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ORIGINAL ARTICLE

Cordillera Chongón Colonche: a diversity hotspot for mammal conservation in western Ecuador

Cordillera Chongón Colonche: un punto caliente de diversidad para la conservación de mamíferos en el occidente de Ecuador

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ABSTRACT

The Cordillera Chongón Colonche, part of the Tumbes-Chocó-Magdalena biodiversity hotspot, is known for its abundance of endemic species. Our research was conducted in six protected areas, including mature and secondary forests. We utilized a grid of camera traps spaced at an

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average distance of 1.2 km, totaling 8819 camera-days. The data yielded 5413 independent events which recorded 29 species of mammals, including 23 native and six introduced species. Based on the documented diversity, conservation status of native mammals, and anthropogenic pressures, we propose the Cordillera Chongón Colonche as a priority area for mammal conservation in western Ecuador. This study provides updated information on mammal presence in the area and represents the first systematized camera-trap study along the mountain range. Furthermore, we strongly recommend the development of a comprehensive management plan for the mountain range. This plan would enhance existing conservation strategies in certain communal forests while also facilitating the reconnection of the mountain range with the Chocó Region. To achieve this, we advocate for the implementation of participatory projects involving local communities, decentralized autonomous provincial and cantonal governments, and non-profit organizations actively working in the area. This collaborative approach would create synergies, fostering more effective and sustainable conservation efforts.

Keywords: camera traps, communal forests, connectivity, dry forest, Guayas, jaguar, Manabí, puma, Santa Elena.

RESUMEN

La cordillera Chongón Colonche forma parte del *hotspot* de biodiversidad Tumbes-Chocó-Magdalena debido a la alta concentración de especies endémicas. El estudio se realizó en dos tipos de hábitat: bosque maduro y bosque secundario, en un total de seis bosques protegidos dentro de la cordillera. Utilizamos datos obtenidos a partir de una cuadrícula de cámaras trampa con una distancia media de 1,2 km entre cámaras. Obtuvimos un total de 8819 cámaras trampa/día y registramos 5413 eventos independientes de 29 especies de mamíferos, 23 nativas y seis introducidas. En base a la diversidad registrada, estado de conservación de los mamíferos nativos y presiones antropogénicas existentes, proponemos a la cordillera Chongón Colonche como un área prioritaria para la conservación de mamíferos en el occidente de Ecuador; proporcionamos información actualizada sobre su presencia al ser el primer estudio sistematizado con cámaras trampa a esta parte del país. Además, recomendamos la elaboración de un plan de manejo para la cordillera que ayude a mejorar las estrategias de conservación ya existentes y formar un corredor con el Chocó; también es necesario que se implementen proyectos participativos entre comunidades, gobiernos autónomos descentralizados provincial y cantonal y organizaciones sin fines de lucro que trabajan en la cordillera para generar sinergia.

Palabras clave: bosque seco, bosques comunitarios, cámaras trampa, conectividad, Guayas, jaguar, Manabí, puma, Santa Elena.

INTRODUCTION

In South America, there are two hotspots characterized by the highest number of threatened species and significant anthropogenic impacts: the Atlantic Forest in Brazil and the Tumbes-Chocó-Magdalena along the Pacific coasts of Colombia, Ecuador, and Peru (Myers et al., 2000). The latter qualifies as a hotspot due to its high concentration of endemic species and threat of habitat loss (Myers et al., 2000). Previous research estimated that more than 70% of the original primary vegetation is already deforested on the Ecuadorian coast (Dodson & Gentry, 1991), the first approximation attempted; however, 30 years have passed since that publication with no update as to the total vegetation loss. However, there are current data regarding deforestation of the tropical dry forest that characterizes the Cordillera Chongón Colonche. This forest represents the most-affected ecosystem from 1990 to 2018, during which 27% of the original remaining area was subject to an annual deforestation rate of 1.12%, as tropical dry forest fragmentation increased in western Ecuador (Rivas et al., 2021). Forest conversion represented one of the main causes of fragmentation and biodiversity loss (Haddad et al., 2015; Pfeifer et al., 2017). Because of these elevated rates of deforestation and fragmentation, the

rainforest and seasonal dry forest ecosystems of western Ecuador are classified as Critically Endangered according to the IUCN Red List of Ecosystems (Ferrer-Paris et al., 2019).

The Cordillera Chongón Colonche extends across the provinces of Guayas, Santa Elena, and Manabí within the Tumbes-Chocó-Magdalena biodiversity hotspot, characterized by rainforest in the upper part of the mountain range and dry forest towards the southern slopes; additionally, its climate favors the presence of a great diversity of mammals and other taxonomic groups that play important roles in the preservation of these ecosystems (Krabbe, 2020). Since mammals are involved in a large number of ecological processes within the ecosystems they inhabit, they represent a crucial taxonomic group for conservation, and the presence of certain species may be indicative of habitat quality (González-Christen, 2010).

The mammalian fauna of Ecuador is threatened by habitat loss and fragmentation; the introduction of exotic species and indiscriminate hunting have also reduced wild mammal populations (Tirira, 2001, 2021). Additionally, on the Ecuadorian coast, agriculture represents a significant threat (Rivas et al., 2021). These problems have been exacerbated over the last two decades, during which a decline in Ecuador's mammal populations has been observed as a result of the hydrocarbon and mining projects that have received governmental approval (Barros-Diaz & Molina-Moreira, 2021).

In order to propose, promote, and implement adequate conservation management strategies in the forests inhabited by mammal species on the Ecuadorian coast, data regarding their presence and the current status of their populations in the dry forest, mangrove, cloud forest, and rainforest ecosystems is required (Barros-Diaz & Molina-Moreira, 2021). Most published studies on mammals in southwestern Ecuador have been carried out in well-conserved forests located in national protected areas, such as Parque Nacional Machalilla (Cervera et al., 2016), Refugio de Vida Silvestre Marino Costero Pacoche (Lizcano et al., 2016), and Reserva Ecológica Arenillas (Espinosa et al., 2016). However, there is a knowledge gap regarding the presence of mammals in fragmented forests outside public protected areas (Solórzano et al., 2021).

