

# Herpetofauna Diversity of Famous Hiking and Trekking sites in Hermosillo, Sonora Mexico

**Jorge Jimenez-Canale**, University of Sonora, Ph.D. student in the Department of Research in Polymers and Materials, Blvd. Luis Encinas & Rosales w/o number, Hermosillo, Sonora, MX, 83000; [jorgejimzc@gmail.com](mailto:jorgejimzc@gmail.com)

## Introduction

Located in northern Mexico, bordering the US states of Arizona and New Mexico, Sonora is the second biggest state in the country of Mexico. With a total extension of 185,430 km<sup>2</sup>, it is geographically located in a transition zone between the Nearctic and Neotropical zone (Molina-Freaner and Van Devender 2010). Sonora is ecologically highly diverse, with an overall of 9 biotic communities that range from sea level up to 2600 m above sea level, owing this to its topography, climate and its biogeography associated with the islands in the Sea of Cortez. Precipitation in the state is bimodal, meaning that the rainy season starts from late June or early July, up to September, characterized by intense localized thunderstorms, whereas during the winter, more gentle, widespread and of longer duration rains are observed (Rorabaugh and Lemos-Espinal 2016). The city of Hermosillo is the capital of Sonora, with an elevation of 200 m above sea level and an extension of 168.2 km<sup>2</sup>, as of the year 2015, it had a population of 884,273 people living in it. It is mostly surrounded by Sonoran desertscrub and agricultural fields, a type of vegetation that is associated 25.6% of the Sonoran herpetofauna (Rorabaugh and Lemos-Espinal 2016). In the last few years outdoor activities such as hiking, trekking, mountain biking, and nocturnal exploration have gained a lot of popularity in the city of Hermosillo. Popularity has risen up to a point where people have formed groups specifically dedicated to these activities. The above has caused an increase in the flow of people going outdoors within the city, producing an increase in the sightings and direct or indirect contact with venomous and non-venomous fauna. Construction in said areas, as well as the constant increase of people outdoors, has led the local media and the Office of Health in Sonora to emit constant reminders of the dangers of having direct contact with noxious fauna (Televisa Sonora 2017). Although not many programs regarding environmental education and the importance of said fauna have been formally implemented in the educational system, experts in the fields of biology, ecology, and medicine are the ones who usually inform of the dangers this may pose. There are three main sites where outdoor activities have been especially popular in the city of Hermosillo, these being Cerro Bachoco, with a maximum height of 610 m above sea level, making it one of the tallest points of the city (INEGI 2015), the new baseball stadium, Estadio Sonora, right next to the construction site of the new Metropolitan Park, which will contain an artificial wetland

and Cerro Cementera, right next to the Abelardo L. Rodríguez Dam (INEGI 2015). Many of the species, whose distributions are found within the city limits Hermosillo, are under the special protection status granted in NOM-059-SEMARNAT-2010 (Rorabaugh and Lemos-Espinal 2016). Local, State, and Federal governments have to take this into consideration if construction projects are to be planned in these sites. In this study, with the help of Tucson Herpetological Society, through the Charles H. Lowe, Jr., Herpetological Research Fund, the herpetofauna biodiversity of these sites was determined during a 1-year period in order to establish preliminary information for future references and research projects.

## Methodology

The Simpson's Index of Diversity (D),

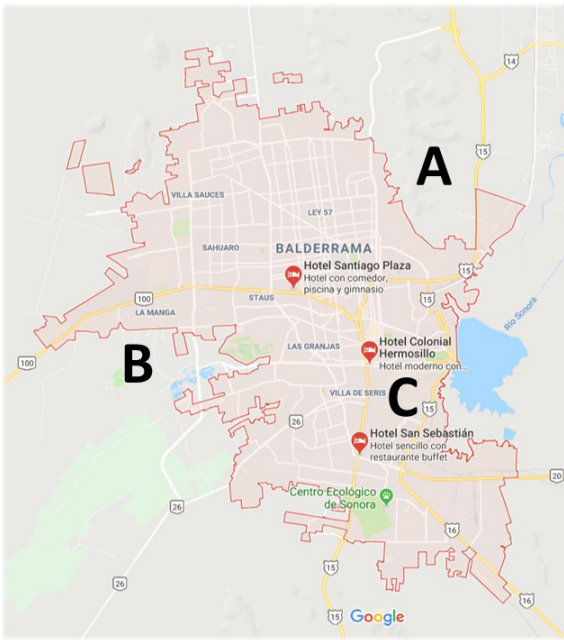
$$D = 1 - \left( \sum \frac{n(n-1)}{N(N-1)} \right),$$

