HERPETOFAUNA OF THE "EL MINERAL DE NUESTRA SEÑORA DE LA CANDELARIA" RESERVE: A BIOLOGICAL TREASURE IN SINALOA, MEXICO

HERPETOFAUNA DE LA RESERVA "EL MINERAL DE NUESTRA SEÑORA DE LA CANDELARIA": UN TESORO BIOLÓGICO EN SINALOA, MÉXICO

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Received: 2023-09-09. **Accepted**: 2023-10-26. **Published**: 2023-11-28.
Editor: Irene Goyenechea Mayer-Goyenechea, México.

Abstract.— Mexico hosts an exceptional diversity of approximately 1 421 species of amphibians and reptiles, many of which are endemic to the country. However, the Sinaloa region has remained largely unexplored due to access challenges and social conflicts. This study focuses on analyzing the biodiversity of amphibians and reptiles in the "El Mineral de Nuestra Señora de la Candelaria" reserve in Sinaloa, Mexico. This reserve, located in the Sierra Madre Occidental, covers 1 256 hectares of diverse habitats, including tropical deciduous and sub-deciduous forests. Through fieldwork conducted between 2017 and 2020, 55 species of amphibians and reptiles were documented in the reserve, of which 34 are endemic to Mexico, highlighting its importance as a refuge for native biodiversity. Furthermore, 20 species are protected by Mexican regulations and are listed on the IUCN Red List, indicating their threatened status. This reserve significantly contributes to Sinaloa's herpetofaunal landscape, safeguarding approximately 32.4% of its diversity and over 53% of the genera present in the state. The presence of endemic and endangered species underscores the need for specific conservation measures. In conclusion, this listing provides a detailed insight into the biological richness of amphibians and reptiles in the "El Mineral de Nuestra Señora de la Candelaria" reserve, emphasizing its value as a refuge for unique and threatened species. The results urge the implementation of effective conservation strategies to protect these unique ecosystems in the context of global environmental changes.

Keywords.— Amphibians, tropical dry forest, diversity, reptiles, snakes, "Golden Triangle".

Resumen.— México alberga una diversidad excepcional de aproximadamente 1 421 especies de anfibios y reptiles, muchas de las cuales son endémicas del país. Sin embargo, la región de Sinaloa ha permanecido en gran medida inexplorada debido a desafíos de acceso y conflictos sociales. Este estudio se enfoca en analizar la biodiversidad de anfibios y reptiles en la reserva "El Mineral de Nuestra Señora de la Candelaria" en Sinaloa, México. Esta reserva ubicada en la Sierra Madre Occidental, abarca 1 256 hectáreas de hábitats variados, que incluyen bosques tropicales caducifolios y subcaducifolios. A través del trabajo de campo realizado entre 2017

y 2020, se documentaron 55 especies de anfibios y reptiles en la reserva, de las cuales 34 son endémicas de México, subrayando su importancia como un refugio para la biodiversidad autóctona. Además, 20 especies están protegidas por regulaciones mexicanas y figuran en la Lista Roja de la UICN, indicando su estado de amenaza. Esta reserva contribuye significativamente al panorama herpetofaunístico de Sinaloa, resguardando alrededor de 32.4% de su diversidad y más del 53% de los géneros presentes en el estado. La presencia de especies endémicas y en peligro resalta la necesidad de aplicar medidas de conservación específicas. En conclusión, este listado brinda una visión detallada a la riqueza biológica de anfibios y reptiles en la reserva "El Mineral de Nuestra Señora de la Candelaria", resaltando su valor como refugio para especies únicas y amenazadas. Los resultados instan a implementar estrategias de conservación efectivas para proteger estos ecosistemas únicos en el contexto de cambios ambientales globales.

Palabras clave.— Anfibios, bosque tropical caducifolio, diversidad, reptiles, serpientes, "Triángulo dorado".

INTRODUCTION

Currently, amphibians and reptiles are experiencing significant population declines and extinctions globally (Lertzman-Lepofsky, 2020; Sinervo et al., 2010; Winter, 2016). This trend underscores the importance of describing and documenting the distribution and biological diversity in megadiverse regions. The herpetofaunal diversity in Mexico is considerably high due to its geographical location and complex topography, which create a wide variety of environments with unique climatic conditions for amphibians and reptiles (Flores-Villela, 1993; Flores-Villela & García-Vazquez, 2014). These characteristics hold profound significance for Mexico and its fauna in terms of biodiversity, endemism, and conservation (Wilson et al., 2010). In this regard, Mexico ranks as one of the top countries worldwide, with approximately 1 421 species recorded in total (Flores-Villela & García-Vázquez, 2014; Parra-Olea et al., 2014; Ramírez-Bautista et al., 2023). This number has steadly increased due to new descriptions in both groups (e.g., López-Luna et al., 2018; Jiménez-Arcos et al., 2019; Arenas-Moreno et al., 2021; Ramirez-Bautista et al., 2023). Additionally, there is a significant percentage of species that are distributed exclusively within the country's borders (Flores-Villela & García-Vázquez, 2014; Ochoa-Ochoa & Villela-Flores, 2006).

It is important to note that various studies on the herpetofauna of the state of Sinaloa have been conducted, some of which were pioneering in the 1950s and 1960s (Smith & Van Gelder, 1955; Lewis & Johnson, 1956; Duellman, 1957; Fugler & Dixon, 1961), followed by more comprehensive species lists (Hardy & McDiarmid, 1969; McDiarmid et al., 1976) and more recent studies (Lavín et al., 2004; Serrano et al., 2014; Lemos-Espinal & Smith, 2020; Castro-Bastidas & Serrano-Serrano, 2022; Aguirre-Zazueta et al., 2023a). However, it's important to mention that Sinaloa is one of the least explored states due to a long period without field studies, caused by difficulties in accessing the higher regions of the Sierra and social conflicts in the region (Hardy & McDiarmid, 1969; Sarukhán & García-Méndez, 2003; Carpio-Domínguez, 2021).

The state of Sinaloa covers an area of 58 200 km^2, which represents approximately 2.9% of Mexican territory, ranking seventeenth among other states (INEGI, 2022). Herpetofaunal studies have identified Sinaloa as one of the ten most species-diverse states, with a total of 170 species, including 44 amphibians and 126 reptiles (Lemos-Espinal & Smith, 2020; Loc-Barragán et al., 2020; Castro-Bastidas & Serrano-Serrano, 2022; Lara-Resendiz & Jacobo-González, 2022; Aguirre-Zazueta et al., 2023b; Devitt et al., 2023; Gamez-Duarte et al., 2023; Grünwald et al., 2023; Payan-Cazares et al., 2023). These numbers represent approximately 12% of Mexico's herpetofauna, with 10.2% being amphibians and 12.9% reptiles according to Ramírez-Bautista et al. (2023).

