Mammal diversity and human impacts in Portobelo National Park, Colón Biological Corridor, Panama

Diversidad de mamíferos e impactos humanos en el Parque Nacional Portobelo, Corredor Biológico Colón, Panamá

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INTRODUCTION
Panama is located in the southern of Mesoamerica, where the Darién forests converge with the expansive Colombian Chocó forests (Sanderson et al., 2002) and link their central region to the Caribbean, Costa Rica, and the broader Central American region. This geographical junction forms an integral segment of the Mesoamerican Biological Corridor (FAO, 2010) with the Colón Biological Corridor at its center. Unfortunately, the lax approach of Panamanian legislation towards conservation has led to various environmental challenges (Moreno et al., 2016).

It is estimated that there are 119 species of terrestrial non-volant mammals in Panama (Samudio & Pino, 2014). Various methods have been used to analyze and understand mammal diversity, including line transect sampling, feces collection, and direct capture (Aranda, 2012; Moreno et al., 2016; Wright et al., 1994); however, camera traps are currently one of the most effective and reliable methods used to study terrestrial mammal populations (Karanth et al., 2004).

One indicator of tropical forest health is the presence of large and medium-sized mammals, since many species are considered rare and display greater niche complexity in tropical forests.

ABSTRACT
We conducted this study in Portobelo National Park and a section of Chagres National Park, both part of the Colón Biological Corridor. To obtain information about the diversity of mammal communities in the study area, estimate their relative abundance and habitat use, and propose the establishment of long-term monitoring stations, we placed 25 camera-trap stations distributed over two transects. We calculated the Shannon-Wiener ($H'$), Simpson (D), and Inverse Simpson (1-D) diversity indices using the BiodiversityR package. For beta diversity, we used the vegan R package to calculate the Bray-Curtis dissimilarity index. We obtained 556 records, belonging to eight orders, 11 families, and 22 species. The dominant species were *Dasyprocta punctata*, with 180 records, and *Syntheosciurus granatensis*, with 65; the rarest species were *Philander melanurus* and *Cebus capucinus*, with only one record each. The transects showed medium to high diversity, with statistically significant differences between them. In our analysis, we discuss some existing problems between humans and certain species that we documented. We also highlight the presence of certain indicator species, which demonstrates a healthy ecosystem that should be maintained.

Keywords: Behavior, camera traps, conservation, diversity, habitat fragmentation.

RESUMEN
Realizamos el estudio dentro del Parque Nacional Portobelo y una sección del Parque Nacional Chagres; ambos forman parte del corredor biológico de Colón. Para obtener información sobre la diversidad y las comunidades de mamíferos en el área de estudio, estimar su abundancia relativa y uso de hábitat, y proponer el establecimiento de estaciones para monitoreo a largo plazo, colocamos 25 estaciones de cámaras trampa distribuidas en dos transectos. Estimamos los índices de diversidad alfa de Shannon-Wiener ($H'$), Simpson (D) y Simpson Inverso (1-D) con el paquete BiodiversityR. Para la diversidad beta, utilizamos el paquete vegan R para calcular el índice de disimilaridad de Bray-Curtis. Obtuvimos 556 registros pertenecientes a ocho órdenes, 11 familias y 22 especies; las especies dominantes fueron *Dasyprocta punctata*, con 180 registros, y *Syntheosciurus granatensis*, con 65; las especies raras fueron *Philander melanurus* y *Cebus capucinus*, con solo un registro por especie. Los transectos presentaron una diversidad de media a alta, con diferencias estadísticamente significativas entre ellos. Planteamos algunas problemáticas existentes entre humanos y algunas especies reportadas en este estudio. También resaltamos la importancia de la presencia de algunas especies indicadoras de un ecosistema saludable que debería mantenerse.

Palabras clave: Cámaras trampa, comportamiento, conservación, diversidad, fragmentación de hábitat.
(Morrison et al., 2007); some of these species are top predators, while others are herbivores, mesopredators, and seed dispersers (Fragoso, 1999; Galetti et al., 2015; O’Farrill et al., 2013; Sunquit & Sunquit, 2002). The complexity of their ecological niches renders them particularly vulnerable to disturbances, as they require large territories; when combined with hunting pressure, this leads to diminished population densities for these species (Benítez-López et al., 2017; Crooks et al., 2017).

The study area borders towns and human settlements, areas with livestock activity in the north of the park, grasslands, and monoculture plantations (Condit et al., 2001). These anthropic impacts increase the probabilities of conflict between large felines and humans, as well as diminishing numbers of potential prey of felines through hunting.

