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HERPETOFAUNA OF THE CHASCHOC LAGOON WETLANDS, TABASCO, MEXICO

HERPETOFAUNA DE LOS HUMEDALES DE LA LAGUNA DE CHASCHOC, TABASCO, MÉXICO

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Resumen.— El conocimiento de la herpetofauna de Tabasco está todavía reducido comparado con el de otros estados de México. Este estudio aporta nueva información sobre la diversidad de anfibios y reptiles en un humedal de Tabasco. Muestreamos mensualmente de enero a diciembre 2014 los humedales de Chaschoc, con el objetivo de establecer una lista de especies de anfibios y reptiles para este sitio y detectar amenazas potenciales para su conservación. Realizamos muestreos diurnos y nocturnos en hábitats terrestres, y muestreos de tortugas y cocodrilos en cuerpos de agua. Cincuenta y cinco especies fueron detectadas (12 anfibios, 43 reptiles), representando 32.4% de las especies registradas para Tabasco. Los modelos de acumulación de especies dieron porcentajes de completitud de los inventarios arriba del 92 %. La mayoría de las especies no aparecen en la lista roja de las especies amenazadas de la UICN, los apéndices de la CITES y la lista de especies amenazadas de la Norma Oficial Mexicana NOM-059-SEMARNAT-2010. Las amenazas principales detectadas para la herpetofauna del sitio estudiado fueron la ganadería, la cacería y colecta ilegal, la destrucción, fragmentación y contaminación del hábitat, y los incendios intencionales. También detectamos a tres especies no-nativas invasoras de reptiles.

Palabras clave.— Amenazas, anfibios, diversidad, Emiliano Zapata, reptiles, riqueza.

Abstract.— The knowledge on the herpetofauna of Tabasco State remains poor compared to other states of Mexico. This study apports new information on the diversity of amphibians and reptiles in a freshwater wetland of Tabasco. From January to December 2014, monthly samplings were conducted in the Chaschoc lagoon wetlands to establish a checklist of amphibians and reptiles for this site and to detect potential threats to their conservation. Diurnal and nocturnal surveys were conducted in terrestrial habitats, while surveys were conducted in water bodies for turtles and crocodiles. Fifty-five species were detected (12 amphibians, and 43 reptiles), representing 32.4% of the species recorded for Tabasco. Species accumulation models resulted in percentages of inventory completeness above 92 %. Most of the species do not appear in IUCN Red List of threatened species, appendices of CITES, or the list of threatened species of the Official Mexican Norm NOM-59-SEMARNAT-2010. Main threats detected for the herpetofauna were cattle ranching, illegal hunting and collecting, destruction, fragmentation and pollution of the habitat, and intentional fires. We also detected three non-native invasive species of reptiles.

Key words.— Amphibians, diversity, Emiliano Zapata, reptiles, richness, threats.

INTRODUCTION

Mexico ranks fifth and second in the world in terms of amphibian and reptile diversity, respectively (Flores-Villela & García-Vázquez, 2014; Parra-Olea et al., 2014). However, the ecosystems used by herpetofauna have been and continue to be seriously disturbed/destroyed since the beginning of the last century, particularly in tropical regions (Böhm et al., 2013). Tabasco is one of the most affected Mexican States in this regard, its natural habitats have been severely cleared over the last 60 years for agriculture, cattle ranching, the oil industry and more recently oil palm production (Tudela, 1989; Reynoso-Rosales et al., 2007; Kolb & Galicia, 2012; Carabias et al., 2015). By the early 2000s, the State of Tabasco had lost over 90% of its original vegetation cover and, unfortunately, this trend has not yet been reversed, with a loss of 18% of the State's remaining tree cover between 2001 and 2021 (Zavala-Cruz & Castillo, 2003; Global Forest Watch, 2022). While some species of amphibians and reptiles are somewhat resistant and are sometimes favored by habitat degradation, many other species are very sensitive to habitat deterioration and could be severely affected (Pyron, 2018). Amphibians are surely the currently most threatened vertebrates in Mexico and the world, experiencing a severe global decline since early 1980s, mostly caused by habitat loss and degradation (Stuart et al., 2004; Lips et al., 2005; Köhler, 2011; Parra-Olea et al., 2014; Whitfield et al., 2016), which is also the principal cause of decline in reptiles (Flores-Villela & García-Vázquez, 2014).

In the discipline of herpetology, Tabasco is one of the Mexican States that received little attention throughout history (Flores-Villela et al., 2004) and even today. Quantification of species diversity is the first important step in identifying/defining information gaps and conservation priorities for herpetofauna diversity. A recent updated checklist reported 170 species of reptiles and amphibians for Tabasco consisting of 39 anurans, five caudates, one caecilian, two crocodylians, 111 squamates and 12 turtles (Barragán-Vázquez et al., 2022).

However, in the last decade there have been many new species records for the State (Charruau et al., 2014, 2015; Hernández-Valadez et al., 2016; Arenas-Moreno et al., 2017; Ríos-Rodas et al., 2019), although many areas have not yet been sampled. In this context, this study presents the first inventory of the herpetofauna of the Chaschoc lagoon wetlands located in the Municipality of Emiliano Zapata, Tabasco. This area has been mentioned to be an important area for biodiversity conservation (Gordillo-Chávez et al., 2015; García-Morales et al., 2022) but no assessment of the amphibian and reptile diversity has been done there.

MATERIALS AND METHODS

The study was conducted in the Chaschoc lagoon wetlands and its surroundings, located at the north of Emiliano Zapata City, municipality of Emiliano Zapata, Tabasco, Mexico (Fig. 1). The climate is warm humid, with an average annual temperature of 26°C, a total annual precipitation from 1500 to 4500 mm, with rainfall from June to September and a dry season in April and May (Instituto Nacional para el Federalismo y el Desarrollo Municipal [INAFED], 2010). The vegetation is composed of remnants of medium flooded forest, medium forest, secondary vegetation, flooded palm groves, and tropical oak groves; there are also extensive areas of rice cultivation, oil palm plantations, and pastures for cattle grazing (Meave et al., 2021; García-Morales et al., 2022).