Camera traps are valuable tools that maximize recording opportunities for medium and large mammals, particularly cryptic species. They offer researchers an efficient and relatively inexpensive means of studying these animals while minimizing direct human intervention, thus preserving their natural behavior (Rovero et al., 2014; Tobler et al., 2008). The strategic placement of camera traps allows for the detection of species presence, abundance, behavior, and movement in their natural habitats. Their utility is evident in their increasingly frequent use along the Ecuadorian coast in recent years (Bravo-Salinas et al., 2021; Cervera et al., 2016; Espinosa et al., 2016; Hurtado & Pacheco, 2015; Lizcano et al., 2016; Salas et al., 2022).

Having established the Cordillera Chongón Colonche as possessing special importance for conservation, since it encompasses remnants of an endangered tropical dry forest ecosystem, and in order to fill the research gaps regarding medium and large mammals, we placed camera traps along the Cordillera Chongón Colonche with the purpose of understanding distributional patterns and the relative abundance of medium and large mammals. Furthermore, we report new records and provide information that will aid decision-makers in developing biodiversity management strategies.

METHODOLOGY

Study area

The Cordillera Chongón Colonche is a mountainous formation that extends northwest from the city of Guayaquil, covering an area 100 km long and 10 to 20 km wide (Figure 1; Ayerza, 2019). It passes through the provinces of Guayas, Santa Elena, and Manabí, reaching the southern limit of the Parque Nacional Machalilla, which is on the coast bordering the Pacific Ocean (Bonifaz & Cornejo, 2004). Its physiography shows the predominance of steep slopes with inclinations exceeding 70%, that terminate in small, isolated valleys within the mountain range (Ayerza, 2019). It is situated

in the Southwestern zoogeographical zone (Piso Zoogeográfico Suroccidental; Tirira, 2017) and encompasses various ecosystems (MAE, 2013): herbazal lacustre inundado del Pacífico ecuatorial [flooded lacustrine grassland of the Equatorial Pacific], bosque estacional siempreverde de piedemonte de la cordillera costera del Pacífico ecuatorial [low montane seasonal evergreen forest of the Equatorial Pacific Coastal Range], bosque semicaducifolio de la cordillera costera del Pacífico ecuatorial [semi-deciduous forest of the Equatorial Pacific Coastal Range], and bosque caducifolio de la cordillera costera del Pacífico ecuatorial [deciduous forest of the Equatorial Pacific Coastal Range].

Field survey

For the study of medium and large mammals, we obtained data from camera traps installed in private and communal forests; we selected six study areas (Figure 1, Table 1). The field phase included 34 months of study between 55 sampling stations. To guarantee the spatial independence of the records, we placed the cameras at a minimum average distance of 1.2 km. Each station consisted of a Bushnell Trophy camera that we installed 30 cm above the ground and programmed to take three photos of each detection; we considered events to be independent if they were separated by at least one hour per station (Barros-Diaz & Vega-Guarderas, 2021). We checked camera traps 15 days after installation and then once every month following.

Data analysis

We used the camtrap R package (Niedballa et al., 2016) in RStudio (R Core Team, 2023) to organize and extract metadata from camera-trap photos in R software (R Core Team, 2023) and generated species rarefaction curves

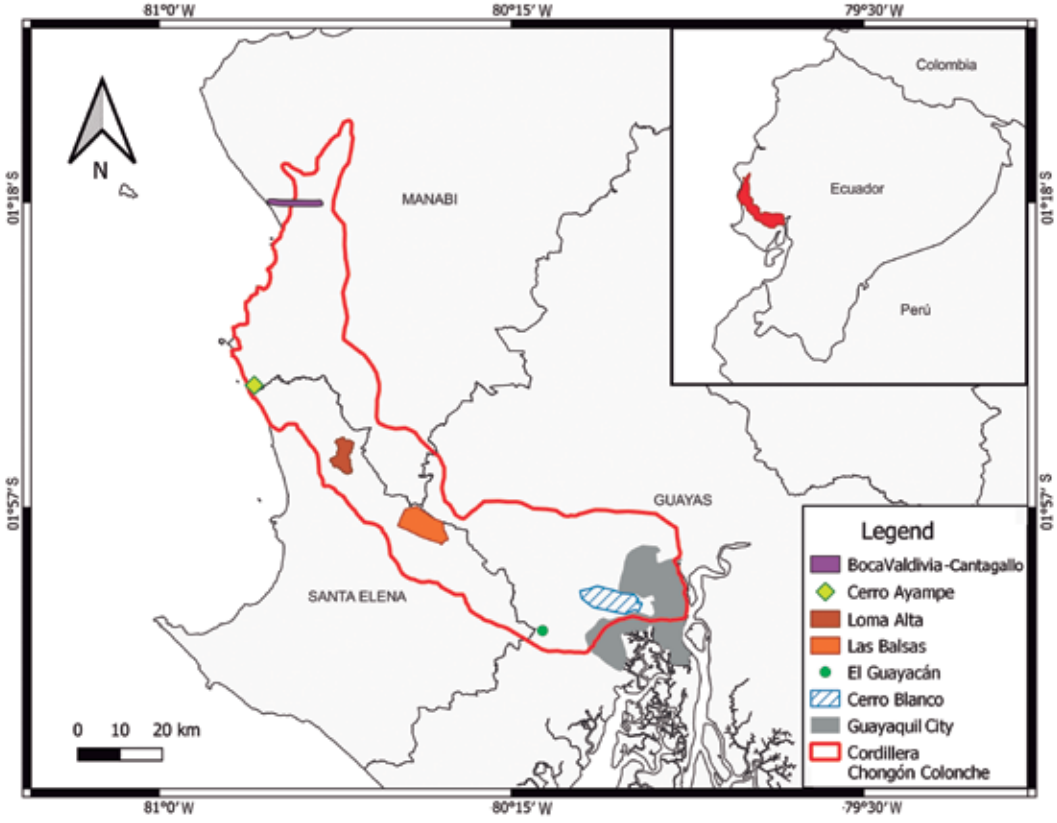

FIGURE 1. Cordillera Chongón Colonche and the studied areas.

