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Medium and large terrestrial mammals in an area voluntarily designated for conservation in the northern Yucatan Peninsula, Mexico

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Conservation areas designated voluntarily are part of a government strategy to protect biodiversity in Mexico and are important for the conservation of medium-sized and large mammals. The objective of this study was to contribute to the knowledge of the diversity of medium- and large-sized mammals in the Voluntarily Designated Conservation Area in the state of Yucatán, Komchén de los Pájaros. Activity patterns and species under some risk category were determined, as well as estimates of species richness, diversity, the relative abundance index of each species. Systematic sampling was conducted from December 2019 to December 2021, selecting four permanent sites and simultaneously carrying out non-systematic sampling The relative abundance index and sampling effort were calculated with non-parametric estimators, Chao 1 and Chao 2, using the EstimateS program. The species accumulation curve was constructed, and the activity patterns were established. Histograms with hours of activity were obtained using the Oriana Version 4.0 software. Fifteen mammal species were identified with a sampling effort of 4256 trap nights, 33 % of which were protected. The independent records and relative abundance index prioritized *Nasua narica, Odocoileus virginianus*, and *Urocyon cinereoargenteus*. Fourteen species were recorded in the northern season, six during rainfall, and six were permanent. The pattern of activity was obtained, being diurnal in *N. narica*, nocturnal in *Didelphis virginiana*, *Dasypus novemcinctus*, *Sylvilagus yucatanicus*, *Canis latrans,* and *Procyon lotor,* and cathemeral in *U. cinereoargenteus* and *O. virginianus*. Photo trapping not only allowed us to know mammal diversity, but also to document their behavior and determine their activity patterns (diurnal, nocturnal, and cathemeral) and degree of sociability (group or solitary). Preserving this habitat is essential to protect regional diversity, particularly for mammals currently threatened by various anthropogenic activities.

Key words: activity patterns, conservation island, diversity, photo records, relative abundance, risk categories, Yucatan Peninsula.

Las áreas destinadas voluntariamente a la conservación forman parte de una estrategia gubernamental para proteger la biodiversidad en México y son importantes para la conservación de mamíferos de talla mediana y grande. El objetivo de este estudio fue contribuir al conocimiento de la diversidad de mamíferos medianos y grandes en el área destinada voluntariamente a la conservación en el estado de Yucatán. Se determinaron los patrones de actividad y las especies en alguna categoría de riesgo, así como estimar la riqueza, diversidad y el índice de abundancia relativa de cada especie. El muestreo sistemático se llevó a cabo de diciembre de 2019 a diciembre de 2021, seleccionando cuatro sitios permanentes y realizando simultáneamente muestreos no sistemáticos. El índice de abundancia relativa y el esfuerzo de muestreo se calcularon con los estimadores no paramétricos Chao 1 y Chao 2, utilizando el programa EstimateS. Se construyó la curva de acumulación de especies y se establecieron los patrones de actividad. Se obtuvieron histogramas con horarios de actividad empleando el software Oriana versión 4.0. Se identificaron 15 especies de mamíferos con un esfuerzo de muestreo de 4256 días-trampa, de las cuales 33 % estuvieron bajo alguna categoría de protección. Los registros independientes y el índice de abundancia relativa destacaron a *Nasua narica, Odocoileus virginianus* y *Urocyon cinereoargenteus*. Se registraron 14 especies en la temporada de nortes, seis durante lluvias y seis fueron permanentes. Se obtuvieron los patrones de actividad, siendo diurno en *N. narica*; nocturnos en *Didelphis virginiana*, *Dasypus novemcinctus*, *Sylvilagus yucatanicus*, *Canis latrans,* and *Procyon lotor,*; y catemerales en *U. cinereoargenteus* y *O. virginianus*. El fototrampeo no solo permitió conocer la diversidad de mamíferos, sino también documentar su comportamiento y determinar sus patrones de actividad (diurnos, nocturnos y catemerales) y su grado de sociabilidad (gregarios o solitarios). Conservar este hábitat es fundamental para proteger la diversidad regional, particularmente de los mamíferos amenazados actualmente por diversas actividades antropogénicas.

Palabras clave: categorías de riesgo, diversidad, isla de conservación, fotoregistros, abundancia relativa, patrones de actividad, Península de Yucatán.

In the Yucatán Peninsula, the presence and distribution of 152 mammal species have been documented; of these, 123 species are terrestrial mammals, belonging to 89 genera, 29 families, and 11 orders (Sosa-Escalante *et al.* 2013), representing approximately 26 % and 2 % of the terrestrial mammal fauna recognized for Mexico and the world, respectively (Ramírez-Pulido *et al.* 2005; Wilson and Reeder 2005). The state of Yucatan has 128 species of mammals, of which 99 are terrestrial, grouped into 78 genera, 29 families, and 11 orders (Sosa-Escalante *et al.* 2014); 36 are of medium size, and five are considered large. Of the total species in this area, 22 are at risk (three subject to special protection, 10 threatened, and nine endangered) according to the Mexican standard NOM-059-SEMARNAT-2010 (SEMARNAT 2010, 2019); the Convention on International Trade in Endangered Species (CITES 2025), lists 12 species (seven in Appendix I and five in Appendix II; https://cites.org/sites/default/files/esp/app/2022/S-Appendices-2022-06-22.pdf) and the International Union for Conservation of Nature (IUCN 2025) lists 96 species (three threatened, two vulnerable, three endangered, one extinct, 87 least concern).

There is a marked variation in mammalian body size and morphology (Arita and Figueroa 1999), traits considered for the various classifications of mammals (Rumiz *et al.* 1998; Garmendia *et al.* 2013; Hernández-Pérez *et al.* 2015; Coronel-Arellano *et al.* 2018; Hernández *et al.* 2018; Pérez-Solano *et al.* 2018; Ruiz-Gutiérrez *et al.* 2020); particularly, body size is of interest in this work to classify mammals into medium-sized (1–30 kg) and large (>30 kg; Pineda-Muñoz *et al.* 2016).

A central aspect in the study of mammals is the direct observation of individuals under natural conditions; however, many species are difficult to observe due to their behavior patterns, low densities, and elusiveness (Chávez *et al.* 2013). For this reason, one of the techniques most widely used worldwide for studying large and medium-sized mammals is photo trapping, which consists of the use of camera traps that are automatically activated when they detect movement or temperature changes, recording the species distributed in the area of interest (Chávez *et al.* 2013; Hernández-Pérez *et al.* 2015).

After Mandujano (2019), which summarizes the use of camera traps in Mexico, at least 19 formal publications have emerged that employed photo trapping as a primary or supplementary method for obtaining data or records of the presence of medium-sized and large mammal and bird species in Mexico. This study reports 34 species of mammals and six species of birds in the title of 188 documents as of 2017. For mammals, the most studied species were *Panthera onca, Leopardus pardalis, Puma concolor, Tapirus bairdii, Tayassu pecari, Odocoileus virginianus,* and *Cuniculus paca*; for birds, *Penelope purpurascens* was the species most frequently studied. Additionally, it mentions that the topics covered include the expansion of the geographic range, species diversity, estimates of relative abundance and population density using capture-recapture, activity patterns between species, and ecological interactions.

