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Potential predation of a mud turtle by a jaguar (*Panthera onca*): evidence from camera traps in the Mexican Maya Forest

Depredación potencial de una tortuga de pantano por un jaguar (*Panthera onca*): evidencia de cámaras trampa en la Selva Maya mexicana

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The jaguar (*Panthera onca*) is a large felid widely distributed throughout the Americas. Across its range, the species primarily preys on mammals, birds, and reptiles. Although reptile consumption is well documented in the southern portions of its distribution, such behavior is rarely reported in Mexico, particularly in the case of chelonians. In this study, we present photographic records suggesting the potential predation and/or consumption of a mud turtle (*Kinosternon* sp.) by a jaguar in the Mexican Maya Forest. Between November 2022 and February 2024, we conducted camera trap surveys to monitor wild vertebrates inhabiting the Maya Forest within the Calakmul Biosphere Reserve, Campeche, México. At the end of the monitoring period, we retrieved the digital data recorded by the devices to identify the documented species. We achieved a sampling effort of 4,700 trap-nights, during which we obtained photographic records of the vertebrate species inhabiting the region. In November 2023, we recorded an event involving a subadult jaguar holding a mud turtle (Testudines: Kinosternidae) in its jaws. Although species-level identification was not possible, we determined that the turtle belonged to the genus *Kinosternon*. Our finding contributes to the limited documentation of jaguar predation on turtles in Mexico and highlights the need for further research on the species' feeding ecology in the tropical forest ecosystems of the Selva Maya.

Key words: Calakmul; Campeche; Felidae; feeding habits; *Kinosternon*; photo-record; prey; reptile; tropical forest.

El jaguar (*Panthera onca*) es un felino con amplia distribución en América. A lo largo del continente, la especie se alimenta principalmente de mamíferos, aves y reptiles. Aunque el consumo de reptiles ha sido extensamente documentado en regiones del sur de su distribución, los reportes de este tipo de presas en México son raros, particularmente en el caso de los quelonios. En este estudio, presentamos registros fotográficos que sugieren la posible depredación o consumo de una tortuga de pantano (*Kinosternon* sp.) por un jaguar en la Selva Maya de México. Entre noviembre de 2022 y febrero de 2024, colocamos cámaras trampa para el monitoreo de vertebrados silvestres que se distribuyen en la Selva Maya de la Reserva de la Biosfera Calakmul, Campeche, México. Al final del monitoreo, recuperamos la información digital obtenida por los dispositivos para la identificación de las especies registradas. Logramos un esfuerzo de muestreo de 4,700 noches/trampa, con lo que obtuvimos registros fotográficos de las especies de vertebrados que se distribuyen en la región. En noviembre de 2023, registramos el evento de un jaguar subadulto sosteniendo una tortuga de pantano (Testudines: Kinosternidae) en sus fauces. Aunque no logramos su identificación a nivel de especie, determinamos que la tortuga pertenece al género *Kinosternon*. Nuestro hallazgo contribuye a incrementar la información limitada sobre la depredación de tortugas por parte del jaguar en México y hace patente la necesidad de continuar investigando los hábitos alimentarios de este felino en los ecosistemas de bosques tropicales de la Selva Maya.

Palabras clave: Bosque tropical; Calakmul; Campeche; Felidae; hábitos alimentarios; *Kinosternon*; presa; registro fotográfico; reptil.