Table 1. Study areas within the Cordillera Chongón Colonche, coastal Ecuador.

Study area	Forest type	# Cam trap	Sampling effort (camera-days)	Study dates	Protection level	Area (ha)	Reference coordinates
Reserva Comunal Ecológica Loma Alta	Tumbesian dry forest and rainforest	8	1585	January to August 2020	Protected area	2100	01°50'26" S, 80°36'29" W
Bosque Comunal Las Balsas	Tumbesian dry forest	16	1680	October 2020 to February 2021	Protected area	5000	01°59'26" S, 80°26'16" W
Bosque Protetor Cerro Blanco	Tumbesian dry forest	24	4615	September 2021 to July 2022	Protected area	6078	02°08'48" S, 80°02'25" W
BocaValdivia-Cantagallo	Tumbesian dry forest and rainforest	3	367	February to May 2022	Protected area	500	01°18'09" S, 80°41'04" W
Cerro Ayampe	Rainforest	2	298	November 2021 to March 2022	Non-protected area	50	01°41'23" S, 80°47'49" W
Área Protegida Nacional de Recreación Bosque El Guayacán	Tumbesian dry forest	2	274	March to July 2022	Protected area	78	02°12'44" S, 80°10'59" W
-	Total	55	8819	January 2020 to July 2022	-	-	-

using camera-trap abundance estimates (Chao et al., 2016) and the iNext package in RStudio to calculate Hill diversity (Hill, 1973). Due to our varied sampling intensity at each location, we standardized species richness by sampling completeness using sampling coverage curves rather than using sample size for comparison (Chao & Jost, 2012). In addition to recording native mammal species, the cameras recorded introduced mammals, but these were not included in the analyses. The taxonomic identification followed the nomenclature of Tirira et al. (2023).

Although we only analyze camera-trap records in this article, due to the critical conservation status of the jaguar (*Panthera onca*) and puma (*Puma concolor*), we include two records obtained from their presence in the Cordillera as additional data; however, these were not included in the camera-trap analyses.

The conservation categories of the native mammal species that we analyzed were taken from IUCN (2023) for global categories and Tirira (2021) for Ecuadorian categories.

RESULTS

We documented a total of 29 mammal species, 23 native species and six introduced, after conducting camera-trap observations over a combined 8819 nights and recording 5413 independent events (Table 2). With reference to the relationship between the number of species

Table 2. Mammal species recorded by camera traps and independent events in the Cordillera Chongón Colonche: 1. Reserva Ecológica Comunal Loma Alta; 2. Bosque Comunal Las Balsas; 3. Bosque Protector Cerro Blanco; 4. BocaValdivia-Cantagallo; 5. Cerro Ayampe; 6. Área Protegida Nacional de Recreación El Guayacán.

Species	Localities							IUCN category	
	1	2	3	4	5	6	Total	Global	Ecuador
Native species									
Didelphimorphia									
Didelphis marsupialis	18	26	4	15	6	21	90	LC	LC
Philander melanurus	36	-	-	-	-	-	36	NE	LC
Cingulata									
Dasypus novemcinctus	52	42	21	2	4	5	126	LC	LC
Pilosa									
Tamandua mexicana	25	41	27	2	-	4	99	LC	EN
Primates									
Cebus aequatorialis	1	3	6	-	-	-	10	CR	CR
Alouatta palliata	1	1	2	-	-	-	4	VU	CR
Rodentia									
Simosciurus stramineus	-	-	9	-	-	-	9	LC	DD
Syntheosciurus granatensis	66	2	75	-	2	-	145	LC	LC
Dasyprocta punctata	687	575	489	74	46	41	1912	LC	LC
Cuniculus paca	215	109	84	2	4	5	419	LC	NT
Lagomorpha									
Sylvilagus daulensis	63	23	39	7	2	11	145	NE	NT
Carnivora									
Herpailurus yagouaroundi	-	6	4	-	-	3	13	LC	VU[1]
Leopardus pardalis	45	98	156	15	10	21	345	LC	VU[1]
Leopardus wiedii	20	5	13	-	-	-	38	NT	VU[1]
Lycalopex sechurae	-	-	-	10	-	-	10	NT	EN
Nasua nasua	18	31	48	-	-	6	103	LC	VU[1]
Procyon cancrivorus	181	42	81	6	9	16	335	LC	NT[1]
Lontra longicaudis	-	-	-	-	-	1	1	NT	EN[1]
Eira barbara	24	84	84	7	-	6	205	LC	LC
Galictis vittata	1	3	3	1	1	1	10	LC	DD
Artiodactyla									
Dicotyles tajacu	105	116	78	-	-	9	308	LC	VU[1]
Mazama gualea	39	25	19	-	-	-	83	NE	EN
Odocoileus virginianus	-	249	429	-	-	18	696	LC	EN[1]
Total records native species	1597	1481	1671	141	84	168	5142	-	-
Total native species	18	19	20	11	9	15	23	-	-

Table 2. Mammal species recorded by camera traps and independent events in the Cordillera Chongón Colonche. Continued.

