	5	4	3	12
<i>Basiliscus vittatus</i>	1	3	3	7

Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Corytophanes hernandesii</i>	4	6	3	13
<i>Laemanctus serratus</i>	2	3	3	8
<i>Norops microlepidotus</i> *	5	7	3	15
<i>Coleonyx elegans</i>	2	3	4	9
<i>Heloderma horridum</i> *	5	4	5	14
<i>Marisora brachypoda</i>	1	2	3	6
<i>Phrynosoma asio</i>	2	6	3	11
<i>Phrynosoma braconnieri</i> *	5	7	3	15
<i>Phrynosoma orbiculare</i> *	5	4	3	12
<i>Phrynosoma taurus</i> *	5	4	3	12
<i>Sceloporus aeneus</i> *	5	5	3	13
<i>Sceloporus bicanthalis</i> *	5	5	3	13
<i>Sceloporus formosus</i> *	5	7	3	15
<i>Sceloporus gadoviae</i> *	5	3	3	11
<i>Sceloporus grammicus</i>	2	4	3	9
<i>Sceloporus horridus</i> *	5	3	3	11
<i>Sceloporus jalapae</i> *	5	5	3	13
<i>Sceloporus melanorhinus</i>	2	4	3	9
<i>Sceloporus mucronatus</i> *	5	5	3	13
<i>Sceloporus ochoterenae</i> *	5	4	3	12
<i>Sceloporus palaciosi</i> *	5	7	3	15
<i>Sceloporus scalaris</i> *	5	4	3	12
<i>Sceloporus spinosus</i> *	5	4	3	12
<i>Sceloporus torquatus</i> *	5	3	3	11
<i>Sceloporus variabilis</i>	1	1	3	5
<i>Urosaurus bicarinatus</i> *	5	4	3	12
<i>Phyllodactylus bordai</i> *	5	5	3	13
<i>Plestiodon brevirostris</i> *	5	5	3	13
<i>Plestiodon copei</i> *	5	6	3	14
<i>Plestiodon lynxe</i> *	5	2	3	10
<i>Sphaerodactylus glaucus</i>	4	5	3	12
<i>Scincella gemmingeri</i> *	5	3	3	11
<i>Scincella silvicola</i> *	5	4	3	12
<i>Aspidoscelis costatus</i> *	5	3	3	11
<i>Aspidoscelis deppii</i>	1	4	3	8
<i>Aspidoscelis parvisocius</i> *	5	7	3	15


Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Aspidoscelis sacki</i> *	5	6	3	14
<i>Lepidophyma sylvaticum</i> *	5	4	2	11
<i>Xenosaurus rectocollaris</i> *	5	8	3	16
<i>Conopsis biserialis</i> *	5	6	2	13
<i>Conopsis lineata</i> *	5	6	2	13
<i>Conopsis nasus</i> *	5	4	2	11
<i>Drymarchon melanurus</i>	1	1	4	6
<i>Ficimia publia</i>	4	3	2	9
<i>Ficimia streckeri</i> *	3	7	2	12
<i>Leptophis diplotropis</i> *	5	5	4	14
<i>Leptophis mexicanus</i>	1	1	4	6
<i>Masticophis mentovarius</i>	1	1	4	6
<i>Mastigodryas melanolomus</i>	1	1	4	6
<i>Pituophis deppei</i> *	5	5	4	14
<i>Pituophis lineaticollis</i>	2	2	4	8
<i>Pseudelaphe flavirufa</i>	2	4	4	10
<i>Pseudoficimia frontalis</i> *				13
<i>Salvadora bairdi</i> *	5	6	4	15
<i>Salvadora intermedia</i> *	5	7	4	16
<i>Salvadora mexicana</i> *	5	6	4	15
<i>Senticolis triaspis</i>	2	1	3	6
<i>Sonora michoacanensis</i> *	5	6	3	14
<i>Tantilla bocourti</i> *	5	2	2	9
<i>Tantilla calamarina</i> *	5	5	2	12
<i>Tantilla rubra</i>	2	1	2	5
<i>Trimorphodon tau</i> *	5	4	4	13
<i>Adelphicos quadrivirgatum</i>	4	4	2	10
<i>Amastridium sapperi</i>	4	4	2	10
<i>Chersodromus liebmanni</i> *	5	5	2	12
<i>Coniophanes bipunctatus</i>	1	5	3	9
<i>Coniophanes imperialis</i>	2	3	3	8
<i>Coniophanes piceivittis</i>	1	3	3	7
<i>Conophis vittatus</i>	2	5	4	11
<i>Geophis dubius</i> *	5	6	2	13
<i>Geophis mutitorques</i> *	5	6	2	13
<i>Geophis semidoliatus</i> *	5	6	2	13

Taxa	Environmental Vulnerability Score (EVS)			
	Geographic Distribution	Ecological Distribution	Reproductive Mode/ Degree of Persecution	Total Score
<i>Hypsiglena torquata</i> *	5	1	2	8
<i>Leptodeira maculata</i>	2	1	4	7
<i>Leptodeira splendida</i> *	5	5	4	14
<i>Ninia diademata</i>	4	3	2	9
<i>Ninia sebae</i>	1	1	2	4
<i>Pliocercus elapoides</i>	4	1	5	10
<i>Pseudoleptodeira latifasciata</i> *	5	5	4	14
<i>Rhadinaea hesperia</i> *	5	3	2	10
<i>Sibon dimidiatus</i>	1	5	4	10
<i>Tropidodipsas sartorii</i>	2	2	5	9
<i>Micrurus bernadi</i> *	5	5	5	15
<i>Micrurus diastema</i>	2	1	5	8
<i>Micrurus elegans</i>	4	4	5	13
<i>Micrurus laticollaris</i> *	5	4	5	14
<i>Micrurus tener</i>	1	5	5	11
<i>Rena maxima</i> *	5	5	1	11
<i>Rena myopica</i> *	5	7	1	13
<i>Nerodia rhombifer</i>	1	5	4	10
<i>Storeria dekayi</i>	1	4	2	7
<i>Storeria storerioides</i> *	5	4	2	11
<i>Thamnophis chrysocephalus</i> *	5	5	4	14
<i>Thamnophis cyrtopsis</i>	2	1	4	7
<i>Thamnophis eques</i>	2	2	4	8
<i>Thamnophis proximus</i>	1	2	4	7
<i>Thamnophis pulchrilatus</i> *	5	6	4	15
<i>Thamnophis scalaris</i> *	5	5	4	14
<i>Thamnophis sumichrasti</i> *	5	6	4	15
<i>Scaphiodontophis annulatus</i>	1	5	5	11
<i>Amerityphlops tenuis</i>	4	6	1	11
<i>Atropoides nummifer</i> *	5	3	5	13
<i>Crotalus intermedius</i> *	5	5	5	15
<i>Crotalus molossus</i>	2	1	5	8
<i>Crotalus polystictus</i> *	5	6	5	16
<i>Crotalus ravus</i> *	5	4	5	14
<i>Crotalus scutulatus</i>	2	4	5	11
<i>Crotalus triseriatus</i> *	5	6	5	16
<i>Kinosternon integrum</i> *	5	3	3	11



Salvadora intermedia Hartweg, 1940. The Oaxacan Patch-nosed Snake “occurs south of the Transverse Volcanic Cordillera, ... from the Sierra Madre del Sur of Guerrero through the highlands of Oaxaca and adjacent southern Puebla” (Heimes, 2016: 150). This individual was found near Tehuacán, in the municipality of Tehuacán, Puebla. Wilson et al. (2013b) determined its EVS as 16, placing it in the middle portion of the high vulnerability category, the IUCN has assessed it as Least Concern, and SEMARNAT lists this snake under the category of special protection (Pr).  © Ricardo Ramírez-Chaparro



Crotalus culminatus Klauber, 1952. The Northwestern Neotropical Rattlesnake occurs in “western Mexico (Chiapas, Guerrero, México, Michoacán, Morelos, Oaxaca)” (Wallach et al., 2014: 189). This individual was found on the road near Tehuacán, in the municipality of Tehuacán, Puebla. Wilson et al. (2013b) calculated its EVS as 15, placing it in the lower portion of the high vulnerability category, its IUCN status remains undetermined, and this taxon is not recognized by SEMARNAT.  © Evan Arambul

RELATIVE HERPETOFAUNAL PRIORITY

Johnson et al. (2015a) developed the concept of Relative Herpetofaunal Priority (RHP), a simple bi-modal means of determining the relative positioning of physiographic regional herpetofaunas in given states and regions in Mexico, for a study of the herpetofauna of Chiapas. This system uses two types of data, the number of state and country endemics and the number of high vulnerability EVS species, to assign priority conservation importance to the herpetofaunas of the physiographic regions recognized. For this study, we calculated the requisite data for the Pueblan herpetofauna and placed them in Tables 16 and 17.

