THERYA, 2025, Vol. 16(2):293-304 DOI:10.12933/therya-25-6192 ISSN 2007-3364

Felid activity at artificial water troughs in a tropical forest in southeastern Mexico

Khiavett Sánchez-Pinzón[1], Fernando M. Contreras-Moreno[2, 3], Daniel Jesús-Espinosa[1], José Méndez-Tun[1], Lizardo Cruz-Romo[4], Sandra Petrone[2], José Juan Flores-Martínez[5], Mario C. Lavariega[6*], Víctor Sánchez-Cordero[5], and Pedro Bautista-Ramírez[1]

[1]Grupo de Monitoreo Socioambiental, calle 27 de febrero no 127, Balancán, CP. 86930. Tabasco, México. Email: khiavettsanchez@hotmail.com (KS-P), danieljesus_esp@outlook.com (DJ-E), herohero_slime@hotmail.com (JM-T), barp920928@gmail.com (PB-R).
[2]World Wildlife Fund Inc, Av. Insurgentes Sur No 1216, CP. 03100. Ciudad de México, México. Email: fernandom28@hotmail.com (FMCM), spetrone@wwfmex.org (SP).
[3]Universidad Tecnológica de Calakmul. Carretera Xpujil-Dzibalchen Km. 2+260, CP. 24640. Campeche, México. Email: fernandom28@hotmail.com (FMCM)
[4]Espacios Naturales y Desarrollo Sustentable A.C., Miguel Hidalgo 143, CP. 14090, Tlalpan, Ciudad de México. Email: lizardo.cruz@endesu.org.mx (LC-R)
[5]Pabellón Nacional de la Biodiversidad, Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, Ciudad de México. jj@ib.unam.mx (JJF-M), victor@ib.unam.mx (VS-C)
[6]Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca, Instituto Politécnico Nacional, Santa Cruz Xoxocotlán, Oaxaca, México. mariolavnol@yahoo.com.mx (MCL)
*Corresponding author: https://orcid.org/0000-0003-2513-8244

Felids play a major role in ecosystems as apex and mesopredators of numerous vertebrate species. Thus, a decline in their populations can directly impact ecosystem functioning. Recently, extreme weather events, such as prolonged droughts, have posed increasing threats to tropical forests. Implementing mitigation measures, such as providing artificial water troughs, can help alleviate water shortages for wildlife during the dry season. However, limited information is available on how species respond to such mitigation measures in tropical ecosystems, particularly concerning visitation rates and temporal patterns of use by felids. We hypothesized that water troughs would be used with similar frequency, irrespective of their spatial arrangement. Additionally, we anticipated that smaller species would exhibit lower visitation rates and reduced temporal overlap compared to larger felid species. Specifically, we evaluated the broad-scale spatial variation in visitation rates to water troughs by felid species and the degree of overlap in activity patterns to infer potential interspecific avoidance. We analyzed five years of camera-trap monitoring data collected at artificial water troughs in the Calakmul Biosphere Reserve, Campeche, Mexico. We measured visitation rates and compared frequencies among water troughs. Temporal overlap was used to evaluate similarities in diel activity patterns among felids. The ocelot (*Leopardus pardalis*) and puma (*Puma concolor*) were the most frequently observed species at water troughs, whereas the margay (*L. wiedii*) was rarely detected. Felid activity at water troughs was mainly crepuscular and nocturnal. We found greater temporal similarity between jaguars (*Panthera onca*) and pumas than with ocelots. Overall, artificial water troughs are an essential management strategy for providing water to felids. Higher visitation rates occurred during the dry years. Temporal similarity between jaguars and pumas suggested that visits by larger species to water resources occur regardless of potential competitors, whereas ocelots seem to avoid them. As prolonged droughts become extreme, management interventions that provide water sources for felid species and other wildlife will be essential for the persistence of their populations in tropical ecosystems.

Los félidos desempeñan un papel fundamental en los ecosistemas como depredadores tope y mesodepredadores de numerosas especies de vertebrados. Por lo tanto, la disminución de sus poblaciones puede afectar directamente el funcionamiento del ecosistema. Recientemente, fenómenos meteorológicos extremos, como sequías prolongadas, han aumentado las amenazas a los bosques tropicales. La implementación de medidas de mitigación, como la provisión de bebederos artificiales, puede contribuir a aliviar la escasez de agua para la fauna silvestre durante la estación seca. Sin embargo, existe información limitada sobre la respuesta de las especies a dichas medidas en los ecosistemas tropicales, en particular en lo que respecta a las tasas de visitación y los patrones temporales de uso por parte de los félidos. Planteamos la hipótesis de que los abrevaderos se utilizarían con una frecuencia similar, independientemente de su disposición espacial. Además, esperamos que las especies más pequeñas presenten tasas de visita más bajas y un traslape temporal menor en comparación con las especies de félidos más grandes. Específicamente, evaluamos la variación espacial en las tasas de visita a bebederos por parte de félidos y el grado de traslape en los patrones de actividad para inferir una posible evitación interespecífica. Analizamos cinco años de datos de monitoreo con cámaras trampa recolectados en bebederos artificiales en la Reserva de la Biosfera de Calakmul, Campeche, México. Medimos las tasas de visita y comparamos las frecuencias entre bebederos. Medimos el traslape temporal para evaluar las similitudes en los patrones de actividad entre los félidos. El ocelote (*Leopardus pardalis*) y el puma (*Puma concolor*) fueron las especies observadas con mayor frecuencia en los bebederos, mientras que el tigrillo (*L. wiedii*) fue detectada con poca frecuencia. La actividad de los félidos en los bebederos fue principalmente crepuscular y nocturna. Encontramos mayor similitud temporal entre jaguares (*Panthera onca*) y pumas que con ocelotes. En general, los bebederos artificiales son una estrategia de manejo esencial para proporcionar agua a los félidos. Las tasas de visita más altas ocurrieron durante los años más secos. La mayor similitud temporal entre jaguares y pumas sugiere que las visitas de especies grandes a los recursos hídricos ocurren independientemente de los competidores potenciales, mientras que los ocelotes parecen evitar a ambos. A medida que las sequías se vuelven extremas, las estrategias de manejo que proporcionen fuentes de agua para las especies de félidos y otros animales silvestres serán esenciales para la persistencia de sus poblaciones en los ecosistemas tropicales.

Keywords: climate change, extreme droughts, *Panthera onca*, Mayan rainforest, neotropical forests, *Leopardus pardalis*, *Puma concolor.*

Introduction

Felid species play an important role in ecosystems by preying on a wide range of small to large-sized terrestrial vertebrates, thereby influencing community structure through trophic cascade effects (Gittleman *et al.* 2001; Lucherini *et al.* 2009; Terborgh *et al.* 2010; Bogoni *et al.* 2020). The reduction or extirpation of felid populations has direct consequences for ecosystem functioning (Ripple *et al.* 2014; Wallach *et al.* 2015; Bogoni *et al.* 2020). For example, jaguars (*Panthera onca*) and pumas (*Puma concolor*), as top predators in the tropical and subtropical ecosystems of the Neotropical region, exert both direct and indirect influences on communities of medium-to-large mammal species (Gómez-Ortiz and Monroy-Vilchis 2013; Hernández-SaintMartín *et al.* 2015; Ávila-Nájera *et al.* 2018a; Galindo-Aguilar *et al.* 2022). On the other hand, medium-sized felids, such as the jaguarundi *(Herpailurus yagouaroundi*), margay (*Leopardus wiedii*), and ocelot *(Leopardus pardalis*), primarily prey on small-sized terrestrial vertebrates (Macdonald and Loveridge 2010). However, in the absence of jaguars and pumas, ocelots have been observed to shift their diet toward medium-sized terrestrial vertebrates (Moreno *et al.* 2006; Flores-Martínez *et al.* 2022).