Species	Localities							IUCN category	
	1	2	3	4	5	6	Total	Global	Ecuador
Introduced species									
Carnivora									
Felis silvestris	-	-	1	-	-	-	1	NE	NA
Canis familiaris	30	19	56	9	10	5	129	NE	NA
Perissodactyla									
Equus asinus	15	1	-	-	-	-	16	NE	NA
Equus caballus	18	17	15	-	-	2	52	NE	NA
Artiodactyla									
Sus scrofa	-	1	-	-	-	-	1	NE	NA
Bos Taurus	40	9	21	2	-	-	72	NE	NA
Total records introduced species	103	47	93	11	10	7	271	-	-
Total introduced species	4	5	4	2	1	2	6	-	-
Total species	22	24	24	13	10	17	29	-	-
Total records	1700	1528	1764	152	94	175	5413	-	-
Sampling effort (camera-days)	1585	1680	4615	367	298	274	8819	-	-

IUCN and Ecuador categories: CR = Critically Endangered; EN = Endangered; DD = Data Deficient; LC = Least Concern; NA = Not Applicable; NE = Not Evaluated; NT = Near Threatened; VU = Vulnerable.
[1] Category corresponding to the Coast of Ecuador (subspecies or populations) (Tirira, 2021).

recorded and the sampling effort per locality, in Bosque Protector Cerro Blanco we carried out a sampling effort almost three times greater than in Reserva Loma Alta and Bosque Las Balsas; a total of 20 native species were recorded. This represents two more species than the number identified in Loma Alta and one more than the number documented in Las Balsas (Table 2). Regarding the number of records by locality, species and sampling effort, Cerro Blanco had the lowest number of records in proportion to its sampling effort. In contrast, Loma Alta and Las Balsas showed an almost equal relationship between number of records and sampling effort. In addition, when considering the smaller localities sampled, El Guayacán stands out, which exhibits a lower sampling effort compared to Cerro Ayampe and BocaValdivia-Cantagallo but a higher diversity (Table 2).

The accumulation curves (Figure 2, top) indicate that the majority of the studied forests reached the asymptote, except for Reserva Ecológica Comunal Loma Alta. Species accumulation curves revealed that three localities exhibited the highest species richness: 20 species in Bosque Protector Cerro Blanco, 19 in Bosque Comunal Las Balsas, and 18 in Reserva Ecológica Comunal Loma Alta (Figure 2, top). The sampling coverage curves demonstrated that we recorded at least 95% of mammal species richness in each locality, demonstrating the thoroughness of our sampling effort (Figure 2, bottom).

The five most common and abundant species throughout the study were *Dasyprocta punctata* (n = 1912), *Odocoileus virginianus* (n = 696), *Cuniculus paca* (n = 419), *Leopardus pardalis* (n = 345), and *Procyon cancrivorus* (n = 335). In terms of conservation, we recorded 12 species native to western Ecuador that are considered species of concern per the national Red List: Critically Endangered, *Cebus aequatoria-*

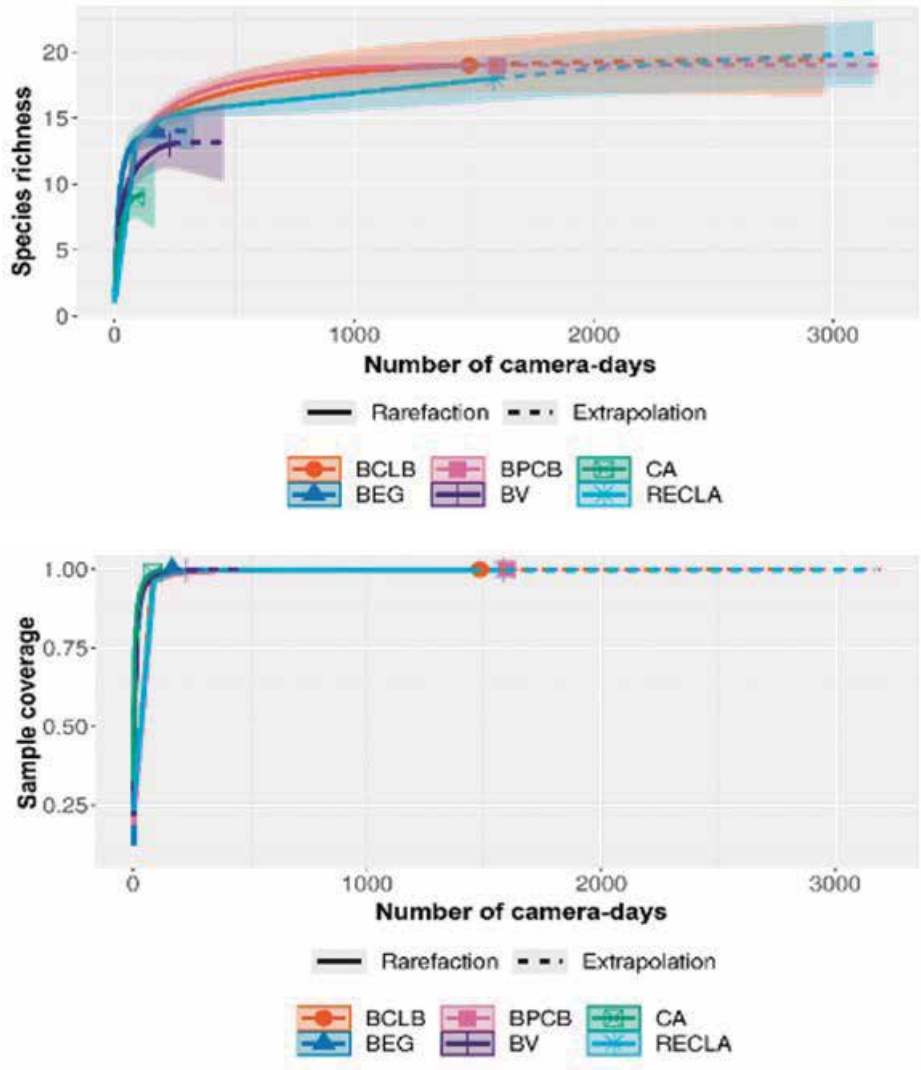

FIGURE 2. A. Species accumulation curves, and B. Sample completeness curves in Cordillera Chongón Colonche. Localities studied: BCLB (Bosque Comunal Las Balsas), BEG (Área Protegida Nacional de Recreación El Guayacán), BPCB (Bosque Protector Cerro Blanco), BV (BocaValdivia-Cantagallo), CA (Cerro Ayampe), and RECLA (Reserva Ecológica Comunal Loma Alta).

lis (n = 10), and *Alouatta palliata* (4); Endangered, *Odocoileus virginianus* (696), *Tamandua mexicana* (99), *Mazama gualea* (83), *Lycalopex sechurae* (10), and *Lontra longicaudis* (1), this latter representing a new record for the mountain range (Figure 3); Vulnerable, *Leopardus pardalis* (345), *Dicotyles tajacu* (308), *Nasua nasua* (103), *Leopardus wiedii* (38), and *Herpailurus yagouaroundi* (13); in addition, Data Deficient species included *Galictis vittata* (n = 10) (Figure 4) and the Guayaquil squirrel (*Simosciurus stramineus*, n = 9). Bosque Protector Cerro Blanco and Bosque Comunal Las Balsas were the localities with the highest number of species reported within a category of concern (CR, EN, and VU), with ten species each.

