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Diversity and activity patterns of medium-and large-sized mammals in an intraurban vegetation fragment in the city of Mérida, Yucatán, Mexico

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Urban sprawl, a type of horizontal urban growth that characterizes many Latin American cities, is associated with low-density developments that encroach upon large natural or agricultural areas, fragmenting and isolating surrounding landscapes. Mérida is a typical example of this urbanization pattern, which has led to habitat fragmentation and significantly affected biodiversity. This study focused on medium- and large-sized mammals in an unprotected urban vegetation fragment, evaluating biodiversity, activity patterns, and the influence of feral fauna. Camera traps were installed across a 38-ha vegetation fragment in Mérida, collecting data during the dry and wet seasons. Photographs were analyzed to identify species, calculate the Relative Abundance Index (RAI), and estimate diversity and activity patterns. Nine wild mammal species were recorded; *Urocyon cinereoargenteus* and *Odocoileus virginianus* were the most abundant. We observed significant diurnal activity, especially in *Odocoileus virginianus* and *Nasua narica*, while *Sylvilagus yucatanicus* and *Urocyon cinereoargenteus* were most active at dawn and dusk, and *Spilogale yucatanensis* focused its activity at nighttime. We observed an overlap in activity between feral fauna and wild mammals. Despite the pressure from urbanization, the vegetation fragment studied harbors a significant diversity of wild mammals. However, feral fauna, including dogs and cats, adversely impacts wild species, highlighting the importance of implementing management and conservation strategies in urban fragments to protect biodiversity.

El crecimiento urbano horizontal, característico de muchas ciudades latinoamericanas, se asocia con desarrollos de baja densidad que invaden grandes áreas naturales o agrícolas, fragmentando y aislando los paisajes circundantes. Mérida es un ejemplo típico de este patrón de urbanización, que ha provocado la fragmentación de hábitats y afectado significativamente la biodiversidad. Este estudio se centra en los mamíferos medianos y grandes de un fragmento de vegetación urbana no protegida, evaluando su biodiversidad, patrones de actividad y la influencia de la fauna feral. Se instalaron cámaras trampa en un fragmento de 38 ha en Mérida, recolectando datos durante las temporadas seca y lluviosa. Las fotografías obtenidas se analizaron para identificar especies, calcular el Índice de Abundancia Relativa (IAR) y estimar la diversidad y los patrones de actividad. Se registraron 9 especies de mamíferos, siendo *Urocyon cinereoargenteus* y *Odocoileus virginianus* las más abundantes. Se observó que existe una importante actividad diurna especialmente en *O. virginianus* y *Nasua narica*. Mientras que especies como *Sylvilagus yucatanicus* y *Urocyon cinereoargenteus* presentan actividad diurna, pero concentrada sobre todo al amanecer y al anochecer. *Spilogale yucatanensis* concentró su actividad durante la noche. Además, se detectó una superposición en la actividad entre la fauna feral y los mamíferos silvestres. A pesar de la presión ejercida por la urbanización, el fragmento de vegetación conserva una diversidad significativa de mamíferos silvestres. Sin embargo, la presencia de fauna feral, como perros y gatos, ejerce un impacto negativo sobre estas especies, subrayando la importancia de implementar estrategias de manejo y conservación en fragmentos intraurbanos para proteger la biodiversidad.

Keywords: biodiversity; camera trap; feral fauna; interactions; urban area.

Introduction

Urban environments are among the terrestrial ecosystems most heavily altered by man, leading to direct and indirect effects on biodiversity (McKinney 2002; Fahrig 2003). Latin American cities are usually characterized by a compact urban core surrounded on the outskirts by uncontrolled urban sprawl, resulting in fragmented habitats and dysfunctional urban matrix (Monkkonen 2011; Inostroza *et al.* 2013; Duque *et al.* 2019). This growth pattern is associated with low-density human settlements spread over large surrounding rural or agricultural areas, characterized by being irregular, dispersed, and fragmented (European Environment Agency 2006). Frequently, housing developments are discontinuous, leaving fragments of natural vegetation or cropland that gradually become isolated patches within the urban matrix. This urbanization pattern affects ecological connectivity and restrains the movement of species across patches, disrupting dispersal corridors and creating habitat "islands" (Davis and Glick 1978; Olejniczak *et al.* 2018). Consequently, richness and abundance of wild species within fragments are severely affected (Crooks 2002; Davis and Glick 1978).

In Mexico, this type of horizontal expansion is common on the urban outskirts, in which housing developments grow at the expense of surrounding agricultural and native vegetation areas (Monkkonen 2012). Mérida, the capital city of the state of Yucatán, is the largest city in the Yucatán Peninsula and an emblematic case of this phenomenon. In recent decades, Mérida has experienced vigorous growth, from 269,000 inhabitants in 1979 to more than 1.2 million in 2020, resulting in the urbanization of 24,215 ha of tropical dry forest (SEDATU 2023; Carrillo-Niquete *et al.* 2022). Although the city has a well-defined and developed downtown core, it is currently surrounded by large and numerous horizontal urban housing developments called "*fraccionamientos*" (Pérez-Medina and López-Farfán 2015). This growth has been facilitated by the local flat topography, low vegetation that is easily cleared, access to groundwater, and poor urban regulation enforcement (Bolio-Osés 2000). As a result, the loss of these natural areas has interrupted dispersal corridors and fragmented habitats, in addition to producing isolated vegetation patches that function as temporary shelters for some species.

Medium- and large-sized mammals are key indicators of ecosystem health and play major ecological roles, such as seed dispersal, population control, and regulation of food webs (Savard *et al.* 2000; Fahrig 2001). Despite the limitations imposed by urbanization, Mexico and other Latin American cities have recorded several species of mammals in vegetation fragments located in urban areas. Species such as *Didelphis virginiana*, *Philander opossum*, *Dasypus novemcinctus*, *Cuniculus paca*, *Canis latrans*, *Leopardus pardalis*, *Herpailurus yaguaroundi*, or *Eira barbara,* among others, have been recorded in parks and vegetation fragments around urban areas, showing the ability of some mammals to adapt to these environments (Bernardo *et al.* 2013; Borges *et al.* 2014; Mella-Méndez *et al.* 2019; Coronel-Arellano *et al.* 2021; García-Padilla *et al.* 2021; Ramos-Luna *et al.* 2023; Gordillo-Chávez *et al.* 2024). However, their coexistence with feral fauna, such as *Canis familiaris*, and *Felis catus*, poses new challenges. These domestic species often reach high densities in urban areas due to their adaptability and opportunistic behavior, adversely affecting native species through competition, predation, and disease transmission (Loss *et al.* 2013; Vanak *et al.* 2014).