The data in Table 16 is based on the relative number of country and state endemic species, and demonstrates that the first rank is held by the SMO with a total of 103 of 186 endemic species (55.4%). The remaining ranks are as follows: second rank = TMV (81 of 125; 64.8%); third rank = UBB (45 of 71; 63.4%); fourth rank = VOT (40 of 60; 66.7%); fifth rank = SMS (27 of 41; 65.9%); and sixth rank = GCL (20 of 74; 27.0%).

Based on the relative number of high vulnerability species (Table 17), the rank order is nearly the same as for the number of country and state endemics, as follows: first rank = SMO (62 of 184 total species; 33.7%); second rank = TMV (43 of 125; 34.4%); third rank = VOT (23 of 60; 38.3%); fourth rank = UBB (17 of 70; 24.3%); fifth rank = SMS (13 of 40; 32.5%); and sixth rank = GCL (9 of 72; 12.5%). The rank order values for high vulnerability species differ from those for the endemic species numbers only in that the rankings for the UBB and the VOT are reversed.

Table 16. Number of herpetofaunal species in four distribution status categories among the six physiographic regions of Puebla, Mexico. Rank determined by adding the state and country endemics.

Physiographic Regions	Distribution Status Categories				Totals	Rank Order
	Non-endemics	Country Endemics	State Endemics	Non-natives		
Gulf Coastal Lowlands	52	18	2	2	74	6
Sierra Madre Oriental	81	101	2	2	186	1
Trans-Mexican Volcanic Belt	44	79	2	—	125	2
Sierra Madre del Sur	13	27	—	1	41	5
Upper Balsas Basin	25	45	—	1	71	3
Valley of Tehuacán	20	40	—	—	60	4

Table 17. Number of herpetofaunal species in the three EVS categories among the six physiographic regions of Puebla, Mexico. Rank determined by the relative number of high EVS species. Non-native species are excluded.

Physiographic Provinces	Low	Medium	High	Totals	Rank Order
Gulf Coastal Lowlands	36	27	9	72	6
Sierra Madre Oriental	57	65	62	184	1
Trans Mexican Volcanic Belt	35	47	43	125	2
Sierra Madre del Sur	12	15	13	40	5
Upper Balsas Basin	24	29	17	70	4
Valley of Tehuacán	17	20	23	60	3

Given the results of the RHP analysis, the physiographic region with the highest priority clearly is the SMO, because it contains the highest numbers of both country and state endemics and of high vulnerability species (Tables 16, 17). The 103 endemics consist of 26 anurans (all country endemics), 17 salamanders (16 country endemics, one state endemic), 59 squamates (58 country endemics, one state endemic), and one turtle (a country endemic). We indicate these species by an asterisk or a double asterisk in Table 4. The SMO also harbors 62 high vulnerability species, including 13 anurans, 16 salamanders, 32 squamates, and two turtles. These 62 species and their respective EVS values are as follows:

<i>Incilius cristatus</i> * (14)	<i>Barisia imbricata</i> * (14)
<i>Craugastor berkenbuschii</i> * (14)	<i>Celestus enneagrammus</i> * (14)
<i>Craugastor decoratus</i> * (15)	<i>Celestus legnotus</i> * (14)
<i>Craugastor galacticorhinus</i> * (15)	<i>Norops cymbops</i> * (17)
<i>Craugastor rhodopis</i> * (14)	<i>Norops quercorum</i> * (16)
<i>Eleutherodactylus verrucipes</i> * (16)	<i>Sceloporus aureolus</i> * (15)
<i>Eleutherodactylus verruculatus</i> * (18)	<i>Sceloporus formosus</i> * (15)
<i>Anotheca spinosa</i> (14)	<i>Sceloporus megalepidurus</i> * (14)
<i>Bromeliohyala dendroscarta</i> * (17)	<i>Plestiodon copei</i> * (14)
<i>Megastomatohyala mixomaculata</i> * (14)	<i>Xenosaurus rectocollaris</i> * (16)
<i>Sarcohyala charadricola</i> * (14)	<i>Xenosaurus tzacualtipantecus</i> * (16)
<i>Lithobates johni</i> * (14)	<i>Conopsis acuta</i> * (14)
<i>Lithobates pueblae</i> * (15)	<i>Pituophis deppei</i> * (14)
<i>Ambystoma subsalsum</i> * (14)	<i>Tantilla robusta</i> ** (16)
<i>Aquiloerycea cafetalera</i> * (17)	<i>Geophis blanchardi</i> * (15)
<i>Aquiloerycea quetzalanensis</i> ** (17)	<i>Geophis lorancai</i> * (14)
<i>Bolitoglossa platydactyla</i> * (15)	<i>Geophis turbidus</i> * (15)
<i>Chiropterotriton arboreus</i> * (18)	<i>Oxyrhopus petolaris</i> (14)
<i>Chiropterotriton orculus</i> * (18)	<i>Rhadinaea cuneata</i> * (15)
<i>Isthmura gigantea</i> * (16)	<i>Rhadinaea quinquelineata</i> * (15)
<i>Parvimolge townsendi</i> * (16)	<i>Micrurus bernadi</i> * (15)
<i>Pseudoeurycea firscheini</i> * (18)	<i>Micrurus nebularis</i> * (18)
<i>Pseudoeurycea leprosa</i> * (16)	<i>Thamnophis chrysocephalus</i> * (14)
<i>Pseudoeurycea lineola</i> * (14)	<i>Thamnophis conanti</i> * (17)
<i>Pseudoeurycea lynchi</i> * (17)	<i>Thamnophis sumichrasti</i> * (15)
<i>Thorius dubitus</i> * (16)	<i>Crotalus intermedius</i> * (15)
<i>Thorius magnipes</i> * (17)	<i>Crotalus ravus</i> * (14)
<i>Thorius schmidtii</i> * (17)	<i>Crotalus triseriatus</i> * (16)
<i>Thorius troglodytes</i> * (16)	<i>Ophryacus smaragdinus</i> * (14)
<i>Abronia graminea</i> * (15)	<i>Ophryacus undulatus</i> * (15)
<i>Abronia taeniata</i> * (15)	<i>Trachemys venusta</i> (19)

Of these 62 species, 57 (91.9%) are country endemics and two are state endemics, and their EVS values range from 14 to 19.



Crotalus intermedius Troschel, 1865. The Mexican Small-headed Rattlesnake is distributed in “several disjunct populations...in the central and southern highland region of Mexico” (Campbell and Lamar, 2004: 553). These individuals were found in the Parque Estatal Flor del Bosque, Amozoc de Mota, Puebla. Wilson et al. (2013b) calculated its EVS as 15, placing it in the lower portion of the high vulnerability category, the IUCN has assessed it as Least Concern, and SEMARNAT lists this rattlesnake as threatened (A).

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Crotalus molossus Baird and Girard, 1853. The Black-tailed Rattlesnake occurs from northwestern Arizona and southwestern New Mexico on the west, southward along the Pacific Coastal Plain, Sierra Madre Occidental, and Mexican Plateau to Michoacán, and from Coahuila and Nuevo León on the east, southward along the Sierra Madre Oriental and Mexican Plateau to northwestern Oaxaca (Anderson and Greenbaum, 2012). This individual was encountered near Tehuacán, in the municipality of Tehuacán, Puebla. Wilson et al. (2013a) calculated its EVS as 8, placing it in the upper portion of the low vulnerability category, the IUCN has assessed it as Least Concern, and SEMARNAT lists this species under the category of special protection (Pr).

