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A visit to the Mountain of Guerrero; first records of medium and large mammals in Atlixtac, Guerrero, México

Una visita a la Montaña de Guerrero; primeros registros de los mamíferos medianos y grandes en Atlixtac, Guerrero, México

Rodolfo Rodríguez-Ruiz[1], Rocío Ramírez Barrios[2], Beatriz Pereyra Cortés[3], Javier Bailón Miranda[4], Carlos Sánchez Castro[5], and Octavio Monroy-Vilchis[6*]

[1]El Colegio de la Frontera Sur (ECOSUR), Departamento de Conservación de la Biodiversidad. Barrio de María Auxiliadora, C. P. 29290, San Cristóbal de Las Casas. Chiapas, México. E-mail: rodolfo.rodriguez@posgrado.ecosur.mx (RR-R).

[2]Universidad Nacional Autónoma de México, Facultad de Ciencias. Coyoacán, C. P. 04510. Ciudad de México, México. E-mail: rociorrb13@ciencias.unam.mx (RRB).

[3]Universidad Autónoma de Guerrero, Facultad de Ciencias Químico Biológicas. Lázaro Cárdenas, C. P. 39086, Chilpancingo de los Bravo. Guerrero, México. E-mail: biologapereyra@gmail.com (BPC).

[4]Técnico independiente. Barrio de San Mateo, C. P. 39022, Chilpancingo de los Bravo. Guerrero, México. E-mail: javier.bm04@gmail.com (JBM).

[5]Comisión Nacional de Áreas Naturales Protegidas, Burócratas, C. P. 39090, Chilpancingo de los Bravo. Guerrero, México. E-mail: carlos.sanchez.castro83@gmail.com (CSC).

[6]Universidad Autónoma del Estado de México. Instituto Literario 100, Centro, C. P. 5000. Toluca, México. E-mail: tavomonroyvilchis@gmail.com (OM-V).

*Corresponding author

The Guerrero state is an important area for its high diversity of mammals. However, there are few studies documenting this diversity in the state. Due to the above, the diversity of terrestrial mammals in the Mountain region of the Atlixtac, Guerrero was analyzed. During September 2021 to March 2022 the community of Atlixtac, Guerrero was visited, camera-traps were placed, and walks were conducted. The information obtained was organized and analyzed for abundance and diversity. Fifteen species distributed in 10 families were recorded; of these, 2 species are under protection in the NOM-059-SEMARNAT-2010; *Leopardus wiedii* by photo-trapping (n = 3) and *Herpailurus yagouaroundi* (n = 1) by hunting report. The study area is important for mammals in the Guerrero state, the distribution and knowledge of species such as *L. wiedii*, *H. yagouaroundi* and *S. angustifrons* are expanded. It is important to increase monitoring in the Mountain region of Guerrero, the results obtained indicate a high probability of increasing the number of species in the state. The study area is of ecological importance because it is located within the Sierra Madre del Sur and connects with the Balsas Basin and serving as a biological corridor for various species of mammals.

Key words: Conservation; diversity; *Leopardus wiedii;* mammals*; Spilogale angustifrons*.

El estado de Guerrero es un área importante por su alta diversidad de mamíferos. Sin embargo, pocos estudios documentan esta diversidad de mamíferos en el estado. Debido a lo anterior, en este estudio se analizó la diversidad de mamíferos terrestres la región de Montaña de Atlixtac, Guerrero. Durante septiembre 2021 a marzo 2022 se visitó la comunidad de Atlixtac, Guerrero, se colocaron cámaras-trampa y se realizaron recorridos. La información obtenida se organizó y se analizó la abundancia y la diversidad. Se registraron 15 especies distribuidas en 10 familias; de éstas, 2 especies se encuentran bajo protección en la NOM 059 SEMARNAT; *Leopardus wiedii* mediante foto trampeo (n = 3) y *Herpailurus yagouaroundi* (n = 1) mediante reporte de caza. La zona de estudio es importante para los mamíferos del estado de Guerrero, se amplía la distribución y el conocimiento de especies como *L. wiedii*, *H. yagouaroundi* y *S. angustifrons*. Es importante incrementar el monitoreo en la región de montaña de Guerrero, los resultados obtenidos indican una alta probabilidad de aumentar el número de especies en el estado. El área de estudio es importante ecológicamente porque se encuentra dentro de la Sierra Madre del Sur, conecta con la Cuenca del Balsas y sirve de corredor biológico para varias especies de mamíferos.

