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Cover: Long-tailed Weasel (*Neogale frenata*)
in the Reserva Geobotánica Pululahua.
Photograph by Nelson Gustavo Monteros.

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EDITORIAL

Five years on the road

We have reached our fifth edition, marking five years of disseminating information about the mammals of Ecuador. The cover of this edition portrays the long-tailed weasel (*Neogale frenata*), one of the smallest carnivores of the continent and a little-known species in Ecuador.

The cover symbolizes our central theme, as we include three publications related to this species in this edition. The first is the report of a confirmed record in the southern region of the province of Esmeraldas, which opens the debate on whether this species, which is typically Andean in this country, may naturally inhabit the humid forests of the Chocó. This hypothesis had been mentioned previously (Parker III & Carr, 1992) but had not been confirmed.

To complement this topic, we add two scientific notes that contribute to our knowledge of the natural history of *Neogale frenata*. One deals with its swimming ability, a behavior that had only been documented in the northern part of its distribution, in North America (Sheffield & Thomas, 1997); the other provides details of an attack on a poultry farm, a behavior previously attributed to this species but poorly documented in the scientific literature.

This edition also brings two contributions to the little-known natural history of the country's bats. One is the first catalog of ectoparasites (Diptera: Streblidae and Nycteribiidae) found on 22 bat species in coastal Ecuador. The other is a note on the capture of a sucker bat (*Thyroptera tricolor*) in a web of *Eriophora* sp. (Araneae: Araneidae) in Yasuní National Park, in the Ecuadorian Amazon.

We also include an article on research trips designed for listening to humpback whales (*Megaptera novaeangliae*) in the southeastern Pacific region and two arti-

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cles that contribute to the knowledge of the species richness of two little-studied areas: the Cordillera Chongón Colonche, in the central-coastal region of the country, and the Reserva Biológica Tapichalaca, in the province of Zamora Chinchipe, in southeastern Ecuador.

This fifth issue of *Mammalia aequatorialis* is the most extensive that we have published since the birth of the journal, motivating us to continue with the belief that we will be able to publish two issues per year in a short time.

Thank you very much for joining us during these first five years.

Diego G. Tirira
Editor-in-chief

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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

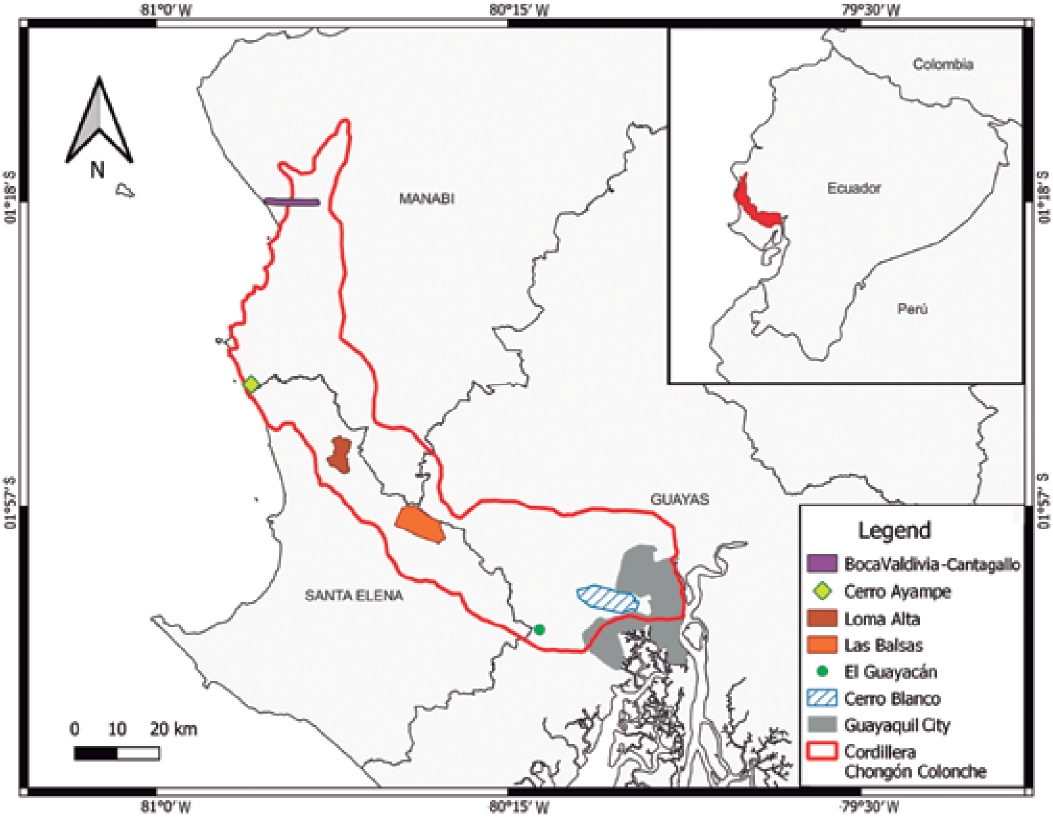

Figure 1. Cordillera Chongón Colonche and the studied areas.

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-*

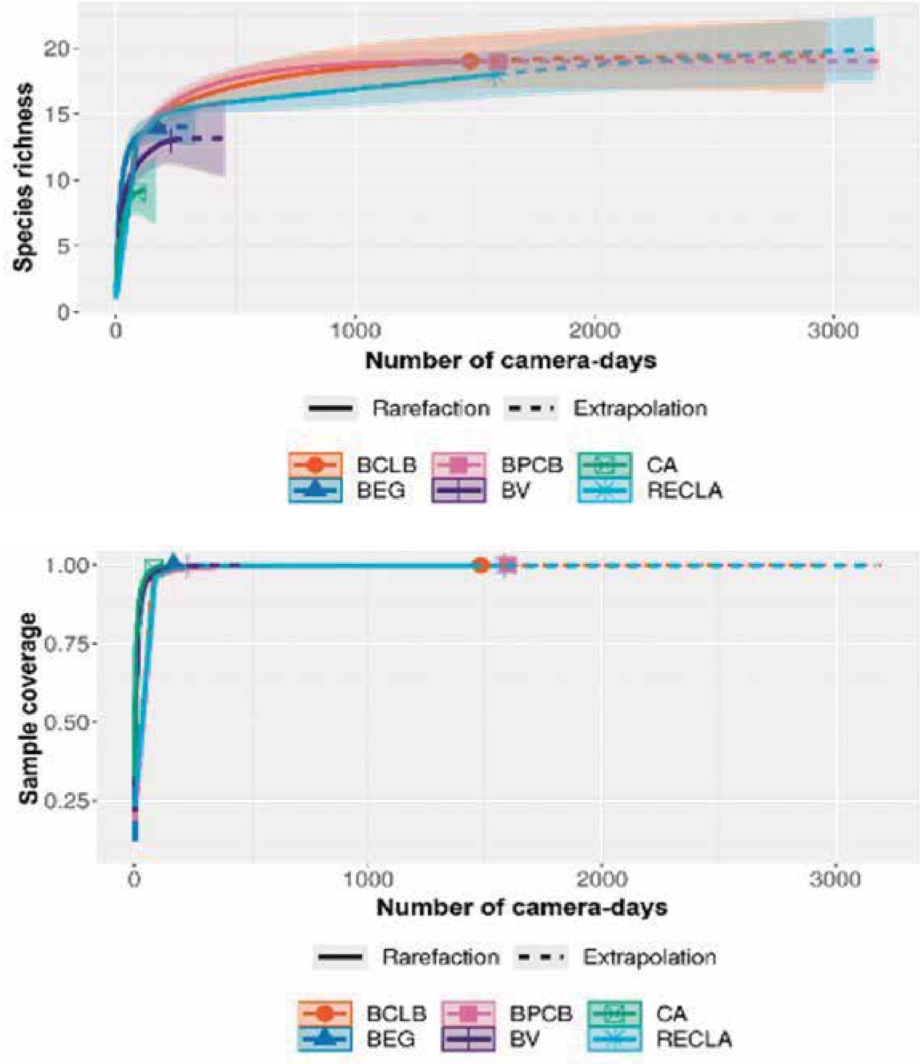

FIGURE 2. A. Species accumulation curves, and B. Sample completeness curves in Cordillera Chongón Colonche. Localities studied: BCLB (Bosque Comunal Las Balsas), BEG (Área Protegida Nacional de Recreación El Guayacán), BPCB (Bosque Protector Cerro Blanco), BV (BocaValdivia-Cantagallo), CA (Cerro Ayampe),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

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ORIGINAL ARTICLE

Mammals of the Tapichalaca Reserve, Zamora Chinchipe, Ecuador

Mamíferos de la Reserva Tapichalaca, Zamora Chinchipe, Ecuador

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ABSTRACT

For some years now, researchers from Abilene Christian University and the Museo de Zoología of the Pontificia Universidad Católica del Ecuador have carried out systematic field studies focused on characterizing the diversity of small mammals in different areas of the Andes mountains of Ecuador. In 2021, we surveyed the mammalian diversity of the Tapichalaca Reserve in Zamora Chinchipe Province, Ecuador. The habitat corresponds to the mountain cloud forest of the eastern Andes. The steep mountain slopes and high rainfall in this habitat cause frequent landslides that result in dense secondary growth forests. The reserve was established to protect the Jocotoco Antpitta (Passeriformes: Grallariidae, *Grallaria ridgelyi*) that is only known from Tapichalaca and a few other nearby mountain forests. The mammalian species we registered were *Didelphis pernigra*, *Marmosops caucae*, *Caenolestes condorensis*, *Syntheosciurus granatensis*, *Oreoryzomys balneator*, *Akodon aerosus*, *Nephelomys albigularis*, *Thomasomys aureus*, *T. caudivarius*, *T. fumeus*, *T. taczanowskii*, *Cuniculus*

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tazanowskii, *Coendou rufescens*, *Anoura geoffroyi*, *Sturnira bidens*, *S. erythromos*, *Myotis oxyotus*, *Leopardus tigrinus* and *Nasua olivacea*.

Keywords: Andes, camera-trapping, diversity, inventory, small mammals.

RESUMEN

Desde hace algunos años, investigadores de Abilene Christian University y del Museo de Zoología de la Pontificia Universidad Católica del Ecuador hemos realizado estudios de campo sistemáticos enfocados en caracterizar la diversidad de pequeños mamíferos en distintas zonas de la Cordillera de los Andes del Ecuador. En 2021 estudiamos la diversidad de mamíferos de la Reserva Tapichalaca, en la provincia de Zamora Chinchipe, Ecuador. El hábitat corresponde a bosque nublado de los Andes orientales. Las empinadas laderas de las montañas y las altas precipitaciones en este hábitat provocan frecuentes deslizamientos de tierra que dan como resultado densos bosques secundarios. La reserva fue establecida para la protección de la gralaria de Jocotoco (Passeriformes: Grallariidae, *Grallaria ridgelyi*) que solo se conoce de Tapichalaca y algunos otros bosques de montanos cercanos. Las especies de mamíferos registradas fueron: *Didelphis pernigra*, *Marmosops caucae*, *Caenolestes condorensis*, *Syntheosciurus granatensis*, *Oreoryzomys balneator*, *Akodon aerosus*, *Nephelomys albigularis*, *Thomasomys aureus*, *T. caudivarius*, *T. fumeus*, *T. taczanowskii*, *Cuniculus tazanowskii*, *Coendou rufescens*, *Anoura geoffroyi*, *Sturnira bidens*, *S. erythromos*, *Myotis oxyotus*, *Leopardus tigrinus* y *Nasua olivacea*.

Palabras clave: Andes, diversidad, fototrampeo, inventario, pequeños mamíferos.

INTRODUCTION

The forests of the Andes Mountains, along the mid-elevations of the eastern and western slopes, constitute a biodiversity hotspot (Myers et al., 2000), characterized by a high number of species and endemics of some groups of fauna. Among them, small non-volant mammals are a key focus for research due to their remarkable diversity and, generally, limited geographic ranges (do Prado et al., 2015). However, our understanding of this diversity remains incomplete, as indicated by the discovery of new taxa in recent years (Maestri & Patterson, 2016).

The Tapichalaca Reserve is located in the southern Ecuadorean province of Zamora-Chinchipe. This survey is part of an ongoing effort to discover information regarding the natural history, distribution, and ecology of mammals living in the Ecuadorean Andes. Since 2003, a team of scientists from Abilene Christian University and the Museo de Zoología of the Pontificia Universidad Católica del Ecuador have surveyed different sites in the Ecuadorean Andes, following standardized methodology, to characterize the mammalian fauna, especially small non-volant species. Figure 1 shows the localities visited so far, with their respective highest elevations:

- Tandayapa Valley (Pichincha, 2000 m; Lee et al., 2006a),
- Cosanga River Drainage (Napo, 2100 m; Lee et al., 2006b),
- Volcán Sumaco (Sucumbíos, 2500 m; Lee et al., 2008),
- Santa Rosa de Naranjal (Imbabura, 450 m; Lee et al., 2010),
- Sangay National Park (Chimborazo and Morona Santiago, 3400 m; Lee et al., 2011),
- Guandera Biological Reserve (Carchi; 3400 m; Lee et al., 2015),
- Yacuri National Park (Loja, 3450 m, Lee et al., 2018),
- Quimsacocha National Recreation Area (Azuay, 3860 m, Lee et al., 2021a), and,
- Otonga Forest Reserve (Cotopaxi, 2300 m; Lee et al., 2021b).

The purpose of this study was to report on the mammalian diversity of the Tapichalaca Reserve and compare our findings with previous studies in other mid- and high-elevation localities in Ecuador.

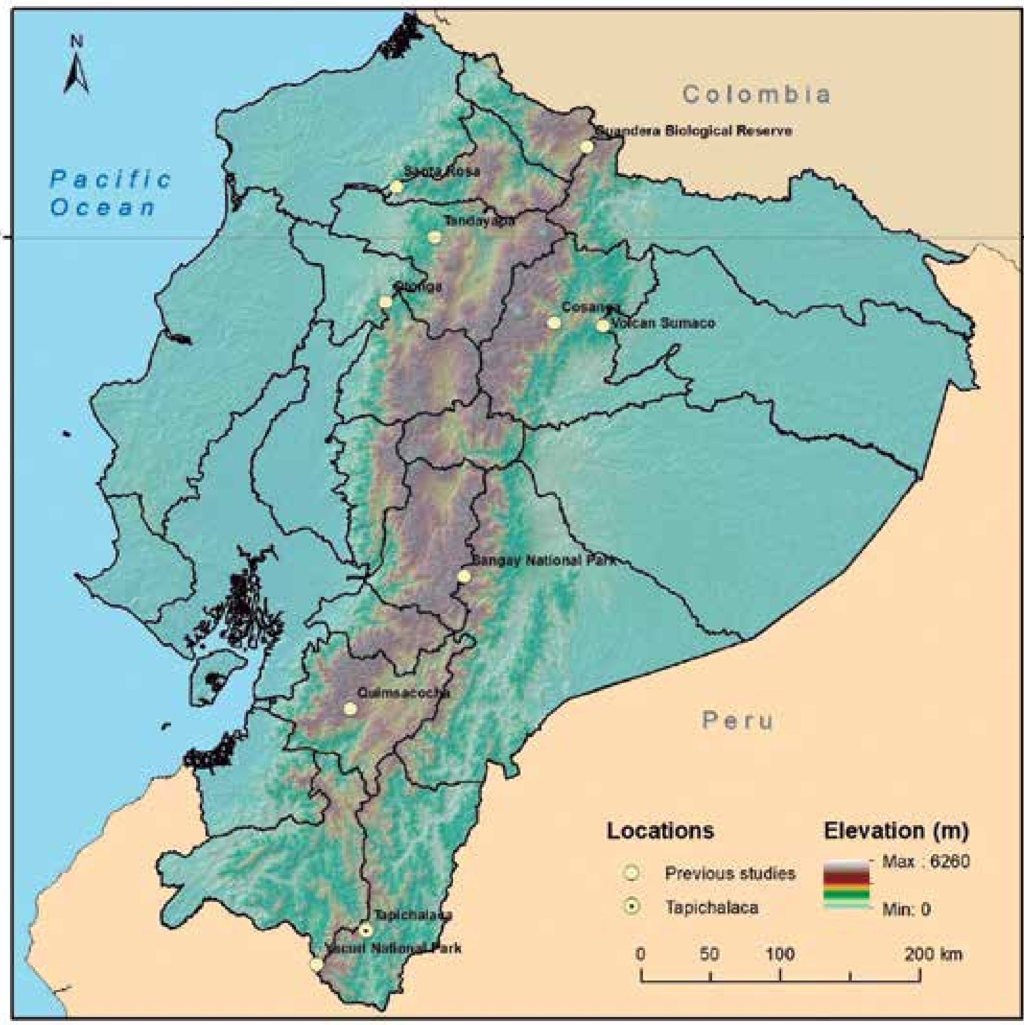

FIGURE 1. Location of Tapichalaca in relation to localities of previous studies.

METHODS

STUDY AREA

The habitat corresponds to a mountain cloud forest of the eastern Andes (coordinates 04°29'31.90" S, 79°07'38.99" W, 2522 m) (Figure 1). According to Tirira (2017), the area is characterized by eastern temperate forests, and the main ecosystem present is the "Southern montane evergreen forest of the Eastern Andes Mountain Range" (BsMn02, Báez et al., 2013). The area has an average annual temperature of 15.7 °C (Hijmans et al., 2005).

The study site is geologically composed of schists, quartzites, and gneisses (Longo & Baldock, 1982). The geology and climate directly impact the soil type, affecting the types of plants that can grow in the area and thus the overall ecology. Moreover, the geophysical structure (steep mountain slopes) and high rainfall (2500 to 3000 mm per year, 10 to 20 °C) provide conditions for frequent landslides (World Weather Online, 2018). Landslides set the successional clock back, creating a patchwork of secondary forests. Some of the patches we encountered were in early-stage succession, with bare ground visible and only sparsely vegetated. Other sections of the patches caused by the same landslide had dense stands of bamboo.

Tapichalaca has dense stands of forest. The trees are usually covered in mosses, ferns, and epiphytic vascular plants. Streamside vegetation includes halloid liverworts. There are thick stands of bamboo (Poaceae). *Lycopodium* is common on the forest floor, and upland open areas usually had lichens and mosses. Plants we identified include: Onagraceae (*Fuchsia* sp.), Polypodiaceae (ferns), Melastomataceae, Campanulaceae (*Centropogon* sp.), Bromeliaceae (*Tillandsia* sp.), Orchidaceae, Araceae, Arecaceae (palms), Violaceae (*Viola* sp.), Asteraceae, Cyatheaceae (tree ferns), Gunneraceae (Gunnera sp.) (MAE, 2013; Patzelt, 2012).

Field work

We surveyed the mammals of Tapichalaca Reserve from 3 July to 24 July 2021. We installed seven Browning Strike Force (model BTC-5HDE) trail cameras along the forest trails for 21 consecutive nights. Outside the trails, the vegetation is too dense to walk through. Digital images were taken with a Canon 5D Mark III camera for all the species recorded.

We set 204 Sherman traps to capture small terrestrial mammals and five Tomahawk traps for medium-sized mammals over 21 nights (for a cumulative effort of 4389 trap-nights); four 9-m mist nets were used to capture bats over the same period (189 net-nights). In addition, some bats of the genus *Anoura* were captured with the use of a butterfly net.

All our voucher specimens, including skins, skulls, skeletons, parasites, and frozen liver tissue, were deposited in the Abilene Christian University Natural History Collection (ACUNHC) and in the Sección de Mastozoología del Museo de Zoología (QCAZ-M) at the Pontificia Universidad Católica del Ecuador.

Specimen identification

To aid in our identification of Thomasomys, DNA was extracted from tissue samples from the specimens in the collections of the ACUNHC. We ran a PCR of each sample for the mitochondrial gene COI. The COI gene was sequenced at Azenta Corporation. We then used Sequencher® to analyze the sequences and check for patterns of similarity within *T. fumeus*, *T. vulcani*, and other *Thomasomys species*. Using the results from Sequencher, we constructed a maximum likelihood bootstrap phylogenetic tree, treating each codon position as a separate partition. The maximum likelihood was selected as a result of 1000 replicated searches. The results were assessed by nonparametric bootstrapping and Bayesian posterior probabilities.

We analyzed the geographic distribution of Cricetid rodent tribes using a classical cluster analysis, with a Euclidean similarity index based on standardized data, conducted in PAST v4.12 (Hammer et al., 2001). We changed the original percentage data to log transformation for standardization. For nomenclature and taxonomic order, we followed Burgin et al. (2020a, b). Even though many other studies with similar goals have been carried out in the Ecuadorian Andes (Anthony, 1922; Barnett, 1999; Brito & Ojala-Barbour, 2016; Curay et al., 2019, 2022; Jarrín-V., 2001; Jarrín-V. & Fonseca, 2001; Ojala-Barbour et al., 2019; Pilatasig, 2022; Tirira & Boada, 2009; Voss, 2003), we decided to use only the inventories previously developed by the same team of scientists so the comparisons could be made with a standardized sampling effort.

RESULTS

We collected 169 specimens from 19 species; six of these taxa were documented using photography only (only species with photos of sufficient quality to ensure an unequivocal taxonomic ID are reported). These species represent five mammalian orders and ten families.

Species accounts

Order Didelphimorphia

Family Didelphidae

Didelphis pernigra J. A. Allen, 1900 (Appendix B:a): This species was only detected using trail cameras. It was the most commonly photographed animal. White head with black mask that starts at the nose and continues past the eyes; triangular stripe in the center of the forehead (Astúa, 2015), recognizable by the white ears and black and white contrasting facial markings (Tirira, 2017).

Marmosops caucae (Thomas, 1900) (Appendix A:a): We collected 15 individuals, eight males and seven females (QCAZ 18936–18950). These specimens are characterized by a dark coloration around the eye. Dorsal fur grayish-brown to brown with uniform gray underparts, ventral fur either light gray or with patches of white in the gular and genital regions. No postorbital process on the skull, nasal bones expanded in the maxilo-frontal suture, palatine fenestrae present, subsquamosal foramen constricted antero-posteriorly, C1 without accessory cusps (Diaz-Nieto et al., 2011). Tail longer than the head and body. Measurements (in mm): total length 246–310, tail length 146–183, hind foot length 18–23, ear length 18–21.

Order Paucituberculata
Family Caenolestidae

Caenolestes condorensis Albuja and Patterson, 1996 (Appendix A:b): We collected 11 specimens (QCAZ 18916–18926), six males and five females. One of the females had two embryos, one in each uterus. Many of these specimens were obtained by setting traps in a small shed. The shed was used to store wooden boards and logs. Some of these specimens, likely juveniles because of their smaller size, conform morphologically to *C. convelatus* (medium size and contrasting ventral fur) while three specimens conform to C. condorensis (large size and ventral fur color that does not contrast with the dorsum) (Ojala-Barbour et al., 2013). Phylogenetic analysis of the COI gene reveals that these specimens form a distinct clade from either *C. convelatus* or *C. sangay* and are monophyletic. The COI sequences for these specimens are nearly identical to each other, indicating that they are part of the same population. Therefore, our assumption is that these specimens are all *C. condorensis*, based on the characteristics of the larger (adult) individuals. Measurements (in mm): total length 237–284, tail length 118–146, hind foot length 24–30, ear length 13–16.

Order Rodentia
Family Sciuridae

Syntheosciurus granatensis (Humboldt, 1811) (Appendix B:d): We obtained two out-of-focus images on a trail camera of S. granatensis. Taxonomy follows De Abreu-Junior et al. (2020), acknowledging that further research is needed into the taxonomic status of Neotropical squirrels, but Tirira et al. (2022) accepted the genus name. No specimens were collected, and none were observed directly.

