Check List the journal of biodiversity data

ANNOTATED LIST OF SPECIES

Check List 17 (4): 1155–1170
https://doi.org/10.15560/17.4.1155

PENSOFT

Inventory of medium-sized and large mammals in La Encrucijada Biosphere Reserve and Puerto Arista Estuarine System, Chiapas, Mexico

Julio C. Hernández-Hernández[1], Cuauhtémoc Chávez[2*]

1 Programa de Doctorado en Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, Ciudad de México, Mexico • biol.julio@mail.com https://orcid.org/0000-0002-1286-2404

2 Departamento de Ciencias Ambientales, CBS Universidad Autónoma Metropolitana-Lerma, Estado de México, Mexico • j.chavez@correo.ler.uam.mx https://orcid.org/0000-0003-2201-4748

* Corresponding author

Abstract

La Encrucijada Biosphere Reserve (REBIEN) and Puerto Arista Estuarine System (SEPA) are natural protected areas and Ramsar sites in Chiapas, Mexico. In this study, we conducted an inventory of medium-sized and large mammals using camera trapping. We recorded 23 species in the REBIEN and 13 species in the SEPA. In addition, 35% of the species recorded in the two sites are at some category of risk of extinction at the national or international level. The most abundant species in the REBIEN were Northern Raccoon (*Procyon lotor* (Linnaeus, 1758)) and White-Nosed Coati (*Nasua narica* (Linnaeus, 1766)). In the SEPA, White-tailed Deer (*Odocoileus virginianus* (Zimmermann, 1780)), Collared Peccary (*Dicotyles crassus* (Merrian, 1901)), and White-Nosed Coati (*Nasua narica*). Our results highlight the importance of both study sites in the conservation of medium-sized and large mammals and underline the urgent need to develop conservation strategies for these areas.

Keywords

Camera trapping, endangered species, diversity, inventory, Mammalia, protected areas, relative abundance

Academic editor: Héctor Ramírez-Chaves | Received 27 January 2021 | Accepted 12 August 2021 | Published 26 August 2021

Citation: Hernández-Hernández JC, Chávez C (2021) Inventory of medium-sized and large mammals in La Encrucijada Biosphere Reserve and Puerto Arista Estuarine System, Chiapas, Mexico. Check List 17 (4): 1155–1170. https://doi.org/10.15560/17.4.1155

Introduction

Wild mammals are one of the most conspicuous groups in terrestrial vertebrate communities (Sánchez-Cordero et al. 2014). Mammals cover a wide range of niches, playing crucial ecological roles that influence community structure and ecosystem functioning (Ripple et al. 2014). However, they are sensitive to human-generated impacts, being the third most vulnerable group among vertebrates, with about 25% of species under some category of risk according to the Red List of Threatened Species (IUCN 2020). Records of the mammalian species at a site, region, or country can help to develop conservation strategies that combine ecological foundations, biodiversity, critical habitat, and key ecological relationships, all of which may be site-specific and species-specific at any given time (Rovero et al. 2014). These assessments also provide information on biodiversity values that are recognized and considered in planning and decision-making processes (Ruíz-Gutiérrez et al. 2020).

The state of Chiapas, which is widely recognized as one of the regions with the greatest richness of wild mammals in Mexico (Ceballos and Oliva 2005; Naranjo et al. 2005), has 207 species, which altogether represent 37% of all the mammalian fauna of Mexico (Rivero and Medellín 2015). However, there are still areas within Chiapas, such as the La Encrucijada Biosphere Reserve (REBIEN) and the federal protected area Puerto Arista Estuarine System (SEPA), with little available information on the mammalian fauna. Within SEPA, the flat landscape on the southern side of the Coastal Plain is interrupted by Cerro de Bernal, which is the only noteworthy mountain south of the Mexican municipality of Tonalá, Chiapas. This mountain is part of the Sierra Madre de Chiapas and makes up part of the biological corridor between SEPA and REBIEN, which spans the area between the coastal plain and the Sierra Madre (INE 1999). This connectivity between mountain and the marine environments maintains important ecotones at the coastal level, and this biological corridor is of great importance for conservation of biodiversity and maintenance of ecosystem services in the region (IDESMAC 2016). Both study sites are located in the Pacific Coastal Plain physiographic region, and they present provide several types of habitats, microhabitats, and unique climatic conditions (INE 1999). However, despite being classified as Ramsar sites in the wetland's convention (FIR 2007), there are no information available on the local mammalian fauna within these areas. Under this premise, we provide a list of medium-sized and large mammals present in the REBIEN and the SEPA.

Study Area

The study sites are located in southern Chiapas, Mexico. They are La Encrucijada Biosphere Reserve (REBIEN, at 15°35.853′N, 093°20.430′W and 14°47.789′N, 092° 30.454′W; 0–10 m a.s.l.) and the northeast portion of the Puerto Arista Estuarine System (SEPA) in the area known as Cerro Bernal (15°54.223′N, 093°35.859′W; 1,020 m a.s.l.). The REBIEN has an area of 144,868 ha, of which 36,216 ha are in two central areas (La Encrucijada and Palmarcito) and 108,651 ha are part of a buffer zone. The types of vegetation present include mangroves, tule marsh, zapotonales, coastal scrub, floating and underwater vegetation, and medium sub-evergreen jungle forest (INE 1999; Fig. 1). There are 64 towns within the reserve with a total of 26,990 inhabitants, and the population has a high growth rate caused by migrants from Central America.

The predominant climate in this area is tropical-humid (Aw) with an average annual temperature of 28 °C and an annual precipitation between 2500 and 3000 mm (García 1973). The REBIEN It is the only area that protects the ecosystems and the flora and fauna species that inhabits the wetlands along the coast of Chiapas. This area is home to mangroves that reach of 35 m in height (considered the highest in North America). It is also one of the only flooded forests in Mexico that is dominated by *Pachira aquatica* (Aubl.), and palmares of *Sabal mexicana* (Mart.) (Mendoza 2000). Cerro Bernal extends over more than 8,000 ha and is home to remnants of medium sub-evergreen forest in the higher elevations and around ravines, and low sub-deciduous forest on the slopes (Fig. 2). The climate is warm sub-humid (Aw) with rains in summer, an average annual temperature of 26 °C, and annual rainfall that oscillates around 1,535 mm (FIR 2007; CONANP 2012).

Methods

Sampling. Field surveys at the REBIEN were carried out from August 2015 to August 2016, during which 30 stations were placed with a digital camera-traps of different models (two LTL Acorn 6210, eight ScoutGuard SG 550, and 20 Cuddeback C1). In the SEPA, sampling was carried out from November 2015 to July 2016, during which eight camera traps were placed (three Cuddeback Attack and five Cuddeback C1). The cameras were installed without any bait and were located in places where mammal signs (e.g., footprints and scat) were detected, with camaras set at a distance of 1–3 km apart; the active period was about 24 hours per day and cameras were programmed to take a photograph at 60-sec intervals. The photographed species were identified using field guides (i.e., Reid 2009). The classification and nomenclature of Mammal Diversity Database (2021) was used. The conservation status of the recorded species was obtained through the Official Mexican Legislation NOM-059-SEMARNAT-2010 (SEMARNAT 2010) and the Red List of Threatened Species (IUCN 2020).