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The TMV harbors 81 endemic species, including 17 anurans (all country endemics), 14 salamanders (12 country endemics, two state endemics), 48 squamates (all country endemics), and two turtles (both country endemics). This region also contains 43 high vulnerability species, including the following five anurans, 12 salamanders, 24 squamates, and two turtles:

<i>Anaxyrus compactilis</i> * (14)	<i>Sceloporus aureolus</i> * (15)
<i>Craugastor decoratus</i> * (15)	<i>Sceloporus megalepidurus</i> * (14)
<i>Craugastor rhodopis</i> * (14)	<i>Sceloporus palaciosi</i> * (15)
<i>Eleutherodactylus verrucipes</i> * (16)	<i>Plestiodon copei</i> * (14)
<i>Lithobates chichicuahutla</i> * (15)	<i>Conopsis acuta</i> * (14)
<i>Ambystoma leorae</i> * (15)	<i>Leptophis diplotropis</i> * (14)
<i>Ambystoma taylori</i> ** (15)	<i>Pituophis deppei</i> * (14)
<i>Ambystoma subsalsum</i> * (14)	<i>Salvadora bairdi</i> * (15)
<i>Aquiloerycea cephalica</i> * (14)	<i>Rhadinaea quinquelineata</i> * (15)
<i>Aquiloerycea quetzalanensis</i> ** (17)	<i>Micrurus bernadi</i> * (15)
<i>Bolitoglossa platydactyla</i> * (15)	<i>Thamnophis pulchrilatus</i> * (15)
<i>Chiropterotriton orculus</i> * (18)	<i>Thamnophis scalaris</i> * (14)
<i>Isthmura gigantea</i> * (16)	<i>Thamnophis scaliger</i> * (15)
<i>Parvimolge townsendi</i> * (16)	<i>Thamnophis sumichrasti</i> * (15)
<i>Pseudoeurycea leprosa</i> * (16)	<i>Crotalus intermedius</i> * (15)
<i>Pseudoeurycea lynchi</i> * (17)	<i>Crotalus polystictus</i> * (16)
<i>Pseudoeurycea melanomolga</i> * (16)	<i>Crotalus ravus</i> * (14)
<i>Abronia graminea</i> * (15)	<i>Crotalus triseriatus</i> * (16)
<i>Abronia taeniata</i> * (15)	<i>Ophryacus undulatus</i> * (15)
<i>Barisia imbricata</i> * (14)	<i>Kinosternon herrerai</i> * (14)
<i>Celestus legnotus</i> * (14)	<i>Trachemys venusta</i> (19)
<i>Norops quercorum</i> * (16)	

All of these 43 species are country endemics, except for two salamanders that are state endemics and one turtle that is a non-endemic, and their EVS values range from 14 to 18.

The UBB encompasses 45 endemic species, including 11 anurans, one salamander, 32 squamates, and one turtle. This region also is inhabited by 17 high vulnerability species, including the following:

<i>Anaxyrus compactilis</i> * (14)	<i>Leptophis diplotropis</i> * (14)
<i>Ambystoma subsalsum</i> * (14)	<i>Salvadora mexicana</i> * (15)
<i>Barisia imbricata</i> * (14)	<i>Sonora michoacanensis</i> * (14)
<i>Norops microlepidotus</i> * (15)	<i>Coniophanes melanocephalus</i> * (14)
<i>Heloderma horridum</i> * (14)	<i>Leptodeira splendida</i> * (14)
<i>Ctenosaura pectinata</i> * (15)	<i>Pseudoleptodeira latifasciata</i> * (14)
<i>Phrynosoma braconnieri</i> * (15)	<i>Micrurus laticollaris</i> * (14)
<i>Aspidoscelis sackii</i> * (14)	<i>Crotalus culminatus</i> * (15)
<i>Boa sigma</i> * (15)	

All 17 of these species are country endemics, and their EVS values range from 14 to 15.

The VOT contains 40 endemic species, including four anurans, two salamanders, 33 squamates, and one turtle. It also harbors 23 high vulnerability species, including the following:

<i>Exerodonta xera</i> * (14)	<i>Boa sigma</i> * (15)
<i>Ambystoma subsalsum</i> * (14)	<i>Conopsis acuta</i> * (14)
<i>Thorius maxillabrochus</i> * (18)	<i>Pituophis deppei</i> * (14)
<i>Barisia imbricata</i> * (14)	<i>Salvadora bairdi</i> * (15)
<i>Norops quercorum</i> * (16)	<i>Salvadora intermedia</i> * (16)
<i>Ctenosaura pectinata</i> * (15)	<i>Tropidodipsas zweifeli</i> * (16)
<i>Phrynosoma braconnieri</i> * (15)	<i>Micrurus laticollaris</i> * (14)
<i>Sceloporus aureolus</i> * (15)	<i>Micrurus pachecogili</i> * (18)
<i>Sceloporus megalepidurus</i> * (14)	<i>Crotalus intermedius</i> * (15)
<i>Aspidoscelis parvisocia</i> * (15)	<i>Crotalus ravus</i> * (14)
<i>Aspidoscelis sackii</i> * (14)	<i>Mixcoatlus melanurus</i> * (17)
<i>Xenosaurus rectocollaris</i> * (16)	

All 23 of these species are country endemics, and their EVS values range from 14 to 18.

The SMS is inhabited by 27 endemic species, including four anurans (all country endemics), one salamander (a country endemic), and 22 squamates (all country endemics). This region also is inhabited by 13 high vulnerability species, including one anuran, one salamander, and 11 squamates:

<i>Eleutherodactylus verrucipes</i> * (16)	<i>Xenosaurus rectocollaris</i> * (16)
<i>Pseudoeurycea mixteca</i> * (17)	<i>Conopsis acuta</i> * (14)
<i>Norops quercorum</i> * (16)	<i>Salvadora intermedia</i> * (16)
<i>Phrynosoma braconnieri</i> * (15)	<i>Crotalus intermedius</i> * (15)
<i>Sceloporus aureolus</i> * (15)	<i>Crotalus ravus</i> * (14)
<i>Sceloporus megalepidurus</i> * (14)	<i>Mixcoatlus melanurus</i> * (17)
<i>Aspidoscelis parvisocia</i> * (15)	

All of these 13 species are country endemics, and their EVS values range from 14 to 17.

The GCL houses 20 endemic species, including four anurans (all country endemics), one salamander (a country endemic), 13 squamates (11 country endemics and two state endemics), and one turtle (a state endemic). The GCL also is occupied by nine high vulnerability species, including the following three anurans, one salamander, four squamates, and one turtle:

<i>Craugastor berkenbuschii</i> * (14)	<i>Tantilla robusta</i> ** (16)
<i>Craugastor decoratus</i> * (15)	<i>Micrurus bernadi</i> * (15)
<i>Lithobates johni</i> * (14)	<i>Thamnophis sumichrasti</i> * (15)
<i>Bolitoglossa platydactyla</i> * (15)	<i>Kinosternon herrerae</i> * (14)
<i>Lepidophyma zongolica</i> ** (16)	

Of these nine species, seven are country endemics and two are state endemics, and their EVS values range from 14 to 16.

We noted that a large proportion of the herpetofaunal species in Puebla are country endemics limited in occurrence to a single physiographic region, so not surprisingly a sizable proportion also consist of high vulnerability species. These results on the Pueblan herpetofauna are important to consider in efforts to protect these organisms.

PROTECTED AREAS IN PUEBLA

Establishing protected areas generally is thought to be the best method for combating the principal causes of biodiversity decline, i.e., habitat degradation and destruction. In the best case scenario, this means setting aside large areas of the national patrimony for perpetuity, which would best protect significant elements of the biodiversity of a given region. Such efforts are based on incomplete databases, inasmuch as they only involve the available information at a given point in time. In the case of the Mexican herpetofauna, as with all other organismal groups in this country, the compendium of available information on which to base these actions increases with time. As a short-term example, Wilson and Johnson (2010) reported 373 amphibians and 830 crocodylians, squamates, and turtles for a total Mexican herpetofauna of 1,203 species. Three years later, Wilson et al. (2013a, b) indicated the comparable numbers as 378 and 849 (total of 1,227) and currently the numbers stand at 394 and 898 (total of 1,292; Johnson et al., 2017). Thus, over the last seven years, the number of amphibian species has increased by 21 (5.6%), those for the crocodylians, squamates, and turtles by 66 (8.9%), and the total by 68 (8.2%). On average, the total number of herpetofaunal species by year has increased by 12.7 (89/7).

Fourteen protected areas have been designated in the state of Puebla (Table 18). Of these, the Mexican federal government administers five, of which one is a biosphere reserve, three are national parks, and one is a protected area for natural resources. The remaining nine are administered at the state level, and are state reserves or state natural parks.

These 14 protected areas were established from 1935 to 2012, with seven inaugurated in 1994 (Table 18). They range in size from 22 to 183,500 ha (0.22 to 183.5 km²). Collectively, these 14 areas occupy 349,993 ha (= 3,500 km²), which amounts to 10.2% of the size of the state. Interestingly, the representation of these areas among the four physiographic regions of the state is skewed toward the TMV, where 12 of the 14 are located. Only a single area, the Cuenca Hidrográfica del Río Necaxa, is located in the SMO and another, the Reserva de la Biosfera Tehuacán-Cuicatlán, in the VOT. Interestingly, this skewed representation of the TMV is not reflective of the relative herpetofaunal importance of this region, as noted above. The most important herpetofaunal region in Puebla is the SMO (Tables 16, 17), in terms of both endemic species and high EVS species, followed by the TMV. Thus, it is extremely important for the priority terrestrial region 102 (PTR-102) “Cloudy forests of the SMO in Puebla,” which was established by CONABIO (Arriaga et al., 2000), to be decreed as a protected natural area based on the diversity of species it shelters. Ochoa-Ochoa et al. (2017) also emphasized the importance of the SMO, among other cloud forest areas in Mexico, for directing efforts to conserve the biota.