was determined for the three most popular sites for outdoor activities in the city of Hermosillo, Sonora, Mexico, throughout a 1-year period, from February 2017- February 2018. The three selected sites were **A**) Cerro Bachoco located in the North at Lat.: 29.146221; Long.: -110.952966, **B**) the new baseball stadium Estadio Sonora located in the West at Lat.: 29.062997 Long.: -111.05092 and **C**) Cerro Cementera located in the Southeast at Lat: 067432; Long: -110.929779, the map of the city of Hermosillo and the three sites are shown in Figure 1. Each site was visited twice a month, for a total of six field trips per month. In order to analyze the data a worksheet was created using Microsoft Excel, where information regarding every amphibian and reptile seen was noted. Species observed were identified and the total sightings of each species identified were noted in order to determine the relative and total abundance over the analyzed period of time of each species. For security reasons, venomous reptiles were handled as little as possible with standard-length stainless-steel snake hooks and photographed with a telephoto lens in order to stay at a safe distance from them. All the pictures were taken *in situ* to provide evidence of the species observed.

## Results and Discussion

The Simpson's Index of Diversity (D) measures the probability that two individuals randomly chosen from a sample will belong to a different species or category, giving values that range from 0 to 1 where 0

Sonora is ecologically highly diverse, with an overall of 9 biotic communities that range from sea level up to 2600 m above sea level, owing this to its topography, climate and its biogeography associated with the islands in the Sea of Cortez.



**Figure 1.** Map of the city of Hermosillo. **A)** Cerro Bachoco, where the highest point of the city is located. **B)** Estadio Sonora, in what's called the West Gate of the city and **C)** Cerro Cementera, right next to the Abelardo L. Rodriguez dam.

represents no diversity and 1 infinite diversity. With this, we assumed that an area with a greater (D) value has a greater diversity of species. A comparative of the Simpson's Index of Diversity (D) of the three sites analyzed can be seen in Table 1, where the new baseball stadium, A) Estadio Sonora had the highest value with a (D) = 0.7262 where a total of 16 different species and 80 sightings were observed. Followed by B) Cerro Cementera with a (D) = 0.4308, with only 2 different species found and 42 sightings observed and lastly C) Cerro Bachoco with a (D) = 0.3359, with 10 different species found and a total of 139 sightings observed. The Simpson's Index of Diversity (D) gives more weight to the more abundant species in a sample, and the addition of rare or cryptic species with low values of abundance cause really small changes to the value of (D) (Simpson 1949). This explains why Cerro Cementera has a higher value of D than Cerro Bachoco, even if the latter had 8 more species observed and almost 100 more sightings. Estadio Sonora and Cerro Bachoco were the only sites with toads and/or frogs. Specifically, Estadio Sonora had 5 species of toads and 1 frog, including the renown species used by the Seri tribe for religious rituals, *Incillius alvarius*, whilst Cerro Bachoco had just one toad observation. This

**Table 1.** Herpetofauna biodiversity throughout February 2017- February 2018.

Herpetofauna biodiversity, Feb 2017-18			
Location	Total species	Total count	Simpson's Index of Diversity (D)
<b>A) Cerro Bachoco</b>	10	139	<b>0.3359</b>
<b>B) Estadio Sonora</b>	16	80	<b>0.7262</b>
<b>C) Cerro Cementera</b>	2	42	<b>0.4308</b>

A) Cerro Bachoco, had the lowest Simpson's Diversity Index (D) of 0.3359. B) Estadio Sonora had the highest (D) value with a 0.7262 while C) Cerro Cementera had the second highest (D) value with 0.4308.

could be due to the fact that Estadio Sonora had some construction activity in the nearby areas, where small bodies of water were formed and stayed for longer periods of time than those found in Cerro Bachoco, making it easier for them to reproduce and therefore to have seen them. It is important to note that in all the areas were species under the special protection tag (NOM-059-SEMARNAT-2010) observed throughout the time the study was realized, as it can be seen in Table 2. There were no species of toads, frogs, or snakes observed in Cerro Cementera during the study time period. This area specifically is surrounded by residential areas and near what's most likely the largest body of water in the city of Hermosillo, the Abelardo L. Rodriguez Dam, although it hasn't reached its full capacity since it reached a dangerous 99% max level in the 90's. The fact that no species of herpetofauna besides lizards were observed throughout the period of time of this study in the aforementioned site raises questions regarding whether nearby activity of the residential areas or the lack of constant bodies of water made a significant difference in comparison with the other two sites.