We conducted monthly five-day field trips from January to December 2014 at the study site, and used different techniques to determine the herpetofauna diversity: diurnal and nocturnal transects, turtle traps, visits and surveys of turtle owners, and nocturnal crocodile samplings. We conducted diurnal (from 8 am to 12 pm) and nocturnal (from 8 pm to 12 am) transects in different terrestrial areas in search of amphibians and reptiles. We installed Fike Net type turtle traps in different waterbodies, using rip fruits (mostly banana) and tuna as bait. We set up the traps during the first day of each trip and checked them every day. In addition, we obtained data on turtles kept in captivity by local people in the different localities of the study area. Additionally, we conducted nocturnal spotlight surveys of crocodiles in the Chaschoc lagoon aboard a 4 m aluminum boat with a 15 hp outboard motor, following the method described by Charruau et al. (2005). During each survey, we also made observations to identify possible threats to the conservation of the herpetofauna in the study area.

We geo-referenced each individual capture (amphibian and reptile) using a global positioning system (GPS; Datum WGS84) and we identified the species using dichotomous keys of Köhler (2008, 2011) and Lee (1996). We collected individuals of some species and deposited them as voucher specimens to the Colección de Anfibios y Reptiles de Tabasco (CART) of the División Académica de Ciencias Biológicas of the Universidad Juárez Autónoma de Tabasco. We conducted the study with permits issued by Dirección General de Vida Silvestre from the Secretaría de Medio Ambiente y Recursos Naturales (SGPA/DGVS/11742/13; SGPA/DGVS/03484/14).

We searched the conservation status of each species in the Red List of threatened species of the International Union

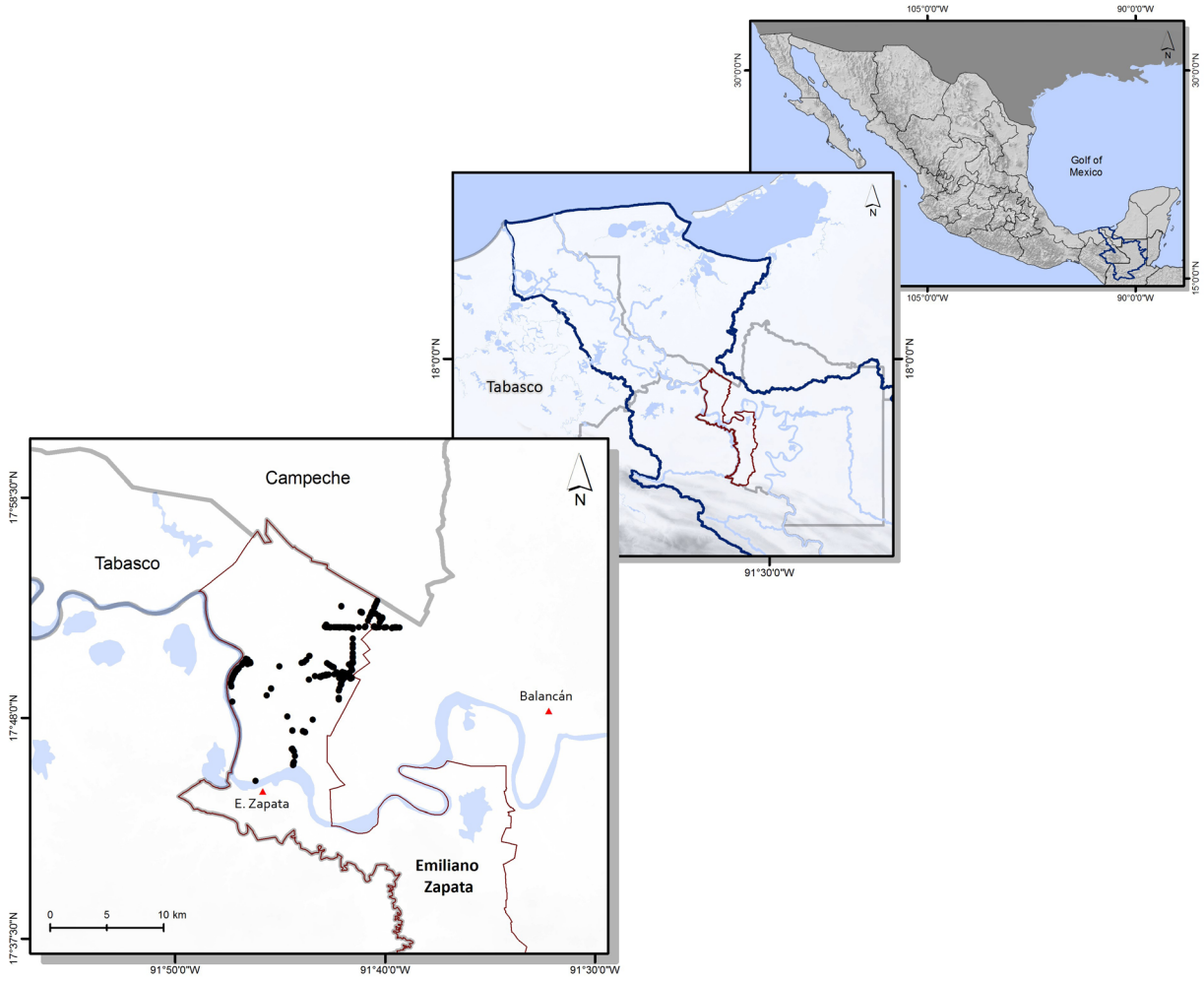


Figura 1. Mapa de localización del área de estudio (Datum: WGS84). Los puntos negros son observaciones de individuos.