Crotalus ravus Cope, 1865. The Mexican Pygmy Rattlesnake is distributed in “temperate montane regions of south-central Mexico” (Heimes, 2016: 463). This individual was found at Zapotitlán Salinas, in the municipality of Zapotitlán Salinas, Puebla. Wilson et al. (2013b) calculated its EVS as 14, placing it at the lower limit of the high vulnerability category, the IUCN has evaluated it as Least Concern, and SEMARNAT lists this rattlesnake as threatened (A).  © Elí García-Padilla

Table 18. Characteristics of Natural Protected Areas in Puebla, Mexico. Abbreviations in Facilities available as follows: A = administrative services; R = park guards; S = systems of pathways; and V = facilities for visitors.

Name	Category	Date of Decree	Area (ha)	Municipalities	Jurisdiction	Physiographic Regions	Facilities Available	Occupied by Landowners	Management Plan Available	Herpetofaunal Survey Completed
Parque Nacional Iztaccihuatl-Popocatepetl	National Park	1935	11,121	San Salvador el Verde, Chiantzingo, Huejotzingo, San Nicolás de los Ranchos y Tochimilco	Mexican Federal Government	TMVB	ARSV	Yes	Yes	Yes
Parque Nacional Pico de Orizaba (Citlaltépetl)	National Park	1937	15,254	Tlachichuca, Chalchicomula de Sesma y Atzitzintla	Mexican Federal Government	TMVB	ARSV	Yes	Yes	Yes
Parque Nacional La Malinche (Matlalcuéyatl)	National Park	1938	14,479	Acajete, Santa María Xonacatepec	Mexican Federal Government	TMVB	ARSV	Yes	Yes	Yes
Cuenca Hidrográfica del Río Necaxa	Area of Protection for Natural Resources	1938	32,292	Ahuazotepec, Chiconcuautla, Huauchinango, Juan Galindo, Jopala, Naupan, Tlaola, Xicotepec, Zacatlán, Zihuateutla	Mexican Federal Government	SMO	ARSV	Yes	Yes	Yes
Reserva de la Biosfera Tehuacán-Cuicatlan	Biosphere Reserve	1998	183,500	Atexcal, Caltepec, Coxcatlán, Coyomeapan, San Gabriel Chilac, San José Miahuatlán, Tehuacán, Zapotitlán, Salinas Chapulco, Cañada Morelos, Santiago Miahuatlán, Palmar de Bravo, Tecamachalco, Tepanco de López, Tlacotepec de Benito Juárez y Yehualtepec.	Mexican Federal Government	SMS-VOT	ARSV	Yes	Yes	Yes
Reserva Estatal Sierra del Tentzo	State Reserve	2011	57,815	Atlixco, Atoyatempan, Huaquechula, Huatlatlauca, Huehuetlán El Grande, Molcaxac, Ocoyucan, Puebla, San Diego La Mesa Tochimiltzingo, San Juan Atzompa, Teopantlán, Tepeojuma, Tzicatlacoayan	State of Puebla	TMVB	ASV	Yes	No	Yes

Name	Category	Date of Decree	Area (ha)	Municipalities	Jurisdiction	Physiographic Regions	Facilities Available	Occupied by Landowners	Management Plan Available	Herpetofaunal Survey Completed
Parque Estatal Humedal de Valsequillo	State Reserve	2012	13,784	Puebla	State of Puebla	TMVB	ASV	Yes	No	Yes
Reserva Ecológica Cerro Totolqueme	State Natural Park	1994	760	San Martín Texmelucan	State of Puebla	TMVB	ASV	Yes	No	Yes
Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	State Natural Park	1994	664	Puebla	State of Puebla	TMVB	ASV	Yes	No	Yes
Reserva Ecológica Cerro Zapotecas	State Natural Park	1994	536	Cholula de Rivadabia	State of Puebla	TMVB	ASV	Yes	No	Yes
Reserva Ecológica Cerro Mendocinas	State Natural Park	1994	230	San Martín Texmelucan	State of Puebla	TMVB	ASV	Yes	No	Yes
Parque Nacional Hacienda de Zoquiapan	State Natural Park	1994	19,400	Río Frío	State of Puebla	TMVB	ASV	Yes	No	Yes
Reserva Ecológica Cerro Comalo	State Natural Park	1994	22	San Gregorio Atzompa	State of Puebla	TMVB	ASV	Yes	No	No
Reserva Ecológica Cerro de Amalucan	State Natural Park	1994	136	Puebla	State of Puebla	TMVB	ASV	Yes	No	No

Complete sets of facilities are available in the federally-administered protected areas, but park guards are not provided in the state-administered areas (Table 18), which is a critical matter to address in the future. Similarly, another matter that needs addressing, at both administrative levels, is that to some degree landowners occupy all 14 areas. Management plans, which are necessary to establish planning procedures for protected areas, are available for all federally-administrated areas but lacking for the state-level ones, an issue that should be addressed as soon as possible.

Importantly, herpetofaunal surveys are available for 12 of the 14 areas, and are lacking only for the Reserva Ecológica Cerro Comalo (a small 22 ha area) and the Reserva Ecológica Cerro de Amaluacan (another relatively small 136 ha area). This deficiency also needs to be addressed.

We catalogued the herpetofaunal content of the 14 protected areas in Puebla, and placed the results in Table 19 and summarize them in Table 20. Of the 267 species in the state, 207 (77.5%) are recorded in one or more of the 14 areas (Table 20). The number of species reported for these areas ranges from 20 in Parque Nacional La Malinche (Matlalcuéyatl) to 108 in the Cuenca Hidrográfica del Río Necaxa. Of the 207 species known from these areas 125 (60.4%) are endemic species, which represents 77.2% of the total number in Puebla (Table 8). The number of non-endemic and non-native species in the state is 82 (39.6% of 207), which represents 84.5% of the 97 species in these categories known from the state. Only a single state endemic (*Tantilla robusta*) is recorded from a protected area, which represents 25.0% of the four found in Puebla; this species, however, remains known only from the holotype (Wilson and Mata-Silva, 2014). Three of the four non-native species in Puebla are reported from one or more of the state's protected areas. Naturally, the presence of these species is not desirable within these areas (or anywhere else outside their natural range), but fortunately only one (*Lithobates catesbeianus*) is found in more than one area (five). Unfortunately, however, of the three exotic species this one is the most threatening to populations of the native herpetofauna, and efforts should be made to remove it from protected areas and to monitor other areas where it might have been introduced.



Crotalus scutulatus Kennicott, 1861. The Mohave Rattlesnake occurs “from the Mohave Desert to northern Sonora, and from extreme southern New Mexico and the Big Bend region of Texas southward across the Mexican Plateau to its southern edge” (Heimes, 2016: 467). This individual was found near Tehuacán, Puebla. Wilson et al. (2013b) calculated its EVS as 11, placing it in the lower portion of the medium vulnerability category, the IUCN assessed it as Least Concern, and SEMARNAT lists this rattlesnake under the category of special protection (Pr).

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Table 19. Distribution of herpetofaunal species in Natural Protected Areas of Puebla, Mexico, based on herpetofaunal surveys. Abbreviations are as follows: * = species endemic to Mexico; ** = species endemic to Puebla; and *** = non-native species.