The objectives of this study were to establish a database of the mammals present in the study area, estimate their relative abundance, determine habitat use and human impacts, and propose the establishment of fixed sampling stations for long-term population ecology studies over large polygons.

**METHODOLOGY**

**Study area**

The area we chose for this study is located in Portobelo National Park (09°26′23.7″ N, 79°37′31.3″ W) and part of Chagres National Park (09°25′25.9″ N, 79°39′20.6″ W), comprising two transects located on the edges of the mountains adjacent to the middle and upper basin of the Piedras River and some of its tributaries (Figure 1).

Portobelo National Park was established on December 22, 1976, and comprises 359 km² (Gaceta Oficial de Panamá, 1977); Chagres was officially created on October 2, 1984, with the primary objective of maintaining the forest cover of the Chagres, Gatún, Boquerón, Indio, and Puquení River basins, with an area of 1290 km² (Gaceta Oficial de Panamá, 1985).

Portobelo and Chagres National Parks have important rivers, such as the Gatún and Chagres, which together with their tributaries supply water for the operation of the Panama Canal. Other rivers, such as the Piedras, Iguanita, and Guanche, supply water to many nearby communities; in the Costa Arriba de Colón area they are used for fishing, agriculture, livestock, and transportation of people and items, forming an important part of the local economy (INRENA-RE, 1998).

**Description of transects**

The study area was divided into two sections, northern and southern transects (Figure 1):

**Northern transect:** Began at the mouth of a tributary on the north side of the Piedras River, at an elevation of 400 m, and ascended to reach the Folofa camp at 720 m, crossing a cloud forest (Frio I and Frio II camps, at elevations of 850 and 825 m, respectively) and ending in Salto del Mono at an elevation of 225 m within Portobelo National Park.

**Southern transect:** Included forested areas on mountain slopes at an elevation of 750 m, then descending to 450 m and running parallel to the Piedras River from east to west. The transect did not include cloud forest, but it did include area used by residents near Portobelo National Park and a small portion of Chagres National Park, ending at Salto del Tigre at an elevation of 350 m.

**Data collection**

We used line transects for data collection. This method allowed us to obtain information based on tracks for many species, although overestimation of some indices is possible in the case of felines (Aranda, 1994). Combining this method with camera traps improves the quality of study results, as observed in a study carried out in Brazil, where a comparison of the line transect and camera-trapping methods concluded that studies with camera traps were the most appropriate and precise method for mammal inventories (Silveira et al., 2003). For this reason, we established 25 sampling stations distributed along two transects, 12 in the northern transect and 13 in the southern. We used camera traps (Bushnell Trophy Cam, Cuddeback E2 IR, Stealth Cam and
Figure 1. Location of the study area.
Covert Illuminator models) distributed in both transects, spaced approximately one kilometer from each other, alternating them over periods of approximately two months between January 9 and May 9, 2020, for the northern transect and November 8, 2019, and March 12, 2020, for the southern transect.

The northern transect included areas with no defined trails. In areas with trails, we installed cameras on each side of the trail to photograph both sides of the species that appeared, facilitating identification and analysis (Moreno, 2006; Silver et al., 2004; Soisalo & Cavalcanti, 2006; Tobler et al., 2013). The southern transect included areas with defined trails used by the inhabitants of nearby communities, since felines frequently use these paths to patrol their areas of action (Chávez et al., 2013; Harmsen et al., 2010). However, we may have reduced the probability of capturing other species, such as ungulates and small mammals, that do not frequent those trails (Moreno, 2006).

**DATA ANALYSIS**

We combined the results obtained from each camera trap and grouped them by zone (north and south). Subsequently, we estimated the Relative Abundance Index (RAI), a standardized metric of how often a species appears on cameras (Botts et al., 2020). To determine the Alpha diversity (diversity on a local scale) we calculated the Shannon-Wiener (H’), Simpson (D), Inverse Simpson (1-D), and Evenness (J) indices using the BiodiversityR package. For Beta diversity (species turnover rate between two communities), we used the vegan R package to calculate the Bray-Curtis dissimilarity index. Using the betadisper function, we carried out a multivariate analysis of group dispersions (variances) to assess whether significant differences existed between the indices obtained for each of the camera traps and sampling zones.

