

Noteworthy records of puma (*Puma concolor*) in Morelos, México

Registros notables de puma (*Puma concolor*) en Morelos, México

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We present noteworthy records of puma (*Puma concolor*) within the Sierra de Huautla Biosphere Reserve (SHBR), Morelos, México, captured in photo-trapping samplings done in 2019 at ejidos, within this natural protected area and Morelos. These records were obtained few years after the first record of jaguar (*Panthera onca*) for this natural protected area and Morelos. Two potentially different adult individuals of puma were identified. These records are the first confirmed photographic evidence of this species for the SHBR and for Morelos. There is little confirmed evidence of the presence of the species which is considered rare or absent in many sites throughout the state. In the case of the SHBR, although there are a few anecdotal reports by local inhabitants of sightings or tracks, the presence of pumas had never been confirmed photographically. We consider that these records are related to evidence from recent studies, showing that the ecological integrity of the area is, on average, moderately high as a consequence of the increase of the tropical deciduous forest cover. This has presumably led to an increase in populations of different species that compose the puma's diet. Furthermore, it has been estimated that the quality of habitat for this predator in the SHBR has been increasing. Therefore, we consider that our photographic records of puma in this natural protected area indicate that the efforts focused on the conservation of the biological diversity have had positive results and strongly suggest that the presence of puma in the area may increase in the medium term.

Key words: Conservation; ecology; Felidae; photo-trapping; tropical dry forest.

Presentamos registros notables de puma (*Puma concolor*) en la Reserva de la Biósfera Sierra de Huautla (REBIOSH), Morelos, México obtenidos en fototrampeos hechos en 2019 en ejidos, dentro de esta reserva. Estas fotografías de puma se obtienen pocos años después del primer registro de jaguar (*Panthera onca*) para esta área natural protegida y para Morelos. Identificamos potencialmente a dos individuos adultos de puma. Estos registros son la primera evidencia fotográfica de puma para la REBIOSH y para Morelos. Existe poca evidencia confirmada de la presencia de la especie, considerada rara o ausente en diferentes sitios del estado. En el caso de la REBIOSH, a pesar de escasos informes anecdóticos por parte de habitantes locales de avistamientos o registros de huellas, su presencia nunca había sido confirmada fotográficamente. Consideramos que estos registros están relacionados con evidencia de estudios recientes que sugieren que la integridad ecológica es, en promedio, moderadamente alta como consecuencia del aumento de la cubierta de bosque tropical caducifolio. Es de suponer que esto ha llevado a un aumento de las poblaciones de diferentes especies que componen la dieta del puma. Además, se ha estimado que la calidad del hábitat de este depredador en la REBIOSH ha ido aumentando. Por lo tanto, consideramos que nuestros registros fotográficos de puma en esta área natural protegida indican que los esfuerzos enfocados en la conservación de la diversidad biológica tienen resultados positivos y sugieren fuertemente que la presencia de puma en el área puede aumentar en el mediano plazo.

Palabras clave: Conservación; ecología; Felidae; fototrampeo; selva baja caducifolia.

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Natural Protected Areas (NPA) are clearly defined geographical spaces that are recognized, dedicated and managed through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley 2008). Their success depends, partially, on maintaining the ecological integrity

of the environments they protect (Parrish *et al.* 2003). Large carnivorous mammals in a particular NPA indicate that this objective is being achieved. Large predators have an important ecological role as population regulators of their prey species and are considered to contribute to natural environment's stability (Ritchie *et al.* 2012).

The puma (*Puma concolor*) is the second largest and most widely distributed wild cat species in America (Nielsen *et al.* 2015), ranging from British Columbia, Canadá and the north-eastern United States to Argentina and Chile. In México, puma has been historically reported in all states (Chávez-Tovar and Ceballos 2014), in practically all vegetation types and at an altitudinal range from sea level to 3,500 m.