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlatzucévatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolque	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
Anura (49 species)														
Bufonidae (5 species)														
<i>Incilius marmoratus</i> *				+										
<i>Incilius nebulifer</i>				+										
<i>Incilius occidentalis</i> *				+	+									
<i>Incilius perplexus</i> *					+									
<i>Rhinella horribilis</i>				+	+									
Craugastoridae (7 species)														
<i>Craugastor angusti</i>					+									
<i>Craugastor decoratus</i> *	+													
<i>Craugastor loki</i>	+													
<i>Craugastor mexicanus</i> *	+			+										
<i>Craugastor pygmaeus</i>	+			+										
<i>Craugastor rhodopsis</i> *	+			+										
<i>Craugastor rugulosus</i> *				+										
Eleutherodactylidae (3 species)														
<i>Eleutherodactylus leprus</i>		+		+										
<i>Eleutherodactylus nitidus</i> *	+	+		+	+	+	+	+	+	+	+	+	+	+

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlacuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Eleutherodactylus verruculatus</i> *				+										
Hylidae (20 species)														
<i>Charadrahyla taeniotus</i> *		+												
<i>Dendropsophus microcephalus</i>				+										
<i>Dryophytes arenicolor</i>		+		+	+	+	+	+	+	+	+	+	+	+
<i>Dryophytes euphorbiaceus</i> *		+												
<i>Dryophytes eximius</i> *	+	+	+	+										
<i>Dryophytes plicatus</i> *	+	+		+										
<i>Exerodonta smaragdina</i> *	+			+										
<i>Exerodonta xera</i> *					+									
<i>Ptychohyla zophodes</i> *				+										
<i>Rheohyla miotympanum</i> *	+			+	+									
<i>Sarcohyla arborescandens</i> *	+			+	+									
<i>Sarcohyla bisincta</i> *				+										
<i>Sarcohyla robertsonum</i> *	+					+								
<i>Scinax staufferi</i>	+			+	+	+								
<i>Smilisca baudinii</i>	+			+	+	+								
<i>Smilisca cyanosticta</i>					+									
<i>Tlalocohyla godmani</i> *					+									

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlacuáyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totoquieme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Tlalocohyla picta</i>					+									
<i>Tlalocohyla smithii</i> *					+									
<i>Trachycephalus vermiculatus</i>					+									
Leptodactylidae (2 species)														
<i>Leptodactylus fragilis</i>				+										
<i>Leptodactylus melanonotus</i>				+										
Microhylidae (2 species)														
<i>Hypopachus ustus</i>					+									
<i>Hypopachus variolosus</i>					+									
Phyllomedusidae (1 species)														
<i>Agalychnis dacnicolor</i> *					+									
Ranidae (8 species)														
<i>Lithobates berlandieri</i>				+	+	+	+	+	+					
<i>Lithobates catesbeianus</i> ***					+	+	+	+	+					
<i>Lithobates chicicuautla</i> *						+								
<i>Lithobates montezumae</i> *						+	+	+	+					
<i>Lithobates pueblae</i> *														
<i>Lithobates spectabilis</i> *					+	+	+	+	+	+	+	+	+	+

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional Malinche (Matlacuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totoqueime	Parque Ecológico Gral. Lázaro Cárdenas “Flor del Bosque”	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Lithobates vaillanti</i>				+										
<i>Lithobates zweifeli</i> *					+									
Scaphiropodidae (1 species)														
<i>Spea multiplicata</i>	+		+	+	+	+	+	+	+	+	+	+	+	+
Caudata (13 species)														
Ambystomatidae (1 species)														
<i>Ambystoma leorae</i> *	+		+											
Plethodontidae (11 species)														
<i>Aquiloerycea cephalica</i> *	+					+	+	+	+	+	+	+	+	+
<i>Bolitoglossa platydactyla</i> *				+		+	+	+	+	+	+	+	+	+
<i>Chiropterotriton oreutus</i> *	+					+	+	+	+	+	+	+	+	+
<i>Isthmura bellii</i> *	+													
<i>Isthmura gigantea</i> *				+		+	+	+	+	+	+	+	+	+
<i>Parvimolge townsendi</i> *						+	+	+	+	+	+	+	+	+
<i>Pseudoerycea gadovii</i> *		+												
<i>Pseudoerycea leprosa</i> *	+		+			+	+	+	+	+	+	+	+	+
<i>Pseudoerycea lineola</i> *		+												
<i>Pseudoerycea melanomolga</i> *		+												

Taxa	Natural Protected Areas														
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlacueyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan	
<i>Pseudoeurycea mixteca*</i>					+										
Salamandridae (1 species)															
<i>Notophthalmus meridionalis</i>					+										
Squamata (144 species)															
Anguidae (5 species)															
<i>Abronia graminea*</i>				+											
<i>Abronia taeniata*</i>				+											
<i>Barisia imbricata*</i>	+						+						+		+
<i>Gerrhonotus liocephalus</i>															
<i>Gerrhonotus ophiurus*</i>				+											
Corytophanidae (1 species)															
<i>Basiliscus vittatus</i>															
Dactyloidae (7 species)															
<i>Norops cymbops*</i>				+											
<i>Norops laevisventris</i>				+											
<i>Norops microlepidotus*</i>				+											
<i>Norops petersii</i>				+											
<i>Norops quercorum*</i>					+										
<i>Norops sericeus</i>				+											

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlacuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Norops tropidonotus</i>				+										
Eublepharidae (1 species)														
<i>Coleonyx elegans</i>				+										
Gekkonidae (1 species)														
<i>Hemidactylus frenatus</i> ***					+									
Helodermatidae (1 species)														
<i>Heloderma horridum</i> *														
Iguanidae (3 species)														
<i>Ctenosaura acanthura</i>				+										
<i>Ctenosaura pectinata</i> *				+	+									
<i>Iguana iguana</i>				+	+									
Mabuyidae (1 species)														
<i>Marisora brachypoda</i>					+									
Phrynosomatidae (19 species)														
<i>Phrynosoma asio</i>					+									
<i>Phrynosoma braconieri</i> *					+									
<i>Phrynosoma orbiculare</i> *						+								+

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlacuáyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas “Flor del Bosque”	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Phrynosoma taurus</i> *					+									
<i>Sceloporus aeneus</i> *	+		+									+		
<i>Sceloporus aureolus</i> *								+						
<i>Sceloporus bicanthalis</i> *	+		+			+								
<i>Sceloporus gadoviae</i> *					+									
<i>Sceloporus grammicus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Sceloporus horridus</i> *					+	+				+	+			+
<i>Sceloporus jalapae</i> *					+									
<i>Sceloporus megalapidurus</i> *					+	+		+	+	+	+		+	+
<i>Sceloporus micronotus</i> *	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Sceloporus ochoterenae</i> *					+									
<i>Sceloporus scalaris</i> *			+			+	+			+	+		+	+
<i>Sceloporus spinosus</i> *									+	+	+		+	+
<i>Sceloporus torquatus</i> *	+													
<i>Sceloporus variabilis</i>				+										
<i>Urosaurus bicarinatus</i> *					+									
Phyllodactylidae (1 species)														
<i>Phyllodactylus bordai</i> *					+									

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlacueyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
Scincidae (3 species)														
<i>Plestiodon brevirostris</i> *	+		+			+				+			+	
<i>Plestiodon copei</i> *	+													
<i>Plestiodon lynxe</i> *				+										
Sphenomorphidae (2 species)														
<i>Scincella cherriei</i>				+										
<i>Scincella silvicola</i> *				+										
Teiidae (5 species)														
<i>Aspidoscelis costata</i> *														
<i>Aspidoscelis deppii</i>														
<i>Aspidoscelis parvisocia</i> *														
<i>Aspidoscelis sackii</i> *														
<i>Holcosus amphigrammus</i> *														
Xantusiidae (1 species)														
<i>Lepidophyma sylvaticum</i> *														
Xenosauridae (1 species)														
<i>Xenosaurus rectocollaris</i> *														
Boidae (1 species)														
<i>Boa imperator</i>														

Taxa	Natural Protected Areas														
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional Malinche (Matlacuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan	
Colubridae (29 species)															
<i>Conopsis acuta</i> *	+	+		+	+	+									
<i>Conopsis biserialis</i> *				+											
<i>Conopsis lineata</i> *	+	+		+		+	+		+	+	+		+	+	
<i>Conopsis nasus</i> *				+											
<i>Drymarchon melamurus</i>	+	+		+											
<i>Drymobius margaritiferus</i>				+	+	+	+			+	+		+		
<i>Ficimia streckeri</i>				+	+										
<i>Lampropeltis polyzona</i> *	+	+	+	+	+	+	+		+	+	+	+	+	+	+
<i>Leptophis diplotropis</i> *					+										
<i>Leptophis mexicanus</i>															+
<i>Masticophis mentovarius</i>	+	+		+	+	+	+		+	+	+	+	+	+	+
<i>Mastigodryas melanolomus</i>	+	+		+	+	+	+		+	+	+	+	+	+	+
<i>Oxybelis aeneus</i>	+	+		+	+	+	+		+	+	+	+	+	+	+
<i>Pituophis deppei</i> *	+	+		+	+	+	+		+	+	+	+	+	+	+
<i>Pituophis lineaticollis</i>				+											
<i>Pseudelaphe flavirufa</i>				+											
<i>Pseudoficimia frontalis</i> *				+											
<i>Salvadora bairdi</i> *	+	+			+	+									