Despite its biodiversity, the state of Sinaloa has a limited number of 22 protected natural areas, covering a total of 580 912.47 hectares (CONANP, 2023). These natural protected areas are divided into four categories, including five at the federal level, nine municipal, four state, and three voluntarily designated conservation areas (ADVC, an acronym in Spanish). In state-level natural protected areas, specifically within the Ecological Conservation Zone category, there exists the Mineral de Nuestra Señora de la Candelaria Ecological Reserve (REMNSC, an acronym in Spanish), established in 2002 and located in the municipality of Cosalá in the central region of Sinaloa. This reserve is situated at the base of the Sierra Madre Occidental and houses a diverse range of plant and animal species native to the country (CONANP, 2023).

It is relevant to note that, up to now, none of the previous studies have conducted comprehensive research within the REMNSC polygon, and currently, there is no complete record

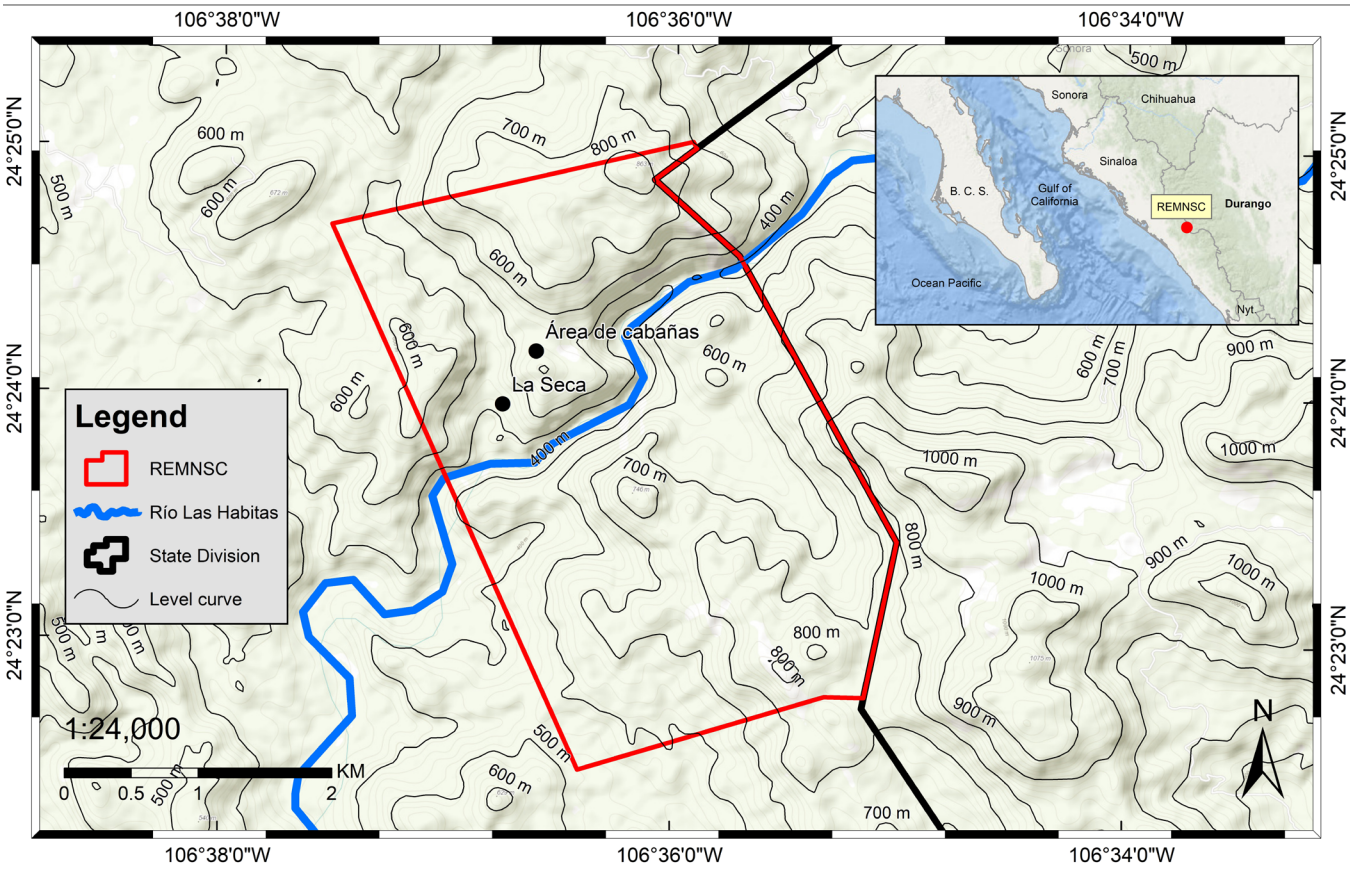

Figura 1. Ubicación de los sitios de muestreo en la reserva "El Mineral de Nuestra Señora de la Candelaria" en Sinaloa, México.

Figure 1. Sampling site locations in the "El Mineral de Nuestra Señora de la Candelaria" reserve in Sinaloa, Mexico.

of the amphibian and reptile species inhabiting this reserve (Romero-García 2018). Therefore, in this study, we provide an updated list of amphibians and reptiles, summarizing all previous herpetofaunistic knowledge of the REMNSC and surroundings and report the records collected between 2017 and 2023. This comprehensive inventory of the REMNSC is crucial for conserving its unique and under-documented biodiversity in the tropical dry forest of Sinaloa. Furthermore, this list represents the first step in future ecology and conservation work amid the enormous loss of biodiversity worldwide (Sinervo et al., 2010; Ceballos et al., 2015).

MATERIALS AND METHODS

Study area

The REMNSC is located in the Sierra Madre Occidental within the municipality of Cosalá, in the state of Sinaloa, bordering the eastern edge of the state of Durango and situated approximately 15 kilometers southeast of the municipal seat (Fig. 1). Its geographical coordinates range from 24°21' to 24°25' north latitude and 106°34' to 106°39' west longitude (Rubio et al., 2010). This reserve is managed by the Universidad Autónoma de Sinaloa and covers an area of 1 256 hectares (Secretaría General de Gobierno, 2002). It lies within the physiographic province of the Sierra Madre Occidental, specifically in the subprovince known as the Gran Meseta and Cañones Duranguenses, resulting in elevations ranging from 400 to 830 meters above sea level.