Figure 1. Locality map of the study area (Datum: WGS84). Black dots are observations of individuals.

for Conservation of Nature (IUCN 2022. IUCN Red List of Threatened Species. Version 2021.3. www.iucnredlist.org), in the appendices of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (https://cites.org/esp/app/index.php), and in the Official Mexican Norm NOM-059-SEMARNAT-2010 (Diario Oficial de la Federación, 2019). We calculated the percentage of species in each category of these listings. The scientific and common names of the species are according to The Reptile Database (http://www.reptile-database.org/; Uetz et al., 2022) and Amphibian Species of the World (https://amphibiansoftheworld.amnh.org/; Frost, 2023).To assess the completeness of herpetofauna diversity for the Chaschoc lagoon wetlands, we used species accumulation models (Soberón & Llorente, 1993), in which the cumulative number of species is plotted against some measure of the effort to obtain that sample. In this case, we considered five-day and night field trips as a measure of effort. We performed the analysis using data for all species recorded (total herpetofauna), and separately for each taxonomic group (Amphibia, Serpentes, Testudines, and Sauria), except for the Order Crocodylia which only presents one species in the region (i.e., Morelet´s crocodile). We discuss below the current doubtful presence of the American crocodile in Tabasco asserted by other authors (Barragán-Vázquez et al., 2022). We calculated the species accumulation curves with the Species Accumulation Functions program (Díaz-Francés & Soberón, 2005). This software uses the probability of the coefficients between candidate models (Clench, Logarithmic and Exponential) to select the best model for a data set, and

calculates the total number of species with the models that reach an asymptote (Díaz-Francés & Soberón, 2005).

RESULTS

We recorded 55 species for the Chaschoc lagoon wetlands, corresponding to 12 amphibians and 43 reptiles (Table 1). One Order and six Families include the 12 amphibian species; while the 43 reptile species are included in 21 Families and four Orders. We also found two introduced invasive species, the Common House Gecko (*Hemidactylus frenatus* Duméril & Bibron, 1836) and the Brown Anole (*Anolis sagrei* Cocteau in Duméril and Bibron, 1837). Another invasive species, the Red-Eared Slider (*Trachemys scripta elegans* Wied, 1839), was observed in captivity, kept by local people along with other turtle species. This turtle was not considered in the species list of the study area because we do not know the origin of this individual.

Snakes was the most diverse group of reptiles observed in the area, with 19 species, followed by lizards (S = 14), freshwater turtles (S = 9), and crocodiles (S = 1) (Table 1). Regarding amphibians, all species represented the Order Anura (Table 1).

A total of 47 specimens of 18 reptiles and nine amphibians were deposited at the CART (Table 1). In the case of 22 species, we limited ourselves to taking a photo of the individuals and releasing them, and in the case of six species, we were only able

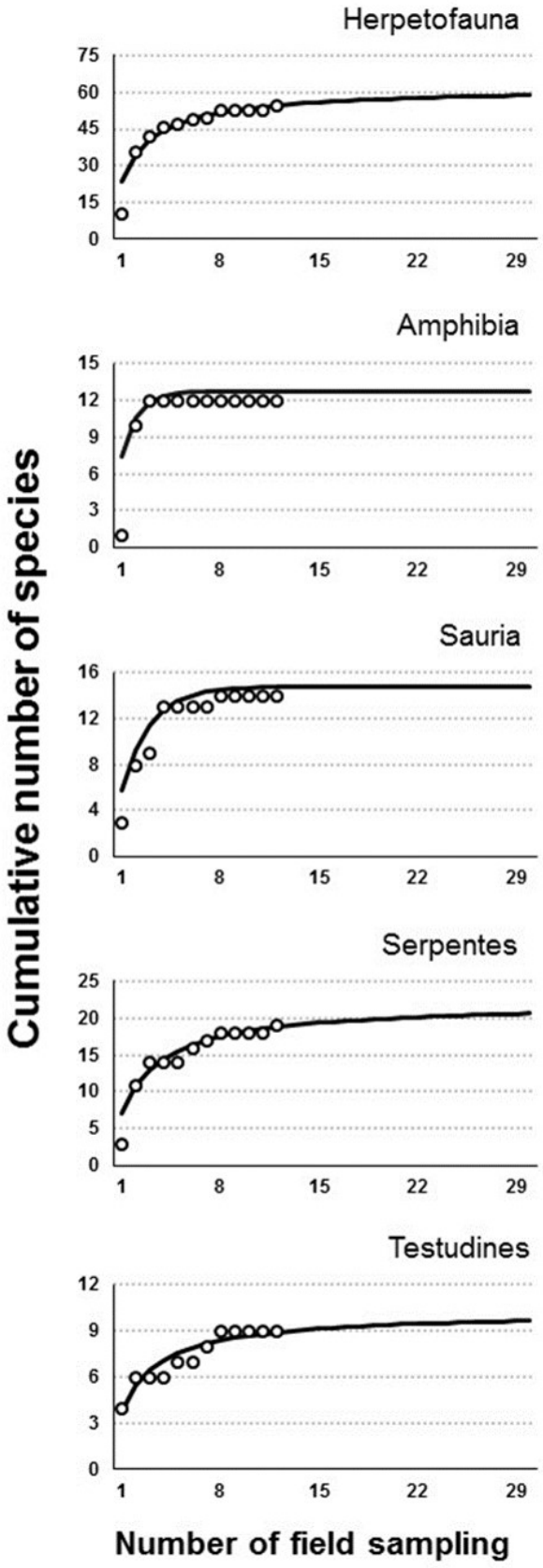
Tabla 1. Anfibios y reptiles registrados en los humedales de la laguna Chaschoc con su número de voucher y estatus de conservación en la lista Roja de la UICN, Apéndices de la CITES y la NOM-059-SEMARNAT-2010. NE: No evaluada, CR: En peligro crítico, NL: No listada, Ap I: Apéndice I, Ap II: Apéndice II, Pr: Bajo protección especial, A: Amenazada, P: En peligro, (c): capturada, (nc): no capturada.