In Mérida, the loss of natural areas associated with urban growth has generated isolated vegetation fragments where many native species are trapped and exposed to the pressure of feral fauna and other impacts derived from urban sprawl. Not only do these fragments represent refuges for biodiversity, but their conservation can be key to mitigating the adverse impacts of urbanization, such as the formation of urban heat islands, and to maintaining the ecosystem services associated with native vegetation (Carrillo-Niquete *et al.* 2021; Villanueva-Solís and Torres-Pérez 2023).

Due to their potentially detrimental effects on native species, it is important to investigate and report the behavior of invasive species, particularly in protected areas (Doherty *et al.* 2015). Feral dogs and cats can be effective competitors and predators in natural ecosystems (Vanak and Gompper 2009). Thus, in urban areas, feral fauna can play an important role as stressors for native wild mammals and affect their persistence and survival (Parsons *et al.* 2016; Zapata-Ríos and Branch 2016). Therefore, it is imperative to evaluate the spatial and temporal overlap between native mammals and wildlife in patches of natural vegetation within urban areas to establish feral wildlife management plans and control programs to promote the establishment and maintenance of wild mammal populations in these areas (Coronel-Arellano *et al.* 2022). Although the effects of feral fauna on mammals in protected areas and urban parks have been studied in Mexico and Latin America (Bernardo *et al.* 2013; Borges *et al.* 2014; Mella-Méndez *et al.* 2019; Coronel-Arellano *et al.* 2021), the impact of these interactions in urban areas remains poorly understood and is considered a priority for wildlife conservation in urban areas (Hortelano-Moncada *et al.* 2024). This is greatly important in isolated fragments associated with urban sprawl, which favor the entry of feral fauna and its interactions with native species (Coronel-Arellano *et al.* 2021).

In this context, the overall objective of this study was to evaluate the activity patterns of medium-sized mammals in an unprotected fragment of urban vegetation in Mérida. Specifically, we answered the following questions: (a) Which mammal species occur in this fragment? (b) What are their activity patterns? (c) Is there temporal or spatial overlap in activity between feral and wild fauna? These questions will enable the identification of key interactions between species and generate valuable information for biodiversity management and conservation in urban areas under horizontal expansion.

Materials and methods

Study area. The study area is an isolated vegetation patch of approximately 38 ha in Gran San Pedro Cholul, located in northeast Mérida, Yucatán, Mexico (21°1′ N, 89°32′ W; Figure 1). The vegetation fragment is currently unprotected, isolated by housing developments (clusters of individual houses, roads, shopping centers, service areas, sports fields, schools, and others) as a result of urban expansion over the past 20 years. The vegetation patch is located in the primary urban growth zone established in the Municipal Urban Development Program (Ayuntamiento de Mérida 2024a), less than 2 km in straight line from kilometer 1 of the Mérida-Motul federal highway and the Licenciado Manuel Berzunza city peripheral highway. The local topography is mainly flat, with an elevation between 5 m and 10 m asl. The climate is warm sub-humid with summer precipitation, with annual precipitation between 800 mm and 1000 mm (INEGI 2017). This study identified two climatic seasons: dry (15 October 15 to 25 May) and wet (26 May to 14 October; de la Barreda *et al.* 2020). The original vegetation was tropical dry forest; however, anthropogenic activities such

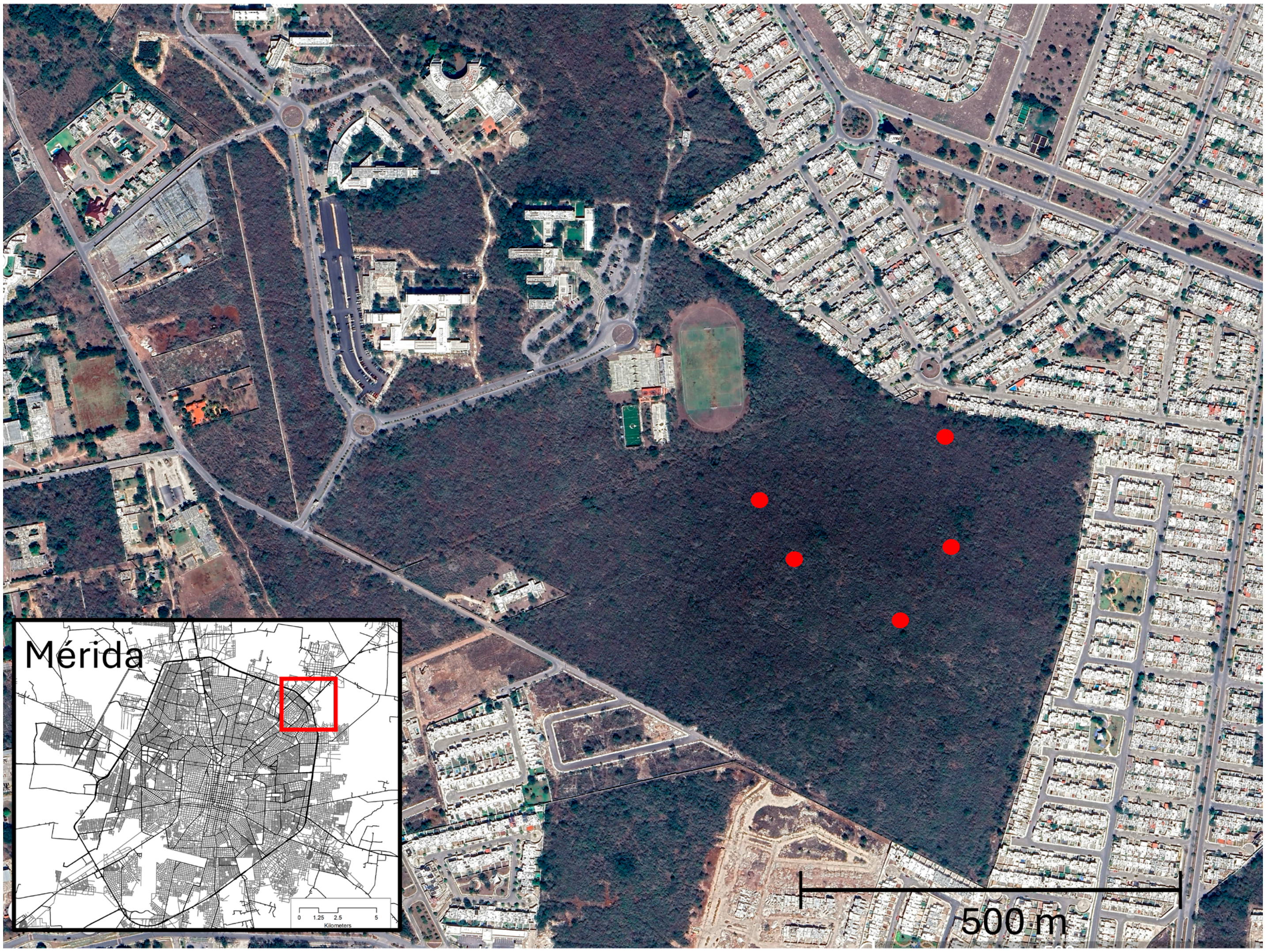

Figure 1. Location of camera trap stations in an isolated vegetation fragment located in the northeast of the city of Mérida, Yucatán, Mexico. Google Earth satellite image from February 2024. The red dots in the image mark the location of camera traps.

as agriculture, livestock raising, and, mainly, Mérida's urban sprawl modified the vegetation matrix from tropical dry forest to secondary successional stages with different ages of abandonment (Ellis *et al.* 2017; Palafox-Juárez *et al.* 2021; Carrillo-Niquete *et al.* 2022).