Felid species are particularly vulnerable to habitat loss, hunting, wildlife trafficking, and prey declines, all of which may contribute to reductions in their abundance and range (Gittleman *et al.* 2001; Ceballos and Oliva 2005; McCarthy *et al.* 2017; Quigley *et al.* 2017; Goodrich *et al.* 2022; Nicholson *et al.* 2024; Stein *et al.* 2024). In Mexico, the jaguar, ocelot, and margay are categorized as "Endangered", while the jaguarundi is classified as "Threatened" (DOF 2010). Water is essential for felids for several physiological processes, including digestion, metabolism, temperature regulation, and the disposal of metabolic waste (Bothma 2005). Felids can obtain water from food or natural deposits (Delgado-Martínez *et al.* 2023), and even by consuming fruits (Bothma 2005; Kitchener *et al.* 2010). Overall, water scarcity significantly affects the abundance, spatial behavior, and interactions within the carnivore guild, posing an additional threat to their persistence under climate change scenarios (Prugh *et al.* 2018; West *et al.* 2024).

Big cats, such as jaguars and pumas, influence medium-sized felid species through interference competition and intraguild predation, modulating how these species use resources (Ritchie and Johnson 2009). In several sites across South America, pumas have been shown to negatively affect ocelots, margays, and jaguarundis (Gil-Sánchez *et al.* 2021). Ocelots exhibited temporal segregation from pumas (Finnegan *et al.* 2021), while pumas tend to avoid jaguars (Contreras-Díaz *et al.* 2021; Galindo-Aguilar *et al.* 2022). In contrast, in parts of Central America, big cats do not appear to influence the habitat use or daily activity patterns of medium-sized felid species (Santos *et al.* 2019).

The Calakmul Biosphere Reserve (CBR), southeastern Mexico, is a protected area within the Mayan Forest, which is part of the largest rainforest in Mesoamerica (Hansen *et al.* 2008). Several studies have demonstrated that this region offers favorable ecological conditions for the presence of medium-to-large felid species, including the jaguar, puma, margay, ocelot, and jaguarundi (Rodríguez-Soto *et al.* 2011; Espinosa *et al.* 2018; Jędrzejewski *et al.* 2018; Lehnen and Lombardi 2023). While deforestation represents a major threat to the Maya Forest (Ferrer-Paris *et al.* 2019), irregular rainfall has recently emerged as an additional risk factor for wildlife (Reyna-Hurtado *et al.* 2010; Pérez-Cortez *et al.* 2012; Pérez-Flores *et al.* 2021; Sandoval-Serés *et al.* 2022). Water scarcity, driven by climate change, is becoming an increasingly significant threat to tropical ecosystems (Bennett *et al.* 2023).

In recent years, ponds (locally named *aguadas*) in the Maya Forest have been observed to dry up well before replenishment during the rainy season (Garcia Gil *et al.* 2002; Dobler-Morales 2018). In response, wildlife managers have implemented artificial water sources for use by wildlife (Rosenstock *et al.* 1999) as a strategy to mitigate the consequences of dry-season water shortages. This approach has been shown to support the short-term maintenance of wildlife populations (Epaphras *et al.* 2008; Mandujano and Hernández 2019). The availability of water bodies is a critical factor influencing the habitat use by jaguars and pumas (Crawshaw *et al.* 1991; De Angelo *et al.* 2011). When water becomes scarce, some mammals change their usual behavior (Pacifici *et al.* 2015), often concentrating their activity around remaining water sources (Redfern *et al.* 2003). Although water can be obtained through food consumption, this is not always sufficient to meet metabolic and thermoregulatory demands (Simpson *et al.* 2011). In consequence, water scarcity represents a considerable challenge for felid species. Moreover, the pressure exerted by limited water availability during periods of extreme drought can facilitate intraguild predation interactions (Perera-Romero *et al.* 2021).

In the CBR, artificial water troughs have been installed and are actively managed to provide wildlife with access to water during the dry season. However, their influence on felid species remains understudied, including visitation rates to these resources, activity patterns, the impact of resource location on visitation, and the potential for temporal segregation driven by interspecific competition (Rosenstock *et al.* 1999). When ecological and morphologically similar species that are also phylogenetically related coexist in the same environment, interspecific competition is likely to arise (Begon *et al.* 1988; Hunter and Caro 2008). One common outcome of such competition is habitat segregation (Cruz *et al.* 2018). It has been found that dominant species, larger in size, exclude subordinate species from preferred areas through interference competition (Steinmetz *et al.* 2013). Consequently, smaller or subordinate species may be displaced to suboptimal habitats, which often have reduced resource availability or great anthropogenic

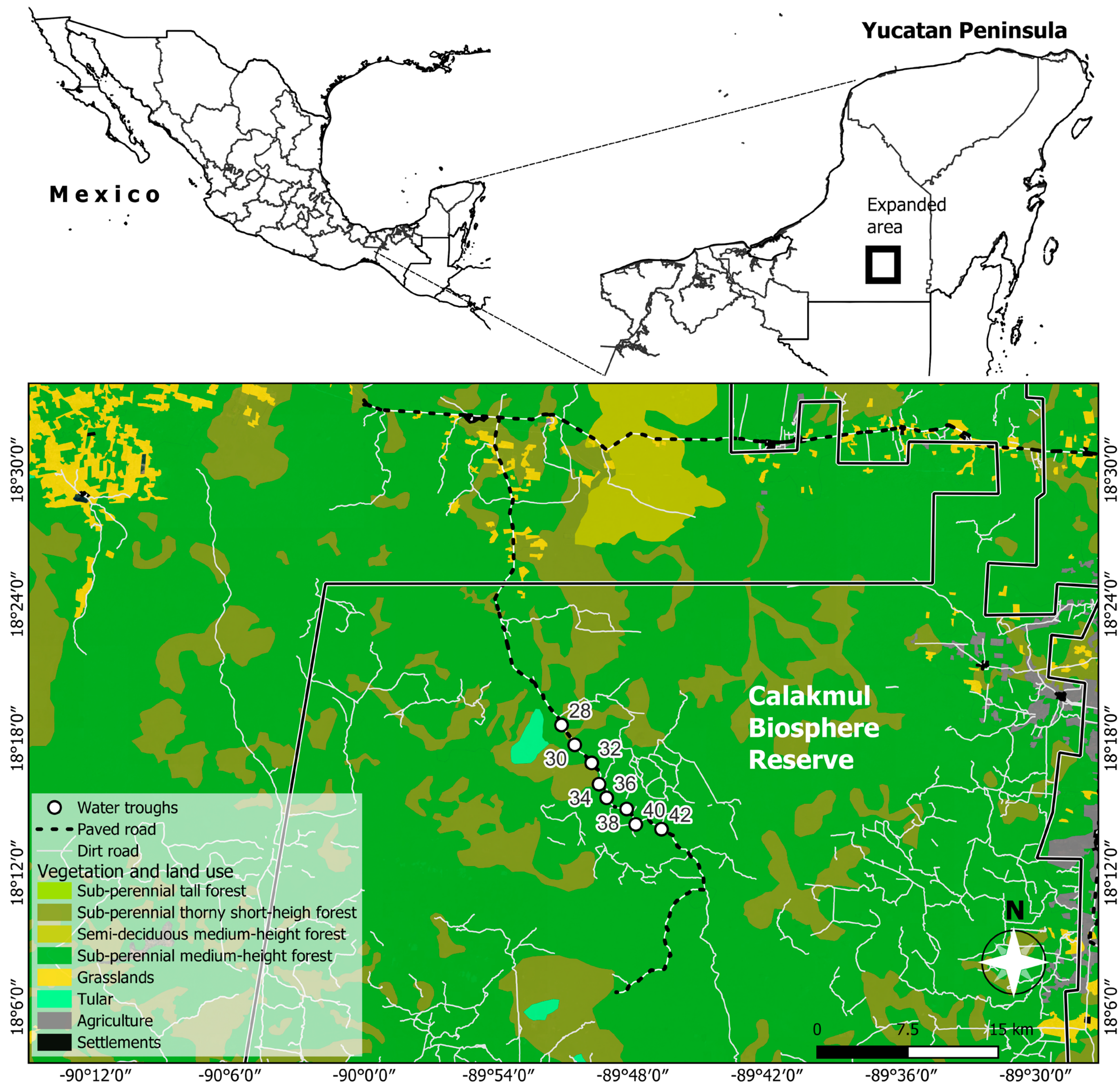

Figure 1. Location of the artificial water trough stations in the Calakmul Biosphere Reserve (CBR) in southeastern Mexico.

presence (Tannerfeldt *et al.* 2002). Therefore, competition over scarce resources, such as water, can intensify intraguild competition.

