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Noteworthy records of Jaguar *Panthera onca* in Guatemala

Registros notables de jaguar *Panthera onca* en Guatemala

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The jaguar is the largest terrestrial carnivore in America. According to the International Union for the Conservation of Nature, its conservation status is "Near Threatened" in its distribution range. In Guatemala, the jaguar is mainly distributed in the Maya Biosphere Reserve (MBR). In the years 2016 and 2018, camera-trapping studies were conducted in the San Miguel La Palotada-El Zotz Protected Biotopo (BPSMPZ) and in Yaxhá Nakum Naranjo National Park (PNYNN), respectively; both core zones of the MBR. Eight camera-trap stations were installed in BPSMPZ and 5 in PNYNN during the dry season, with at least 90 trap-days/nights in each site. In BPSMPZ, one adult jaguar of undetermined sex was recorded in one of the eight sampling stations installed; in PNYNN, there were 22 records (independent events) of at least 6 adult individuals (1 female, 3 males, 2 of undetermined sex) in three of the five sampling stations installed. This work reports important records on the presence of jaguars in core zones currently under pressure from human activities conducted within the southern limits of the MBR. Maintaining the integrity of these two areas is imperative to preserve this species in the MBR.

Key words: Camera-traps; core zones; habitat loss; Selva Maya; threatened species.

El jaguar es el carnívoro terrestre de mayor talla en América. Según la Unión Internacional para la Conservación de la Naturaleza, su estado de conservación es "Casi Amenazado" en su área de distribución. En Guatemala, el jaguar se distribuye principalmente en la Reserva de la Biosfera Maya (RBM). En los años 2016 y 2018, respectivamente, se realizaron estudios de fototrampeo en el Biotopo Protegido San Miguel La Palotada-El Zotz (BPSMPZ) y el Parque Nacional Yaxhá Nakum Naranjo (PNYNN), zonas núcleo de la RBM. Se emplearon 8 estaciones de trampas-cámara en el BPSMPZ y 5 en el PNYNN durante la época seca con al menos 90 noches-trampa en cada estación. Se obtuvo el registro de 1 individuo de jaguar adulto de sexo indeterminado para el BPSMPZ en una de las ocho estaciones de muestreo instaladas y 22 registros (eventos independientes) en el PNYNN de al menos 6 individuos adultos (1 hembra, 3 machos y 2 de sexo indeterminado) en tres de las cinco estaciones de muestreo. Se muestran registros importantes sobre la presencia actual de jaguares en zonas núcleo que están bajo presión de actividades humanas presentes dentro de los límites del sur de la RBM. Mantener la integridad de estas dos áreas es urgente, para garantizar el cumplimiento de conservación para esta especie en la RBM.

Palabras clave: Especies amenazadas; pérdida de hábitat; Selva Maya; trampas-cámara; zonas núcleo.

The jaguar, *Panthera onca,* is the largest terrestrial mammal predator in continental America (Nowell and Jackson 1996; Sollman 2010). Currently, the conservation status of the jaguar throughout its range (from northern Mexico to northern Argentina) is "Near Threatened" (Quigley *et al.* 2017). According to Sanderson *et al.* (2002), the current global area of distribution of this species is only 46 % of its historic range due to the loss of forest cover over the past century. In Guatemala, despite the still uncertain conservation status of the species, García-Anleu *et al.* (2016) estimated that the jaguar is distributed approximately across 58 % of the national territory. Currently, the main distribution area of the jaguar in Guatemala is the Maya Biosphere Reserve (MBR), home for viable populations, and where major efforts have been made to the study of this species (García-Anleu *et al.* 2016; De la Torre *et al.* 2017).

The MBR includes 2,090,667 ha of the more than 4,000,000 hectares of the so-called Selva Maya (SM), a territory shared with Mexico and Belize (CONAP 2015). The SM represents the largest remnant of tropical forest in Mesoamerica and the second largest in America, after the Amazon rainforest in South America (Sanderson *et al.* 2002). The MBR includes zones in three categories: a Buffer Zone (BZ), a Multiple-use Zone (MUZ), and many Core Zones (CZ). The latter comprises a total of 817,206 ha and consist of five National Parks (PN): PN Tikal (PANAT), PN Yaxhá Nakum Naranjo or PN Yaxhá (PNYNN), PN Sierra del Lacandón (PNSL), PN Mirador-Río Azul (PNMRA), and PN Laguna del Tigre (PNLT); and four Protected Biotopos (BP): BP San Miguel La Palotada-El Zotz or BP El Zotz (BPSMPZ), BP Dos Lagunas (BPDL), BP Laguna del Tigre-Río Escon-

dido (BPLT), and BP Cerro Cahuí (CONAP 2015). The MUZ comprises mainly industrial and community forestry concessions, and the BZ is a 15 km-wide strip in the southern border of the reserve, where productive activities compatible with conservation are allowed.

