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Presence of medium-sized mammals in a fragment of tropical forest on the banks of the Bacalar Lagoon, Quintana Roo

Presencia de mamíferos de talla media en un fragmento de selva a orillas de la laguna de Bacalar, Quintana Roo

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Faunal research is crucial in wildlife and ecosystem conservation studies. In the case of Bacalar, research on local wildlife is scarce. This study aimed to identify the presence of wild mammals in a fragment of semi-preserved forest associated with the Bacalar Lagoon. The study was carried out over the period 2022–2023. Systematic sampling included direct observations along transects 1 km long by 2 m wide during daytime (7:00 hr) and nighttime (20:00 hr) routes and through photo-trapping with 10 camera traps installed in strategic areas (wildlife trails, watering holes, and periphery of fruit trees). The presence of 12 species of wild mammals belonging to 6 orders and 9 families was recorded, highlighting the order Carnivora with 4 species. A second record of *Potos flavus* (martucha) was obtained in Bacalar, and also recorded were *Herpailurus yagouaroundi* (jaguarundi) and *Leopardus wiedii* (ocelot), scarcely documented in the area. Eight of the 12 reported species were observed in the dry season (May-August). The richness of predators of the order Carnivora is attributed to the good state of conservation of the study area and the presence of prey. In addition, the increase in records during the dry season may be related to the Bacalar Lagoon as a water source. This paper highlights the importance of local fauna studies and the need for further studies of wild mammals in the state of Quintana Roo.

Key words: Jaguarundi; *Potos flavus*; predators; tropical forest.

Las investigaciones faunísticas desempeñan un papel crucial en los estudios de conservación de la fauna y ecosistemas. En el caso de Bacalar, existe escasez de investigaciones locales sobre la fauna silvestre. El objetivo de esta investigación fue identificar la presencia de mastofauna en un fragmento de selva semiconservada asociada a la Laguna de Bacalar. La investigación se llevó a cabo en el periodo 2022-2023. Se empleó un muestreo sistemático con transectos de 1 km y 2 m de ancho, recorridos diurnos (7:00 hr) y nocturnos (20:00 hr), y la técnica de fototrampeo con 10 cámaras trampa colocadas en zonas estratégicas (senderos de fauna, abrevaderos y periferia de árboles frutales). Se registró la presencia de 12 especies de mamíferos, pertenecientes a 6 órdenes y 9 familias, destacando el orden Carnivora con 4 especies. Se obtuvo un segundo registró de *Potos flavus* (martucha) en Bacalar, y *Herpailurus yagouaroundi* (jaguarundi) y *Leopardus wiedii* (tigrillo) escasamente citados en la zona. Durante la temporada de secas (mayo-agosto), se observaron 8 de las 12 especies reportadas. La riqueza de depredadores del orden Carnivora se atribuye al buen estado de conservación del área de estudio y la presencia de presas. Además, el aumento de registros durante la temporada de secas puede relacionarse con la Laguna de Bacalar como fuente de abrevadero. Se destaca la importancia de los estudios locales de fauna y la necesidad de efectuar mayores estudios de la mastofauna del estado de Quintana Roo.

Palabras clave: Depredadores; jaguarundi; *Potos flavus*; selva.

Studies on wild fauna are overly important because they are crucial for conservation studies of both animals and ecosystems (Sosa-Escalante *et al.* 2013). However, studies related to the local fauna of some regions, such as the one associated with the Bacalar lagoon, are scarce despite providing data of biological relevance, such as new records, descriptions of new species, or unknown ecological interactions (Sosa-Escalante *et al.* 2013; Mandujano *et al.* 2017).

In this sense, in a study on mammal richness in México, Rodríguez *et al.* (2003) point out that the Yucatán province (which includes the states of Campeche, Yucatán, and Quintana Roo) is the area with the lowest richness of mammals in the territory, with only 60 species recorded. This assertion is largely due to the small number of studies conducted in these states (Sosa-Escalante *et al.* 2013), especially in Quintana Roo, where work on terrestrial mammals is limited (*i.e.*, Pozo de la Tijera and Escobedo Cabrera 1999; Escobedo-Cabrera *et al.* 2002; Escobedo-Cabrera *et al.* 2009).