Palabras clave: Conservación; diversidad; *Leopardus wiedii*; mamíferos; *Spilogale angustifrons*.

Guerrero, located in southern México, is an important area for wild land mammals. The state possesses a diversity of 71 species of mammals (Flores-Villela and Fernández 1994; Espinosa-Martínez *et al.* 2017). Mammals are important in the dynamics of ecosystems because they participate in processes and interactions that shape their structure and function (Sato *et al.* 2019; Miller and Rabinowitz 2002). In addition, the richness and abundance of wild mammals are frequently used as indicators of the state of conservation of ecosystems (Galetti *et al.* 2015; Macario-Cueyactle *et al.* 2019; Pozo-Montuy *et al.* 2019).

Currently, studies of the diversity of mammals in the Guerrero state have been carried out mainly in the Coastal, Central, and Northern regions of the state (León-Pani-

agua and Romo-Vázquez 1993; Ramírez-Pulido *et al.* 1977; Almazán-Catalán *et al.* 2005, 2013, 2015; Marín *et al.* 2016; Ruiz-Gutiérrez *et al.* 2020; Briseño-Hernández and Naranjo 2021; Osorio-Rodríguez *et al.* 2021), and particularly for the Mountain region they are scarce (Almazán-Catalán *et al.* 2013; Ruiz-Gutiérrez *et al.* 2020). Due to the above, the objective of this study was to know the diversity and abundance of medium and large wild mammals in the Mountain region of Atlixtac, Guerrero.

The study area is located northwest of the municipality of Atlixtac, Guerrero (17° 37' 52.37" N, 98° 56' 14.15" W), in the geo-cultural region known as La Montaña. It is located at the intersection of the Sierra Madre del Sur and the Balsas Basin. La Montaña region presents rugged orography with vegetation composed mainly of pine-oak in areas > 1,500 m and deciduous forest in areas of lower altitude (Figure 1).

From September 2021 to March 2022, 10 stations (camera traps) were placed at a minimum distance of 800 m and a maximum distance of 4 km between cameras, in an altitude range of 1,400 to 1,812 m. The sampling design was adjusted according to the site conditions following the suggestion of Chávez *et al.* (2013), the camera traps were located near roads, trails, paths and water bodies (Figure 1).

The cameras were programmed to obtain day and night photographic records. The photographic records were analyzed according to specialized literature (Ramírez-Pulido *et al.* 2014). Sampling effort was calculated by multiplying the days of camera activity by the number of camera traps. Those individuals registered with 24 hr time gap between them were treated as independent records. The index of relative abundance (IAR) was calculated by dividing the number of photographic records (independent) by the sampling effort (measured in days-trap) and then multiplying by 100 (O'Brien *et al.* 2003; Monroy-Vilchis *et al.* 2011). For *Leopardus wiedii*, individuals were identified based on their pattern of spots on the skin.

Species richness and sampling effort were analyzed with 2 non-parametric estimators (Bootstrap, ACE) using the EstimateS version 9.1.0 program (Colwell 2013). These estimators are intended to reduce the effect of under sampling, which inevitably biases the observed species count. For this purpose, a matrix was created with the number of species as rows and the sampling months as columns; 1,000 randomizations were then run using a bootstrap process. The species accumulation curve was generated from the expected richness (number of species) per month elapsed