Table 1. Amphibians and reptiles recorded in the Chaschoc lagoon wetlands with their voucher number and conservation status in the IUCN Red List, CITES Appendices and the NOM-059-SEMARNAT-2010. NE: Not evaluated, LC: Least concern, NT: Near threatened, VU: Vulnerable, CR: Critically endangered, NL: Not listed, Ap I: Appendix I, Ap II: Appendix II, Pr: Under special protection, A: Threatened, P: Endangered, (c): captured, (nc): not captured.

ORDER Family Species	IUCN	CITES	NOM	Voucher number
ANURA				
Bufonidae				
Rhinella horribilis	LC	NL	NL	CART 00930
Incilius valliceps	LC	NL	NL	Photo only (c)
Hylidae				
Dendropsophus microcephalus	LC	NL	NL	CART 00911, 939
Trachycephalus vermiculatus	LC	NL	NL	CART 00912
Scinax staufferi	LC	NL	NL	CART 00933, 940
Smilisca baudinii	LC	NL	NL	CART 00924
Leptodactylidae				
Leptodactylus fragilis	LC	NL	NL	Observed only (c)
Leptodactylus melanonotus	LC	NL	NL	CART 00919, 941-943
Leiuperidae				
Engystomops pustulosus	LC	NL	NL	Observed only (c)
Microhylidae				
Hypopachus variolosus	LC	NL	NL	CART 00931
Ranidae				
Lithobates brownorum	LC	NL	Pr	CART 00907-909
Lithobates vaillanti	LC	NL	NL	CART 00922

ORDER Family Species	IUCN	CITES	NOM	Voucher number
CROCODYLIA				
Crocodylidae				
Crocodylus moreletii	LC	Ap II	Pr	Photo only (c)
TESTUDINES				
Dermatemydidae				
Dermatemys mawii	CR	Ap II	P	Photo only (c)
Geoemydidae				
Rhinoclemmys areolata	NT	NL	A	Photo only (c)
Emydidae				
Trachemys venusta	NE	NL	NL	Photo only (c)
Chelydridae				
Chelydra rossignonii	VU	NL	Pr	Photo only (c)
Kinosternidae				
Claudius angustatus	NT	NL	P	Photo only (c)
Kinosternon acutum	NT	NL	Pr	Photo only (c)
Kinosternon scorpioides	NE	NL	Pr	Photo only (c)
Kinosternon leucostomum	NE	NL	Pr	Photo only (c)
Staurotypus triporcatus	NT	NL	A	Photo only (c)
SAURIA				
Eublepharidae				
Coleonyx elegans	LC	NL	A	Photo only (c)
Gekkonidae				
Hemidactylus frenatus	LC	NL	NL	CART 00903-904
Sphaerodactylidae				
Sphaerodactylus glaucus	LC	NL	Pr	CART 00913-915, 921, 945
Dactyloidae				
Anolis sagrei	LC	NL	NL	CART 00910
Anolis sericeus	LC	NL	NL	CART 00929, 936-938
Anolis rodriguezii	LC	NL	NL	CART 00923, 926
Anolis lemurinus	LC	NL	NL	CART 00906
Corytophanidae				
Basiliscus vittatus	LC	NL	NL	CART 00900
Iguanidae				
Ctenosaura similis	LC	NL	A	Photo only (nc)

ORDER Family Species	IUCN	CITES	NOM	Voucher number
Iguana iguana	LC	Ap II	Pr	Photo only (c)
Mabuyidae				
Marisora unimarginata	LC	NL	NL	CART 00927
Sphaenomorphidae				
Scincella cherriei	LC	NL	NL	CART 00901
Teiidae				
Holcosus undulatus	LC	NL	NL	CART 00918
Aspidoscelis deppii	LC	NL	NL	Observed only (nc)
SERPENTES				
Boidae				
Boa imperator	LC	Ap II	A	Photo only (c)
Colubridae				
Drymarchon melanurus	LC	NL	NL	Photo only (c)
Lampropeltis polyzona	LC	NL	A	Observed only (c)
Leptophis mexicanus	LC	NL	A	Photo only (c)
Masticophis mentovarius	LC	NL	A	CART 00934
Spilotes pullatus	LC	NL	NL	Photo only (nc)
Dipsadidae				
Coniophanes fissidens	LC	NL	NL	Photo only (c)
Coniophanes bipunctatus	LC	NL	NL	Observed only (c)
Coniophanes imperialis	LC	NL	NL	CART 00916, 920
Imantodes gemmistratus	LC	NL	Pr	CART 00732
Leptodeira frenata	LC	NL	NL	CART 00925
Leptodeira septentrionalis	LC	NL	NL	Photo only (c)
Ninia sebae	LC	NL	NL	CART 00905
Natricidae				
Nerodia rhombifer	LC	NL	NL	CART 00928
Thamnophis proximus	LC	NL	A	CART 00917
Viperidae				
Bothrops asper	LC	NL	NL	Photo only (nc)
Agkistrodon russeolus	NE	NL	NL	CART 00702, 902, 932, 935
Crotalus tzabcan	LC	NL	NL	Photo only (c)
Elapidae				
Micrurus diastema	LC	NL	Pr	Observed only (nc)



to observe them (Table 1). Photographs of some of the species are presented in figures 2, 3, 4, 5, and 6.

All species accumulation curves and fitted models reached an asymptote (Fig. 7). The models that best fit the data were the Clench model for total herpetofauna, Serpentes and Testudines, and the exponential model for Amphibia and Sauria (Fig. 7). Inventory completeness percentages for the different groups were 93 % for total herpetofauna, 94 % for Amphibia and Sauria, 93 % for Testudines, and 92 % for Serpentes.