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlalcuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Salvadora intermedia</i> *					+									
<i>Salvadora mexicana</i> *					+									
<i>Senticolis triaspis</i>	+				+	+				+				
<i>Sonora michoacanensis</i> *					+									
<i>Spilotes pullatus</i>				+	+									
<i>Tantilla bocourti</i> *					+									
<i>Tantilla calamarina</i> *					+									
<i>Tantilla robusta</i> **				+										
<i>Tantilla rubra</i>				+										
<i>Trimorphodon biscutatus</i>					+									
<i>Trimorphodon tau</i> *	+				+	+							+	+
Dipsadidae (30 species)														
<i>Adelphicos quadrivirgatum</i>				+										
<i>Amastidium sapperi</i>				+										
<i>Chersodromus liebmanni</i> *				+										
<i>Contiophanes bipunctatus</i>				+										
<i>Contiophanes fissidens</i>				+		+	+	+	+	+	+	+	+	+

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional Malinche (Matlacuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Coniophanes imperialis</i>	+			+	+	+	+	+	+	+		+	+	+
<i>Coniophanes piceivittis</i>			+											
<i>Geophis dubiis</i> *				+										
<i>Geophis multitorques</i> *		+		+										
<i>Geophis semidoliatus</i> *				+										
<i>Geophis turbidus</i> *				+										
<i>Hypsigena torquata</i> *					+									
<i>Imantodes cenchoa</i>		+		+										
<i>Imantodes gemmistratus</i>					+									
<i>Leptodeira maculata</i>		+				+	+	+				+	+	
<i>Leptodeira septentrionalis</i>	+	+		+	+	+						+		
<i>Leptodeira splendida</i> *					+									
<i>Ninia diademata</i>		+		+		+								
<i>Ninia sebae</i>				+										
<i>Oxyrhopus petolaris</i>				+										
<i>Pliocercus elapoides</i>				+										

Natural Protected Areas														
Taxa	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlalcuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas “Flor del Bosque”	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Pseudoleptodeira latifasciata</i> *					+									
<i>Rhadinaea decorata</i>	+	+		+	+	+	+		+	+				+
<i>Rhadinaea fulvivittis</i> *					+									
<i>Rhadinaea hesperia</i> *					+									
<i>Rhadinaea marcellae</i> *				+										
<i>Rhadinaea quinque-lineata</i> *	+	+				+	+	+				+		
<i>Sibon dimidiatus</i>					+									
<i>Sibon nebulatus</i>	+	+				+	+	+	+			+		+
<i>Tropidodipsas sartorii</i>	+	+			+	+	+	+	+	+	+	+	+	+
Elapidae (7 species)														
<i>Micrurus bernadi</i> *		+												
<i>Micrurus diastema</i>				+										
<i>Micrurus elegans</i>				+										
<i>Micrurus laticollaris</i> *					+									
<i>Micrurus nebularis</i> *				+										
<i>Micrurus pachecogitii</i> *					+									

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlalcuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Micrurus tener</i>				+										
Leptotyphlopidae (2 species)														
<i>Rena maxima</i> *					+									
<i>Rena myopica</i> *		+												
Natricidae (10 species)														
<i>Storeria dekayi</i>														
<i>Storeria storerioides</i> *	+							+				+		
<i>Thamnophis chrysocephalus</i> *					+									
<i>Thamnophis conanti</i> *					+									
<i>Thamnophis cyrtopsis</i>					+									
<i>Thamnophis eques</i>	+				+							+		
<i>Thamnophis proximus</i>		+												
<i>Thamnophis scalaris</i> *	+	+				+			+			+	+	+
<i>Thamnophis scaliger</i> *	+	+				+			+			+	+	+
<i>Thamnophis sumichrasti</i> *		+												
Typhlopidae (2 species)														

Taxa	Natural Protected Areas													
	Parque Nacional Iztaccihuatl-Popocatepetl	Parque Nacional Pico de Orizaba (Citlaltépetl)	Parque Nacional La Malinche (Matlacuéyatl)	Cuenca Hidrográfica del Río Necaxa	Reserva de la Biosfera Tehuacán-Cuicatlán	Reserva Estatal Sierra del Tentzo	Parque Estatal Humedal de Valsequillo	Reserva Ecológica Cerro Totolqueme	Parque Ecológico Gral. Lázaro Cárdenas "Flor del Bosque"	Reserva Ecológica Cerro Zapotecas	Reserva Ecológica Cerro Mendocinas	Parque Nacional Hacienda de Zoquiapan	Reserva Ecológica Cerro Comalo	Reserva Ecológica Cerro de Amaluacan
<i>Amerityphlops tenuis</i>					+									
<i>Indotyphlops braminus</i> ***				+										
Viperidae (11 species)														
<i>Atropoides nummifer</i> *				+										
<i>Bothrops asper</i>				+										
<i>Crotalus culminatus</i> *				+										
<i>Crotalus intermedius</i> *	+	+	+			+	+	+	+	+	+	+		
<i>Crotalus molossus</i>	+	+		+	+	+	+	+	+	+	+	+		
<i>Crotalus polystictus</i> *	+		+			+	+	+				+		
<i>Crotalus ravus</i> *	+	+	+	+	+	+	+	+	+		+	+		
<i>Crotalus scutulatus</i>		+		+										
<i>Crotalus riseriatus</i> *	+	+	+			+						+		
<i>Mixcoatlus melanurus</i> *					+									
<i>Ophryacus undulatus</i> *		+												
Testudines (1 species)														
Kinosternidae (1 species)														
<i>Kinosternon integrum</i> *					+									



Mixocoatlus melanurus (Müller, 1923). The Black-tailed Horned Pitviper is distributed “from southern Puebla to central Oaxaca” (Campbell and Lamar, 2004: 452). This individual was found near Tehuacán, in the municipality of Tehuacán, Puebla. Wilson et al. (2013b) determined its EVS as 17, placing it in the middle portion of the high vulnerability category, the IUCN has assessed it as Endangered, and SEMARNAT lists this pitviper under the category of special protection (Pr). © Evan Arambul

Table 20. Summary of the distribution status of herpetofaunal species in protected areas in Puebla, Mexico. Totals = total number of species recorded in all of the listed protected areas.

Protected Areas	Number of Species	Distribution Status			
		Non-endemic (NE)	Country Endemic (CE)	State Endemic (SE)	Non-native (NN)
Parque Nacional Iztaccíhuatl-Popocatepetl	51	16	35	—	—
Parque Nacional Pico de Orizaba (Citlaltépetl)	52	24	28	—	—
Parque Nacional La Malinche (Matlalcuéyatl)	20	3	17	—	—
Cuenca Hidrográfica del Río Necaxa	108	57	49	1	1
Reserva de la Biosfera Tehuacán-Cuicatlán	93	39	52	—	2
Reserva Estatal Sierra del Tentzo	56	21	34	—	1
Parque Estatal Humedal de Valsequillo	37	15	21	—	1
Reserva Ecológica Cerro Totolqueme	35	12	22	—	1
Parque Ecológico Gral. Lázaro Cárdenas “Flor del Bosque”	32	12	19	—	1
Reserva Ecológica Cerro Zapotecas	33	12	21	—	—
Reserva Ecológica Cerro Mendocinas	31	10	21	—	—
Parque Nacional Hacienda de Zoquiapan	35	13	22	—	—
Reserva Ecológica Cerro Comalo	32	11	21	—	—
Reserva Ecológica Cerro de Amalucan	31	10	21	—	—
Totals	207	79	124	1	3

Of the 60 species not recorded in any of the 14 protected areas, 39 are country endemics, 17 are non-endemics, three are state endemics, and one is a non-native.