The state of Quintana Roo is one of the most important tourist hotspots in México, which has allowed the development and changes in land use in different municipalities, fostering the expansion of tourism and housing (Cárdenas-

Gómez 2020). An example is the Bacalar Lagoon in the municipality of Bacalar, where illegal deforestation has led to the loss and displacement of wild mammals (Ellis *et al.* 2017; Huchin-Ochoa *et al.* 2022). These mammals have been scarcely studied in the geographic area of Bacalar (*i.e.*, Escobedo-Cabrera *et al.* 2002; Escobedo-Cabrera *et al.* 2009); for example, the Neotropical otter *Lontra longicaudis*, whose presence in the Bacalar Lagoon was challenged until it was confirmed through photographs captured in 2021–2022 (Corona-Figueroa *et al.* 2022).

Therefore, the main objective of the present study was to identify the wild mammals that inhabit a fragment of semi-preserved tropical forest associated with the Bacalar Lagoon. Considering that food and water availability can influence the distribution of most species and that water bodies serve as reference points to assess the presence of various mammal species (Pérez-Cortez *et al.* 2012), the working hypothesis proposes that water availability positively influences the presence of medium-sized mammals in the forest fragment adjacent to the shores of the Bacalar Lagoon, Quintana Roo.

The study area is located at 18°36'33.90" N and 88°25'57.53" W, being a slightly disturbed private property known as the Zulia project (Figure 1). Its plant composition is dominated by medium tropical subdeciduous forest with species such as *Metopium brownei* (chechen), *Manilkara zapota* (sapote), and *Lysiloma latisiliquum* (tzalam). On the banks of the Bacalar Lagoon, the vegetation is composed of lowland flooded forest and the mangroves *Rhizophora mangle* (red mangrove) and *Conocarpus erectus* (button mangrove).

The study was carried out from January 2022 to January 2023 using a systematic sampling method with transects traveled during daytime (7:00 hr) and nighttime (20:00 hr) for the direct observation of specimens (Narváez and Zapata-Ríos 2020). This method is based on the distance sampling technique proposed by Sprent *et al.* (1994), where silent walks are carried out on previously established trails; in this study, we considered the proximity to trees such as *Manilkara zapota*, *Guazuma ulmifolia*, and *Brosimum alicastrum*, whose fruits are frequently consumed by several animal species, and the proximity to the water body.

The transects were designed to run across 1 km, and signs were placed every 25 m with colored ribbons to readily estimate the distance at which the observation was made and measured 2 m wide to increase the possibility of observing larger fauna such as jaguars or pumas. Transects were georeferenced using a GPS model Xtrail 30 (Garmin®,