We completed this analysis using nonmetric multidimensional scaling (NMDS) to assess the proximity of dissimilarities obtained between different sampling points and zones, indicating how similar or dissimilar the zones are in terms of Beta diversity. In addition, ANOVA and Tukey tests were applied to evaluate if there were significant differences between the Beta diversities obtained between and among the camera traps by zones. Finally, we evaluated completeness using the iNext package, which is based on estimations using Hill numbers (Hsieh et al., 2016), allowing for inter/extrapolations of diversity based on richness and abundance. We performed all analyses using R statistical software (version 4.3.0; R Core Team, 2021).

**SAMPLING EFFORT**

The sampling effort was quantified by the number of hours (24 each full day or a respective fraction if it was not completed) multiplied by the number of days that each camera trap was active. Both amounts were added to obtain the total. In the special case of the stations that had two camera traps during the same sampling time, we considered both as a single camera trap.

**TAXONOMIC REVIEW**

We used the Mammal Diversity Database of the American Society of Mammalogists (Version 1.11; ASM, 2023) for our taxonomic review, as it records the latest taxonomic changes in living and recently extinct species, higher mammalian taxa, and internationally accepted common names. It also curates the taxonomic implications of new research publications in real time to promote rigorous studies of mammal biodiversity around the world.

**CONSERVATION STATUS**

We used the International Union for Conservation of Nature Red List (IUCN, 2023) and the List of Threatened Species of the Ministerio del Ambiente de Panama (MiAmbiente, 2016) to verify if the reported species are classified in categories of conservation concern.

**RESULTS**

We obtained 556 records of mammals belonging to eight orders, 13 families, and 22 species, which represent 19% of the 119 species of ter-
terrestrial mammals reported for Panama. The order Rodentia was the most abundant, with four families, followed by Carnivora, with three, and Perissodactyla, Artiodactyla, and Primates, with one family each. The most abundant family was Felidae, with five species; then Didelphidae, with three; Procyonidae and Tayassuidae with two species each; the remaining ten families were represented by a single species each.

The most dominant species was Dasyprocta punctata (Figure 2A), with 180 captures (32% of the captured individuals), followed by the Syntheosciurus granatensis, with 65 (12%). The species with the least captures were Philander melanurus and Cebus capucinus, with one individual each, representing 0.2% of the captured individuals (Table 1). These results correspond to a sampling effort of 2211 trap-nights at 25

![Figure 2. Examples of some of the mammals recorded: A. Central American Agouti (Dasyprocta punctata); B. Lowland Paca (Cuniculus paca); C. Collared Peccary (Dicotyles tajacu); D. White-lipped Peccary (Tayassu pecari); E. Central American Tapir (Tapirus bairdii); F. Jaguarundi (Herpailurus yagouaroundi); G. Ocelot (Leopardus pardalis); H. Puma (Puma concolor); I. Jaguar (Panthera onca).]
Table 1. Species of mammals recorded at Portobelo and Chagres National Parks.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>Transect</th>
<th>Records</th>
<th>Conservation</th>
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<td>- ●</td>
<td>1</td>
<td>VU EN</td>
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<tr>
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<tr>
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<tr>
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<td>67</td>
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<tr>
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<tr>
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<td>Tomes’ Spiny Rat</td>
<td>● ●</td>
<td>34</td>
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</tr>
<tr>
<td>Carnivora</td>
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<tr>
<td>Felidae</td>
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<tr>
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<td>Jaguarundi</td>
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<td>5</td>
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</tr>
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<td>31</td>
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</tr>
<tr>
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<td>Margay</td>
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<td>35</td>
<td>LC VU</td>
</tr>
<tr>
<td>Panthera onca</td>
<td>Jaguar</td>
<td>● ●</td>
<td>13</td>
<td>NT EN</td>
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<tr>
<td>Procyonidae</td>
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<tr>
<td>Nasua narica</td>
<td>White-nosed Coati</td>
<td>● ●</td>
<td>21</td>
<td>LC NE</td>
</tr>
</tbody>
</table>
Relative abundance index

The species with the highest relative abundance were *Dasyprocta punctata* and *Synthoeosciurus granatensis*, with RAI of 13.2 and 4.9, respectively; those with the lowest RAI were *Philander melanurus* and *Cebus capucinus*, with 0.07; the rest of the species had indices ranging between 0.14 and 2.6. We recorded a RAI of 39.6 (220 captures) along the northern transect and a RAI of 60.4 along the southern transect (336 captures; Figure 3).