The 39 country endemics are as follows:

<i>Anaxyrus compactilis</i>	<i>Celestus enneagrammus</i>
<i>Incilius cristatus</i>	<i>Celestus legnotus</i>
<i>Craugastor berkenbuschii</i>	<i>Norops naufragus</i>
<i>Craugastor galacticorhinus</i>	<i>Sceloporus formosus</i>
<i>Eleutherodactylus verrucipes</i>	<i>Scincella gemmingeri</i>
<i>Bromeliohyala dendroscarta</i>	<i>Holcosus sinister</i>
<i>Megastomatohyala mixomaculata</i>	<i>Lepidophyma tuxtlae</i>
<i>Sarcohyala charadricola</i>	<i>Xenosaurus grandis</i>
<i>Lithobates johni</i>	<i>Xenosaurus tzacualtipantecus</i>
<i>Ambystoma subsalsum</i>	<i>Boa sigma</i>
<i>Aquiloerycea cafetalera</i>	<i>Ficimia olivacea</i>
<i>Chiropterotriton arboreus</i>	<i>Coniophanes melanocephalus</i>
<i>Pseudoeurycea firscheini</i>	<i>Geophis blanchardi</i>
<i>Pseudoeurycea lynchi</i>	<i>Geophis lorancai</i>
<i>Pseudoeurycea mixteca</i>	<i>Rhadinaea cuneata</i>
<i>Thorius dubitus</i>	<i>Tropidodipsas zweifeli</i>
<i>Thorius magnipes</i>	<i>Thamnophis pulchrilatus</i>
<i>Thorius maxillabrochus</i>	<i>Ophryacus smaragdinus</i>
<i>Thorius schmidti</i>	<i>Kinosternon herrerae</i>
<i>Thorius troglodytes</i>	

The 17 non-endemic species not represented in Puebla's protected areas are as follows:

<i>Incilius valliceps</i>	<i>Sphaerodactylus glaucus</i>
<i>Hyalinobatrachium fleischmanni</i>	<i>Ficimia publia</i>
<i>Craugastor alfredi</i>	<i>Conophis vittatus</i>
<i>Anotheca spinosa</i>	<i>Enulius flavitorques</i>
<i>Agalychnis callidryas</i>	<i>Nerodia rhombifer</i>
<i>Agalychnis moreletii</i>	<i>Scaphiodontophis annulatus</i>
<i>Corytophanes hernandesii</i>	<i>Agkistrodon bilineatus</i>
<i>Laemanctus serratus</i>	<i>Trachemys venusta</i>
<i>Sceloporus melanorhinus</i>	

The state endemics not represented are *Ambystoma taylori*, *Aquiloerycea quetzalanensis*, and *Lepidophyma zongolica*. The non-native is *Apalone spinifera*.

Thus, a major conservation goal for the state of Puebla would be to document the presence of these 60 species in one or more of the protected areas and/or to identify other areas where they occur and which of those could be set aside for protection.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- A. At the present time, the herpetofauna of Puebla is composed of 267 species, including 64 anurans, 25 salamanders, 174 squamates, and four turtles.
- B. The six physiographic regions we recognize contain from 41 species in the SMS to 185 in the SMO.
- C. The number of herpetofaunal species shared between physiographic regions ranges from five between the GCL and SMS to 98 between the SMO and TMV. The Coefficient of Biogeographic Resemblance values range from 0.09 between the GCL and SMS to 0.68 between the SMS and VOT. The UPGMA analysis demonstrates that in the state of Puebla, two distinct clusters of three regions each are associated with the Pacific versant (SMS, VOT, UBB) and the other with the Atlantic versant (Gulf of Mexico) of Mexico (TMV, SMO, GCL). In addition, the Pacific slope regions are found primarily in subhumid to semihumid environments, whereas the Atlantic slope regions primarily share humid environments. Apparently, the coefficient values among all the physiographic regions are relatively low, indicating that they include many species found only within single regions.
- D. A relatively high level of endemism characterizes the herpetofauna of Puebla. Of the 267 species comprising this herpetofauna, 166 (62.2%) are limited in geographic distribution to Mexico, with four of them restricted to the state of Puebla. The level of endemism for Puebla is almost the same as that for the entire country of Mexico (61.1%; 789/1,292).
- E. The distribution status of the Pueblan herpetofauna is as follows (in order of the size of the categories): country endemics (162; 60.7%); non-endemics (97; 36.3%); state endemics (4; 1.5%); and non-natives (4; 1.5%).
- F. The principal environmental threats in Puebla are deforestation, livestock ranching, infrastructure and extractive industry construction, desiccation and contamination of bodies of water, diseases, and global warming.
- G. We used the SEMARNAT, IUCN, and EVS systems to evaluate the herpetofauna of Puebla. As in previous MCS studies, we determined the SEMARNAT system to be of little value, given that to date only 43.3% of the native species have been assessed. Of these 114 species, three are allocated to the endangered category (P), 35 to the threatened category (A), and 76 the special protection category (Pr).



Kinosternon herrerae Stejneger, 1925. Herrera's Mud Turtle ranges from "southern Tamaulipas, eastern San Luis Potosí, northern Veracruz, Hidalgo, and Puebla" in east-central Mexico (Lemos-Espinal and Dixon, 2013: 84). This individual came from Ozelonacaxtla, 6.7 km southeast of Huehuetla, in the municipality of Huehuetla, Puebla. Wilson et al. (2013b) ascertained its EVS as 14, placing it at the lower limit of the high vulnerability category, the IUCN has assessed it as Near Threatened, and SEMARNAT lists this turtle under the category of special protection (Pr). © Guillermo Woolrich-Piña

- H. We applied the IUCN system of conservation status to evaluate the native Pueblan herpetofauna, and the results (by category and proportion) are as follows: CR (12 of 263 species; 4.6%); EN (17; 6.5%); VU (20; 7.6%); NT (8; 3.0%); LC (152; 57.8%); DD (12; 4.6%); and NE (42; 16.0%).
- I. We also applied the EVS system to the 263 species of the native herpetofauna of Puebla for which the EVS can be calculated, allocated the resulting EVS values to the low, medium, and high categories of vulnerability, and determined that the values increase, respectively, from 70 (26.6%) through 95 (36.1%) to 98 (37.3%).
- J. We compared the IUCN and EVS conservation status categories and determined that only 49.5% of the EVS high vulnerability species have been allocated to the three IUCN threat categories (CE, EN, or VU), and only 45.8% of the EVS low vulnerability species have been placed in the LC category. Therefore, the results of the application between these two systems do not complement one another.
- K. An evaluation of the conservation status of the IUCN species placed into the DD, NE, and LC categories indicates that many of these species have been assessed inadequately when compared to their respective EVS values. Thus, we highly recommend the reevaluation of these species to better specify their prospects for survival.
- L. We applied the Relative Herpetofaunal Priority (RHP) measure to determine the conservation significance of the six regional herpetofaunas in Puebla, which demonstrates that the most significant regional herpetofauna is that of the SMO, inasmuch as it harbors the greatest number of country endemics and high vulnerability species. The other five physiographic regions are arranged in decreasing order of significance on the basis of their number of endemic species, as follows: TMV; UBB; VOT; SMS; and GCL. On the basis of their number of high vulnerability species, the rankings are the same, except that those for the UBB and VOT are reversed.
- M. Fourteen protected areas are established in Puebla, five at the federal level and nine at the state level. The representation of these areas among the physiographic regions is heavily weighted in favor of the TMV, which of the six regions in Puebla ranked second in herpetofaunal importance. Unfortunately, all of the 14 areas are occupied to some degree by landowners, and established management plans are available only for the five federal areas. On the positive side, herpetofaunal surveys have been completed in 12 of the 14 areas.
- N. The information from these surveys indicates that 207 of 267 species (77.5%) have been reported from the state's protected areas. These species include 82 of 97 non-endemic species, 125 of 162 country endemics, one of four state endemics, and three of four non-native species. Of the 60 species not known to occur within the state's protected areas, 39 are country endemics, 17 are non-endemics, three are state endemics, and one is a non-native. The non-native species are not desirable for inclusion in the protected areas system.
- O. Future conservation efforts should be directed toward establishing the presence of these 59 native species within the system of protected areas. Beyond this concern, the health of the populations included within this system should be determined by the development of long-term monitoring programs.

Recommendations

- A. Our overriding interest in this paper has been to determine the conservation status of the 267 members of the herpetofauna of Puebla by employing the EVS methodology, as done in the previous eight entries in the MCS. We ascertained that the numbers of species placed in the low, medium, and high vulnerability categories increase from low (70) through medium (95) to the high category (98). In addition, our application of the Relative Herpetofaunal Priority methodology demonstrates that the herpetofauna of the SMO physiographic region is of greatest conservation significance, since it includes the highest numbers of both country and state endemics and of high EVS ranked species. Given the status of the SMO, it is of great significance that only one of the 14 currently recognized protected areas has been established in this region. Thus, the greatest conservation challenge in Puebla is to address the imbalance between the conservation status of the herpetofauna of the SMO and the representation of protected areas within this physiographic region.
- B. The second most important step needed to address the conservation challenges in Puebla is to identify protected areas in which the 59 native species not currently reported might be found. These 59 species include 39 country endemics, three state endemics, and 17 non-endemics.
- C. Establishing the presence of herpetofaunal species within a system of protected areas is only the first step for providing lasting protection to a given herpetofauna. Beyond this step, it is even more important to determine

the ecological health and sustainability of populations of these species. Such work would involve a long-term monitoring program, within the context of assessing the sustainability of the environments found within the established protected areas.

- D. Given the rate at which environmental degradation and destruction is occurring within the state such work should proceed as rapidly as possible, especially since the state of Puebla ranks 5th in population and 6th in density in the country.