Inventories carried out with the photo-trapping technique for studies focused on diversity (Hernández-Pérez *et al.* 2015; Coronel-Arellano *et al.* 2018), population ecology and activity patterns (Monroy-Vilchis *et al.* 2009; Hernández-Hernández *et al.* 2018) for large and mid-sized mammals represent a reliable and non-invasive tool (Silveira *et al.* 2003; Monroy-Vilchis *et al.* 2009); when these are combined with the use of attractants (artificial drinking fountains and olfactory stimuli), they are highly efficient to detect both diurnal and nocturnal animals, and even cryptic, rare and evasive species that are hard to detect with other techniques.

Other works that demonstrate the effectiveness of photo trapping include those of Hidalgo-Mihart *et al.* (2017). These authors used camera traps to inventory medium-sized and large mammals in the Laguna de Términos and Pantanos de Centla wetlands, in southeastern Mexico, which are highly complex and hard-to-access habitats, recording 30 native species, including *Cuniculus paca*, five feline species, *Lontra longicaudis, Eira barbara,* and an introduced species, *Sus scrofa*.

Over the years, several studies on terrestrial mammals have been carried out within the peninsula and the state of Yucatan. A recent work at the peninsular scale using photo trapping is that of Hernández-Pérez *et al.* (2015). At the local level in the state of Yucatán, several studies have also employed photo trapping (Hernández-Betancourt *et al.* 1996; Faller-Méndez *et al.* 2005; Mejenes-López *et al.* 2021; Peláez-Cruz *et al.* 2022). Additionally, recent studies have employed other techniques for recording diversity (Balam-Ballote *et al.* 2020; Cimé-Pool *et al.* 2020). The results of these studies provide information required to confirm the presence of mammal species in unexplored areas; additionally, there are projects aimed at identifying suitable zones for maintaining viable populations in the long term (Hernández-Pérez *et al.* 2015). Recent contributions focusing on confirming mammal diversity at local and state levels enrich the information on this group for the state of Yucatan; the latest update of the taxonomic list was contributed by Sosa-Escalante *et al.* (2014). However, the great extension and diversity of the state of Yucatan require focusing research efforts on the diversity of mammals in Protected Natural Areas (private, municipal, state, and federal) and on the evaluation of priority areas for ecological restoration (Sosa-Escalante *et al.* 2013). These would provide solid scientific ground for the design of strategies, since mammals should not be a focal group only because of their market or use value but should be considered marker groups for assessing the health status of habitats (Sosa-Escalante *et al.* 2014), with particular emphasis on the species listed in a risk category.

According to their activity patterns, mammals are classified into diurnal, nocturnal, crepuscular, and catameral. Diurnal species are active mainly during daylight hours; nocturnal species are active mainly at night; crepuscular species show peak activity during sunrise and sunset; and catameral species distribute their activity evenly

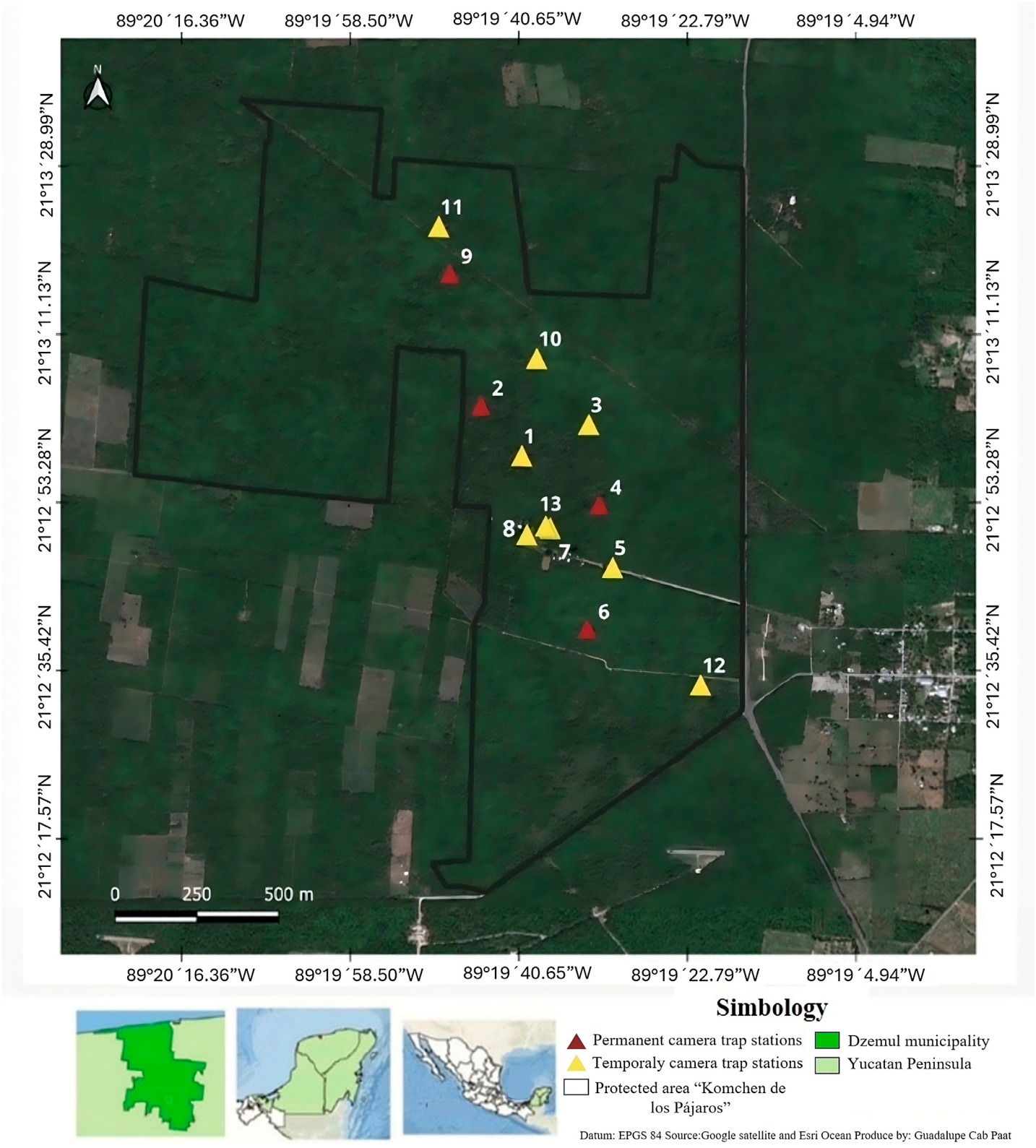

Figure 1. Photo trapping stations and geographical location of the conservation area designated voluntarily Komchén de los Pájaros, Dzemul, Yucatán, Mexico.

throughout the 24-h cycle or at peaks of activity, particularly regarding feeding or displacements, in both daytime and at night (Tattersall 2006). These patterns are useful for understanding how species utilize their local environment, predicting the times and seasons with the highest impact due to hunting, and contributing to management elements for the conservation of the area.