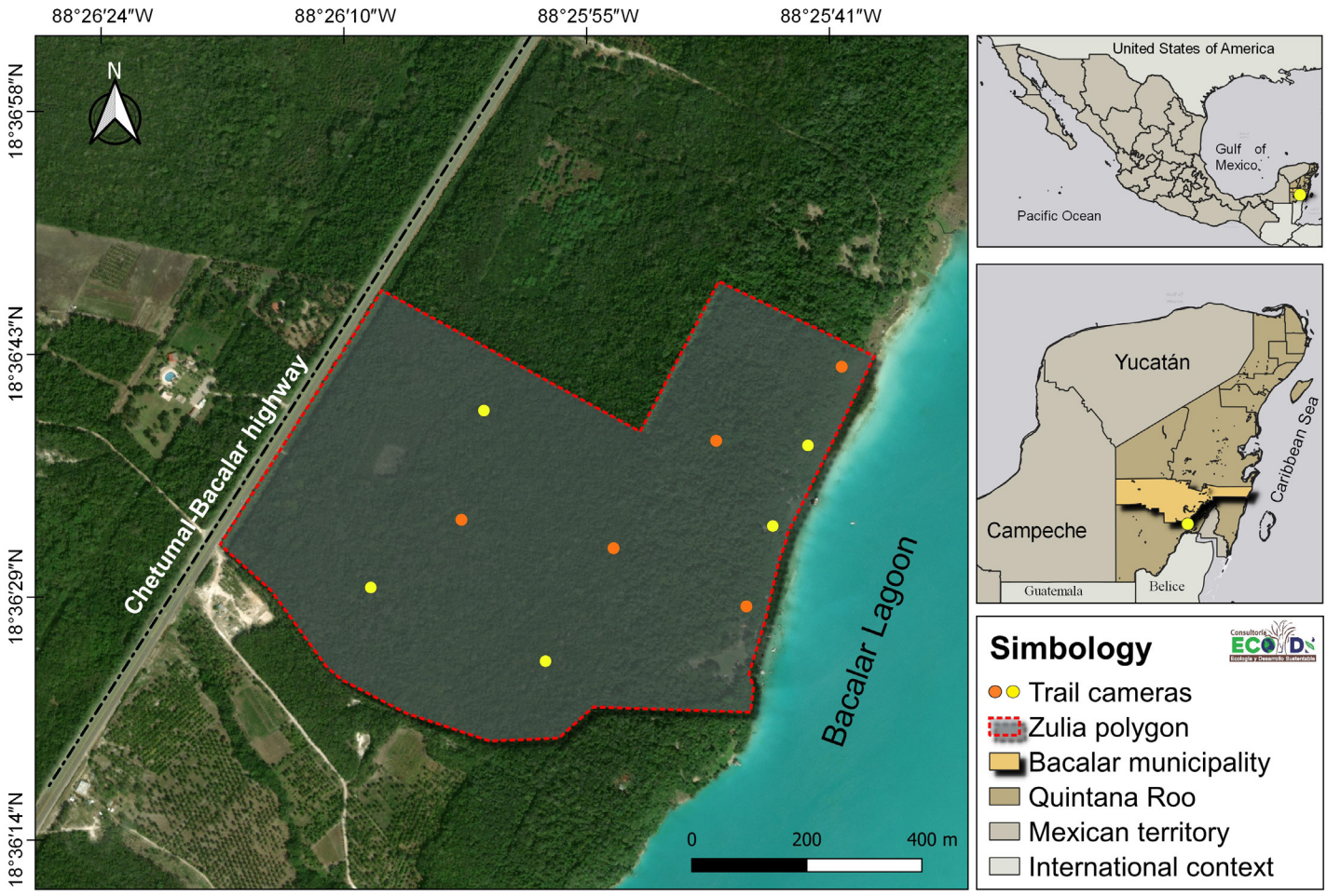

Figure 1. Geographic location of the study area, the Zulia private property in Bacalar. The orange circle marks a camera trap for predators; the yellow circle marks a camera trap for prey.

Olathe, Kansas), recording the start and end coordinates of each transect along with the route.

In addition to direct transect sampling, photo-trapping was implemented (Díaz-Pulido and Payán-Garrido 2012) using 10 prime low glow trail camera traps (Bushnell®, Kansas City, Missouri) with a passive activation system and a trigger speed of 0.3 sec, which allows daytime and nighttime images to be captured. Camera traps were placed on wildlife trails (evidenced by hair and excreta), areas near watering holes (inside the forest and in the vicinity of the lagoon), and on the periphery of fruit trees such as *Manilkara zapota* (Karanth *et al.* 2002). Baits were used to increase the recording probability. Five camera traps (Figure 1) were baited with fresh squid and sardines to attract carnivores (Prado *et al.* 2023), while fruits such as papaya, mango, and banana were left in the vicinity of the remaining 5 camera traps (Santos-Moreno and Pérez-Irineo 2013; Sebastián-González *et al.* 2020). Camera traps were set following the recommendations of Chávez *et al.* (2013), placing them at an angle that prevented direct exposure to light during sunrise and sunset to avoid overexposed photographs, at a height between 60 and 40 cm from the ground to capture the full body of small to medium-sized specimens. After installation, camera traps were covered with mud to reduce the smell left in them when handled. Finally, cameras were left in place for 365 days and reviewed once a month to extract the memories and replace the baits.