Data analysis. In this study, medium-sized and large mammals were considered to be those whose adult body weight exceeded 500 g (Reid 2009). The species in both study sites are distributed in five trophic guilds: omnivorous, herbivorous, carnivorous, insectivorous, and frugivorous (González-Salazar et al. 2014). Species richness at both study sites was determined through an interpolation and extrapolation analysis proposed by Chao et al. (2014) using Hill's numbers (Hill 1973) for species richness ($q = 0$) based on incidence data. Likewise, richness species by sampling coverage was estimated, which is a measure of sample's completeness with respect to the community's size (Chao and Jost 2012). We analyzed data using the iNEXT package (Hsieh et al. 2016) integrated into R (R CoreTeam 2020). Additionally, we calculated the relative abundance index (RAI) for all species as:

$$\text{RAI} = (E/TN) \times 100 \text{ days/trap},$$

where E is the number of events photographed, TN is the total number of trap nights and 100 trap days (Lira-Torres et al. 2014). We used RAI because it is considered an accurate index of abundance for some species (Parsons et al. 2017; Palmer et al. 2018). However, the use of this index without calibration and its comparison

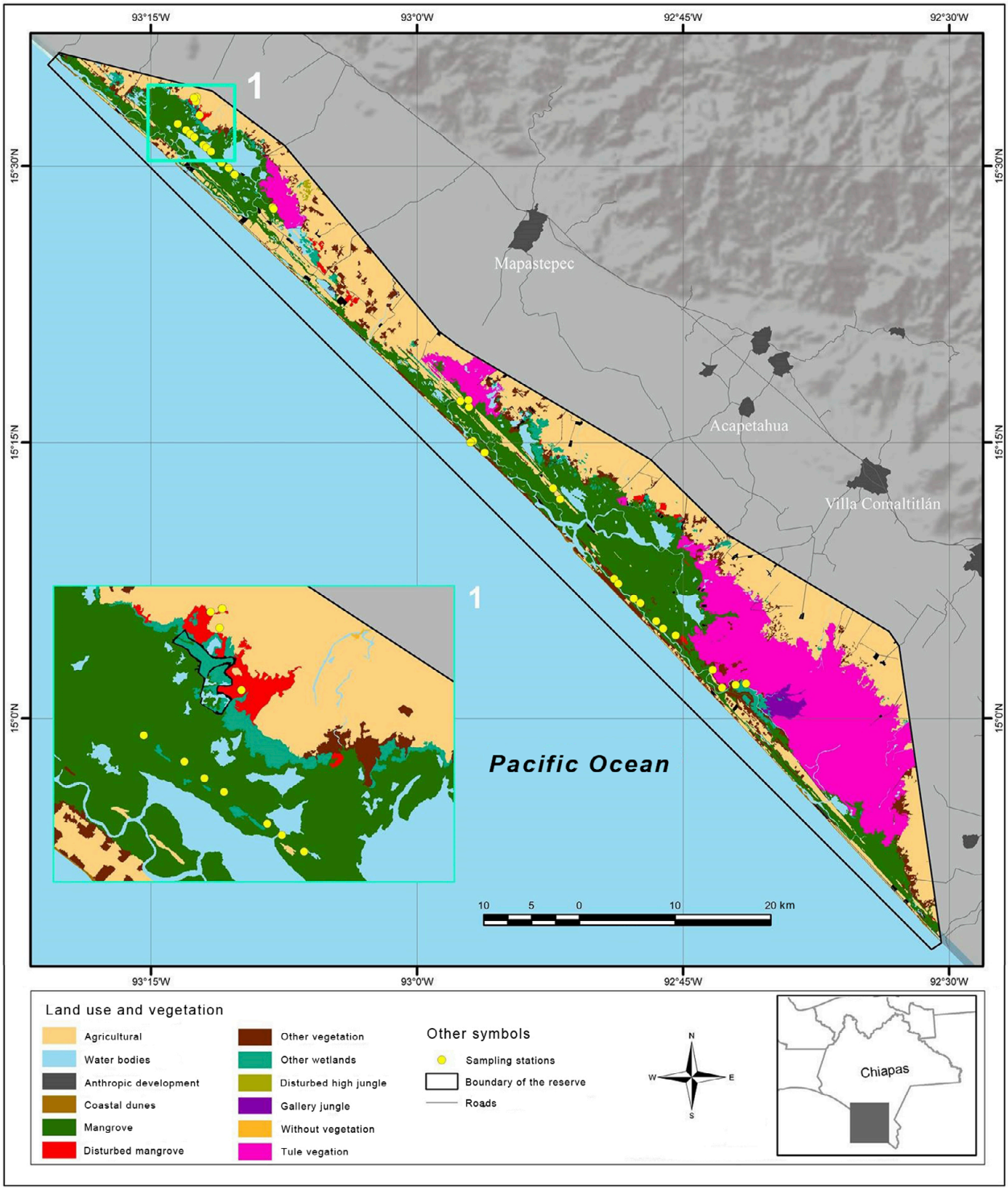

Figure 1. La Encrucijada Biosphere Reserve, Mexico, and camera-traps locations.

across time, space, or species is extremely problematic (O'Brien 2011); as a consequence, the use of the RAI can lead to erroneous conclusions about species abundance (Sunarto et al. 2013). Because it was not possible to individually identify to species all records, they were considered independent when consecutive photographs of clearly differentiable individuals were obtained or when consecutive photographs of individuals of the same species were separated by more than 24 h between an event and the next (Srbek-Araujo and Chiaraiello 2005; Chávez et al. 2013). For species with herd behavior, the number of independent records was considered equal to the number of individuals observed in the photographs (Maffei et al. 2002). For the annotated list we mention the number of independent records in stations in which each species was recorded when there were less than three and multiple when there were more than four.

Results

In the REBIEN, 19 species of medium-sized and large mammals were recorded, belonging to eight orders, 16

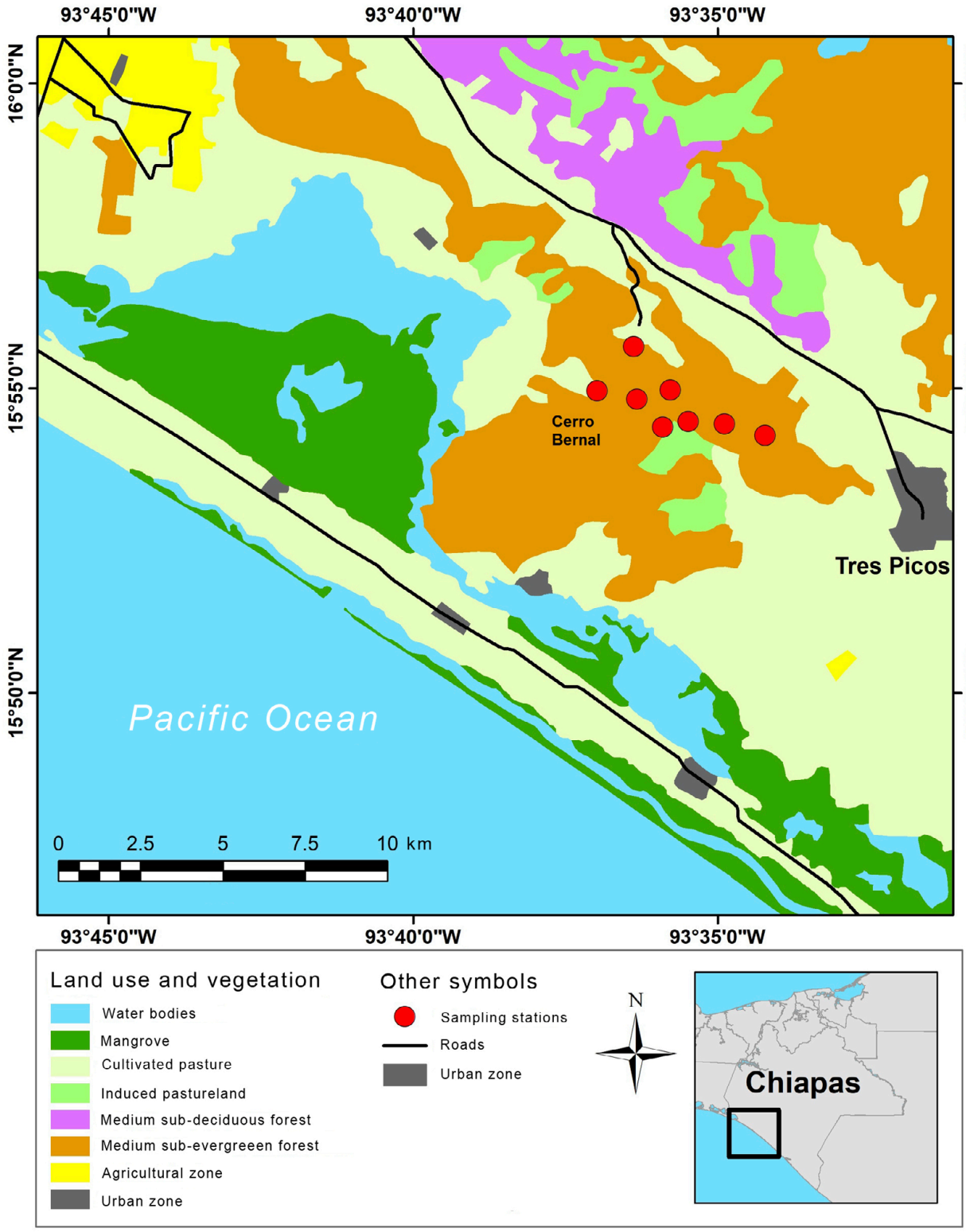

Figure 2. Location of the Puerto Arista Estuarine System and points of the photo-trapping stations at Cerro Bernal.