Mammal sampling. Five stations were established over the isolated vegetation fragment (Figure 1). Each station consisted of a camera trap (Brownig Dark Ops Pro X 1080; Browning, Morgan, Utah) that operated continuously between 30 May 2023 and 4 April 2024, covering the 2023 wet season (30 May to 14 October 2023) and the 2023–2024 dry season (15 October 2023 to 4 April 2024). Camera traps were placed along paths that delimit the properties into which the vegetation fragment was divided. The cameras were strapped to trees approximately 50 cm above the ground and set to work 24 h per day, capturing 3 photographs for each recorded event and with a 1-minute delay between events. Cameras were checked every 45 days to verify their operation, replace the batteries, and make a backup of the photographs captured.

Data analysis. The captured photographs were stored and processed using Camera Base (Tobler 2015). Specimen images were identified according to Reid (2009). Only photographs of medium- and large-sized domestic and wild mammals (i.e., with a mean weight of at least 0.5 kg) and with terrestrial or semi-arboreal habits were analyzed (Reid 2009). Since the photographs did not allow us to identify the taxonomic characteristics that differentiate opossum species of the genus *Didelphis* (*i.e., D. virginiana* and *D. marsupialis*), the data for these specimens were grouped as *Didelphis* sp. Once the list of medium- and large-sized mammals was created, it was supplemented with the conservation status of each species according to the Mexican legislation (SEMARNAT 2010) and the Red List of the International Union for Conservation of Nature (IUCN 2024).

The number of independent records for each species of medium- and large-sized mammals captured at each photo-trapping station was obtained. A record of a species at a given station was considered independent of another record of the same species at the same station when the time interval between photographs exceeded 60 minutes (Tobler *et al.* 2008). To calculate the sampling effort, we obtained the number of trap days that each camera trap station operated in the field from the time the camera was active to the date when the last photograph was captured. A trap day was considered to be a 24-hour period. The total sampling effort was obtained by adding the number of days that each camera trap station operated during the study.

The Relative Abundance Index (RAI) was estimated for each treatment per season as a measure of the rate of visits (O'Brien 2011). The RAI was calculated by dividing the total number of independent records of each species per season by the camera trap effort at each station for each site per season, multiplied by 100.

Diversity was estimated for equally large (common sample size) or equally complete (common sample coverage) standardized samples for wild mammals in the vegetation fragment based on the integrated rarefaction and extrapolation sampling curves of true diversity indices for q = 0 and 1 (Chao and Jost 2012; Colwell *et al.* 2012; Chao *et al.* 2014). To this end, asymptotic diversity profiles were obtained based on the statistical estimation of Hill numbers of orders q = 0 and q = 1 (Chao and Jost 2015). We assumed that species were present in the vegetation fragment throughout the sampling period and that the seasonal presence or absence of any of them was due to differences in activity and catchability. Therefore, the diversity analysis was not divided by seasons, and it was carried out using all data recorded during the sampling. Species accumulation curves and true diversity analyses were performed using the iNEXT package in R (Hsieh *et al.* 2016).

A Kernel density estimator was used (Ridout and Linkie 2009) to generate seasonal activity patterns for domestic species and those wild species for which at least 25 independent records were captured during each season. To compare the activity patterns of domestic and wild species between the two seasons, treatment pairs were compared using the R package overlay (Meredith and Ridout 2014). The overlap coefficient (Δ) was calculated with 95 % confidence intervals (CI) using a bootstrap of 1000 samples. Following Meredith and Ridout (2014), Δ1 was used as the overlap estimator if the smallest sample had less than 50 photographic records; otherwise, Δ4 was used. The estimated overlap coefficient ranges from 0 (no overlap) to 1 (complete overlap). Activity was classified as (1) daytime, from 1 hour after sunrise to 1 hour before sunset; (2) nighttime, from 1 hour after sunset to 1 hour before sunrise; and (3) twilight, from 1 hour before to 1 hour after sunrise and sunset (Foster *et al.* 2013).

Results

During 1545 trap nights (860 in the dry season and 685 in the wet season), 1352 records of medium- and large-sized mammals were captured (1045 in the dry season and 307 in the wet season; Table 1). The captured mammals belonged to 11 species: 9 native wild species (8 in the dry season and 7 in the wet season) and 2 domestic mammals. Of the native species, *Didelphis* sp., *Dasypus novemcinctus*, and *Procyon lotor* were recorded in only one season, while the other 6 species were present in both seasons (Table 1; Figure 2). The most abundant native species in both seasons was *Urocyon cinereoargenteus*, followed by *Odocoileus virginianus* in the dry season and *Spilogale yucatanensis* in the wet season. The domestic species *Felis catus* and *Canis familiaris* were recorded in both seasons; *F. catus* was more abundant in the dry season and *C. familiaris* in the wet season. The photographs showed both collared dogs and cats and collarless individuals whose ownership could not be established. In the case of *C. familiaris*, 15 photographs were captured showing that dogs form groups of between 2 and 5 adult individuals. Over the course of the study, no photographs of people unrelated to the project were captured, even though the vegetation fragment includes free-access areas and indicators of human presence, such as litter, construction debris, and fires, are common along its borders.

Table 1. Number of independent seasonal records, number of seasons in which the species was recorded, and relative abundance index (RAI) of medium- and large-sized mammals recorded in an isolated vegetation fragment in the city of Mérida, Yucatán, Mexico. Dry season: 15 October 2023 to 4 April 2024. Wet season: 30 May to 14 October 2023

Species	Dry season			Rainy season		
	Number of records	Number of stations	RAI	Number of records	Number of stations	RAI
Didelphimorphia						
Didelphis sp.	18	1	1.20			
Cingulata						
Dasypus novemcinctus				5	4	0.33
Lagomorpha						
Sylvilagus yucatanicus	55	4	3.65	25	3	1.66
Rodentia						
Sciurus yucatanensis	17	3	1.13	1	1	0.07
Carnivora						
Felis catus	285	5	18.94	49	4	3.26
Canis familiaris	147	5	9.77	78	5	5.18
Urocyon cinereoargenteus	796	5	52.89	210	5	13.95
Spilogale yucatanensis	33	3	2.19	31	2	2.06
Nasua narica	20	5	1.33	6	3	0.40
Procyon lotor	3	1	0.20			
Artiodactyla						
Odocoileus virginianus	103	5	6.84	29	5	1.93

The diversity analysis in the fragment revealed a sample coverage of 0.999 for wild mammals, indicating that the sampling was adequate. For the expected species richness ^0D (Figure 3), for the maximum value of independent records (1.351), ^0D was 9.0 (confidence interval = 0.27), while Shannon's exponential ^1D was 2.67 (confidence interval = 0.240).