Family Cricetidae

Akodon aerosus Thomas, 1913 (Appendix A:c): Thirty-seven specimens (QCAZ 18875–18911) were collected (21 males and 16 females). These specimens are very dark in color when compared with *A. mollis* specimens, which is consistent with published descriptions (Tirira, 2017). Skull strongly-built, with broad interorbital region, rostrum short and broad; smooth and non-beaded supraorbital ridges, anterior edges of zygomatic plates straight to slightly concave; incisive foramina long and wide, broad mesopterygoid fossa (Thomas, 1913). One female had two embryos. Measurements (in mm): total length 162–197, tail length 75–100, hind foot length 12–18, ear length 12–18.

Nephelomys albigularis (Tomes, 1860) (Appendix A:d): We collected 23 specimens (12 males and 11 females, QCAZ 18928–18935, 18955–18969). One female had two embryos. Rostrum slightly narrow, nasolacrimal capsules inflated, interorbital region narrow, hourglass-shaped, and without ridges, zygomatics arches are convergent and narrow, incisive foramen is short with slightly broad, mesopterigoid fossa present with anterior margin rounded or V-shaped, without postpalatal processes (Ruelas et al., 2021). The presence or absence of an alisphenoid strut is variable in these specimens; they have an anterior median flexus. Measurements (in mm):

total length 207–341, tail length 113–191, hind foot length 31–37, ear length 17–23.

Oreoryzomys balneator (Thomas, 1900) (Appendix A:e): Thirty-five specimens were collected of this species (QCAZ 18973–19007). There were 23 males and 12 females in this sample, and four females had embryos; three had two embryos and one had three. Very small and delicate skull, rostrum long and narrow, flanked by small and discrete nasolacrimal foramina, zygomatic arches slightly divergent posteriorly, jugals absent, interorbital region is antero-posteriorly short, wide, and hourglass-shaped, rounded anterior border of mesopterygoid fossa, alisphenoid strut absent; stapedial foramen and sphenofrontal foramen present, configuring carotid circulatory pattern 1 (Percequillo et al., 2015). Measurements (in mm): total length 175–223, tail length 98–132, hind foot length 18–30, ear length 14–18.

Thomasomys aureus (Tomes, 1860; Appendix A:f): Six individuals were collected (two males and four females; QCAZ 19018–19023). This is one of the largest species within the genus *Thomasomys* (head body length 154–159 mm). Braincase moderately broad and not inflated, incisive foramina long and moderately narrow, usually extending posteriorly between molar anterocones. Palatal bridge short and narrow with maxillary palatal pits present. Auditory bullae small and uninflated, mesopterygoid fossa broad and somewhat parallel-sided, carotid circulatory pattern derived (stapedial foramen small, internal squamosal-alisphenoid groove absent, sphenofrontal foramen absent; Pacheco, 2015). The dorsal fur is orange/brown with dark gray underfur. Measurements (in mm): total length 367–405, tail length 213–242, hind foot length 34–39, ear length 20–24.

Thomasomys caudivarius Anthony, 1923 (Appendix A:g): Twenty-one individuals were captured (13 males and 8 females; QCAZ 19028–19048). Skull moderately long, interorbital region moderately broad and hourglass-shaped, oval incisive foramina, more contracted anteriorly, and moderately long, mesopterygoid fossa broad with subparallel margins, carotid circulatory pattern primitive (stapedial foramen present, squamosal alisphenoid groove and sphenofrontal foramen present; Pacheco, 2015). These specimens have a white-tipped tail and are a medium-sized group of *Thomasomys*. Measurements (in mm): total length 232–300, tail length 139–186, hind foot length 26–32, ear length 16–21.

Thomasomys fumeus Anthony, 1924: Three males were collected (QCAZ 19025–19027). Dorsal fur has a brownish wash; lighter (than the dorsum) brown wash on ventral fur. Short skull with moderately broad rostrum, interorbital region moderately broad and hourglass-shaped with rounded margins, zygomatic plates narrow, zygomatic arches moderately convergent anteriorly, incisive foramina wide with contracted anterior and posterior margins, mesopterygoid fossa broad, wider anteriorly and convergent posteriorly. Carotid circulatory pattern primitive (Pacheco, 2015; Brito & Arguero, 2016). This is the southernmost record for *T. fumeus* by 264 km from the previous record (Brito & Arguero, 2016). Measurements (in mm): total length 257–271, tail length 126–137, hind foot length 29–31, ear length 18–20.

Thomasomys taczanowskii (Thomas, 1882) (Appendix A:h): Four individuals were collected (QCAZ 18970, 19024, 19049, 19050) (three males and one female). These specimens are similar in appearance in fur color to *Thomasomys paramorum*; however, skull morphology differs. Short and delicate rostrum, short nasals, interorbital region narrow with faintly marked edges, zygomatic arches narrow and converging anteriorly, incisive foramina narrow and long extending backward between anterior borders of M1s. Carotid circulatory pattern derived (Pacheco, 2015). Measurements (in mm): total length 207–248, tail length 124–138, hind foot length 25, ear length 13–16.

Family Erethizontidae

Coendou rufescens (Gray, 1865) (Appendix B:b): We captured an individual with a butterfly net, photographed it, and released it after identification. A few of the quills that the individual shed were collected (QCAZ 18927). Long dorsal fur absent and only spikes present; most spikes tricolored (with brownish or reddish tips), defensive spikes on rump and base of tail bicolored; bristle-spikes absent (Voss, 2015).

Family Cuniculidae

Cuniculus taczanowskii (Stolzmann, 1885) (Appendix B:c): Images of *C. taczanowskii* were captured with a trail camera set up to face a compost pile at night. This animal had rows of spots along the dorsum. This pattern differentiates *C. taczanowskii* from *C. paca*. Furthermore, it would be unusual to find *C. paca* above 2000 m altitude.

Order Chiroptera
Family Phyllostomidae

Anoura geoffroyi Gray, 1838 (Appendix C:a,b): We observed about 60–100 individuals of *Anoura* feeding at hummingbird feeders on most nights. We obtained four specimens (one male and three females; QCAZ 18912–18915) using a handheld butterfly net. Dorsal fur presents a silvery gray coloration on the sides of the neck and shoulders; ears short and rounded. Tail absent, short calcar, and caudal membrane reduced and hairy. Zygomatic arches incomplete, lower jaw protrudes well beyond the upper lip. Measurements (in mm): total length 63–70, hind foot length 9–16, ear length 10–12, forearm 42.5–43.7.

Sturnira bidens Thomas, 1915 (Appendix C:c): Five specimens were collected (two males and three females; QCAZ 19008–19012). All these bats had two lower incisors; this character differentiates this species from the others (with the exception of *S. nana*, which has a pair of tiny, spiculated external lower incisors, and is much smaller than *S. bidens*; Gardner, 2008). Measurements (in mm): total length 65–70, hind foot length 14–17, ear length 12–16, forearm 42.3–45.0.

Sturnira erythromos (Tschudi, 1844) (Appendix C:d): Five specimens were collected (one male and four females; QCAZ 19013–19017). Small, with an elongated rostrum, upper central incisors projecting anteriorly and spaced at the tip; lower central incisors bilobed. Mandibular molars have poorly defined lingual-sided cusps, giving each molar a continuous, flat appearance (Gardner, 2008). Measurements (in mm): total length 63–68, hind foot length 13–16, ear length 12–14, forearm 40.5–44.5.

Family Vespertilionidae

Myotis oxyotus (W. Peters, 1866) (Appendix C:e, f): Three specimens were collected (QCAZ 18951–18953) (two males and one female). These bats were seen on the eaves of the house in which we were staying. We obtained our specimens using mist nets. The dorsal fur on these specimens is dark brown with yellow tips. Basic measurements (in mm): total length 90–95, tail length 38–41, hind foot length 9–10, ear length 13–15, forearm 39.3–40.2.

Order Carnivora
Family Felidae

Leopardus tigrinus (Schreber, 1775) (Appendix B:e): Two cameras set along trails captured images of a cat; the combination of a short, many-banded tail and a short face are indicative of *L. tigrinus* (Roland Kays, pers. comm.).

Family Procyonidae

Nasua olivacea Gray, 1866 (Appendix B:f): One individual was captured in a Tomahawk trap. This individual had thick dark brown pelage with a light gray-brown underfur on the dorsum. The head had a dark mid-dorsum stripe that covered the rostrum and narrowed to a midpoint between the ears. The tail was bushy, and the dorsal fur was dark gray with blackish tips; the ventral fur was light brown. We took blood samples (QCAZ 18954), photographs, and released the individual. This species was formerly designated as *Nasuella olivacea* but recently reclassified as *Nasua* (Ruiz-García et al., 2021).

DISCUSSION

The Tapichalaca Reserve was established to protect the endangered Jocotoco Antpitta (*Grallaria ridgelyi*) that we observed. The Jocotoco Antpitta's known range is limited to a few small areas of mountain cloud forests near Mount Tapichalaca, Ecuador. and nearby northern Peru (Del Hoyo & Collar, 2016). The forest preserved for the Jocotoco Antpitta has become an important refuge for other forest-dependent species, such as small and medium-sized mammals, such as the ones we reported here.

The mammal species diversity we encountered is similar to a number of cloud forests areas that have been previously surveyed. These areas include Otonga and Guandera; in comparison, both had similar species diversity of *Anoura*, *Sturnira*, *Thomasomys*, and *Nephelomys* (Lee et al., 2015, 2021b). The vegetation in all three locations was indicative of high mountain temperate cloud forests.

The rodent data (Cricetidae: Sigmodontinae) were compared with past studies with similar sampling efforts that were conducted in different areas of Ecuador (Table 1, Figure 1).

TABLE 1. Elevation and latitudinal distribution of the tribes of the rodent subfamily Sigmodontinae. Survey locations in Ecuador arranged by elevation.

Location	Elevation range (m)	Latitude (degrees)	Thomasomyini	Oryzomyini	Akodontini	Ichthyomyini	Reithrodontomyini	Phyllotini	Sigmodontini
Santa Rosa de Naranjal (Lee et al., 2010)	450–700	0.3308	0	100%	0	0	0	0	0
Tandayapa (Lee et al., 2006a)	1500–2000	0.0036	0	95%	0	5%	0	0	0
Cosanga (Lee et al., 2006b)	1900–2100	-0.5500	5%	93%	0	2%	0	0	0
Otonga (Lee et al., 2021b)	1300–2300	-0.4197	19%	80%	0	1%	0	0	0
Volcan Sumaco (Lee et al., 2008)	2400-2500	-0.5719	70%	25%	0	5%	0	0	0
Tapichalaca (Lee et al., this study)	2500-2550	-4.4922	27%	43%	30%	0	0	0	0
Sangay National Park (Lee et al., 2011)	2900-3400	-2.1933	59%	5.6%	35.4%	0	0	0	0
Guandera Biological Reserve (Lee et al., 2015)	2960–3400	0.5892	68%	4%	0	1%	27%	0	0
Yacuri National Park (Lee et al., 2018)	3080–34545	-4.7118	35%	20%	45%	0	0	0	0
Quimsacocha (Lee et al., 2021a)	3570–3865	-3.0542	0	26%	61%	0	0	11.3%	1.1%

Cluster analysis shows more similarity using latitude as a predictor rather than elevation in the way localities are arranged by tribe composition (Figure 2).

When a comparison is made with other sites, Tapichalaca Reserve does present some differences from trends seen at other sites where a similar collecting effort was made. Tapichalaca presents a lower abundance of Thomasomyini as a percentage of the Sigmodontinae rodents that were captured when compared with other sites of similar elevation, such as Volcan Sumaco, Sangay, and Guandera (Table 1). Therefore, Tapichalaca does not show the trend of increasing Thomasomyini numbers and decreasing Oryzomyini numbers with increasing elevation in forested habitats. There is a possibility that Thomasomys numbers are low due to wide fluctuations in rodent numbers from year to year (Lee et al., 2015). This taxonomic/ecological

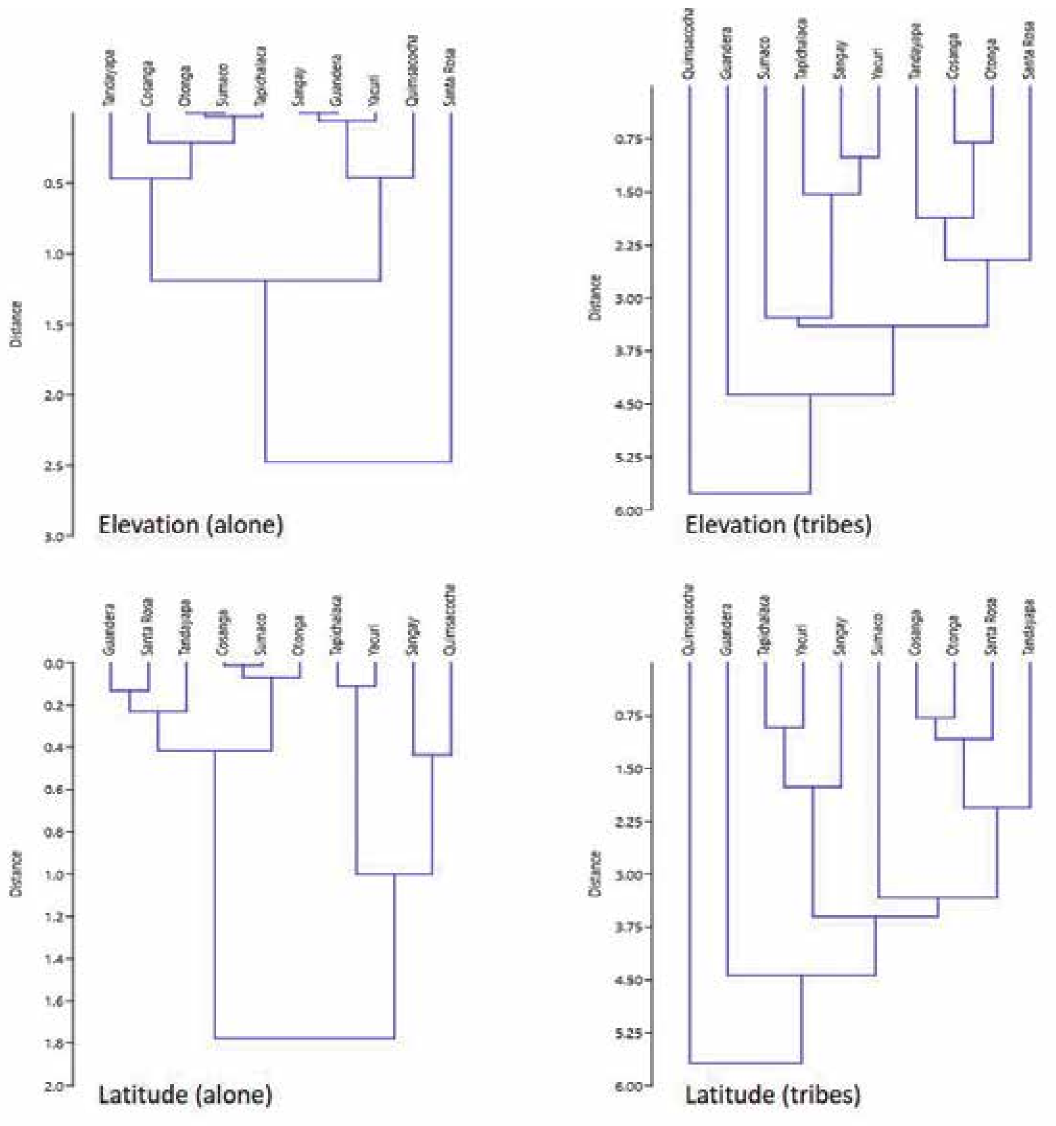

FIGURE 2. Clustering analysis of sampling localities where similar efforts have been made (Table 1). Left: clusters formed by using only elevation (top) and latitude (bottom). Right: clusters formed by using tribe similarity percentages combined with elevation (top) or latitude (bottom).

trend does not hold for paramo locations of Yacuri and Quimsacocha because Akodontini and high-elevation Oryzomyini become more common in this habitat (Table 1).

The abundance of rodent tribes is not only related to elevation, as it may seem intuitively, but also to latitude and even to the side of the Andes on which these populations are located. All these factors affect the dispersal capabilities of small mammals (Brown, 2001). In terms of the connectivity of topography, according to a cluster analysis of the information provided in Table 1, latitude of occurrence explains the similarities of groups assembled by tribe better than elevation (Figure 2), with exceptions made in cases of locations on different slopes of the Andes. Clusters like Tandayapa, Cosanga, Otonga, Santa Rosa and Sumaco, are clustered together by latitude (northern localities, between -0.57 to 0.33 degrees) more closely than when combined by tribe similarity percentages, except for Guanderas, which has a noticeably higher elevation. A similar pattern occurs with southern localities like Tapichalaca, Yacuri, Quinsacocha, and Sangay (-4.71 to -2.19 degrees).

Bat diversity and numbers were similar to other Andean forest sites. For example, *Sturnira bidens*, *S. erythromos*, *Anoura geoffroyi*, and *Myotis oxyotus* are commonly encountered in habitats above 1500 m (Lee et al., 2006a; 2006b; 2008; 2010; 2011; 2015; 2018; 2021a; 2021b). These four species were the only bat species we encountered during the Tapichalaca survey. Bats that are found at high elevations tend to occur over a wide elevation distribution (Patterson et al., 1996). The four species that we found on this survey are most likely habitat generalists and therefore able to survive across a wide range of mountain ecological and vegetation zones (Lee et al., 2018).

There are several conservation concerns regarding the mammals of Tapichalaca. Some of the species we encountered at Tapichalaca were either categorized as IUCN Vulnerable or Near Threatened. For example, *Leopardus tigrinus* and *Caenolestes condorensis* are considered as Vulnerable per the IUCN Red List, both globally and according to the *Red List for Ecuadorian Mammals* (Tirira, 2021). *Nasua olivacea* and *Cuniculus taczanowskii* are listed as Vulnerable on the Ecuadorian Red List and Near Threatened globally. *Nephelomys albigularis* and *Thomasomys caudivarius* are listed as Vulnerable on the Ecuadorian list. *Oreoryzomys balneator* is listed as Data Deficient globally and Near Threatened on the Ecuadorian list. *Thomasomys taczanowskii*, *T. fumeus*, and *Coendou rufescens* are listed as Near Threatened on the Ecuadorian list (Tirira, 2021).

Our camera traps captured a domestic dog feeding at the reserves compost pile. The dog was photographed in the same place as the *C. taczanowskii* and, on occasion, *D. pernigra*. A domestic dog can be a threat to a wide variety of wildlife (Zapata Ríos & Branch, 2018). In addition, agricultural areas can be found all around the reserve, which means that the forests have been removed and that these areas are under grazing pressure.

CONCLUSIONS

With the addition of our specimens and photographic data from Tapichalaca Reserve, we can present a finer-grained picture of the biogeography of the Andean mammals of Ecuador when compared with previous studies. Furthermore, these data highlight the complex biogeographic context in which the mammals of the Andes of Ecuador find themselves. The mammals have had to adapt to the tectonic plate, climatic, and ecological history of the Andes. Hopefully, they will continue to persist and adapt in the face of increasing anthropogenic pressure.

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Authors' contributions: TEL and NT completed fieldwork and ran taxonomical analyses on the specimens; TEL drafted the manuscript; MAC curated, catalogued, and accessed specimens in the QCAZ mammal collection; SFB facilitated fieldwork, procured all necessary permits for research, collection, and export, developed the geographical analysis, and drafted and formatted the manuscript.

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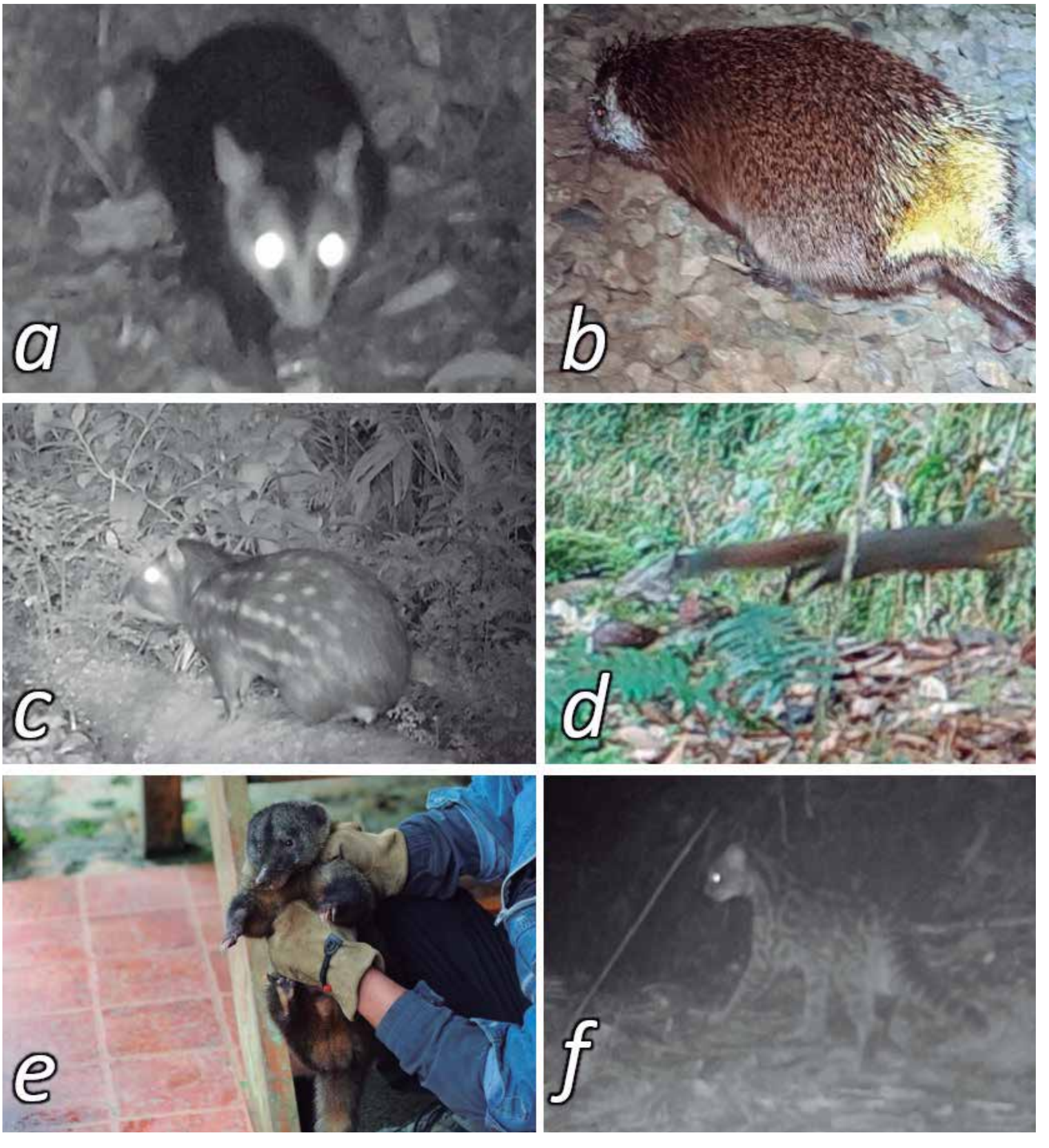
Recorded non-volant small mammal species: Didelphidae: a) *Marmosops caucae*; Caenolestidae: b) *Caenolestes condorensis*; Cricetidae: c) *Akodon aerosus*, d) *Nephelomys albigularis*, e) *Oreoryzomys balneator*, f) *Thomasomys aureus*, g) *Thomasomys caudivarius*, h) *Thomasomys taczanowskii*. Photos by: T. E. Lee Jr.