“...Don't let anyone steal those assets [threatened species and the habitats they live in] from you, and don't be complicit in wasting them yourself, because if you do, you'll suddenly find that they are gone forever.”

—ANTHONY D. BARNOSKY (2014)

Acknowledgments.—Part of the fieldwork for this study was completed with funds from the Instituto Tecnológico Superior de Zacapoaxtla through projects P.I.LB-17-08; P.I.LB-17-09; P.I.LB-17-10; P.I.LB-17-19, as well as CONACyT 270547, all granted to GAWP. Ing. Amb. Mónica Flores kindly elaborated the map of physiographic provinces. Adán Alvarado-Hernández, Jonathan Olvera-Arrieta, Sonia Márquez-Guerra, Guadalupe Yazmín González-González, and Yenifer Arrellano-Carcamo strongly supported the fieldwork. Peter Heimes, Enrique Barquet, Brandon Thomas LaForest, Evan Arambul, Ricardo Ramírez-Chaparro, Fernando Martínez-Belmar, José Alfredo Hernández-Díaz, Guillermo Ortega-Vázquez, José Edgar Valera-Sánchez, César Barrio-Amorós, and Arnold Brandon Medina-Guzmán kindly provided us with photographic material. We also thank the ITSZ authorities M. A. Arminda Juárez-Arroyo, Biól. Juan Carlos García-Montiel, M. A. Sergio Cosme Jiménez-Rodríguez, M. A. Pablo Flores-Segura, and M. C. Rosario Haydeé García-Pérez for logistical support provided to GAWP. EGP is grateful to Haydeé Morales-Flores for her field support and companionship. Finally, we appreciate the thoughtful comments provided Fausto R. Méndez de la Cruz and those of an anonymous reviewer, which helped improve the quality of the manuscript.

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Elí García-Padilla is a herpetologist primarily focused on the study of the ecology and natural history of the Mexican herpetofauna. His research efforts have centered on the Mexican states of Baja California, Tamaulipas, Chiapas, and Oaxaca. His first experience in the field was researching the ecology of the insular endemic populations of the rattlesnakes *Crotalus catalinensis*, *C. muertensis* (*C. pyrrhus*) and *C. tortugensis* (*C. atrox*) in the Gulf of California. For his Bachelor's degree he presented a thesis on the ecology of *C. muertensis* (*C. pyrrhus*) on Isla El Muerto, Baja California, Mexico. To date, he has authored or co-authored over 75 peer-reviewed scientific publications. Currently, he is employed as a formal Curator of Amphibians and Reptiles from Mexico in the electronic platform “Naturalista” of the Comisión Nacional para el Uso y Conocimiento de la Biodiversidad (CONABIO; www.naturalista.mx). One of his main passions is environmental education, and for several years he has been working on a variety of projects that include the use of audiovisual media as a powerful tool to reach large audiences and to promote the importance of the knowledge, protection, and conservation of the Mexican biodiversity. Elí's interests include wildlife and conservation photography, and his art has been published in several recognized scientific, artistic, and educational books, magazines, and websites. Presently he is collaborating in a research project about an evaluation of the jaguar (*Panthera onca*) as an umbrella species for the conservation of the herpetofauna of Nuclear Central America.



Dominic L. DeSantis is a Ph.D. candidate and National Science Foundation-Graduate Research Fellow at the University of Texas at El Paso in the Ecology and Evolutionary Biology program. He received his Bachelor's degree at Texas State University, where he also completed multiple research projects on the anti-predator behavior of the critically endangered Barton Springs Salamander (*Eurycea sosorum*). His ongoing dissertation research integrates radio-telemetry with recent advances in animal biologging technologies to study movement and behavioral ecology in Western Diamond-backed Rattlesnakes (*Crotalus atrox*). Dominic accompanied Vicente Mata-Silva, Elí García-Padilla, and Larry David Wilson on survey and collecting trips to Oaxaca in 2015, 2016, and 2017 and is a co-author on numerous natural history publications that were produced from those visits. Overall, Dominic has co-authored 41 peer-reviewed natural history publications and 6 research papers, including an in-press book chapter entitled "Conservation of herpetofauna in disturbed habitats: Perspectives from short-term surveys in the Sierra Madre del Sur, Oaxaca, Mexico."



Jerry D. Johnson is Professor of Biological Sciences at The University of Texas at El Paso, and has extensive experience studying the herpetofauna of Mesoamerica, especially that of southern Mexico. Jerry is the Director of the 40,000-acre "Indio Mountains Research Station," was a co-editor on *Conservation of Mesoamerican Amphibians and Reptiles* and co-author of four of its chapters. He also is the senior author of the recent paper "A conservation reassessment of the Central American herpetofauna based on the EVS measure" and is the Mesoamerica/Caribbean editor for the Geographic Distribution section of *Herpetological Review*. Johnson has authored or co-authored over 120 peer-reviewed papers, including two 2010 articles, "Geographic distribution and conservation of the herpetofauna of southeastern Mexico" and "Distributional patterns of the herpetofauna of Mesoamerica, a Biodiversity Hotspot." One species, *Tantilla johnsoni*, has been named in his honor. Presently, he is an Associate Editor and Co-chair of the Taxonomic Board for the journal *Mesoamerican Herpetology*.



Vicente Mata-Silva is a herpetologist born in Río Grande, Oaxaca, Mexico. His interests include ecology, conservation, natural history, and geographic distribution of the herpetofaunas of Mexico (particularly Oaxaca) and the southwestern United States. His Bachelor's thesis at the Universidad Nacional Autónoma de México (UNAM) compared herpetofaunal richness in Puebla, Mexico, in habitats with different degrees of human-related disturbance. Vicente's Master's thesis at the University of Texas at El Paso (UTEP) focused primarily on the diet of two syntopic whiptail lizard species, one unisexual and the other bisexual, in the Trans-Pecos region of the Chihuahuan Desert. His dissertation, also at UTEP, was on the ecology of the Rock Rattlesnake, *Crotalus lepidus*, in the northern Chihuahuan Desert. To date, Vicente has authored or co-authored over 100 peer-reviewed scientific publications. Currently, he is a researcher and lecturer at the University of Texas at El Paso. He also is the Distribution Notes Section Editor for the journal *Mesoamerican Herpetology*.



Larry David Wilson is a herpetologist with lengthy experience in Mesoamerica. He has authored or co-authored over 390 peer-reviewed papers and books on herpetology, including two papers published in 2013 entitled “A conservation reassessment of the amphibians of Mexico based on the EVS measure” and “A conservation reassessment of the reptiles of Mexico based on the EVS measure,” one in 2014 entitled “Snakes of the genus *Tantilla* (Squamata: Colubridae) in Mexico: taxonomy, distribution, and conservation,” four in 2015 entitled “A conservation reassessment of the Central American herpetofauna based on the EVS measure,” “The herpetofauna of Oaxaca, Mexico: composition, physiographic distribution, and conservation status,” “The herpetofauna of Chiapas, Mexico: composition, distribution, and conservation,” and “A checklist and key to the snakes of the *Tantilla* clade (Squamata: Colubridae), with comments on taxonomy, distribution, and conservation,” and three in 2016 entitled “The herpetofauna of Tamaulipas: composition, distribution, and conservation,” “The herpetofauna of Nayarit: composition, distribution, and conservation status,” and “The herpetofauna of Nuevo León: composition, distribution, and conservation.” He also is a co-author of three 2017 papers entitled “The herpetofauna of Jalisco, Mexico: composition, distribution, and conservation status,” “The herpetofauna of the Mexican Yucatan Peninsula: composition, distribution, and conservation status,” and “The endemic herpetofauna of Mexico: organisms of global significance in severe peril.” Larry is the senior editor of *Conservation of Mesoamerican Amphibians and Reptiles* and the co-author of seven of its chapters. His other books include *The Snakes of Honduras*, *Middle American Herpetology*, *The Amphibians of Honduras*, *Amphibians & Reptiles of the Bay Islands and Cayos Cochinos, Honduras*, *The Amphibians and Reptiles of the Honduran Mosquitia*, and *Guide to the Amphibians & Reptiles of Cusuco National Park, Honduras*. To date, he has authored or co-authored the descriptions of 71 currently recognized herpetofaunal species, and seven species have been named in his honor, including the anuran *Craugastor lauraster*, the lizard *Norops wilsoni*, and the snakes *Oxybelis wilsoni*, *Myriopholis wilsoni*, and *Cerrophidion wilsoni*. Currently, Larry is an Associate Editor and Co-chair of the Taxonomic Board for the journal *Mesoamerican Herpetology*.