Furthermore, there is the possibility of expanding the surface area by 1,500 adjacent hectares that currently lack official designation. Within this area, several seasonal watercourses, such as the Santiaguillo and Candelaria streams, as well as the Habitas River (a tributary of the Elota river). The dominant vegetation consists of tropical deciduous forest, with fragments of subdeciduous forest and oak forests in small remnants at higher elevations (BirdLife International, 2022) (Fig. 2). Additionally, secondary forests exist due to mining

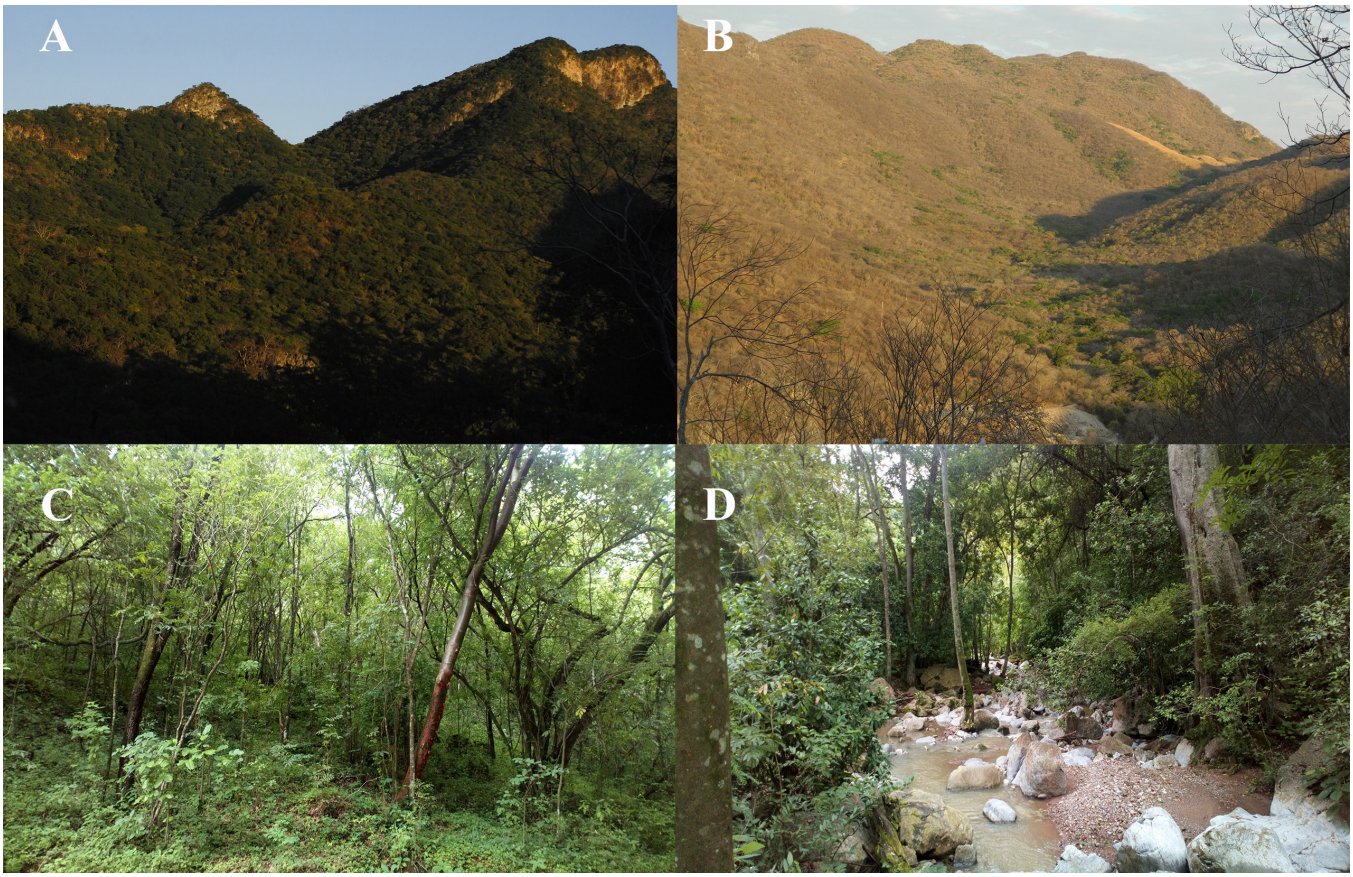

Figura 2. Ejemplos de algunos tipos de vegetación presentes en la reserva "El Mineral de Nuestra Señora de la Candelaria" en Sinaloa, México. A) Panorámica del bosque tropical caducifolio durante la temporada de lluvias y B) en temporada seca. C) Microhábitats dentro del bosque tropical caducifolio durante la temporada de lluvias. D) Microhábitats dentro del bosque subcaducifolio y quebrada de Santiaguillo durante la temporada de lluvias. Fotos: JDJG.

Figure 2. Examples of some vegetation types found in the "El Mineral de Nuestra Señora de la Candelaria" reserve in Sinaloa, Mexico. A) Panoramic view of the deciduous tropical forest during the rainy season, and B) during the dry season. C) Microhabitats within the tropical dry forest during the rainy season. D) Microhabitats within the subdeciduous forest and Santiaguillo creek during the rainy season. Photos: JDJG.

activities carried out at various times and rainfed agriculture (Guevara, 2013). The climate is classified as warm subhumid with summer rainfall, AW(e) according to Köppen classification, characterized by extreme oscillations and thermal variations ranging from minimum values of 10°C to maximums of 38.7°C. The study region experiences an average annual temperature of 23.7°C. The average annual precipitation reaches 923.5 mm, with the rainiest months spanning from June to October, and some rainfall in winter significantly contributing to the area's climate patterns (CONAGUA, 2023).

The typical characteristic habitat is identified as a tropical deciduous forest, distinguished by a rich variety of perennial plant species. Among woody plants, notable examples include *Bursera* spp., *Ficus* sp., *Acacia* sp., *Ceiba* sp., *Heamatoxylum brasiletto*, *Lysiloma divaricatum*, *Cedrela odorata*, and *Gyrocarpus americanus*, among other significant tree species. The presence of relevant cacti, such as *Pachycereus pecten-aboriginum*, *Pilosocereus purpusii*, and *Opuntia karwinskiana*, adds a distinctive component to this habitat. The sub-shrub layer is dominated by species such as *Ambrosia* sp., *Senna* sp., *Ipomoea* spp., and *Pluchea salicifolia* (Álvarez-Yépiz, et al., 2008; Lara-Resendiz & Jacobo González, 2022).