Species diversity/richness index per transect

The evaluated area presented the following Alpha diversity values in the northern transect: Shannon-Wiener index = 2.5; Simpson index = 0.88; Hill numbers = 12. The values corresponding to the southern transect were: Shannon-Wiener index = 2.3; Simpson index = 0.83; Hill numbers = 10. Beta diversity for both transects with Bray-Curtis index = -0.024.

In the principal component analysis, we see that the northern and southern records overlap but maintain some differences (Figure 4A). According to our nonmetric multidimensional scaling analysis, the northern records are more dispersed than those in the south; the southern records were more similar to each other in terms of beta diversity (Figure 4B).

Statistical tests

Performing an ANOVA and Tukey test on the diversity values of the transects, we calculated that for the northern transect $p = 0.03$, and for the southern transect $p = 0.045$; the difference between northern and southern with adjusted $p = 0.045$.

Conservation status

According to the IUCN Red List, we recorded one Endangered species (*Tapirus bairdii*), two Vulnerable, two Near Threatened, one belonging to the Data Deficient category, and 16 in the Least Concern category (Table 1). According to the national assessment by the Ministerio del Ambiente de Panamá, we recorded one Critically Endan-
gered species (Tapirus bairdii), three Endangered (Cebus capucinus, Panthera onca, and Tayassu pecari), and six Vulnerable (Table 1).

**DISCUSSION**

This study established an important database of mammal diversity in Portobelo National Park, on the edges of the mountains adjacent to the middle and upper basins of the Limoncito and Piedras rivers, and along some tributaries of the headwaters of these rivers. Using the camera-trap method in two transects, we estimated the relative abundance of these communities, providing a basis for future studies and laying groundwork for strategies to conserve these species.

Camera traps generate data with considerable heterogeneity; this was confirmed in our study, since according to the ANOVA-Tukey test, the $p$ value = 0.044 and demonstrated a small but significant difference between the transects. According to the Shannon-Wiener (northern transect = 2.5 and southern transect = 2.3) and Simpson indices (northern transect = 0.88 and southern transect = 0.83), the transects presented medium to high diversity (Hernández-Salinas & Ramírez-Bautista, 2013; León et al., 2014; Tobler et al., 2008; Figures 3 and 4).

The studies conducted by Meyer et al. (2015) in the nearby communities of Sierra Llorona and Santo Domingo (15 km SW and 8 km S of our study area, respectively) indicate a richness of 15 species over 29 stations and 766 camera-nights, lower than our reports of 22 species over 25 stations and 2211 sampling nights. We consider that methodology, study duration, and station location are determining factors as well as the habitats and areas impacted by humans. Additionally, we only evaluated information from camera traps (photos and videos), unlike Araúz (2006) and Araúz et al. (2008), who used mist nets, traps, and other records such as tracks.

The Alpha diversity that we found in our study was similar to that determined by other studies in the region (Meyer et al., 2015); it is possible to obtain projections per transect from the analysis of diversity indices and Hill numbers.

In this sense, the northern transect was close to reaching stability; a large increase in species was not predicted (Figure 3A). However, the southern transect, despite having greater richness, projected a considerable increase in the number of species compared to the northern before reaching curve stability (Figure 3A). The fact that both curves overlap explained the relationship between both transects; a similar number of species could be found in both.

Beta diversity explains in more detail the relationship between both sampling sites; despite being close, they presented statistically significant differences. The diversity obtained at each station was compared, and stations
with extreme values became apparent. However, these occurrences were rare, since the vast majority of stations had very similar values as far as rarity of the data or observations, that is, considering species that were recorded in multiple seasons (Figure 4). The boxplot shows that the southern transect has a lower variance in community composition than northern transect, since the distance to the centroid is smaller. This difference could be due to the southern transect having outlier values that represent rare records, such as those species that either occurred only once or are abundant (Figure 4C).

Portobelo and Chagres National Parks form part of the Colon Biological Corridor (Fuentes et al., 2023) and are located in one of the most diverse ecoregions in the world, connecting to the Chocó-Manabí Conservation Corridor (Myers et al., 2000). However, habitat fragmentation is widespread in the area, caused by human activities such as livestock farming and agriculture intensified by the presence of roads that facilitate access for these activities in the buffer zones of protected areas (Moreno et al., 2015, 2016). Although our study presented an average species richness (n = 22) similar to studies in other protected areas of the country (Brown, 2014; Meyer et al., 2015; Ortega, 2016), we recommend expanding future studies by increasing the number of stations, trap-nights, and sampling areas because of the aforementioned concerns.