In this study, we analyzed five years of monitoring on the use of artificial water troughs by the felid species in the CBR**.** We hypothesized that felids would use water troughs with similar frequency regardless of their spatial arrangement. Also, we hypothesized that medium-sized felids (ocelot, jaguarundi, and margay) would exhibit lower temporal overlap and reduced visitation rates compared to large-sized felids (jaguar and puma), as a strategy to avoid intraguild predation (De Oliveira and Pereira 2014). In specific, we expected smaller temporal overlap between pairs of felids with the highest morphological similarity (puma-jaguar and puma-ocelot) than the more morphologically distinct jaguar and ocelot (Herrera *et al.* 2018). Our main objective was to evaluate the spatial and temporal variation in the visitation rates and the degree of temporal activity overlap among felid species to infer patterns of interspecific avoidance.

Materials and methods

Study area. The study was conducted at the CBR located in the municipality of Calakmul, Campeche, Mexico (18°40′07.7″N, 89°12′34.3″W). The area of the CBR is 7,289.08 km^2 of continuous protected tropical forest (Morales and Magaña

2001; Figure 1). The region is characterized by a diversity of plant associations, including medium sub-perennial medium-height forests, sub-perennial thorny short-height forests, short-height flooded forests, semi-deciduous medium-height forests, tular, and secondary vegetation (INEGI 2021; Figure 1). The climate is tropical, warm, humid, and warm sub-humid with rainfall in summer (García and CONABIO, 2008). The average annual temperature ranges between 24 and 28 °C (Vester *et al.* 2007), the maximum temperature is 36 °C during May and June (Hernández *et al.* 2018), but in the last years temperatures above 40 °C have been reached (Comisión Nacional del Agua; smn.conagua.gob.mx). During January occurs the minimum temperature averages 18 °C (Hernández *et al.* 2018). Average annual precipitation is highly variable, ranging from 900 mm to 1,400 mm. The dry season is from November to May, and the rainy season is from June to October (García and CONABIO 2008; Mardero *et al.* 2012; CONANP 2023).

Data collection. From 2019 to 2023, we set up eight artificial water trough stations along the primary access route of the CBR, separated by a minimum distance of 2 km (Contreras-Moreno *et al.* 2024), at an average distance of 100 m from the highway. The troughs were arranged in a latitudinal sequence reflecting a climatic gradient (Figure 1). Troughs located at higher latitudes have higher average annual temperatures and less precipitation than those located at lower latitudes; from northern to southern troughs, annual mean temperatures, calculated with interpolated data from climatic stations, are 25.3° C and 24.7° C; and annual precipitation is 1,156 mm and 1,204 mm in the same troughs (Cuervo-Robayo *et al.* 2014). The water troughs were made from plastic (Rotoplas®) with a capacity of 300 L and were supplied with water every two weeks. A simple camera-trapping station was attached to each artificial water trough. Eight Bushnell HD119876c (Trophy Cam; Outdoor Operations LLC. Los Angeles, USA), Browning Strike force 850 (Strike force; Browning Trail Cameras, Alabama, USA), or Cuddeback IR-20 (Cuddeback IR; Non-Typical Inc., Wisconsin, USA) cameras were used, which were attached to trees at approximately 50 cm above the ground, facing the troughs at approximately five meters to allow a complete view around it (Contreras-Moreno *et al.* 2024). The cameras were programmed to take three consecutive photos with a five-second delay period and remained active for 24 hours. Cameras worked during the first six months of each year, corresponding to the dry season. Revisions were conducted every two months to change batteries and replace camera memory cards. The records obtained were stored in a database using the R package of the R Studio program, version 2024.04.2+764, and a database was constructed with these data using the camtrapR interface in RStudio software 12.0 (Niedballa *et al.* 2020).

Data analysis. To evaluate the use of artificial water troughs per year, the visitation rate (*VR*) was calculated for each of the species of felids as $VR=N/SE*100$ trap-days. Where: N = number of independent records, SE = sampling effort (number of days the cameras were in operation), and 100 trap-days as a standard unit (Mandujano and Hernández 2019). A 1-hr interval was used to account for independent records (Briones-Salas *et al.* 2016). A nonparametric Kruskal-Wallis test was used to determine whether there were differences in the visitation rates between species during sampling years and between artificial water deposits. A Mann-Whitney *post hoc* test was then used to determine which cases differed.

Felid activity at the drinking troughs was described with kernel density curves (Ridout and Linkie 2009) using the times stamped on the photographs. Subsequently, the level of overlap (Δ) between species pairs and 95% confidence intervals were examined using a Bootstrap with 1,000 iterations. We compared the statistical differences between the hours of greatest activity with a Kernel density analysis. Analyses were done with packages activity (Rowcliffe 2016) and overlap (Meredith and Ridout 2014) in R 3.4.0 (R Core Team 2017).

Results

A total sampling effort of 5,465 trap-days included 588 grouped records of four felid species at artificial water troughs. Jaguar, puma, ocelot, and margay were recorded (Figure 2), whereas no records of jaguarundi were obtained. The ocelot showed the highest visitation rate throughout the five years of monitoring (4.57 records/100 trap-days), followed by the puma (3.84 records/100 trap-days) and the jaguar (2.18 records/100 trap-days). The margay was rarely observed (0.16 records/100 trap-days) (Table 1).

The visitation rate was variable over the years. Considering all the felid species, the visitation rate was higher in 2023 (*VR* = 20.10), 2022 (*VR* = 17.96), and 2019 (*VR* = 12.25). In 2021, felid species exhibited a lower rate (*VR*

Table 1. Frequency of independent records (FIR) and visitation rate (*VR*) of felid species during five sampling periods (2019-2023) in the Calakmul Biosphere Reserve (CBR) in southeastern Mexico.