A total of 12 mammal species (Figure 2) were recorded, belonging to 6 orders, 9 families, and 12 genera (Table 1). The best-represented order was Carnivora, with 4 species, followed by Rodentia, with 3 species. The presence of 2 species belonging to the order Didelphimorphia is worth highlighting since these are the only marsupials present in the state of Quintana Roo, listed as Least Concern according to the International Union for Conservation of Nature (IUCN 2023). This species diversity was captured mainly by camera traps, with 83.33 % (Table 1), and the remaining 16.67 % was recorded during the transect tours. *Sciurus yucatanensis* (Yucatán squirrel) was observed during the day, and the opossum *Didelphis marsupialis* during a night tour. The highest number of species was recorded in the dry season (May–August), with 8 species observed, whereas only 5 species were recorded during the rainy season.

The richness of predators (order Carnivora) registered can be explained by the good state of conservation of the study area, as it has a robust vegetation cover and little deforestation or habitat fragmentation compared to other nearby areas (Huchin-Ochoa *et al.* 2022); predators have been mentioned to be abundant in areas with low disturbance (Serna-Lagunes *et al.* 2019). The prevalence of carnivore records may also be due to the presence of prey in the study area, such as *Cuniculus paca* (tepezcuintle), *Dasypus novemcinctus* (nine-banded armadillo), *Dasyprocta punctata* (Central American aguti), *Nasua narica* (coati), *Potos flavus* (martucha), and *Mazama pandora* (temazate; Figure 2).

It is worth noting the solitary presence of *Ateles geoffroyi* (spider monkey), a species endangered of extinction according to the Secretariat of Environment and Natural Resources (Table 1; SEMARNAT 2010), which suggests that the area could be a transit area but not a feeding area for these animals, as this behavior was not observed during any of the tours. Additionally, according to Aliaga-Samanez *et al.* (2016), the feeding areas of this species are characterized by the presence of groups of at least 5 individuals. Also noteworthy are the records of *Herpailurus yagouaroundi* (jaguarundi), a threatened species, and *Leopardus wiedii* (ocelot), a species endangered of extinction (Table 1; SEMARNAT 2010), which have been scarcely reported in previous studies in this area of Quintana Roo (*i.e.*, Escobedo-Cabrera *et al.* 2002; Escobedo-Cabrera *et al.* 2009; Sánchez-Soto 2020). Furthermore, until now, there was only one record of *Potos flavus* (martucha) in the municipality (Hernández and Calmé 2002), a species subject to special protection (Table 1; SEMARNAT 2010); therefore, the record reported in this study is the second record for this species in the area.

Table 1. List of orders, families, and species of wild mammals recorded on private land on the banks of the Bacalar Lagoon, Quintana Roo, as well as risk categories and recording method. Risk categories according to NOM-059-SEMARNAT-2010 (SEMARNAT 2010): Threatened (A), Endangered (P), Subject to Special Protection (Pr). Global threat categories according to the Red List (IUCN 2023): Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN).