The International Union for Conservation of Nature (IUCN) considers the species in the category of Least Concern (LC). However, recent evidence indicates that its populations are declining over most of its distribution range (Nielsen *et al.* 2015). In México, its populations have been decreasing or extirpated from many areas, mostly due to depletion of their prey species, conflicts with humans over livestock predation or disturbance of their habitat (Laundré and Hernández 2010; Chávez-Tovar and Ceballos 2014; Guerisoli *et al.* 2020). There are currently few studies on this species, and existing information is insufficient to determine its presence and abundance across the country (Soria-Díaz *et al.* 2010).

The first record of puma for the state of Morelos was provided by Davis and Russell (1954), reporting the examination of the skin of an individual apparently in Yautepec, noting that the puma was not abundant in the state. Sánchez-Hernández and Romero-Almaráz (1995), considered that there was potential for the presence of puma in Sierra de Huautla, Morelos. However, these authors consider that its presence in the area might be restricted mostly to sites with conserved vegetation and high prey abundance. Álvarez-Castañeda (1996) considered puma to be present in Morelos in his book "The Mammals of Morelos" based on the report by Davis and Russell (1954). The few reports of puma for Morelos after this book are based on records of tracks and feces (Altamirano-Álvarez *et al.* 2009; Hernández-Silva *et al.* 2011) or ethnomastozoological interviews (Martínez *et al.* 2012; García-Flores *et al.* 2014, 2018). A search for *Puma concolor* records in Morelos in the databases of the Global Biodiversity Information Facility (GBIF 2021), the Sistema Nacional de Información sobre Biodiversidad (SNIB; CONA-BIO 2020) and the Naturalista online platform produced no additional reliable records of puma for Morelos.

Better documentation of the puma's presence in the state is essential to direct conservation strategies and provide baseline information to prevent potential threats that can arise from human-puma conflicts, especially with cattle ranchers. Such conflicts are likely to occur even within NPA (Guerisoli *et al.* 2020). In this work, we report recent notable records of puma (*Puma concolor*) for the Sierra de Huautla Biosphere Reserve (SHBR) in Morelos, using camera traps. We consider that our photographic records of puma are relevant because, in addition to being one of the very few reliable records of the species in the state, they provide evidence that the efforts that have been implemented to protect SHBR's biodiversity and its habitats have produced positive outcomes. By documenting the presence of pumas in this NPA and Morelos state may also allow us to plan strat-

egies to mitigate potential puma-livestock conflicts before they arise and result in retaliatory killings, and hence facilitate the coexistence of pumas and humans in Morelos.

SHBR protects 59,030 ha covered mostly by tropical dry forest (TDF). It is one of the largest NPAs established to protect this type of vegetation, which is rich in endemic species of plants and animals. However, it is under strong transformation pressure due to human activities (Janzen 1988; Trejo and Dirzo 2000; Ceballos and Valenzuela-Galván 2010). Although it has some level of human disturbance, its rugged topography and difficult accessibility favor preserving large fragments of TDF. Steep slopes have prevented transforming some areas into pastures or agricultural fields, whereas more accessible areas have been transformed (Trejo and Dirzo 2000).

The Sierra de Huautla is considered a priority terrestrial region for conservation (Arriaga *et al.* 2000) and has a carnivore community made up of 16 species. However, before this report, the presence of puma in SHBR has been considered potential, and no previous report had provided conclusive evidence (Sánchez-Hernández and Romero-Almaráz 1995; Valenzuela-Galván *et al.* 2020).