For the above, this work aims to contribute to the knowledge of the local diversity of medium-sized and large mammals in a conservation area designated voluntarily (AVDC, in Spanish) in the state of Yucatán to highlight it as a wildlife refuge; particularly, our objectives are to estimate the diversity and relative abundance index (RAI) for each species, species richness using Chao 1 and 2,

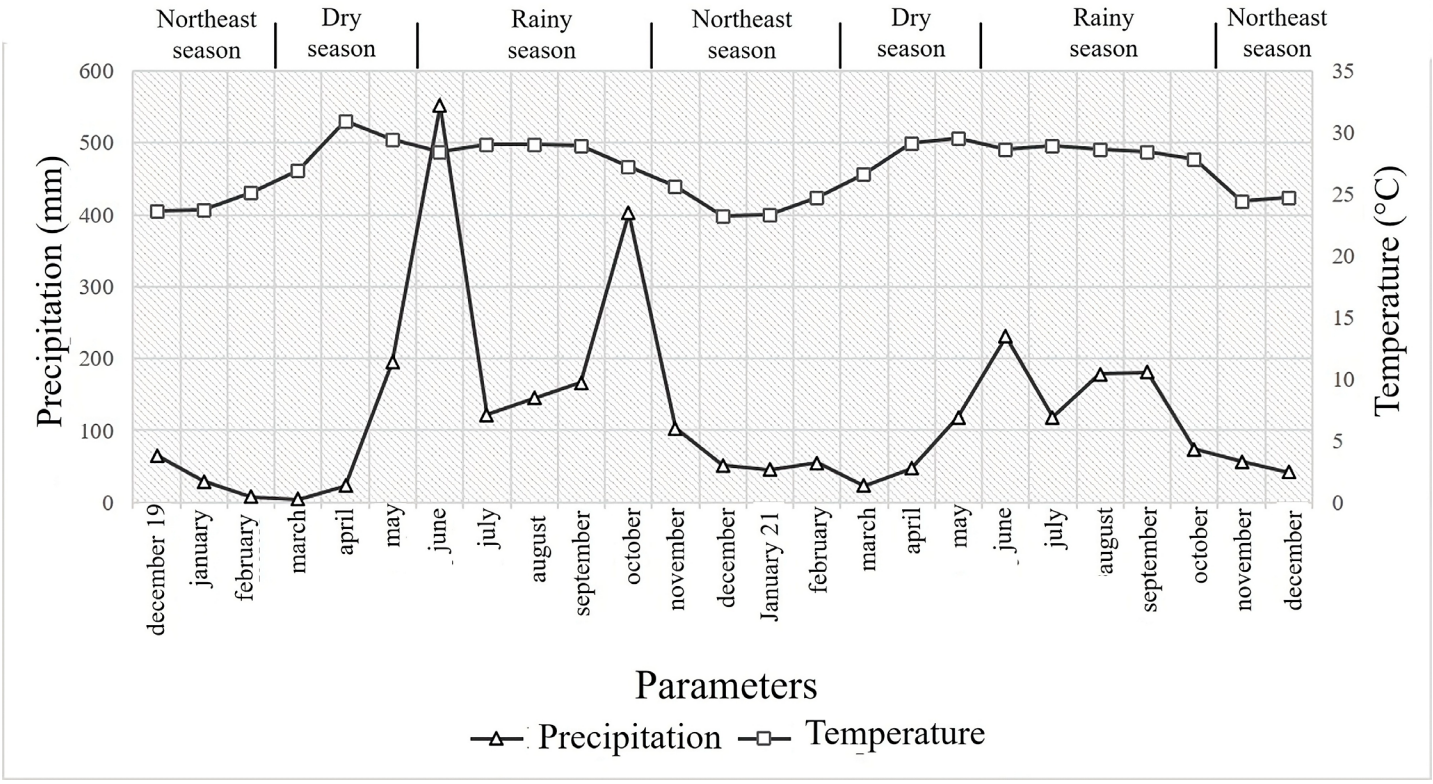

Figure 2. Climate chart with monthly mean temperature and precipitation from 2020 to 2021 in the conservation area designated voluntarily Komchén de los Pájaros, Dzemul, Yucatán, Mexico.

and determine the species in risk categories, and activity patterns using the photo trapping technique.

Materials and methods

Study area. The voluntary designated for conservation area (AVDC) named Komchén de los Pájaros (KdlP) is located at kilometer 1.5 of the Dzemul-Xtampú road pass, south of the municipality of Dzemul, in the north of the state of Yucatán (Figure 1); it has an area of 300 ha within an altitude range of 0 to 15 m (Rzedowski 1978; INEGI 2005; Morrone 2005). The soil type is Leptosol with outcrops of limestone rocks and slabs, well drained, and with little moisture retention (Flores and Espejel 1994; Olmstead *et al.* 1995; INEGI 2009). The local vegetation is a low deciduous tropical forest, characterized by trees less than 15 m in height with non-thorny trunks and that shed their leaves in the dry season; the dominant species belong to the family Fabaceae (Miranda and Hernández-X. 1963), with the presence of columnar cacti (*Pterocereus gaumeri* and *Nopalea gaumeri*; Flores and Espejel 1994). The regional climate is warm and semi-dry, with a mean annual temperature ranging from 18 °C to 24 °C, and a mean annual precipitation between 700 mm and 1200 mm (Miranda and Hernández-X. 1963; Holdridge *et al.*1971). The climate seasons for the study area were defined more accurately by reviewing the annual temperature and precipitation summaries for the sampling period (2020, 2021) based on data recorded by the Telchac Puerto weather station obtained from CONAGUA (2020, 2021). In those years, the mean annual temperature was 27.3 °C and 27.1 °C, and the mean annual precipitation was 1802.2 mm and 1172.6 mm, respectively. These characteristics confirm the temporal pattern reported by Herrera-Silveira (1994) for the Yucatán peninsula, where the dry season occurs from March to May, in which temperature is high and precipitation is extremely low; it is followed by the rainy season from June to October, with high precipitation and lower temperatures; finally, the "*nortes*" season occurs from November to February, recording the lowest temperatures and precipitation (Figure 2).