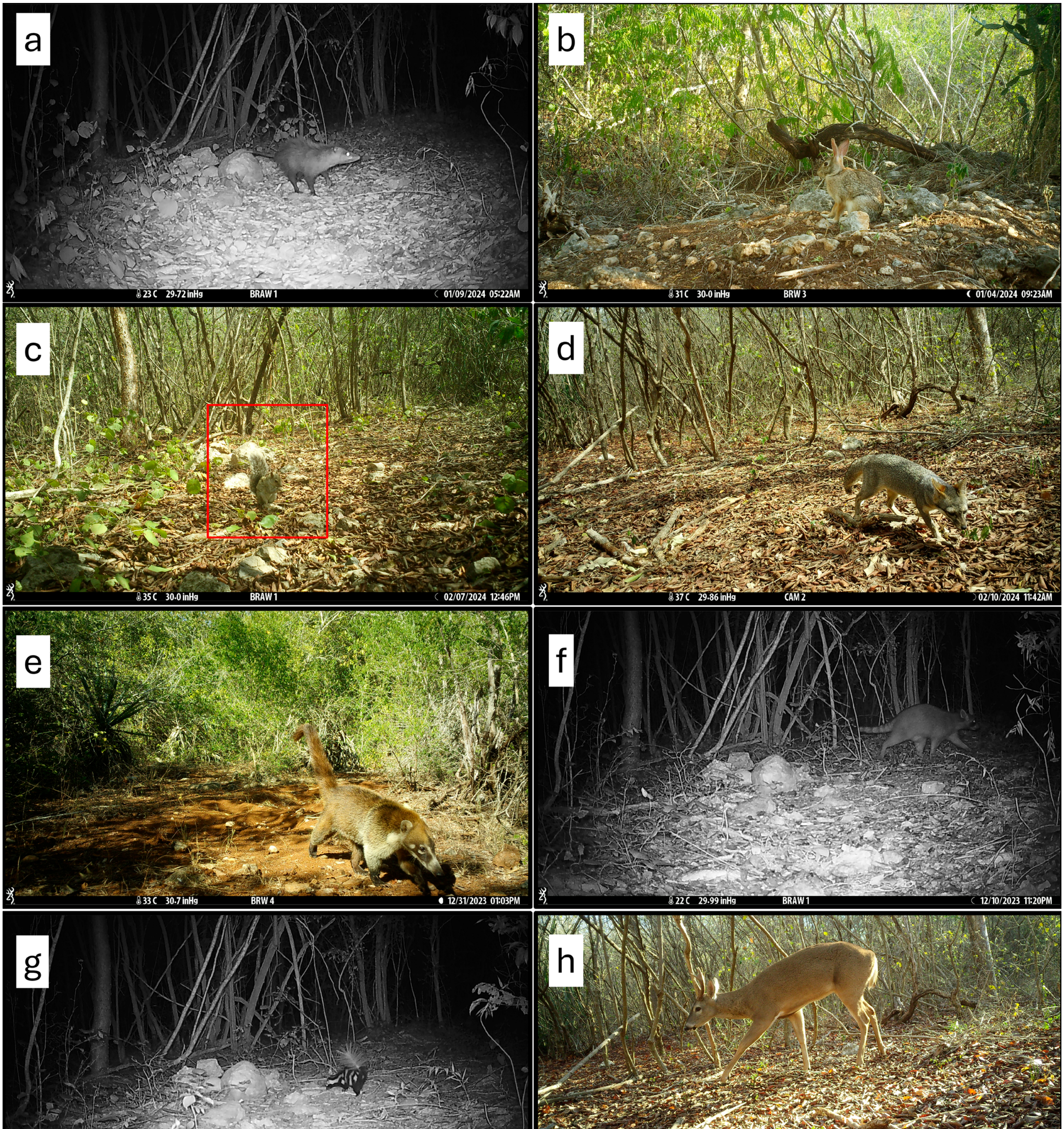

Figure 2. Photographs of wild mammals captured by camera traps in an isolated vegetation fragment in Mérida, Yucatán, Mexico. a) *Didelphis* sp.; b) *Sylvilagus yucatanicus*; c) *Sciurus yucatanensis*; d) *Urocyon cinereoargenteus*; e) *Nasua narica*; f) *Procyon lotor*; g) *Spilogale yucatanensis*; h) *Odocoileus virginianus*.

Activity patterns were analyzed for 6 species (4 native and 2 domestic) having sufficient records (Table 2; Figure 4). *Sylvilagus yucatanicus*, *O. virginianus*, *U. cinereoargenteus*, *Spilogale yucatanensis*, and *F. catus* showed consistent patterns between seasons, although with slight variations. *S. yucatanicus*, *U. cinereoargenteus*, and *F. catus* had both daytime and nighttime activity, with peaks at dawn and dusk; *O. virginianus* was mainly diurnal and *Spilogale yucatanensis* nocturnal. In contrast, *C. familiaris* was the only species that showed seasonal variations in Δ, being

Table 2. Temporal overlap Δ between medium- and large wild mammal species with domestic species in an isolated vegetation fragment in the city of Mérida, Yucatán, Mexico. The number corresponds to the value of Δ. The figure in parentheses corresponds to the 95 % confidence interval.

Species 1	Species 2	Dry season	Rainy season
Canis familiaris	*Urocyon cinereoargenteus*	0.357 (0.297-0.421)	0.771 (0.674-0.861)
	Odocoileus virginianus	0.403 (0.323-0.480)	0.561 (0.399-0.718)
	Sylvilagus yucatanicus	0.346 (0.251-0.442)	0.707 (0.562-0.842)
Felis catus	*Urocyon cinereoargenteus*	0.860 (0.803-0.915)	0.776 (0.650-0.874)
	Sylvilagus yucatanicus	0.783 (0.670-0.891)	0.688 (0.522-0.825)
	Spilogale yucatanensis	0.562 (0.433-0.683)	0.581 (0.438-0.723)

predominantly diurnal in the wet season and concentrating its activity at dawn in the dry season. Species with insufficient records for the kernel density analysis, such as *Didelphis* sp., *D. novemcinctus*, and *P. lotor*, were exclusively nocturnal, while *Nasua narica* showed daytime activity in both seasons.