We also observed the presence of the two species of monkey at ground level (Figure 5).

Figure 3. Noteworthy records in the Cordillera Chongón Colonche: Above, Neotropical otter (*Lontra longicaudis*), reported from the Área Protegida Nacional de Recreación El Guayacán; and below, dark-tailed four-eyed opossum (*Philander melanurus*), reported from Reserva Comunal Loma Alta.

Figure 4. Some examples of mammals recorded in the Cordillera Chongón Colonche: Top left, *Mazama gualea*; top right, *Herpailurus yagouaroundi*; center left, *Leopardus wiedii*; center right: *Galictis vittata*; and bottom: *Lycalopex sechurae*.

Figure 5. Presence of *Cebus aequatorialis* (top) and *Alouatta palliata* (below) at ground level.

In the case of the Ecuadorian white-fronted capuchin (*Cebus aequatorialis*), its presence at ground level was associated with camera traps positioned within or in close proximity to water bodies, resulting in 10 independent events. Regarding the mantled howler monkey (*Alouatta palliata*), we recorded a total of four independent ground-level movements across three localities (Reserva Loma Alta, Bosque Las Balsas, and Bosque Protector Cerro Blanco).

The rarest species recorded by locality, excluding monkey and squirrel records, were: Loma Alta: *Nasua nasua* (n = 18) and *Galictis vittata* (1); Las Balsas: *Leopardus wiedii* (5) and *Galictis vittata* (3); Cerro Blanco, *Herpailurus yagouaroundi* (4) and *Galictis vittata* (3); BocaValdivia-Cantagallo, *Cuniculus paca* (2), *Dasypus novemcinctus* (2), *Tamandua mexicana* (2), and *Galictis vittata* (1); Cerro Ayampe, *Dasypus novemcinctus* (4) and *Galictis vittata* (1); and El Guayacán, *Lontra longicaudis* (1) and *Galictis vittata* (1).

Furthermore, in addition to the camera trap events, we recorded two noteworthy findings. The first was the presence of *Panthera onca* in Bosque Comunal Las Balsas in December of 2020. This was the sole record of a jaguar in the mountain range during nearly three years of monitoring. The second was a record of a female *Odocoileus virginianus* that fell prey to a *Puma concolor* in October of 2020 in Bosque Protector Cerro Blanco (Figure 6).

DISCUSSION

Our study provides updated information regarding medium and large mammal species present in the Cordillera Chongón Colonche in southwestern Ecuador. This investigation represents the first systematic camera-trap study conducted for the mountain range outside of Ecuador's national protected areas, laying the groundwork for future conservation projects in western Ecuador. In total, 33 native mammal species were reported using camera traps and direct or indirect observation (Appendix 1). Our study focuses on 23 of these species recorded using camera traps and identifies two additional species through indirect records, including a new record for the Cordillera, the *Lontra longicaudis*.

The localities with the highest species richness (Cerro Blanco and Las Balsas with 19

Figure 6. Predatory attack on a adult female of white-tailed deer (*Odocoileus virginianus*) in Bosque Protector Cerro Blanco. From the marks on the neck, the predator is presumed to be a puma (*Puma concolor*) (coordinates 02°08'08" S and 80°05'26" W). Photos by ranger Armando Manzaba.

records, and Loma Alta with 18) have a greater number of reports compared to other camera-trap studies in western Ecuador (Cervera et al., 2016; Espinosa et al., 2016; Hurtado & Pacheco, 2015; Lizcano et al., 2016; Salas et al., 2022). Although we observed species that were common in those studies, such as *Dasyprocta punctata*, *Dicotyles tajacu*, *Leopardus pardalis*, and *Odocoileus virginianus*, our study stands out as the first comprehensive camera-trap investigation for all the study areas except Cerro Blanco (Salas et al., 2022), where results were similar. However, our study revealed three additional species (*Leopardus wiedii*, *Mazama gualea*, and *Simosciurus stramineus*), potentially attributable to our utilization of eight more camera traps, which enabled extensive sampling efforts and coverage of previously unexplored areas.

Another investigation that yielded similar data to ours monitored 11 locations in northern Peru and southern Ecuador (García-Olaechea et al., 2021). This study encompassed 3839 camera-trap days and documented 27 mammal species, 20 native and seven introduced (García-Olaechea et al., 2021). In comparison, our study encompassed 8819 camera-trap days and reported 29 mammal species, including 23 native and six introduced. Our extensive sampling effort yielded a higher diversity in comparison to the aforementioned studies conducted along the Ecuadorian coast and northern Peru. Additionally, we recorded species such as *Leopardus wiedii*, *Lontra longicaudis*, *Philander melanurus*, and *Syntheosciurus granatensis*.

Researchers have determined that there is no relationship between detection rate and the number of cameras within a survey area, suggesting that a more closely spaced approach between cameras may be as effective as a less closely spaced approach for obtaining accurate wildlife data (Kays et al., 2020). This finding supports our choice of systematically spaced survey design, as it allowed us to have a more accurate representation of species diversity, their movement patterns, and areas of higher diversity; also, spacing the cameras further apart reduces the number of cameras needed, thereby reducing the cost of the project.