Fieldwork. Sampling was carried out from December 2019 to December 2021, using eight camera traps, one Moultrie (model M-4000), one Primo (model 63053), three Bushnell HD (model 119876), and three CuddeBack (model h-1453). The sites were selected based on accessibility (trails) and water availability (artificial water fountains and cenotes) to capture the highest species diversity (O'Brien *et al.* 2011). As a systematic sampling, we selected four permanent sites (positions 2, 4, 6, and 9; Figure 1); at the same time, we performed random sampling by installing four temporary cameras for variable periods of time at each site (positions 1, 3, 5, 7, 8, 10, 11, 12, and 13; Figure 1), selected based on the previous finding of indirect records of mammals (stools/feces or footprints). Permanent sites 2 and 6 functioned as dual stations for six months (January–July 2021). Camera traps were installed on live tree trunks approximately 0.5 m above the ground, each along trails near water sources. Each camera trap was set to produce three consecutive shots when activated and operated for 24 h, until the batteries were depleted. Camera traps were reviewed once a week, and the cards were replaced each month. Camera traps

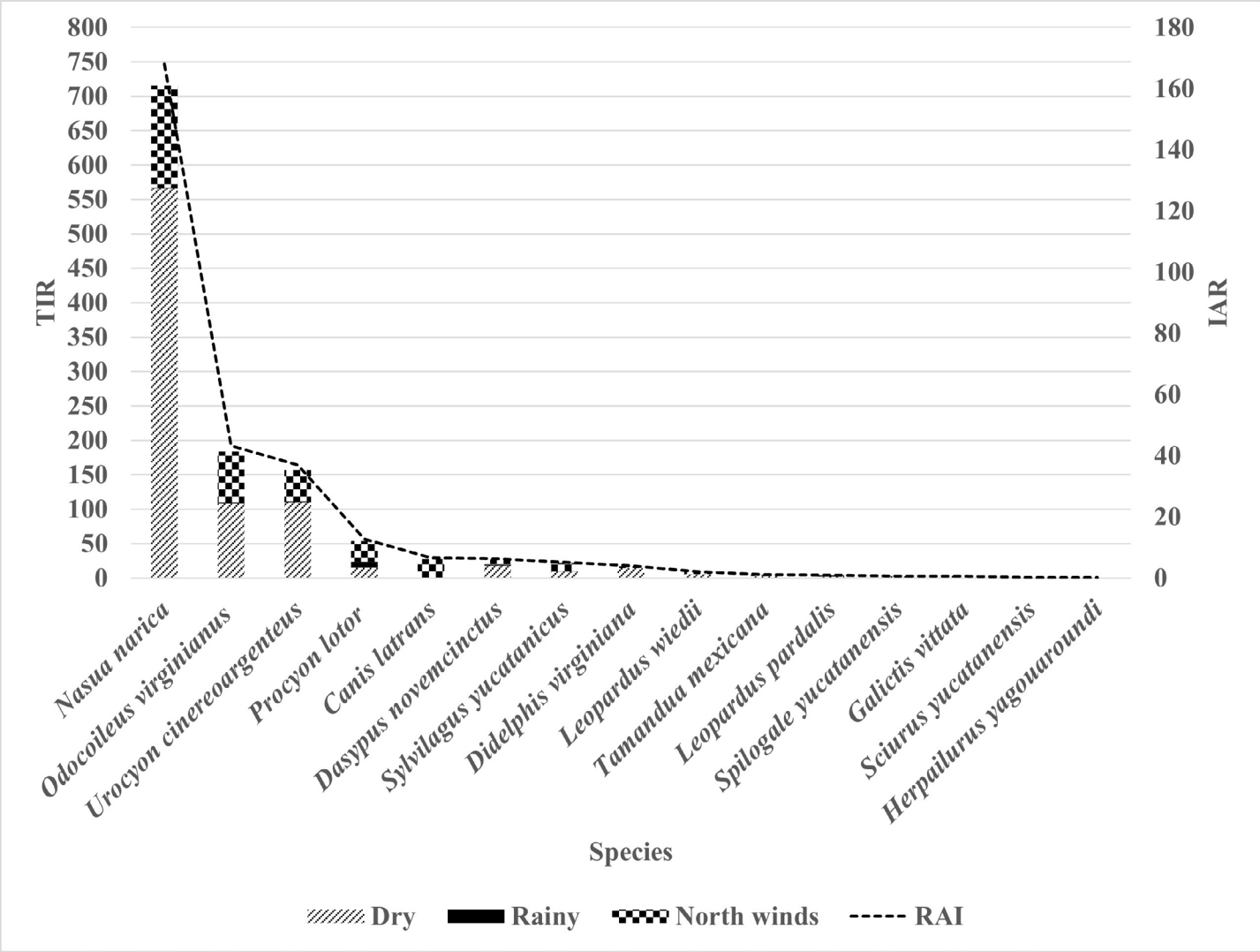

Figure 3. Total independent records (TIR) and Relative Abundance Index (RAI) for each species recorded in the conservation area designated voluntarily Komchén de los Pájaros, Dzemul, Yucatán, Mexico.

were in operation for 89 weeks. We divided the sampling into three periods due to the flooding of the study area in early May, leading to the following periods: first period, from December 2019 to May 2020, with seven camera traps and covering a total of 20 effective weeks; second period, from June to December 2020, with only four camera traps and covering a total of 20 effective weeks; and third and last period, from January to December 2021, with eight camera traps operating for 48 effective sampling weeks.

The sampling effort was calculated using a formula that considers the number of camera traps multiplied by the number of sampling days (Medellín *et al.* 2006; Lira-Torres and Briones-Salas 2012). This formula was adapted to meet the project needs, as the sampling time was divided into periods. We first calculated a partial sampling effort per period, and then the three results were added to obtain the total effort (SE_T): $SE_T = SE_{P1} + SE_{P2} + SE_{P3}$. The relative abundance index (RAI; Medellín *et al.* 2006; Lira-Torres and Briones-Salas 2012) was calculated with the formula $RAI = C/SE * 1000$ trap nights, where C = number of captures or independent photographed events, SE = sampling effort (number of camera traps multiplied by number of monitoring days), and 1000 trap nights = (standard unit).

Office work. In order to estimate the total number of independent records (TIR), to avoid counting the same individual several times, only the following cases were considered independent photo captures: 1) consecutive photographs of different individuals; 2) consecutive photographs of individuals of the same species separated by more than 24 h; this criterion was applied when it was not clear whether a series of photographs corresponded to the same individual; 3) non-consecutive photographs of individuals of the same species (Medellín *et al.* 2006; Monroy-Vilchis *et al.* 2011; Lira-Torres and Briones-Salas 2012). Photo-recorded species were determined by comparison with several guides (Reid 1997; Ceballos and Oliva 2005; Aranda 2012), and scientific names were standardized according to Ramírez-Pulido *et al.* (2014). An Excel data matrix was constructed (Microsoft Windows 10) entering the data of records selected as independent captures (scientific name, common name, number of individuals, year, season (rainy, dry, or "*nortes*"), photo-capture date and time, coordinates