Appendix A

Mammal species recorded at Tapichalaca Reserve, Zamora Chinchipe, Ecuador

Appendix B

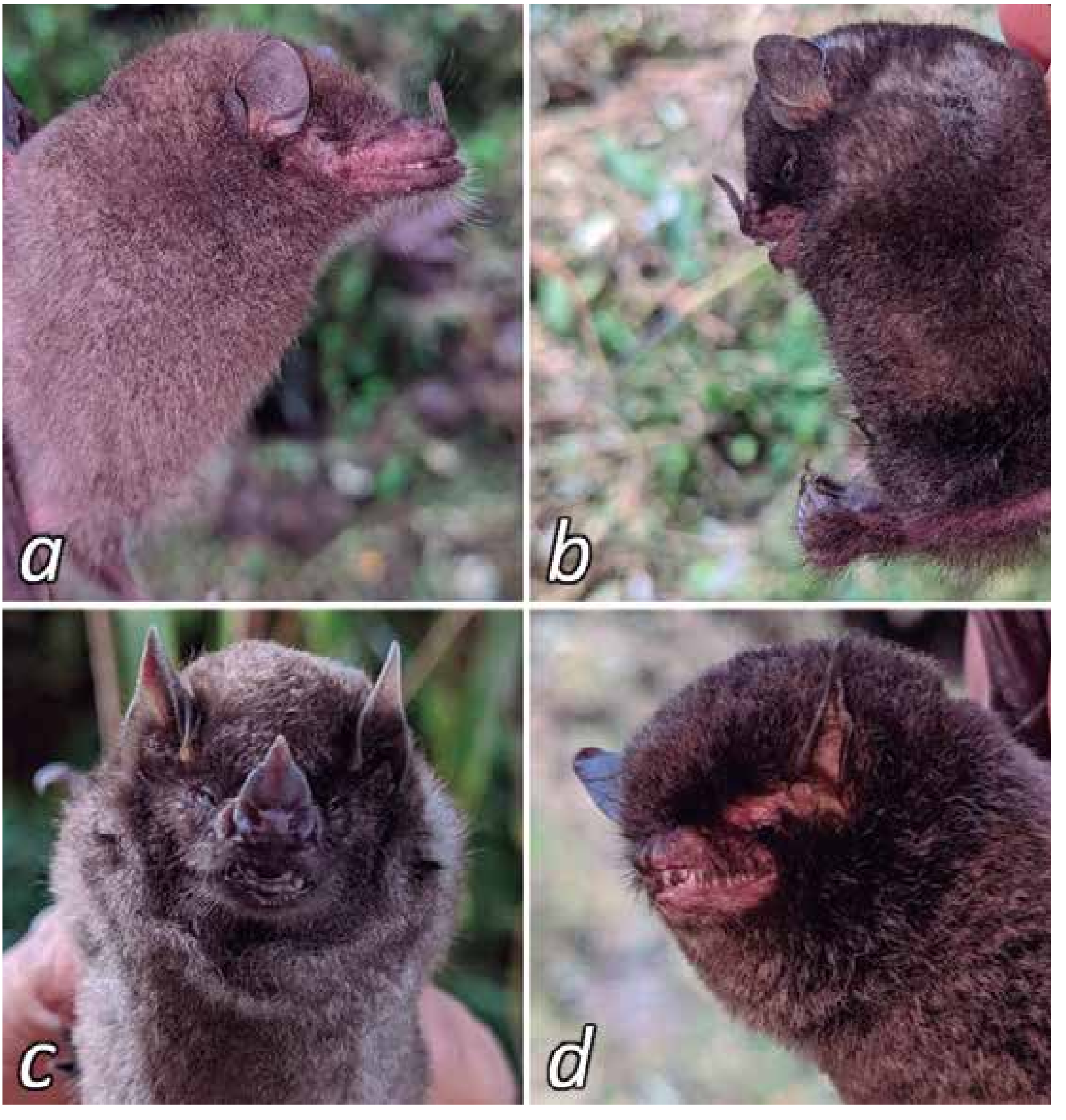
Mammal species recorded at Tapichalaca Reserve, Zamora Chinchipe, Ecuador



Recorded middle and large sized species. Didelphidae: a) *Didelphis pernigra*; Erethizontidae, b) *Coendou rufescens*; Cuniculidae: c) *Cuniculus taczanowskii*; Sciuridae: d) *Syntheosciurus granatensis*; Procyonidae: e) *Nasua olivacea*; Felidae: f) *Leopardus tigrinus*. Photos by: T. E. Lee Jr.

Appendix C

Mammal species recorded at Tapichalaca Reserve, Zamora Chinchipe, Ecuador



Recorded volant small mammal species. Phyllostomidae: a) *Anoura geoffroyi*, b) *Sturnira bidens*, c) *S. erythromos*; Vespertilionidae: d) *Myotis oxyotus*. Photos by: T. E. Lee Jr.

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ORIGINAL ARTICLE

Ectoparasites (Diptera: Streblidae and Nycteribiidae) of bats from some localities of the Coast of Ecuador

Ectoparásitos (Diptera: Streblidae y Nycteribiidae) de murciélagos en algunas localidades de la Costa del Ecuador

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ABSTRACT

In Ecuador, studies of parasitic bat flies are scarce and biased towards the family Streblidae: reports indicate the existence of 50 species, five of them on the western lowlands. In this study, in addition to Streblidae, we include information of the family Nycteribiidae that has not been studied in Ecuador. Both families are associated with bats in several localities of the western lowlands of the country. We used samples from the associated collection of parasites of the Mammalogy Section of the Museo de Zoología at Pontificia Universidad Católica del Ecuador (QCAZ-M), as well as the database of the collection that allowed obtaining information on the host taxa. Thus, 145 individuals of bats of 22 species of the families Phyllostomidae and Vespertilionidae and 424 individuals of 29 species of parasitic flies are reported. Of these, five species are new in Ecuador, 19 are confirmed records in the west and the geographic distribution was extended for species previously reported in this region. *Trichobius joblingi* was the most abundant parasitic fly species and together with *Speiseria ambigua* were associated

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with the greatest number of bat species. Species of the genus *Carollia* were the most abundant and harbored the greatest diversity of flies. The study constitutes the first extensive review of Diptera (Streblidae and Nycteribiidae) in the area and, therefore, contributes to expanding the knowledge of the diversity of ectoparasites of bats in Ecuador.

Keywords: bats, ectoparasites, host, parasitic flies, Ecuadorian coast.

RESUMEN

En Ecuador, los estudios de moscas parásitas de murciélagos son escasos y sesgados hacia la familia Streblidae: los reportes indican la existencia de 50 especies, cinco de ellas en las tierras bajas del occidente. En este estudio, además de Streblidae, incluimos información de la familia Nycteribiidae que no ha sido estudiada en Ecuador. Las dos familias están asociadas a murciélagos de varias localidades del occidente. Utilizamos muestras de la colección asociada de parásitos de la sección de Mamíferos del Museo de Zoología de la Pontificia Universidad Católica del Ecuador (QCAZ-M), así como de la base de datos de la colección para obtener información de los taxones hospederos. Reportamos 145 individuos de murciélagos de 22 especies de las familias Phyllostomidae y Vespertilionidae y 424 individuos y 29 especies de las moscas parásitas. De ellas, cinco especies son nuevos registros para Ecuador, 19 son registros confirmados en el Litoral y ampliamos la distribución geográfica para especies previamente reportadas en esta región. *Trichobius joblingi* fue la especie de mosca parásita más abundante y, en conjunto con, *Speiseria ambigua*, se asociaron con el mayor número de especies de murciélagos. Las especies de murciélagos del género *Carollia* fueron las más abundantes y albergaron la mayor diversidad de moscas. El estudio constituye la primera revisión extensa de dípteros (Streblidae y Nycteribiidae) de la zona y, por consiguiente, contribuye a mejorar el conocimiento de la diversidad de ectoparásitos de murciélagos en Ecuador.

Palabras claves: ectoparásitos, hospedero, murciélagos, moscas parásitas, Costa ecuatoriana.

INTRODUCTION

Ectoparasites are organisms that can adhere and introduce themselves to the skin or its excretions for variable periods (Hopla et al., 1994). They are mainly part of the phylum Arthropoda and are made up of different taxonomic groups, such as fleas (Siphonaptera), lice (Phthiraptera), flies (Diptera), bedbugs (Hemiptera), ticks (Ixodida), and mites (Mesostigmata) (Sánchez et al., 2020).

A characteristic of ectoparasites is the ability to establish associations in the host to protect themselves from the external environment and changes in temperature and humidity, factors that determine their life cycle (Amat-Valero et al., 2013). They use the host as a means of transport to new and suitable habitats, increasing their dispersal capacity (Baumann, 2018).

Around 6000 species of insects have been reported worldwide as external parasites of warm-blooded vertebrates; of these, 742 parasitize bats (Haelewaters et al., 2018; Marshall, 1982). In accordance with the most recent catalogues, Central and South America are inhabited by a comprehensive array of 273 ectoparasite species associated with bats, comprising 187 species of flies (141 belonging to the family Streblidae and 46 within Nycteribiidae), eight flea species, four bedbug species, and 74 mites and tick species (Frank et al., 2014).

It is noteworthy that the families Streblidae and Nycteribiidae have been the primary focus of research in the Neotropical region. As evidenced by various publications, 68 species have been documented in Peru (Minaya et al., 2021), 82 in Colombia (Dick et al., 2016; Graciolli et al., 2016; Pastrana-Montiel et al., 2019), 130 in Venezuela (Guerrero, 2019; Guimarães, 1972; Wenzel, 1976), and 119 in Brazil (Graciolli & Hrycyna, 2023; Hrycyna et al., 2019).

In Ecuador, 59 species of bat ectoparasites have been reported; among these, 54 correspond to the order Diptera (families Streblidae and Nycteribiidae), two belong to the order Prostigmata (Trombiculidae and Myobiidae), two conform the order Mesostigmata (Macronyssidae and Spinturnicidae), and one is member of the order Siphonaptera (Ischnopsyllidae) (Camacho et al., 2014; Correa et al., 2019; Espinoza, 2020; Guerrero, 1997; Guimarães & D'Andretta, 1956; Liu et al., 2020; Salgado, 2019; Stamper, 2012; Tello, 2005). Of these species, five are located on the Ecuadorian Coast and belong to the family Streblidae (Correa et al., 2019; Liu et al., 2020; Tello, 2005).

Of the studies, only Salgado (2019), Stamper (2012), and Tello (2005) focused directly on the study of ectoparasites and bats in Ecuador. It is important to note that research on this topic, and even more so those focused on the Coast, are scattered in time, very scarce, primarily focused on dipterous of the family Streblidae and, therefore, exclude information on other families and orders presents in the country and their association with different species of bats. This is due to two essential aspects: the findings of Streblidae in bats are better documented and this is the ectoparasite family with the highest species richness and most abundant in the Western Hemisphere (Calonge-Camargo & Pérez-Torres, 2018; Reeves et al., 2016; Santos et al., 2016).

The present study consists of an extensive and detailed review covering a larger number of bat species, their parasitic bat flies, and several coastal areas duly associated with the host collection site. In this sense, the objective is to identify the diversity of ectoparasites of the families Streblidae and Nycteribiidae associated with bats in some localities on the Coast of Ecuador.

MATERIALS AND METHODS

Sample

The study sample came from the associated collection of ectoparasites of the Mammalogy Section of the Museo de Zoología at Pontificia Universidad Católica del Ecuador (QCAZ-M) and, specifically, those that registered collection sites on the Ecuadorian Coast. The sample, being conformed by a collection of ectoparasites of bats, contained specimens of different species, so it was necessary to carry out a first revision to isolate the parasitic bat flies of the families Streblidae and Nycteribiidae from the rest of the ectoparasites.

We obtained most of the samples from the project "Caracterización de la Diversidad Biológica y Genética de los Mamíferos del Ecuador" carried out in 2017; a smaller proportion came from the project "Prevalencia y Diversidad Genética de Coronavirus en Murciélagos del Ecuador" carried out in 2021, and only one specimen came from a different project.

Taxonomic identification

We used a stereo microscope to identify specimens to the genus level, and an optical microscope to observe in detail the specific structures required for species identification. In this process, we used several morphological keys (Graciolli, 2004; Guerrero, 1994a, 1994b, 1995a, 1995b, 1996, 1998, 2019; Guimarães & D'Andretta, 1956; Jobling, 1936; Peterson, 1959; Theodor, 1967; Wenzel, 1976; and Wenzel et al., 1966).

We took microscopic photographs based on distinctive taxonomic characters to compare more than two species of the same genus. For species in Streblidae, we photographed the thorax, head, and wings, in addition to capturing images of the entire body for genera with only one species. For species of Nycteribiidae, we focused on taking pictures of the abdomen.

Host information, including identification to species level and site of capture, was obtained from the QCAZ-M database (https://bioweb.bio/faunaweb/mammaliaweb/). We needed to identify some bat specimens that were only available at the genus level. For this, we used the taxonomic key of Diaz et al. (2021).

The annotated list of bat fly species is presented as family, subfamily, genus, and species. The details of each species are divided into three sections: the first includes information about the number of specimens reviewed, locality, collection date, sex of bat flies, and host species; the second corresponds to diagnostic characters, which can be reviewed in detail in the publications of Guerrero (2019), Guimarães & D'Andretta (1956), Wenzel (1976) and Wenzel at al. (1966). The third section provides information on host-parasite interactions according to bibliographic records, as well as relevant findings.

We have maintained the phylogenetic order proposed by Guerrero (2019) in one of his most current works on the family Streblidae. The species of the family Nycteribiidae are organized alphabetically.

The nomenclature for bat host species follows Tirira et al. (2022). The species of bat flies belonging to the families Streblidae and Nycteribiidae, aligns with the nomenclature of Guerrero (2019) and Guimarães & D'Andretta (1956), respectively.

Appendix 1 presents a toponymic index, with all the localities referred to in the text, as well as the species of bat flies and their geographic distribution reported in this study.

RESULTS

Diversity

We recorded 424 parasitic bat flies belonging to nine genera and 26 species of the family Streblidae, and one genus and three species of the family Nycteribiidae. The most abundant bat fly species were *Trichobius joblingi* (24%) and *Basilia ferrisi* (21%) (Table 1).

In terms of bat hosts, we obtained information from 145 individuals of two families, 13 genera and 22 species (Phyllostomidae, n = 18; Vespertilionidae, n = 4). *Carollia brevicauda* (15%), *C. perspicillata* (14%), and *C. castanea* (12%) were the most abundant species (Table 1; Figure 1).

In the context of host-parasite interactions, *Trichobius* joblingi and *Speiseria ambigua* were associated with the highest number of host species: five each (Table 1). Similarly, *Carollia brevicauda*, *C. castanea*, and *Glossophaga soricina* harbored five species of parasitic flies (Figure 1).

New records

Of the 29 species analyzed, five (17%) are new records for Ecuador, 19 (66%) are confirmed records from the Ecuadorian Coast, and three (10%) correspond to previous report in other regions of Ecuador (Sierra and Amazonia). In addition, we were not able to determine the species for two morphotypes from *Trichobius* (Streblidae) and *Basilia* (Nycteribiidae) (Table 1).

We report the presence of Streblidae and Nycteribiidae species in nine localities distributed in Esmeraldas, Manabí, Santo Domingo de los Tsáchilas, Los Ríos, and El Oro, provinces (Figure 2). Records in Manabí and Los Ríos correspond to new distribution data for *Strebla altmani*, *Speiseria ambigua*, and *Trichobius joblingi*.

Annotated list of ectoparasite species

Family Streblidae Kolenati, 1863

Subfamily Trichobiinae Jobling, 1936

Genus *Trichobius* Gervais, 1844

Trichobius uniformis Curran, 1935

Figure 3A

Material examined [6]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 23.XI.2021, 1♂, 1♀ ex *Glossophaga soricina*; 25.XI.2021, 1♂, 1♀ ex *Glossophaga soricina*; 26.XI.2021, 1♂ ex *Lonchophylla concava* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 22.VII.2017, 1♂ ex *Glossophaga soricina*.

Identification: The species was identified from the presence of setae on the basal angle of vein 6 of the wing. In addition, vein R1 is straight, and each occipital lobe has a tubercle on the posterior edge (Guerrero, 1994a).

Remarks: *Trichobius uniformis* is a characteristic species of the genus *Glossophaga*, particularly associated with *Glossophaga soricina* (Cuxim-Koyoc et al., 2018; Wenzel, 1976), which is the same host reported from Ecuador (Stamper, 2012). In this study, we found this species in association with *Lonchophylla concava*.

Trichobius longipes (Rudow, 1871)

Figure 3B

Material examined [1]: **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 25.VII.2017, 1♂ ex *Phyllostomus hastatus*.

Identification: This species is distinguished by short setae along the anterior margin of the prescutum and long ones along the midline. Also, those found in the lateral rows are longer compared to those found in the center (Guerrero, 1994a, 2019).

Table 1. Host taxon association and parasitic bat flies in some localities of the Ecuadorian Coast.

Parasitic bat flies	Type of report	N	Host	N
Family Streblidae				
Subfamily Trichobiinae				
Trichobius uniformis	b	6	*Glossophaga soricina*	4
			Lonchophylla concava	1
Trichobius longipes	b	1	*Phyllostomus hastatus*	1
Trichobius costalimai	b	11	*Phyllostomus discolor*	2
Trichobius dugesii	b	5	*Glossophaga soricina*	4
Trichobius joblingi	c	100	*Glossophaga soricina*	1
			Carollia brevicauda	18
			Carollia castanea	11
			Carollia perspicillata	17
			Myotis riparius	1
Trichobius parasiticus	b	2	*Platyrrhinus* sp.	1
Trichobius dugesioides	b	25	*Trachops cirrhosus*	2
			Lonchorhina aurita	1
			Carollia brevicauda	1
Trichobius flagellatus	a	14	*Lonchorhina aurita*	2
Trichobius anducei	b	14	*Carollia brevicauda*	4
			Carollia castanea	2
			Carollia perspicillata	5
Trichobius sp.	d	1	*Platyrrhinus umbratus*	1
Trichobioides perspicillatus	b	15	*Phyllostomus discolor*	3
			Carollia castanea	1
Speiseria ambigua	c	23	*Glossophaga soricina*	2
			Lonchorhina aurita	1
			Carollia brevicauda	4
			Carollia castanea	7
			Carollia perspicillata	7
Paratrichobius longicrus	b	2	*Artibeus lituratus*	1
Paratrichobius dunni	a	4	*Uroderma convexum*	1
Megistopoda aranea	b	8	*Artibeus fraterculus*	2
			Artibeus lituratus	1
			Platyrrhinus umbratus	1
Megistopoda proxima	b	9	*Sturnira bakeri*	6
			Sturnira ludovici	1
Aspidoptera phyllostomatis	b	5	*Artibeus fraterculus*	4
Aspidoptera falcata	b	2	*Sturnira ludovici*	1
Exastinion clovisi	b	1	*Carollia castanea*	1

TABLE 1. Continued.

Parasitic bat flies	Type of report	N	Host	N
Subfamily Streblinae				
Strebla mirabilis	b	21	*Trachops cirrhosus*	2
Strebla guajiro	c	16	*Carollia brevicauda*	6
			Carollia perspicillata	4
Strebla hertigi	b	2	*Phyllostomus discolor*	1
			Phyllostomus hastatus	1
Strebla galindoi	b	32	*Tonatia bakeri*	5
Strebla machadoi	a	2	*Micronycteris simmonsae*	1
Strebla altmani	a	5	*Lonchorhina aurita*	2
Metelasmus pseudopterus	b	1	*Artibeus lituratus*	1
Family Nycteribiidae				
Subfamily Nycteribiinae				
Basilia carteri	a	7	*Myotis albescens*	1
			Myotis nigricans	1
Basilia ferrisi	b	88	*Glossophaga soricina*	1
			Myotis diminutus	15
			Myotis nigricans	6
			Myotis riparius	12
Basilia sp.	d	2	*Myotis riparius*	1
Total		424		145

N: Number of individuals.
a: New report for Ecuador.
b: Report confirmed for the Coast region.
c: Previous report in the Ecuadorian Sierra and Amazonia.
d: Species not determined.

Remarks: Although *Phyllostomus hastatus* is the characteristic host of *Trichobius longipes* (Wenzel, 1976), several species of the family Phyllostomidae have been reported as hosts in Ecuador (Stamper, 2012).

Trichobius costalimai Guimarães, 1938
Figure 3C
Material examined [11]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 27.XI.2021, 2♂, 2♀ ex *Phyllostomus discolor* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 21.VII.2017, 7♂ ex *Phyllostomus discolor*.
Identification: It is possible to differentiate between 10 to 12 setae in the anterolateral region of the prescutum and short setae between the transverse and median sutures of the mesonotum. These characteristics are exclusive to this species (Guerrero, 1994a).
Remarks: *Phyllostomus discolor* is the main host of *Trichobius costalimai* (Wenzel, 1976), also occurring in Ecuador (Stamper, 2012).

Trichobius dugesii Townsend, 1891
Figure 3D
Material examined [5]: **Esmeraldas**: Eloy Alfaro, La Tola, Finca Cocadilla; 21.VIII.2017, 1♂, 2♀ ex *Glossophaga soricina* • Eloy Alfaro, La Tola, Centro de Interpretación Majagual; 19.VIII.2017, 1♀ ex *Glossophaga soricina*; 22.VIII.2017, 1♀ ex *Glossophaga soricina*.

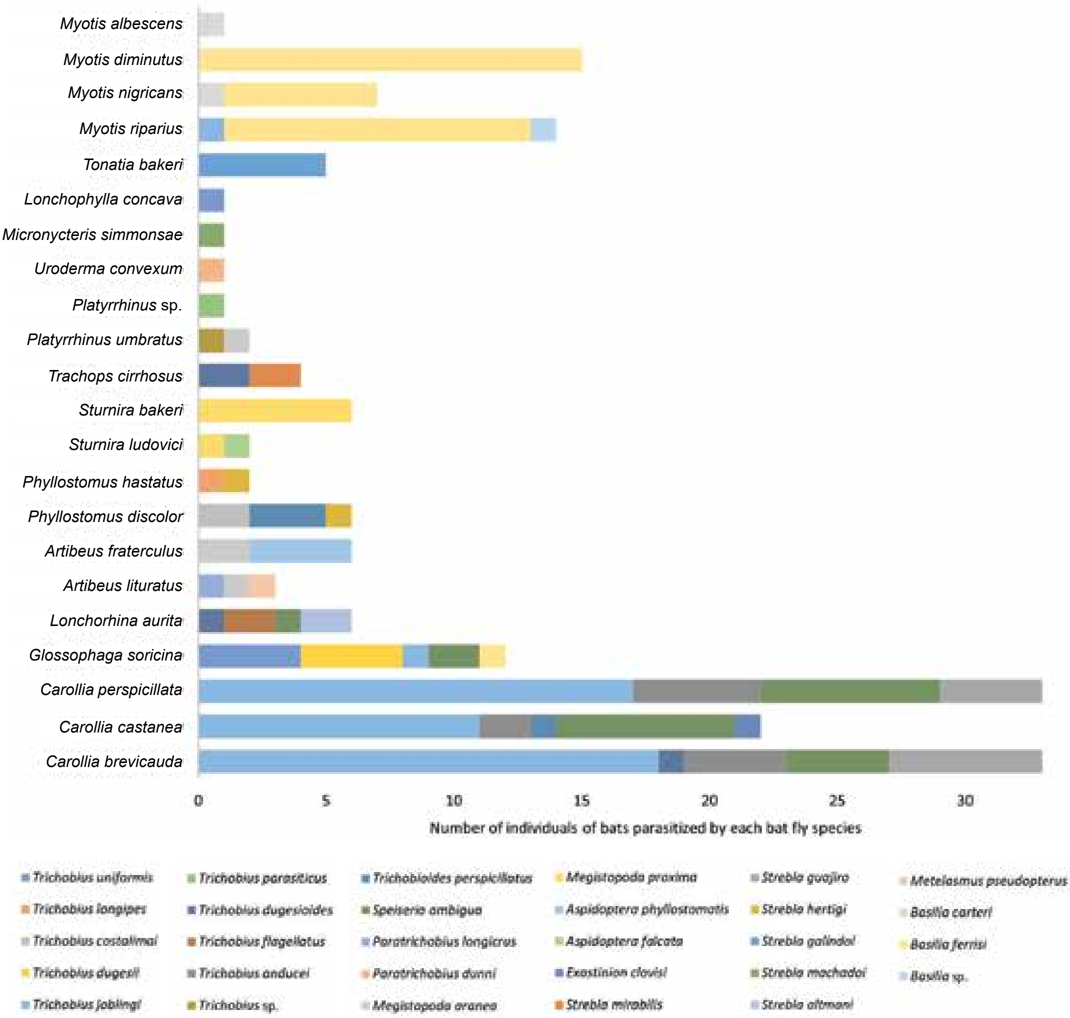

FIGURE 1. Association of bats and their parasitic bat flies from some localities of the Coast of Ecuador.