We conducted our photo-trapping from July to September 2019 by installing 89 camera traps, of different models and characteristics: Cuddeback (models 1151, E and H-1453; Non Typical, Inc., Park Falls, Wisconsin) and Moultrie (Models D444 and D880; EBSCO Industries, Inc., Alabaster, Alabama). We installed them within SHBR in 29 single sampling stations and 30 double sampling stations, distributed in 4 ejidos (a mode of communal land tenancy in México used by a group of people for common services such as crops or cattle pastures; Schumacher *et al.* 2019): El Limón de Cuauchichinola, Tepalcingo municipality; and the ejidos of Huautla, Santiopa and Rancho Viejo, all three at Tlaquiltenango municipality (Figure 1). The distance between each camera varied between 0.5 km and 1 km. We placed olfactory attractants, on the ground at a close range (1.5-2 m) in front of each camera trap. The olfactory attractants we used were 425 g cans of sardine with tomato (GUAYMEX™) with holes punched in the top of the can, and small strips of cloth dipped in commercial Cat Passion and Gumbo attractants (O'Gorman Enterprises Inc., Montana, USA). Additionally, we conducted a community monitoring sampling between October and December 2019 in the ejido El Limón de Cuauchichinola. For this monitoring, we used 19 Bushnell camera traps (Trophy Cam E3; Bushnell Corporation, Overland Park, Kansas, USA), spaced 0.5 km to 1 km apart, with no olfactory attractants.

A database for each photo-trapping sampling was built using the software Wild.ID (TEAM Network 2009). All wildlife images obtained were analyzed to determine independent records and trapping efforts (sum of days that each camera trap effectively operated). We estimated basic information derived from photo-trapping, such as naive occupancy, relative abundance indexes, activity patterns and number of species recorded (Mandujano 2019).