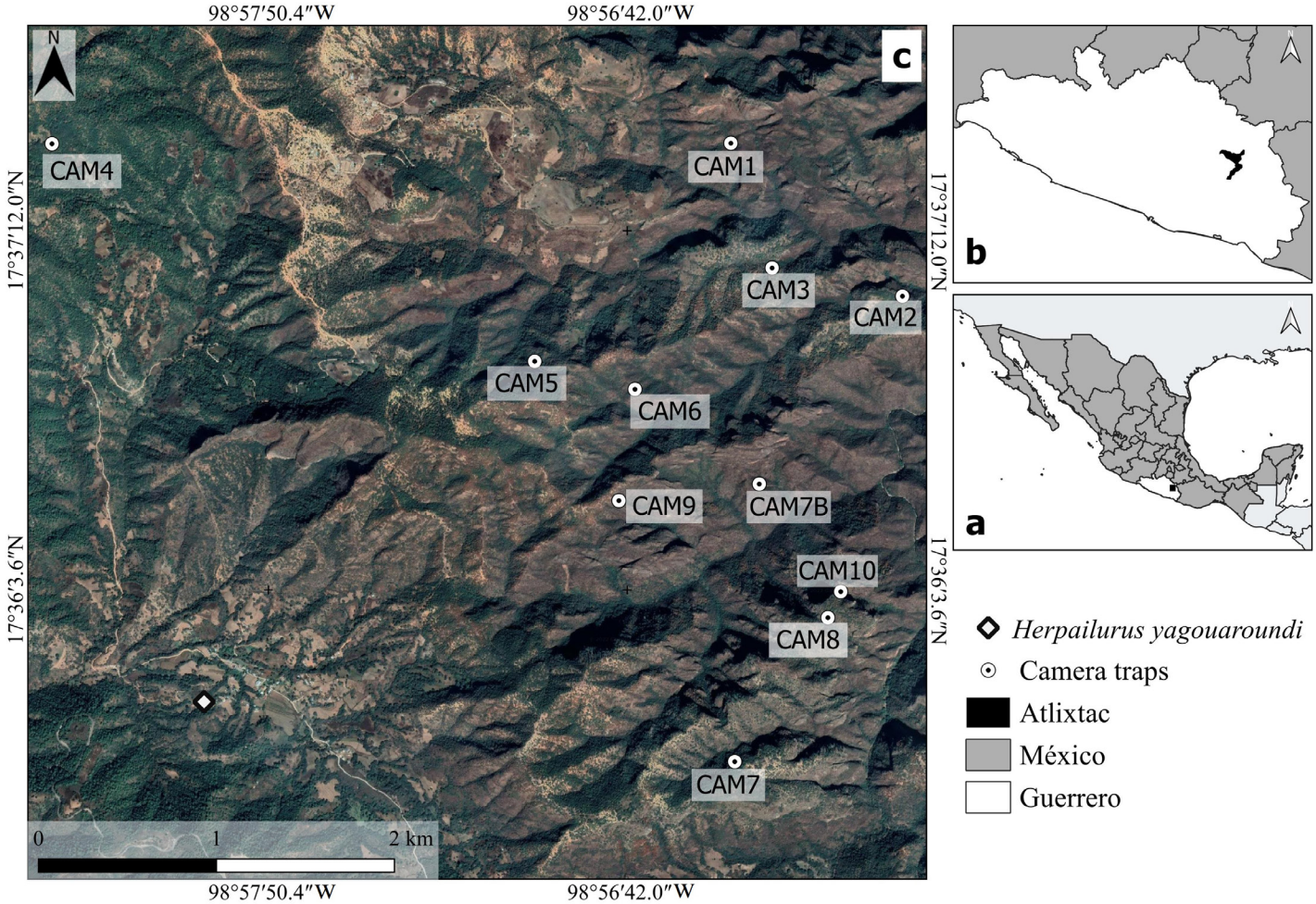

Figure 1. Study area. The map of the sampled area is presented in Atlixtac, Guerrero, México. a) the national location; b) state location; c) location of each camera trap and *Herpailurus yagouaroundi* (in diamond).

in the sampling (Escalante and Morrone 2002). During the first month of sampling, CAM8 was lost and later, in December 2021 CAM10 was missing as well. For this reason, the information was analyzed with the remaining 8. Besides, CAM7 was moved from its original location (CAM7B; Figure 1). A month after the camera traps were removed, a phone call was received notifying us about that a specimen of *Herpailurus yagouaroundi* had been hunted in Ahuitla, an adjacent area to the sampling site, it was added as an additional record in this study.