In the dry season (Figure 5), *C. familiaris* had a low overlap in activity patterns with wild species with sufficient records (*U. cinereoargenteus*, *O. virginianus*, *S. yucatanicus*, and *Spilogale yucatanensis*). However, in the wet season (Figure 6), the activity pattern of *C. familiaris* broadly coincided with those of *U. cinereoargenteus* and *S. yucatanicus*, but not with those of *O. virginianus* due to the diurnal activity of the latter.

Regarding *F. catus*, its activity patterns overlapped significantly with those of *U. cinereoargenteus* and *S. yucatanicus* in both seasons (Figure 5, 6), which could facilitate negative interactions or induce pathogen exchange. On the other hand, the overlap with *Spilogale yucatanensis* was low because the latter is mainly nocturnal, while *F. catus* has high crepuscular and diurnal activity (Figure 5, 6).

Discussion

Vegetation fragments are common in the interior of the city of Mérida due to population growth and urban expansion. Despite the magnitude of urban impact, the studied fragment is home to several species of wild mammals typical of low deciduous forests in northern Yucatán (Sosa-Escalante *et al.* 2017). The number of species found (9) represents 21 % of the 42 species of medium- and large-sized terrestrial mammals recorded in the state (Sosa-Escalante *et al.* 2014), which is remarkable considering the size of the fragment (38 ha). However, species such as *Herpailurus yaguaroundi*, *Galictis vittata*, and *Canis latrans*, reported in the nearby Cuxtal Ecological Reserve (Sosa-Escalante *et al.* 2017), were not detected in the fragment, possibly due to the habitat and home range requirements of these species (Caso 2013). An isolated fragment such as the one studied here

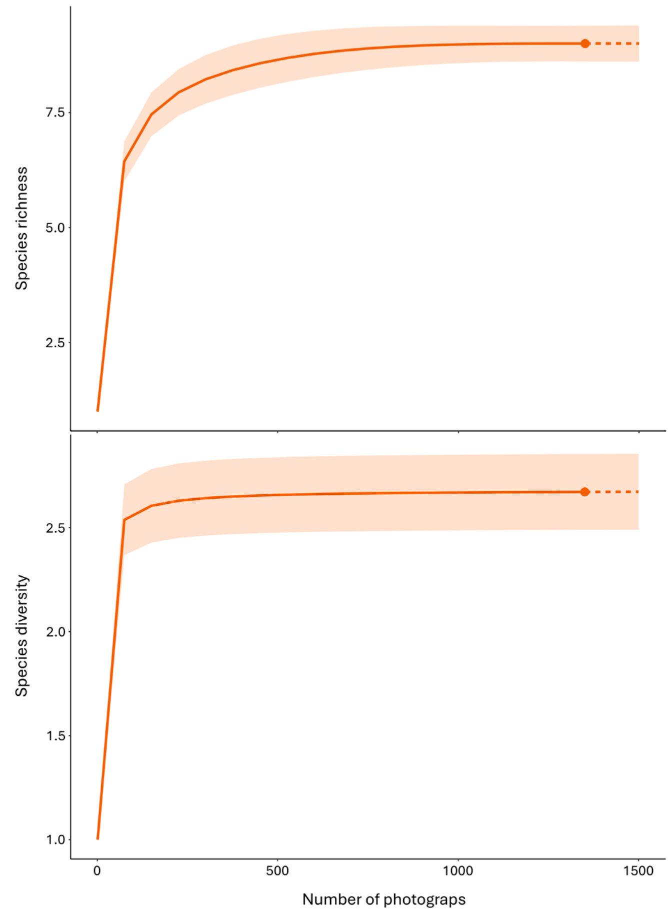

Figure 3. Species accumulation curves and confidence intervals for medium- and large-sized mammals captured in an isolated vegetation fragment in the city of Mérida, Yucatán, Mexico. These curves were constructed using diversity indices at two levels: ^{0}D (species richness) and ^{1}D (Shannon's exponential). The solid line refers to the interpolated data, and the dotted line refers to the extrapolated data.

can hardly support multiple species of medium- and large-sized mammals, since small fragments are rarely suitable to sustain a population, or even an individual, of species such as *H. yaguaroundi*, whose minimum home range is 10 km^2 (Caso 2013). However, it cannot be ruled out that individuals of this or other species, such as *C. latrans*, may occasionally transit through the fragment during dispersal, as recently reported for the suburban area of Mérida in the media (Diario de Yucatán 2023; El Universal 2024).

Species such as *Urocyon cinereoargenteus*, *Procyon lotor*, *Didelphis* sp., and *Dasypus novemcinctus* have been commonly recorded in urban environments in Mexico (Mella-Méndez *et al.* 2019; Coronel-Arellano *et al.* 2021; García-Padilla *et al.* 2021; Ramos-Luna *et al.* 2023), but this study reports for the first time the presence of *Nasua narica* and *Odocoileus virginianus* in an urban area of the country. The presence of *O. virginianus* is notable, as it is the largest wild species (approximately 30 kg) recorded in urban areas in Mexico (Contreras-Moreno *et al.* 2021); it is remarkably abundant in the vegetation fragment studied, being the second-most abundant species in the study. We identified at least 4 distinct males, recognizable by their