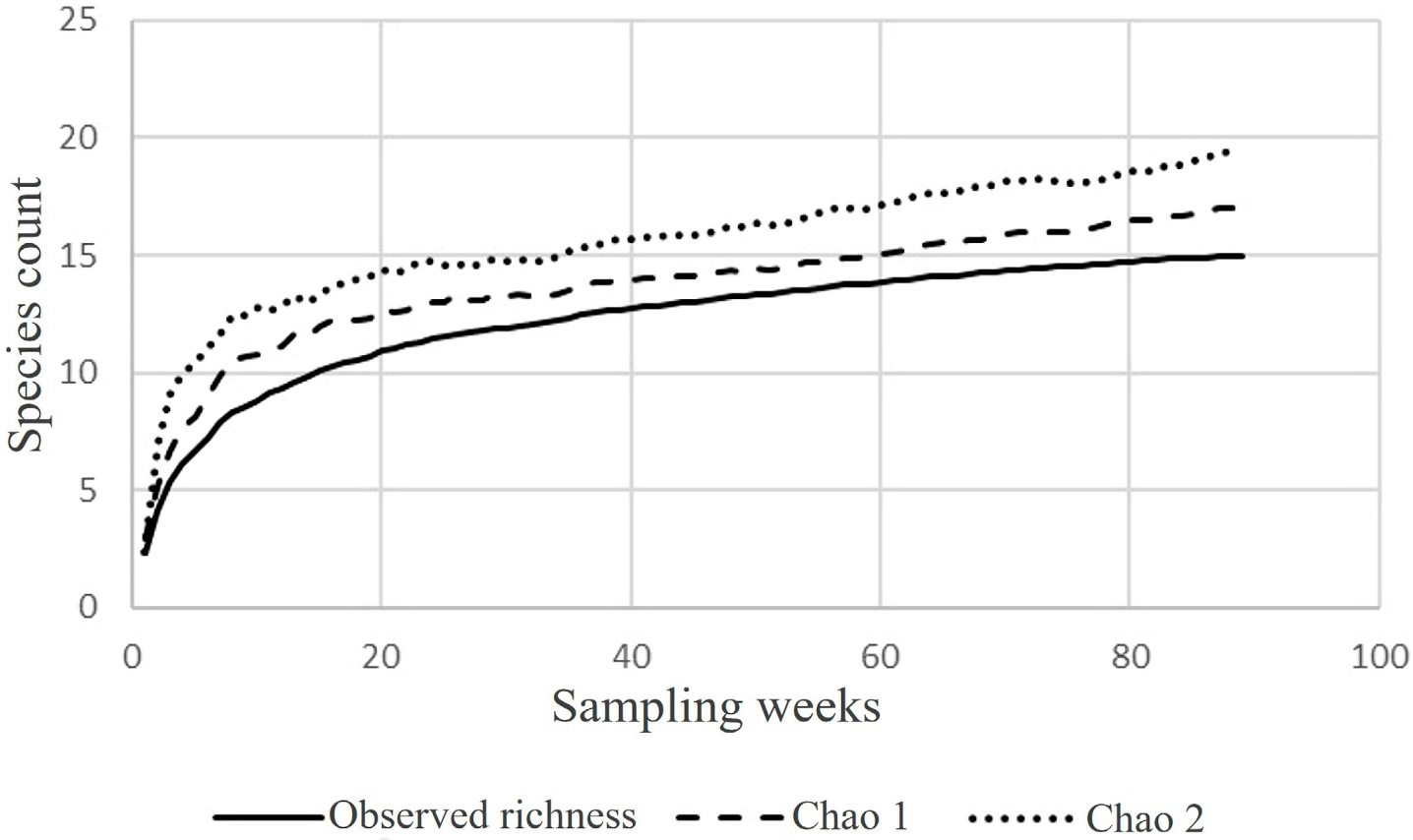

Figure 4. Accumulation curve of observed species and values of species richness estimators in the conservation area designated voluntarily Komchén de los Pájaros, Dzemul, Yucatán, Mexico.

(latitude and longitude, in degrees, minutes, and seconds), sex and age of the specimen: female (F), male (M), young offspring (Y), juvenile (J), or adult (A), and remarks.

We reviewed the Mexican Official Standard NOM-059-SEMARNAT-2010 (SEMARNAT 2010, 2019) and the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN 2025; https://www.iucnredlist.org/) to identify the species listed in a risk category or as threatened.

All the records captured were organized into data matrices and statistically analyzed with two non-parametric estimators (Villarreal *et al.* 2004) using the EstimateS program (version 9; Colwell 2013). The estimator based on record abundance was Chao 1: $S = S_{obs} + F2/2G$, where S_{obs} = number of observed species in a sample, F = number of singletons, G = number of doubletons; additionally, the estimator used for presence-absence data was Chao 2: $S = S_{obs} + (L2/2M)$, where S_{obs} = number of observed species in a sample, L = number of species recorded in only one sample (unique species), and M = number of species recorded in exactly two samples (duplicated species). The values of species richness were used to construct the species accumulation curve in Excel (Microsoft Windows 10).

To establish activity patterns, we considered species with at least 11 independent records, including the time of photo capture (Maffei *et al.* 2002, Monroy-Vilchis *et al.* 2009). Afterwards, the records for each time interval were counted and classified into four patterns based on the time of peak activity: diurnal, peak activity from 08:01 h to 17:59 h; nocturnal, from 20:01 h to 05:59 h; crepuscular, from 06:00 h to 08:00 h and from 18:00 h to 20:00 h), and catameral (species that are active all day and night; Monroy-Vilchis *et al.* 2011). With this information, histograms of activity periods were constructed using the Oriana version 4.0 software (Kovach Computing Services, 2011).

Results

A sampling effort of 4256 trap nights resulted in a total of 1230 independent photo captures, identifying 14 species of medium-sized mammals (93 %) and one large mammal (7 %), grouped into 11 families and six orders (Table 1). We found that 33 % (5) of these species are listed in a risk category established in the Mexican Official Standard NOM-059-SEMARNAT-2010 (SEMARNAT 2010, 2019), while 14 species are listed as Least Concern (LC) and one as Near Threatened (NT) by the IUCN (2025; Table 1).

The TIR and RAI of each species prioritized *Nasua narica* (n = 715, RAI = 168.00), followed by *Odocoileus virginianus* (n = 184, RAI = 43.23), *Urocyon cinereoargenteus* (n = 157, RAI = 36.89), in contrast to those that yielded lower values, such as *Sciurus yucatanensis* and *Herpailurus yagouaroundi* (each with TIR = 1, RAI = 0.23; Figure 3). The highest species richness was recorded during the *nortes* season (December to February), with 14 species, in contrast to the rainy season, which recorded six species. On the other hand, the species recorded in the three seasons were *Dasypus novemcinctus*, *Sylvilagus yucatanicus*, *U. cinereoargenteus*, *N. narica*, *Procyon lotor*, and *O. virginianus* (Table 1).

Table 1. Taxonomic list of medium and large mammals associated with ecological data in "Komchén de los Pájaros", Dzemul, Yucatan according to Ramírez-Pulido *et al.* (2014). Conservation status according to NOM-059-SEMARNAT-2010 (P = endangered and A = threatened) and IUCN (LC = least concern and NT = near threatened). Abbreviations: TIR (Total independent records), RAI (Relative abundance index of each species), seasonality (D = dry season, R = rainy season, N = north winds season), and body size (M = medium and L = large). Feeding habits are based on Mayani-Parás *et al.* (2023). Activity: blank data are not recorded, while superscript 1 was taken from Mejenes-López *et al.* (2021).