	2019 FIR (*VR*)		2020 FIR (*VR*)		2021 FIR (*VR*)		2022 FIR (*VR*)		2023 FIR (*VR*)		Total in five years FIR (*VR*)	
Jaguar	85	3.00	18	1.32	0	0.00	4	1.07	12	2.87	119	2.18
Puma	115	4.06	24	1.77	9	1.87	34	9.11	28	6.67	210	3.84
Ocelot	146	5.15	23	1.69	10	2.08	29	7.77	42	10.05	250	4.57
Margay	1	0.03	6	0.04	0	0.00	0	0.00	2	0.48	9	0.16

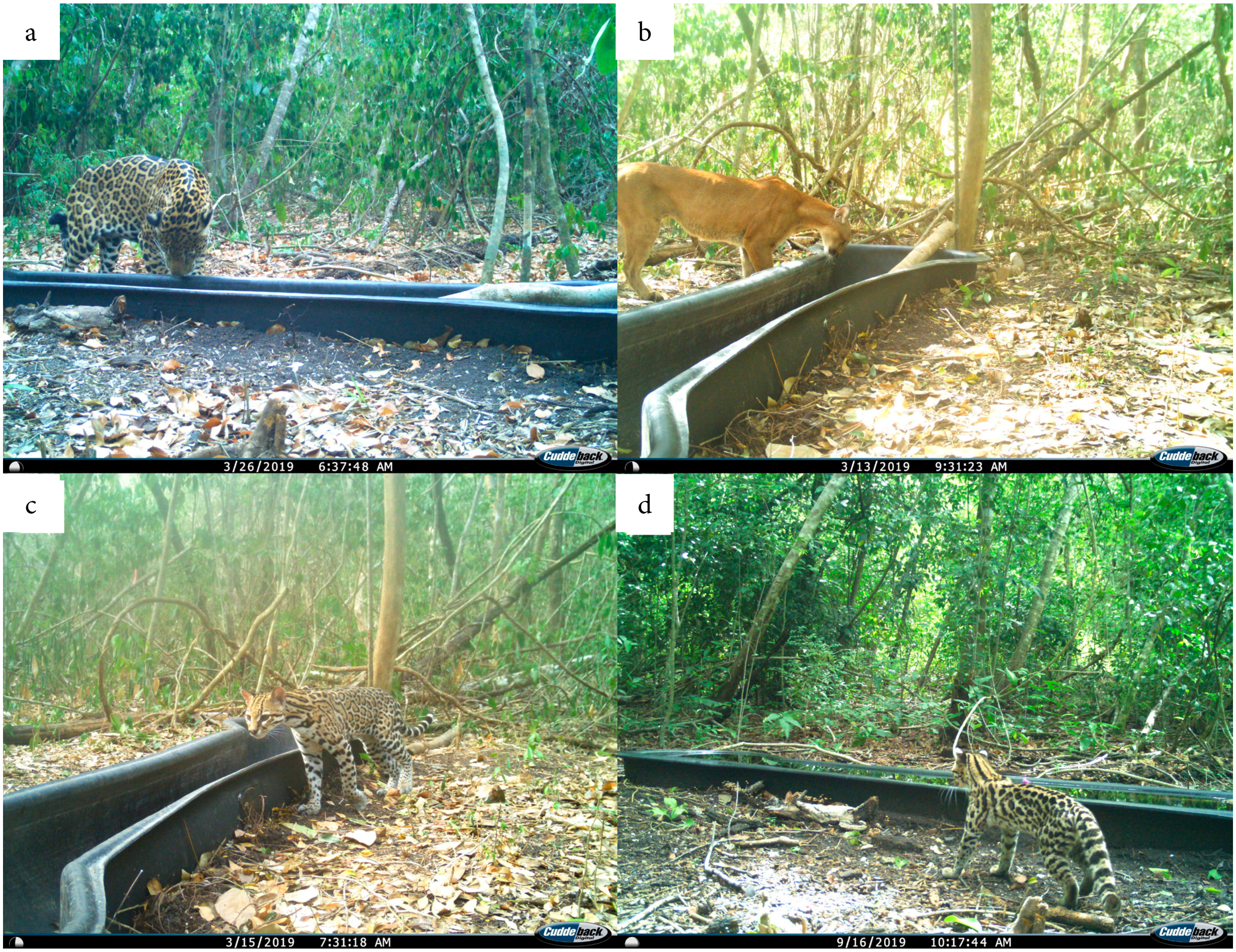

Figure 2. Felid species recorded visiting artificial water troughs in the Calakmul Biosphere Reserve, Mexico. a) Jaguar (*Panthera onca*), b) Puma (*Puma concolor*), c) Ocelot (*Leopardus pardalis*), d) Margay (*Leopardus wiedii*).

= 3.96). The visitation rate of jaguars decreased between 2019 and 2020, whereas in 2021 it was not detected, and the visitation rate in 2023 was similar to 2019. Puma and ocelot also experienced a reduction in visitation rates between 2019 and 2021, but their rates increased in 2022 and 2023 (Table 1).

The jaguar exhibited significantly variable records at stations between km 32 and km 42; in contrast, the puma showed near-homogeneous records across all eight stations, and the ocelot displayed a similar trend but at stations km 36 and km 32. We found a weak significant difference between felid visitation rates at artificial water troughs (*K-W* test; $H = 6.06$, $p = 0.047$); only the ocelot had differences among water troughs ($U = 11.5$; $p = 0.035$), but we did not find differences among years (*K-W* test; $H = 6.24$, $p = 0.180$).

Felids were detected visiting the drinking troughs mainly during nocturnal hours.

Ocelots were observed mainly between 18:00-06:00 h, with a principal peak before midnight.

Jaguars and pumas exhibited a most extended activity throughout the day, with a peak around 19:00 hr and another at 06:00 hr (Figure 3).

Lastly, a high degree of use overlap was observed in felids at the artificial water trough stations over the five-year study period, with more than 70% of the recorded observations, indicating the presence of multiple species of felids at the same location. The highest overlap was observed between jaguar and puma ($\Delta = 0.89$; 95% CI = 0.79-0.93), followed by puma and ocelot ($\Delta = 0.76$; 95% CI = 0.65-0.80), and jaguar and ocelot ($\Delta = 0.72$; 95% CI = 0.62 to 0.76) (Figure 3).

Discussion

This study showed that felid species frequently used artificial water troughs in the CBR. Overall, we found that different felid species did not visit all water troughs with equal frequency, and no consistent pattern of use was observed among the species. For instance, jaguars were recorded more frequently at northern water troughs than