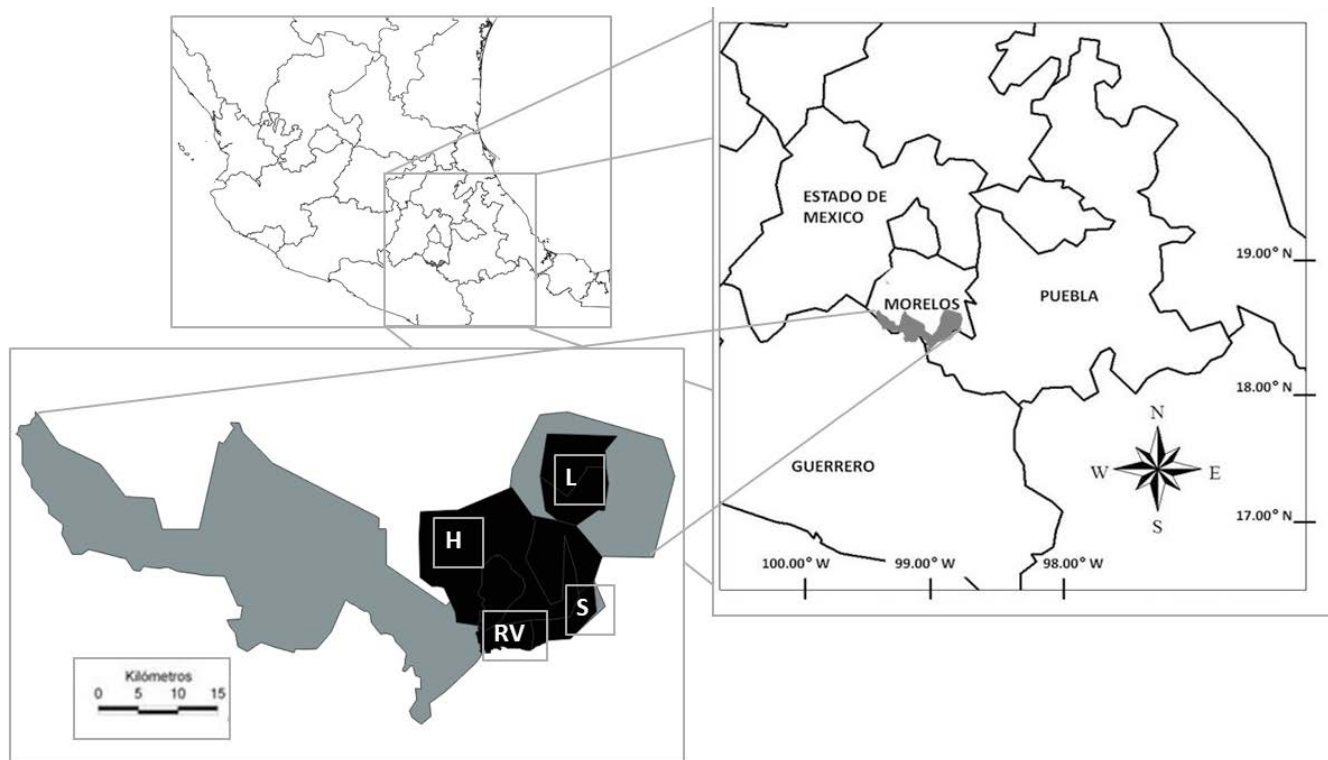


Figure 1. Location of the study area, the Sierra de Huautla Biosphere Reserve (gray polygon) in the south of Morelos state, central México and the 4 ejidos where the photo-trapping was done (polygons in black): El Limón de Cuauchichinola (L; Tepalcingo municipality), Huautla (H), Rancho Viejo (RV) and Santiopan (S; Tlaquiltenango municipality), inside the SHBR.

In the first sampling, after accumulating 5,645 trap days of sampling effort, we obtained two records of puma in two different sites. The first record was from July 15, 2019 at 10:48 hr in a double station, within the ejido of El Limón de Cuauchichinola ($18^{\circ} 29' 24.00''$ N and $98^{\circ} 56' 24.00''$ W; 1,400 m). The recorded individual is an adult male, based on visible scrotal testicles, that appears to be relatively old and in good condition (Figure 2a, b; P1 in Figure 3).

The second record was obtained from a camera installed in the ejido of Huautla, about 8 km southwest of the site of the previous record ($18^{\circ} 26' 60.00''$ N and $99^{\circ} 0' 0.00''$ W; 1,100 m), on September 8, 2019, at 19:30 hr. A male puma was caught in video footage (Figure 2 c, d, e; P2 in Figure 3), displaying a Flehmen response in which lift their lips and hold the mouth slightly open while doing a long sniff. This behavior is associated with the search for a mate and the detection of urine from an individual of the other sex, which may suggest that this individual identified a female in the area or that it has detected another male as a potential competitor (Allen et al. 2016). We suspect that this puma is a different individual based on a larger black-brown mark on its right cheek and that his head seems smaller than that of the individual recorded at El Limón de Cuauchichinola (P2 in Figure 3).

In the community monitoring sampling in El Limon de Cuauchichinola, we accumulated 1,368 trap days of photo-trapping effort. We recorded an individual drinking from a small water pool ($18^{\circ} 32' 24.00''$ N and $98^{\circ} 54' 36.00''$ W; 1,600 m). The images show a robust adult puma, whose sex could not be determined (Figure 2f, g, h; P1? In Figure 3). It

could be the same individual recorded on July 15, 2019 in the same ejido, considering that in both records there is a similar faint dark line down the middle of the head, from the ears to the front of the eyes (P1 and P1? in Figure 3). This record was obtained on October 9, 2019, at 23:59 hr (the date and time of this camera were initially misprogrammed but based on the installation data we recalculated the correct date and time).

The three records were in large fragments of tropical dry forest, classified as conserved. Some of the abundant tree species in the area are: *Conzattia multiflora*, *Amphipterygium adstringens*, various species of *Bursera*, *Jacaratia mexicana*, and *Lysiloma divaricata* (CONANP 2005). In the camera traps where we recorded puma, we also obtained photos of several species frequently reported as prey for the puma, such as white-tailed deer (*Odocoileus virginianus*), collared peccary (*Dicotyles angulatus*), white-nosed coati (*Nasua narica*) and nine-banded armadillo (*Dasybus novemcinctus*). In addition, other species of carnivores were also recorded such as coyote (*Canis latrans*), margay (*Leopardus wiedii*), jaguarundi (*Herpailurus yagouaroundi*), northern raccoon (*Procyon lotor*), grey fox (*Urocyon cinereoargenteus*), southern spotted skunk (*Spilogale angustifrons*). Also, species from other taxa: Virginia opossum (*Didelphis virginiana*), Mexican grey squirrel (*Sciurus aureogaster*), West Mexican chachalaca (*Ortalis poliocephala*), Turkey vulture (*Cathartes aura*) and American black vulture (*Coragyps atratus*). There were also records of domestic species such as donkey (*Equus asinus*) and cattle (*Bos taurus*).