Order	Family	Species	Risk category (SEMARNAT 2010)/global threat (IUCN 2023)	Registration method
Rodentia	Cuniculidae	*Cuniculus paca*	LC	Photo-trapping
	Sciuridae	*Sciurus yucatanensis*	LC	Direct observation
	Dasyproctidae	*Dasyprocta punctata*	A / LC	Photo-trapping
Carnivora	Felidae	*Herpailurus yagouaroundi*	A / LC	Photo-trapping
		Leopardus wiedii	P / NT	Photo-trapping
	Procyonidae	*Potos flavus*	Pr / LC	Photo-trapping
		Nasua narica	LC	Photo-trapping
Didelphimorphia	Didelphidae	*Didelphis marsupialis*	LC	Photo-trapping / Direct observation
		Philander opossum	LC	Photo-trapping
Primates	Atelidae	*Ateles geoffroyi*	P / EN	Photo-trapping
Artiodactyla	Cervidae	*Mazama pandora*	VU	Photo-trapping
Cingulata	Dasypodidae	*Dasypus novemcinctus*	LC	Photo-trapping

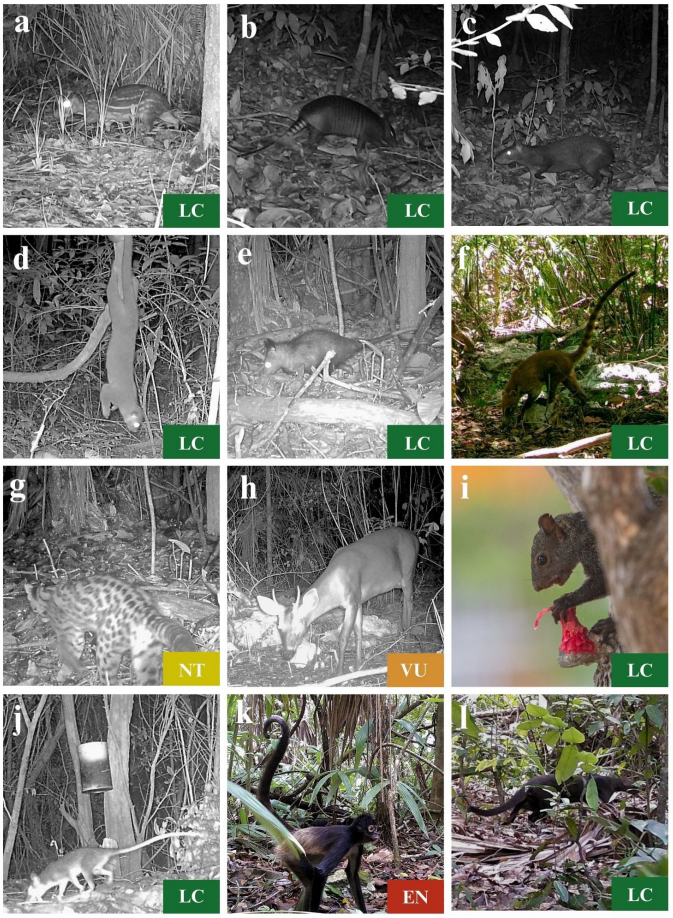

Figure 2. Species recorded during wildlife monitoring at the Zulia private property in Bacalar, Quintana Roo, from January 2022 to January 2023; a) *Cuniculus paca*, b) *Dasypus novemcinctus*, c) *Dasyprocta punctata*, d) *Potos flavus*, e) *Didelphis marsupialis*, f) *Nasua narica*, g) *Leopardus wiedii*, h) *Mazama pandora*, i) *Sciurus yucatanensis*, j) *Philander opossum*, k) *Ateles geoffroyi*, l) *Herpailurus yagouaroundi*. The bottom right corner of each image indicates the global threat category for each species. LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered (IUCN 2023).

The difference in species richness between seasons can be attributed to the study area being close to the Bacalar Lagoon, at a distance between 100 and 500 m, which is used as a watering hole for wildlife species during the drought season. This finding is consistent with the observation by Epaphras *et al.* (2008), who point out that, in times of drought, both prey and predators spend the night near water bodies.

The results of this study highlight the need to conduct further studies of wild mammals in the state of Quintana Roo, which has been scarcely studied in this respect. Local wildlife studies broaden the understanding of a territory's biodiversity, facilitating the development of guidelines for best wildlife conservation and management practices.

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