As regards their spatial arrangement, the CZ are distributed to the periphery of the MBR. As a result, BPSMPZ, PANAT, and PNYNN are vulnerable areas that are vulnerable due to the edge effect, for being located in the southern limit of the forest cover in the MBR, adjacent to communities and farms in the BZ (CONAP 2015; Figure 1).

Various camera-trapping studies have confirmed the presence of jaguar in CZ of the MBR such as PANAT (García *et al.* 2005; Ruano *et al.* 2010), BP and PN Laguna del Tigre (García and Radachowsky 2004; Márquez 2009; Moreira *et al.* 2009b), PN Sierra del Lacandón (Soto 2003; Márquez 2009), PN Mirador-Río Azul (Moreira *et al.* 2008a; Moreira *et al.* 2011; González-Castillo *et al.* 2018), and in BP Dos Lagunas (Moreira *et al.* 2008a; González-Castillo *et al.* 2018). The presence of the jaguar has also been confirmed in the MUZ, specifically in the forestry concessions of Melchor de Mencos (Moreira *et al.* 2009a), Carmelita (Moreira *et al.* 2008b), La Gloria-El Lechugal (Moreira *et al.* 2007), and in other areas to the south of the MBR, such as the Montañas Mayas-Chiquibul Biosphere Reserve (García 2013). This study reports important photographic records of jaguar for BPSMPZ and PNYNN, both core zones of the MBR where no camera-trapping studies had been conducted previously.

The BPSMPZ is located in northern Guatemala, west of PANAT, in the Department of Petén (Figure 1). Its territorial extension is 34.934 ha and is currently one of the CZ facing higher risks and threats due to the advance of the agricultural frontier, extraction of precious woods, poaching, and forest fires (CECON 1996; CONAP 2015). It is located in the Neotropical Biogeographic Province in the upper part of the San Pedro River basin, which in turn belongs to the Usumacinta River basin draining into the Gulf of Mexico (CECON 1996). The mean temperature ranges between 20