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Despite continental-scale population declines, the jaguar (*Panthera onca*) remains widely distributed, ranging from the southern United States to central Argentina in the Americas (Seymour 1989; Quigley *et al*. 2017; Jędrzejewski *et al*. 2018). Across its distribution, the jaguar inhabits a variety of habitat types (Sanderson *et al*. 2002; Quigley *et al*. 2017; Castelló 2020), where its feeding habits can vary considerably (Seymour 1989; de Oliveira and Medellín 2002; Hayward *et al*. 2016). Jaguars are obligate carnivores and are widely regarded as opportunistic predators, exploiting prey in relation to its availability in the environment (Rabinowitz and Nottingham 1986; Astete *et al*., 2007;

Carrillo *et al*. 2009; Hayward *et al*. 2016; Ferreti *et al*. 2020; Entringer *et al*. 2022; Foster and Harmsen 2022). However, at a population-level, jaguar feeding behavior may also reflect ecological specializations, relying on foraging strategies that target specific prey species (Aranda 1994; de Oliveira and Medellín 2002; Novack *et al*. 2005; Weckel *et al*. 2006; de Azebedo 2008) based on their morphological (Carbone *et al*. 1999) and behavioral traits such as group size and gregariousness (Hayward *et al*. 2016), rather than solely on opportunistic encounters (Weckel *et al*. 2006).

Based on the above, jaguar prey selection and diet composition appear to be context-dependent, varying primarily with habitat type, prey availability, and the ecological traits of potential prey species (Seymour 1989; Hayward *et al*. 2016; Entringer *et al*. 2022). Throughout its distribution, the jaguar has been recorded consuming at least 111 prey species, ranging from small rodents to livestock (Seymour 1989; Weckel *et al*. 2006; Hayward *et al*. 2016; Entringer *et al*. 2022; Foster and Harmsen 2022). While its diet primarily consists of medium- to large-sized terrestrial mammals, typically averaging 32 ± 13 kg (López-González and Miller 2002; Hayward *et al*. 2016), in habitats with low mammalian abundance—such as wetlands, coastal areas, and floodplains—jaguars may incorporate armored reptiles, including crocodilians and chelonians (Emmons 1989; Cavalcanti and Gese 2010; Da Silveira *et al*. 2010; Azevedo and Verdade 2012; Brito *et al*. 2018).

Reptile consumption by jaguars in South America has been extensively documented (e.g., Troëng 2000; Garla *et al*. 2001; Weckel *et al*. 2006; Da Silveira *et al*. 2010; Veríssimo *et al*. 2012; Herrera *et al*. 2016; Brito *et al*. 2018; Morera-Chacón *et al*. 2019; Entringer *et al*. 2022). However, such reports from northern populations, particularly in México, remain scarce. In southeastern Mexico, the main prey species identified in the jaguar's diet include the collared peccary (*P. tajacu*), armadillo (*Dasypus novemcinctus*), coati (*Nasua narica*), brocket deer (*Mazama temama* and *M. pandora*), and white-tailed deer (*Odocoileus virginianus*; Aranda and Sánchez-Cordero 1996; Hernández 2008). In contrast, records of reptile predation in this region are limited to cases involving sea turtles—*Caretta caretta*, *Chelonia mydas*, and *Eretmochelys imbricata*—in Quintana Roo (Cuevas *et al*. 2014; Rosales-Hernández *et al*. 2022) and Morelet's crocodiles (*Crocodylus moreletii*) within the Calakmul Biosphere Reserve (CBR) in Campeche, located in the Mexican Maya Forest (Pérez-Flores 2018; Simá-Pantí *et al*. 2020). Reports of predation on terrestrial chelonians are even scarcer, with only a single documented event, in which the tortoise could not be identified to the species level (Aranda and Sánchez-Cordero 1996), also occurring within the CBR region.

In this study, we report a case of a mud turtle (*Kinosternidae*) captured by a jaguar, based on photographic evidence obtained from camera traps in the CBR region. This key record contributes to the very limited knowledge of terrestrial turtle potential consumption by jaguars in northern populations and within Mexico.

The study was conducted in the Calakmul Biosphere Reserve (CBR), located in the Maya Forest region of Campeche, southeastern México (18° 38′–18° 08′ N, 89° 44′–89° 31′ W). The protected area covers 7,231.85 km^2 and is characterized by a tropical subhumid climate (Aw), with an average annual temperature of 24.6 °C (SEMARNAP 2000). Rainfall is concentrated between June and November, with an average annual precipitation ranging from 1,000 to 1,500 mm (García *et al*. 2002). The CBR includes a mosaic of tropical forests with diverse characteristics, where the main vegetation types are Medium Sub-Perennial Forest, Low-Flooded Forest, and Medium and Low Semi-Deciduous Forests (Martínez and Galindo-Leal 2002).