Identification: The antescutellar setae of *Trichobius dugesii* are shorter, and the setae of the prescutum are gradually reduced towards the discal area. Also, behind the lateral lobe of tergum 1+2, no long setae are evident in females, but in males, sternum 6 is present (Guerrero, 1995a).

Remarks: *Glossophaga soricina* is considered the main host of *Trichobius dugesii* (Dick & Gettinger, 2005). However, in Ecuador, it is also found on *Artibeus lituratus* and *Carollia brevicauda* (Stamper, 2012).

Trichobius joblingi Wenzel, 1966
Figure 3E

Material examined [100]: **Esmeraldas**: Eloy Alfaro, La Tola, Finca Cocadilla; 21.VIII.2017, 2♂ ex *Carollia perspicillata* • Eloy Alfaro, La Tola, Centro de Interpretación Majagual; 21.VIII.2017, 1♂ ex *Glossophaga soricina*, 1♂ ex *Carollia perspicillata* • Eloy Alfaro, Luis Vargas Torres, Playa de Oro; 25.VIII.2017, 1♂, 3♀ ex *Carollia perspicillata* • Quinindé, Rosa Zárate, Jaboncillo, Finca La Esperanza; 09.IX.2021, 4♂, 5♀ ex *Carollia brevicauda*, 1♂ ex *Carollia castanea*, 3♂, 1♀ ex *Carollia perspicillata* • **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 20.XI.2021, 2♂, 1♀ ex *Carollia brevicauda*; 25.XI.2021, 3♂,

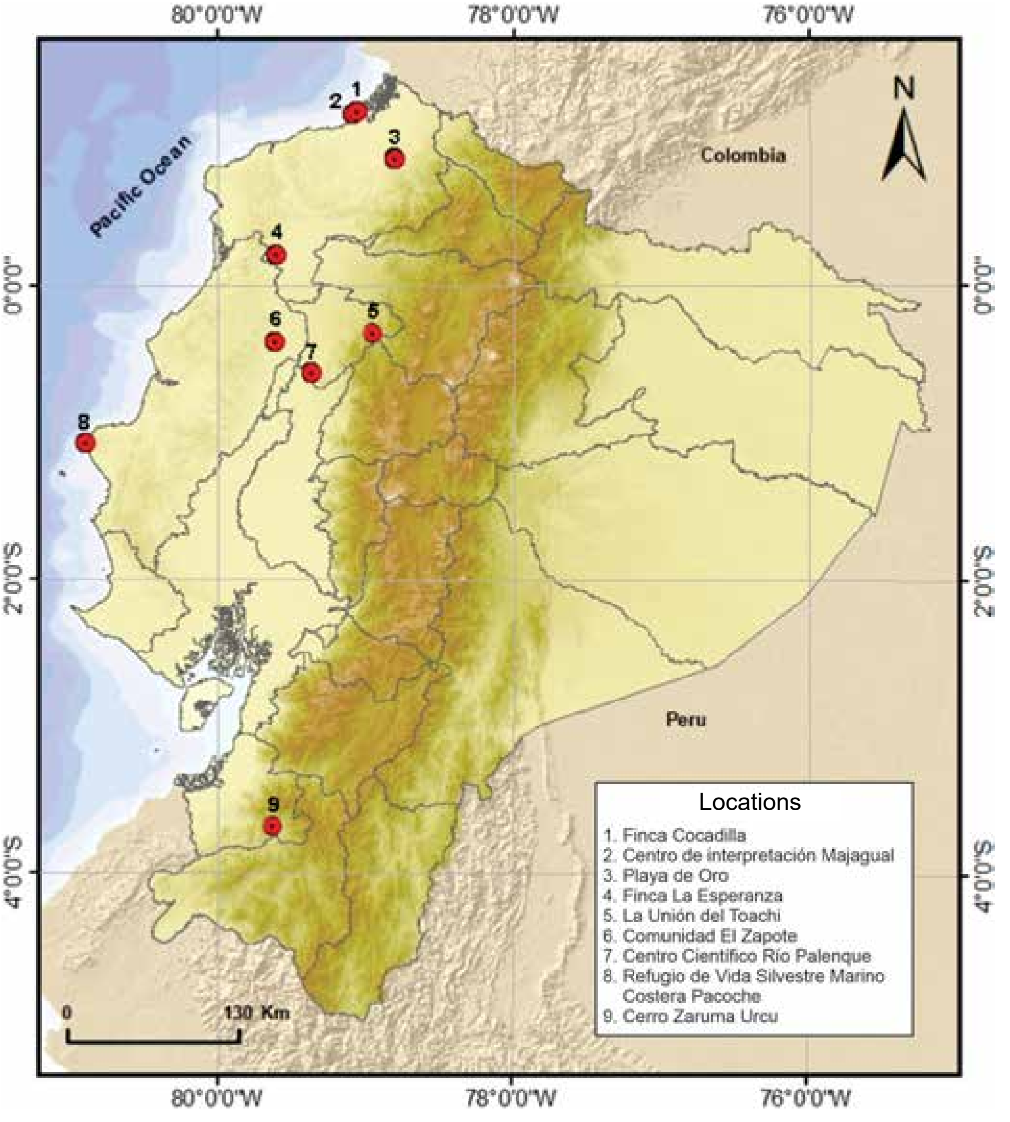

FIGURE 2. Collection localities of bats and their ectoparasites in the provinces of Esmeraldas, Manabí, Santo Domingo de los Tsáchilas, Los Ríos, and El Oro.

2♀ ex *Carollia brevicauda*; 26.XI.2021, 4♂ ex *Carollia brevicauda*; 20.XI.2021, 1♀ ex *Carollia castanea*; 24.XI.2021, 3♂ ex *Carollia castanea*; 25.XI.2021, 1♂ ex *Carollia castanea*; 26.XI.2021, 1♂, 2♀ ex *Carollia castanea*; 19.XI.2021, 1♂, 1♀ ex *Carollia perspicillata*; 23.XI.2021, 3♂, 5♀ ex *Carollia perspicillata*; 24.XI.2021, 1♂, 1♀ ex *Carollia perspicillata*; 26.XI.2021, 1♂, 2♀ ex *Carollia perspicillata*; 19.XI.2021, 1♂ ex *Myotis riparius* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 22.VII.2017, 6♂, 6♀ ex *Carollia brevicauda*; 23.VII.2017, 1♂, 2♀ ex *Carollia brevicauda*; 25.VII.2017, 4♂, 2♀ ex *Carollia brevicauda*; 21.VII.2017, 2♂, 1♀ ex *Carollia castanea*; 24.VII.2017, 3♂, 3♀ ex *Carollia castanea*; 22.VII.2017, 2♂, 5♀ ex *Carollia perspicillata*; 23.VII.2017, 1♂ ex *Carollia perspicillata*; 25.VII.2017, 3♂ ex *Carollia perspicillata*.

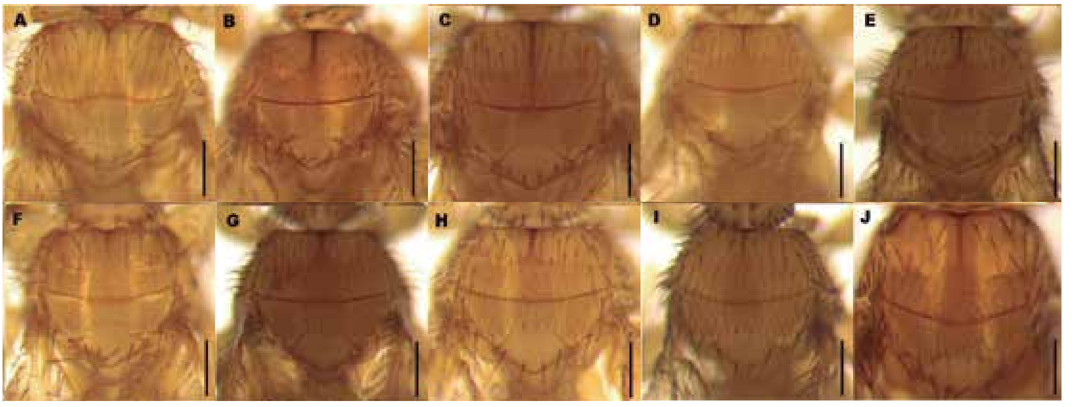

FIGURE 3. Dorsal view of the thorax. A. *Trichobius uniformis*; B. *Trichobius longipes*; C. *Trichobius costalimai*; D. *Trichobius dugesii*; E. *Trichobius joblingi*; F. *Trichobius parasiticus*; G. *Trichobius dugesioides*; H. *Trichobius flagellatus*; I. *Trichobius anducei*; J. *Trichobius* sp. Scale bars: A–I = 0.2 mm; J = 0.3 mm.

Identification: It is possible to differentiate *Trichobius joblingi* by the combination of short and long setae on the antescutellar row and prescutellar setae that gradually shorten to the discal area. Behind the lateral lobe of tergum 1+2 there are two to five long setae in females, while sternum 6 is observed in the males (Guerrero, 1995a).
Remarks: According to Wenzel (1976), *Carollia perspicillata* is the characteristic host of *Trichobius* joblingi, although in Ecuador it is also reported in 10 species of the families Phyllostomidae and Vespertilionidae (Stamper, 2012; Tello, 2005). In this study, we report *Trichobius* joblingi associated with *Glossophaga soricina* and *Myotis riparius*; for the first species, there are no previous mentions of this type of association.

Trichobius parasiticus Gervais, 1844
Figure 3F
Material examined [2]: **El Oro**: Zaruma, Zaruma, Cerro Zaruma Urcu; 2♂ ex *Platyrrhinus* sp.
Identification: The mesonotum of *Trichobius parasiticus* has distinctive characteristics that make it easy to recognize, such as long setae on the anterolateral angles of the prescutum, short setae arranged in a row anterior to the transverse suture and the antescutellar row (Guerrero, 1995a).
Remarks: According to Wenzel (1976), the primary host of *Trichobius parasiticus* is *Desmodus rotundus*, but it has also been documented in *Glossophaga soricina* in Ecuador (Stamper, 2012).

Trichobius dugesioides Wenzel, 1966
Figure 3G
Material examined [25]: **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 21.VII.2017, 2♂, 2♀ ex *Trachops cirrhosus*; 25.VII.2017, 1♂, 1♀ ex *Carollia brevicauda*, 2♂ ex *Lonchorhina aurita*; 26.VII.2017, 9♂, 8♀ ex *Trachops cirrhosus*.
Identification: *Trichobius dugesioides* can be identified by the row of antescutellar setae slightly longer than those preceding it. In addition, sternite 7 has 13 to 14 setae in females, and tergite 9 has 17 to 18 setae in males (Guerrero, 1998).
Remarks: *Trachops cirrhosus* is the main host species of this parasite (Wenzel, 1976). However, in Ecuador, it was also associated with *Phyllostomus elongatus* (Stamper, 2012). In this study, we found this species in association with *Lonchorhina aurita* and *Carollia brevicauda*.

Trichobius flagellatus Wenzel, 1976
Figure 3H
Material examined [14]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 19.XI.2021, 3♂, 7♀ ex *Lonchorhina aurita* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río

Palenque; 25.VII.2017, 2♂, 2♀ ex *Lonchorhina aurita*.
Identification: In this species, the setae of the antescutellar row are the same size as those preceding them. Also, very small setae are found behind the lateral lobes of tergum 1+2 of females and males have 22 to 25 setae on tergum 9 (Guerrero, 1995a).
Remarks: *Lonchorhina aurita* is the main host of *Trichobius flagellatus* (Wenzel, 1976).

Trichobius anducei Guerrero, 1998
Figure 3I
Material examined [14]: **Esmeraldas**: Eloy Alfaro, Luis Vargas Torres, Playa de Oro; 25.VIII.2017, 1♂ ex *Carollia perspicillata* • **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 20.XI.2021, 1♀ ex *Carollia brevicauda*; 23.XI.2021, 1♀ ex *Carollia perspicillata*; 24.XI.2021, 1♂, 1♀ ex *Carollia brevicauda*, 1♀ ex *Carollia castanea*; 26.XI.2021, 1♂ ex *Carollia perspicillata* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 22.VII.2017, 1♂ ex *Carollia brevicauda*; 23.VII.2017, 1♀ ex *Carollia brevicauda*; 25.VII.2017, 1♂, 1♀ ex *Carollia castanea*, 3♂ ex *Carollia perspicillata*.
Identification: Females of *Trichobius anducei* differ in having a more extended band of setae on the lateral margin of the abdomen, as well as 9 to 11 setae on sternite 7. In contrast, the tergite 9 of males has 11 to 12 setae (Guerrero, 1998).
Remarks: *Trichobius anducei* parasitizes mainly *Carollia perspicillata* (Guerrero, 2019; Hiller et al., 2021); however, in Ecuador, it was also associated with *Carollia brevicauda* (Stamper, 2012). Furthermore, in this study, we document that *Trichobius anducei* parasitizes *Carollia castanea*.

Trichobius sp. (complex *dugesii*)
Figure 3J
Material examined [1]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 19.XI.2021, 1♂ ex *Platyrrhinus umbratus*.
Remarks: We were unable to identify this species; however, it has specific characteristics close to *Trichobius angulatus* such as the angled transverse suture, prescutellar setae shortening towards the center and setae of the antescutellar row longer than the predecessors (Guerrero, 1995a).

Genus *Trichobioides* Wenzel, 1966
Trichobioides perspicillatus (Pessôa & Galvao, 1937)
Figure 4
Material examined [15]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 23.XI.2021, 5♂, 2♀ ex *Phyllostomus discolor*; 26.XI.2021, 1♂ ex *Carollia castanea*; 27.XI.2021, 2♂, 2♀ ex *Phyllostomus discolor* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 21.VII.2017, 2♂, 1♀ ex *Phyllostomus discolor*.
Identification: There is only one species in the genus *Trichobioides*. Although it is very similar to *Trichobius*, the difference lies in the median suture that extends to the transverse suture but does not unite. Also, a row of short and long antescutellar setae is present (Guerrero, 1994b).
Remarks: According to Wenzel (1976), *Trichobioides perspicillatus* is the parasite commonly associated with *Phyllostomus discolor*, a situation also evidenced by Stamper (2012) in Ecuador. In this study, we found an association with *Carollia castanea* that has not previously documented.

FIGURE 4. *Trichobioides perspicillatus*. Scale bars = 2 mm.

Genus *Speiseria* Kessel, 1925
Speiseria ambigua Kessel, 1925
Figure 5
Material examined [23]: **Esmeraldas**: Eloy Alfaro, La Tola, Finca Cocadilla; 21.VIII.2017, 1♂, 1♀ ex *Glossophaga soricina*, 1♀ ex *Carollia perspicillata* • Eloy Alfaro, La Tola, Centro de Interpretación Majagual; 21.VIII.2017, 1♂ ex *Carollia perspicillata* • Eloy Alfaro, Luis Vargas Torres, Playa de Oro; 25.VIII.2017, 1♀ ex *Carollia castanea*, 1♂, 1♀ ex *Carollia perspicillata* • **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 19.XI.2021, 1♂ ex *Lonchorhina aurita*; 20.XI.2021, 1♂, 1♀ ex *Carollia castanea*; 23.XI.2021, 1♂ ex *Carollia castanea*; 24.XI.2021, 1♂ ex *Carollia brevicauda*, 1♀ ex *Carollia castanea*, 1♂ ex *Carollia perspicillata*; 25.XI.2021, 1♂ ex *Carollia castanea* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 22.VII.2017, 3♂, 2♀ ex *Carollia brevicauda*, 1♀ ex *Carollia castanea*; 25.VII.2017, 1♂, 1♀ ex *Carollia perspicillata*.
Identification: In this species, females are distinguished by having tergum 7 longer than the supra-anal plate and with parallel sides. In contrast, males exhibit strongly curved postgonites and tergum 9 between nine and ten setae (Guerrero, 1994b).
Remarks: According to Wenzel (1976), *Speiseria ambigua* infests mainly *Carollia perspicillata*; but in Ecuador, it was also associated with several species of the family Phyllostomidae and with greater incidence in bats of the genus *Carollia* (Stamper, 2012; Tello, 2005). Additionally, during the research, we documented a new association with *Glossophaga soricina*.

FIGURE 5. *Speiseria ambigua*. Scale bars = 2 mm.

Genus *Paratrichobius* Costa Lima, 1921
Paratrichobius longicrus (Miranda-Ribeiro, 1907)
Figure 6A
Material examined [2]: **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 25.VII.2017, 1♂, 1♀ ex *Artibeus lituratus*.
Identification: The relevant characteristics of this species are the rounded anterior angles on the pronotum and the internal face of the profemurs covered only by small setae accompanied by a row of six thick spines (Guerrero, 1994b).
Remarks: *Artibeus lituratus* is the characteristic host of *Paratrichobius longicrus* (Dick &

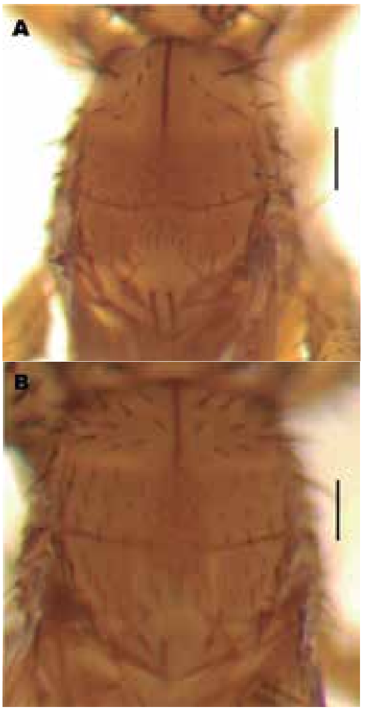

FIGURE 6. Dorsal view of the thorax: A. *Paratrichobius longicrus*; B. *Paratrichobius dunni*. Scale bars = 0.3 mm.

Gettinger, 2005; Wenzel,1976), and the same host has been reported in Ecuador (Stamper, 2012).

Paratrichobius dunni (Curran, 1935)
Figure 6B
Material examined [4]: **Manabí**: Manta, San Lorenzo, Refugio de Vida Silvestre Marino Costera Pacoche; 09.IX.2017, 1♂, 3♀ ex *Uroderma convexum*.
Identification: *Paratrichobius dunni* was identified by the straight anterior angles of the pronotum and its profemurs, with two to three short spines extending parallel to a line of six thick spines on the inner side (Guerrero, 1994b).
Remarks: It is mainly found in species of the genus *Uroderma*, especially in *Uroderma bilobatum* (Guerrero, 2019; Hiller et al., 2021).

Genus *Megistopoda* Macquart, 1852
Megistopoda aranea (Coquillet, 1899)
Figure 7A
Material examined [8]: **Manabí**: Manta, San Lorenzo, Refugio de Vida Silvestre Marino Costera Pacoche; 09.IX.2017, 1♂, 1♀ ex *Artibeus fraterculus* • El Carmen, El Carmen, comunidad El Zapote; 19.XI.2021, 3♂, 1♀ ex *Platyrrhinus umbratus* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 22.VII.2017, 1♂, 1♀ ex *Artibeus lituratus*.

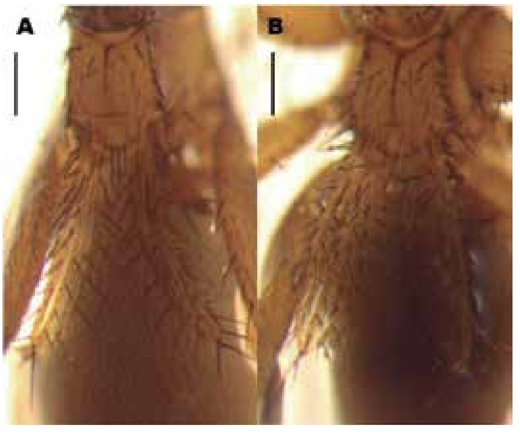

FIGURE 7. Wings and dorsal view of the thorax. A. *Megistopoda aranea*; B. *Megistopoda proxima*. Scale bars = 0.2 mm.

Identification: This species has narrow wings with four longitudinal veins, long hind legs, and a scutellum with two macrosetae (Guerrero, 1994b).
Remarks: Dick & Gettinger (2005) state that *Artibeus fimbriatus* and *A. jamaicensis* are the primary hosts of *Megistopoda aranea*. However, Stamper (2012) indicates that in Ecuador, it has been reported in association with several species of the family Phyllostomidae. In addition, in the study, we document the association with *Platyrrhinus umbratus*.

Megistopoda proxima (Seguy, 1926)
Figure 7B
Material examined [9]: **Esmeraldas**: Quinindé, Rosa Zárate, Jaboncillo, Finca La Esperanza; 09.IX.2021, 1♂ ex *Sturnira bakeri* • **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 25.XI.2021, 3♀ ex *Sturnira bakeri*; 26.XI.2021, 1♀ ex *Sturnira bakeri*; 26.XI.2021, 1♀ ex *Sturnira ludovici* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 22.VII.2017, 1♂ ex *Sturnira bakeri*; 25.VII.2017, 1♀ ex *Sturnira bakeri*; 27.VII.2017, 1♀ ex *Sturnira bakeri*.
Identification: *Megistopoda proxima* is distinguished by its broad wings with six longitudinal veins and the scutellum with four macrosetae (Guerrero, 1994b).
Remarks: Dick and Gettinger (2005) mention that *Sturnira lilium* is the main host of *Megistopoda proxima*. However, in Ecuador, it is also found in different species of the genus *Sturnira* (Stamper, 2012).

Genus *Aspidoptera* Coquillett, 1899
Aspidoptera phyllostomatis (Perty, 1833)
Figure 8A
Material examined [5]: **Manabí**: Manta, San Lorenzo, Refugio de Vida Silvestre Marino Costera Pacoche; 09.IX.2017, 2♂, 2♀ ex *Artibeus fraterculus*; 11.IX.2017, 1♀ ex *Artibeus fraterculus*.
Identification: Unlike *Aspidoptera falcata*, the mesepisternum of this species exhibits long setae on the dorsal side and shorter on the periphery. Likewise, the supra-anal plate of females has a short seta; in males, the postgonites are slightly curved (Guerrero, 1995b).

Remarks: *Aspidoptera phyllostomatis* is mainly found in *Artibeus jamaicensis* (Wenzel, 1976). However, in Ecuador, we reported in other species of the genus *Artibeus* (Stamper, 2012).