Fieldwork

Non-systematic samplings were conducted every month from April 2017 to December 2020 to actively search for amphibian and reptile species within the REMNSC. These samplings were carried out with surveys during the early hours of the day (7:00-11:00 am) and around sunset (5:00-9:00 pm). In addition, records

Tabla 1. Listado herpetofaunístico en la Reserva Ecológica del Mineral de Nuestra Señora de la Candelaria: Mundo natural, Cosalá, Sinaloa, México. *= Endémico de México y += exótico. Estado de conservación según la NOM-059-ECOL-2010-SEMARNAT 2010: A= Amenazado, PR= Protección Especial, NL= No Listado, NA= No Aplica; y Lista Roja de la Unión Internacional para la Conservación de la Naturaleza (UICN): NA= No Aplica, DD= Datos Insuficientes NE= No Evaluado, LC=Preocupación Menor, NT= Casi Amenazado; CITES: NL= No Listado, II= Apéndice 2. Todas las especies listadas (55) fueron encontradas por los autores en este estudio y las fotografías obtenidas fueron depositadas como foto ejemplares en la Colección Nacional de Anfibios y Reptiles del Instituto de Biología, UNAM. La columna referencia se refiere a las publicaciones usadas para apoyar los datos en áreas limítrofes a la reserva en ambientes similares, así como si estos registros fueron registrados en Global Biodiversity Information Facility (GBIF) o en proyectos de ciencia ciudadana (*iNaturalist*).

Table 1. Herpetofauna list in the El Mineral de Nuestra Señora de la Candelaria reserve in Sinaloa, Mexico. *= Endemic to Mexico and += exotic. Conservation status according to NOM-059-ECOL-2010-SEMARNAT 2010: A= Threatened, PR= Special Protection, NL= Not Listed, NA= Not Applicable; and Red List of the International Union for Conservation of Nature (IUCN): NA= Not Applicable, DD= Data Deficient, NE= Not Evaluated, LC= Least Concern, NT= Near Threatened; CITES: NL= Not Listed, II= Appendix 2. All the listed species (55) were encountered by the authors in this study, and the obtained photographs were deposited as photo specimens in the Collección Nacional de Anfibios y Reptiles of the Instituto de Biología, UNAM. The reference column mentions the publications used to support the data in areas adjacent to the reserve or in similar habitats, as well as whether these records were also registered in the Global Biodiversity Information Facility (GBIF) or in citizen science projects (*iNaturalist*).

Taxa	SEMARNAT	IUCN	CITES	Reference
Class Amphibia (17 Species)				
Orden Anura (17 Species)				
Family Bufonidae				
*Incilius marmoreus**	NL	LC	NL	Mendelson et al., 2011; iNaturalist, 2023
*Incilius mazatlanensis**	NL	LC	NL	Mendelson et al., 2011; iNaturalist, 2023
Rhinella horribilis	NL	NE	NL	Acevedo-Rincón et al., 2016; iNaturalist, 2023
Family Craugastoridae				
*Craugastor occidentalis**	NL	DD	NL	Hedges et al., 2008; iNaturalist, 2023
Craugastor augusti	NL	LC	NL	Hedges et al., 2008
Family Eleutherodactylidae				
*Eleutherodactylus interorbitalis**	PR	DD	NL	Grünwald et al., 2018; iNaturalist, 2023
Family Hylidae				
*Agalychnis dacnicolor**	NL	LC	II	Duellman et al., 2016; iNaturalist, 2023
Dryophytes arenicolor	NL	LC	NL	Duellman et al., 2016
*Exerodonta smaragdina**	PR	LC	NL	Faivovich et al., 2005; iNaturalist, 2023
Smilisca baudinii	NL	LC	NL	Hardy & McDairmid 1969; iNaturalist, 2023
*Tlalocohyla smithii**	NL	LC	NL	Faivovich et al., 2005; iNaturalist, 2023
*Triprion spatulatus**	NL	LC	NL	Duellman, 1970
Family Leptodactylidae				
Leptodactylus melanonotus	NL	LC	NL	Frost, 2023; iNaturalist, 2023
Family Microhylidae				
Hypopachus variolosus	NL	LC	NL	Frost, 2023

Tabla 1 (Cont.). Listado herpetofaunístico en la Reserva Ecológica del Mineral de Nuestra Señora de la Candelaria: Mundo natural, Cosalá, Sinaloa, México. *= Endémico de México y += exótico. Estado de conservación según la NOM-059-ECOL-2010-SEMARNAT 2010: A= Amenazado, PR= Protección Especial, NL= No Listado, NA= No Aplica; y Lista Roja de la Unión Internacional para la Conservación de la Naturaleza (UICN): NA= No Aplica, DD= Datos Insuficientes NE= No Evaluado, LC=Preocupación Menor, NT= Casi Amenazado; CITES: NL= No Listado, II= Apéndice 2. Todas las especies listadas (55) fueron encontradas por los autores en este estudio y las fotografías obtenidas fueron depositadas como foto ejemplares en la Colección Nacional de Anfibios y Reptiles del Instituto de Biología, UNAM. La columna referencia se refiere a las publicaciones usadas para apoyar los datos en áreas limítrofes a la reserva en ambientes similares, así como si estos registros fueron registrados en Global Biodiversity Information Facility (GBIF) o en proyectos de ciencia ciudadana (*iNaturalist*).

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Taxa	SEMARNAT	IUCN	CITES	Reference
Family Ranidae				
Lithobates forreri	PR	LC	NL	Zaldívar-Riverón et al., 2004; iNaturalist, 2023
*Lithobates magnaocularis**	NL	LC	NL	Frost, 2023
*Lithobates pustulosus**	PR	LC	NL	Frost, 2023; iNaturalist, 2023
Class Reptilia (38 Species)				
Orden Squamata (36 species)				
Family Anolidae				
*Anolis nebulosus**	NL	LC	NL	Hardy & McDairmid 1969; iNaturalist, 2023
Family Gekkonidae				
Hemidactylus frenatus+	NA	LC	NL	Valdez-Villavicencio & Peralta-García, 2008
Family Helodermatidae				
*Heloderma horridum**	A	LC	II	Reiserer et al., 2013
Family Iguanidae				
*Ctenosaura pectinata**	A	NE	NL	Lara-Resendiz et al., 2017; iNaturalist, 2023
Family Phrynosamatidae				
Sceloporus clarkii	NL	LC	NL	Hardy & McDairmid 1969
*Sceloporus nelsoni**	NL	LC	NL	Hardy & McDairmid 1969; iNaturalist, 2023
*Urosaurus bicarinatus**	NL	LC	NL	Feldman et al., 2011; iNaturalist, 2023
Family Phyllodactylidae				
*Phyllodactylus homolepidurus**	PR	LC	NL	Dixon, 1964
Phyllodactylus tuberculosus	NL	LC	NL	Dixon, 1964