This fortifies the idea of having the Local, State, and Federal governments paying more attention to what public workers, first responders such as policemen and firefighters, are trained to do in case they have to attend an emergency involving these animals. Some of the observed herpetofauna is considered of medical importance (rattlesnakes and Gila Monsters) (Castro et al. 2013, Tasoulis and Isbister 2017, Borja et al. 2018) and, the venom composition may change, leading to different clinical symptoms presented by envenomation. This reinforces the idea of federal, state, and local governments paying attention and giving more importance to the biodiversity held in these sites.

Zebra-tailed Lizards (*Callisaurus draconoides*) were the most observed herpetofauna in Cerro Bachoco, alongside Western Whiptail Lizards (*Aspidoscelis tigris*) and Tiger Rattlesnakes (*Crotalus tigris*), Picture 1. Couch's Spadefoot Toads (*Scaphiopus couchii*) were the most observed herpetofauna in the new baseball stadium, Estadio Sonora (B), alongside Western Diamondback Rattlesnakes (*Crotalus atrox*), Picture 2 and Sonoran Desert Toads (*Incillius alvarius*), Picture 3. We would like to emphasize that the only Gila Monster (*Heloderma suspectum*), Picture 4 observed throughout the 2017-2018 study was here. Zebra-tailed Lizards, Picture 5 and Western Whiptail Lizards on the other

Zebra-tailed Lizards (*Callisaurus draconoides*) were the most observed herpetofauna in Cerro Bachoco, alongside Western Whiptail Lizards (*Aspidoscelis tigris*) and Tiger Rattlesnakes (*Crotalus tigris*). Couch's Spadefoot Toads (*Scaphiopus couchii*) were the most observed herpetofauna in the new baseball stadium, Estadio Sonora (B), alongside Western Diamondback Rattlesnakes (*Crotalus atrox*), and Sonoran Desert Toads (*Incillius alvarius*).



**Picture 1.** Juvenile Tiger Rattlesnake (*Crotalus tigris*). This species is considered, as all pit-vipers, of medical importance, and is under special protection under the NOM-059-SEMARNAT-2010 by Mexican federal law.



**Picture 2.** Western Diamondback Rattlesnake (*Crotalus atrox*). This species is considered, as all pit-vipers, of medical importance, and is under special protection under the NOM-059-SEMARNAT-2010 by Mexican federal law. The usual white and black bands of the tail can be observed.



**Picture 3.** Sonoran Desert Toad (*Incilius alvarius*). This species is under special protection under the NOM-059-SEMARNAT-2010 by Mexican federal law.



**Picture 4.** Gila Monster (*Heloderma suspectum*). This species is under special protection under the NOM-059-SEMARNAT-2010 by Mexican federal law. As one of the most representative species of the Sonoran Desert, we were specially thrilled to find this critter. Background lights belong to the baseball stadium.



**Picture 5.** Zebra-tailed lizard (*Callisaurus draconoides*). This species is under special protection under the NOM-059-SEMARNAT-2010 by Mexican federal law.

hand, were the only herpetofauna observed in Cerro Cementera (C).

With the formation of the Gila Hikers group we were able to show and teach the community of the city of Hermosillo about the importance of the local herpetofauna. Although it was not among the objectives of this study, we were able, and continue to, use social media to keep informing the communities. This has proven to be a very effective way to reach out to non-scientific people and inform them, in a more attractive way, of the biology and ecology of said critters.

## Conclusion

The new baseball stadium, Estadio Sonora, had the most biodiverse herpetofauna observed through February 2017- February 2018 in comparison with

Cerro Bachoco and Cerro Cementera. The Simpson's Index of Diversity (D) equation gives more value to abundant species, giving rare species a minimum, if none, changes to the value of D; which is most likely why Cerro Cementera obtained a higher value of D than Cerro Bachoco, since in the latter, even when more species were observed, some of them were only seen once.

Although no analysis to confirm this was performed, we assume that constant construction, which includes earth removal and having constant bodies of water, have an influence in the presence or absence of herpetofauna. This, by removing the possible hiding places and burrows of many of these specimens and forcing them to go out, which was most likely the case for Estadio Sonora. Having construction activities all year long, the presence of constant bodies of water favoring the amphibians and the low human activity during the night as the cause of the observation of more different species than the other two sites.

More studies are required in order to establish solid information for future conservation programs or as a reference for future research. This study confirms that all of the areas had species under the Threatened or Special Protection tag under Mexican Federal Law. This denotes the importance for the development of environmental education programs, as well as for workshops aimed at police and firefighter departments,

The new baseball stadium, Estadio Sonora, had the most biodiverse herpetofauna observed through February 2017- February 2018 in comparison with Cerro Bachoco and Cerro Cementera.

Although no analysis to confirm this was performed, we assume that constant construction, which includes earth removal and having constant bodies of water, have an influence in the presence or absence of herpetofauna.