Aspidoptera falcata Wenzel, 1976
Figure 8B
Material examined [2]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 26.XI.2021, 1♂, 1♀ ex *Sturnira ludovici*.
Identification: In contrast to *Aspidoptera phyllostomatis*, this species has a more setose appearance and the setae on the dorsal surface of the mesepisternum are long. In addition, in females, the supra-anal plate includes six apical macrosetae and a short seta on each side of the anterior ones; on the other hand, males have very curved postgonites (Wenzel et al., 1966; Wenzel,1976).
Remarks: Although *Sturnira lilium* is the primary host of *Aspidoptera falcata* (Dick & Gettinger, 2005), most of the parasitized species in Ecuador belong to the genus *Sturnira* (Stamper, 2012).

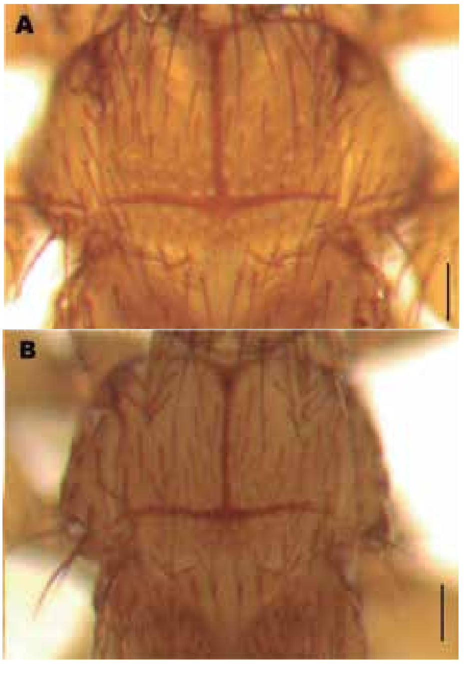

Figure 8. Dorsal view of the thorax. A. *Aspidoptera phyllostomatis*; B. *Aspidoptera falcata*. Scale bars = 0.3 mm.

Genus *Exastinion* Wenzel, 1966
Exastinion clovisi (Pessôa & Guimarães, 1936)
Figure 9
Material examined [1]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 19.XI.2021, 1♀ ex *Carollia castanea*.
Identification: This species is characterized by the presence of eight setae on the scutum, and a very setose area on sternum 2 that extends anteriorly to the middle. In addition, females have a group of five setae on the abdominal connexivum that are longer than the following ones (Wenzel, 1976).
Remarks: In this study, we document that *Exastinion clovisi* parasitizes *Carollia castanea*; Stamper (2012) also evidenced its association with *Glossophaga soricina* in Ecuador. The characteristic host is *Anoura geoffroyi* (Guerrero, 2019).

Subfamily Streblinae Jobling, 1936

Genus *Strebla* Wiedemann, 1824
Strebla mirabilis (Waterhouse, 1879)
Figure 10A
Material examined [21]: **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 21.VII.2017, 1♂ ex *Trachops cirrhosus*;

Figure 9. *Exastinion clovisi*. Scale bars = 1 mm.

26.VII.2017, 8♂, 12♀ ex *Trachops cirrhosus*.
Identification: Unlike other species, *Strebla mirabilis* has eyes with several facets, a pointed anterior end of the postvertex that forms an angle close to 90 degrees and, finally, all setae are strong. In addition, the metatibia has two to three macrosetae; and on the mesonotum, between the transverse and pigmented suture, three rows of setae are located (Guerrero, 2019; Wenzel et al., 1966).
Remarks: Although *Strebla mirabilis* is commonly associated with *Trachops cirrhosus* (Wenzel, 1976), hosts in Ecuador include several species of the family Phyllostomidae (Stamper, 2012).

Strebla guajiro (García & Casal, 1965)
Figure 10B
Material examined [16]: **Esmeraldas**: Quinindé, Rosa Zárate, Jaboncillo, Finca La Esperanza; 09.IX.2021, 1♂ ex *Carollia brevicauda* • Eloy Alfaro, La Tola, Finca Cocadilla; 21.VIII.2017, 1♂ ex *Carollia perspicillata* • Eloy Alfaro, La Tola, Centro de Interpretación Majagual; 21.VIII.2017, 1♀ ex *Carollia perspicillata* • Eloy Alfaro, Luis Vargas Torres, Playa de Oro; 25.VIII.2017, 1♀ ex *Carollia perspicillata* • **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 25.XI.2021, 1♂, 1♀ ex *Carollia brevicauda*; 26.XI.2021, 1♀ ex *Carollia perspicillata* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 22.VII.2017, 5♂, 4♀ ex *Carollia brevicauda*.
Identification: The anterior end of the postvertex of *Strebla guajiro* is more rounded than in other species and forms an angle of fewer than 90 degrees. All its setae are strong, and two to three rows are found between the transverse and pigmented suture, as well as two or three mac-

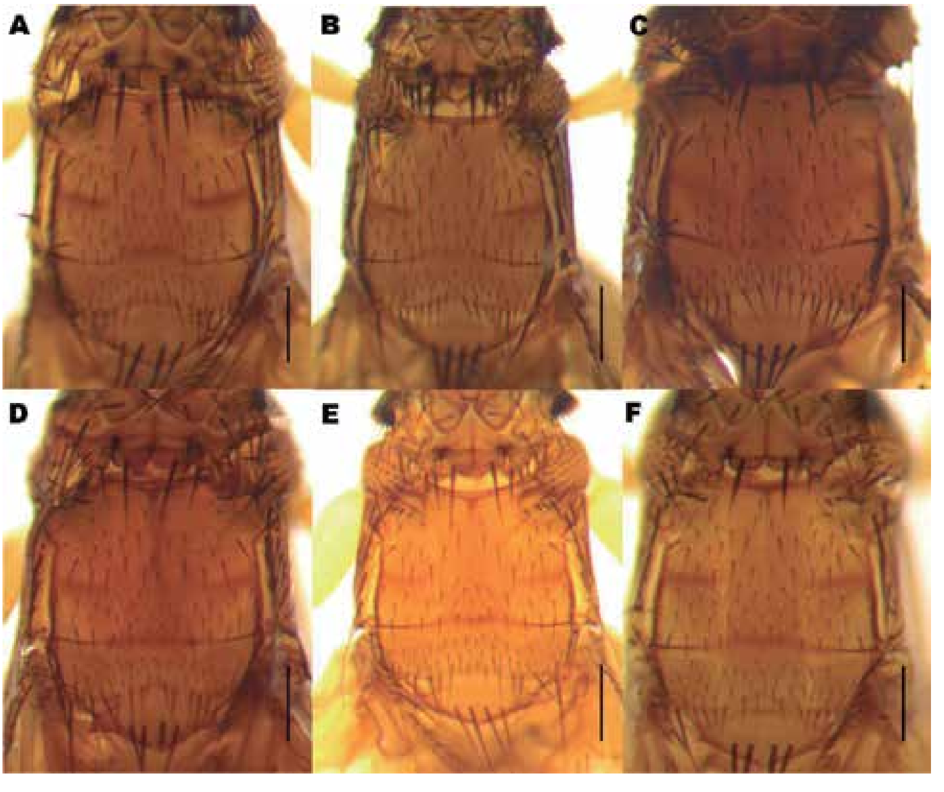

Figure 10. Dorsal view of the thorax, postvertex and occipital lobes. A. *Strebla mirabilis*; B. *Strebla guajiro*; C. *Strebla hertigi*; D. *Strebla galindoi*; E. *Strebla machadoi*; F. *Strebla altmani*. Scale bars: A, B, D = 0.5 mm; E, F = 0.3 mm; C = 0.6 mm.

rosetae on the metatibia (Guerrero, 1996; Wenzel et al., 1966).
Remarks: *Strebla guajiro* is mainly associated with *Carollia perspicillata* (Dick & Gettinger, 2005; Wenzel, 1976). In the case of Ecuador, it usually also parasitizes several species of the family Phyllostomidae, especially bats of the genus *Carollia* (Stamper, 2012; Tello, 2005).

Strebla hertigi Wenzel, 1966
Figure 10C
Material examined [2]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 23.XI.2021, 1♀ ex *Phyllostomus hastatus*; 27.XI.2021, 1♂ ex *Phyllostomus discolor*.
Identification: *Strebla hertigi* has a distinctive subquadrate postvertex, the anterior end of which forms an angle greater than 120 degrees; in addition, the internal setae of the occipital plates are short; there are three rows of setae located between the transverse and pigmented sutures on the mesonotum; finally, the metatibia has two to three macrosetae (Guerrero, 1996; Wenzel et al., 1966).
Remarks: *Strebla hertigi* is a characteristic parasite of *Phyllostomus discolor* (Wenzel, 1976). According to Stamper (2012), this species is associated with *Phyllostomus discolor* and *Phyllostomus hastatus* in Ecuador.

Strebla galindoi Wenzel, 1966
Figure 10D
Material examined [32]: **Esmeraldas**: Eloy Alfaro, Luis Vargas Torres, Playa de Oro; 25.VIII.2017, 19♂, 13♀ ex *Tonatia bakeri*.
Identification: It is possible to recognize this species by several characteristics: it has eight facets on the eyes; the anterior end of the postvertex forms an angle greater than 120 degrees; its setae are thin and elongated; before the pigmented suture on the mesonotum, a row of longer setae stands out; finally, it has three large setae on the metatibia (Guerrero, 1996).
Remarks: *Tonatia bidens* is the characteristic host of *Strebla galindoi* (Wenzel, 1976). In Ecuador, this species parasitizes those of the genus *Tonatia* (Stamper, 2012).

Strebla machadoi Wenzel, 1966
Figure 10E
Material examined [2]: **Santo Domingo de los Tsáchilas**: Santo Domingo de los Colorados, Alluriquín, La Unión del Toachi; 09.IX.2017, 2♂ ex *Micronycteris simmonsae*.
Identification: *Strebla machadoi* has eyes with a single facet, a postvertex with a pointed anterior end forming an angle of fewer than 45 degrees, and two dorsal rows containing six to eight setae longer than the rest on the metatibia (Guerrero, 1996; Wenzel et al., 1966).
Remarks: *Strebla machadoi* parasitizes some species of *Micronycteris* (Guerrero, 2019).

Strebla altmani Wenzel, 1966
Figure 10F
Material examined [5]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 19.IX.2021, 2♂, 1♀ ex *Lonchorhina aurita* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 25.VII.2017, 1♂, 1♀ ex *Lonchorhina aurita*.
Identification: This species is distinguished by the following characteristics: six facets are identified on the eyes; the anterior end of the postvertex is pointed and forms an angle close to 90 degrees; the internal setae of the occipital plates are very short and thin; between the transverse and pigmented suture of the mesonotum there are two to three rows of setae; finally, two of the setae of the metatibia are noticeably longer (Guerrero, 1996).
Remarks: *Lonchorhina aurita* is the characteristic host of *Strebla altmani* (Guerrero, 2019).

Genus *Metelasmus* Coquillett, 1907
Metelasmus pseudopterus Coquillett, 1907
Figure 11
Material examined [1]: **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 23.IX.2021, 1♀ ex *Artibeus lituratus*.
Identification: According to Guerrero (2019), only one species of the genus *Metelasmus* has been determined so far. Its characteristics include the following: well-developed frontoclypeus; large postvertex, with triangular anterior margin and flattened posterior margin and two strong setae; it also has a hook-shaped postgena with a remiform seta; complete ctenidium;

Figure 11. *Metelasmus pseudopterus*. Scale bars = 3 mm.

small wings with reduced venation; posterior tibiae with very small setae and, finally, setae that completely covering the dorsal connexivum (Guerrero, 2019; Jobling, 1936).

Remarks: *Metelasmus pseudopterus* was reported by Wenzel (1976) as a characteristic parasite of *Artibeus jamaicensis*. In Ecuador, it also parasitizes some species of *Artibeus* (Stamper, 2012).

Family Nycteribiidae Samouelle, 1819
Subfamily Nycteribiinae Samouelle, 1819

Genus *Basilia* Miranda-Ribeiro, 1903
Basilia carteri Scott, 1936
Figure 12A

Material examined [7]: **Esmeraldas**: Quinindé, Rosa Zárate, Jaboncillo, Finca La Esperanza; 09.IX.2021, 1♂, 1♀ ex *Myotis nigricans* • **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 24.XI.2021, 2♂, 3♀ ex *Myotis albescens*.

Identification: Females of *Basilia carteri* are differentiated by tergite 1 having eight to nine long setae on the posterior margin, while tergite 2 has a subcodiform shape with very few disc-like setae. Conversely, males exhibit a sternite V with two asymmetrical rows of setae (Graciolli, 2004).

Remarks: *Basilia carteri* has been documented in association with *Myotis albescens*, *M. levis*, *M. nigricans*, and *M. riparius*; also, with *Tadarida brasiliensis* (Autino et al., 2009).

Basilia ferrisi Schuurmans Stekhoven, 1931
Figure 12B

Material examined [88]: **Esmeraldas**: Eloy Alfaro, La Tola, Finca Cocadilla; 20.XII.2017, 1♂ ex *Glossophaga soricina* • Eloy Alfaro, La Tola, Centro de Interpretación Majagual; 23.VIII.2017, 1♀ ex *Myotis nigricans* • Eloy Alfaro, Luis Vargas Torres, Playa de Oro; 23. VIII.2017, 1♀ ex

Figure 12. Dorsal view of the abdomen. A. *Basilia carteri*; B. *Basilia ferrisi*; C. *Basilia* sp. Scale bars: A = 0.7 mm; B = 0.9 mm; C = 1 mm.

Myotis riparius; 25.VIII.2017, 8♂, 26♀ ex *Myotis riparius* • **Manabí**: El Carmen, El Carmen, comunidad El Zapote; 26.XI.2021, 2♂, 1♀ ex *Myotis riparius* • **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 20.VII.2017, 6♂, 15♀ ex *Myotis diminutus*; 24.VII.2017, 5♂, 6♀ ex *Myotis diminutus*; 27.VII.2017, 1♂, 7♀ ex *Myotis diminutus*; 27.VII.2017, 3♂, 5♀ ex *Myotis nigricans*.

Identification: Tergite 1 of females is very long in this species and has six to nine bristles on the posterior margin. In contrast, the sternite V of males is slightly rounded and with a small notch in the middle (Guimarães & D'Andretta, 1956; Peterson, 1959).

Remarks: *Basilia ferrisi* is associated with *Carollia brevicauda*, *Histiotus montanus*, *Myotis nigricans*, and *M. keaysi* (Raigosa et al., 2020); however, in Ecuador, it was also associated with bats of the genus *Myotis* and *Platyrrhinus matapalensis* (Stamper, 2012). In addition, we report the association with *Myotis diminutus* and *Glossophaga soricina*.

Basilia sp. (group *ferruginea*)

Figure 12C

Material examined [2]: **Los Ríos**: Buena Fe, Patricia Pilar, Centro Científico Río Palenque; 21.VII.2017, 2♀ ex *Myotis riparius*.

Remarks: We were unable to identify this species; however, the bilobed tergite 2 is a characteristic of the *ferruginea* group (Theodor, 1967).

DISCUSSION

Ecuador, known for its remarkable biodiversity (Mittermeier et al., 2011), lacks comprehensive information about specific taxonomic groups such as the parasitic bat flies from the families Streblidae and Nycteribiidae. Most of the known records come from localities in Amazonia, and only five species have been documented in the few studies conducted on the Coast (Camacho et al., 2014; Correa et al., 2019; Guerrero, 1997; Guimarães & D'Andretta, 1956; Liu et al., 2020; Stamper, 2012; Tello, 2005). This study aims to address this knowledge gap by providing valuable insights. Our findings contribute to the knowledge of bat flies of the families Streblidae and Nycteribiidae, as we have documented new records for Ecuador (*Trichobius flagellatus*, *Paratrichobius dunni*, *Strebla machadoi*, *S. altmani*, and *Basilia carteri*), bringing the species richness to 61. In addition, their geographic range has expanded, as they had previously only been documented in countries such as Argentina, Panama, Mexico, and Venezuela (Cuxim-Koyoc et al., 2018; Guerrero, 2019; Hiller et al., 2021; Oscherov et al., 2012). Notably, in the coastal region, the species count has shown a substantial increase from 5 to 31.

Stamper (2012), documented 42 species of bat flies in Ecuador, 19 of which we report in this study. However, Stamper's study provided only general locality descriptions without additional information that could establish a direct association between each specimen and its collection site. This lack of specific data has raised concerns regarding the accurate distribution patterns of these species. Our research considers these findings as confirmed records specifically within the Ecuadorian coastal region, offering more precise insights into their distribution. *Trichobius joblingi*, *Speiseria ambigua*, and *Strebla guajiro* had already been documented in Morona Santiago, Orellana, Pastaza, Cotopaxi, Pichincha, Esmeraldas, and Santo Domingo de los Tsáchilas (Tello, 2005). This study extends the records to Manabí and Los Ríos.

The most abundant fly parasite was *Trichobius joblingi*, and some of the factors influencing these results are probably due to the fact that it is a generalist species (Barbier & Bernard, 2017; Tlapaya-Romero et al., 2015), which has been reported parasitizing several bat species (de Groot et al., 2020; Santos et al., 2016; Soares et al., 2017). Additionally, previous research mentions that parasite abundance is related to host abundance (Ascuntar-Osnas et al., 2020; Cuxim-Koyoc et al., 2015). *Carollia perspicillata* is the main host (Wenzel, 1976), and in the present investigation, it is documented among the most abundant bat species, along with *Carollia brevicauda* and *C. castanea*, all widely distributed on the Ecuadorian Coast (Tirira, 2017).

Bat flies are highly host-specific, that is, they parasitize a single bat species (Dick & Gettinger, 2005; Wenzel et al., 1966; Wenzel, 1976;).

However, we report some novel interactions, such as the association of one bat fly species with multiple host species, as well as the presence of several bat fly species on the same host, which have also been documented in previous research (Barbier & Graciolli, 2016; da Silva et al., 2023; Durán et al., 2017; França et al., 2013; Lira-Olguin et al., 2020; Menezes et al., 2021). Factors such as sample contamination, transfers due to disturbance at the time of capture (Dick, 2007; Fritz, 1983), and accidental transfers when bat hosts share roosts with other species (Aguiar & Antonini, 2016; Barbier & Bernard, 2017; Hernández-Martínez et al., 2019; ter Hofstede et al., 2004), could explain these findings. It is important to clarify that the aim of the present study did not include at any time to assess specificity or factors influencing host-parasite associations. Therefore, these aspects were not explored to avoid misinterpretations, but relevant association findings that may be the subject of future research were documented.

It is important to point out that during the taxonomic identification process there were certain limitations since it was not possible to determine the species level in three individuals, due to taxonomical publications with ambiguous descriptions and outdated illustrations. The taxonomic keys used for the family Streblidae are the result of very complete works that include the description of a large number of species. On the other hand, the information on the family Nycteribiidae is scattered; in fact, most of the available works describe mainly females and relegate the identification of males to the background. Several of these problems coincide with those described by Lira-Olguin et al. (2020) and Trujillo-Pahua & Ibáñez-Bernal (2019, 2020), demonstrating the need for further research on this taxon.

According to studies by Barbier & Bernard (2017) and Dick & Gettinger (2005), the great variety of bat fly species is correlated with host diversity. Under this premise, we consider that the current species richness of the families Streblidae and Nycteribiidae is still underestimated, since 179 species of bats have been reported in Ecuador (Tirira et al., 2022), 120 of them in the Coast (Brito et al., 2023; Carrera et al., 2010). Along the same lines, in countries of the region with a similar number of bat species, there are even twice as many records of flies that parasitize them, in contrast to those documented at the national level. A notable example is Brazil, which has 181 species of bats (Garbino et al., 2022) and 119 species of the family Streblidae and Nycteribiidae (Graciolli & Hrycyna, 2023; Hrycyna et al., 2019); it also ranks among the nations with the highest number of publications on the taxonomic group under discussion (Urbieta et al., 2022). This shows that there are several species to be identified and, therefore, it is relevant to propose more studies such as the one carried out throughout this research.

The natural history collections reflect the planet's biota over time (Bradley et al., 2014). Therefore, the results of this research, obtained based on museum specimens and associated data, provide valuable information on this taxonomic group in the country, which evidences the importance of the collections and the need to continue collecting more specimens as possible.

Future research should include the analysis of specimens in other regions and from different families, as well as the use of molecular techniques that facilitate species identification and validate the findings of host-parasite interaction reported in this study. Undoubtedly, works such as this one contributes to expanding the knowledge of the diversity of parasitic bat flies in the country and consolidate the basis for future research to address ecological and evolutionary questions due to the close relationship of bat flies with their hosts (Brown et al., 2022; Hiller et al., 2020). They are also important in the public health area since bat flies are reservoirs of viruses and bacteria and could act as vectors of zoonotic pathogens (Lee et al., 2021; Morse et al., 2012; Ramirez-Martinez et al., 2021).

CONCLUSION

The study contributed to increasing the knowledge of the diversity of parasitic bat flies as well as broadening their distribution. The document also consolidates baseline information on host-parasite associations and establishes the first collection with the largest number of identified bat fly species of the families Streblidae and Nycteribiidae in the Ecuadorian coastal region.

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Appendix 1
Toponymic index

El Oro

Zaruma Urcu, Cerro (03°41’01.6” S, 79°37’21.4” W; 1126 m a.s.l.). *Trichobius parasiticus*.

Esmeraldas

Cocadilla, Finca (01°11’29.2” N, 79°03’07.7” W; 5 m a.s.l.). *Trichobius dugesii*, *T. joblingi*, *Speiseria ambigua*, *Strebla guajiro*, *Basilia ferrisi*.

La Esperanza, Finca (00°12’54.3” N, 79°35’54.9” W; 100 m a.s.l.). *Trichobius joblingi*, *Strebla guajiro*, *Megistopoda proxima*, *Basilia carteri*.

Majagual, Centro de Interpretación (01°10’23.0” N, 79°04’45.8” W; 11 m a.s.l.). *Trichobius dugesii*, *T. joblingi*, *Speiseria ambigua*, *Strebla guajiro*, *Basilia ferrisi*.

Playa de Oro (00°52’33.0” N, 78°47’40.7” W; 113 m a.s.l.). *Trichobius joblingi*, *T. anducei*, *Speiseria ambigua*, *Strebla guajiro*, *S. galindoi*, *Basilia ferrisi*.

Los Ríos

Río Palenque, Centro Científico (00°35’19.8” S, 79°21’39.8” W; 150 m a.s.l.). *Trichobius uniformis*, *T. longipes*, *T. costalimai*, *T. joblingi*, *T. dugesioides*, *T. flagellatus*, *T. anducei*, *Trichobioides perspicillatus*, *Speiseria ambigua*, *Paratrichobius longicrus*, *Megistopoda aranea*, *M. proxima*, *Strebla mirabilis*, *S. guajiro*, *S. altmani*, *Basilia ferrisi*, *Basilia* sp.

Manabí

El Zapote, comunidad (00°22’31.4” S, 79°36’ 16.3” W; 200 m a.s.l.). *Trichobius uniformis*, *T. costalimai*, *T. joblingi*, *T. flagellatus*, *T. anducei*, *Trichobius* sp., *Trichobioides perspicillatus*, *Speiseria ambigua*, *Megistopoda aranea*, *M. proxima*, *Aspidoptera falcata*, *Exastinion clovisi*, *Strebla guajiro*, *S. hertigi*, *S. altmani*, *Metelasmus pseudopterus*, *Basilia carteri*, *B. ferrisi*.

Pacoche, Refugio de Vida Silvestre Marino Costera (01°04’00.91” S, 80°53’20.00” W; 118 m a.s.l.) *Paratrichobius dunni*, *Megistopoda aranea*, *Aspidoptera phyllostomatis*.