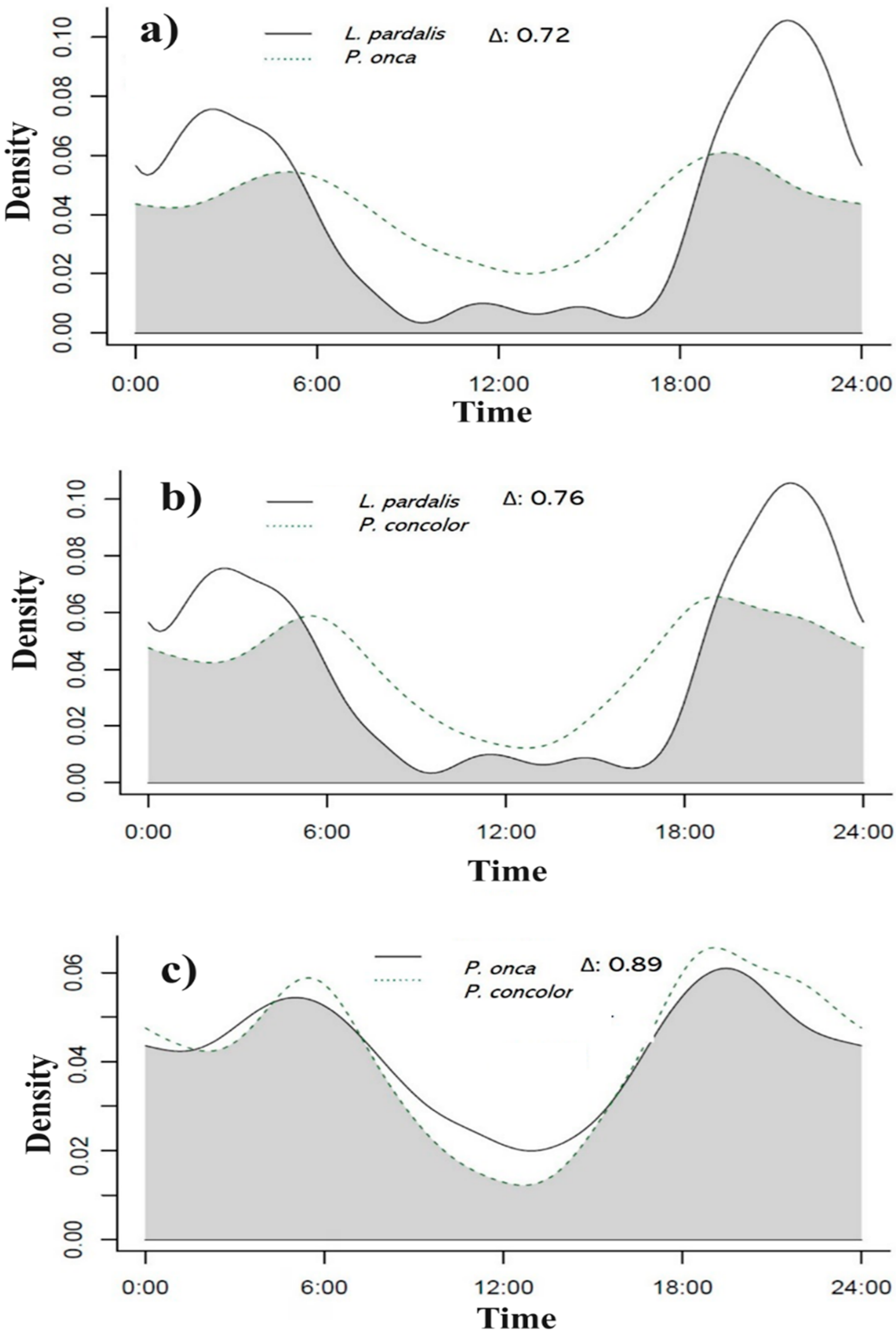

Figure 3. Temporal overlaps among felid species visiting artificial water troughs in the in the Calakmul Biosphere Reserve, Mexico. a) Ocelot and jaguar, b) ocelot and puma, and c) jaguar and puma.

pumas and ocelots. In contrast, margays were uncommon, and jaguarundis were not recorded. Compared to visitation rates at natural water bodies, our results show higher visitation rates for both jaguars and ocelots (2.18 and 4.57 grouped records/100 camera-trap days, respectively) than those reported in surrounding areas (1.31 and 2.3 grouped records/100 camera-trap days, respectively; Gaitán *et al.* 2021; Sandoval-Serés *et al.* 2022). Therefore, our results reveal the importance of water troughs as mitigation management to reduce hydric stress in felid species.

The highest visitation rate to water troughs was recorded for the ocelot, with the highest activity at night. It has been documented that ocelots are active throughout the day, with an increased activity during nocturnal hours (Sunquist 1991; Maffei *et al.* 2005; Di Bitetti *et al.* 2006). However, in certain localities, ocelot activity patterns are strongly influenced by the behavior of their prey (Murray and Gadner 1997; De Villa *et al.* 2002).

Pumas had the second-highest visitation rate at water troughs, followed by jaguars. Both species were active throughout the day but exhibited a bimodal activity pattern, with peaks at dawn and dusk. The timing of the puma visits to the water troughs was consistent with activity patterns recorded by camera traps in forested areas of the Yucatan Peninsula (Ávila-Nájera *et al.* 2018b; Argudín-Violante *et al.* 2023). Estrada (2008) and Moreira *et al.* (2009) also recorded a crepuscular and nocturnal activity pattern for puma in both the CBR and in the Maya Biosphere Reserve. Also, the activity pattern observed for jaguars in our study was similar to that found in the Maya Forest, with two peaks but higher activity after 20:00 hr (Estrada 2008). These findings align with our results, indicating that both pumas and jaguars exhibited crepuscular and nocturnal activity around water troughs. This suggests that these large-sized felids did not alter their temporal activity in response to the artificial water troughs but rather incorporated their use into their existing behavioral patterns.

The margay had the lowest visitation rate among the felid species, a result that may be attributed to several non-exclusive factors. First, the margay is primarily an arboreal species that prefers to hunt in the canopy and avoid unfavorable encounters with potential competitors (De Oliveira and Pereira 2014; De Oliveira *et al.* 2015). Second, it prefers habitats with dense shrubs and tree cover and is rarely found deep in areas with closed canopy, although it has also been recorded in open environments with some degree of disturbance (Paviolo *et al.* 2015). Third, the presence of competitors, since it has been found that margay densities increase in the absence of ocelots (Prugh *et al.* 2009; Jachowski *et al.* 2020), suggesting that ocelots may directly or indirectly suppress margay presence (Macdonald and Loveridge 2010). These factors provide explanations for the low number of observations of the margay at water troughs, as well as their comparatively low records at natural water sources compared to those of other felids (e.g., in rock pools and tree holes; Delgado-Martínez *et al.* 2023).

The overlap in activity patterns at the artificial water troughs varied among the pair of felids studied. Contrary to expectations of a smaller temporal overlap between pairs of felids with the highest morphological similarity (puma-jaguar and puma-ocelot) than the more morphologically distinct (jaguar and ocelot; Herrera *et al.* 2018), we found that jaguars and pumas exhibited high overlap in their activity patterns ($\Delta = 0.89$). This suggests that both species shared similar temporal use of artificial water troughs, a result that contrasts with expectations and with previous findings in forested areas of Calakmul ($\Delta = 0.75$; Argudín-Violante *et al.* 2023). Whereas high temporal overlap has also been observed in community-managed conservation areas in southern Mexico (Galindo-Aguilar *et al.* 2022), lower overlaps ($\Delta = 51\text{-}75$) have been reported in the northeastern part of the Yucatan peninsula (Ávila-Nájera *et al.* 2016). The necessity of water as a limiting resource likely contributes to the increased temporal overlap observed in this study.

The ocelots appear to be slightly influenced by the presence of large-sized species of felids (Macdonald and Loveridge 2010; Santos *et al.* 2019). However, the lowest overlap was observed between the jaguars and ocelots ($\Delta = 0.72$). Similarly, the temporal overlap between ocelots and pumas at water troughs was moderate ($\Delta = 0.76$). This discrepancy may be attributed to differences in peak activity times, which have been interpreted as a strategy by ocelots to avoid intraguild predation by jaguars (Fedriani *et al.* 2000; Lira-Torres and Briones-Salas 2012). Our overlap estimate between jaguar and ocelot was similar to observations at waterholes in Guatemala ($\Delta = 0.65\text{-}0.70$), where direct evidence of jaguar predation on ocelots has been recorded (Perera-Romero *et al.* 2021). It is plausible that our observed temporal overlap of ocelot with larger felids is a strategy to avoid encounters and possible predation.

The study of the mechanisms of coexistence among large-sized felids has primarily focused on three dimensions: diet, spacial use, and temporal activity (Ávila-Nájera *et al.* 2016). Among these, temporal segregation is generally considered less influential than spatial or trophic segregation in explaining coexistence (Santos *et al.* 2019; Argudín-Violante *et al.* 2023). This trend can be attributed to species-specific constraints imposed by biological rhythms and the physiological and ecological costs associated with shifting from one circadian cycle to another (Kronfeld-Schor and Dayan 2003). Factors such as density, seasonality, prey type, and prey density play a significant role in mediating the predator interaction and influence the degree of tolerance for temporal overlap (Ávila-Nájera *et al.* 2016). Predators often exhibit a higher temporal overlap and spatial association with key prey species than with competitors. In such circumstances, the coexistence of predator species may be influenced by the selection of prey with varying activity patterns (Hernández-Sánchez and Santos-Moreno 2020). The absence of strong segregation has been observed previously (Santos *et al.* 2019), but fine-scale segregation has been proposed as a spatiotemporal strategy facilitating coexistence between these felids (Galindo-Aguilar *et al.* 2022).