The most threatened species is the Central American River Turtle *Dermatemys mawii* Gray, 1847 (Table 1; Fig 4H), which is also the most threatened freshwater turtle in Mesoamerica, classified as Critically Endangered by the IUCN. The other amphibians and reptiles were classified as Vulnerable (n = 1), Near Threatened (n = 4), and Least Concern (n = 45), or had not yet been assessed (n = 4) by the IUCN (Table 2). Four species appear in CITES Appendix II (Tables 2): The Boa *Boa imperator* Daudin, 1803 (Table 1, Fig. 6H), the Green Iguana *Iguana iguana* (Linnaeus, 1758) (Fig. 6H), the Morelet´s Crocodile *Crocodylus moreletii* (Duméril & Bibron, 1851) (Fig. 3B), and the Central American River Turtle (Table 1). Only two species are considered endangered by the Mexican law (Table 2), the Central American River Turtle and the Narrow-bridged Mud Turtle *Claudius angustatus* (Cope, 1865) (Fig. 4C). The remaining species are considered threatened (n = 9), under special protection (n = 10) or do not appear in the NOM-059-SEMARNAT-2010 (Table 2). All amphibians are considered as Least Concern by IUCN, and none appear in CITES Appendices (Table 2). Only one species, the Browns' Leopard Frog *Lithobates brownorum* (Sanders, 1973), is listed in the NOM-059-SEMARNAT-2010, as under special protection (Table 1). Six threats to the conservation of the herpetofauna of the Chaschoc lagoon wetlands have been detected: cattle ranching, illegal hunting and collection, habitat destruction and fragmentation, pollution, invasive species, and intentional fires (Fig. 8).

DISCUSIÓN

According to the models of species accumulation, we obtained a good representation of the species of amphibians and reptiles in Chaschoc lagoon wetlands, as the inventories completeness were greater than 92 % for the total herpetofauna and the different taxonomic groups. Thus, a notable portion of the

Figura 7. Curvas de acumulación de especies para la herpetofauna de los humedales de la laguna Chaschoc.

Figure 7. Species accumulation curves for the herpetofauna of the Chaschoc lagoon wetlands.

Figure 2. Photographs of six amphibian species from Chaschoc lagoon wetlands. A) *Hypopachus variolosus,* B) *Trachycephalus vermiculatus,* C) *Incilius valliceps,* D) *Scinax staufferi,* E) *Smilisca baudinii* in amplexus, F) *Dendropsophus microcephalus.* Photos: P. Charruau (A, B, E), A.G. González-Desales (C, D, F).

Figura 2. Fotografías de seis especies de anfibios de los humedales de la laguna Chaschoc. A) *Hypopachus variolosus,* B) *Trachycephalus vermiculatus,* C) *Incilius valliceps,* D) *Scinax staufferi,* E) *Smilisca baudinii* in amplexus, F) *Dendropsophus microcephalus.* Fotos: P. Charruau (A, B, E), A.G. González-Desales (C, D, F).

Figura 3. Fotografía de un nido (A) y de un individuo (B) de cocodrilo de Morelet (*Crocodylus moreletii*) de los humedales de la laguna Chaschoc. Fotos: M.A. Morales-Garduza (A), P. Charruau (B).

Figure 3. Photographs of a nest (A) and of an individual (B) of Morelet´s crocodile (*Crocodylus moreletii*) from Chaschoc lagoon wetlands. Photos: M.A. Morales-Garduza (A), P. Charruau (B).

Tabla 2. Número y porcentaje de especies de anfibios y reptiles registradas en los humedales de la laguna Chaschoc en cada categoría de la Lista Roja de la UICN, los Apéndices de la CITES y la NOM-059-SEMARNAT-2010.

Table 2. Number and percentage of species of amphibians and reptiles recorded in the Chaschoc lagoon wetlands in each category of the IUCN Red List, the Appendices of CITES, and the NOM-059-SEMARNAT-2010.

	Amphibia n = 12	Sauria n = 14	Serpentes n = 19	Testudines n =9	Crocodylia n = 1	Total n = 55
IUCN						
Not evaluated	-	-	1 (5.3)	3 (33.3)	-	4 (7.3)
Least Concern	12 (100)	14 (100)	18 (94.7)	-	1 (100)	45 (81.8)
Near Threatened	-	-	-	4 (44.5)	-	4 (7.3)
Vulnerable	-	-	-	1 (11.1)	-	1 (1.8)
Critically Endangered	-	-	-	1 (11.1)	-	1 (1.8)
CITES						
Appendix I	-	-	-	-	-	-
Appendix II	-	1 (7.1)	1 (5.3)	1 (11.1)	1 (100)	4 (7.3)
Not listed	12 (100)	13 (92.9)	18 (94.7)	8 (88.9)	0 (0)	51 (92.7)
NOM-059-SEMARNAT-2010						
Not listed	11 (91.7)	10 (71.4)	12 (63.2)	1 (11.1)	-	34 (61.8)
Under special protection	1 (8.3)	2 (14.3)	2 (10.5)	4 (44.5)	1 (100)	10 (18.2)
Endangered	-	-	-	2 (22.2)	-	2 (3.6)
Threatened	-	2 (14.3)	5 (26.3)	2 (22.2)	-	9 (16.4)

Figura 4. Fotografías de las nueve especies de tortugas registradas en los humedales de la laguna Chaschoc. A) *Staurotypus triporcatus*, B) *Kinosternon leucostomum*, C) *Claudius angustatus*, D) *Kinosternon scorpioides*, E) *Rhinoclemmys areolata*, F) *Kinosternon acutum*, G) *Trachemys venusta*, H) *Chelydra rossignonii*, I) *Dermatemys mawii*. Fotos: M.A. Morales-Garduza (A, E, F, H), P. Charruau (B, C, D), A.G. González-Desales (G, I).