A sampling effort of 1,504 days-trap was applied, 1,028 photographic records were analyzed, of these, 171 were independent records. Fourteen medium and large sized mammal species distributed in 10 families and 6 orders were recorded, and 1 additional species was recorded with a specimen in the possession of a local inhabitant (n = 15; Table 1).

The species accumulation curve did not show a defined asymptote, presenting a high initial growth for the ACE estimator. A richness of 18 species (83 % efficiency) is predicted, so it is likely that additional species will be recorded in the area in the future (Figure 2). Two species under some status protection were registered (SEMARNAT 2010): *L. wiedii* (endangered) and *H. yagouaroundi* (threatened; Figure 3). In the case of *L. wiedii*, 2 different individuals were identified according to their spotting pattern.

The species with highest IAR were: *Nasua narica* (IAR = 4.0) followed by *Odocoileus virginianus* (IAR = 2.8), recorded in all cameras. The species with the lowest records were *Mephitis macroura* (IAR = 0.06) and *Spilogale angustifrons* (IAR = 0.06), with 1 record for each species in CAM6 and CAM7B, respectively (Table 1).

The 15 wild terrestrial mammal's species reported here, represent 21 % of the terrestrial mammals reported previously for Guerrero (Espinosa-Martínez *et al.* 2017). Particularly, the records of *Bassariscus astutus* and *S. angustifrons*, for the Guerrero state are scarce (León-Paniagua and Romo-Vázquez 1993; Almazán-Catalán *et al.* 2015; Espinosa-Martínez *et al.* 2017), with this study, both species expand its distribution towards the mountain region of the northeast of the state. Although, the Guerrero state is recognized as a distribution area for *S. angustifrons*, there is not enough information on its abundance and local distribution. Therefore, these first records are relevant in broadening the knowledge of its distribution in Guerrero.

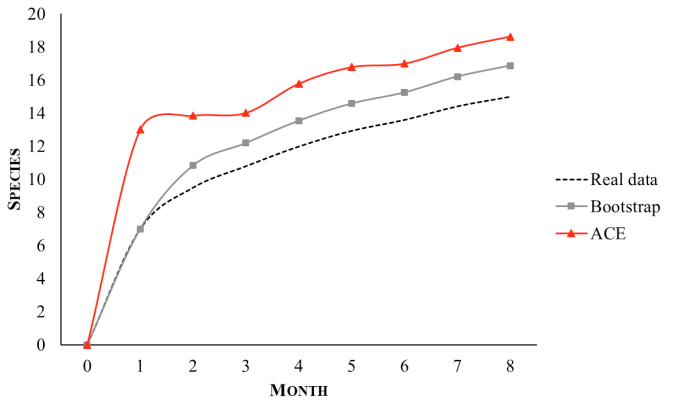

Figure 2. Cumulative curve of mammal species recorded during the period September 2021 to March 2022. The black line represents the non-parametric ACE estimator, the gray line represents the non-parametric Bootstrap estimator, and the dotted line represents the actual values obtained.

Carnivore species richness (n = 9) was higher than that obtained by Pérez-Irineo and Santos-Moreno (2012) in a semi-deciduous forest in northeastern Oaxaca; this suggests the importance of the southern Mexican mountain region, where oak forest and low deciduous forest converge (Altamirano Álvarez *et al.* 2009; Ruiz-Gutiérrez *et al.* 2020).

The abundance data indicates that *N. narica* is the dominant species in the study area; similar values were reported

Table 1. Mammals of Atlixtac Guerrero. Taxonomic list based on the proposal of Ramírez-Pulido *et al.* (2014). Mammals recorded, chamber in which the species was recorded (CAM), independent records (RI) and index of relative abundance (IAR) are presented.