families, and 22 genera, with a sampling effort of 5,400 trap days. In addition, we added four other species to the list based on direct observations and the references consulted (Table 1; Figs. 3–5). In the SEPA, 13 mammal species were recorded, belonging to six orders, 11 families and 13 genera, with a sampling effort of 760 trap nights (Table 1; Figs. 3–5). An asymptotic trend in the curve was observed at both study sites (Fig. 6). Sample coverage was 99.8% for the REBIEN and 99.5% for the SEPA, indicating that the sampling effort was representative. The species in both study sites are distributed in five trophic guilds; seven are omnivorous, six are herbivorous, five are carnivorous, three insectivorous, and two frugivorous (Table 1). Of the recorded species, four are considered threatened; four are Endangered under Mexican legislation. Globally, two species, are categorized as Near Threatened and one Endangered (Table 1). The species with the highest RAI in the REBIEN were *Procyon*

Table 1. Species list of medium-sized and large land mammals detected with camera traps in La Encrucijada Biosphere Reserve (REBIEN) and Puerto Arista Estuarine System (SEPA). Conservation status according to the IUCN Red List (2020) and Mexican legislation (NOM-059-SEMARNAT 2010). IUCN categories: (LC) Least Concern, (NT) Near Threatened, and (EN) Endangered. NOM-059: (Th) Threatened, and (En) Endangered. The method by which the records of the species were obtained at the study sites is indicated by a P, when obtained through camera traps. L when it was obtained through literature, and Ob when it was obtained by direct observation. In the cases where literature was the information source, the superscript indicates the specific citation. Trophic guild: (O) omnivore, (C) carnivore, (I) insectivore, (H) herbivore, (F) frugivore.

Taxon	Common name	IUCN status	NOM-059	REBIEN	SEPA	Trophic guild
Didelphimorphia						
Didelphidae						
Philander vossi	Gray Four-eyed Opossum	LC		P	P	O
Didelphis marsupialis	Common Opossum	LC		P	P	O
Cingulata						
Dasypodidae						
Dasypus novemcinctus	Nine-banded Armadillo	LC		P	P	I
Pilosa						
Myrmecophagidae						
Tamandua mexicana	Northern Tamandua	LC	En	P	P	I
Primates						
Atelidae						
Ateles geoffroyi	Central American Spider Monkey	En	En	Ob		F
Lagomorpha						
Leporidae						
Sylvilagus floridanus	Eastern Cottontail	LC		P		H
Rodentia						
Cuniculidae						
Cuniculus paca	Lowland Paca	LC		P	P	H
Dasyproctidae						
Dasyprocta punctata	Central American Agouti	LC		P	P	F
Erethizontidae						
Coendou mexicanus	Mexican Porcupine	LC	Th	P, Ob		O
Sciuridae						
Sciurus aureogaster	Mexican Gray Squirrel	LC		L[1]		H
Sciurus variegatoides	Variegated Squirrel	LC		L[1]		H
Carnivora						
Canidae						
Urocyon cinereoargenteus	Gray Fox	LC		P		O
Canis latrans	Coyote	LC		P		O
Felidae						
Herpailurus yagouaroundi	Jaguarundi	LC	Th	P	P	C
Panthera onca	Jaguar	NT	En	P		C
Leopardus pardalis	Ocelot	LC	En	L[1]	P	C
Mephitinae						
Conepatus leuconotus	American Hog-nosed Skunk	LC		P	P	I
Mustelidae						
Galictis vittata	Greater Grison	LC	Th	P		C
Lontra longicaudis	Neotropical River Otter	NT	Th	P		C
Procyonidae						
Procyon lotor	Northern Raccoon	LC		P	P	O
Nasua narica	White-nosed Coati	LC		P	P	O
Artiodactyla						
Tayassuidae						
Dicotyles crassus	Collared Peccary	LC		P	P	H
Cervidae						
Odocoileus virginianus	White-tailed Deer	LC		P	P	H
Total				**23**	**13**	

[1]Espinoza et al. (2001).

lotor (Linnaeus, 1758) (RAI = 4.35) and *Nasua narica* (Linnaeus, 1766) (RAI = 3.91). In comparison species with the highest RAI in the SEPA were *Odocoileus virginianus* (Zimmermann, 1780) (RAI = 2.82), *Dicotyles crassus* (Merriam, 1901) (RAI = 1.92), and *N. narica* (RAI = 2.23) (Table 2).

Table 2. Relative abundance index of medium-sized and large land mammals detected with camera traps in some tropical areas of Mexico. The predominant vegetation type of the study site is indicated in parenthesis: (W) wetlands, (TSF) tropical semideciduous forest.

Species list	Study sites					
	REBIEN (W)[2]	SEPA (W)[2]	Marismas (W)[3]	Petenes (W)[4]	Tolistoque (TSF)[5]	Tepezcuintle (TSF)[1, 6]
Didelphimorphia						
Philander opossum	2.04	0.23	7.67	0.76		
Didelphis marsupialis	1.67	0.86	13.64	1.36		
Didelphis virginiana					0.52	
Cingulata						
Dasypus novemcinctus	1.02	0.86	0.11	0.68	0.51	0.07
Pilosa						
Tamandua mexicana	0.12	0.08			0.01	0.01
Primates						
Ateles geoffroyi				0.08		
Lagomorpha						
Sylvilagus floridanus	0.01					0.01
Sylvilagus sp.			0.4		0.11	
Rodentia						
Cuniculus paca	1.89	0.86		8.78		0.14
Dasyprocta punctata	0.08	0.16		17.05		
Dasyprocta mexicana					0.01	0.15
Coendou mexicanus	0.06					
Sciurus aureogaster					0.03	
Sciurus variegatoides						
Carnivora						
Procyon lotor	4.35	0.08	1.86	2.98	0.01	
Nasua narica	3.91	2.23	0.96	22.25	1.28	0.23
Herpailurus yagouaroundi	0.26	0.12	0.06			0.02
Puma concolor					0.11	
Panthera onca	0.06		2.65		0.01	
Leopardus pardalis		0.16	1.02	1.1	0.32	0.1
Leopardus wiedii				0.25		
Lynx rufus			1.41			
Urocyon cinereoargenteus	0.19			0.25	0.01	0.01
Canis latrans	0.18		1.02		0.6	0.02
Conepatus leuconotus	0.11	0.23			0.57	
Conepatus semistriatus				0.08		
Spilogale pygmaea					0.01	
Mephitis macroura					0.01	
Galictis vittata	0.02					
Lontra longicaudis	0.01					
Eira barbara						0.02
Artiodactyla						
Dicotyles crassus	0.29	1.92	0.28	1.53	2.62	0.22
Odocoileus virginianus	0.03	2.82	1.19	2.13	0.17	
Total no. of species per site	**19**	**13**	**14**	**14**	**18**	**12**

[1]The study was performed using camera-traps and complimentary methods such the use of live traps.
[2]This study.
[3]CONANP (2011).
[4]Hernández-Pérez et al. (2015).
[5]Cortés-Marcial and Briones-Salas (2014).
[6]Pérez-Irineo and Santos-Moreno (2012).

Annotated list

Family Didelphidae

Didelphis marsupialis Linnaeus, 1758

Common Opossum

Figure 3A

Material examined. MEXICO • Multiple; Salto de Agua, Isla Concepción, El Castaño, Salto de Agua, Cerro Bernal, Ejido Ceniceros; 15°27′44.93″N, 093°08′07.78″W; first capture on 27 August 2015; camera trap photos. Recorded in various habitat types in all seasons.

Identification. The back is gray to black, with hair in two layers; one hair layer is dense, short, and pale yellow, and the other, long and black or gray. This species can be confused with the Virginia Opossum (*D. virginiana* Kerr, 1792) (Colchero et al. 2014), but they differ in cheek coloration (cream to yellow in *D. marsupialis* and white

Figure 3. Medium-sized and large mammals detected by the camera traps in La Encrucijada Biosphere Reserve and Cerro Bernal of Puerto Arista Estuarine System, southeastern Mexico. **A.** *Didelphis marsupialis* **B.** *Philander vossi*. **C.** *Dasypus novemcinctus*. **D.** *Tamandua mexicana* **E.** *Ateles geoffroyi*. **F.** *Sylvilagus floridanus*. **G.** *Cuniculus paca.* **H.** *Dasyprocta punctata.*

in *D. virginiana*) and the length of the dark portion of the tail, which reaches more than half in *D. marsupialis.*

***Philander vossi* Gardner & Ramírez-Pulido, 2020**
Gray Four-eyed Opossum
Figure 3B

Material examined. MEXICO • Multiple; Salto de Agua, Isla Concepción, El Castaño, Salto de Agua; Cerro Bernal; 15°54′48.66″N, 093°36′19.62″W; first capture on 27 August 2015; camera trap photos. Recorded in various habitat types in all seasons. Very common in the study site. Recorded in various habitat types in all seasons.