Tabla 1 (Cont.). Listado herpetofaunístico en la Reserva Ecológica del Mineral de Nuestra Señora de la Candelaria: Mundo natural, Cosalá, Sinaloa, México. *= Endémico de México y += exótico. Estado de conservación según la NOM-059-ECOL-2010-SEMARNAT 2010: A= Amenazado, PR= Protección Especial, NL= No Listado, NA= No Aplica; y Lista Roja de la Unión Internacional para la Conservación de la Naturaleza (UICN): NA= No Aplica, DD= Datos Insuficientes NE= No Evaluado, LC=Preocupación Menor, NT= Casi Amenazado; CITES: NL= No Listado, II= Apéndice 2. Todas las especies listadas (55) fueron encontradas por los autores en este estudio y las fotografías obtenidas fueron depositadas como foto ejemplares en la Colección Nacional de Anfibios y Reptiles del Instituto de Biología, UNAM. La columna referencia se refiere a las publicaciones usadas para apoyar los datos en áreas limítrofes a la reserva en ambientes similares, así como si estos registros fueron registrados en Global Biodiversity Information Facility (GBIF) o en proyectos de ciencia ciudadana (*iNaturalist*).

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Taxa	SEMARNAT	IUCN	CITES	Reference
Family Scincidae				
Plestiodon callicephalus	NL	LC	NL	Lieb, 1985; iNaturalist, 2023
Family Teiidae				
*Aspidoscelis costatus**	PR	LC	NL	Hardy & McDairmid 1969; iNaturalist, 2023
Family Boidae				
*Boa sigma**	NL	NE	II	Card et al., 2016; iNaturalist, 2023
Family Colubridae				
Drymarchon melanurus	NL	LC	NL	Uetz et al., 2023; iNaturalist, 2023
Drymobius margaritiferus	NL	LC	NL	Hardy & McDairmid 1969; iNaturalist, 2023
*Lampropeltis polyzona**	NL	LC	NL	Ruane et al., 2014; iNaturalist, 2023
*Leptophis diplotropis**	A	LC	NL	Peres-Higareda & Smith, 1989; iNaturalist, 2023
Masticophis bilineatus	NL	LC	NL	Myers et al., 2017
*Mastigodryas cliftoni**	NL	DD	NL	Aguirre-Zazueta et al., 2023a
Oxybelis microphthalmus	NL	NE	NL	Jardin et al., 2020; iNaturalist, 2023
Senticolis triaspis	NL	LC	NL	Keogh, 1996; GBIF, 2023; iNaturalist, 2023
*Sympholis lippiens**	NL	NE	NL	Humphrey & Shannon, 1958
Tantilla yaquia	NL	LC	NL	Aguirre-Zazueta et al., 2023a
*Trimorphodon paucimaculatus**	NL	NE	NL	Devitt et al., 2008
Family Colubridae (Dipsadinae)				
*Coniophanes lateritius**	NL	DD	NL	Aguirre-Zazueta et al., 2023a; iNaturalist, 2023
*Enulius oligostichus**	PR	DD	NL	Lara-Resendiz & Jacobo González, 2022

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Taxa	SEMARNAT	IUCN	CITES	Reference
*Hypsiglena torquata**	PR	LC	NL	Mulcahy 2008; Mulcahy et al., 2014
Imantodes gemmistratus	PR	LC	NL	Zweifel 1959
Leptodeira septentrionalis	NL	LC	NL	Aguirre-Zazueta et al., 2023b
*Leptodeira splendida**	NL	LC	NL	Hardy & McDairmid 1969; iNaturalist, 2023
*Geophis annuliferus**	PR	LC	NL	Grünwald et al., 2021
*Tropidodipsas philippi**	PR	LC	NL	Montaño-Ruvalcaba et al., 2021
Family Elapidae				
Micruroides euryxanthus	A	LC	NL	Uriarte-Garzon et al., 2020
*Micrurus distans**	PR	LC	NL	Aguirre-Zazueta et al., 2023b
Family Leptotyphlopidae				
*Rena dugesii**	NL	NE	NL	Lemos-Espinal et al., 2004
Family Viperidae				
Agkistrodon bilineatus	PR	NT	NL	Porras et al., 2013; iNaturalist, 2023
*Crotalus basiliscus**	PR	LC	NL	Lara-Resendiz et al., 2017; iNaturalist, 2023
Orden Testudines (2 Species)				
Family Geoemydidae				
*Rhinoclemmys pulcherrima rogerbarbouri**	A	NE	II	Lara-Resendiz et al., 2017
Family Kinosternidae				
*Kinosternon integrum**	PR	LC	II	Lara-Resendiz et al., 2017

obtained by reserve staff during their biological monitoring activities, mainly on roads and trails within the reserve, were included. In both cases, photographs of the organisms were taken, and dichotomous keys were used for identification (Flores-Villela et al., 1995; Lemos-Espinal et al., 2004; Lemos-Espinal & Smith, 2009a; Lemos-Espinal & Smith, 2009b; Rorabaugh & Lemos-Espinal, 2016; González-Hernández et al., 2021).

Furthermore, records from the Global Biodiversity Information Facility (GBIF, 2023) within the REMNSC were included and subjected to a thorough review and curation to validate the observations. The coordinates of the search box in GBIF were as follows: from 24.35 to 24.417 latitude and from -106.65 to -106.567 longitude. The search on GBIF included 202 records, with 199 records coming from citizen science (iNaturalist), and only two records deposited in the collection of the Museo de Zoología at the Facultad de Ciencias (MZFC) of UNAM (*Aspidoscelis costatus* and *Senticolis triaspis*). In Table 1, the records were labeled as either from GBIF or iNaturalist. It is worth noting that the iNaturalist records were exclusively categorized as "Research Grade", which are entries that include all the necesary metadata and have been identified down to the species level (Clare et al., 2019). Records with doubtful identification or location were excluded and subjected to verification or elimination, with the purpose of having in the database only those records that demonstrated higher certainty, plausibility, and accuracy in presence locations (Kittelberger et al., 2021; Castro-Bastidas & Serrano-Serrano 2022). To determine protection categories, we used the NOM-ECOL-059-SEMARNAT-2010 (SEMARNAT, 2023), the Red List published by the International Union for Conservation of Nature (IUCN, 2023), and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

During the fieldwork, auditory identification of amphibians was not conducted. However, we used vocalizations as a guide to locate some species. Furthermore, no specimens were collected in this study. Instead, individuals were temporarily contained for photography, identification, and subsequently released in the same location where they were found. It's worth noting that there are no local scientific collections or verified lists within the REMNSC.

RESULTS

A total of 55 amphibian and reptile species were observed, captured, and/or photographed within the REMNSC polygon, distributed among 22 families and 48 genera (Fig. 3; Table 1).