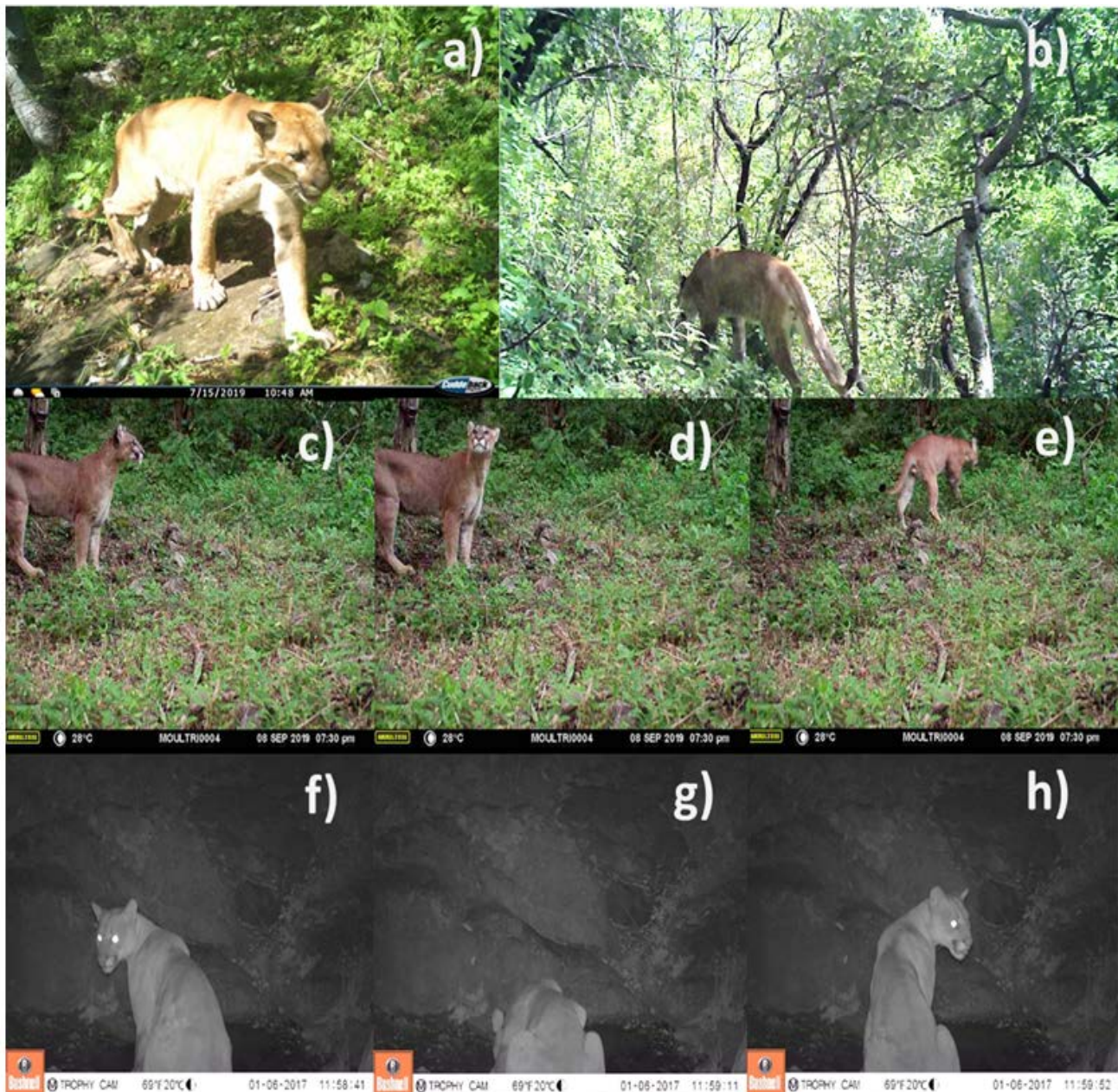


Figure 2. Sequence of recent photographic records of puma (*Puma concolor*) obtained in tropical dry forest sites of the Sierra de Huautla Biosphere Reserve, Morelos, México: a) and b) an adult male recorded at the ejido of El Limón de Cuauchichinola, July 15, 2019; c), d) and e) frame photos from an adult male individual, recorded at the ejido of Huautla, September 8, 2019; f), g) and h) photographs of an adult individual (sex could not be determined), also recorded at the ejido of El Limón de Cuauchichinola, in a community monitoring sampling, on October 9, 2019.

Despite more than 15,000 camera trap-days of sampling effort between 2009 and February 2018 (Valenzuela-Galván *et al.* 2020; D. Valenzuela-Galván, pers. obs.), there were no photographic records of puma in the SHBR prior to the three we report here. Thus, the records presented here are the first photographic evidence confirming the current presence of puma in this NPA and more importantly, in Morelos state.

Our records of puma, probably of two different individuals, at three different photo-trapping stations suggest that the species might be increasing in abundance in the area of the SHBR. Although we suspect that these were two different individuals, species that are not striped or spotted can be misidentified (see Oliveira-Santos *et al.* 2010), also

the quality of the images we recorded is not optimal to allow the detection of more details. Therefore, we cannot be completely sure that the photographic records we have correspond to two different individuals.

It is also possible that the recorded individuals do not reside within the state, but rather are from neighboring populations belonging to México State, Puebla or Guerrero. Puma has been recorded as abundant in the Sierra de Nanchititla Natural Reserve in México State, about 145 km west of the current record sites (Monroy-Vilchis *et al.