Santo Domingo de los Tsáchilas

La Unión del Toachi (00°19’14.2”S, 78°57’08.8” W; 811 m a.s.l.). *Strebla machadoi*.

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SCIENTIFIC NOTE

First report of *Thyroptera tricolor* (Chiroptera: Thyropteridae) caught in a web of *Eriophora* sp. (Araneae: Araneidae) in the Ecuadorian Amazon

Primer reporte de *Thyroptera tricolor* (Chiroptera: Thyropteridae) capturado en una telaraña de *Eriophora* sp. (Araneae: Araneidae) en la Amazonía de Ecuador

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ABSTRACT

Predation of bats by large arthropods has rarely been documented. Here we describe the first record of a Spix's disk-winged bat (*Thyroptera tricolor*) caught in a web of *Eriophora* sp. in Yasuní National Park, Ecuador. This observation contributes to the knowledge of bat biology and predator-prey interactions in the Amazon region.

Keywords: arthropod, ecology, predator-prey interaction, spider, Spix's Disk-winged Bat, tropical rainforest.

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RESUMEN

La depredación de murciélagos por grandes artrópodos se ha documentado con poca frecuencia. Aquí describimos el primer registro de captura de un murciélago de alas de disco de Spix (*Thyroptera tricolor*) en una red de *Eriophora* sp. en el Parque Nacional Yasuní, Ecuador. Esta observación contribuye al conocimiento de la biología de los murciélagos y de las interacciones depredador-presa en la región Amazónica.

Palabras clave: araña, artrópodo, bosque húmedo tropical, ecología, interacción depredador-presa, murciélago de ventosas de Spix.

The range of Spix's disk-winged bat (*Thyroptera tricolor*) extends from Mexico to southeast Brazil (Reyes-Amaya et al., 2016). In Ecuador, this species inhabits tropical and subtropical rainforst on the northern part of the coast, in the foothills of the Andes, and in the Amazon region (Tirira, 2017). It feeds on a wide variety of arthropods, which it mostly obtains by capturing them from the substrate (Dechmann et al., 2006). It has short and wide wings allowing for slow and maneuverable flight, necessary to capture leafhoppers and jumping spiders (Chaverri & Kunz, 2011). There is little information about its ecology. Its morphological adaptation to its unusual resting behavior is its most distinctive characteristic (Vonhof et al., 2004).

The most common natural predators of bats are owls, hawks, and snakes (Nyffeler & Knörnschild, 2013). However, predation by big arthropods has also been reported, although less frequently (de Noronha et al., 2015; Nyffeler & Knörnschild, 2013). There are reports of five families of bats as prey for spiders: Emballonuridae, Hipposideridae, Phyllostomidae Rhinolophidae, and Vespertilionidae (Nyffeler & Knörnschild, 2013), among which two families (Vespertilionidae and Emballonuridae) have been reported as prey for spiders belonging to the genus *Eriophora* (Nyffeler & Knörnschild, 2013). There are four reported cases of bats captured and predated by *Eriophora fuliginea* (Nyffeler & Knörnschild, 2013). In Ecuador, there is only one report of predation of *Myotis nigricans* by a tarantula of the genus **Avicularia** (Theraphosidae) in a tropical rainforest in the eastern part of the country (Nyffeler & Knörnschild, 2013).

In this paper, we report the first record of *Thyroptera tricolor* caught in the web of *Eriophora* sp. (Araneidae) in a tropical rainforest in the Ecuadorian Amazon. The observation was made on September 4th, 2021, at 20:53 h on the Botanical trail (00°40'28.70" S, 76°23'56.95" W, 210 m altitude), a terra firme forest near the Yasuní Scientific Station, located in Yasuní National Park in the Orellana Province of Ecuador. This forest is classified as Bosque siempreverde de tierras bajas del Napo-Curaray (MAE, 2013).

The sound of the bat flapping its wings in an attempt to escape was what alerted the authors to this event. Initially, we observed a single adult of *Thyroptera tricolor* trapped in the center of the web, with its wings outstretched (Figure 1A), about 60 cm above the ground. Subsequently, we observed an individual of *Eriophora* sp. in the immediate vicinity of the web approaching the bat (Figure 1B). During our observation the spider never came close to the bat; we surmise that it was attempting to hide from our presence. Unfortunately, we were not able to continue the observation due to time restrictions. The web was built among plants of the Rubiaceae and Melastomataceae families at the edge of the trail, in an area with little mature vegetation (Figure 1C).

Only one record of bat predation by spiders exists for Ecuador (Nyffeler & Knörnschild, 2013). The report of observations such as this one contributes to the knowledge of bat biology and predator-prey relationships. Few direct bat predation events are observed and reported, although they comprise an essential part of bat biology and merit further study.

Acknowledgments: This observation was made during the field work of research project PIM-19-0, funded by the Escuela Politécnica Nacional, Quito, Ecuador.

FIGURE 1. A. Individual of *Thyroptera tricolor* trapped in a spider web. B. Individual of *Eriophora* sp. observed in the vicinity of the spider web. C. Environment where the observation took place. Photos by Iván de la Cruz and Álvaro Dueñas.

Conflict of interest: The authors have declared that no competing interests exist.

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ORIGINAL ARTICLE

First confirmed record of *Neogale frenata* (Carnivora, Mustelidae) in the Chocó rainforest

Primer registro confirmado de *Neogale frenata* (Carnivora, Mustelidae) en los bosques húmedos del Chocó

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ABSTRACT

Despite the large geographic and elevational range of *Neogale frenata* (long-tailed weasel), records of this species in the lowland forests of coastal Ecuador are sparse, and some of them are of dubious provenance. Here, we report the first confirmed record of *N. frenata* in the Chocó forests of the province of Esmeraldas in northwestern Ecuador, an area of forests highly threatened by fragmentation and deforestation. For this reason, new surveys are necessary to determine the conservation status of this mammal species from coastal Ecuador.

Keywords: Bilsa Biological Station, Esmeraldas province, long-tailed weasel, Mache-Chindul Ecological Reserve, noteworthy record, Ecuador

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RESUMEN

A pesar del amplio rango geográfico y altitudinal de *Neogale frenata* (comadreja de cola larga), los registros de esta especie en los bosques de tierras bajas de la Costa ecuatoriana son pocos y algunos de ellos dudosos. Aquí reportamos el primer registro confirmado de *N. frenata* en los bosques húmedos del Chocó, en la provincia de Esmeraldas, noroccidente de Ecuador, una zona de bosques altamente amenazados por la fragmentación y la deforestación. Por este motivo, consideramos necesario realizar nuevos muestreos para conocer el estado de conservación de esta especie de mamífero en la Costa ecuatoriana.

Palabras clave: Estación Biológica Bilsa, comadreja de cola larga, provincia de Esmeraldas, Reserva Ecológica Mache-Chindul, registro notable, Ecuador.

Neogale frenata (long-tailed weasel; Lichtenstein, 1831) has the largest distribution of any species of the family Mustelidae in the Western Hemisphere (Helgen & Reid, 2016), spanning 80° of latitude from northern Canada to Bolivia (Helgen & Reid, 2016; Sheffield & Thomas, 1997). In this broad geographical range, 42 subspecies of *N. frenata* have been recognized (Larivière & Jennings, 2009).

This species is common in a variety of habitats but prefers forested areas, including humid and dry primary or secondary forests (Emmons & Feer, 1997; Larivière & Jennings, 2009; Tirira, 2017); also, it tolerates human-disturbed land (e.g., deforested and agricultural areas and even human settlements) (Larivière & Jennings, 2009; Sheffield & Thomas, 1997). *N. frenata* occurs over a wide range of elevations, from sea level to an altitude of 4220 m (Escobar-Lasso & Gil-Fernández, 2014; Hall, 1951; Larivière & Jennings, 2009).

The subspecies *N. f. aureoventris* (Gray, 1864) is restricted to Ecuador and Colombia (Larivière & Jennings, 2009; Tirira et al., 2022), where it is associated with the premontane and montane forests of the Andean slopes, subtropical, temperate, and high Andean altitudes, and paramo (Eisenberg & Redford, 1999; Harding & Dragoo, 2012; Larivière & Jennings, 2009; Solari et al., 2013; Tirira, 2008, 2017). Its confirmed altitudinal range extends from 1100 to 4220 m (Escobar-Lasso & Gil-Fernández, 2014; Palacios et al., 2014; Tirira, 2007, 2017).

Despite its wide distribution on the continent, there are no records of the species in the Chocó ecoregion between the Panama Canal Zone and the Pacific tropical forest of Colombia (GBIF, 2023; Helgen & Reid, 2016; iNaturalist, 2023; Navarro et al., 2005); also, there are no records in northwestern Peru within the Tumbesian ecoregion (Helgen & Reid, 2016; Larivière & Jennings, 2009).

In western Ecuador, some records of *N. frenata* exist, mainly from dry forests that range from 70 to 1014 m in altitude (iNaturalist, 2023; Parker III & Carr, 1992; Tirira, 2022; Tirira & Azurduy Högström, 2011), but some of these records are questionable or unconfirmed (Table 1, Figure 1). Four records have been reported in locations below 800 m (Parker III & Carr, 1992): Manta Real (Cañar province), Cerro Blanco (Guayas), Jauneche (Los Ríos), and Cerro Pata de Pájaro (Manabí). These records, however, are secondhand accounts from local inhabitants and do not include direct observations or voucher specimens. A museum specimen is preserved at the Goteborg Natural History Museum in Sweden, collected in 1924 at "Santo Domingo de los Colorados (1,625 feet [495 m])" (Tirira & Azurduy Högström, 2011).

Other additional museum specimens from western Ecuador were captured at sites in the province of Loja: Alamor, at an elevation of 1014 m (AMNH 60509), and Huanchi (also Guainche o Huainche), between Alamor and Celica, at 975 m (AMNH 61406). These specimens were collected in 1920 and 1921, respectively. Another museum specimen was reported from Guayaquil, at an elevation of 10 m (Guayas province; USNM 270408), but the record does not include the name of the collector or the date of collection. Due to their historical ages and incomplete collection data, the provenance of these museum specimens cannot be confirmed.

TABLE 1. Records of *Neogale frenata* in western Ecuador, in chronological order.

Year	Province: Locality [number in Figure 2]	Coordinates, altitude	Comments	Source
Unknown	Guayas: Guayaquil [1]	02°10’58” S, 79°54’28” W, 10 m	Provenance of voucher doubtful	USNM 270408 (USNM museum catalogue; GBIF, 2023)
1920	Loja: Alamor [2]	04°01’32” S, 80°02’21” W, 1014 m	Historical record	AMNH 60509 (AMNH museum catalogue; GBIF, 2023)
1921	Loja: Huanchi, between Alamor and Celica [3]	04°02’14” S, 79°59’18” W, 975 m	Historical record	AMNH 61406 (AMNH museum catalogue; GBIF, 2023)
1924	Santo Domingo de los Tsáchilas: Santo Domingo de los Colorados [4]	00°14’18” S, 79°08’46” W, 495 m	Historical record	GNM 1649 (Tirira & Azurduy Högström, 2011)
1992	Cañar: Manta Real [5]	02°33’56” S, 79°21’13” W, 670 m	Information provided by local inhabitants	Parker & Carr (1992)
1992	Guayas: Cerro Blanco [6]	02°09’19” S, 80°01’43” W, 405 m	Information provided by local inhabitants	Parker & Carr (1992)
1992	Los Ríos: Jauneche [7]	01°14’54” S, 79°39’19” W, 70 m	Information provided by local inhabitants	Parker & Carr (1992)
1992	Manabí: Cerro Pata de Pájaro [8]	00°00’59” N, 79°58’35” W, 725 m	Information provided by local inhabitants	Parker & Carr (1992)
2017	Esmeraldas: Bilsa Biological Station [red star]	00°20’48” S, 79°42’42” W, 512 m	First confirmed record in the tropical rain-forest	This report
2018	Imbabura, Parambas [9]	00°49’01” S, 79°20’09” W, 780 m	Confirmed record	iNaturalist (2023)

In 2018, a roadkill specimen was reported on the Ibarra-San Lorenzo highway, near Parambas in the province of Imbabura (780 m in altitude) (iNaturalist, 2023). This is the most recent record and the first that confirms the presence of the species in a tropical climate zone west of the South American Andes, although the ecological conditions of the zone correspond to an ecotone between the Chocó ecoregion and the inter-Andean dry valleys (MAE, 2013).

For these reasons, the status of *N. frenata* in the western lowlands of Ecuador is uncertain, and some distribution maps and analyses exclude coastal Ecuador in the distribution of the species (e.g., Eisenberg & Redford, 1999; Helgen & Reid, 2016; Larivière & Jennings, 2009; Tirira, 1999, 2007).

From July 2016 to May 2018, we conducted research to determine the species that feed on the fruits of ungurahua (*Oenocarpus bataua*), a species of palm tree that occurs in the tropical rainforests of the country. This study was carried out at the Bilsa Biological Station (00°20’48” S, 79°42’42” W, 512 m a.s.l.), located in the

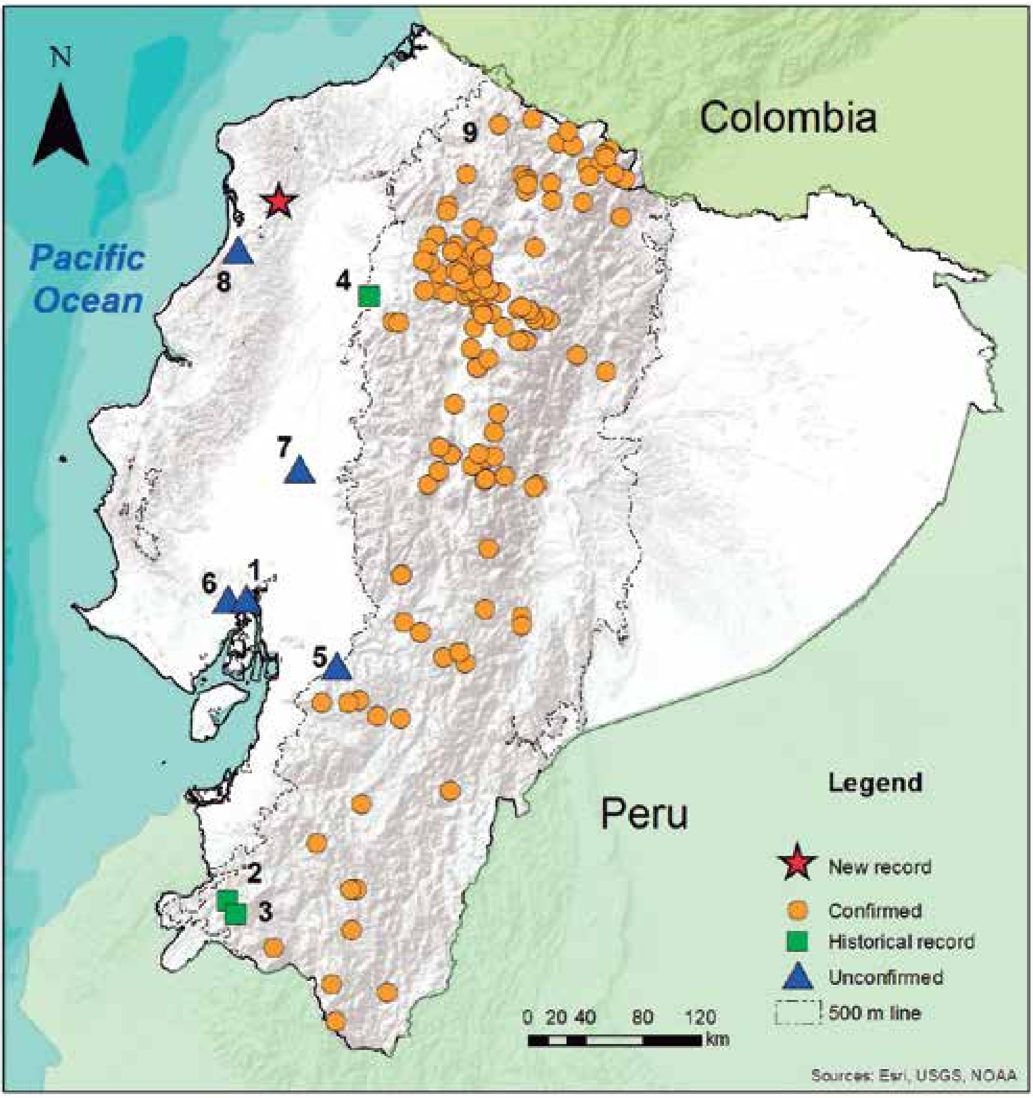

FIGURE 1. *Neogale frenata* in Ecuador. The map shows the new record reported here as well as other records in Ecuador (according to GBIF, 2023; iNaturalist, 2023; and Tirira, 2022). The corresponding numbers (1–9) are indicated in Table 1.

Mache-Chindul Ecological Reserve, on the border between the provinces of Esmeraldas and Manabí. The area corresponds to northwestern tropical rainforests (Tirira, 2017), and the main ecosystem present is the Bosque siempreverde montano bajo de Cordillera Costera del Chocó (Low montane evergreen forest of the coastal Chocó range) (Cornejo et al., 2013). The area has an average annual temperature of 22.8 °C (Hijmans et al., 2005).

In the study area, we placed a total of 151 camera traps (Strikeforce Pro, Browning Trail Cameras, Birmingham, USA) around individual *Oenocarpus bataua* palm trees; we accumulated 25,968 trap-hours (mean ± SE: 298 ± 74.2). In 22 trees, we installed cameras to capture images at ground level, and in an additional 21 trees, we installed cameras that captured images at both ground and canopy level.

FIGURE 2. Still image extracted from a 10-second camera-trap video taken at the Bilsa Biological Station (00°0'48" S, 79°42'42" W, 512 m), located in the Mache-Chindul Ecological Reserve in the northwestern Ecuadorian province of Esmeraldas.

Here, we report the first confirmed record for the *N. frenata* in the coastal lowlands of western Ecuador based on a photograph and a video (10 seconds of footage) of one individual (Figure 2) taken on 23 June 2017 at 14:33 hours. The *N. frenata* individual crossed the field of view of the camera quickly before passing out of sight.

Out of 5553 videos in which animals appear, *N. frenata* occurs in only one, suggesting either that it is rare in the area or that the camera traps fail to detect small and relatively fast-moving species due to the sensitivity of the passive infrared sensor. We recorded 24 other mammal species in this study (Appendix 1), including the mustelids *Eira barbara* (tayra) and *Galictis vittata* (greater grison).

The *N. frenata* individual at the Bilsa Biological Station was identified based on distinct morphological traits (according to Larivière & Jennings, 2009; Tirira, 2017). First, the dorsal fur of the individual was dark brown and uniform. White facial marks on the head, as well as a creamy-white chin and neck, were evident. The creamy-white underside of the head and neck gave way to a pale orange belly. The individual had a black-tipped tail that was shorter than the length of the head and body. Identification was further aided by the lack of morphologically similar species, as no other species of Neogale are predicted to inhabit the area.

The first question is whether the record corresponds to a wild specimen or an intentional introduction. To begin with, the place where it was registered is located within a large protected area (119,172 hectares; MAE, 2021) in a remote area of the country. There are reports in Ecuador stating that *N. frenata* is an aggressive species when captured and is difficult to handle (D. G. Tirira, pers. obs.), in spite of evidence suggesting that some weasels may be kept as pets in North America (WebMD Editorial Contributors, 2023). Additionally, there are no reports that this species has been detected in wildlife trafficking in Ecuador (CITES, 2022; Tirira, 2012, 2022); therefore, there is no reason to conclude that this individual is not a wild specimen.

This new report represents a significant extension of the confirmed geographical range of *N. frenata*. The nearest confirmed sighting, 120 km to the southeast and at a similar elevation, is the 1924 museum specimen from Santo Domingo de los Colorados in the province of Santo Domingo de los Tsáchilas (Tirira & Azurduy Högström, 2011). The nearest unconfirmed sighting is 40 km south, in an area of similar elevation (725 m) in the dry forests of Cerro Pata de Pájaro in the province of Manabí (Parker III & Carr, 1992).

This new record is the first confirmed record in the province of Esmeraldas, a transition zone between the Tumbesian and Chocó ecoregions (Parker III & Carr, 1992). These ecoregions belong to the Tumbes-Chocó-Magdalena corridor, which extends from the Panama Canal Zone and the Pacific coast of Colombia to the lowlands of southwestern Ecuador and northwestern Peru (Rodríguez-Mahecha et al., 2004). Its estimated area exceeds 100,000 km^2, of which less than 20% lies within Ecuador, including lowland and montane forests of the western foothills of the Andes (Myers et al., 2000). The Tumbes-Chocó-Magdalena corridor is a hotspot characterized by high biological diversity and endemism (Myers et al., 2000) but threatened by anthropogenic pressures, particularly in Ecuador where 98% of the original forest cover has been removed (Rodríguez-Mahecha et al., 2004).

As a result of its large distribution and apparently stable populations across its range, *N. frenata* was listed as Least Concern by the IUCN Red List (Helgen & Reid, 2016) and the *Libro Rojo de los mamíferos del Ecuador* [*Red Book of Mammals of Ecuador*] (Tirira, 2021). While *N. frenata* is tolerant of moderate human disturbance (King, 1990), populations of small carnivores can fluctuate and may become locally extirpated due to reduced prey numbers and the introduction of exotic predators (Zapata Ríos & Branch, 2016). This species may be sensitive to agriculturally-induced habitat fragmentation, indicating the importance of maintaining landscape connectivity for its populations (Gehring & Swihart, 2004). Additionally, *N. frenata* faces persecution since it preys on poultry, with individuals killing entire flocks, a phenomenon known as surplus killing (Tirira, 2017). Road mortality is also a significant threat to *N. frenata* (R. Benavides in iNaturalist, 2023; R. Cisneros-Vidal and D. G. Tirira, pers. obs.).

In Ecuador, *N. frenata* has been found in some high-elevation protected areas: Cajas, Cayambe-Coca, Cotacachi-Cayapas, Cotopaxi, Llanganates, Podocarpus, and Sumaco-Napo Galeras national parks; and the El Ángel Ecological Reserve (Tirira, 2017).

Other camera-trap studies have noted that species with short limbs and slender, low-to-the-ground bodies make detection difficult (Hackett IV, 2008; Hodge & Arbogast, 2016; Jiménez et al., 2010; O'connell et al., 2006), as in the case of *N. frenata*. However, due to habitat loss in the coastal lowlands of Ecuador (Dodson & Gentry, 1991), it is unlikely that *N. frenata* has a stable population.

The question that remains is whether there are small populations of *N. frenata* in western Ecuador as a result of recent colonization or if the documented records correspond to a much longer occupation in the region. Future surveys of *N. frenata* populations in the lower elevations west of the Ecuadorian Andes are necessary in addition to genetic analysis of museum samples (Table 1), thereby obtaining better information about this species in western Ecuador and, if applicable, prioritizing conservation efforts.

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Authors' contributions: KN: fieldwork and data analysis. DT: database with Ecuadorian records and map. All authors contributed to the conceptualization of the manuscript and its writing.