Between November 2022 and February 2024, we conducted 10 camera trap sampling sessions to monitor medium- and large-sized vertebrate species distributed within the CBR. The duration of each of the ten sampling sessions varied: the shortest period lasted 31 days (October–November 2022), while the longest extended over 86 days (July–October 2023; Table 1). The average sampling duration was 47 ± 18.6 days. During each session, 10 camera trap stations (Reconyx™ HyperFire 2 Professional Covert IR, Holmen, WI, USA) were deployed within the buffer zone of the CBR, spaced at an average distance of 1.16 ± 0.1 km, collectively covering approximately 19 km^2. Camera traps were mounted on trees at a height of 30–60 cm above ground level in locations showing signs of wildlife activity, to maximize the likelihood of detecting target species (Zimmerman and Rovero 2016). Each camera trap was programmed to operate continuously, 24 hours per day, capturing two images per trigger event with a 60-second delay between activations. At the end of each sampling session, the digital data recorded by the devices were retrieved, and the species detected—along with the date, time, and location of each capture—were identified.

We achieved a total sampling effort of 4,700 trap-nights, during which we obtained photographic records of medium- and large-sized vertebrate species within the CBR. Among these, we documented 15 independent jaguar presence events, defined as at least one detection within a 24-hour period. These events represented a minimum of six distinct individuals: 1 adult male, 3 adult females, and 2 subadult males.

Of particular interest were two sequential jaguar records obtained on November 3, 2023, at a monitoring station located at 18°30′46.3″ N and 89°52′05.1″ W. These images were captured in a low-lying, flood-prone area within a transitional zone between Medium Sub-Perennial Forest and Low Semi-Deciduous Forest. In the first image, taken at 12:16 h, an adult female jaguar was photographed moving in a northwest–southeast direction through the Low Semi-Deciduous Forest (Figure 1). Two minutes later (12:18 h), a subadult male was recorded following the same trajectory.

Table 1. Start and end dates of 10 camera-trap sampling periods used to monitor medium- and large-sized vertebrate species in the Calakmul Biosphere Reserve, Campeche, Mexico.

Season	Number of camera traps	Start date	End date	Duration (days)	Sampling effort (night-traps)
1	10	01/11/2022	04/12/2022	33	330
2	10	05/12/2022	15/01/2023	41	410
3	10	18/01/2023	21/02/2023	34	340
4	10	05/03/2023	16/05/2023	72	720
5	10	05/06/2023	23/07/2023	48	480
6	10	25/07/2023	19/10/2023	86	860
7	10	22/10/2023	22/11/2023	31	310
8	10	25/11/2023	17/01/2024	53	530
9	10	19/01/2024	20/02/2024	32	320
10	10	21/02/2024	01/04/2024	40	400
			Total	470	4700

This individual was carrying a mud turtle in its jaws (Figure 2), which was identified to the genus *Kinosternon* (Testudines: Kinosternidae) based on visible morphological traits. However, due to photographic limitations, species-level identification was not possible.

Our record contributes to the scarce documentation of jaguar potential predation on turtles in Mexico—an interaction rarely reported within the Mexican Maya Forest. It also underscores the value of camera traps in providing direct, non-invasive insights into jaguar hunting behavior, particularly in relation to potential prey detection and recognition (Mills *et al*. 2004; Smith *et al*. 2020). While camera traps provide valuable information on specific aspects of predation, such as encounter rates and behavioral cues preceding attacks, their ability to evaluate prey selection is inherently constrained. Prey selection involves complex ecological and behavioral processes that often require complementary approaches—such as scat analysis, prey availability surveys, or integrative modeling frameworks—for robust evaluation (Kelt *et al*. 2019). Continued documentation of such predation events and behavioral interactions is essential to deepen our understanding of the trophic ecology and behavioral plasticity of jaguar populations in this region.