* 2011). In Puebla, Farías *et al.* (2015) reported the presence of puma, with the detection of adults of both sexes and young, at the Tehuacán-Cuicatlán Biosphere Reserve in the southern part of the state, about 180 km southwest of the present reg-

istry of puma in Morelos. [Ramírez-Bravo et al. \(2018\)](#) also reported puma for the Sierra del Tentzo and for a locality in the Mixteca Baja Poblana, located about 78 km NW and 30 km SW, respectively, of the records that we now report. In Guerrero, [Almazán-Catalán et al. \(2013\)](#), obtained five records of skins and a puma skull from different localities within the state; the closest localities to the SHBR were Teloapan and Leonardo Bravo, about 95 km to the E and 117 km SE of the SHBR's records we report here.

Although it has been reported that the puma is tolerant to moderate levels of human disturbance in its habitats, its abundance may be linked to areas with an abundance of potential prey, low hunting pressure or low abundance of potential competitors (see [Miotto et al. 2014](#); [Smith et al. 2019](#)). There is evidence that puma was hunted in the area before the formation of the SHBR in 1999. Some potential preys have been locally extirpated by hunting pressure, such as white-lipped peccary (*Dicotyles angulatus*; [Sánchez-Hernández and Romero-Almaráz 1995](#); [Álvarez-Castañeda 1996](#)). However, since the SHBR was established, different conservation actions have been implemented, including

promoting reforestation and ecological restoration projects, supporting actions to retain soil and reduce water runoff speed in deforested areas, and strong support to alternative productive projects for sustainable development of local communities (e. g., wildlife management units, which require proper management of forested habitats).