Figure 4. Photographs of the nine species of turtles recorded at Chaschoc lagoon wetlands. A) *Staurotypus triporcatus*, B) *Kinosternon leucostomum*, C) *Claudius angustatus*, D) *Kinosternon scorpioides*, E) *Rhinoclemmys areolata*, F) *Kinosternon acutum*, G) *Trachemys venusta*, H) *Chelydra rossignonii*, I) *Dermatemys mawii*. Photos: M.A. Morales-Garduza (A, E, F, H), P. Charruau (B, C, D), A.G. González-Desales (G, I).

Figura 5. Fotografías de 10 especies de lagartijas de los humedales de la laguna Chaschoc. A) *Basiliscus vittatus*, B) *Ctenosaura similis*, C) *Scincella cherriei*, D) *Anolis lemurinus*, E) *Anolis sericeus*, F) *Sphaerodactylus glaucus*, G) *Holcosus undulatus*, H) *Coleonyx elegans*, I) *Anolis rodriguezii*. Fotos: A.G. González-Desales (A), P. Charruau (B, D, E, F, G, I), y M.A. Morales Garduza (C, H).

Figure 5. Photographs of 10 lizard species from Chaschoc lagoon wetlands. A) *Basiliscus vittatus*, B) *Ctenosaura similis*, C) *Scincella cherriei*, D) *Anolis lemurinus*, E) *Anolis sericeus*, F) *Sphaerodactylus glaucus*, G) *Holcosus undulatus*, H) *Coleonyx elegans*, I) *Anolis rodriguezii*. Photos: A.G. González-Desales (A), P. Charruau (B, D, E, F, G, I), and M.A. Morales Garduza (C, H).

Figura 6. Fotografía de 10 especies de serpientes observadas en los humedales de la laguna de Chaschoc. A) *Coniophanes imperialis*, B) *Coniophanes fissidens*, C) *Agkistrodon russeolus*, D) *Leptodeira septentrionalis*, E) *Thamnophis proximus*, F) *Spilotes pullatus*, G) *Crotalus tzabcan*, H) *Boa imperator* comiendo una *Iguana iguana*, I) *Drymarchon melanurus*, J) *Nerodia rhombifer*. Fotos: P. Charruau (A, B, D, G, H, J), A.G. González-Desales (C, E, I), M.A. Morales-Garduza (F).

Figure 6. Photographs of 10 species of snakes observed at Chaschoc lagoon wetlands. A) *Coniophanes imperialis*, B) *Coniophanes fissidens*, C) *Agkistrodon russeolus*, D) *Leptodeira septentrionalis*, E) *Thamnophis proximus*, F) *Spilotes pullatus*, G) *Crotalus tzabcan*, H) *Boa imperator* eating a *Iguana iguana*, I) *Drymarchon melanurus*, J) *Nerodia rhombifer*. Photos: P. Charruau (A, B, D, G, H, J), A.G. González-Desales (C, E, I), M.A. Morales-Garduza (F).

species present in Chaschoc wetlands was recorded, but more species are expected to be found in the area. This is supported by recent first records of several reptile and amphibian species for Tabasco State (Charruau et al., 2014, 2015; Hernández-Valadez et al., 2016; Arenas-Moreno et al., 2017; Ríos-Rodas et al., 2019). The amphibians recorded in the area correspond to species commonly found in other parts of Tabasco and are species that are adapted, favored or resistant to anthropogenic disturbance rather than species of conservation concern.

Concerning crocodiles, only the Morelet's Crocodile has been observed in Chaschoc area and it is likely the only species present in Tabasco. The American Crocodile (*Crocodylus acutus* Cuvier, 1807) was mentioned to occur in Tabasco in the Usumacinta and Grijalva rivers by some authors since middle of the twentieth century (Smith & Taylor, 1966; Ross & Ross, 1987; Lee, 1996; Ernst et al., 1999). The occurrence of this species has been accepted and published in checklists of the herpetofauna of Tabasco (Barragan-Vázquez et al., 2022); however, this information must be verified, as there is no recent credible record of this species in Tabasco. Furthermore, the great majority of the Morelet´s crocodiles from northern Tabasco, and other Mexican regions of the Gulf of Mexico, present some level of hybridization with *C. acutus* (Pacheco-Sierra et al., 2016). Recently, Pacheco-Sierra et al. (2018) conducted genomic analyses within and between *C. acutus* and *C. moreletii* demonstrating that hybrids are represented by two groups, one of which is morphologically similar to *C. moreletii* because has little genetic contribution of *C. acutus*; the first occurs on the lowlands of the Gulf of Mexico, and the second is found on the Yucatán Peninsula. This would prove, at least, a former presence of *C. acutus* in the Usumacinta region.

Respecting the diversity of the freshwater turtles, we found the nine species previously reported for the region (Fig. 4). Our study area lies over an important region of endemism of Neotropical turtles (Ippi & Flores, 2001), which convert it in an important area for conservation. *Chelydra rossignonii* (Bocourt, 1868), the Central American Snapping Turtle, is the largest of the nine species of freshwater turtles present in the region. *Chelydra rossignonii* was elevated to species level 20 years ago by Phillips et al. (1996) and very few information exists specifically on this species; therefore knowledge on all aspect of its distribution, biology, and conservation status is urgently needed (van Dijk et al., 2007; Legler & Vogt, 2013). The registered individuals in this study were kept illegally in captivity at Emiliano Zapata city where they were overfed and appear obese (Fig. 4G).

The species of lizards and snakes also correspond to the species reported in the region, being few of conservation concern. However, the proximity of the study site to the Yucatán Peninsula allows the presence of some species that are rarely or not found in other areas of the State, such as the Yucatecan Cantil (*Agkistrodon russeolus* Gloyd, 1972) and the Yucatan Neotropical Rattlesnake (*Crotalus tzabcan* Klauber, 1952). This gives another importance to the area for the conservation of herpetofauna diversity in Tabasco.