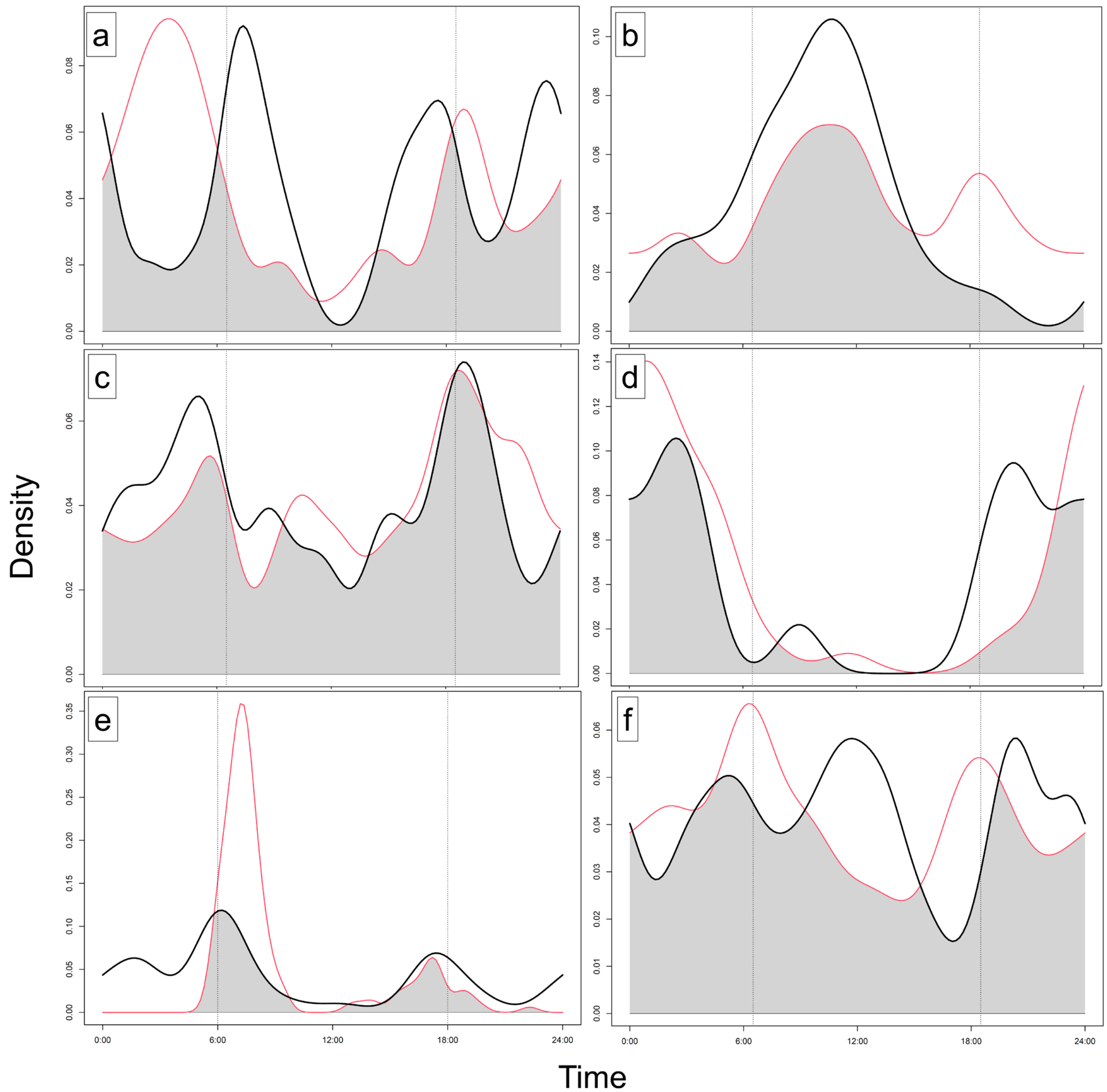

Figure 4. Seasonal activity patterns of medium- and large domestic and wild mammals were recorded in an isolated vegetation fragment in the city of Mérida, Yucatán, Mexico. a) *Silvilagus yucatanicus*; b) *Odocoileus virginianus*; c) *Urocyon cinereoargenteus*; d) *Spilogale yucatanensis*; d) *Canis familiaris*; e) *Felis catus*. The black line corresponds to the wet season (30 May to 14 October 2023). The red line corresponds to the dry season (15 October 2023 to 4 April 2024). The shaded gray space indicates the areas of overlap between the two seasons. The vertical line indicates the approximate time of sunrise (06:00 h) and sunset (18:00 h).

antlers, as well as probably several females that could not be identified individually. In Campeche wetlands, the home range of white-tailed deer covers 12.67 ha to 21.57 ha in females and 37.31 ha to 90.16 ha in males, depending on the season, water availability, and flood levels (Contreras-Moreno *et al.* 2021). In the Yucatán region, this species is subject to intense pressure from subsistence poachers, which has led to significant reductions in its populations (Burgos-Solís *et al.* 2023). The presence of this species in unprotected urban vegetation fragments within Mérida could reflect the difficulties of poaching in urban areas due to vigilance by police and neighbors.

Some of the native species recorded in this study, such as *Didelphis* sp., *P. lotor*, and *U. cinereoargenteus*, are classified by McKinney (2002) as adapted to rural, suburban, and urban areas. This group includes medium-sized species with a generalist and opportunistic diet that take advantage of food and other resources subsidized by man in suburban spaces, forest patches, and surrounding green spaces. Open dumps, where organic waste is usually disposed of, are common in the surroundings of the fragment. These may benefit mainly *U. cinereoargenteus*, since several photographs showed individuals carrying bags that probably contained food remains. *Didelphis* sp.