Identification. The is a small marsupial. The color of the body varies from pale gray to black, and the face has darker hair in the form of a mask and a pair of white spots around each eye. Ventrally, including the bottom of the cheeks, the hair is whitish. The hair is relatively short (Castro-Arellano and Medellín 2014). Gardner and Ramírez-Pulido (2020) suggested using the name *P. vossi*, as the original name *Metachirus fuscogriseus pallidus* (J. A. Allen, 1901) is pre-occupied by *Philander laniger pallidus* (Thomas, 1899).

Family Dasypodidae

***Dasypus novemcinctus* Linnaeus, 1758**
Nine-banded Armadillo
Figure 3C

Material examined. MEXICO • Multiple; Ejido Ceniceros; Isla Concepción, El Castaño, Isla Tahití; Salto de Agua; Cerro Bernal; 15°06′16.07″N, 092°47′24.66″W; first capture on 12 September 2015; camera trap photos. Recorded in various habitat types in all seasons.

Identification. This is a medium-sized mammal and the only species of dasypodid found in Mexico (Hall 1981). Armadillos are the only mammal on the American continent whose body is covered with ossified dermal plates on the back, sides, tail, and top of the head, forming a carapace (Mendoza-Durán and Ceballos 2014a).

Family Myrmecophagidae

***Tamandua mexicana* (Saussure, 1860)**
Northern Tamandua
Figure 3D

Material examined. MEXICO • Multiple (sex unknown); Salto de Agua; Isla Solo Tú; Isla Novillero; Laguna Campón; Cerro Bernal; 15°11′54.19″N, 092° 51′55.88″W; first capture on 09 October 2015; camera trap photos. Usually recorded in mangroves. At Cerro Bernal we recorded only 2 individuals.

Identification. This species has a peculiar shape: the head and snout are elongated in a tubular form, and the opening of the mouth is small. It has a long, narrow tongue covered with sticky saliva produced by large salivary glands (Cuarón 2014).

Family Atelidae

***Ateles geoffroyi* Kuhl, 1820**
Central American Spider Monkey
Figure 3E

Material examined. MEXICO • 1 ♂ and 1 ♀; Isla Concepción; 15°04′08.04″N, 092°45′19.29″W; capture on 30 August 2015. Opportunistic observation of two individuals in the southern area of REBIEN, in a fragment of arboreal vegetation (jungle-mangrove).

Identification. Elongated, with the extremities particularly long and thin and a prominent abdomen. The head is small, with the muzzle well marked. The hair color is variable, brown, dark-brown, or black, although the dark coloration is dominant. The thumb is vestigial or absent, which limits spider monkeys from handling food and objects like other primates (Silva 2014).

Family Leporidae

***Sylvilagus floridanus* (Allen, 1890)**
Eastern Cottontail
Figure 3F

Material examined. MEXICO • 1 (sex unknown); El Castaño; 15°16′54.41″N, 092°57′03.87″W; capture on 16 December 2015; camera trap photo. Recorded in the northern area of REBIEN, in mangrove forest.

Identification. The coat is long and dense, brown to gray dorsally, and white on the belly and tail (Chapman et al. 1982; Ceballos and Galindo 1984). Due to its wide distribution, the diagnostic characteristics vary according to the location (Chapman et al. 1980).

Family Cuniculidae

***Cuniculus paca* (Linnaeus, 1766)**
Lowland Paca
Figure 3G

Material examined. MEXICO • Multiple; Ejido Ceniceros; Isla Concepción, El Castaño, Isla Tahití; Salto de Agua; Cerro Bernal; 15°06′16.07″N, 092°47′24.66″W; first capture on 20 August 2015; camera trap photos. Recorded in various habitat types in all seasons.

Identification. This is the largest rodent of the Mexican tropics. The coat is light brown with four longitudinal rows of white spots on the sides. The body is robust, and the ears and tail are short; it has four digits on the forefeet and five on the hind feet (Ortega-R. and Arita 2014).

Family Dasyproctidae

***Dasyprocta punctata* Gray, 1842**
Central American Agouti
Figure 3H

Material examined. MEXICO • Multiple; Ejido Ceniceros; El Castaño, Isla Tahití; Salto de Agua; Cerro Bernal; 15°06′16.07″N, 092°47′24.66″W; first capture on

30 August 2015; camera trap photos. Usually recorded in mangroves.

Identification. This is one of the largest rodents in Mexico. The body is slim and elongated, the ears are short, the tail is small and barely visible, and the hind feet are relatively longer than the forefeet and have three fingers. Usually the coat is rough and glossy, reddish-brown, yellowish-brown, or yellowish-gray, and it is relatively uniform on the back and sides, with fine blackish lines (Santos del Prado and Arita 2014).

Family Erethizontidae

***Coendou mexicanus* (Kerr, 1792)**
Mexican Porcupine
Figure 4A

Material examined. MEXICO • 7 (sex unknown); Ejido Ceniceros; El Castaño; 15°15′03.90″N, 092°56′50.21″W; first capture on 06 December 2015; camera trap photos. Independent records in mangroves.

Identification. This is a large rodent with a robust body, similar in size to a medium-sized rabbit. The head and the ears are very small. The paws have four fingers (the fifth is vestigial) fitted with long and curved nails. The body is covered by white-yellowish spines, with dark tips mixed with long hair which is dorsally yellow to dark brown; the underside has shorter spines, which are flexible and scarce and mixed with light gray fur. The tail is long with few spines and black hair in the lower third; the tip is naked and is prehensile (Juárez-G. 2014).

Family Felidae

***Herpailurus yagouaroundi* (É. Geoffroy Saint-Hilaire, 1803)**
Jaguarundi, Yaguarundi
Figure 4B

Material examined. MEXICO • Multiple ♂ and ♀; Laguna Campón, Isla Concepción, Isla Koakespala, El Castaño, Salto de Agua, Cerro Bernal; 15°33′42.91″N, 093°12′25.34″W; first capture on 30 August 2015; camera trap photos. Recorded in various habitat types in all seasons.

Identification. This is a small felid. Its coloration is uniform, but there are two basic colors: gray and reddish-brown with a variety of shades (da Silva et al. 2016). The body is slim and elongated, with a small head and a long tail (Aranda and Caso 2014).

***Leopardus pardalis* (Linnaeus, 1758)**
Ocelot
Figure 4C

Material examined. MEXICO • 2 (sex unknown); Cerro Bernal; 15°54′48.66″N, 093°36′19.62″W; first capture on 12 December 2015; camera trap photos. Rare in the study area.

Identification. This is a medium-sized felid. The body is light sandy brown to pale yellow and grayish-white on the interior parts of the limbs. The body is entirely covered with black spots, which on the flanks become elongated rosettes with brown centers; these spots are commonly obliquely oriented. This species differs from the Margay (*L. wiedii* (Schinz, 1821)) in its greater size, shorter tail, and pattern of spots (Moreno and Aranda 2014).

***Panthera onca* (Linnaeus, 1758)**
Figure 4D
Jaguar

Material examined. MEXICO • 1 ♀; Isla Rancho Viejo; Isla Mingo Hueso, Novillero; 15°27′44.93″N, 093°08′07.78″W; only record was 14 September 2015 by camera trap photos. Recorded within mangrove forests.

Identification. This is the largest American felid. The color of the fur varies from pale yellow to reddish-brown with white color gradations on the jowls, chest, and internal parts of the limbs. The body is entirely covered with black spots which form rosettes on the sides of the body; within these rosettes, there may be one or more small spots.

Family Canidae

***Urocyon cinereoargenteus* (Schreber, 1775)**
Gray Fox
Figure 4E

Material examined. MEXICO • Multiple; Laguna Campón, Isla Concepción, Isla Koakespala, El Castaño, Salto de Agua, Cerro Bernal; 15°16′54.41″N, 092°57′03.87″W; first capture on 14 October 2015; camera trap photos. Recorded in various habitat types in all seasons.