Many of the recorded species do not appear in the Appendices of CITES and/or the Mexican list of endangered species (NOM-059-SEMARNAT-2010) or their status has not been evaluated yet (Table 2). Most of the species (94.5 %) appear in the IUCN Red List of threatened species but only 3.6 % (n = 2) of the species are listed in an endangered category (Table 2). Furthermore, discrepancies in the status of some species among IUCN, CITES and the NOM-059-SEMARNAT-2010 exist. For example, the Yucatán Banded Gecko (*Coleonyx elegans* Gray, 1845) (Fig. 5H) is listed as threatened in the NOM-059-SEMARNAT-2010 but do not appear in the IUCN Red List nor in the CITES Appendices. The Narrow-bridged Musk Turtle (*Claudius angustatus* Cope, 1865) also appears as endangered in the NOM-059-SEMARNAT-2010 but do not appear in CITES Appendices and is considered as near threatened by the IUCN. This is because each organization has different criteria to assess species status. Also, in the past, there was a lack of specialists in some of the species, and assessments of these species were subjective. Currently, criteria have been standardized through manuals (e.g., MER in Mexico; Sánchez et al., 2007) and assessments have been carried out based on reunions/workshops of specialists. However, many species still need an assessment of their current conservation status. Therefore, it would be important to start to determinate or review the status of each species.

In addition, the constant or more frequent updating of species names is necessary in the NOM-059-SEMARNAT-2010, because for example *Chelydra rossignonii* is still listed as *Chelydra serpentina* (Linnaeus, 1758), the Common Snapping Turtle, and several species do not appear but it is not known if it is because they have not been evaluated or if the species name is not updated, as is the case of *Trachemys venusta* (Gray, 1855), *Agkistrodon russeolus* and *Crotalus tzabcan* (considered not listed in NOM-059-SEMARNAT-2010 in this study).

In terms of threats, there is a relatively large presence of livestock in the study area that could affect the diversity and health of amphibians and reptiles. As an example of possible health impacts, 11 individuals (i.e., six snakes, one toad, and four turtles) have been found with ticks attached to their bodies (from one to >12 ticks per individual). These ticks could transmit

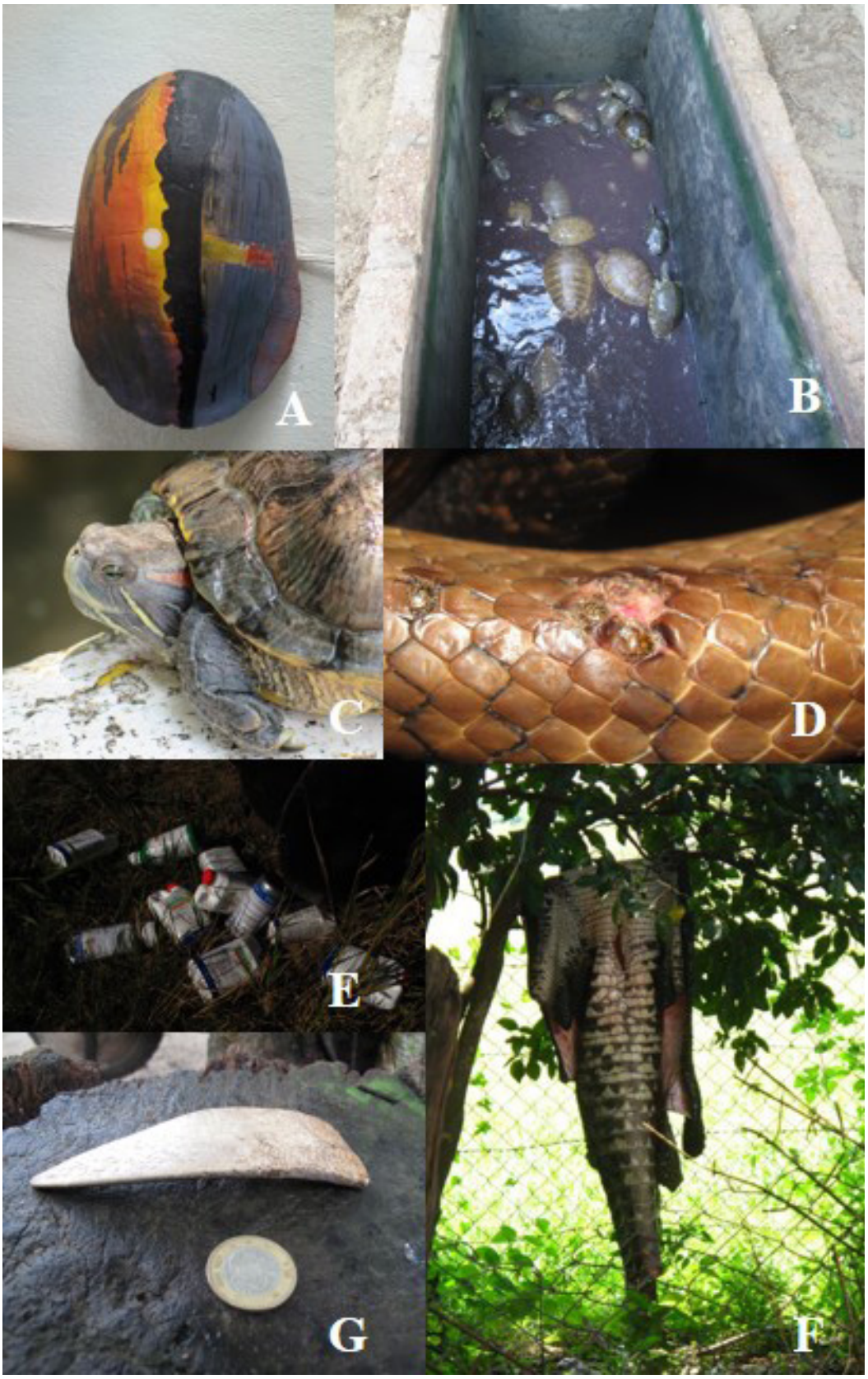


Figura 8. Fotografías de artesanía hecha con carapacho de tortuga de la laguna Chaschoc A), un estanque con tortugas capturadas ilegalmente en los humedales de la laguna Chaschoc B), una *Trachemys scripta elegans* mantenida en cautividad por la población local en el área de estudio C), garrapatas que parasitan a la serpiente *Drymarchon melanurus* D), envases de agroquímicos encontrados en el área de estudio E), una piel fresca de un cocodrilo de Morelet adulto cazado ilegalmente en la laguna de Chaschoc F), una costilla de *Dermatemys mawii* utilizada para desgranar la mazorca de maíz G). Fotos: P. Charruau (A-F), G. Cruz-Morales (G).