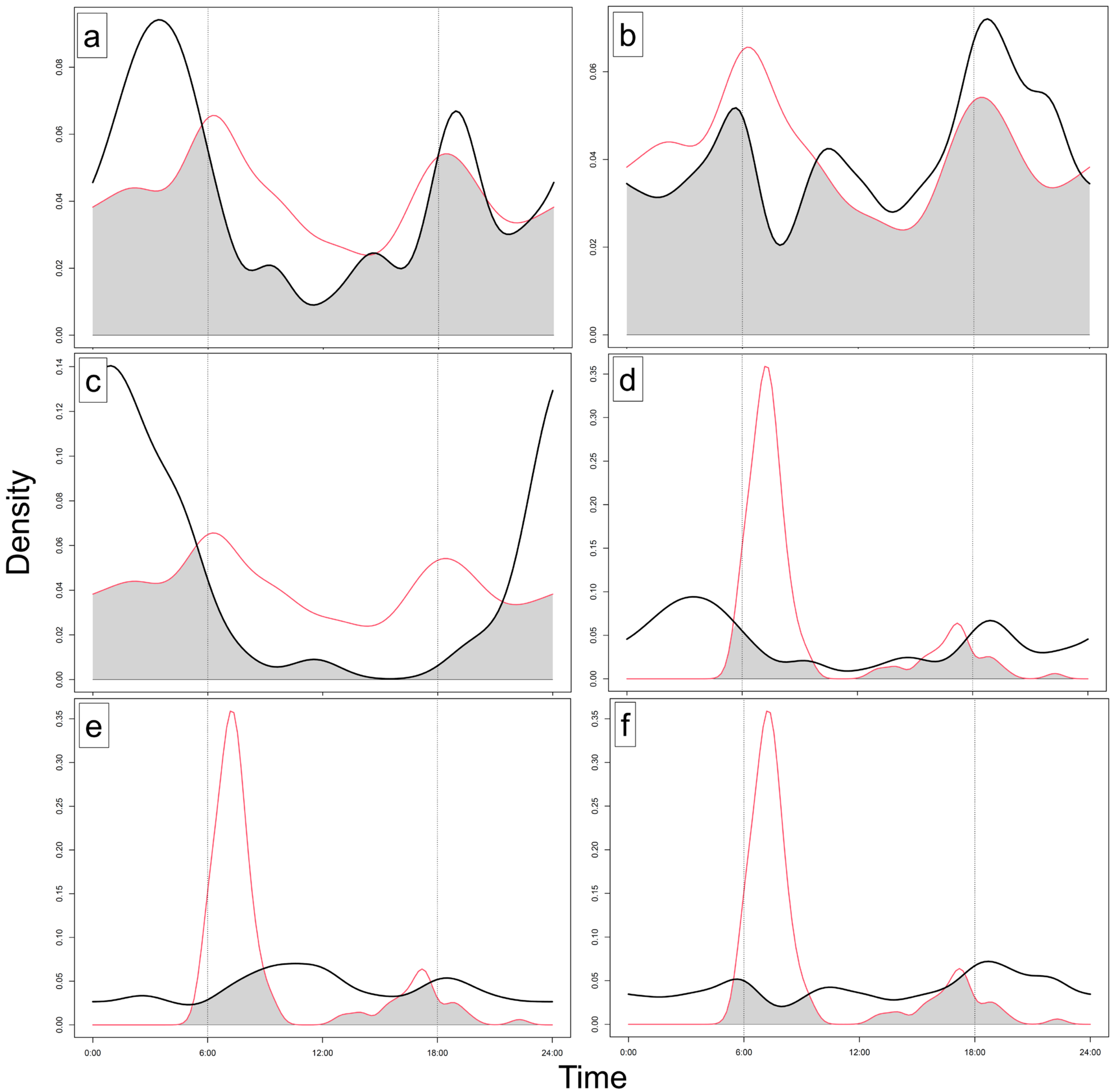

Figure 5. Comparison of the activity pattern of medium- and large-sized mammals with the activity pattern of domestic mammals during the dry season (15 October 2023 to 4 April 2024) in an isolated vegetation fragment in the city of Mérida, Yucatán, Mexico. Panels a, b, and c correspond to the comparison between *Felis catus* and a) *Silvilagus yucatanicus*; b) *Urocyon cinereoargenteus*; c) *Spilogale yucatanensis*. Panels d, e, and f correspond to the interaction of *Canis familiaris* with d) *Silvilagus yucatanicus*; e) *Odocoileus virginianus*; f) *Urocyon cinereoargenteus*. The red line corresponds to the domestic mammal, and the black line corresponds to the wild mammal. The shaded gray space indicates the areas of overlap between the two species. The vertical line indicates the approximate time of sunrise (6:00 h) and sunset (18:00 h).

and *P. lotor* were not abundant in the interior of the studied fragment; in the particular environment of Mérida, they may not be as abundant as in other urban areas (e. g., Coronel-Arellano *et al.* 2021; García-Padilla *et al.* 2021). However, it is worth mentioning that in the present study *Didelphis* sp. was observed on numerous occasions (living and roadkill animals) in urban areas surrounding the vegetation fragment, even though the species is not abundant inside it. *Didelphis* sp., and particularly *Didelphis virginiana,* are highly adaptable to anthropized and urban environments in Mexico, where they are most abundant species (Cruz-Salazar *et al.* 2016; Coronel-Arellano *et al.* 2021; García-Padilla *et al.* 2021). There is no clear explanation for the low abundance of *Didelphis* sp. inside the fragment studied. Possible hypotheses could be associated with the high abundance of wild species such as *U. cinereoargenteus,* which is a potential competitor and predator, or that *Didelphis* sp. uses mostly human resources, and it uses the

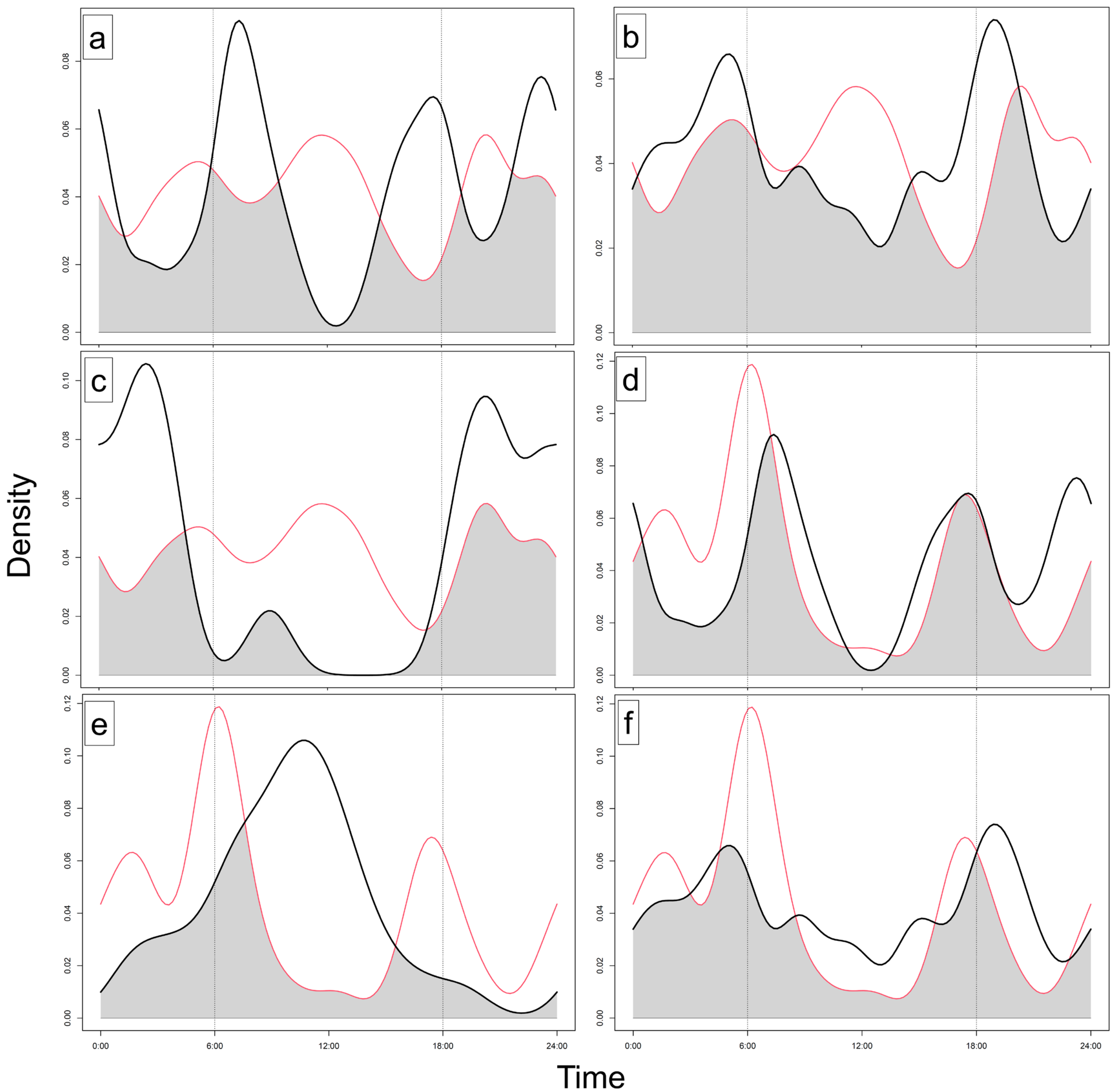

Figure 6. Comparison of the activity pattern of medium- and large-sized mammals with the activity pattern of domestic mammals during the wet season (30 May to 14 October 2023) in an isolated vegetation fragment in the city of Mérida, Yucatán, Mexico. Panels a, b, and c correspond to the comparison between *Felis catus* and a) *Silvilagus yucatanicus*; b) *Urocyon cinereoargenteus*; c) *Spilogale yucatanensis*. Panels d, e, and f correspond to the interaction of *Canis familiaris* with d) *Silvilagus yucatanicus*; e) *Odocoileus virginianus*; f) *Urocyon cinereoargenteus*. The red line corresponds to the domestic mammal, while the black line corresponds to the wild mammal. The shaded gray space indicates the areas of overlap between the two species. The vertical line indicates the approximate sunrise time (6:00 h) and sunset time (18:00 h).

forest cover to a lesser extent (Rodríguez *et al.* 2021).