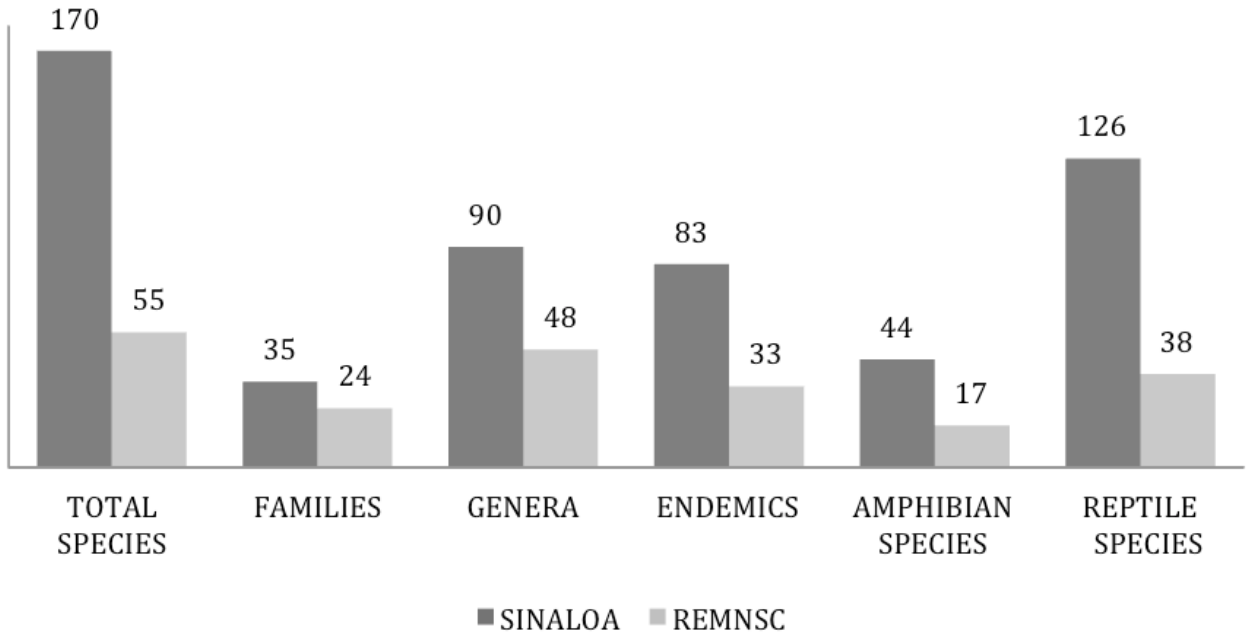

Figura 3. Comparación herpetofaunística entre el estado de Sinaloa y la reserva "El Mineral de Nuestra Señora de la Candelaria" en Sinaloa, México.

Figure 3. Herpetofaunal comparison between the state of Sinaloa and the "El Mineral de Nuestra Señora de la Candelaria" reserve in Sinaloa, Mexico.

Of these species, 34 are endemic to Mexico. In the case of amphibians, 17 species (30.9% of the total species) belonging to 7 families and 13 genera were recorded, with 10 species being endemic to Mexico. Regarding reptiles, 38 species (69.1% of the total species) from 15 families and 35 genera were documented, with 24 species being endemic to Mexico. Additionally, a single introduced species of gecko (*Hemidactylus frenatus*) was identified. Figures 4, 5, and 6 depict representative species of amphibians, snakes, and lizards and turtles, respectively, found in the REMNSC.

Among the 55 recorded species, 20 of them are included in some category of protection according to NOM-ECOL-059-SEMARNAT-2010, with 15 classified as "Special Protection" (Pr) and five as "Threatened" (A). According to the IUCN Red List, 45 species are categorized as "Least Concern" (LC), four as "Data Deficient" (DD), and only one as "Near Threatened" (NT) (IUCN, 2023). Additionally, five species are included in Appendix II of CITES (2023; Table 1).

Specifically for amphibians, four are categorized as Pr according to NOM-ECOL-059-SEMARNAT-2010. According to the IUCN, 16 amphibian species are classified as LC, and only one species is listed in Appendix II of CITES, as shown in Table 1. For reptiles, 16 species fall into some category of protection according to NOM-059-ECOL-059 (11 as Pr and five as A). Following the IUCN classification, 19 reptile species are considered LC, four as DD, and one as NT, in addition to 4 species in CITES Appendix II (Table 1).

Compared to previous records in Sinaloa, the REMNSC harbors approximately 32.4% of the state's herpetofauna species. Of the 35 families present in Sinaloa, only 11 do not have records within the study area of the reserve. Furthermore, nearly 39.7% of the species recorded in the REMNSC are endemic to Mexico. Surprisingly, over half of the genera recorded in the state of Sinaloa are also present in the REMNSC, reaching 53%. Concerning amphibians, this reserve protects a significant 38.6% of the species present in the state, while for reptiles, this value is 30.2% (Fig. 3).

DISCUSSION

Despite not being executed with systematic sampling, the present study holds significant importance due to the extensive time that has passed since the last field exploration in the municipality of Cosalá, which took place in the late 1960s, during which an exhaustive inventory was not achieved, and the mountainous regions of the municipality were not thoroughly explored (Hardy & McDiarmid, 1969). This resulted in a lack of valuable information, which is underscored by the recent confirmation of the presence of the Mexican long-tailed snake (*Enulius oligostichus*; Lara-Resendiz & Jacobo González, 2022), the mountain horned lizard (*Phrynosoma orbiculare*; Payan Cazares et al., 2023), the twin-spotted rattlesnake (*Crotalus pricei*; Gamez-Duarte et al., 2023), and the ridge-nosed rattlesnake (*Crotalus willardi*; Grünwald et al., 2023) in the state of Sinaloa.

Additionally, this study has contributed to expanding the distribution range of several reptile species, which have been formally recorded for the first time within the municipality thanks to this research (*Hypopachus variolosus* [Fig. 4G], *Enulius oligostichus* [Fig. 5F], *Leptodeira septentrionalis* [Fig. 5G], *L. splendida*, *Phyllodactylus homolepidurus* [Fig. 6B], *Sympholis lippiens*, *Tantilla yaquia*, *Tripion spatulatus*, and *Tropidodipsas philippi*). Furthermore, this effort has allowed for the creation of a comprehensive list of the herpetofauna in this area of the Cosalá municipality, including two snake species that had gone unnoticed in the last state inventory (*E. oligostichus* and *L. septentrionalis*; Lemos-Espinal & Smith, 2020) (Fig. 5F and G).