Identification. This is a medium-sized canid. The throat is white and the face gray, and the sides of the neck, the abdomen and the base of the tail are reddish. The back is grayish. The tail is also gray on the top, with a black distal end and a mid-dorsal line of the same color. The colors of the upper and lower sides are delimited by a brown opaque band that runs along each side of the body (Servín and Chacón 2014).

***Canis latrans* Say, 1822**
Coyote
Figure 4F

Material examined. MEXICO • Multiple; Laguna Campón, Isla Concepción, Isla Koakespala, El Castaño, Salto de Agua, Cerro Bernal; 15°15′03.90″N, 092°56′50.21″W; first capture on 10 September 2015; camera trap photos. Recorded in various habitat types in all seasons.

Identification. This is a medium-sized canid, similar to a thin German shepherd dog. The snout is elongated, and the eyes are small and relatively close together. The pelage varies from gray to reddish, passing through brown tones; the tail has a black tip. The underfur is always a lighter color. The ears are large and pointed (Servín et al. 2014)

Figure 4. Medium-sized and large mammals detected by the camera traps in La Encrucijada Biosphere Reserve and Cerro Bernal of Puerto Arista Estuarine System, southeastern Mexico. **A.** *Coendou mexicanus*. **B.** *Leopardus pardalis*. **C.** *Herpailurus yagouaroundi*. **D.** *Panthera onca*. **E.** *Urocyon cinereoargenteus* **F.** *Canis latrans*. **G.** *Conepatus leuconotus*. **H**. *Galictis vittata*.

Family Mephitidae

***Conepatus leuconotus* (Lichtenstein, 1832)**
American Hog-nosed Skunk
Figure 4G

Material examined. MEXICO • Multiple; Salto de Agua, El Castaño, Salto de Agua, Cerro Bernal; 15°14′26.37″N, 092°56′10.83″W; first capture on 01 September 2015; camera trap photos. Recorded in various habitat types in all seasons.

Identification. This skunk species is similar in size to a large domestic cat. The fur is highly variable in color, but the body is usually black, with a wide white dorsal band running from the top of the head to the tail. The white band can be very narrow in some individuals. The nose is long, naked, and flexible (Mendoza-Durán and Ceballos 2014b).

Family Mustelidae

***Galictis vittata* (Schreber 1776)**
Greater Grison
Figure 4H

Material examined. MEXICO • 2 (sex unknown); Ejido Ceniceros; 15°27′44.93″N, 093°08′07.78″W; first capture on 06 September 2015; camera trap photos. Two independents record within mangrove forests.

Identification. This mustelid is similar in size to a domestic cat, but the body is long and the legs and tail are very short. The neck is long, and the head is flat with small and rounded ears. The back is gray (white-haired), and there is a narrow white band on the forehead. The rest of the face, neck, belly, and limbs are black (Chávez 2014).

***Lontra longicaudis* (Olfers, 1818)**
Neotropical River Otter
Figure 5A

Material examined. MEXICO • 1 (sex unknown); El Castaño; 15°15′03.90″N, 092°56′50.21″W; first capture on 21 December 2015; camera trap photo. Recorded within mangrove forests near a body of water.

Identification. This is a medium-sized otter. The body is long, slim, and with a cylindrical trunk. The width of the neck is equal to the width of the skull, and the head is flat and rounded. The pinna of the ear is small. The muzzle is short but wide. The legs have short feet with interdigital webbing. The tail is wide at the base and in transverse view, long and oval. The fur is soft, fine, and arranged in two layers: the first one consists of long and short hair, the second has soft and abundant short hair that protects the skin from water (Gallo and Casariego 2014).

Family Procyonidae

***Nasua narica* (Linnaeus, 1766)**
White-Nosed Coati
Figure 5B

Observations. MEXICO • Multiple; Laguna Campón, Isla Concepción, Isla Koakespala, El Castaño, Cerro Bernal; 15°05′17.24″N, 092°46′31.32″W; first capture on 01 September 2015; camera trap photos. Recorded in groups (<20 individuals) in various habitat types in all seasons.

Identification. This is a medium-sized procyonid. The body is long and slender. The tail is long and often erect. The dorsal coloration varies from dark chestnut to reddish-brown or golden brown, the neck and shoulders tend to be golden chestnut (Valenzuela 2014a).

***Procyon lotor* (Linnaeus, 1758)**
Nothern Raccoon
Figure 5C

Material examined. MEXICO • Multiple; Laguna Campón, Isla Concepción, Isla Koakespala, El Castaño, Cerro Bernal; 15°15′03.90″N, 092°56′50.21″W; first capture on 28 August 2015; camera trap photo. Recorded in groups (<4 individuals) in various habitat types in all seasons.

Identification. This is a medium-sized procyonid with a robust body and short legs. The face has a black mask which covers the eyes and cheeks and extends from the nose to the forehead and across the middle of the eyes (Valenzuela 2014b). This is the only raccoon to occur in continental Mexico.

Family Tayassuidae

***Dicotyles crassus* (Merriam, 1901)**
Collared Peccary
Figure 6D

Material examined. MEXICO • Multiple ♂ and ♀; Isla Tahití; Isla Solo Tú; Cerro Bernal; 15°06′16.07″N, 092° 47′24.66″W; first capture on 01 September 2015; camera trap photos. Recorded in groups only in the southern zone of REBIEN and Cerro Bernal.

Identification. The body is robust, the tail is vestigial, and the head is large. The canines are well developed, and the nose ends in a nasal disk. The legs are short and thin, and end in hooves (March and Mandujano 2014).

Family Cervidae

***Odocoileus virginianus* (Zimmermann, 1780)**
While-tailed Deer
Figure 6E

Material examined. MEXICO • Multiple ♂ and ♀; El Castaño; Cerro Bernal; 15°15′03.90″N, 092°56′50.21″W; first capture on 17 November 2015; camera trap photos. We only recorded three individuals in the northern area of REBIEN. At Cerro Bernal we had 72 independent records.

Identification. The head and the neck are long and elongated. The legs are thin but strong. This cervid presents sexual dimorphism: only males have antlers, which are directed beyond and ahead of the skull, the main emerging branch has 2–6 ramifications. The tuft of white hairs on the base of the tail that bristles when it is excited

Figure 5. Medium-sized and large mammals detected by the camera traps in La Encrucijada Biosphere Reserve and Cerro Bernal of Puerto Arista Estuarine System, southeastern Mexico. **A.** *Lontra longicaudis*. **B.** *Procyon lotor*. **C** *Nasua narica*. **D.** *Dicotyles crassus*. **E.** *Odocoileus virginianus*.

or running away characterizes the white-tailed deer (Galindo-Leal and Weber 2014).

Discussion

This is the first study that estimates richness and abundance of medium-sized and large mammal species in the REBIEN and SEPA protected areas on Mexico's Pacific coast. The results of the interpolation and extrapolation curves (Fig. 6) can be considered as an accurate approximation of species richness of medium-sized and large mammals at these study sites. Although the two protected areas differ in their vegetation types and areas (INE 1999), of the 19 species recorded, 12 were found to occur at both sites, representing a species similarity of 75%. In instances such as this, an assessment of shared responses to environmental or spatial gradients and the natural history of the species are useful to identify the causes of this concordance (Ruíz-Gutiérrez et al. 2020), and additional study including biotic interactions and temporal and environmental variation at a fine scale may better explain the presence/absence of species in these areas (Rovero et al. 2014).