	Feeding habits/ Activity	Conservation status		TIR	RAI	Number of records per season			Size M / L
		NOM-059/UICN				D	R	N	
CLASS MAMMALIA Linnaeus, 1758									
ORDER DIDELPHIMORPHIA									
FAMILY DIDELPHIDAE									
Didelphis virginiana Kerr,1792	Omnivore/ Nocturnal		LC	17	3.99	14	-	3	M
ORDER CINGULATA									
FAMILY DASYPODIDAE									
Dasypus novemcinctus Linneo, 1758	Invertivore/ Nocturnal		LC	27	6.34	18	1	8	M
ORDER PILOSA									
FAMILY MYRMECOPHAGIDAE									
Tamandua mexicana (de Saussure. 1860)	Invertivore/	P	LC	5	1.17	3	-	2	M
ORDER LAGOMORPHA									
FAMILY LEPORIDAE									
Sylvilagus yucatanicus (Allen, 1890)	Herbivore/ Nocturnal		LC	22	5.17	9	1	12	M
FAMILY SCIURIDAE									
Sciurus yucatanensis Allen, 1877	Frugivore/		LC	1	0.23	-	-	1	M
ORDER CARNIVORA									
FAMILY FELIDAE									
Herpailurus yagouaroundi (Hilaire, 1803)	Carnivore/	A	LC	1	0.23	-	-	1	M
Leopardus pardalis (Linneo, 1758)	Carnivore/	P	LC	4	0.94	2	-	2	M
Leopardus wiedii (Schinz, 1821)	Carnivore/	P	NT	9	2.11	6	-	3	M
FAMILY CANIDAE									
Canis latrans (Say, 1822)	Omnivore/ Nocturnal		LC	28	6.58	1	-	27	M
Urocyon cinereoargenteus (Schreber, 1775)	Omnivore/ Cathemeral[1]		LC	157	36.89	110	1	46	M
FAMILY MEPHITIDAE									
Spilogale yucatanensis (Howell, 1902)	Invertivore/ Nocturnal[1]		LC	3	0.70	3	-	-	M
FAMILY MUSTELIDAE									
Galictis vittata (Schreber, 1776)	Carnivore/	A	LC	3	0.70	-	-	3	M
FAMILY PROCYONIDAE									
Nasua narica (Linneo, 1766)	Omnivore/ Diurnal		LC	715	168.00	566	1	148	M
Procyon lotor (Linneo, 1758)	Omnivore/ Diurnal		LC	54	12.69	15	9	30	M
ORDER ARTIODACTYLA									
FAMILY CERVIDAE									
Odocoileus virginianus (Zimmermann, 1780)	Herbivore/ Cathemeral		LC	184	43.23	108	2	74	L

The two recorded canid species, *Canis latrans* and *U. cinereoargenteus*, differed in their relative abundances (RAI = 6.58 and 36.89, respectively). However, it should be mentioned that the coyote was always recorded in groups of two or three individuals and in the *nortes* season (n = 27), while fox specimens were virtually always captured as single individuals (97 %), mostly in the dry season (n = 110) and the *nortes* season (n = 46). We expected to record high abundances of both species, since they are generalists commonly found in the study region. *Dasypus novemcinctus, Sylvilangus yucatanicus, U. cinereoargenteus*, *N. narica, P. lotor*, and *O. virginianus* were recorded in all seasons. The three felid species differed in the season of capture: *Leopardus weidii* and *Leopardus pardalis* were recorded only in the dry

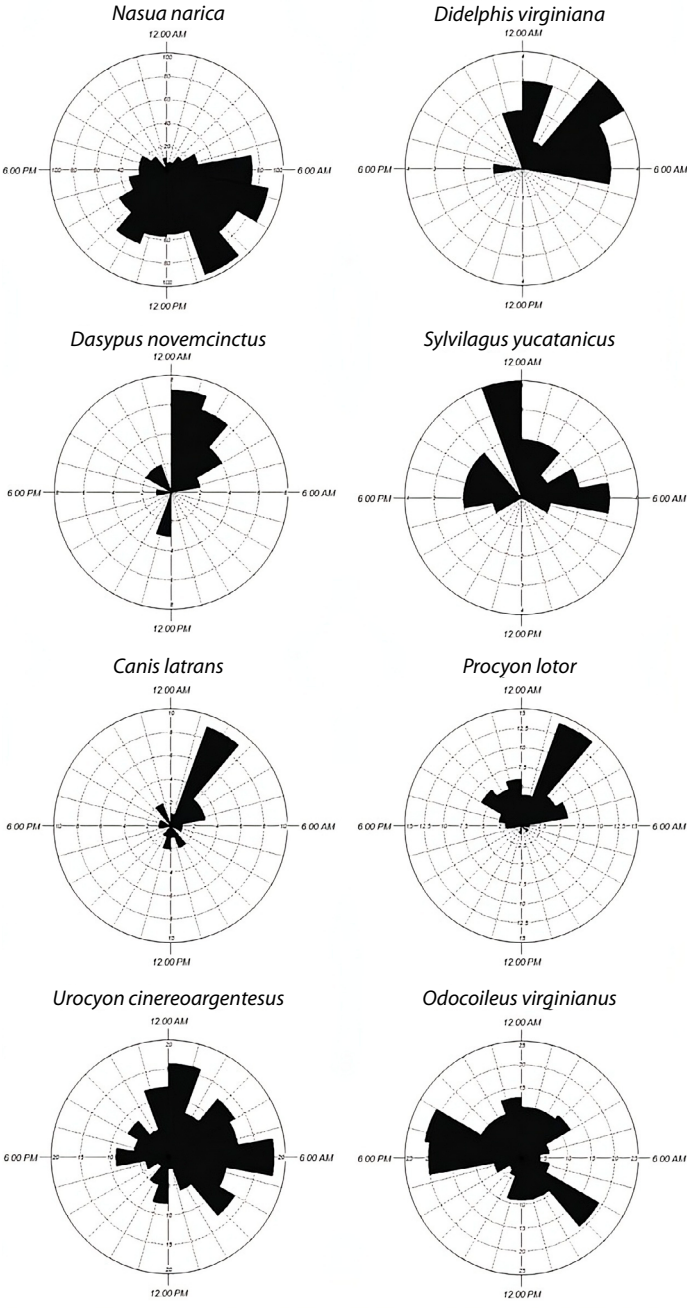

Figure 5. Activity patterns of medium-sized and large mammals with more than 10 independent records in the conservation area designated voluntarily Komchén de los Pájaros, Dzemul, Yucatán, Mexico.

season (n = 2; n = 6, respectively) and the *nortes* season (n = 2, n = 6), while *H. yagouaroundi* was active only during the *nortes* season (Table 1). The accumulation curve shows a gradual increase that did not stabilize after the 89 weeks of sampling, suggesting the possibility of adding new records. This was confirmed with estimators, with Chao 1 being the most accurate and least biased, as it is closer to the observed richness, suggesting the potential presence of two additional species (n = 17); for its part, Chao 2 estimates a higher number of species (n = 19.45; Figure 4).