**Most Abundant and Rare Species**

*Dasyprocta punctata*, a terrestrial species, was the most frequent species recorded, coinciding with results of other studies conducted within its area of distribution (Meyer et al., 2015; Mosquera-Muñoz et al., 2014). *Syntheosciurus granatensis* was expected to have low capture frequency via camera traps due to its arboreal habits; however, it was the second most frequent species recorded. Despite this, we mention the recapture of two individuals, via camera 2 of the northern transect and camera 1 of the southern transect; they are not the same individual, since several are found kilometers away and the Piedras River runs between both sites.

Due to their arboreal habits, the opossum *Philander melanurus* and the primate *Cebus capucinus* were the species recorded the fewest number of times. Arboreal behavior is common in primates such as *C. capucinus* (Fleagle, 2013), which justifies the low occurrence; the
presence of potential predators in their habitat may discourage terrestrial behavior of the species (Monteza-Moreno et al., 2020). These arboreal species have a wide variety of predators, from mustelids, such as *Eira barbara*, to felines, such as *Panthera onca* (Figure 2I), *Puma concolor* (Figure 2H), *Herpailurus yagouaroundi* (Figure 2F), *Leopardus pardalis* (Figure 2G), and *Leopardus weidii* (Rose et al., 2003), which were all reported in this study.

Species such as the red brocket (*Mazama americana*) and the white-tailed deer (*Odocoileus virginianus*) were reported in previous studies in Portobelo and Chagres National Parks (Meyer et al., 2016), so with an increase in sampling we hope to detect them in our study area. These two species are sympatric; however, *M. americana* is smaller and displays different habitat use, preferring primary forest and old secondary forest (Reid, 1997). Additionally, this species is sensitive to anthropogenic disturbances, which cause their movement to other sites (Jordan et al., 2016; Reid, 1997). *Odocoileus virginianus* occurs more frequently in areas of mature forests or with open undergrowth and in the ecotone between forest/grassland and grassland (Meyer et al., 2016; Naranjo & Bodmer, 2007).

We predict that both species (*M. americana* and *O. virginianus*) have moved to the most remote areas of the parks due to hunting pressure and habitat use, which is why they have not been detected in this study. Similarly, the giant anteater (*Myrmecophaga tridactyla*) is another species that we expected to detect and is threatened mainly by poaching, habitat loss and fragmentation, fires, and vehicle collisions (Cáceres et al., 2010; Lacerda et al., 2009; Noss et al., 2008). Although they can be present in many types of habitats throughout their range in Panama, they are restricted to primary rainforest and are considered one of the rarest species of large mammals (Meyer et al., 2019) with low probabilities of occurrence throughout the country and low connectivity with other populations (Meyer et al., 2020). In Portobelo National Park, previous studies did not detect *Myrmecophaga tridactyla*. However, there was a sighting of an individual on the Camino Real colonial trail, specifically in the Boquerón area near our study site (R. Morales, pers. obs.), which means that the species is present in the area.

Although *Myrmecophaga tridactyla* tolerates some degree of disturbance, such as livestock and moderate fire (Shaw et al., 1987), it avoids areas with high levels of contact with humans, livestock, and other domestic animals, and appears to require well-preserved forests (Di Blanco et al., 2015; Shaw et al., 1987; Vynne et al., 2011). We surmise that this is one of the reasons why the species was not detected, given that our cameras were placed relatively close to human settlements.

**IMPORTANT SPECIES, HABITATS, AND HUMAN IMPACT**

Small, insectivorous, omnivorous, and generalist mesocarnivorous species appeared in different stations of both transects. This shows that, in general, the mammal community is not limited to the use of specific sectors of the Portobelo National Park. However, larger mammals behaved differently. In the northern transect, which contained uninterrupted habitats far from communities and farms, we detected the greatest number of *Tapirus bairdii* occurrences (12 of the 13 captures in this study); this species had been previously reported in areas surrounding Portobelo and Chagres National Parks (Meyer et al., 2016). Other species, including *Tayassu pecari* (8 of 13 captures), had not been previously detected in the area in studies with camera traps (Meyer et al., 2016). This pattern correlates with the study results of Meyer et al. (2015), which indicate that larger herbivores are more frequently found in large forested areas with low disturbance. However, it supports the hypothesis that their populations have been decimated, emphasizing their rarity in the region (Meyer et al., 2016; MiAmbiente, 2016). Both species, *T. bairdii* and *T. pecari*, are found in one of the remotest and best preserved sites in Portobelo National Park; nonetheless, they are prone to disappear under any type of anthropogenic pressure or change (Reyna-Hurtado et al., 2009; Schank et al., 2017, 2020).