The photographic evidence reported here was obtained shortly after the peak of the rainy season (September), in a transitional ecotone between Medium Sub-Perennial and Low Semi-Deciduous forest. During the wettest months, this habitat develops temporary wetland-like conditions that facilitate the presence of aquatic and semi-aquatic fauna, including freshwater turtles. The scarcity of records documenting jaguar predation on such prey in Mexico may be partly attributed to suboptimal monitoring of habitats such as seasonally flooded habitats, wetlands, and floodplains, where reptiles, including crocodiles, caimans, and turtles are more frequently found (De Azevedo and Murray 2007; Azevedo and Verdade 2012; Simá-Pantí *et al*.

Figure 1. Photographic record of an adult female jaguar (*Panthera onca*) in the Calakmul Biosphere Reserve, Selva Maya region, Campeche, Mexico. The image was captured at 12:16:15 h on 3 November 2023, in an area characterized by low semi-deciduous forest.

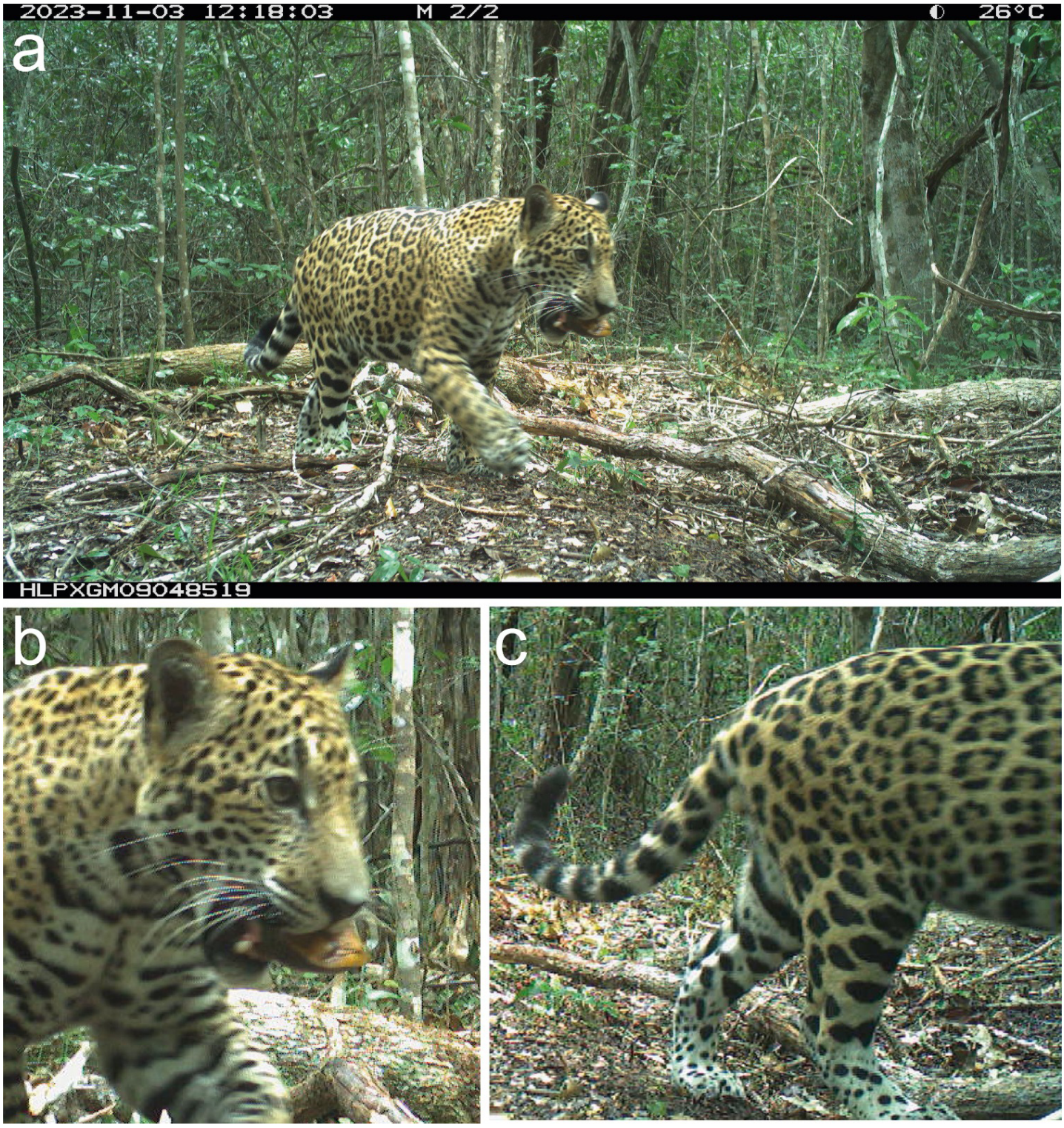

Figure 2. Photographic record of a sub-adult male jaguar (*Panthera onca*) in the Calakmul Biosphere Reserve, Selva Maya region, Campeche, Mexico. The individual was recorded at 12:18:03 h on 3 November 2023. The images show: (a) the jaguar moving through an area of low semi-deciduous forest; (b) the same individual carrying a mud turtle (Testudines: Kinosternidae), presumably *Kinosternon* sp., in its jaws; and (c) a clearer view of the genital region, confirming the individual's sex.