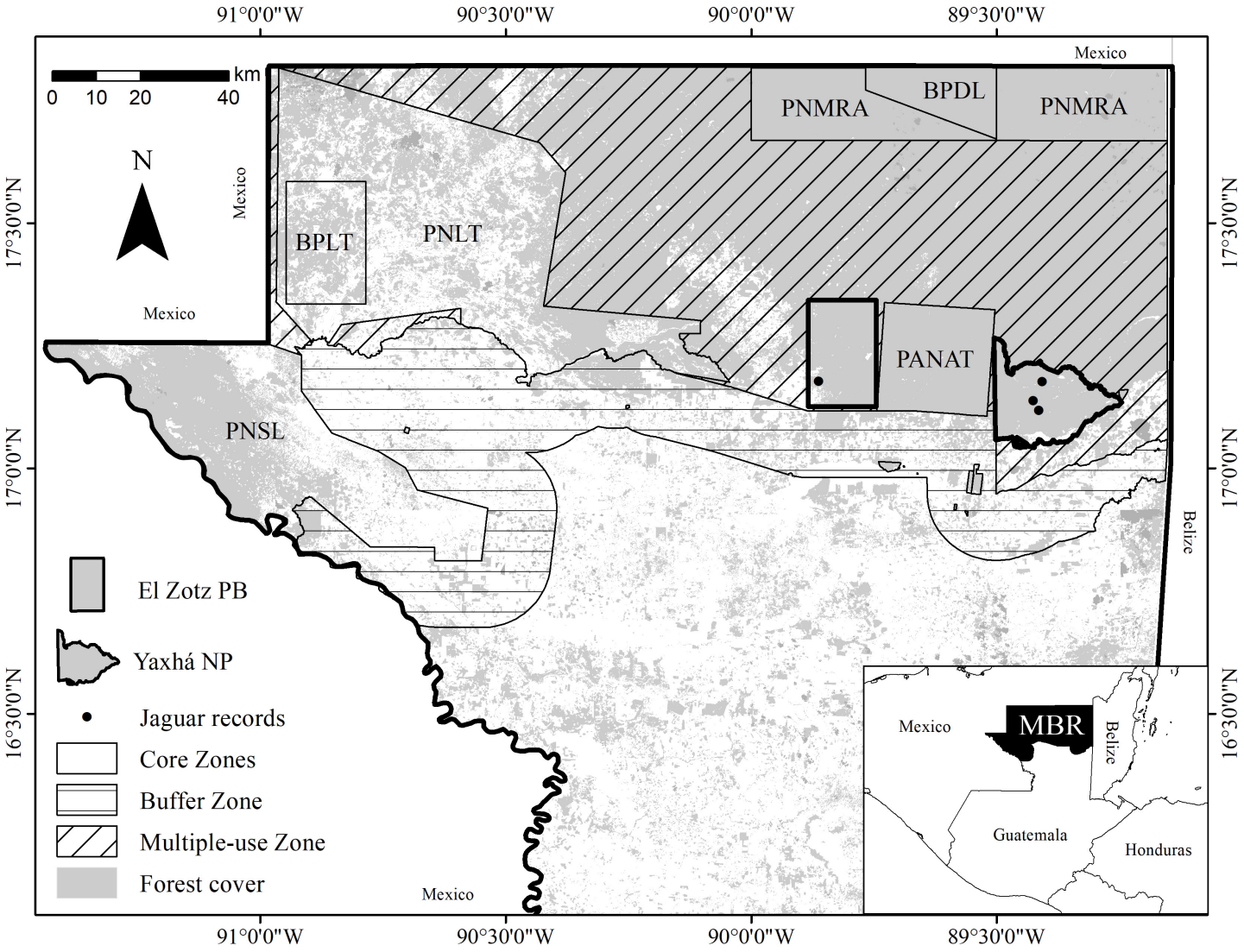

Figure 1. Location and administrative boundaries of San Miguel La Palotada-El Zotz Protected Biotopo and Yaxhá Nakum Naranjo National Park in the Maya Biosphere Reserve (MBR), Guatemala. PNSL: Sierra del Lacandón National Park; BPLT: Laguna del Tigre-Rio Escondido Protected Biotopo; PNLT: Laguna del Tigre National Park; PNMRA: Mirador-Río Azul National Park; BPDL: Dos Lagunas Protected Biotopo; PANAT: Tikal National Park.

°C and 32 °C, with an average of 26 °C; the mean annual precipitation ranges from 1,200 to 1,400 mm, and elevation ranges from 50 to 300 m. Soils are calcareous, clayey, shallow, and of low fertility (CECON 1996). BPSMPZ is home to at least 160 plant species, 223 species of vertebrates (not including fish), fungi, and invertebrates (Ixcot *et al.* 2005).

PNYNN is located in northeastern Guatemala, to the southeast of PANAT and west of the city of Melchor de Mencos (Figure 1). It stretches across 37,160 ha and is currently one of the CZ most at risk of threats within the MBR (CONAP 2015). It encompasses two physiographic provinces, the Lacandón Fold Belt and the Yucatan Platform (CECON 1996). The physiography is typical of low lands, also including a number of hills, which makes water to accumulate in lower areas. The topsoil is shallow and mainly made of organic matter, with a clayey subsoil on limestone rock; the susceptibility to erosion is 30 % (CECON 1996; CONAP 2015). Hydrologically, PNYNN is a priority area for conservation, as it includes important water bodies such as the Holmul and Naranjo rivers, the Yaxhá, Sacnab, and Lancajá lagoons, along with numerous ponds and temporary water bodies, locally known as *aguadas* (CECON 1996). The mean annual temperature ranges between 11 and 39.7 °C, averaging 25.3 °C; the mean annual precipitation is 1,800 mm, and the altitude varies between 50 and 400 m asl (CECON 1996; CONAP 2006). This area has reported at least 62 tree species and 22 species of fish, 14 of amphibians, 45 of reptiles, 99 of birds, and 42 of mammals (CONAP 2015).