We consider that all these actions have maintained and increased the NPA's biodiversity since its decree in 1999. The rate of transformation of the vegetation has been very low and there has been a moderate increase in the area of conserved TDF ([Sorani et al. 2020](#)). An increase in the abundance of wildlife species has also been reported ([Castro-Campos 2016](#); [López-Medellín et al. 2017](#)) including species that are potential prey for puma. For example, the white-tailed deer (*Odocoileus virginianus*) has a high population density (21.3 to 28 ind. / km²; [Corona et al. 2010](#); [Hernández-Silva et al. 2011](#)), and the white-tailed coati (*Nasua narica*) present the second highest value of relative abundance among carnivore species in the SHBR ([Valenzuela-Galván et al. 2020](#)). In addition, species that had no previous records or were considered locally extinct are now frequently

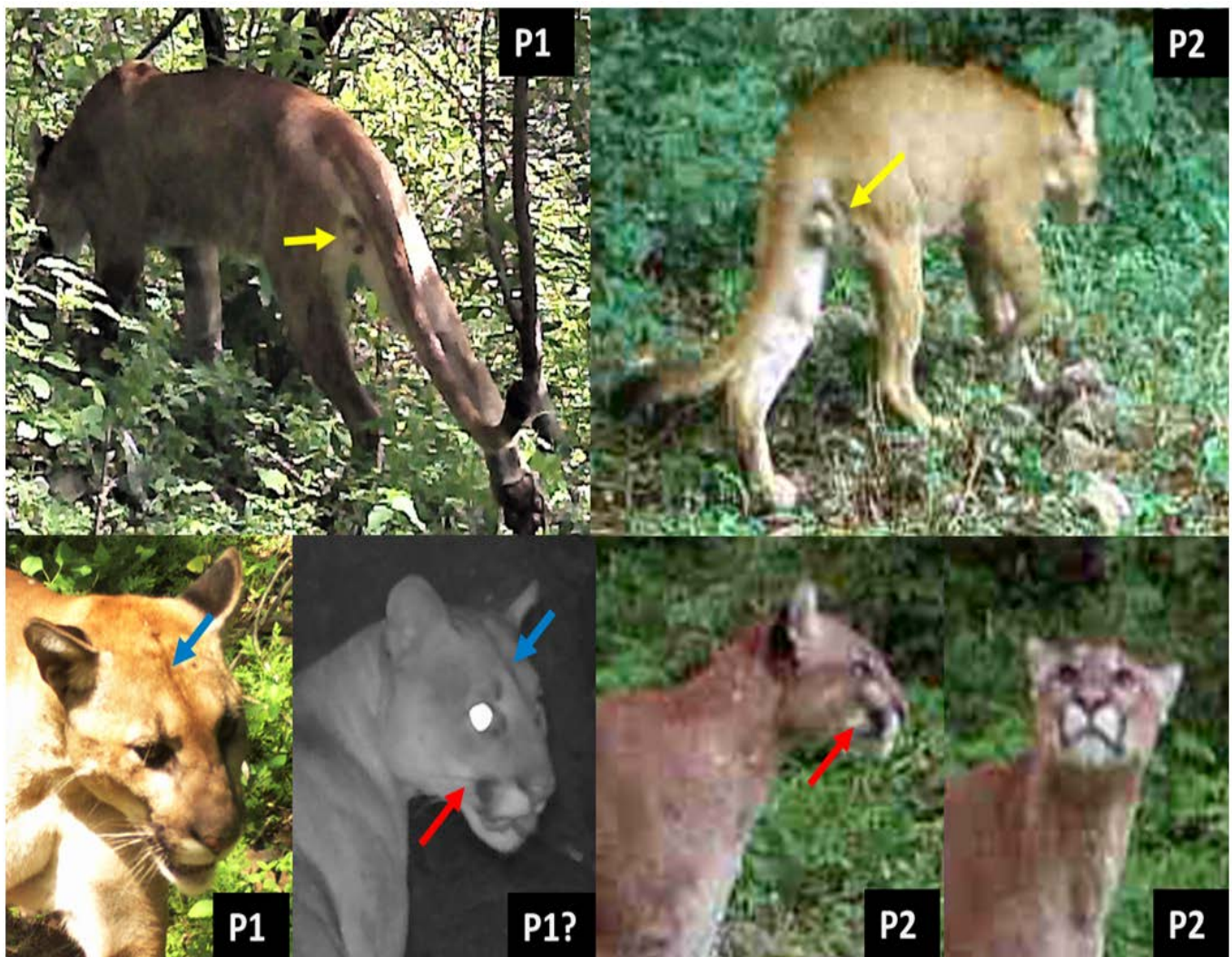


Figure 3. Differences between recorded individuals of *Puma concolor*. We suspect that we photographed two different individuals, P1 at the ejido of El Limón de Cuauchichinola and P2 at the ejido of Huautla. Both were adult males based on their noticeable scrotal testicles (yellow arrows). We consider that P1 and P2 are likely different individuals. The photographs obtained on October 9, 2019, of an individual of unidentified sex (P1?) might be the same as P1, recorded on the same ejido and on both, it is noticeable a faint dark line, that goes from the middle of the head to the front of the eyes (blue arrows).

recorded, for example, margay (*Leopardus weidii*), jaguar (*Panthera onca*) and collared peccary (*Dicotyles angulatus* "Pecari tajacu"; [Mason-Romo et al. 2008](#); [Valenzuela-Galván et al. 2013](#); [Valenzuela-Galván et al. 2015](#)).

All this suggests that the ecological integrity of the SHBR has improved, favoring the presence of large predators. A recent analysis by CONABIO (National Commission for the Use and Knowledge of Biodiversity; https://monitoreo.conabio.gob.mx/i-efectividad/reportes_html/6104.html, accessed on October 25, 2020) supports this assumption. They found that the rate of transformation of the vegetation in SHBR was close to zero in the last five years. Also, the average value of ecosystem integrity ([Equihua et al. 2014](#)) of the reserve is higher than 0.6 (1 being the maximum value), and the quality of the habitat for puma increased steadily between 2008 and 2014 (analysis period).