The results obtained reveal a remarkable diversity of amphibian and reptile species in the "El Mineral de Nuestra Señora de la Candelaria: Mundo Natural" reserve. The presence of 55 species, distributed across 22 families, underscores the importance of this ecosystem as a critical habitat for herpetofauna in the region. Particularly significant is the fact that 34 of these species are endemic to México (Table 1), highlighting the reserve's role as a key repository for the conservation of unique species adapted to local conditions. The high proportion of endemic species underscores the importance of directing conservation and management efforts towards the preservation of habitats within the reserve. This is particularly crucial given the existing challenges such as cattle grazing, wood extraction for construction and firewood, as well as the continuous rise in tourist numbers and the use of automotive vehicles.

The inclusion of 20 species in protection categories, both according to NOM-ECOL-059-SEMARNAT-2010 and the IUCN Red List, underscores the vulnerability of many of the species found in the reserve (Table 1). The classification of five species as "Threatened" and one as "Near Threatened" suggests the presence of risk factors that could impact their long-term survival. The inclusion of five species in CITES Appendix II also highlights the importance of addressing the illegal trade and trafficking of species in the region. These results provide a solid foundation for the implementation of effective conservation measures, such as the creation of special protection areas and the promotion of

Figura 4. Especies representativas de anfibios encontrados en la reserva "El Mineral de Nuestra Señora de la Candelaria" en Sinaloa, México. A) *Tlalocohyla smithii*, B) *Eleutherodactylus interorbitalis*, C) *Exerodonta smaragdina*, D) *Incilius mazatlanensis*, E) *Lithobates magnaocularis*, F) *Leptodactylus melanonotus*, G) *Hypopachus variolosus*, H) *Craugastor occidentalis*. (Fotografías de ECA).

Figure 4. Representative amphibian species found in the "El Mineral de Nuestra Señora de la Candelaria" reserve in Sinaloa, Mexico. A) *Tlalocohyla smithii*, B) *Eleutherodactylus interorbitalis*, C) *Exerodonta smaragdina*, D) *Incilius mazatlanensis*, E) *Lithobates magnaocularis*, F) *Leptodactylus melanonotus*, G) *Hypopachus variolosus*, H) *Craugastor occidentalis*. (Photographs by ECA).

Figura 5. Especies representativas de serpientes encontrados en la reserva "El Mineral de Nuestra Señora de la Candelaria" en Sinaloa, México. A) *Micrurus distans*, B) *Agkistrodon bilineatus*, C) *Oxybelis microphthalmus*, D) *Drymarchon melanurus* (neonato), E) *Leptophis diplotropis*, F) *Enulius oligostichus*, G) *Leptodeira septentrionalis*, H) *Drymobius margaritiferus*. Fotografías de ECA (A-E) and JDJG (F-H).

Figure 5. Representative snake species found in the "El Mineral de Nuestra Señora de la Candelaria" Reserve in Sinaloa, Mexico. A) *Micrurus distans*, B) *Agkistrodon bilineatus*, C) *Oxybelis microphthalmus*, D) *Drymarchon melanurus* (neonate), E) *Leptophis diplotropis*, F) *Enulius oligostichus*, G) *Leptodeira septentrionalis*, H) *Drymobius margaritiferus*. (Photographs by ECA (A-E) and JDJG (F-H).

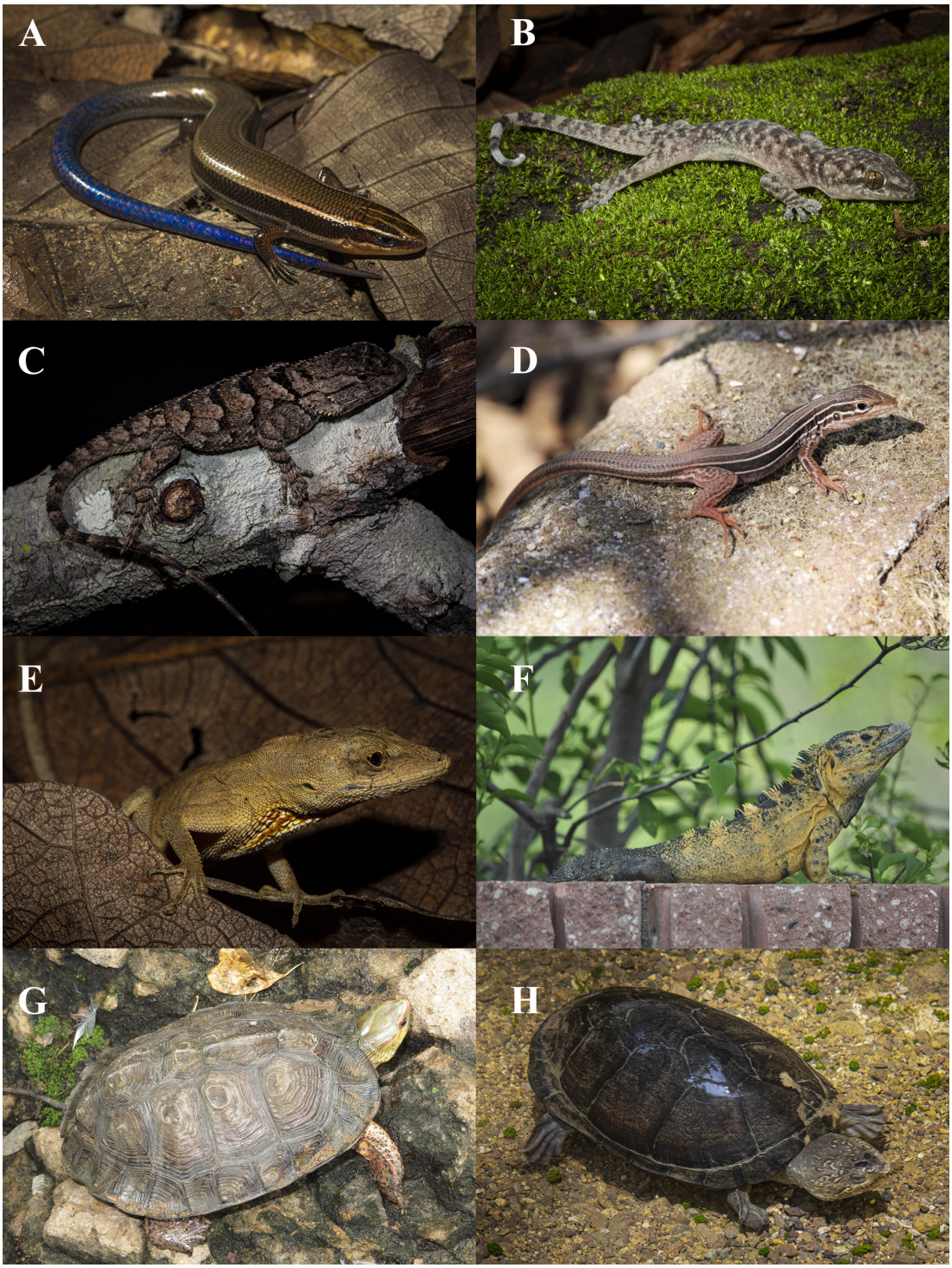

Figura 6. Especies representativas de lartijas y tortugas encontrados en la reserva "El Mineral de Nuestra Señora de la Candelaria" en Sinaloa, México. A) *Plestiodon callicephalus*, B) *Phyllodactylus homolepidurus*, C) *Sceloporus clarkii*, D) *Aspidoscelis costatus*, E) *Anolis nebulosus*, F) *Ctenosaura pectinata*, G) *Rhinoclemmys pulcherrima*, H) *Kinosternon integrum*. Fotografías de ECA (A-E, H) and RALR (F-G).