As a result of the promotion by the "Guatemala Baird's Tapir Conservation Program" of the Centro de Estudios Conservacionistas (CECON) of the Faculty of Chemical Sciences and Pharmacy at Universidad de San Carlos, Guatemala, and the Fundación Defensores de la Naturaleza (FDN), several research projects and initiatives for the monitoring and conservation of fauna have been launched in various CZ of the MBR. For BPSMPZ and PNYNN, these projects started in 2016 and 2018, respectively. Annual sampling campaigns were conducted in the dry season and early rainy season (March to August), using camera-trapping stations according to the methodology proposed by the CECON and FDN (2016) for the monitoring of the Central-American tapir, *Tapirella bairdii*. For the above, priority was given in both areas to locating the sampling stations in sites with a greater probability of tapir detection, mainly on the banks of water bodies such as *aguadas* and rivers; camera-traps were placed at approximately 40 cm above ground, affixed to trees (García *et al.* 2017; García *et al.* 2019). In BPSMPZ, in each of eight stations, we installed a Bushnell® Trophy Cam automatic camera-trap with 8 MP resolution, set to take three images per capture event, with a 15-second interval between capture events. In PNYNN, camera-traps were installed in 5 sampling stations; we used Bushnell® Trophy Cam AGRESSOR No-Glow automatic camera-traps with 14 MP resolution, taking one image per capture event, and with 1-second intervals between capture events. All cameras were set to be activated by a motion sensor 24 hours a day. All cameras were operating for at least 90 trap-days/nights at each site.

One jaguar individual (adult, undetermined sex) was recorded in 1 of the 8 sampling stations at BPSMPZ during the 2016 dry season (10:26 h of 7 August 7; Figure 2a). Twenty-two individual records or events were also recorded (involving at least six adults: 1 female, 3 males, and 2 individuals of undetermined sex) in three of the five sampling stations in PNYNN during the 2018 dry season (February to August; Figure 2b).

In BPSMPZ, the sampling station where the jaguar individual was captured is located in a secondary forest near the southwestern border of the Biotopo, at approximately 8 km from the nearest town (Cruce Dos Aguadas town), and 22 km from the nearest jaguar camera-trapping record in PANAT (García *et al.* 2005; Ruano *et al.* 2010; García-Anleu *et al.* 2015). In PNYNN, the sampling stations where jaguar individuals were captured are located in two *aguadas* (ponds) and a river, recording more than one event per site, 11 km away from the nearest town (Yaxhá) and 15 km from the nearest jaguar records reported for PANAT (García *et al.* 2005; Ruano *et al.* 2010; García-Anleu *et al.* 2015).

These photographic records of jaguars in BPSMPZ and PNYNN represent a relevant event for both CZ, since this species, along with the puma *Puma concolor*, the tapir *Tapirella bairdii*, the white turtle *Dermatemys mawii*, the white-lipped peccary *Tayassu peccari*, and the scarlet macaw *Ara macao*, are conservation elements at the species level and, therefore, they are conservation and management priorities across the MBR according to its Master Plan (CONAP 2015).

The presence of jaguar in the MBR is well-documented, and previous studies (García *et al.* 2005; Ruano *et al.* 2010; García-Anleu *et al.* 2015) had reported the presence of jaguar in PANAT (Figure 1). The recent photographic records of adults of both sexes reported herein suggest that jaguars may reproduce in the southern portions of the MBR. These new records are relevant given their proximity to human settlements and the edge of the forest cover in the south of the MBR. Also, these records confirm the presence of jaguars in areas subjected to a high degree of anthropic pressure in southern MBR.

Both BPSMPZ and PNYNN are currently under pressure from illegal logging, poaching, and livestock raising (CECON 1996; CONAP 2015). In addition, along with PANAT and Montañas Mayas-Chiquibul Biosphere Reserve, these are protected areas bordering areas with a high incidence of livestock-related conflicts within the BZ (CONAP 2015). Therefore, the presence of jaguars in zones near the southern border of BPSMPZ and PNYNN may trigger potential conflicts between humans and jaguars in relation to human settlements and farms (CONAP 2015; García-Anleu *et al.* 2016). This possibility highlights the importance of implementing programs aiming to reduce potential human-carnivore conflicts in these areas. The photographs captured during the sampling in this study evidenced the presence of poachers in sampling stations, which represent an additional threat related to the proximity to populated areas (CONAP 2015).