**Table 2.** Species under the Special Protection or Threatened tag under NOM-059-SEMARNAT-2010.

Species under Special Protection or Threatened tag in NOM-059-SEMARNAT-2010	
<b>Cerro Bachoco (Northern area)</b>	<i>Aspidoscelis tigris</i> (lizard) <i>Callisaurus draconoides</i> (lizard) <i>Coleonyx variegatus</i> (gecko) <i>Crotalus tigris*</i> (pit-viper) <i>Phyllodactylus homolepidurus</i> (gecko)
<b>Estadio Sonora (Western area)</b>	<i>Anaxyrus retiformis</i> (toad) <i>Callisaurus draconoides</i> (lizard) <i>Coleonyx variegatus</i> (gecko) <i>Crotalus atrox*</i> (pit-viper) <i>Heloderma suspectum*</i> (Gila Monster) <i>Masticophis flagellum</i> (colubrid)
<b>Cerro Cementera (Southeastern area)</b>	<i>Aspidoscelis tigris</i> (lizard) <i>Callisaurus draconoides</i> (lizard)

\*Herpetofauna who may pose a life-endangering situation to whomever goes into direct contact with them.

in case of having direct contact with noxious fauna who may pose a life-endangering situation.

With the formation of the Gila Hikers exploration group, we managed to reach the common citizenship, or non-biologist, non-ecologist, non-researcher community of the city of Hermosillo, which led to the conclusion that people who don't work on anything field-related have almost no knowledge of the presence of some animals within the city and how their biology works. This denotes the lack of environmental education, or rather, the great opportunities we have to educate and teach people about the importance of such misunderstood critters, specially the amphibians and snakes.

### Acknowledgements

To Dr. José Andre-i Sarabia-Sainz for taking the time to review this work and coaching. To all the people who made the field trips possible and had to withstand whenever things didn't go the way everything was planned. Also, the formation of the research and outdoor activity group, Gila Hikers, was all thanks to the participation of these people, Hector Rogel-Martinez, Angel Ortega-Borchardt, Erick Guzman-Becerra, Cristian Navarro-Corrales, Diego Felix-Sobarzo, Renee Mange-Villarreal, Jose Vazquez-Aguilar, Estephania Monteverde-Bernal, Israel Luna, Rodolfo Vega-Littlewood, and Ana Paula Peñuñuri-Gomez. Also, to Gerardo Lorenzo Acosta Campaña, general director of the MIVIA in Hermosillo, Sonora, MX. Especially thankful to everyone at the Tucson Herpetological Society and of course the committee of the Charles H. Lowe, Jr., Herpetological Research Fund for granting us the opportunity to do some much-needed research in the region. To the THS president, Robert A. Villa, for always checking on the project, answering questions, and giving advice. Thank you all.

### Literature Cited

- Borja, M., E. Neri-Castro, R. Pérez-Morales, J. Strickland, R. Ponce-López, C. Parkinson, G. Castañeda-Gaytán, et al. 2018. Ontogenetic change in the venom of Mexican Black-Tailed Rattlesnakes (*Crotalus molossus nigrescens*). *Toxins* 10:501 (27 pages).
- Castro, E.N., B. Lomonte, M. del Carmen Gutiérrez, A. Alagón, and J.M. Gutiérrez. 2013. Intraspecies variation in the venom of the rattlesnake *Crotalus simus* from Mexico: Different expression of crotoxin results in highly variable toxicity in the venoms of three subspecies. *Journal of Proteomics* 87:103-121.
- Inegi, X.I. 2015. XII Censo general de población y vivienda.
- Molina-Freaner, F.E., and T.R. van Devender. 2010. *Diversidad biológica de Sonora*. Universidad Nacional Autónoma de México. México, DF Mexico.
- Rorabaugh, J.C., and J.A. Lemos-Espinal. 2016. *A Field Guide to the Amphibians and Reptiles of Sonora, Mexico*. ECO Herpetological Publishing and Distribution.
- Simpson, E.H. 1949. Measurement of diversity. *Nature* 163:688.
- Tasoulis, T., and G.K. Isbister. 2017. A review and database of snake venom proteomes. *Toxins* 9:290 (23 pages).
- Televisa Sonora. 2017. Note from the official website: <http://televisasonora.tv/noticia/piden-extremar-precauciones-al-subir-el-cerro-del-bachoco>

With the formation of the Gila Hikers exploration group, we managed to reach the common citizenship, or non-biologist, non-ecologist, non-researcher community of the city of Hermosillo, which led to the conclusion that people who don't work on anything field-related have almost no knowledge of the presence of some animals within the city and how their biology works.