Figure 6. Representative species of lizards and turtles found in the "El Mineral de Nuestra Señora de la Candelaria" reserve in Sinaloa, Mexico. A) *Plestiodon callicephalus*, B) *Phyllodactylus homolepidurus*, C) *Sceloporus clarkii*, D) *Aspidoscelis costatus*, E) *Anolis nebulosus*, F) *Ctenosaura pectinata*, G) *Rhinoclemmys pulcherrima*, H) *Kinosternon integrum*. (Photographs by ECA (A-E, H) and RALR (F-G).

environmental education programs to raise awareness among local communities about the importance of conservation.

The comparison of herpetofauna records in the reserve with those existing in Sinaloa highlights the value of REMNSC as a significant biodiversity reservoir. With 32.4% of the state's species present in the reserve, it demonstrates its fundamental role in preserving regional biological diversity. The presence of over half of the genera recorded in the state within the reserve further reinforces its importance as a representative and essential habitat for herpetofauna. Of the families recorded in Sinaloa (35), 11 were not recorded in the REMNSC, suggesting the possibility that the reserve may host even more species, emphasizing the need for additional research and continued monitoring (Figure 3).

The results of this study substantially contribute to scientific knowledge of biodiversity and the ecology of herpetofauna in the region. In addition to enriching the taxonomic database, these findings provide vital information for the design of specific conservation strategies. The detection of an introduced species (*Hemidactylus frenatus*) in the reserve underscores the need to implement control measures to minimize possible negative effects on native species. The combination of data from NOM-ECOL-059-SEMARNAT-2010, the IUCN, and CITES allows for a comprehensive assessment of the conservation status of species, supporting informed decision-making in the planning of conservation and restoration activities in the reserve and its surroundings. We recommend a set of actions to manage non-native species in the REMNSC, which involve regular monitoring to detect and control their presence, establishing strict rules to limit their introduction, raising awareness about the associated risks. Additionally, we recommend improving the restoration of native habitats and working together with local communities, scientists, and authorities to develop effective management strategies for protected species.

Since the sampling conducted did not follow a systematic approach, it is plausible that the number of species recorded in the REMNSC will increase as systematic efforts are made, targeting both target species and more general sampling. Nonetheless, the non-systematic approach of our study and our inability to construct a species accumulation curve could be considered a potential limitation. However, there is currently significant participation in citizen science projects by herpetofauna enthusiasts and photographers in the region, as documented on platforms like iNaturalist (Castro-Bastidas & Serrano-Serrano 2022). These projects have recorded species in areas adjacent to the study area and represent potential additions to the REMNSC. Based on the records present in iNaturalist and observations made by the authors, among the species suggested as possible additions are: *Smilisca fodiens*, *Incilius punctatus*, *Sceloporus utiformis*, *Urusaurus ornatus*, *Heloderma exasperatum*, *Masticophis mentovarius*, *Pseudoficimia frontalis*, *Rhinocheilus antonii*, *Tantilla calamarina*, *Salvadora deserticola*, *Leptodeira punctata*, *Gyalopion quadrangulare*, *Crotalus stejnegeri*, *Terrapene nelsoni*, and *Trachemys ornata*. If these species were studied more comprehensively, they could further enrich the herpetofauna landscape in the reserve. Therefore, it is likely that the number of species is higher, further highlighting the continuously increasing ecological value of the area.

The rich diversity of amphibian and reptile species documented in REMNSC reveals its vital role as a crucial refuge for herpetofauna in the region known as the "Golden Triangle". This area has been relatively understudied and is indirectly conserved due to restricted access and social challenges. These findings not only enrich our understanding of local biodiversity but also provide essential information for conservation and ecosystem management decision-making. The presence of endemic and protected species within the reserve underscores the need to implement effective conservation strategies to safeguard these unique habitats and their inhabitants. Furthermore, the identification of an introduced species highlights the importance of ongoing monitoring and control measures to prevent potential negative impacts on native wildlife. These results further underpin the reserve's status as an area of high ecological value and emphasize the importance of its long-term preservation.

CONCLUSION

In summary, this study on the herpetofauna in the "El Mineral de Nuestra Señora de la Candelaria: Mundo Natural" reserve has revealed remarkable biological richness and uniqueness in the area. The notable diversity of amphibian and reptile species, along with the presence of endemics and species under protection categories, emphasizes the significance of this reserve as a crucial stronghold for their conservation.

The combination of taxonomic and conservation data provides a solid foundation for the formulation of ecological management strategies and long-term conservation plans. As the region faces increasing challenges in the context of environmental changes, these results offer a detailed overview of local diversity and underscore the pressing need to preserve and protect these unique ecosystems to maintain ecological balance and conserve herpetofauna in the region.

Acknowledgments.– We want to express our gratitude to the staff of the "El Mineral de Nuestra Señora de la Candelaria" Reserve (REMNSC) for their collaboration and support. We extend our recognition to Dr. Jesús Madueña Molina, the Rector of the Universidad Autónoma de Sinaloa, and Mrs. Rafaela Corrales Salcido, Coordinator of REMNSC, for her constant support and dedication. Special thanks to Dr. Alfredo Leal Sandoval for his invitation to contribute to this university bastion dedicated to conservation, and to Msc. Edgar Alberto Gamez Duarte for his invalualble cartography contribution. RALR extends gratitude to CONAHCyT and ITSON for their support in the repatriation process, as well as PROFAPI 2023_033RALR. Specimens were collected in accordance with SEMARNAT capture permits SGPA/DGVS/06768/17, SGPA/DGVS/003209/18, and SGPA/DGVS/05789/19, issued by the Dirección General de Vida Silvestre, Mexico. Finally, we would like to thank two anonymous reviewers.

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