Order	Family	Species	CAM	RI	IAR
Carnivora	Mephitidae	*Mephitis macroura*	6	1	0.06
		Spilogale angustifrons	7B	1	0.06
	Canidae	*Canis latrans*	2, 4, 5, 6	11	0.73
		Urocyon cinereoargenteus	4, 5, 6, 7	13	0.86
	Felidae	*Leopardus wiedii*	10, 5	3	0.49
		Herpailurus yagouaroundi		1	
	Procyonidae	*Bassariscus astutus*	2, 7	2	0.49
		Procyon lotor	2	3	0.49
		Nasua narica	1, 2, 3, 4, 5, 6, 7,7B, 9, 10	61	4.06
Rodentia	Sciuridae	*Sciurus aureogaster*	3. 7, 9	7	0.46
	Cricetidae	*Peromyscus* sp.	7B	1	0.06
Didelphimorphia	Didelphidae	*Didelphis virginiana*	1, 7B, 9	3	0.19
Lagomorpha	Leporidae	*Sylvilagus cunicularius*	4	6	0.39
Cingulata	Dasypodidae	*Dasypus novemcinctus*	1, 5, 6, 7, 7B, 10	16	1.06
Cetartiodactyla	Cervidae	*Odocoileus virginianus*	1, 2, 3, 4, 5, 6, 7, 7B, 9, 10	43	2.86

Figure 3. Photographic records obtained by camera trapping of *Nasua narica* (a), *Odocoileus virginianus* (b), *Bassariscus astutus* (c), *Leopardus wiedii* (d), *Spilogale angustifrons* (e) and *Herpailurus yagouaroundi* (f) in the community of Ahuitla belonging to the agrarian nucleus of Atlixtac, Guerrero, México.

for Oaxaca (Pérez-Irineo and Santos-Moreno 2010), it is worth noting that none of these study areas in Oaxaca and the present have records of large carnivores, which may explain that the abundance of *N. narica* and *O. virginianus* was influenced by the scarcity of larger predators such as *Puma concolor* (Núñez *et al.* 2000; Hernández 2008). In addition, *N. narica* is an omnivorous species with generalist habits, and in general, both species are tolerant to human activities as long as there are habitat relicts that provide food, water and vegetation cover enough (Mandujano 2004; Torres 2006).

Three records of *L. wiedii* were obtained, these corresponding to 2 different individuals, obtained in low deciduous forest in CAM10 ($n = 1$) and CAM5 ($n = 2$), which were separated by 2.18 km (Figure 1). Previously, *L. wiedii* had been recorded towards the centre of the state (Almazán-Catalán *et al.* 2013; Briseño-Hernández and Naranjo 2021). However, there was no information for the Mountain region.

Species richness in Atlixtac was in the average richness reported by Ruiz-Gutiérrez *et al.* (2020) for landscapes of the Sierra Madre del Sur in Guerrero. However, it is essential to increase sampling efforts in the Mountain Guerrero region. The recorded number of species could potentially increase as residents provide us inputs regarding the presence of other larger carnivores, such as the puma (*P. concolor*) and the wild cat (*Lynx rufus*). Additionally, Almazán-Catalán *et al.* (2013) had documented their presence in La Montaña region through fur records showed by local people.

The finding of *H. yagouaroundi* confirms that a greater sampling effort is required in the study area. Since its conservation status in the state of Guerrero is unknown, and only few records from the coast and centre of the state are known (Ramírez-Pulido *et al.* 1977; Almazán-Catalán *et al.* 2013; Briseño-Hernández and Naranjo 2021), our registry adds information for the northeastern.

This study contributes to the knowledge about the distribution of mammals in the Sierra Madre del Sur, Mountain region in the state of Guerrero, providing the first records of the mammal species for the area. La Montaña region is a great biological area because of its location within the Sierra Madre del Sur and its conection with the Balsas Basin, serving as a biological corridor for mammals' species (Rodríguez-Soto *et al.* 2013; Ruiz-Gutierrez *et al.* 2020).

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