2020). Alternatively, it could reflect the broader availability of other prey species within the jaguar's range, rendering turtles a comparatively limited food resource that jaguars exploit opportunistically under favorable conditions— such as peaks in abundance associated with seasonal flooding, increased susceptibility to predation as individuals disperse farther from water bodies, and prolonged use of terrestrial habitats (Azevedo and Verdade 2012; Guilder *et al.* 2015). Such ecological scenarios have been widely documented in the southern range of the species in South America (Emmons 1987, 1989; Da Silveira *et al.* 2010; Azevedo and Verdade 2012; Guilder *et al.* 2015).

As a wide-ranging apex predator, the jaguar regularly consumes large-bodied prey (32 ± 13 kg; Hayward *et*

al. 2016) to meet its substantial energetic demands, consistent with allometric models linking predator energy requirements to prey size (Carbone *et al*. 1999). Nevertheless, its diet exhibits a degree of flexibility, with smaller-bodied taxa incorporated opportunistically as their availability fluctuates, reflecting responses to spatiotemporal variation in prey assemblages (Entringer *et al*. 2022). Within this context, our photographic records suggesting potential predation and consumption of a mud turtle (*Kinosternon* sp., 100–750 g; Buhlmann *et al*. 2008) likely represents a low-cost, opportunistic foraging event rather than a targeted strategy. Such behavior aligns with ecological opportunism, wherein suboptimal prey are exploited when encounter rates or handling costs favor inclusion (Stevens and Krebs 1986; Chan *et al*. 2017). Previous observations of jaguar predation on crocodylians in flood-prone areas of the CBR (Pérez-Flores 2018; Simá-Pantí *et al*. 2020), further highlight the species' ecological plasticity in response to seasonal pulses in the availability of armored reptiles and indicate that armored reptiles could be included into its diet at least occasionally.