Local legislation places all felines, and some of their prey, in Vulnerable and Endangered cat-
categories; however, the IUCN places these same species in categories such as Near Threatened and Least Concern due to different evaluation methods and their wide distributions (R. Moreno, personal communication; November 28, 2023). In addition, the IUCN Red List is updated regularly, whereas the list generated by the Ministerio del Ambiente of Panama has not been updated since 2016, making studies such as these useful tools for guiding new national assessments of the species.

Fort et al. (2022) used covariates to model Tayassu pecari occupancy in Darién National Park, demonstrating that its detectability is influenced by longer sampling duration. Thus, we expect greater detectability of the species if we increase sampling effort over the area, as indicated by our species rarefaction curve (Figure 3A). *Puma concolor*, unlike *Panthera onca*, is the feline most tolerant of human presence (Scognamillo et al., 2003), thus explaining its high number of records in the southern transect (24 of 35 captures), which has anthropogenic impacts similar to other study areas in Belize (Silver et al., 2004) and Guatemala (García-Anleu et al., 2016). The southern transect included access to livestock farms. Feline-livestock conflict might occur in these locations, but only conflicts involving jaguars have been documented in this region (Moreno et al., 2017), unlike in Colombia, where conflicts between pumas and cattle have been studied (Valderrama-Vásquez et al., 2017).

In the central region of Panama, which is home to Portobelo and Chagres National Parks, the probabilities of habitat use and occupation are estimated to be low (Calderón et al., 2022; Meyer et al., 2019) due to habitat loss, among other reasons (Meyer et al., 2019, 2020; Moreno et al., 2015, 2016). Likewise, poaching pressure in the center of the country and nearby areas is high because of the easy accessibility of many of these areas (Wright et al., 2000), increasing prey loss and conflict between humans and jaguars (Moreno et al., 2017). Some sites in the Costa Arriba de Colón area and sectors of Portobelo National Park are cataloged as possessing the greatest conflict levels between jaguars and humans, including retaliatory jaguar deaths in response to livestock predation (Moreno et al., 2015), which may be the reason for the low detection level and the low index of relative abundance of jaguars compared to other felines.

During field work, we confirmed the presence of hunters in the areas near settlements and towns and a high presence of livestock activities in the north of the park. The lack of official presence, specifically park rangers, to monitor and protect the resources within protected areas makes it easier for activities like these to be carried out within these parks. Outside of the protected areas in the Panama Canal Basin, we find landscapes of patches of secondary forest, grasslands, monoculture plantations, and human settlements (Condit et al., 2001). One of the threats that would endanger this area of the park is the Quebrada Ancha and María Chiquita highway project, which crosses the Sierra Llorona area. This would jeopardize the buffer zones of the park through habitat loss and fragmentation and chemical contamination (van der Ree et al., 2015) along with vehicle collisions, one of the main causes of vertebrate mortality globally (Hill et al., 2019), and would act as an anthropogenic barrier dividing the biological corridor in two (Fuentes et al., 2023).

If measures such as the implementation of park guard posts are not enacted, many species could be affected, even if there is only a slight degradation of the habitat that affects the continuity of their distributions; this is particularly true in areas where there are narrow forest corridors that form a bottleneck effect and spaces that are critical for connectivity, such as the central zone and the Panama Canal Basin (Meyer et al., 2019). Local extirpations of species such as the jaguar, tapir, giant anteater, and white-lipped peccary have already occurred in places in the western regions of the country (Meyer et al., 2015). Many protected areas are not effective in supporting ungulate and carnivorous populations across Panama (Meyer et al., 2016).

This is the first comprehensive investigation carried out in these particular study areas, although in the late 2000s and early 2010s sampling via camera-trap methods was carried out in various sectors near these protected areas (Meyer et al., 2015, 2016).
We were able to observe the habitat use of emblematic mammal species and propose the establishment of fixed sampling stations, using Playita as a base camp for its qualities as a central location and fixed infrastructure and Folofa, Frío 1, and Frío 2 as monitoring points. Future studies at these sites should use these starting points to establish new transects to study the connectivity, behavior, and other aspects of these mammal communities over the long term, generating vital information for the protection and conservation of these species.

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