The activity pattern was obtained only for eight of the 15 species documented in this study. The records reflected that mammals are active throughout the day, but each showed a particular preference (based on the highest number of records): diurnal, *N. narica*; nocturnal, *D. virginiana, D. novemcinctus, S. yucatanicus*, *C. latrans*, and *P. lotor*; whereas *U. cinereoargenteus* and *O. virginianus* were recorded evenly throughout the 24 hours, so they are considered catameral species (Figure 5).

Discussion

This study reports for the first time the diversity of medium-sized and large mammals inhabiting KdlP AVDC, where low deciduous tropical forests predominate, in the municipality of Dzemul, Yucatán. This work confirms the presence of 15 species (37 %) recorded for the state of Yucatán (Sosa-Escalante *et al.* 2014). Given this, the KdlP AVDC, a 300-ha fragment of typical vegetation (low deciduous tropical forest), is important as it maintains a diverse functional group of mammals, including omnivores, carnivores, invertivores, herbivores, and frugivores (Mayani-Parás *et al.* 2023).

The species richness recorded in this study was intermediate compared to other studies carried out in the state. This is the case of the Dzilam State Reserve, with a land area of 42 555 ha, where six species of medium-sized mammals were recorded, 67 % of which are shared with those recorded in the present study (*Didelphis marsupialis, Tamandua mexicana, U. cinereoargenteus*, and *N. narica*; Hernández-Betancourt *et al.* 1996); in El Zapotal Private Reserve in the municipality of Tizimín, with an area of 2300 ha, 21 species were recorded, 43 % of which are shared (*D. marsupialis, T. mexicana, Sciurus yucatanensis, L. pardalis, L. wiedii, U. cinereoargenteus, N. narica, P. lotor*, and *O. virginianus* (Faller-Méndez *et al.* 2005); in the ejido Progresito, municipality of Peto, only 67 % of 12 documented species are shared (*D. novemcinctus, T. mexicana, Sciurus yucatanensis, U. cinereoargenteus, Spilogale yucatanensis, N. narica, P. lotor*, and *O. virginianus* (Cimé-Pool *et al.* 2020); and in the ejido of Xcan, municipality of Chemax, with an area of 24 516 ha, 35 % of the 17 species recorded are shared (*Sylvilangus yucatanicus, Sciurus yucatanensis, Spilogale yucatanensis, N. narica, P. lotor*, and *O. virginianus* (Balam-Ballote *et al.* 2020). *Nasua narica* is present at the five sites, displaying a wide distribution. Considering the extension of all the areas just mentioned, KdlP AVDC stands out due to its intermediate-to-high richness of medium-sized and large mammals despite its smaller size. This work is considered relevant because its intensive sampling effort provides a close approximation to the species richness of medium-sized and large mammal species in the area. Additionally, we believe that including non-accessible areas and increasing the sampling effort could increase the number of species, as suggested by the estimators (Chao 1 and 2; Figure 4).

The participation of local communities and other landowners is crucial for raising awareness and promoting the responsible use and conservation of wildlife, with photo trapping as its primary tool. For example, Duque-Moreno *et al.* (2024), in their study on potential ecotourism based on the observation of wild mammals in the AVDC

Centauro del Norte in Calakmul, Campeche, Mexico (9722.75 ha), recorded 14 species of medium-sized and large mammals of importance for ecotourism with a sampling effort of 549 trap nights. On the other hand, Medina-Torres *et al.* (2015) documented participatory sampling with a sampling effort of 426 trap nights in the ejido San Ignacio, municipality of Morelos, Chihuahua. This AVDC has an area of 7662.2 ha where the presence of nine species of medium-sized and large mammals was reported in different types of vegetation.

In other private conservation areas, the sampling effort and size undoubtedly determine the differences between them. For example, only considering photo-trap sampling, Cruz-Bazán *et al.* (2017), with a sampling effort of 42 trap nights, reported eight mammal species for the Talhpan private conservation area in Papantla, Veracruz, with an extension of 24 ha that includes different habitats; most species recorded in the medium semi-evergreen tropical forest. In contrast, Galindo-Aguilar *et al.* (2024), in a study involving community monitoring in 18 AVDCs in Oaxaca along an altitudinal gradient of 50 to 3000 m asl that included a mosaic of conditions, with the predominance of tropical forests, captured 26 species of medium-sized and large mammals representing 49 % of the 53 species reported for the state, with a sampling effort of 4384 trap nights. It is worth mentioning that these 18 AVDCs are immersed in a gradient of conditions over areas of differentiated sizes, the smallest of 600 ha and the largest of 9670 ha (Miguel A. Briones Salas, pers. comm.), and are a public policy conservation strategy where the communities are involved (Galindo-Aguilar *et al.* 2024).

In the Ceratozamia Protection and Development Area located in Ixhuatlán del Sureste, in the south of the State of Veracruz, Mexico, covering 100 ha and managed under a private regime, Pelayo-Martínez *et al.* (2023) investigated the patterns of daily activity of arboreal mammals and their degree of overlap with a sampling effort of 996 trap nights in 50 ha of forest area, a remnant of evergreen tropical forest. These authors documented the presence of seven species of medium-sized mammals (*Potos flavus, Caluromys derbianus, Coendou mexicanus, D. marsupialis, T. mexicana, P. lotor*, and *Philander opossum*).

Comparing the areas under the community and private management regimes mentioned above with our study area data in terms of surface area (24–24 516 ha) and species richness of medium-sized and large mammals (7–26), we found that KdlP AVDC is of intermediate size (300 ha) and has an intermediate richness of medium-sized and large mammals (15 species) relative to the data reported to date, despite being under anthropic pressure due to changes in land use and hunting. Therefore, we maintain that the AVDC studied is a wildlife protection site that should be included in monitoring and conservation programs. Additionally, according to Padilla *et al.* (2025), it can also be considered a "conservation island", as the surrounding matrix is being altered and is adjacent to a human community.

We agree with Briones-Salas *et al.* (2023) in highlighting that records of mammals in AVDCs by community monitors reflect the central role of indigenous or local communities in the knowledge and conservation of biodiversity; some of these mammal species are listed in a risk category. For example, according to NOM-059-SEMARNAT-2010 (DOF 2019), of the species listed for the state of Yucatán, KdlP AVDC reports 33 % of the species classified as endangered of extinction and 20 % as threatened, which together represent 22.7 % of the protected terrestrial mammal species (Sosa-Escalante *et al.* 2014). This data highlights the importance of KdlP AVDC for mammalian conservation. However, this mammal fauna is under pressure, as evidenced by roadkill incidents and hunting activities observed during the study period.

The coati (*N. narica*) was the species with the highest number of records in the sampling area, likely due to the availability of food and water; this species is reported to be common in low deciduous tropical forests of Mexico (Alfaro-Espinosa *et al.* 2006; Pérez-Irineo and Santos-Moreno 2012).