We also expect that the mammal richness at these areas

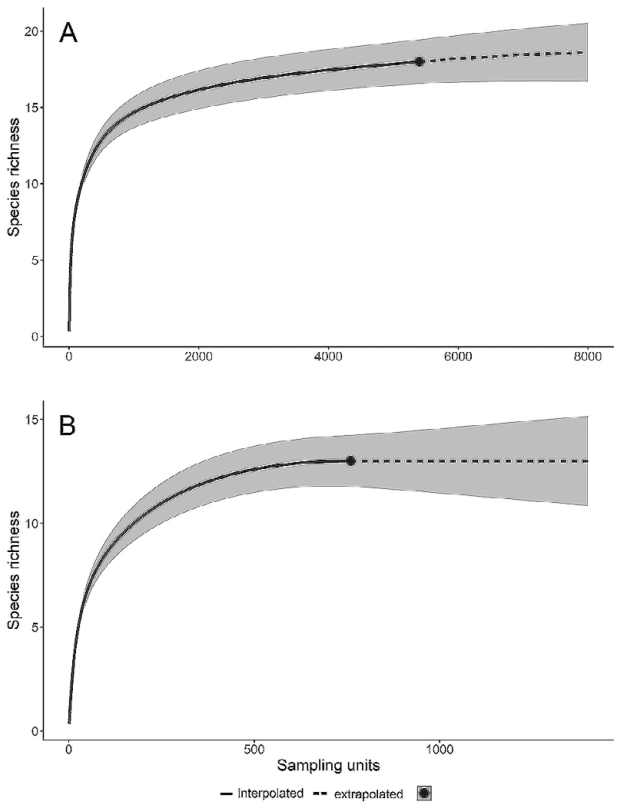

Figure 6. Species accumulation curve for mammal species richness (q = 0) where interpolated and extrapolated based on sampling effort (trap days). **A.** in La Encrucijada Biosphere Reserve (REBIEN). **B.** Puerto Arista Estuarine System (SEPA). The shaded area indicates the 95% confidence intervals. The extrapolation extends up to twice the reference sampling effort.

is similar to other areas in tropical Mexico. For example, 29 species have been reported in the Laguna de Terminos and Pantanos de Centla wetlands in southeastern Mexico (Hidalgo-Mihart et al. 2019), 20 species have been reported in both the Chaschoc-Sejá wetland in the state of Tabasco (Gordillo-Chávez et al. 2015) and the El Zapotal private reserve in the northeast of the Yucatán peninsula, and 16 species have recorded in El Edén Ecological Reserve, in Quintana Roo (Lazcano-Barrero et al. 2012).

Considering RAI in the REBIEN, the two most abundant species were *Procyon lotor* and *Nasua narica*. These results were similar to those reported in the wetlands of the Marismas Nacionales Biosphere Reserve in western Mexico (CONANP 2011) and Los Petenes Biosphere Reserve in the northwest of Yucatan Peninsula, Mexico (Hernández-Pérez et al. 2015), where the abundances of both these species was also high (Table 2). Reports of high abundance values of these species are common, as they have general or opportunistic feeding habits and a good capacity for adaptation to survive in a great variety of environments, even with the presence of human activity (Valenzuela and Ceballos 2000; Alfaro-Espinosa et al. 2006; Pérez-Irineo and Santos-Moreno 2010). *Nasua narica* is a highly social species that forms groups of up to 20 individuals (Valenzuela 2014a), with groups of up to 38 individuals having occasionally been reported (Kaufmann et al. 1976).

Regarding the RAI in the SEPA, *Odocoileus virginianus*, *N. narica*, and *Dicotyles crassus* were the most abundant species, which coincides with results recorded in other tropical forests of Mexico, such as the Sierra Tolistoque and the Tepezcuintle hill, two sites in Oaxaca (Pérez-Irineo and Santos-Moreno 2012; Cortes-Marcial and Briones-Salas 2014) (Table 2). *Odocoileus virginianus*, *N. narica*, and *D. crassus* predominate in several regions of Mexico (Valenzuela 1998; Bolaños and Naranjo 2001; González-Marín et al. 2008; Cortes-Marcial et al. 2014; Cruz-Jácome et al. 2015), likely due to their adaptability to disturbed environments or the plasticity of their feeding habits (Lowry et al. 2015).

Our study documented three species with relatively low RAI in both study sites: *Panthera onca*, *Herpailurus yagouaroundi*, and *Leopardus pardalis*. In contrast with results of some other studies, eight individuals of *P. onca* were reported in the Laguna de Terminos and Pantanos de Centla wetlands on the coast of the Gulf of Mexico (Hidalgo-Mihart et al. 2012), and the RAI of *H. yagouaroundi* in the El Edén Ecological Reserve (Torres-Romero et al. 2017) and in the Chimalapas forest (Briones-Salas et al. 2016) was higher than that observed in our study. Trolle and Kéry (2003) and Di Bitetti et al. (2006), mentioned that populations of *L. pardalis* tend to be higher in better conserved areas than in those exposed to human activity. However, anthropogenic factors (social and economic) are the cause of changes and disturbances in the natural and physical environment in the REBIEN and the SEPA, where the human use and modification of natural resources and soil are the main causes of transformation of these areas (IDESMAC 2016).

We note that our data and analysis are from a specific period of time and that there may be other explanations for the presence and absence of some species and these may be due to population dynamics. However, human impacts on both natural areas negatively affect species presence. Many of the species that we recorded have been traditionally used by local people for food, and medicinal purposes, so many of them are now absent in the immediate vicinity of villages (Barrasa 2012). Finally, biodiversity knowledge of the conservation units is a basic requirement for management plans, conservation strategies, and studies on ecological patterns and species distribution (Estes et al. 2018). We demonstrate the importance of the REBIEN and the SEPA as refugia for medium-sized and large mammals on the Chiapas coast. Unfortunately, we observed the presence of people and domestic dogs in the photographs from camera traps, and we had cameras stolen at some sites. The presence of hunters and domestic dogs highlight the need for greater vigilance and control to reduce the impact of hunting and exotic species, as well as to develop of environmental education programs in local communities.

Acknowledgements

We thank La Encrucijada Biosphere Reserve and the Sanctuary Beach of Puerto Arista, and in particular R.

Paredes-Montesinos for the facilities granted. Likewise, we thank F. Ruiz-Gutiérrez, E. Vázquez-Arroyo, U. Hernández-Sarabia, and the people of each locality for their help in the field. The financing of this study was supported by the Program for the Conservation of Species at Risk (PROCER), with the project "Conservation of the jaguar (*P. onca*) and other felines in the La Encrucijada Biosphere Reserve and the Puerto Arista Estuarine System". C. Chávez had support of Sistema Nacional de Investigadores and UAM-Lerma project (agreement 15.19.3) while conducting this research.

Authors' Contributions

Conceptualization: CC, JCHH. Data curation: JCHH. Formal analysis: JCHH, CC. Funding acquisition: CC. Investigation: JCHH, CC. Methodology: CC, JCHH. Supervision: CC. Writing – original draft: JCHH, CC. Writing – review & editing: JCHH, CC.

References

Alfaro-Espinosa AM, García-García JL, Santos-Moreno A (2006) Mamíferos de los municipios Santiago Jocotepec y Ayotzintepec, Chinantla Baja, Oaxaca. Revista Naturaleza y Desarrollo 4: 19–23.

Aranda M, Caso A (2014) *Herpailurus yagouaroundi* (Lacépede 1809). In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 498–499.

Barrasa S (2012) Conocimiento y usos tradicionales de la fauna en dos comunidades campesinas de la Reserva de Biosfera de la Encrucijada, Chiapas. Revista Etnobiología 10 (1): 16–28.

Bolaños JE, Naranjo E (2001) Abundancia, densidad y distribución de las poblaciones de ungulados en la cuenca del río Lacantún, Chiapas, México. Revista Mexicana de Mastozoología 5: 45–47.

Briones-Salas M, Lira-Torres I, Carrera-Treviño R, Sánchez-Rojas G (2016) Abundancia relativa y patrones de actividad de los felinos silvestres en la selva de los Chimalapas, Oaxaca, México. Therya 7 (1): 123–134. https://doi.org/10.12933/therya-16-320

Castro-Arellano I, Medellín R (2014) *Philander opossum* Linnaeus 1758. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA 80–82.

Ceballos G, Galindo C (1984) Mamíferos silvestres de la cuenca de México. Edit. Limusa, México, Mexico, 299 pp.

Ceballos G, Oliva G (2005) Los mamíferos silvestres de México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Fondo de Cultura Económica, México, DF, Mexico, 986 pp.

Chao A, Jost L (2012) Coverage-based rarefaction: standardizing samples by completeness rather than by size. Ecology 93 (12): 2533–2547. https://doi.org/10.1890/11-1952.1

Chao A., Gotelli NJ, Hsieh TC, Sander EL, Ma KH, Colwell RK, Ellison, AM (2014) Rarefaction and extrapolation with Hill numbers: a framework for sampling and estimation in species diversity studies. Ecological Monographs 84: 45–67. https://doi.org/10.1890/13-0133.1

Chapman JA, Hockman JG, Edwards WR (1982) Cottontails. In: Chapman JA, Feldhamer GA (Eds.) Wild mammals of north America: biology, management, economics. Johns Hopkins University Press, Baltimore, USA, 83–123.