Another suggested practice (proposed by Kays et al., 2020) is to leave cameras running at a site for two weeks and then move them, as this is most efficient for detecting new species. However, it takes three to four weeks to get accurate estimates of the local detection rate, and they did not observe an increase in accuracy after one month. This trend was not observed during our study, as records were sparse during the first two weeks, likely due to avoidance of the area by mammal species because of the odors we left behind. In addition, placing cameras in random locations tends to result in significantly lower event capture rates than placing them systematically on animal trails and logs (Cusack et al., 2015).

The systematic approach and spacing used in our study are also consistent with a study in Pakistan on snow leopard density, which found that a more diffuse spacing of cameras and the resulting increase in spatial coverage led to the detection of more individuals and more species, generating estimates of density and spatial use that were more consistent with expectations for the region than if cameras were placed closer together (Nawaz et al., 2021). Therefore, we conclude that the methodology employed in this study was adequate for our purpose. The use of a more widely spaced sampling design and time-based camera configuration may allow for a better understanding of spatial variation in site-specific detection and capture rates (Kays et al., 2020). These proposals should be evaluated to improve future camera-trap projects that seek to apply the systematic and more widely spaced method (2 km grid) to assess species diversity, movement patterns, and areas of higher diversity while decreasing the cost of the projects. In our case, we obtained remarkable records of *Mazama gualea* (83), *Leopardus wiedii* (38), *Philander melanurus* (36), *Herpailurus yagouaroundi* (13), *Lycalopex sechurae* (10), *Galictis vittata* (10), and *Lontra longicaudis* (1).

Two species reported are globally threatened according to the IUCN (2023): the two species of monkeys reported for southwestern Ecuador (Tirira, 2017), *Cebus aequatorialis* and *Alouatta palliata* (Figure 5), are listed as Critically Endangered and Vulnerable, respectively. Both are classified as Critically Endangered according to the *Libro Rojo de los mamíferos del Ecuador* [*Red Book of mammals of Ecuador*] (Tirira, 2021). This analysis highlights the importance of considering the global, national, and local context when assessing the conservation status of biodiversity in the Cordillera and underlines the need to implement conservation strategies adapted to the specific realities of the region. A clear example of this is the Cordillera Chongón Colonche, where we report 10 species in threatened categories: two Critically Endangered, five Endangered, and five Vulnerable species, further highlighting the importance of improving conservation actions in the Cordillera, which functions as a refuge for these species.

This study significantly contributes to our understanding of the conservation status of the Cordillera Chongón Colonche and southwestern Ecuador. We documented several records of *Galictis vittata* in nearly all study areas across the entire mountain range, particularly in well-conserved forest regions. However, our findings also shed light on the main threats facing mammal populations in the area. Deforestation, fragmentation, the introduction of exotic species, indiscriminate hunting, trafficking, and illegal possession of these species (Tirira, 2021) all pose significant challenges. Moreover, the expansion of agriculture and livestock industries, extractive activities, roadkill incidents, and environmental noise (Burneo et al., 2015; Tirira, 2011; Tirira et al., 2018) further exacerbates the loss of biodiversity in the region.

Understanding these threats and their impacts on local mammal populations is crucial for developing effective conservation strategies. By addressing these challenges, we can work towards safeguarding the unique and diverse wildlife of the Cordillera Chongón Colonche and promoting the overall ecological health of southwestern Ecuador. Although our sampling effort was not equal in all study areas, and low in some forests, sampling completeness curves show that most of the mammal community in each area was sampled (Figure 2). The species accumulation curves show that we were close to reaching the asymptote in the large forests (Bosque Protector Cerro Blanco, Bosque Comunal Las Balsas, and Reserva Ecológica Comunal Loma Alta), while we did reach the asymptote in

the small forests (Cerro Ayampe, BocaValdivia-Cantagallo, and El Guayacán). This may be due to the fact that in the large forests, monitoring was maintained long enough to sample also during the rainy season, which is when records increased. Furthermore, the fact that we recorded cryptic species such as the margay (*Leopardus wiedii*), the greater grison (*Galictis vittata*), the Gualea red brocket deer (*Mazama gualea*), the jaguarundi (*Herpailurus yagouaroundi*), and the Sechuran fox (*Lycalopex sechurae*) (Figure 4) shows that we had rigorous sampling, as these species have been poorly reported by other authors for the Cordillera (Albuja 1997; Barros-Diaz et al., 2018; Lizcano et al., 2016; Parker & Carr, 1992; Salas et al., 2022).

In a noteworthy discovery, we obtained the first record of the Neotropical otter (*Lontra longicaudis*) for the Cordillera Chongón Colonche (Figure 3). This finding expands its distribution within the country, as it was previously recorded based on the distribution proposed by the IUCN (Rheingantz et al., 2021) but not by the Ecuadorian distribution (Tirira, 2017). Its habitat is threatened by mining activities, pollution, cattle ranching, urban expansion, and the hydroelectric network across its range. Over the last 27 years, these threats have intensified, potentially leading to local extinctions (Rheingantz et al., 2021).

The situation may be critical for otter populations in western Ecuador, although further studies are required to assess the specific anthropogenic impacts affecting them along the coast. Despite the lack of critical data on their biology, demography, and behavior in many areas, a comprehensive assessment of the effects of various anthropogenic threats on this species is still lacking (Rheingantz et al., 2021). Research and conservation projects should be considered to address these ecological aspects in western Ecuador. The involvement of local, parish, and communal governments and organizations would increase the effectiveness of these projects. Anecdotally, villagers in the Loma Alta and Las Balsas communes have reported sighting otters fishing in swollen rivers during the rainy season, an observation that has become rarer over time and was not recorded by our camera traps.