The presence of puma in SHBR as well as the recent record of jaguar (*Panthera onca*; [Valenzuela-Galván et al. 2015](#)), also in this NPA, strongly suggest that both species could need large areas covered with tropical deciduous forest. Although both species do not need exclusively forested areas, both prefer sites with primary forest over areas heavily disturbed by human activities. Especially in the case of jaguar, large areas of primary forest should be guaranteed to ensure its long-term conservation ([De la Torre et al. 2017](#)).

Only a few kilometers at the southeast of the sites where we recorded puma, there are large unprotected fragments of conserved TDF, in the area known as the Mixteca Baja Poblana (MBP), in the state of Puebla. The TDF in that area may be beneficial for the conservation of puma, but needs to be protected. In fact, an extensive study has already been done to support the establishment of a new NPA of nearly 60,000 ha, mostly covered by TDF, in the MBP. That study, done by researchers from the Centro de Investigación en Biodiversidad y Conservación, coordinated by the second author of this note, and financed by the Volkswagen Program "For the love of the planet" was presented to the pertinent area of Comisión Nacional de Áreas Naturales Protegidas ([CONANP-CIBYC-UAEM 2013](#)). We are also aware that there is a similar proposal for a new state natural protected area in the northern portion of Guerrero state (along the southwest border of the SHBR) that also contains large tracts of well-preserved TDF (V. Sorani, pers. com.).

We consider that our present records of puma in the SHBR provide even further justification for the establishment of the new NPA. Which in turn, would also help to maintain a large biological corridor for felines, such as the one proposed by [Ramírez-Bravo et al. \(2010\)](#) or the one proposed for jaguars by [Ceballos et al. \(2018\)](#). This area extends from the Zicuarain-Infiernillo Biosphere Reserve in the state of Michoacán, through northern Guerrero, southeastern México State, and southern Morelos state, to connect to the Tehuacán-Cuicatlán Biosphere Reserve in Puebla and Oaxaca. We are confident that our records suggest that this predator may become more abundant locally

in the medium term and indicate that the management and conservation actions implemented in the SHBR have been effective.

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