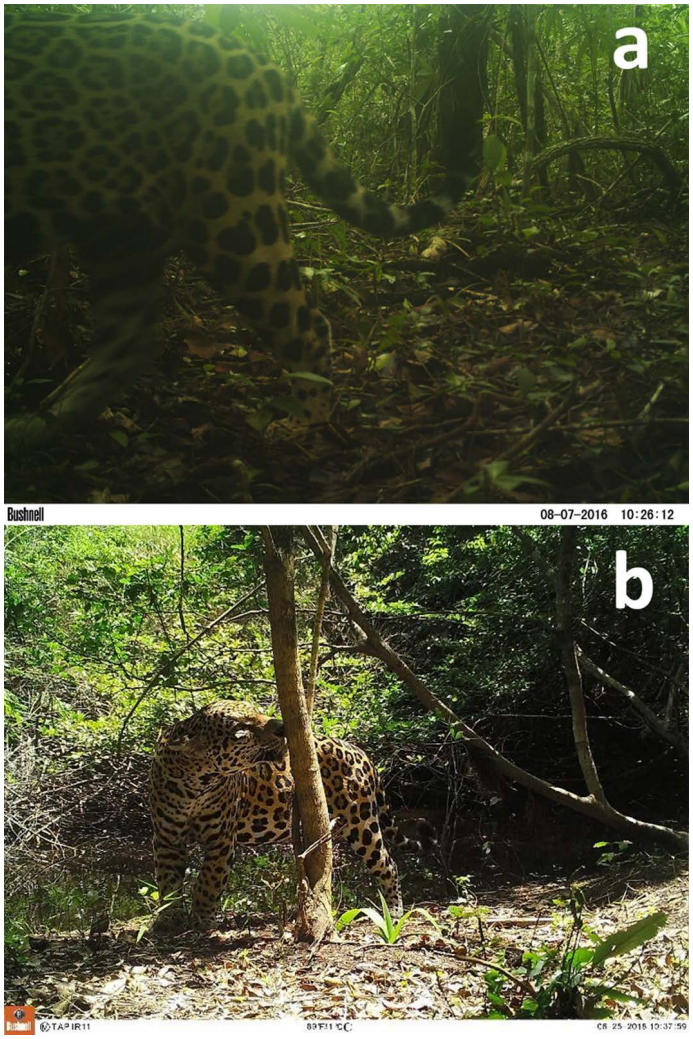

Figure 2. Photographic records of jaguar, *Panthera onca*, in a) San Miguel La Palotada-El Zotz Protected Biotopo, "Saulito", and b) the Yaxhá Nakum Naranjo National Park, "Leonel," Maya Biosphere Reserve, Guatemala.

In spite of a lower sampling effort in PNYNN, we obtained 95 % more independent records of jaguars relative to those captured in BPSMPZ. In 2019, we completed the fourth year of regular sampling in BPSMPZ; however, only one jaguar individual has been captured in a single sampling event, namely the one described herein. This suggests that the probability of recording jaguars in BPSMPZ is very low, despite its primary forest cover (Figure 1). In this sense, it can be assumed that the conservation of forest cover does not warrant the sustainability of large mammal species such as the jaguar and its main prey, nor the ecological integrity of the protected areas, giving rise to negative phenomena such as the empty forest syndrome or defaunation (Wilkie *et al*. 2011; Young *et al*. 2014; García *et al*. 2019).

There are currently no studies for the evaluation of jaguar populations in BPSMPZ and PNYNN; however, there are several studies in other areas of the MBR, including those by García *et al*. (2005), Moreira *et al*. (2009b), Ruano *et al*. (2010), García-Anleu *et al*. (2015), and Tobler *et al*. (2018). The records reported herein highlight the need to conduct sampling with an appropriate design and determine the conservation status of the jaguar in southern areas of the MBR under high risk of defaunation or with low ecological integrity (García *et al*. 201). We also recommended conducting studies on activity patterns, prey availability, population density, and occupancy for the jaguar as a conservation element of the MBR. This work highlights the importance of preserving the ecological integrity of the BPSMPZ-PANAT-PNYNN complex, together with the Bio Itzá Indigenous Community Reserve, through the strengthening of its administration and the development of integrated management programs, taking local communities into account.

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