Concerning *Philander melanurus*, this species has been classified as Least Concern in the Ecuadorian *Red Book* (Tirira, 2021) but has not been evaluated by the IUCN (2023). The presence of the species in Reserva Comunal Ecológica Loma Alta serves as a strong indication that it still inhabits the Cordillera Chongón Colonche. However, our observations suggest that the species exhibits a distinct preference for areas with permanent bodies of water, such as those found in Loma Alta, where we recorded 36 independent events. Conversely, a recently published study using camera traps in Bosque Protector Cerro Blanco did not report its presence (Salas et al., 2022). Nevertheless, the species has been documented in the Santay Island National Recreation Area (Torres-Domínguez et al., 2022), a locality in close proximity to Cerro Blanco. This discrepancy may arise from the genus' preference for large and perennial bodies of water, which are characteristic of Santay Island but not found in the other study areas we sampled.

In the case of the records of *Cebus aequatorialis* and *Alouatta palliata*, we report their presence at ground level only in three large forests (Bosque Protector Cerro Blanco, Bosque Comunal Las Balsas, and Reserva Ecológica Comunal Loma Alta). The photos of *C. aequatorialis* showed the species descending to bodies of water and drinking, while the photos of *A. palliata* showed each individual passing by but exhibiting no other activity. However, one *A. palliata* individual in Reserva Ecológica Comunal Loma Alta passed through one of the chambers with an injured front leg, which could have been the reason for its descent to the ground. The presence at ground level of both species is not rare, since they are known to descend to drink water, especially in the case of *C. aequatorialis*.

In the context of the last hypothesis, we were able to corroborate its validity through an isolated event we witnessed in the Bosque Protector Cerro Blanco on 19 October 2021, at 14:28 hours. Unfortunately, we were unable to capture this event on video, but we clearly observed *Eira barbara* engaging in hunting howler monkeys. During the incident, we noticed that this mustelid species was moving nimbly among the branches of the trees, which were on average 20

m high. It was chasing a group of howler monkeys, who, alarmed, emitted their characteristic cries as they tried to escape. Our unexpected presence interrupted the chase, as the *Eira barbara* retreated when it came across us. However, we were able to ascertain that its target was a young monkey that had strayed from the group. This group of howler monkeys consisted of more than 20 individuals; interestingly, this was the same group where the presence of a full-body leucistic monkey had previously been documented (Barros-Diaz et al., 2022). Notably, the leucistic monkey chose to climb to the top of the trees and positioned itself against the light, which hindered our ability to distinguish it clearly. This incident aligns with what has previously been recorded regarding the behavior of *Eira barbara*, specifically the predation of a juvenile marmoset (*Callithrix* sp.) and a young sloth (*Bradypus tridactylus*) (Bezerra et al., 2009), both arboreal species. Based on this episode, we hypothesized that other species such as *Leopardus pardalis* and *L. wiedii* might also attempt to prey on these species, especially the latter, given its marked arboreal behavior.

We reported the presence of introduced mammals; their presence in the Cordillera is of concern due to their negative impacts on native species (da Rosa et al., 2017; Pudyatmoko, 2017; Zapata Ríos & Branch, 2018). The presence of the domestic dog (*Canis familiaris*) is the most concerning because it was present in all study areas; another species of concern was the domestic cat (*Felis silvestris*). Both species can compete for resources (space, time, and prey) with native carnivores (Medina et al., 2011; Vanak & Gompper, 2009); additionally, due to close phylogenetic kinship, they can transmit several diseases to wild mammals (da Rosa et al., 2017). Therefore, the presence of both carnivores in the mountain range implies a great risk for the conservation of native mammals and other taxonomic groups in the area. Continued camera trap monitoring is recommended, as it will aid in discovering their current distribution, allowing for biodiversity preservation measures to be proposed. Other introduced species recorded in several localities included *Bos taurus*, *Equus asinus*, and *E. caballus*, which can severely modify native vegetation by browsing, crushing, and trampling, exposing the forest floor, and eliminating almost all the young trees, shrubs, and ferns until only a few unappetizing or browsing-resistant species remain (CABI, 2007). In the case of Sus scrofa, this was probably a single isolated event.

Although *Panthera onca* and *Puma concolor* were not recorded by camera traps, we did manage to record *P. onca* via footprints in Bosque Comunal Las Balsas, in December 2020 (coordinates 01°58’55.1” S, 80°28’38.9” W). However, this event was the only occurrence documented in the range during almost three years of continuous monitoring. Despite the last reported *P. onca* sighting in the range being on July 25, 2011, in Cerro Blanco (Saavedra Mendoza et al., 2017), our record illustrates the critical situation of these species in the area. It appears that these records correspond to some of the last surviving *P. onca* individuals in southwestern Ecuador.

Regarding *Puma concolor*, we obtained a record of possible predation of *Odocoileus virginianus* in Bosque Protector Cerro Blanco, in October 2020 (Figure 6); we determined *P. concolor* to be the most likely predator, ruling out domestic dog and jaguar (G. Zapata Ríos, pers. comm., August 27, 2023). We also used guidance from Narváez and Zapata Ríos (2016) to evaluate other possible predators, but we dismissed these possibilities. The dead deer was found and photographed by park rangers Benito Choez and Armando Manzaba, who mention that the event occurred near the Jaguar Hut at 04:00 hours, when they heard a deer screaming desperately. Only the body was found upon inspection later that morning (pers. comm., August 27, 2023). The only record of the possible presence of *P. concolor* in the Cordillera Chongon Colonche was a footprint reported by Barros-Diaz et al. (2018), but he was not able to conclude decisively that it was from a puma because of the size of the footprint. However, because of the shape of the pad and toes, he did not rule out that it was a juvenile puma. It was suggested that it could be a wandreing young male that was passing through but does not inhabit the area (G. Zapata Ríos, pers. comm., August 27, 2023). However, it is interesting to note that despite the fact that *P. concolor* is a generalist species, no direct records of its presence in

western of Cordillera Chongón Colonche have been documented (Tirira, 2023).