The use of both natural and artificial water sources by mammals highlights the value of water troughs as a management strategy in arid climates and tropical regions with pronounced seasonality, such as Calakmul (Contreras-Moreno *et al.* 2024; Sánchez-Pinzón *et al.* 2024). In general, several mammal species have shown a positive correlation between their occupancy and the presence of permanent water sources (Reyna-Hurtado *et al.* 2009; O'Farrill *et al.* 2014; Rich *et al.* 2016). Although occupancy was not evaluated because small sample size, we found high visitation use by part of felids compared to natural water sources (Gaitán *et al.* 2021; Sandoval-Serés *et al.* 2022). The importance of water is critical, as prolonged periods of low precipitation can lead to dehydration-related mortality in large-sized species such as jaguars, tapirs (*Tapirus bairdii*), and white-lipped peccaries (*Tayassu pecari*) (Gandiwa *et al.* 2016). Thus, the use of artificial water troughs represents a viable approach to ensuring water availability during the dry season for predators and other wildlife (Mandujano and Hernández 2019), while addressing the growing challenge of water scarcity (Epaphras *et al.* 2008). Accordingly, the installation of artificial water troughs emerges as a valuable strategy for mitigating the adverse effects of droughts on wildlife populations.

The high number of visits to artificial troughs by felid species in 2019, compared to the subsequent two-year period, can be attributed to the extreme drought that occurred in that year. This drought caused the widespread desiccation of natural water bodies and led to several critical incidents, including mortality events of tapirs due to dehydration, which was classified as an "environmental crisis" in the region (Contreras-Moreno 2020). The situation changed in 2020, following two major climatic events that replenished natural water bodies. A concurred decrease in the number of species of felids visiting artificial water troughs was observed, mirroring similar patterns recorded for ungulate species such as white-tailed deer (*Odocoileus virginianus*) and brockets (*Mazama temama* and *Mazama pandora*), and tapirs during the same period in the Selva Maya (Contreras-Moreno *et al.* 2024). These findings underscore the functional importance of artificial water sources in supporting wildlife during the dry season.

Our study demonstrated that felid species present in the CBR actively visited artificial water troughs. These findings are aligned with previous reports of other wildlife species using such water reservoirs, particularly during periods of extreme droughts. Although the implementation of artificial water provision has been widely recognized as a valuable management strategy, several concerns have been proposed. These include pervasive changes in abundances and diversity, risk of intoxication due to biological and non-natural contaminants, modifications in predator-prey dynamics, and the facilitation of disease transmission (Rosenstock *et al.* 1999; Simpson *et al.* 2011). However, many of these potential negative impacts are speculative (Simpson *et al.* 2011); others, such as changes in diversity and abundance, have not been empirically supported (Kluever *et al.* 2016).

The impact of climate change, particularly the severe shortage of natural water supplies, as the *aguadas* in the region, poses a significant threat to wildlife. Managing practices, such as the installation of artificial water troughs, must be implemented on a broader scale to effectively address this challenge. Further research is needed to assess variations in wildlife demand for artificial water sources across different ecosystems, as well as to evaluate any potential negative effects associated with their use in Neotropical forests.

Acknowledgments

To the United Nations Development Program (UNDP) project 00092169: "Strengthening the management of the Protected Areas System to improve the conservation of species at risk and their habitats", implemented by the National Commission of Natural Protected Areas (CONANP) and financed by the Global Environment Facility (GEF). To the colleagues of the Calakmul Biosphere Reserve, who were always willing to support the monitoring project. To the World Wildlife Fund Inc (WWF-Mexico) for the funding granted through the Monitoring of Water Bodies in the Calakmul Biosphere Reserve program, within the framework of the project "Saving the jaguar: ambassador of America". MCL acknowledges Secretaría de Investigación y Posgrado, Instituto Politécnico Nacional.

Literature cited

Argudín-Violante, C., *et al.* 2023. Neo-tropical felid activity patterns in relation to potential prey and intraguild competitors in the Calakmul Biosphere Reserve, Mexico. Biotropica 55:969–977.

Ávila-Nájera, D. M., *et al.* 2016. Overlap in activity patterns between big cats and their main prey in northern Quintana Roo, Mexico. Therya 7:439–448.

Ávila-Nájera, D. M., *et al.* 2018a. Jaguar (*Panthera onca*) and puma (*Puma concolor*) diets in Quintana Roo, Mexico. Biodiversity and Conservation 41:257–266.

Ávila-Nájera, D. M., *et al.* 2018b. Ecology of *Puma concolor* (Carnivora: Felidae) in a Mexican tropical forest: adaptation to environmental disturbances. Revista de Biología Tropical 66:78–90.

Begon, M., J. L. Harper., and C. R. Colin. 1988. Ecology: individuals, populations and communities. Editorial Omega SA, Barcelona, Spain.

Bennett, A. C., *et al.* 2023. Sensitivity of South American tropical forests to an extreme climate anomaly. Nature Climate Change 13:967–974.

Bogoni, J. A., C. A. Peres, and K. M. Ferraz. 2020. Extent, intensity and drivers of mammal defaunation: a continental-scale analysis across the Neotropics. Scientific Reports 10:14750.

Bothma, J. D. P. 2005. Water-use by southern Kalahari leopards. South African Journal of Wildlife Research 35:131–137.

Briones-Salas, M., *et al*. 2016. Relative abundance and activity patterns of wild felids in Chimalapas rainforest, Oaxaca, Mexico. Therya 7:123–34.

Ceballos, G., and G. Oliva (Coords.). 2005. The wild mammals of Mexico. Conabio/Fondo de Cultura Económica, Mexico D. F.

Comisión Nacional de Áreas Naturales Protegidas (CONANP). 2023. Estudio previo justificativo para la modificación de la declaratoria del Área Natural Protegida Reserva de la Biosfera Calakmul, Campeche, México.

Contreras-Díaz, C. A., *et al*. 2021. Temporal and spatial segregation of top predators (Felidae) in a tropical Mexican Biosphere Reserve. Zoologia (Curitiba) 38:e63231.

Contreras-Moreno, F. M. 2020. Tapir crisis in Calakmul, an effect of climate change. Hypatia 53:10–14.

Contreras-Moreno, F. M., *et al*. 2024. Water supply in artificial troughs: a strategy to mitigate the impacts of climate change in the Maya forest. Agro Productividad 17:69–77.

Crawshaw, P. G., and H. B. Quigley. 1991. Jaguar spacing, activity and habitat use in a seasonally flooded environment in Brazil. Journal of Zoology 223:357–370.

Cruz, P., *et al*. 2018. Effects of human impacts on habitat use, activity patterns and ecological relationships among medium and small felids of the Atlantic Forest. PloS ONE 13:e0200806.

Cuervo-Robayo, A. P., *et al*. 2014. An update of high-resolution monthly climate surfaces for Mexico. International Journal of Climatology 34:2427–2437.

De Angelo, C., A. Paviolo, and M. Di Bitetti. 2011. Differential impact of landscape transformation on pumas (*Puma concolor*) and jaguars (*Panthera onca*) in the Upper Paraná Atlantic Forest. Diversity and Distributions 17:422–436.

De Oliveira, T. G., and J. A. Pereira. 2014. Intraguild predation and interspecific killing as structuring forces of carnivoran communities in South America. Journal of Mammalian Evolution 21:427–436.

De Oliveira, T., *et al*. 2015. *Leopardus wiedii*. In: IUCN 2015. The IUCN Red List of Threatened Species 2015: e. T9948A50653167. www.iucnredlist.org . Accessed on 25 June 2024.

De Villa, A., E. Martínez-Meyer, and C. A. López González. 2002. Ocelot (*Leopardus pardalis*) food habits in tropical deciduous forest Jalisco, Mexico. The American Midland Naturalist 148:146–154.

Delgado-Martínez, C. M., *et al*. 2023. Differential utilization of surface and arboreal water bodies by birds and mammals in a seasonally dry Neotropical forest in southern Mexico. Ecology and Evolution 13:e10781.