In the CBR, at least 10 terrestrial turtle species have been documented, belonging to 4 families and 6 genera, with the family Kinosternidae and the genus *Kinosternon* being the most represented (40%; Colston *et al*. 2015; Barão-Nóbrega *et al*. 2022). In our record, species-level identification of the mud turtle was not possible due to photographic limitations, as part of the turtle's body was obscured within the jaguar's jaws. However, visible features include: (*i*) the absence of the head, limbs, and neck, suggesting the turtle had fully retracted into its shell to minimize predation damage; (*ii*) a yellowish-brown plastron with darker joints; and (*iii*) observable axillary and inguinal scutes, indicating the plastron is not reduced in size or cruciform but instead connected to the carapace by a bridge. These characteristics are consistent with the four *Kinosternon* species distributed in the study area: Tabasco Mud Turtle (*K. acutum*), Creaser's Mud Turtle (*K. creaseri*), White-lipped Mud Turtle (*K. leucostomum*), and Red-Cheeked Mud Turtle (*K. scorpioides*; Iverson 1976; Hutchison and Bramble 1981; Lee 1996; Colston *et al*. 2015; Díaz-Gamboa *et al*. 2020; Barão-Nóbrega *et al*. 2022). While the turtle in question likely belongs to one of these species, differentiating among species within this genus is notoriously challenging (Legler and Vogt 2013), and thus we identify it conservatively as *Kinosternon* sp.

Natural predation events are inherently rare and challenging to document in the wild due to their unpredictable occurrence and the limitations of conventional methods such as scat analysis and stable isotope analysis, which do not capture predator behavior (Lima 2002; Akcali *et al*. 2019). The use of camera traps has substantially advanced the study of predator–prey interactions by providing direct, non-invasive observations of hunting behavior, including prey detection and recognition (Mills *et al*. 2004; Smith *et al*. 2020). Notably, camera traps have yielded valuable evidence of predation events—the final stage in the predation sequence (Suraci *et al*. 2022)—which may result in successful prey capture, prey escape, or injury to either the predator or the prey (Lima and Dill 1990). However, although camera traps are valuable tools for documenting predator–prey interactions, actual predation events are rarely captured (Akçali et al. 2019). This limitation constrains their utility for systematically monitoring predation behavior and highlights the importance of integrating complementary methodologies to gain a more complete understanding of predator–prey dynamics (Kelt et al. 2019; Smith et al. 2020).

In this study, we present camera trap evidence of a mud turtle being captured by a jaguar in southeastern Mexico. Similar photographic records are increasingly appearing in the scientific literature, documenting jaguars capturing and potentially preying upon a wide range of vertebrate species in the Selva Maya region, including crocodilians (Simá-Pantí *et al*. 2020), black vultures (*Coragyps atratus*; González-Gallina *et al*. 2017), and nine-banded armadillos (*Dasypus novemcinctus*; Briceño-Méndez and Puc-Kauil 2021). Additionally, other reports from the region have documented jaguar predation on a variety of prey species, including crocodilians (Pérez-Flores 2018), marine turtles (Rosales-Hernández et al. 2022), and Baird's tapir (Tapirus bairdii; Pérez-Flores et al. 2020).

Collectively, these records contribute to a growing body of evidence supporting the jaguar's trophic flexibility in the Mexican Maya Forest and highlight the utility of camera traps in advancing our understanding of predator–prey interactions in tropical ecosystems. Our observation provides the first photographic evidence of a jaguar capturing a mud turtle in southeastern Mexico, offering a rare and direct account of potential reptile predation in the region. This record complements previous reports of jaguars preying on unconventional species—such as crocodilians, vultures, and armadillos—and broadens the ecological context by highlighting the species' opportunistic feeding behavior. Taken together, our finding and related evidence emphasize the need for further research on jaguar feeding ecology, particularly with respect to prey diversity, habitat-specific seasonality, and resource availability in southern Mexico. A more comprehensive understanding of the jaguar's dietary ecology is essential for elucidating its interspecific interactions, ecological and energetic requirements, and the breadth and variability of its trophic niche in response to spatial and temporal fluctuations in prey availability. Such insights are critical for developing effective conservation strategies for large carnivores, particularly in landscapes like the Maya Forest, where jaguar populations are increasingly threatened by anthropogenic pressures—even within protected areas such as the Calakmul Biosphere Reserve.

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