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Appendix 1

Mammal species captured with camera traps at Bilsa Biological Station, Ecuador

Scientific name	Common name	Sightings	Percentage
Undetermined	Rodents	1385	24.9
Dasypus novemcinctus	Nine-banded Armadillo	1028	18.5
Syntheosciurus granatensis	Red-tailed Squirrel	675	12.2
Nasua nasua	South American Coati	458	8.2
Cuniculus paca	Lowland Paca	416	7.5
Dasyprocta punctata	Central American Agouti	260	4.7
Dicotyles tajacu	Collared Peccary	136	2.4
Proechimys semispinosus	Tomes' Spiny Rat	136	2.4
Didelphis marsupialis	Common Opossum	100	1.8
Potos flavus	Kinkajou	84	1.5
Metachirus myosuros	Temminck's Brown Four-eyed Opossum	82	1.5
Tamandua mexicana	Northern Tamandua	19	0.3
Leopardus wiedii	Margay	11	0.2
Eira barbara	Tayra	7	0.1
Leopardus pardalis	Ocelot	6	0.1
Mazama gualea	Gualea Red Brocket	5	0.1
Herpailurus yagouaroundi	Jaguarundi	3	0.1
Canis familiaris	Domesticated Dog	1	0.0
Procyon cancrivorus	Crab-eating Raccoon	1	0.0
Galictis vittata	Greater Grison	1	0.0
Neogale frenata	Long-tailed Weasel	1	0.0
Undetermined	Bat	1	0.0
Other records	Birds, reptiles, and others undetermined	737	13.3
	Total records	5553	100.0

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SCIENTIFIC NOTE

Observation of *Neogale frenata aureoventris* (Carnivora, Mustelidae) swimming in an irrigation canal in Urcuquí, Imbabura, Ecuador

Evento de natación de *Neogale frenata aureoventris* (Carnivora, Mustelidae) en un canal de riego en Urcuquí, Imbabura, Ecuador

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ABSTRACT

Instances of *Neogale frenata* swimming are rare to observe and have not been recorded in South America. Here, we present a note regarding an observation at an irrigation canal in Urcuquí, Ecuador. In a period of less than two minutes, *Neogale frenata aureoventris* swam twice in the canal for a distance of about two meters.

Keywords: agricultural area, Andes, behavior, disturbed area, long-tailed weasel.

RESUMEN

Los eventos de natación de *Neogale frenata* son raros de observar y no existen registros en Sudamérica. Aquí presentamos una nota de natación dentro de un canal de irrigación en Ur-

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cuquí, Ecuador. En un período inferior a dos minutos, *Neogale frenata aureoventris* nadó en dos ocasiones en un canal de irrigación de agua una distancia de alrededor de dos metros.

Palabras clave: área agrícola, área perturbada, Andes, comadreja de cola larga, comportamiento.

Physical forces encountered by swimming mammals differ markedly from those encountered by running mammals (Dejours, 1987). These differences undoubtedly influenced many of the morphological modifications that occurred during the transition from terrestrial to aquatic locomotion (Williams, 2001). Members of the family Mustelidae are generally terrestrial; however, there are a few reports that mustelids can swim, hunt, and adapt to aquatic life in Neotropical fresh waters (Sheffield & Thomas,1997). Here we report two events during which a adult male long-tailed weasel, *Neogale frenata aureoventris*, swam in an irrigation canal in the Andes mountains of Ecuador.

In Ecuador, *Neogale frenata aureoventris* (Gray, 1865) inhabits the Andean highlands and foothills in subtropical, temperate, and high Andean forests and páramo throughout the country, between elevations of 1100 and 4225 m; it can be found in primary and secondary forest, humid and dry environments, deforested and cultivated areas, and near human developments (Tirira, 2017).

The records of swimming behavior reported here took place in the Jardín Botánico Yachay, a conservation area comprised of dry-preserved forest located near the San Eloy Hill in northern Urcuquí, Imbabura province, Ecuador (00°25’4” N, 78°11’18” W, 2289 m a.s.l.). The native ecosystem that characterizes the area is classified as Bosque y Arbustal semideciduo del norte de los Valles [semideciduous forest and shrubland of the northern valleys], also known as dry interandean valley vegetation (MAE, 2013); it is located in the temperate zoogeographic zone of the northern Andes. Historically, the water irrigation canals in Urcuquí have provided water daily to hundreds of farmers who harvest beans, corn, and peppers, and other traditional products grown in this area (Ruf, 1995).

On September 26, 2023, at 08:07 hours, we observed a long-tailed weasel swimming in an irrigation canal. The individual ran out of a bean field, *Phaseolus vulgaris*, and stood on its hind legs at the edge of the irrigation ditch (*acequia*). It turned its head from right to left twice and jumped into the water canal (about 30 cm wide and deep) to swim for about five seconds over a distance of 1.5 meters. Then the weasel exited the canal and quickly ran to another area about 10 meters away, where it jumped into a new water channel (15 cm wide and 20 cm deep). It swam for less than a meter and entered a broken pipe (Figure 1) in an area of avocado trees, sliding over the water for about 1.5 meters. This individual repeated this behavior on two occasions, sticking its head out, watching, and sliding back over the water. Finally, a couple of minutes later, the weasel took another dip in the water, exited the ditch, shook itself off quickly, and ran off through the avocado trees.

These two instances of successful swimming, carried out in less than two minutes, point to the importance of this aquatic behavior as an unusual yet necessary ability for long-tailed weasels to cross channels of water. There is a little evidence of other weasel species (genera *Neogale* and *Mustela*) spending time swimming that varied depending on body fat and fur present and occurred at different speeds (Dagg & Windsor, 1972). The subspecies *Neogale frenata noveboracensis* was reported swimming in Gratiot County, Michigan (Green, 1936), and other locations in North America (Davis, 1994; Wobeser, 1966), but to our knowledge, this is the first report of this species swimming in South America.

It is remarkable that the long-tailed weasel swam around the water canals on both occasions, suggesting that it may use specific criteria to move through different agricultural areas where there is a water canal. The behavior of the weasel during swimming, such as moving lithely, hiding in the water canals, and shaking its head to remove excess water,

FIGURE 1. *Neogale frenata aureoventris* in a broken pipe near the irrigation water canal in Urcuquí, Ecuador. Photograph by J. Picho-Paucar.

demonstrates how this animal has evolved adaptations to the different ecosystems in which it lives. This response points to the strong influence that intermittent swimming by mammals, together with the pressure of increasing energetic efficiency (Williams, 2001), may have on long-tailed weasel behavior.

Semi-aquatic behavior has been documented for another species of the genus, *Neogale vison* (American mink) from North America (Larivière & Jennings, 2009). Additionally, the other species of the genus *Neogale* in Ecuador, *N. africana* (Amazon weasel) and *N. felipei* (Colombian weasel) present naked foot soles with slight interdigital webbing, suggesting that they may have semi-aquatic habits, although the natural history of both species is poorly known (Schreiber et al., 1989; Tirira, 2017). However, these traits are found in other mustelids (e.g., *Gulo* and *Martes*) with terrestrial and arboreal habits (Ramírez-Chaves & Patterson, 2014).

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SCIENTIFIC NOTE

Report of attack by *Neogale frenata* (Carnivora, Mustelidae) on a chicken coop in Cuyuja, Napo, Ecuador

Reporte del ataque de *Neogale frenata* (Carnivora, Mustelidae) a un gallinero en Cuyuja, Napo, Ecuador

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ABSTRACT

In this scientific note, I document an attack by *Neogale frenata* (long-tailed weasel) on a chicken coop near Cuyuja, in the province of Napo, Ecuador. Early in the morning, in less than five minutes, the carnivore killed all 20 chickens in the coop with quick and effective bites to the neck, retreating into the forest carrying only one chicken. Although the carnivorous habits of weasels are frequently discussed in the literature, there are no specific reports detailing the behavior recorded in this scientific note.

Keywords: *Gallus gallus domesticus*, Human-wildlife conflict, Parque Nacional Cayambe-Coca, poultry, predation.

RESUMEN

En esta nota científica documento el ataque de *Neogale frenata* (comadreja de cola larga) a un gallinero, cerca de Cuyuja, en la provincia de Napo, Ecuador. A primera hora de la mañana, y en

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menos de cinco minutos, el carnívoro mató a las 20 gallinas existentes con mordidas rápidas y efectivas a la altura del cuello, para luego marcharse al interior del bosque con solo una. Si bien en la literatura se comenta con frecuencia los hábitos carnívoros de esta comadreja, no existen reportes específicos que detallen esta conducta, según se narra en esta nota científica.

Palabras clave: ave de corral, conflicto gente-fauna silvestre, depredación, *Gallus gallus domesticus*, Parque Nacional Cayambe-Coca.

Neogale frenata (long-tailed weasel) is a small carnivore within the family Mustelidae (total length 279–412 mm; Larivière & Jennings, 2009). However, among the small Neotropical carnivores, it is considered the largest and least-specialized, as it is a generalist predator that feeds mainly on small and medium-sized mammals (Rosenzweig, 1966; Sheffield & Thomas, 1997). In North America (Canada and the United States), there are several studies that report *N. frenata* preying upon a wide variety of small vertebrates, such as rodents (mice and squirrels) and rabbits of small to medium size (Sheffield & Thomas, 1997); it also eats moles and bats, but less frequently (Hall, 1951; Mumford, 1969). Its diet also features some avian prey, such as quail, blackbirds, flickers, sparrows, and juncos, among others (Fagerstone, 1987; Hall, 1951). Rarely, it preys on snakes, lizards, ground beetles, grasshoppers, and other insects (Sheffield & Thomas, 1997). However, there are hardly any reports on prey consumed within the Neotropical region, despite its wide distribution (Larivière & Jennings, 2009); in the Neotropics, its diet is thought to consist mainly of small mammals, rabbits, and birds and their eggs (Larivière & Jennings, 2009). This species has often been considered an agricultural pest due its predation on poultry (*Gallus gallus domesticus*; Quick, 1944; Sheffield & Thomas, 1997), mainly due to surplus killing, a documented and known behavior in other Mustelidae species (Oksanen et al., 1985).

Although several reports comment on prey captured by *N. frenata*, and some of them mention predation of poultry, no study that I am aware of presents specific data on this activity anywhere throughout its extensive geographic range. Its range is the largest for any mustelid species within the Americas, with records from Canada to northern South America, extending southward along the Andes Mountains to southern Peru and northern Bolivia (Larivière & Jennings, 2009).

The event I document in this scientific note occurred 5 km NW of the town of Cuyuja, on the road to Papallacta (00°22'57" S, 78°03'52" W, 2750 m altitude), on a small farm near Parque Nacional Cayambe-Coca. The locality is located in the Piso Templado Oriental (Western Temperate Zone; Tirira, 2017) and corresponds to the Bosque siempreverde montano del norte de la Cordillera Oriental de los Andes (northern montane evergreen forest of the eastern Andes mountains; MAE, 2013).

During my one-week stay in the locality, I observed how the owner of the farm built a chicken coop with the objective of avoiding possible long-tailed weasel attacks; thus, the coop was covered with mesh on all sides and roofed. On the evening before the attack, the owner of the farm brought 20 white chickens for their first night in the new coop.

At 06:30 hours the next day (November 5, 1991), while camping a few meters from the coop, I was awakened by a commotion. Upon investigation, I observed that a long-tailed weasel had entered the coop and proceeded to chase and kill each hen in a matter of seconds using only quick and effective bites to the neck. In less than five minutes, it had killed all 20 hens; it proceeded to grab one of them and drag it through a small opening it had found at the bottom of the coop door, carrying the corpse into the adjacent forest. In the literature, it has been recorded that *N. frenata* kills prey by subduing it through a ventral attack and then asphyxiating it by biting its neck (Larivière & Jennings, 2009). However, this method would take longer than what was observed in the attack described here, as the death of the hens was instantaneous.

In popular Ecuadorian culture, farmers attribute a hematophagous diet to the long-tailed weasel (locally called *chucuri* or *chucurillo*) due to the habit of this carnivore of killing its prey via bites to the neck, without eating the corpses.

This scientific note provides specific information regarding the carnivorous habits of this small mustelid in the form of an unpublished report of a behavior widely mentioned but lacking specific documentation. Notes such as these contribute to the knowledge of the natural history of little-known mammal species.

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ORIGINAL ARTICLE

Whale-listening research tours in the Southeast Pacific region: a case study of scientific tourism in Ecuador

Viajes de investigación para escuchar ballenas en la región del Pacífico Sudeste: un estudio de caso del turismo científico en Ecuador

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ABSTRACT

Scientific tourism is an emerging but poorly studied field in the Southeast Pacific region. We conducted a literature review to assess the current state of scientific tourism and included a case study of humpback whale-listening research tours off the coast of Esmeraldas in northern Ecuador. Additionally, we conducted online interviews to examine changes in people's perception of whale-observation tours (comparing visual and auditory experiences). The literature review revealed more published articles related to whale-watching aided research than to scientific tourism. Still, we found that humpback whale-listening research tours operate in the region. Human facial expressions showing emotions such as happiness and surprise were the most frequently recorded reactions when

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people listened to humpback whale songs. Online respondents mostly expressed high satisfaction when listening to whale songs or seeing whales up close (< 5 m). However, after respondents read about the impact of tour boats on whales' well-being, most respondents preferred to watch and listen to whales at a distance of 100 m. Whale-listening tours generate emotional well-being in people who participate, and we consider that the whale-watching industry could implement this activity to promote compliance with distance guidelines for observing humpback whales in their breeding grounds.

Keywords: Satisfaction, preferences, facial expressions, tourism, *Megaptera novaeangliae*, whale-listening research tours.

RESUMEN

El turismo científico es un campo emergente y poco estudiado en la región del Pacífico sudeste. Realizamos una revisión bibliográfica para evaluar el estado del turismo científico e incluimos un estudio de caso sobre los viajes de investigación para escuchar ballenas jorobadas en la costa de Esmeraldas, norte de Ecuador. Realizamos entrevistas para conocer los cambios en la percepción de las personas sobre el avistamiento de ballenas (visual frente a auditiva). La evaluación de la revisión bibliográfica arrojó más artículos publicados relacionados con el avistamiento de ballenas asistidas por la investigación que literatura de turismo científico. Aun así, constatamos que en la región se realizan viajes de investigación para escuchar a las ballenas jorobadas. Las expresiones faciales humanas de emoción, como felicidad y sorpresa, fueron las más frecuentes cuando la gente escuchaba el canto de las jorobadas. Además, los encuestados expresaron una mayor satisfacción al escuchar el canto de las ballenas o verlas de cerca (< 5 m). Sin embargo, después de que los encuestados leyeran sobre el impacto de los barcos turísticos en el bienestar de las ballenas, la mayoría prefirió escuchar y observarlas a una distancia de 100 m. Los viajes de escucha de ballenas generan bienestar emocional en las personas que viven esta experiencia, por lo que la industria de avistamiento de ballenas podría adoptar este tipo de experiencias para promover el cumplimiento de las directrices de distancia para su observación en sus zonas de reproducción.

Palabras clave: Satisfacción, preferencia, expresión facial, *Megaptera novaeangliae*, turismo, viaje de investigación sobre la escucha de ballenas.

INTRODUCTION

The presence of humpback whales (*Megaptera novaeangliae*) along the coast of Ecuador and the Southeast Pacific region represents a valuable opportunity for economic development through whale-watching tourism (Cárdenas et al., 2021; García-Cegarra & Pacheco, 2017; Pacheco et al., 2011). In Latin America, the whale-watching industry focused on humpback whales is one of the most popular tourist activities and represents an important source of income in coastal areas (Cisneros-Montemayor et al., 2010; Hoyt & Íñiguez, 2008). During the last decade, in some Central and South American countries, whale-watching tourism has experienced unprecedented economic growth (Amrein et al., 2020; Ávila et al., 2021; Cárdenas et al., 2021).

The rapid expansion of whale-watching tourism in the region has not only improved the local economy but has also provided a valuable opportunity to educate tourists and promote environmental awareness and marine conservation in the local population (Ávila et al., 2021; Hoyt & Íñiguez, 2008; Zapetis et al., 2017). However, along with its socioeconomic benefits and educational potential, the growth of whale-watching tourism has intensified pressure on the whales through increased marine traffic and harassment, especially for humpback whales (Ávila et al., 2021). For instance, changes in humpback whale behavior have been documented, mainly in mother-calf groups (Amrein et al., 2020; Ávila et al., 2015; García-Cegarra et al., 2019; Villagra et al., 2021), involving a high risk of collisions (Ransome et al., 2021), changes in energy budget (Amrein et al., 2020; Ávila et al., 2015; García-Cegarra et al., 2019; Villagra et al., 2021), and habitat disturbances by direct acoustic masking of their vocalizations caused by boat noise (Rey-Baquero et al., 2021).

Guidelines have been developed to minimize the impact on whales during whale-watching activities (Lewis & Walker, 2018). For example, when approaching whales, it is recommended that the boat maintains a distance of 100–300 m from the animals. Additionally, the recommended speed during an approach is four knots (approx. 7 km/h), and the number of boats near whales is limited to three for a single whale or a group of whales. Observation time should be limited to a maximum of 25 minutes for whale groups and reduced to 15 minutes when calves are present (Félix, 2015). But these recommendations are not always applied by boat captains, due to inadequate training, insufficient control and enforcement (Sitar et al., 2016), and the pressure to satisfy tourists' demands to be as close to the whales as possible.

In their breeding grounds, humpback whales prefer shallow water (Denkinger et al., 2023), which makes this charismatic species even more attractive and easier to access. Furthermore, humpback whales are famous for producing complex, melodic songs, which has increased both humpback whale bioacoustics research and whale-watching interest in the Southeast Pacific region (Ávila et al., 2021; Chávez-Andrade et al., 2023). The number of humpback whale-watching operators has increased in certain breeding areas, such as Ecuador and Colombia (Ávila et al., 2021; Castro et al., 2022), which could augment the pressure to provide views of whales up close. However, harassment of whales has begun to cause concern among some tourists who are worried about their conservation (García-Cegarra & Pacheco, 2017; Sitar et al., 2016).

Despite the potential adverse effects of whale watching, the industry has also contributed to humpback whale research. For instance, research groups from Panama, Colombia, Ecuador, Peru, and Chile have collaborated with the whale-watching industry to collect behavioral, acoustic, and population density information (e.g., Acevedo et al., 2017; Barragán, 2019; Félix & Botero-Acosta, 2011; Félix et al., 2001a; Felix et al., 2006; Pacheco et al., 2011; Pacheco et al., 2021; Valdivia et al., 2017). This type of collaboration has facilitated important advances in research about the ecology and distribution not only of humpback whales (e.g., Amrein et al., 2020; Guidino et al., 2014) but also of other species occasionally observed, such as fin whales (*Balaenoptera physalus*), blue whales (*Balaenoptera musculus*) (Catalan et al., 2011; Sepúlveda et al., 2017), and coastal dolphin species (e.g., Félix et al., 2019).

While cooperation between research groups and tourist operations provides a unique opportunity for data collection (whale-watching aided research), researchers depend on the itinerary organized for tourists. In whale research tours (science tourism), however, tourists adapt to the research schedule of scientists according to the focus of these trips and actively participate in scientific observations for behavior analyses, photo-identification studies, and acoustic surveys. In this case, tourists can participate as observers and data collectors (e.g., taking pictures of humpback whale flukes for photo-identification) while financially supporting the activity (Parsons et al., 2006).

A recent study recommended the implementation of acoustic whale tourism in the Southeast Pacific region (Ávila et al., 2021). Specifically, whale-listening research tours can be considered a form of scientific tourism because they integrate recreative (exploration) and educational (interpretation) activities (Bosak, 2015) while simultaneously providing scientific data and supporting research initiatives (Dionisio et al., 2022; Molokáčová & Molokáč, 2011). Scientific tourism can also provide a platform for sharing environmental and cultural knowledge acquired at the study area with tourists and members of the local community who are employed by whale-watching operations (Boldt, 2016; Bourlon & Mao, 2011; Hoyt, 1999).

Whale-listening research tours provide an alternative activity that reduces the negative impacts of the whale-watching industry on whales' well-being (Ávila et al., 2021; Hoyt, 1999). But it is also essential to study the social aspects of this activity to understand which experiences contribute to tourist satisfaction. So far, most studies have focused on the economic aspects of whale watching (Dalfo et al., 2017; Guidino et al., 2020; Herrera & Lasso, 2014; Torres-Matovelle & Molina-Molina, 2018; Zapetis et al., 2017). Only a few studies have aimed to understand the perceptions and emotions of tourists during whale-watching operations (e.g., Cárdenas et al., 2021; Cornejo-Ortega et al., 2018; García-Cegarra & Pacheco, 2017).

Finally, scientific tourism in the form of whale-listening research tours could evoke empathy from tourists towards whales and their environment, thus promoting changes in attitude towards conservation (e.g., Cárdenas et al., 2021; García-Cegarra & Pacheco, 2017; Wilson & Tisdell, 2003; Zeppel, 2008). Most whale-watching activities are focused on the visual experience; the effects of listening to humpback whale songs on people's perceptions and emotions are poorly understood. Specifically, social studies about human emotional responses to hearing the songs of humpback whales in real-time during whale-listening research tours have not been conducted.

In this study, we aimed to 1) assess the current state of scientific tourism focused on humpback whales in the Southeast Pacific region, 2) determine the emotions (based on facial expressions) of tourists during whale-listening research tours, and 3) document human perspectives in terms of tourists' preferences during whale-watching tours off the coast of Ecuador.

METHODS

Literature review

We conducted a literature review during June 2022, following search steps adapted from PRISMA (Urrutia & Bonfill, 2010). We used Google Scholar and Web of Science to search for scholarly literature and academic resources (Meho & Yang, 2007). We used the following search keywords in both English and Spanish: "whale-listening research tour," OR "whale-watching aided research," OR "whale tourism," OR "scientific whale tourism" ("viajes de investigación sobre la escucha de ballenas," "investigación asistida por avistamiento de ballenas", "turismo de ballenas", "turismo científico de ballenas") combined alternately with each of the countries of the Southeast Pacific region (AND Panama, AND Colombia, AND Ecuador, AND Peru, AND Chile).

We searched for these terms in titles and abstracts with at least two keywords referring to scientific tourism, whale-watching aided research, or whale-listening research tour. Two of us manually screened the titles and abstracts of the resulting articles. In addition, we complemented the review using "snowball sampling," which consisted of subsequently inspecting literature cited in articles found on whale-watching aided research (Naderifar et al., 2017). We omitted articles, workshops, or conference proceedings that contained incomplete or repetitive data.

Finally, via email, we contacted research program leaders conducting whale research tours or whale-watching aided research in the Southeast Pacific region. Some program leaders were personal contacts of the authors, and others were recommended by colleagues who work with cetaceans. Reaching out to these leaders allowed us to complement our findings with unpublished information regarding ongoing research-tourism operations in the region.

Human facial expressions of emotion

To analyze the emotional reactions of tourists listening to humpback whale songs *in situ*, we collected 60 photos of facial expressions during 25 whale-listening research tours conducted between July and August in 2014, 2018, and 2019. The whale research trips were primarily conducted in shallow waters in the province of Esmeraldas, on the northern coast of Ecuador (Figure 1). The scientific tourism activities included observations of whale behavior and listening to whale songs and were conducted offshore while no other boats were near the whales.