Di Bitetti, M. S., A. Paviolo, and C. De Angelo. 2006. Density, habitat use and activity patterns of ocelots (*Leopardus pardalis*) in the Atlantic Forest of Misiones, Argentina. Journal of Zoology 270:153–163.

Dobler-Morales, C. 2018. Analysis of precipitation patterns of the Yucatan using multiple gridded datasets. Ph.D. Dissertation. Clark University.

Diario Oficial de la Federación. 2010. NOM059-SEMARNAT-2010. Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo.

Epaphras, A. M., *et al*. 2008. Wildlife water utilization and importance of artificial waterholes during dry season at Ruaha National Park, Tanzania. Wetlands Ecology and Management 16 183–188.

Espinosa, C. C., *et al*. 2018. Geographic distribution modeling of the margay (*Leopardus wiedii*) and jaguarundi (*Puma yagouaroundi*): a comparative assessment. Journal of Mammalogy 99:252–262.

Estrada, H. 2008. Diet, habitat use and activity patterns of puma (*Puma concolor*) and jaguar (*Panthera onca*) in the Mayan jungle. Revista Mexicana de Mastozoología (Nueva Época) 12:113–130.

Fedriani, J. M., *et al*. 2000. Competition and intraguild predation among three sympatric carnivores. Oecologia 125:258–270.

Ferrer-Paris, J. R., *et al*. 2019. An ecosystem risk assessment of temperate and tropical forests of the Americas with an outlook on future conservation strategies. Conservation Letters 12: e12623.

Finnegan, S. P., *et al*. 2021. When the felid's away, the mesocarnivores play: seasonal temporal segregation in a neotropical carnivore guild. Mammalian Biology 101:631–638.

Flores-Martínez, J. J., *et al*. 2022. Spatiotemporal coexistence of mesopredators and their prey in a defaunated Neotropical rainforest. Tropical Conservation Science 15:19400829221084261.

Gaitán, C. A., *et al*. 2021. Visitation patterns of jaguars *Panthera onca* (Carnivora: Felidae) to isolated water ponds in a tropical forest landscape. Therya 12:45–55.

Galindo-Aguilar, R. E., *et al*. 2022. Co-occurrence of predators and prey in a neotropical mammal community in southern Mexico. Journal of Tropical Ecology 38:285–294.

Gandiwa, E., *et al*. 2016. Rainfall variability and its impact on large mammal populations in a complex of semi-arid African savanna protected areas. Journal of Tropical Ecology 57:163–180.

García, E., and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. 2008. Climate (Koppen classification, modified by García), scale 1:1000,000. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. Mexico City, Mexico.

Garcia Gil, G., J. L. Palacio-Prieto, and M. A. Ortiz-Pérez. 2002. Reconnaissance géomorphologique et hydrographique de la Réserve de la Biosphère de Calakmul, Mexique. Investigaciones Geográficas 48:7–23.

Gil-Sánchez, J. M., *et al*. 2021. Structure and inter-specific relationships of a felid community of the upper Amazonian basin under different scenarios of human impact. Mammalian Biology 101:639–652.

Gittleman, J. L., S. Funk, D. Macdonald, and R. Wayne (eds). 2001. Carnivore Conservation. Cambridge University Press. Cambridge, UK.

Gómez-Ortiz, Y., and O. Monroy-Vilchis. 2013. Feeding ecology of puma *Puma concolor* in Mexican montane forests with comments about jaguar *Panthera onca*. Wildlife Biology 19:179–187.

Goodrich, J., *et al*. 2022. *Panthera tigris*. In: IUCN 2015. The IUCN Red List of Threatened Species 2015: e.T9948A50653167. www.iucnredlist.org . Accessed on 25 June 2024.

Hansen, M. C., *et al*. 2008. Humid tropical forest clearing from 2000 to 2005 quantified by using multitemporal and multiresolution remotely sensed data. Proceedings of the National Academy of Sciences of the United States of America 105:9439–9444.

Hernández, J., *et al*. 2018. Correlation between TDR and FDR soil moisture measurements at different scales to establish water availability at the south of the Yucatan Peninsula. Pp 1–18, in Soil Moisture. (Civeira, G., ed.), IntechOpen, London, UK.

Hernández-SaintMartín, A. D., *et al*. 2015. Food habits of jaguar and puma in a protected area and adjacent fragmented landscape of Northeastern Mexico. Natural Areas Journal 35:308–317.

Hernández-Sánchez, A., and A. Santos-Moreno. 2020. Activity patterns in a feline assemblage in south-west Mexico, and their relationship with prey species. Journal of Tropical Ecology 36:225–233.

Herrera, H., *et al*. 2018. Time partitioning among jaguar *Panthera onca*, puma *Puma concolor* and ocelot *Leopardus pardalis* (Carnivora: Felidae) in Costa Rica's dry and rainforests. Revista de Biología Tropical 66: 1559–1568.

Hunter, J., and T. Caro. 2008. Interspecific competition and predation in American carnivore families. Ethology Ecology & Evolution 20:295–324.

Instituto Nacional de Estadística y Geografía (INEGI). 2021. Land use and vegetation scale 1:250,000. National Institute of Statistics and Geography, San Luis Potosí.

Jachowski, D. S., *et al*. 2020. Identifying mesopredator release in multi-predator systems: a review of evidence from North America. Mammal Review 50:367–381.

Jędrzejewski, W., *et al*. 2018. Estimating large carnivore populations at global scale based on spatial predictions of density and distribution-Application to the jaguar (*Panthera onca*). PloS One 13:e0194719.

Kitchener, A. C., B. Van Valkenburgh, N. Yamaguchi, N., D. Macdonald, and A. Loveridge. 2010. Felid form and function. Biology and conservation of wild felids 2:83–106.

Kluever, B. M., E. M. Gese, and S. J. Dempsey. 2016. The influence of wildlife water developments and vegetation on rodent abundance in the Great Basin Desert. Journal of Mammalogy 97:1209–1218.

Kronfeld-Schor, N., and T. Dayan. 2003. Partitioning of time as an ecological resource. Annual Review of Ecology Evolution Systematics 34:153–81.

Lehnen, S. E., and J. V. Lombardi. 2023. Climate envelope modeling for ocelot conservation planning: peering inside the black box. Ecosphere 14:e4477.

Lira-Torres, I., and M. Briones-Salas. 2012. Relative abundance and activity patterns of mammals of the Chimalapas, Oaxaca, Mexico. Acta Zoológica Mexicana (n. s.) 28:566–585.

Lucherini, M., *et al*. 2009. Activity patterns segregation of carnivores in the high Andes. Journal of Mammalogy 90:1404–1409.

Macdonald, D. W., and A. J. Loveridge (Eds.). 2010. The biology and conservation of wild felids (Vol. 2). Oxford University Press. Oxford, UK.

Maffei, L., *et al*. 2005. Ocelot (*Felis pardalis)* population densities, activity, and ranging behaviour in the dry forests of eastern Bolivia: data from camera trapping. Journal of Tropical Ecology 21:349–353.

Mandujano, S., and C. Hernández. 2019. Use of artificial waterers by white-tailed deer in an extensive UMA in the Tehuacán-Cuicatlán Biosphere Reserve, Mexico. Agro Productividad 12:37–42.

Mardero, S., *et al*. 2012. Sequías en el sur de la península de Yucatán: análisis de la variabilidad anual y estacional de la precipitación. Investigaciones Geográficas 78:19–33.

McCarthy, T., *et al*. 2017. *Panthera uncia*. In: IUCN 2015. The IUCN Red List of Threatened Species 2015: e. T9948A50653167. www.iucnredlist.org. Accessed on 25 June 2024.

Meredith, M., and M. Ridout. 2014. Overlap: Estimates of coefficient of overlapping for animal activity patterns. R package version 0.2.4. Available at: http://CRAN. R-project. org/package=overlap.