Reports in the literature state that most species of wild mammals observed in urban environments tend to display nocturnal activity patterns, which have been commonly related to avoidance of human activity (e.g., Mella-Méndez *et al.* 2019; Coronel-Arellano *et al.* 2021). In the present study, the wild mammals found in Mérida showed significant diurnal activity, especially *O. virginianus* and *N. narica*, likely due to the limited access of people to the vegetation fragment studied. For their part, *S. yucatanicus* and *U. cinereoargenteus* showed diurnal activity, but concentrated especially at dawn and dusk, similar to their behavior in Mexico City or Xalapa (Mella-Méndez *et al.* 2019; Coronel-Arellano *et al.* 2021). The strictly nocturnal species found in the vegetation fragment of Mérida were *Spilogale yucatanensis*, *D. novemcinctus*, *Didelphis* sp., and *P. lotor*, which, except for the first one, had already been reported as mainly nocturnal species in other urban areas of Mexico

(Mella-Méndez *et al.* 2019). Regarding domestic species, cats were active during the day and night, as previously reported for this species in urban areas (Coronel-Arellano *et al.* 2021; Horn *et al.* 2011). In the case of dogs, activity in Mérida is concentrated at dawn and dusk, with very little activity at night. This finding contrasts observations in other areas, where dogs tend to be diurnal in a rural-urban gradient (Wang *et al.* 2015) and nocturnal within cities (De Andrade Silva *et al.* 2018; Mella-Méndez *et al.* 2019; Coronel-Arellano *et al.* 2021).

The results showed that during the dry season, the activity period of dogs overlaps slightly with those of *U. cinereoargenteus*, *O. virginianus,* and *S. yucatanicus*. In the wet season, the activity patterns of dogs are similar to those of *U. cinereoargenteus* and *S. yucatanicus* but differ from those of *O. virginianus*. In the dry season, dogs are predominantly diurnal, being most active at dawn, while *U. cinereoargenteus* and *S. yucatanicus* are active throughout the day, and *O. virginianus* is mainly diurnal, with greater activity at noon. *U. cinereoargenteus* and dogs share hours of activity in urban areas, which can lead to the death of *U. cinereoargenteus* due to this interaction (Mella-Méndez *et al.* 2019). In Mérida, no interactions were observed between these species, although the high overlap during the wet season suggests the possibility of interactions. The peaks of activity of dogs at dawn and dusk reduce this possibility.

Odocoileus virginianus shows significant twilight and nighttime activity in the dry season in warm areas of southern Mexico, probably to reduce hydric stress (Hidalgo-Mihart *et al.* 2024). However, in an isolated vegetation fragment in Mérida, despite comparable temperatures and water scarcity, *O. virginianus* was most active at noon. The avoidance of interactions with dogs could explain the peaks of activity at times of high temperatures. In the study, two series of photographs showed dogs running one minute after an *O. virginianus* passed, suggesting a chase and a negative interaction that *O. virginianus* would avoid by being active when dogs are not.

Cats were observed to be active both day and night, with a great overlap with *U. cinereoargenteus* and *S. yucatanicus* during the dry and wet seasons, but not with *Spilogale yucatanensis*, which is mostly nocturnal in the vegetation fragment. In urban areas, *U. cinereoargenteus* and other Sylvilagus species coincide in their hours of activity with cats (Coronel-Arellano *et al.* 2021), as observed in observed in S. yucatanicus in the vegetation fragment in Mérida. Cats are highly active during S. *yucatanicus* activity peaks, suggesting that cats could be important predators of this species, although no predation events were recorded (Loyd *et al.* 2017). In the case of *U. cinereoargenteus*, four series of photographs showing close interactions with cats were recorded. In all cases, both species seem to detect each other, but they stay away and evade encounters, which does not rule out the possibility of negative interactions. However, the frequent observation of interactions between these species suggests the possibility of pathogen exchange, posing the potential risk of transmission of infectious diseases between wild and domestic species (Clifford *et al.* 2006). Finally, the activity of *Spilogale yucatanensis* has been recorded mostly at night (Pérez-Irineo *et al.* 2020), consistent with our observations in the vegetation fragment in Mérida. The reduced temporal interaction with cats is likely due to its nocturnal habits rather than to its active avoidance of cats.

The case of the vegetation fragment in Mérida illustrates that urban patches of natural vegetation, despite their isolation and the pressures of urbanization, can host important communities of medium- and large-sized mammals. This fact highlights the importance of implementing urban conservation strategies that consider interactions between wild and domestic species while mitigating the impacts of urban sprawl. The protection of these fragments must be a priority, recognizing them as strategic areas for ecological restoration, intra-urban biological corridors, or archipelago-model protected natural areas (Carrillo-Niquete *et al.* 2021; Sosa-Escalante and González-Herrera 2022).

The present study also underlines the need to update land-use planning and urban development instruments in Mérida, such as Urban Development Programs (PDU, in Spanish) and Local Ecological Land-Use Planning (OETL, in Spanish), to include specific guidelines to promote the conservation of intra-urban natural vegetation fragments (Sosa-Escalante 2024). These efforts would prevent biodiversity loss, mitigate urban heat islands, and reduce the risk of zoonotic diseases by implementing nature-based solutions and green infrastructure (Carrillo-Niquete *et al.* 2021; Villanueva-Solís and Torres-Pérez 2023; Ayuntamiento de Mérida 2016; Ayuntamiento de Mérida 2024b).

In a broader context, the case of Mérida reflects the challenges and opportunities associated with urban sprawl in Mexico and Latin America. Cities with similar urbanization patterns face common problems of habitat fragmentation, loss of ecological connectivity, and pressure on biodiversity. However, the implementation of public policies focused on the conservation of intra-urban fragments and the improvement of the urban landscape can contribute significantly to the sustainable coexistence between humans and wildlife, serving as a model for other urban contexts in the region.

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