The diversity of mammals documented in the Cordillera Chongón Colonche is notably high compared to other studies in western Ecuador (Barros-Diaz et al., 2018; Barros-Diaz et al., 2021; Cervera et al., 2016; Espinosa et al., 2016; Hurtado & Pacheco, 2015; Lizcano et al., 2016; Salas et al., 2022). Given the cryptic behavior and wide spatial requirements of many species reported, such as *Mazama gualea*, *Lontra longicaudis*, *Leopardus wiedii*, and *Panthera onca*, obtaining these records presented challenges that limited the number gathered. This underscores the significance of the Cordillera Chongón Colonche as a potential Biosphere Reserve. Moreover, the mountain range plays a crucial role in providing essential ecosystem services to various communities and cities in the region, including water supply, oxygen production, climate regulation, pollination, vegetation preservation, and erosion prevention, among others. Given these ecological values, it is imperative to take immediate conservation actions to safeguard the well-being of the communities and the native mammal species, some of which are critically endangered both globally and nationally.

This project will significantly contribute to the knowledge of mammalogy in western Ecuador and South America. The comprehensive inventory of these species will serve as a foundation for enhancing future management plans and implementing conservation measures, particularly for species in high-threat categories. Furthermore, documenting the distribution of these species represents a crucial initial step towards conducting population density studies.

In light of our findings, it is essential that conservation and restoration efforts in the mountain range become a top priority for the authorities responsible for protecting biodiversity hotspots. Creating ecological corridors both within and outside the Cordillera Chongón Colonche will play a pivotal role in reestablishing a connection with the Chocó, offering genetic protection to mammal species present in western Ecuador. A clear example of this need is provided by *Alouatta palliata* populations in Bosque Protector Cerro Blanco, where leucistic individuals have been reported (Barros-Diaz et al., 2022).

However, achieving this objective requires concerted efforts involving inter-institutional participation from both the public and private sectors of the country. Integrating local communities into conservation efforts is imperative, fostering their involvement in protecting their forests through participatory activities like courses and workshops. Empowering community members to manage their natural resources effectively, promote their territories as eco-tourist destinations, and integrate environmental education into local schools are essential steps towards achieving sustainable conservation goals.

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Appendix 1

Mammal species recorded in the Cordillera Chongón Colonche, southwestern Ecuador

Species	Inventory references									Present study
	A	B	C	D	E	F	G	H	I	
Didelphimorphia										
Didelphidae										
Caluromys derbianus	●	-	-	-	-	-	-	-	-	-
Didelphis marsupialis	●	-	●	●	-	-	●	-	-	●
Marmosa simonsi	-	-	-	-	-	-	-	-	●	-
Philander melanurus	-	-	-	-	-	-	-	-	-	●
Cingulata										
Dasypodidae										
Dasypus novemcinctus	●	-	●	●		-	●	-	-	●
Pilosa										
Megalonychidae										
Choloepus hoffmanni	●	●	-	-	-	-	-	-	-	-
Cyclopedidae										
Cyclopes dorsalis	-	-	-	-	-	-	-	●	-	-
Myrmecophagidae										
Tamandua mexicana	●	●	●	●	●	-	●	-	-	●
Primates										
Cebidae										
Cebus aequatorialis	●	●	●	●	●	-	-	-	-	●
Atelidae										
Alouatta palliata	●	●	●	●	●	-	●	-	-	●
Rodentia										
Sciuridae										
Simosciurus stramineus	-	-	●	●	-	-	-	-	-	●
Syntheosciurus granatensis	-	●	-	-	-	-	-	-	-	●
Cricetidae										
Aegialomys baroni	-	-	-	-	-	-	-	-	●	-
Rhipidomys latimanus	-	-	-	-	-	-	-	-	●	-
Dasyproctidae										
Dasyprocta punctata	●	●	●	●	●	-	●	-	-	●
Cuniculidae										
Cuniculus paca	●	●	●	●	-	-	●	-	-	●
Echimyidae										
Proechimys decumanus	-	-	-	-	-	-	-	-	●	-
Lagomorpha										
Leporidae										
Sylvilagus daulensis	●	-	●	●	●	-	●	-	-	●

Appendix 1 (continued)

Species	Inventory references									Present study
	A	B	C	D	E	F	G	H	I	
Carnivora										
Felidae										
Herpailurus yagouaroundi	●	-	●	●	●	●	●	-	-	●
Leopardus pardalis	-	●	●	●	●	●	●	-	-	●
Leopardus wiedii	-	●	●	●	-	-	-	-	-	●
Puma concolor	-	-	-	-	-	●	-	-	-	●
Panthera onca	-	-	-	-	●	-	-	-	-	●
Canidae										
Lycalopex sechurae	-	●	-	-	-	-	-	-	-	●
Procyonidae										
Nasua nasua	-	●	●	-	●	-	●	-	-	●
Potos flavus	●	●	-	-	-	-	-	-	-	-
Procyon cancrivorus	●	●	●	●	●	●	●	-	-	●
Mustelidae										
Lontra longicaudis	-	-	-	-	-	-	-	-	-	●
Eira barbara	●	●	●	●	●	●	●	-	-	●
Galictis vittata	-	-	-	●	-	●	●	-	-	●
Artiodactyla										
Tayassuidae										
Dicotyles tajacu	●	-	●	-	●	-	●	-	-	●
Cervidae										
Mazama gualea	●	●	●	-	-	-	-	-	-	●
Odocoileus virginianus	●	●	●	●	●	-	●	-	-	●
Total species	**17**	**16**	**18**	**16**	**13**	**6**	**15**	**1**	**4**	**25**

Inventory references: **A.** Parque Nacional Machalilla (Parker & Carr, 1992); **B.** Parque Nacional Machalilla (Albuja, 1997); **C.** Parque Nacional Machalilla (Cervera et al., 2016); **D.** Refugio de Vida Silvestre Marina Pacoche (Lizcano et al., 2016); **E.** Bosque Protector Cerro Blanco (Saavedra et al., 2017); **F.** Bosque Protector Cerro Blanco (Barros-Diaz et al., 2018); **G.** Bosque Protector Cerro Blanco (Salas et al., 2022); **H.** Bosque Protector Cerro Blanco (Barros-Diaz et al., 2021); **I.** Bosque Protector Cerro Blanco (Bravo-Salinas et al., 2021).