The largest number of mammal records in this study corresponds to nocturnal mammals (20:01 to 05:59), probably because most Neotropical mammals are nocturnal (Srbek-Araujo and Chiarello 2005). Among these, *P. lotor* displayed a peak of activity at midnight, an observation consistent with the preferred time of activity recorded by Valenzuela (2005). *Leopardus wiedii* also showed activity during the night, coinciding with the report of Valenzuela (2005). In the case of *Sylvilagus yucatanicus*, *D. virginiana*, and *D. novemcinctus*, Monrroy-Vilchis *et al.* (2011) mention that their preference for nocturnal/crepuscular habits is related to the avoidance of predation, as their body mass is less than 10 kg; this behavior was confirmed in the present study, recording the peak of activity of these species at night: *Sylvilagus yucatanicus*, from 23:00 h to 00:00 h; *D. virginiana*, from 03:00 h to 04:00 h; and *D. novemcinctus*, from 00:00 h to 01:00 h. In the case of cathemeral species, *U. cinereoargenteus* has been reported as a mainly nocturnal species (Reid 1997; Mejenes-López *et al.* 2021); however, this work showed diurnal and crepuscular activity, probably due to lower food availability in some seasons, which requires more time and effort to meet its needs (González-Pérez *et al.* 1992; Pelaez-Cruz *et al.* 2022). *Odocoileus virginianus* was recorded by Monrroy-Vilchis *et al.* (2011) to be active throughout the day, a finding that aligns with the present study, without showing a preference for any particular time of day.

The work geographically closest to our study area is that of Hernández-Pérez *et al.* (2015). These authors provided a list of 16 species of medium-sized and large mammals that inhabit the northwest and north coasts of the Yucatán Peninsula, of which seven are shared with KdlP AVDC. Of these, three species are nocturnal (*D. novemcinctus*, *L. pardalis*, and *L. weidii*) and another three are cathemeral (*N. narica, P. lotor*, and *O. virginianus*), which is consistent with our records in the present study; the only exception is *U. cinereoargenteus*, reported as diurnal by Hernández-

Pérez *et al.* (2015), with three records, and as cathemeral in the present study, with 157 records, of which 66 are diurnal. Therefore, we consider that a larger number of independent records helps represent and characterize the activity patterns of mammals more accurately.

When sociability is encouraged, animals can form groups ranging from pairs to large congregations. In mammals, sociability can be beneficial because it provides greater protection from predators, improves the success in locating or maintaining access to resources, creates mating opportunities, reduces vulnerability to infanticide, or facilitates mate selection. However, sociability can have drawbacks for individuals because it exposes them to infections, can increase their visibility to predators, and intensifies competition for access to resources and mating opportunities. Animals living in larger groups may attempt to expel other residents, disperse, or attempt to exclude immigrants (Silk 2007). These are possible explanations for the finding that 11 out of 15 species recorded in the tropical forests of the northern Yucatan Peninsula are solitary.

Kappeler *et al.* (2013) discuss the social organization of adult mammals that can lead a solitary life (e.g., in the KdlP AVDC, *U. cinereoargenteus, D. novemcinctus, Sylvilagus yucatanicus, P. lotor, O. virginianus, L. weidii, L. pardalis, H. yagouaroundi, D. virginianus, T. mexicana, Spilogale yucatanensis*, and *Galictis vittata*), coordinate their activities with a member of the opposite sex forming pairs (not predominant in the study area), or associate and coordinate their activities with two or more conspecifics forming groups (*P. lotor, C. latrans*, and *N. narica*). However, this author does not mention interspecific groupings, such as the case of *Spilogale yucatanensis* and *U. cinereoargenteus, which were* recorded in the AVDC studied (Mejenes-López *et al.* 2021).

The group behavior of some mammals was recorded by photo recording. For example, *N. narica* was recorded forming herds of 13 to 17 individuals in the dry season (April 2020 and March to April 2021). For its part, *O. virginianus* was observed in groups, one with one female and two juveniles in the dry season (April to May 2020, March to June 2021) and in the *nortes* season (November and December 2021); these records contrast with studies carried out in temperate forests of Oaxaca, Morelos, and the State of Mexico, where the largest population was found in October (Ortiz-Martínez *et al.* 2005) and in winter (Flores-Armillas *et al.* 2011; Beltrán and Díaz de la Vega 2017), and coincides with the study of Mandujano and Gallina (1993) in tropical areas with deciduous and semi-evergreen vegetation, which recorded deer between February and June, with a lower record between November and January. Additionally, *P. lotor* was recorded in pairs in the dry season (March 2021) and in groups of three in the rainy season (June 2021) and the *nortes* season (December 2021). The data recorded in this study on the size of *N. narica* herds are similar to those reported by various authors (Burger and Gochfeld 1992; Valenzuela 2005; Di Blanco and Hirsch 2006).

Solitary behavior has been scarcely documented and is exhibited by more than 80 % of species in the order Carnivora (Gittleman 1989). Sandell (1989) noted that solitary individuals have little social interaction, except in the mating season. Meanwhile, Bekoff *et al.* (1984) mentioned that they communicate with each other through olfactory, auditory, and even visual signals, thus avoiding contact and maintaining distribution areas or territories that do not overlap; to obtain food, these individuals depend on being stealthier and more cryptic to catch prey dispersed in complex habitats. In the present study, *O. virginianus* was recorded not only in groups but also individually; for example, solitary females in the dry season (March 2021), the rainy season (June 2021), and the *nortes* season (from November to December 2021), and solitary males in the dry season (June 2021) and the *nortes* season (from November to December 2021). Additionally, one adult of *G. vitata* was recorded in the dry season (May 18, 2021, at 15:25 h) and in two rainy seasons (June 4, 2021, at 07:38 h and June 5, 2021, at 15:25 h); this same species was also photo recorded in a group of three individuals outside the sampling period, on February 4, 2023 (Asis Alcocer García, pers. comm.). Based on these observations, a mid- to long-term study is recommended to define patterns of group or individual behavior.

Finally, the photo trapping technique facilitated better recording of mammal species that are difficult to detect (e.g., *H. yagouaroundi, Spilogale yucatanensis*, and *G. vittata*). Furthermore, we confirmed that it is a reliable non-invasive method that provides physical evidence of the presence of individuals, in addition to contributing data regarding the natural history of the species mentioned here. Compared to other conservation areas in the region, KdlP AVDC is a small area of 300 ha of low deciduous forest that is home to various functional groups of mammals, including omnivores, herbivores, carnivores, and invertivores, and functions as a wildlife refuge or conservation island. In addition, it protects one-fifth of the mammal species of Yucatan according to NOM-SEMARNAT-2010, which are being threatened by strong anthropogenic stressors, including urban growth, hunting, and deforestation, all of which jeopardize the persistence of the habitat and its natural communities. The results obtained here should promote environmental education and long-term monitoring.

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