Chapman JA, Hockman JG, Ojeda CMM (1980) *Sylvilagus floridanus*. Mammalian Species 136: 1–8.

Chávez C (2014) *Galictis vittata* Schreber 1776. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 544–545.

Chávez C, De la Torre A, Bárcenas H, Medellín RA, Zarza H, Ceballos G (2013) Manual de fototrampeo para estudio de fauna silvestre: el jaguar en México como estudio de caso. Alianza WWF, Telcel, Universidad Nacional Autónoma de México, México, Mexico, 103 pp.

Colchero F, O'Farrill G, Medellín R (2014) *Didelphis marsupialis* Linnaeus 1758. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 74–76.

CONANP (Comisión Nacional de Áreas Naturales Protegidas) (2011) Monitoreo de Jaguar (*Panthera onca*) en la Reserva de la Biosfera Marismas Nacionales, 11 pp. https://simec.conanp.gob.mx/pdf_monitoreo/77-marismas_jaguar.pdf. Accessed on: 2019-11-14.

CONANP (Comisión Nacional de Áreas Naturales Protegidas) (2012) Comisión Nacional de Áreas Naturales Protegidas. Directrices de Conservación y Manejo: Sistema Estuarino Puerto Arista, 49 pp. http://www.conanp.gob.mx/conanp/dominios/ramsar/docs/sitios/lineamientos_instrumentos/SISTEMA_ESTUARINO_PUERTO_ARISTA.pdf. Accessed on: 2018-1-17.

Cortés-Marcial M, Briones-Salas M (2014) Diversidad, abundancia relativa y patrones de actividad de mamíferos medianos y grandes en una selva seca del Istmo de Tehuantepec, Oaxaca, México. Revista de Biología Tropical 62 (4): 1433–1448. https://doi.org/10.15517/rbt.v62i4.13285

Cortés-Marcial M, Martínez-Ayón YM, Briones-Salas M (2014) Diversity of large and medium mammals in Juchitan, Isthmus of Tehuantepec, Oaxaca, Mexico. Animal Biodiversity and Conservation 37 (1): 1–12.

Cruz-Jácome O, López-Tello E, Delfín-Alfonso CA, Mandujano S (2015) Riqueza y abundancia relativa de mamíferos medianos y grandes en una localidad en la Reserva de la Biosfera Tehuacán-Cuicatlán, Oaxaca, México. Therya 6 (2): 435–448. https://doi.org/10.12933/therya-15-277

Cuarón AD (2014) *Tamandua mexicana* Saussure, 1860. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 100–101.

da Silva LG, de Oliveira TG, Kasper CB, Cherem JJ, Morales Jr. EA, Paviolo A, Eizirik E (2016) Biogeography of polymorphic phenotypes: Mapping and ecological modelling of coat colour variants in an elusive Neotropical cat, the jaguarundi (*Puma yagouaroundi*). Journal of Zoology 299: 295–303. https://doi.org/10.1111/jzo.12358

Di Bitetti MS, Paviolo A, De Angelo C (2006) Density, habitat use and activity patterns of Ocelots (*Leopardus pardalis*) in the Atlantic Forest of Misiones, Argentina. Journal of zoology 270: 153–163. https://doi.org/10.1111/j.1469-7998.2006.00102.x

Espinoza E, Cruz E, Kramsky H, Sánchez I (2003) Mastofauna de la Reserva de la Biosfera La Encrucijada, Chiapas. Revista Mexicana de Mastozoología 7: 5–19.

Estes L, Elsen PR, Treuer T, Ahmed L, Caylor K, Chang J, Choi J. Ellis EC (2018) The spatial and temporal domains of modern ecology. Nature. Ecology and Evolution 2: 819–826. https://doi.org/10.1038/s41559-018-0524-4

FIR (Ficha Informativa de los Humedales de Ramsar_ (2007) Sistema Estuariano Puerto Arista, 14 pp. https://rsis.ramsar.org/RISapp/files/RISrep/MX2045RIS.pdf. Accessed on: 2020-8-16.

Galindo-Leal C, Weber M (2014) *Odocoileus virginianus* Zimmermann, 1780. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 595–598.

Gallo JP, Casariego MA (2014) *Lontra longicaudis* Olfers, 1818. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 540–542.

García E (1973) Modificación al sistema de clasificación climática de Köppen. Instituto de Geografía, UNAM, México, Mexico, 90 pp.

Gardner A, Ramirez-Pulido J (2020) Type localities of Mexican land mammals, with comments on taxonomy and nomenclature. Special Publications of the Museum of Texas Tech University 73: 1–134.

González-Marín RM, Gallina S, Mandujano S, Weber M (2008) Densidad y distribución de ungulados silvestres en la reserva ecológica

El Edén, Quintana Roo, México. Acta Zoológica Mexicana 24 (1): 73–93.

González-Salazar C, Martínez-Meyer E, López-Santiago G (2014) A hierarchical classification of trophic guilds for North American birds and mammals. Revista Mexicana de Biodiversidad 85 (3): 931–941. https://doi.org/10.7550/rmb.38023

Gordillo-Chávez EJ, Mata EE, García-Morales R, Morales MA, Villanueva C, Valdéz-Leal JD (2015) Mastofauna del humedal Chaschoc-Sejá en Tabasco, México. Therya 6 (3): 535–544. https://doi.org/10.12933/therya-15-259

Hall ER (1981) The mammals of North America. 2 vols. John Wiley and Sons, New York, USA, 1300 pp.

Hernández-Pérez E, Reyna-Hurtado R, Castillo G, Sanvicente M, Moreira-Ramírez JF (2015) Fototrampeo de mamíferos terrestres de talla mediana y grande asociados a petenes del noroeste de la península de Yucatán, México. Therya 6 (3): 559–574. https://doi.org/10.12933/therya-15-290

Hidalgo-Mihart MG, Contreras-Moreno FM, Pérez-Solano L (2012) Jaguares de los humedales del sureste de México. Biodiversitas 104: 6–11.

Hidalgo-Mihart MG, Contreras-Moreno FM, Jesús-de la Cruz A, Juárez-López R, Bravata de la Cruz Y, Pérez-Solano LA, Hernández-Lara C, Friedeberg D, Thornton D, Koller-González JM (2019) Inventory of medium-sized and large mammals in the wetlands of Laguna de Terminos and Pantanos de Centla, Mexico. Check List 13 (6): 711–726. https://doi.org/10.15560/13.6.711

Hill MO (1973) Diversity and evenness: a unifying notation and its consequences. Ecology 54 (2): 427–432. https://doi.org/10.2307/1934352

Hsieh TC, Ma KH, Chao A (2016) iNEXT: an R package for interpolation and extrapolation in measuring species diversity. Methods in Ecology and Evolution 7: 1451–1456. https://doi.org/10.1111/2041-210X.12613

IDESMAC (Instituto para el Desarrollo Sustentable en Mesoamérica, A.C.) (2016) Instituto para el Desarrollo Sustentable en Mesoamérica, A. C. Atlas de riesgo Reserva de la Biosfera La Encrucijada, México, Mexico, 200 pp.

INE (Instituto Nacional de Ecología) (1999) Instituto Nacional de Ecología. Programa de manejo de la Reserva de Biosfera La Encrucijada. Secretaría de Medio Ambiente Recursos Naturales y Pesca, México, Mexico, 184 pp. http://www.paot.mx/centro/ine-semarnat/anp/AN09.pdf Accessed on: 2018-2-15.

IUCN (International Union for Conservation of Nature) (2020) The IUCN Red List of species. Version 2020-1. International Union for Conservation of Nature. https://www.iucnredlist.org/. Accessed on: 2020-4-13.

Juárez-G JR (2014) *Sphiggurus mexicanus* Kerr 1792. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA. 442–443.

Kaufmann JH, Lanning DV, Poole SE (1976) Current status and distribution of the coati in the United States. Journal of Mammalogy 57: 621–637. https://doi.org/10.2307/1379435

Lazcano-Barrero MA, Torres EJ, Castillo J, Espinoza E (2012) Reserva Ecológica El Edén, Quintana Roo. In: Ceballos G, Chávez C, Zarza H (Eds.) Censo Nacional del Jaguar y sus Presas (1ª Etapa). Informe Final SNIB-CONABIO Proyecto HE011. CONANP, IE-UNAM ALIAZA WWF-TELCEL, TELMEX y CONABIO. México, DF. http://www.conabio.gob.mx/institucion/proyectos/resultados/InfHE011.pdf. Accessed on: 2021-8-19.