Figure 8. Photographs of handicraft made from turtle carapace from Chaschoc lagoon A), a pond with illegally collected turtles in the wetlands of Chaschoc lagoon B), a *Trachemys scripta elegans* kept in captivity by local people in the study area C), ticks parasitizing the snake *Drymarchon melanurus* D), agrochemical containers found in the study area E), a fresh skin of an illegally hunted adult Morelet´s crocodile in Chaschoc lagoon F), a *Dermatemys mawii* rib used to remove corn grain from the ear of corn G). Photos: P. Charruau (A-F), G. Cruz-Morales (G).

diseases or damage the skin of amphibians and reptiles (Fig. 8D). Illegal collection of turtles for different uses (e.g., food, pet, trade, ornaments, tool; Fig. 8) was also observed. An example of a tool made from turtles is the use of the ribs of *D. mawii* to remove kernels from corn cobs (Fig. 8G). This collection seems to occur throughout the year, but with a peak a few weeks before or during Holy Week (March-April), as turtle is a typical dish consumed during this period in this region. Prices for individuals can range from 300 to 2,000 Mexican pesos (i.e., 18 to 118 USD), depending on the species and size of the individuals. The local population keeps the individuals of all species of turtles that they occasionally capture in corals or in small ponds made of cement (Fig. 8B); these conditions are not suitable for the turtles, and they often present problems due to poor feeding, and injuries due to inter-specific interactions or rubbing against the infrastructure.

People of the area also kill any snake they found and use rattlesnakes (Fig. 6G) as medicine against cancer; the procedure consists in drying the snake and grind it to obtain a powder which is mixed with food or beverage. Also, illegal hunt of crocodiles for food, their skin or oil has been observed (Fig. 8F). The oil is used as medicine against asthma by local people. The density of crocodiles is low in the area, likely due to the illegal exploitation and disturbance by human activities (i.e., fishing nets). However, two nests (Fig. 3A) and various young individuals have been observed during the study, indicating that the population still reproduce. Studies on crocodiles and turtles populations are strongly recommended to determine their conservation status.

Habitat destruction, fragmentation and pollution are other important threats to the herpetofauna in the study area. A significant percentage of the original vegetation cover has been lost due to the increase in oil palm plantations and other crops such as rice. We were also able to observe agrochemical containers dumped into the habitat and aquatic systems (Fig 8E). These chemicals, especially pesticides, can produce adverse effects on amphibians and reptiles (Guillette & Milnes, 2000; Gardner & Oberdörster, 2005; Adlassnig et al., 2013).

The presence of polycyclic aromatic hydrocarbons (PAHs) of petrogenic and pyrogenic origin, and organochlorine pesticides (OCs) has been confirmed in substrates and aquatic organisms in the study area, with bioaccumulation and biomagnification processes in trophic chains (López-Escamilla et al., 2022). This represents a threat to the herpetofauna and further ecotoxicological studies are needed to determine the effects of these chemicals on organisms in the Chaschoc Lagoon wetlands. In addition, large areas of Tabasco are burned every year due to intentional fires, including the study area, where habitat burning is a common technique used to hunt turtles.

Finally, two invasive species have been detected in the study area, the Common House Gecko (*H. frenatus*) and the Brown Anole (*A. sagrei*). These are known invasive species that pose a threat to native lizard species; they have been responsible for the displacement or extinction of several native or introduced lizards (mainly geckos) on islands and the mainland worldwide (Case et al., 1994; Campbell, 1999; Echternacht, 1999; Norval et al., 2002; Cole et al., 2005; Caicedo-Portilla & Dulcey-Cala, 2011). *Hemidactylus frenatus* is known to especially affect smaller local species of geckos (Yang et al., 2012), thus it represents a threat to the Least Gecko (*Sphaerodactylus glaucus* Cope, 1866), a much smaller species detected in the study area (Fig. 5F). In addition, we observed a Red-eared Slider *T. scripta* kept in captivity with local turtle species (Fig. 8C). This species has long been sold in Mexican pet shops (Legler & Vogt, 2013), and poses a risk for the local species if released into the wild (Global Invasive Species Database, 2022). The Red-eared Slider is recognized as an invasive species that may out-compete local turtle species, threaten local endangered species, transmit diseases, prey on local animal and plant species, threaten human health, and could impact ecosystems (Global Invasive Species Database, 2022).

CONCLUSIONS

This study represents the first effort to determine the checklist of reptile and amphibian species present in the Chaschoc lagoon wetlands. Although very few species of conservation concern inhabit the area, we found a non-negligeable number of species (n = 55) with percentage of inventory completeness >92%, representing 32.4% of the herpetofauna of Tabasco. The number of known vertebrate species in the study area now amounts to 150, consisting of 12 amphibians, 43 reptiles, 47 aquatic birds and 48 mammals (Gordillo-Chávez et al., 2015; García-Morales et al., 2022), and confirm the importance of the Chaschoc lagoon wetlands for the conservation of native biodiversity in the region. The potential threats to the conservation of the herpetofauna detected in this work should be studied to conclude on their impact on amphibians and reptiles in the region.

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