Morales, R. J., and R. S. Magaña. 2001. Sources of impact, scientific research needs and monitoring in Calakmul, Campeche. PRONATURA Yucatan Peninsula and The Nature Conservancy. Mexico City, Mexico.

Moreira, J., *et al*. 2009. Abundance of jaguars and evaluation of prey associated with photo-trapping in the community concessions of the Melchor de Mencos block, Maya Biosphere Reserve, Petén, Guatemala. Final Report. Wildlife Conservation Society, Guatemala Program. Guatemala, Guatemala.

Moreno, R. S., R. W. Kays, and R. Samudio. 2006. Competitive release in diets of ocelot (*Leopardus pardalis*) and puma (*Puma concolor*) after jaguar (*Panthera onca*) decline. Journal of Mammalogy 87:808–816.

Murray, R. L., and G. L. Gardner. 1997. *Leopardus pardalis*. Mammalian Species 548:1–10.

Nicholson, S., *et al*. 2024. *Panthera leo* **(**amended version of 2024 assessment**)**. In: IUCN 2015. The IUCN Red List of Threatened Species 2015: e. T9948A50653167. www. iucnredlist.org. Accessed on 25 June 2024.

Niedballa, J., et al. 2020. CamtrapR Package. Camera Trap Data Management and Preparation of Occupancy and Spatial Capture-Recapture Analyses. Available online: https://cran.r-project.org/web/packages/camtrapR/camtrapR.pdf (accessed on 9 October 2024).

O'Farrill, G., et al. 2014. The potential connectivity of waterhole networks and the effectiveness of a protected area under various drought scenarios. PlosOne 9:e95049.

Pacifici, M., et al. 2015. Assessing species vulnerability to climate change. Nature Climate Change 5:215–224.

Paviolo, A., et al. 2015. *Leopardus pardalis* (errata version published in 2016). In: IUCN 2015. The IUCN Red List of Threatened Species 2015: e.T11509A97212355. www.iucnredlist.org. Accessed on 25 June 2024.

Perera-Romero, L., et al. 2021. When waterholes get busy, rare interactions thrive: Photographic evidence of a jaguar (*Panthera onca*) killing an ocelot (*Leopardus pardalis*). Biotropica 53:367–371.

Pérez-Cortez, S., et al. 2012. Influence of water availability on the presence and abundance of *Tapirus bairdii* in the Calakmul rainforest, Campeche, Mexico. Revista Mexicana de Biodiversidad 83:753–761.

Pérez-Flores, J., et al. 2021. Human-wildlife conflicts and drought in the greater Calakmul Region, Mexico: implications for tapir conservation. Neotropical Biology and Conservation 16:539.

Prugh, L. R., et al. 2009. The rise of the mesopredator. Bioscience 59:779–791.

Prugh, L. R., et al. 2018. Ecological winners and losers of extreme drought in California. Nature Climate Change 8:819–824.

Quigley, H., et al. 2017. *Panthera onca* **(**errata version published in 2018**).** In: IUCN 2015. The IUCN Red List of Threatened Species 2015: e.T9948A50653167. www.iucnredlist.org. Accessed on 25 June 2024.

R Core Team. 2017. R: a language and environment for statistical computing. Versión 3.4.3 Vienna, Austria, R Foundation for Statistical Computing. https://www.r-project.org/

Redfern, J. V., et al. 2003. Surface-water constraints on herbivore foraging in the Kruger National Park, South Africa. Ecology 84:2092–2107.

Reyna-Hurtado, R., E. Rojas-Flores, and G. W. Tanner. 2009. Home range and habitat preferences of white-lipped peccaries (*Tayassu pecari*) in Calakmul, Campeche, Mexico. Journal of Mammalogy 90:1199–1209.

Reyna-Hurtado, R., et al. 2010. Hunting and the conservation of a social ungulate: the white-lipped peccary *Tayassu pecari* in Calakmul, Mexico. Oryx 44:89–96.

Rich, L. N., et al. 2016. Using camera trapping and hierarchical occupancy modelling to evaluate the spatial ecology of an African mammal community. Journal of Applied Ecology 53:1225–1235.

Ridout, M. S., and M. Linkie. 2009. Estimating overlap of daily activity patterns from camera trap data. Journal of Agricultural, Biological, and Environmental Statistics 14:322–337.

Ripple, W. J., et al. 2014. Status and ecological effects of the world's largest carnivores. Science 343:1241484.

Ritchie, E. G., and C. N. Johnson. 2009. Predator interactions, mesopredator release and biodiversity conservation. Ecology Letters 12:982–998.

Rodríguez-Soto, C., et al. 2011. Predicting potential distribution of the jaguar (*Panthera onca*) in Mexico: identification of priority areas for conservation. Diversity and Distributions 17: 350–361.

Rosenstock, S. S., W. Ballard, and J. C. DeVos. 1999. Benefits and impacts of wildlife water developments. Journal of Range Management 52:302–311.

Rowcliffe, M. J. 2016. Activity: animal activity statistics, No. R package version 1.1. https://cran.r-project.org/package=activity

Sánchez-Pinzón, K., F. Contreras-Moreno, D. Jesús-Espinosa, J. Méndez-Tun, and L. Cruz-Romo, L. 2024. Use of water bodies by the collared peccary *Pecari tajacu* (Artiodactyla: Tayassuidae) in the Maya Forest, Mexico. Acta Zoológica Mexicana (nueva serie) 40:1–13.

Sandoval-Serés, M. E., K. Sánchez-Pinzón, and R. Reyna-Hurtado. 2022. Waterhole use and diel activity pattern of ocelots in Calakmul rainforest, Mexico. Revista Mexicana de Biodiversidad 93: e933930.

Santos, F., et al. 2019. Prey availability and temporal partitioning modulate felid coexistence in Neotropical forests. PLoS ONE 14:e0213671.

Simpson, N. O., Stewart, K. M., and Bleich, V. C. 2011. What have we learned about water developments for wildlife? Not enough! California Fish and Game 97: 190–209.

Stein, A. B., et al. 2024. *Panthera pardus*. In: IUCN 2015. The IUCN Red List of Threatened Species 2015: e.T9948A50653167. www.iucnredlist.org. Accessed on 25 June 2024.

Steinmetz, R., N. Seuaturien, and W. Chutipong. 2013. Tigers, leopards, and dholes in a half-empty forest: Assessing species interactions in a guild of threatened carnivores. Biological Conservation 163:68–78.

Sunquist, M. 1991. The ecology of ocelot: the importance of incorporating life history traits into conservation plans. Pp. 117–128 in Felines of Venezuela: Biology, Ecology and Conservation, Fudeci, Venezuela.

Tannerfeldt, M., B. Elmhagen and A. Angerbjorn. 2002. Exclusion by interference competition? The relationship between red and arctic foxes. Oecologia 132:213–220.

Terborgh, J., R. D. Holt, and J. A. Estes. 2010. Trophic cascades: What they are, how they work, and why they matter. Pp. 1–18 in Trophic cascades. Predators prey and the changing dynamics of nature (J. Terborgh and J. Estes, eds.). Island Press, Washington, USA.

Vester, H. F., et al. 2007. Land change in the southern Yucatan and Calakmul Biosphere Reserve: Effects on habitat and biodiversity. Ecological Applications 17: 989–1003.

Wallach, A. D., et al. 2015. What is an apex predator? Oikos 124:1453–1461.

West, L. *et al*. 2024. Droughts reshape apex predator space use and intraguild overlap. Journal of Animal Ecology 93:1785–1798.

Associated editor: Eduardo Mendoza Ramírez
Submitted: March 19, 2025; Reviewed: March 20, 2025
Accepted: May 16, 2025; Published on line: May 30, 2025