Lira-Torres I, Briones-Salas M, Sánchez-Rojas G (2014) Abundancia relativa, estructura poblacional, preferencia de hábitat y patrones de actividad del tapir centroamericano *Tapirus bairdii* (Perissodactyla: Tapiridae), en la selva de Los Chimalapas, Oaxaca, México. Revista de Biología Tropical 62: 1407–1419.

Lowry H, Lill A, Wong BM (2013) Behavioural responses of wildlife to urban Environments. Biological Reviews 88: 537–549. https://doi.org/10.1111/brv.12012

Maffei L, Cuellar E, Noss J (2002) Uso de trampas cámara para la evaluación de mamíferos en el ecotono Chaco-Chiquitanía. Revista boliviana de ecología y conservación ambiental 11: 55-65.

Mammal Diversity Database (2021) Mammal diversity database (version 1.5) [data set]. Zenodo. http://doi.org/10.5281/zenodo.4139818

March IJ, Mandujano S (2014) *Pecari tajacu* Linnaeus, 1758. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 582–585.

Mendoza OE (2000) Support of the project to protect and conserve sea turtles in "La Encrucijada" Biosphere Reserve, Chiapas, México. In: Mosier A, Allen F, Beth B (Eds.) Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech Memo. NMFS-SEFSC, Orlando, Florida, USA. 340–342.

Mendoza-Durán A, Ceballos G (2014a) *Dasypus novemcinctus* Linnaeus 1758. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 92–93.

Mendoza-Durán A, Ceballos G (2014b) *Conepatus leuconotus* Lichtenstein 1832. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 551–552.

Moreno R, Aranda M (2014) *Leopardus pardalis* Linnaeus 1758. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 499–501.

Naranjo EJ, Lorenzo C, Horváth A (2005) La diversidad de mamíferos en Chiapas. In: González-Espinosa M, Ramírez-Marcial N, Ruiz-Montoya, L (Eds.) Diversidad biológica en Chiapas. Plaza y Valdés, México, D.F., Mexico, 221–263.

O'Brian TG (2011) Abundance, density and relative abundance: a conceptual framework. In: O'Connell AF, Nichols JD, Karanth KU (Eds.) Camera traps in animal ecology: methods and analyses. Springer, New York, USA, 71–96.

Ortega-R J, Arita H (2014) *Cuniculus paca* Linnaeus, 1766. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 448–449.

Palmer MS, Swanson A, Kosmala M, Arnold T, Packer C (2018) Evaluating relative abundance indices for terrestrial herbivores from large-scale camera trap surveys. African Journal of Ecology 56 (4): 791–803. https://doi.org/10.1111/aje.12566

Parsons AW, Forrester T, McShea WJ, Baker-Whatton MC, Millspaugh JJ, Kays R (2017) Do occupancy or detection rates from camera traps reflect deer density? Journal of Mammalogy 98 (6): 1547–1557. https://doi.org/10.1093/jmammal/gyx128

Pérez-Irineo G, Santos-Moreno A (2010) Diversidad de una comunidad de mamíferos carnívoros en una selva mediana del noreste de Oaxaca, México. Acta Zoológica Mexicana (Nueva Serie) 26: 721–736.

Pérez-Irineo G, Santos-Moreno A (2012) Diversidad de mamíferos terrestres de talla grande y mediana de una selva subcaducifolia del noreste de Oaxaca, México. Revista Mexicana de Biodiversidad 83: 164–169. https://doi.org/10.22201/ib.20078706e.2012.1.792

R Core Team (2020) A language and environment for statistical computing. The R Foundation for Statistical Computing, Vienna, Austria. https://www.r-project.org/. Accessed on: 2020-3-20.

Reid F (2009) A field guide to the mammals of Central America and southeast Mexico. 2nd ed. Oxford University Press, New York, USA, 384 pp.

Ripple WJ, Estes JA, Beschta RL, Wilmers CC, Ritchie EG, Hebblewhite M, Berger J, Elmhagen B, Letnic M, Nelson MP (2014) Status and ecological effects of the world's largest carnivores. Science 343 (6167): 1241484. https://doi.org/10.1126/science.1241484

Rivero M, Medellín R (2015) Mamíferos del estado de Chiapas. Revista Mexicana de Mastozoología (Nueva Época) 5 (2): 23–38.

Rovero F, Martin E, Rosa M, Ahumada JA, Spitale D (2014) Estimating species richness and modelling habitat preferences of tropical forest mammals from camera trap data. PLoS ONE 9 (7): e103300. https://doi.org/10.1371/journal.pone.0110971

Ruíz-Gutiérrez F, Chávez C, Sanchéz-Rojas G, Moreno CE, González-Zalazar Ruíz-Gutiérrez BO, Torres-Bernal R (2020) Mamífe-

ros medianos y grandes de la Sierra Madre del Sur de Guerrero, México: evaluación integral de la diversidad y su relación con las características ambientales. Revista Mexicana de Biodiversidad 91: 913168. https://doi.org/10.22201/ib.20078706e.2020.91.3168

Sánchez-Cordero V, Botello F, Flores-Martínez JJ, Gómez-Rodríguez RA, Guevara L, Gutiérrez-Granados G, Rodríguez-Moreno A (2014) Biodiversidad de Chordata (Mammalia) en México. Revista Mexicana de Biodiversidad 85: 496–504. https://doi.org/10.7550/rmb.31688

Santos del Prado K, Arita H (2014) *Dasyprocta punctata* Gray 1842. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 445–447.

SEMARNAT (Secretaría del Medio Ambiente y Recursos Naturales) (2010) Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección Ambiental. Especies Nativas de México de Flora y Fauna Silvestres. Categorías de Riesgo y Especificaciones para su Inclusión, Exclusión o Cambio. Lista de Especies en Riesgo. Diario Oficial de la Federación. 30 de diciembre de 2010, Segunda Sección. SEMARNAT, México DF, Mexico, 78 pp.

Servín J, Chacón E (2014) *Urocyon cinereoargenteus* Schreber 1775. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 514–515.

Servín J, Chacón E, List R (2014) *Canis latrans* Say 1823. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 510–511.

Silva G (2014) *Ateles geoffroyi* Kuhl 1820. In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 108–109.

Srbek-Araujo AC, Chiarello AG (2005) Is camera-trapping an efficient method for surveying mammals in neotropical forests? A case study in south-eastern Brazil. Journal of Tropical Ecology 21: 121–125. https://doi.org/10.1017/S0266467404001956

Sunarto S, Sollman R, Mohamed A, Kelly M (2013) Camera trapping for the study and conservation of tropical carnivore. The Raffles Bulletin of Zoology, Supplement 28: 21–42.

Torres A, Velázquez A, Lobato J (2003) Riqueza, diversidad y patrones de distribución espacial de los mamíferos. In: Velázquez A, Torres A, Bocco G (Eds) Las enseñanzas de San Juan, Investigación participativa para el manejo integral de recursos naturales. Instituto Nacional de Ecología, Secretaría de Medio Ambiente y Recursos Naturales, México, DF, Mexico, 277–299.

Torres-Romero EJ, Espinoza-Medinilla E, Lazcano-Barrero MA, Maffei L (2017) Ecology and conservation of Ocelot (*Leopardus pardalis*) in northern Quintana Roo, Mexico. Therya 8 (1): 11–18. https://doi.org/10.12933/therya-17-439

Trolle M, Kéry M (2003) Ocelot density estimation in the pantanal using capture-recapture analysis of camera-trapping data. Journal of Mammalogy 84: 607–614. https://doi.org/10.1644/1545-1542(2003)084<0607:eoodit>2.0.co;2

Valenzuela D (1998) Natural history of the White-nosed Coati, *Nasua narica*, in a tropical dry forest of western Mexico. Revista Mexicana de Mastozoología 3: 26–44.

Valenzuela D (2014a) *Nasua narica* (Linnaeus 1766). In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 566–569.

Valenzuela D (2014b) *Procyon lotor* (Linnaeus 1758). In: Ceballos G (Ed.) Mammals of Mexico. Johns Hopkins University Press, Baltimore, USA, 571–573.

Valenzuela D, Ceballos G (2000) Habitat selection, home range and activity of the white nosed coati (*Nasua narica*) in a mexican tropical dry forest. Journal of Mammalogy 81: 810–819. https://doi.org/10.1644/1545-1542(2000)081<0810:hshraa>2.3.co;2