We took photographs of tourists' facial reactions with their prior verbal consent to use the data exclusively for educational and research purposes, following the guidelines of the CETACEA Ecuador project and Universidad San Francisco de Quito. To listen to humpback whale songs in real-time, tourists were given semi-professional headphones (Sony ZX110) connected to a Tascam DR-40 digital recorder and an H2aXLR or DolphinEar/PRO omnidirectional hydrophone submerged up to 10 m

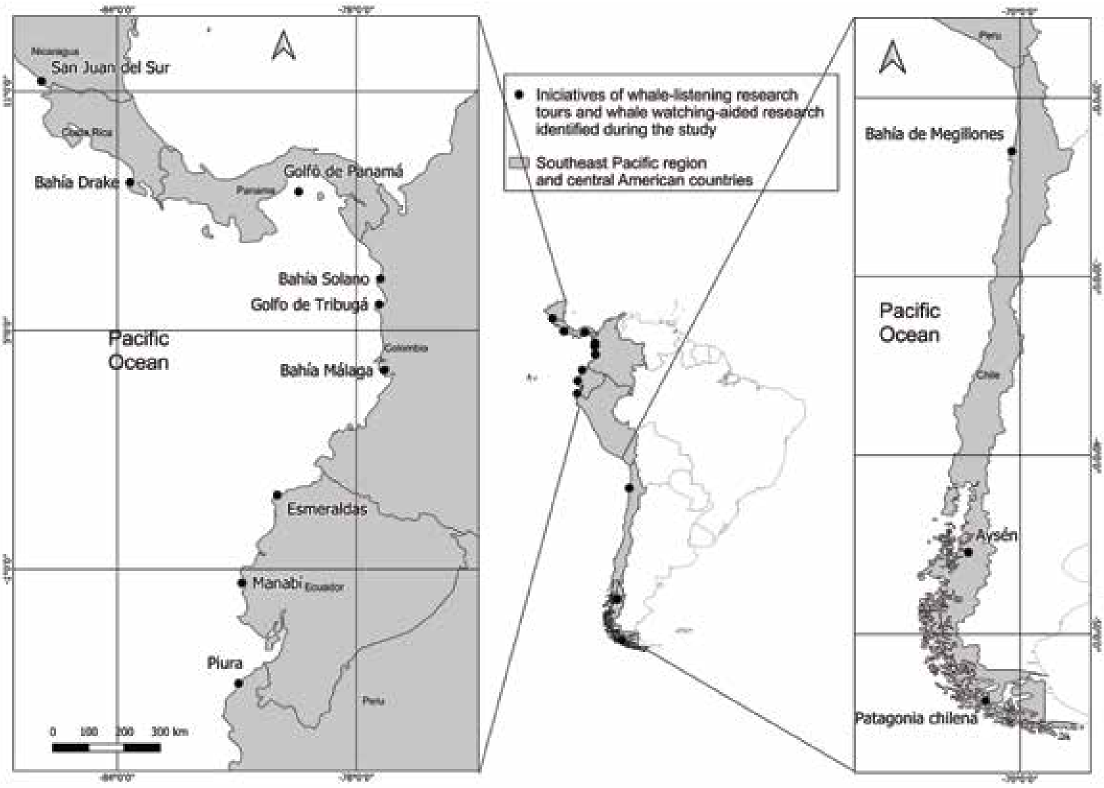

FIGURE 1. Location of whale-listening research tour operations and whale-watching aided research operations in the Southeast Pacific region (Panama, Colombia, Ecuador, Peru, and Chile) and some Central American countries (Nicaragua and Costa Rica).

depth. Tourists heard mainly the well-known, repetitive sounds of humpback whales known as "songs" (Cholewiak et al., 2013; Roger & McVay, 1971).

We photographed facial expressions of emotion when tourists began listening to the humpback whales' song for the first time. To determine the emotion most associated with each tourist's facial expression, we asked 20 volunteers to match each facial expression to emotions used in cognitive studies (Du et al., 2014). The options included happiness, surprise, sadness, fear, disgust, anger, intrigue, curiosity, tranquility, concentration, confusion, anguish, neutral, or unclear. Following established practices of identifying emotional facial expressions, we considered the emotions most frequently identified by volunteers for further analyses (Bandyopadhyay et al., 2020).

Tourist perspectives

To assess satisfaction and preferred experiences during whale-watching tours in Ecuador, we designed an online questionnaire in Spanish using the JOTFORM platform (accessible through https://form.jotform.com/201055469743053). The respondents were asked to rate their satisfaction and preferences for different scenarios during a simulated whale-watching tour on a 5-point Likert scale (Cornejo-Ortega et al., 2018).

Scenarios included different sighting distances and the option to listen to humpback whale songs in situ. Respondents were also asked to read information regarding the impact of irresponsible whale watching on whale welfare and then choose between the previously provided scenarios again.

This allowed us to determine whether knowledge about the effects of irresponsible whale watching influences the preferences reported in the questionnaire. The survey also included general sociodemographic questions (e.g., gender, age, education, and previous participation in whale-watching tours). To recruit volunteers to complete the surveys, we published the online survey in the Facebook group Proyecto CETACEA (https://www.facebook.com/proyectocetaceaecuador), managed by some of the authors of this paper; we promoted the survey through Facebook advertisements.

RESULTS

Literature review

The literature search initially generated 321 documents. Of these, 31 documents were full-text articles that met the original criteria, and 17 papers were about either whale-watching aided research on humpback whales or scientific tourism (Table 1). Most of these articles represented research projects in which whale-watching operations were used as a platform for collecting acoustic, distribution, and behavioral data of humpback whales (N = 14). Of these articles, 79% were peer-reviewed scientific articles, and 21% were short notes, academic reports, or dissertations. Only three publications were associated with scientific tourism (Table 1). By contacting colleagues in the field, we gathered additional information on scientific tourism through locating whale-listening research tours. We thus established the presence of scientific tourism, primarily characterized by whale-listening research tours, as well as whale-watching aided research along the coast of the Southeast Pacific region and some Central American countries, such as Nicaragua and Costa Rica (Figure 1).

Human facial expressions of emotion

Volunteers could consistently identify the emotions associated with 60 photographs of facial expressions of tourists listening to live whales. The most frequently identified emotions were happiness (55%, n = 33) and surprise (28%, n = 17). Conversely, neutral, curiosity, fear, and tranquility were identified less frequently (Figure 2; see examples of facial expressions of emotion in Figure 3).

Human perceptions

Sample characteristics

Surveys were completed by 100 participants, of whom 91% were Ecuadorian and 9% were non-Ecuadorian (European, North American, and South American tourists). Seventy-six participants indicated that they had previously participated in whale-watching tours in Esmeraldas (50%), Manabí (39%), Guayas (7%), and Galápagos (5%). Participants were between 18 and 60 years old and responded from Esmeraldas, Manabí, Santa Elena, Guayas, and El Oro, coastal provinces that offer whale-watching services in Ecuador. Forty-one percent of respondents were male, while 59% were female. Most participants reported having postgraduate-level education (50%), while 38% of respondents had a third-level education (undergraduate), and 12% had a basic education (primary and secondary, including technical degrees).

Satisfaction and preferences

Of the respondents who had previously participated in whale-watching tours, the majority (75%) expressed that hearing whale songs would provide them with a very satisfying experience. Meanwhile, 46% of respondents felt that seeing the whales up close (< 5 m) would offer a very satisfying experience. This proportion was slightly higher than that of respondents who characterized seeing the whales more than 100 m away from the boat as a very satisfying experience (42%). Only 9% of respondents said seeing the whales close to the boat would fail to satisfy them (Figure 4). But after participants read about the impact that irresponsible whale watching can have on whales, 65% of respondents expressed that they would prefer to listen to and observe humpback whales at a distance of 100 m rather than being close to the animals (Figure 5).

TABLE 1. Publications reviewed as part of the literature search about whale-watching aided research and scientific tourism, considering the Southeast Pacific country of origin.

Southeast Pacific countries	Publication type	References	Tourism type	Principal data collection or research context
Ecuador	Article	Félix & Haase (1998)	Whale-watching aided research	Distribution and photo-ID data aboard tour vessels
Ecuador	Article	Félix & Haase (2001a, b)	Whale-watching aided research	Distribution and photo-ID data aboard tour vessels
Ecuador	Academic report	Woods (2007)	Whale-watching aided research	Distribution and photo-ID data aboard tour vessels
Ecuador	Article	Félix et al. (2011)	Whale-watching aided research	Distribution and photo-ID data aboard tour vessels
Ecuador	Article	Félix & Botero-Acosta (2011)	Whale-watching aided research	Distribution and photo-ID data aboard tour vessels
Ecuador	BSc Thesis	Barragán (2019)	Whale-watching aided research	Acoustic data aboard tour vessels
Peru	Short note	Pacheco et al. (2011)	Whale-watching aided research	Distribution data aboard tour vessels
Peru	Article	Pacheco et al. (2013)	Whale-watching aided research	Behavior and distribution data aboard tour vessels
Peru	Article	Guidino et al. (2014)	Whale-watching aided research	Distribution data on aboard tour vessels
Peru	Article	Pacheco et al. (2021)	Whale-watching aided research	Distribution and photo-ID data aboard tour vessels
Colombia	Article	Zapetis et al. (2017)	Whale-watching aided research	Behavior and distribution data aboard ecotourism vessels
Chile	Article	Bourlon & Mao (2011)	Scientific tourism	Cetacean studies permitted the creation of a scientific tourism product
Chile	Article	Boldt (2016)	Scientific tourism	Tourist participation in the development of cetacean-focused scientific tourism
Chile	Article	Rovira-Pinto & Quintana-Becerra (2019)	Scientific tourism	Knowledge base for the development of cetacean-focused scientific tourism
Ecuador, Chile	Article	García Cegarra et al. (2021)	Whale-watching aided research	Opportunistic behavior observations aboard tour vessels
Panama, Colombia, Ecuador, Peru	Article	Valdivia et al. (2017)	Whale-watching aided research	Photo-ID data aboard tour vessels
Panama, Colombia, Ecuador, Peru, Chile	Article	Acevedo et al. (2017)	Whale-watching aided research	Photo-ID data aboard tour vessels

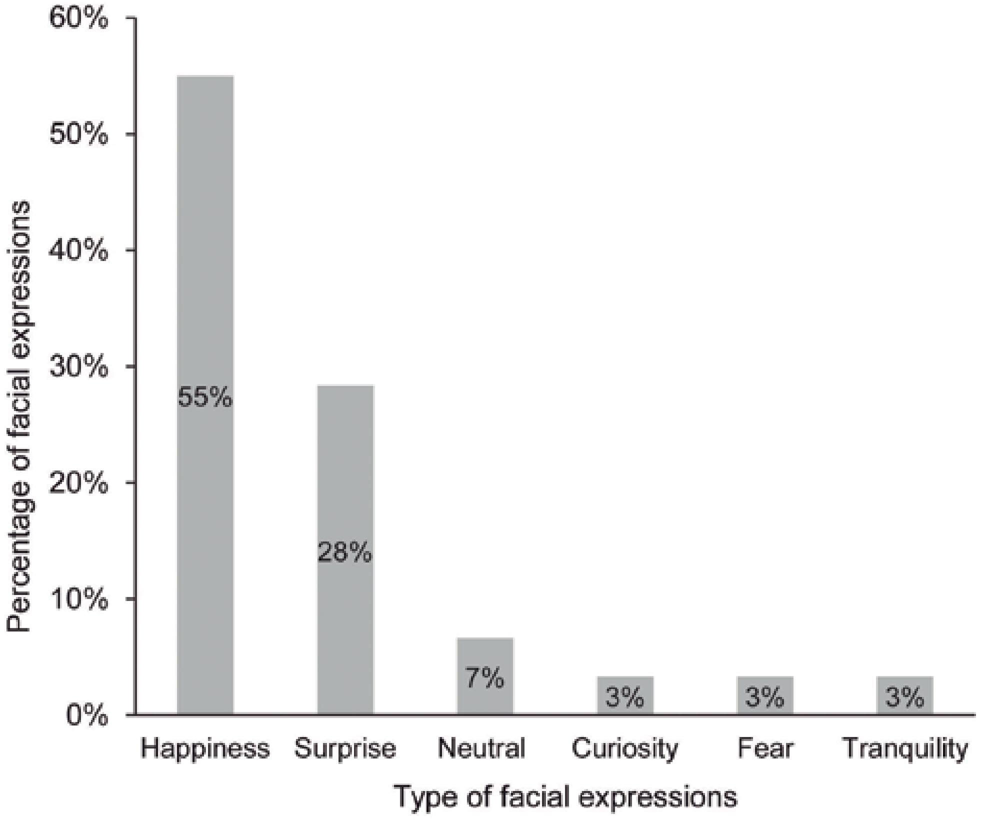

FIGURE 2. Percentages of human facial expressions according to emotion identified during whale-listening research tours off the coast of Esmeraldas in northern Ecuador.

DISCUSSION

The term "scientific tourism" has not been used frequently by the whale-watching industry nor mentioned in scientific publications from the Southeast Pacific region. Scientific tourism has often been associated with voluntarism and ecotourism, which support education, management, and conservation efforts (Bosak, 2015). Our literature search showed that most published research-tourism collaborations took the form of whale-watching aided research rather than scientific tourism.

We found three studies that mentioned scientific tourism activities associated with cetacean research. These research projects are located along the coast of Chile and involve tourist participation in expeditions dedicated to studying small dolphins, such as the bottlenose dolphin (*Tursiops truncatus*), Peale's dolphin (*Lagenorhynchus australis*), and the Chilean dolphin (*Cephalorhynchus eutropia*) (Boldt, 2016; Bourlon & Mao, 2011; Rovira & Quintana, 2019). Conversely, in Ecuador and Peru, we found studies mainly related to whale-watching aided research that highlight the essential logistical contribution of tour operators to humpback whale researchers. This collaboration is especially valuable due to the high costs of monitoring cetaceans and collecting relevant ecological and environmental information, especially in underdeveloped countries (Boldt, 2016; Pacheco et al., 2011).

Scientific tourism initiatives associated with whale research in the region have not yet resulted in scientific production. On the other hand, citizen science and long-term research programs

FIGURE 3. Examples of facial expressions of emotion recognized during whale-listening research tours: A–B. Happiness; C–D. Surprise; E–F. Tranquility; G–H. Neutral; I. Fear; J. Curiosity; K. Whale-listening research tour off the coast of Esmeraldas in northern Ecuador.

have generated crucial scientific information and promoted some local scientific tourism initiatives in coastal and remote areas of the region. For instance, in Nuquí, Colombia, training local people in a citizen science program has not only allowed them to monitor cetaceans and generate scientific articles (e.g., Vallejo et al., 2022a, b) but has also provided workshops and promoted better whale-watching practices for local operators (Ann Carole Vallejo, pers. comm.). Likewise, in Chilean Patagonia, whale monitoring has been carried out with the help of tourists, taking advantage of cetacean research programs that study dolphins, especially in the northern fjords of Aysén (Boldt, 2016; Bourlon & Torres, 2016).

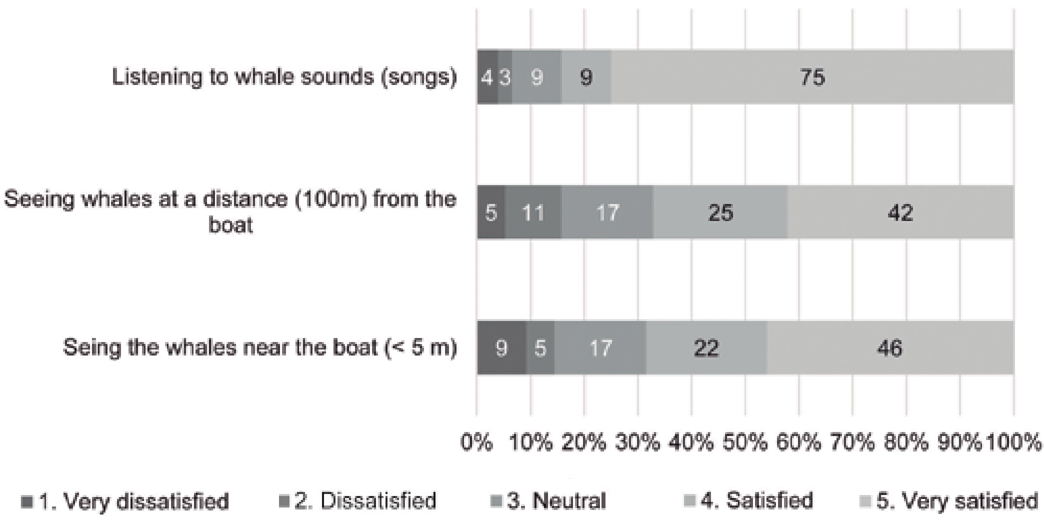

FIGURE 4. Levels of satisfaction expressed (percentages on the bars) under three different scenarios during a potential whale-watching tour in Esmeraldas, northern Ecuador.

Compared to participants in the traditional whale-watching industry, tourists participating in whale monitoring and research are more likely to follow conservation guidelines and maintain a respectful distance from the animals under observation (Juan Capella, pers. comm.). In addition, whale-listening research tours and social, cultural, and environmental projects promoting humpback whale songs have been implemented in areas such as Bahía Málaga, Colombia (Isabel Ávila, pers. comm.). Thus, scientific tourism guided by trained local residents or conducted by scientists in collaboration with tourist companies can guarantee a satisfactory experience and decrease the risks of harassment of whales.

Additionally, we found that listening to whales in situ had an immediate emotional impact on participants. The most frequently detected emotional responses to hearing humpback whale songs were happiness and surprise. These emotions were also observed during a recent study about whale-watching aided research integrating whale-listening research tours on the Pacific coast of Colombia (Ocean Conservation Community Foundation, unpublished data). The emotional experiences of hearing whale songs can be diverse due to different individual reactions and interpretations. Nevertheless, positive emotions experienced by tourists during whale-watching expeditions can contribute to an increased desire to support conservation actions for marine species (e.g., feelings of responsibility for their protection; Jacobs & Harms, 2014). Additionally, understanding the natural soundscape and its impact on human emotive perceptions can contribute to the development of activities that contribute to human well-being (Moscoso et al., 2018), a current focus of the Sustainable Development Goals (SDGs) of the United Nations (UN, 2021).

Our analyses of tourist perceptions on whale-watching tours showed high levels of satisfaction and preference associated with listening to humpback whale songs while observing the animals at a regulated distance (up to 100 m). However, the growing whale-watching industry may require more stringent control of its operations (e.g., Amrein et al., 2020; Ávila et al., 2015, 2021). With the increased popularity of whale watching and the growing number of whale-watching boats, scientists have suggested increasing the minimum observation distance to 200 m in the region (Ávila et al., 2015, 2021; Cárdenas et al., 2021; Castro et al., 2022).

Competition among tourist boats for close-up sightings of humpback whales can instigate noncompliance with the distance regulations (Amrein et al., 2020). While some studies report

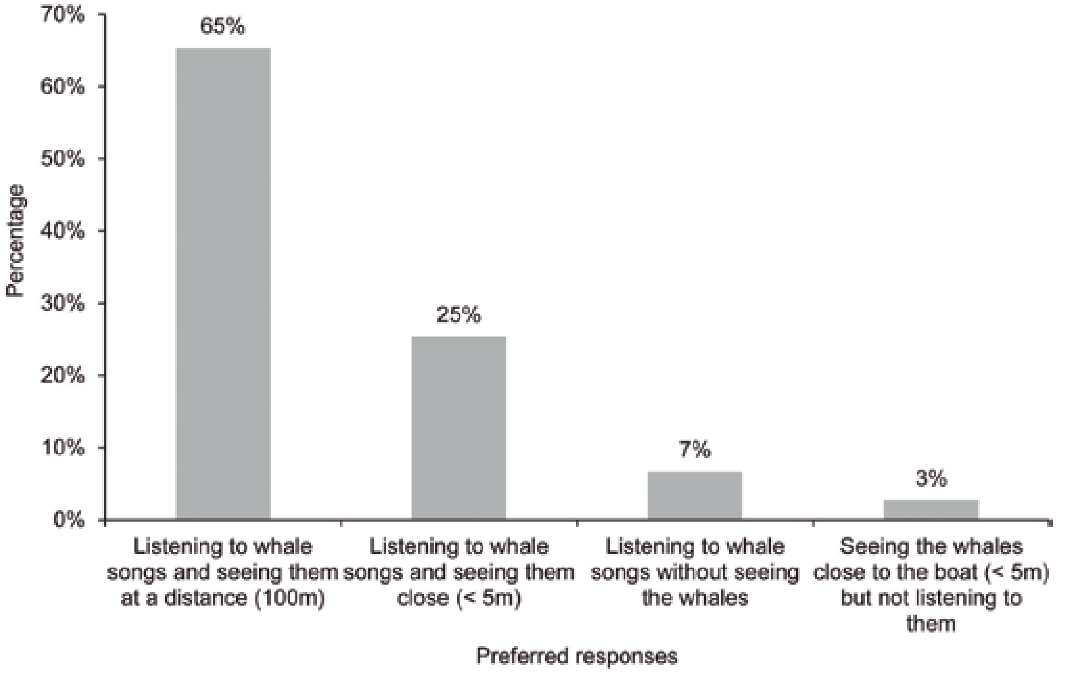

FIGURE 5. Preferences expressed after respondents read about the impact that irresponsible whale watching can have on whale behavior.

a strong tourist preference for being as close as possible to the whales, others indicate that distance is not a limiting factor (Hoyt & Parsons, 2014; Orams, 2000). These findings are consistent with our results, showing that much of this variability depends on the individual choice of whale-watchers; we found similar proportions of respondents who preferred to be either very close (< 5 m) or far away (100 m) from whales before reading about the impacts of irresponsible whale-watching.

Likewise, a recent human perception study in Golfo de Tribugá, Colombia, showed a preference for listening to whales while maintaining the regulated distance over not listening to the songs and seeing the whales up close (Ocean Conservation Community Foundation, unpublished data). Therefore, we encourage the implementation of scientific tourism that incorporates acoustic experiences; not only do these experiences serve as tourist attractions and opportunities to collect data, but they also promote more responsibility among whale-watching tour operators, encouraging them to follow up-to-date recommendations to ensure animal welfare and support respectful wildlife tourism (Ávila et al., 2021).

We also found that access to conservation information influences tourist satisfaction and encourages respectful whale-watching activities. At the same time, the lack of both surveillance and compliance with regulations can lead to concern and dissatisfaction among tourists (Ávila et al., 2021; García-Cegarra & Pacheco, 2017). For example, a study conducted in Sri Lanka reported that the factors that most contributed to tourist dissatisfaction were the lack of information about the species, the violation of sustainable whale-watching practices, seasickness, and stormy weather during the whale-watching tours (Buultjens et al., 2016).

A study in Australia reported that 35% of participants were satisfied with whale-watching tours that included adequate information about the whales, despite not observing humpback whales (Orams, 2000). On the other hand, according to a study conducted in Bahía de Banderas, Mexico, at least one whale sighting can be more important than species information as regards tourist satisfaction (Cornejo-Ortega et al., 2018). Nonetheless, an effective way to generate a satisfactory experience includes raising awareness about the environment and the species of concern before, during, and after the trips (De la Cruz-Modino & Cosentino, 2022; García-Cegarra & Pacheco, 2017). Therefore, humpback whale-watching operations do not need to provide close-up observations (violating regulations and disturbing individual whales), but can instead focus on delivering enriching experiences through providing relevant information about the biology and ecology of the species, incorporating local knowledge and opportunities to listen to humpback whale songs in their breeding areas (e.g., Ávila et al., 2021; Oña et al., 2017, 2019; Perazio et al., 2018).

CONCLUSIONS

We found few peer-reviewed articles related to scientific tourism compared to studies based on cooperation between the whale-watching industry and researchers. Despite this, we established that whale-listening research tour initiatives in the region are facilitating the collection of crucial information about humpback whale ecology while promoting a sustainable tourism experience. Our work highlights the importance of implementing more scientific activities in the whale-watching industry, such as whale-listening and recording, to provide environmental education and enhance tourist welfare. Our findings on tourist perceptions and emotions when observing and hearing humpback whales establish a promising path towards implementing a sustainable model that both meets the expectations of tourists and mitigates harassment of whales. Scientific tourism opportunities will contribute to tourists' emotional well-being and promote positive attitudes toward ocean conservation, especially as regards the spatial needs of humpback whales in their reproductive areas along the coasts of Ecuador and the Southeast Pacific region.

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RESUMEN DE TESIS

Mortalidad de mamíferos silvestres por efecto del atropellamiento en las provincias de Guayas y Santa Elena, Ecuador

Mortality of wild mammals caused by roadkill in the provinces of Guayas and Santa Elena, Ecuador

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Las infraestructuras viales y el tráfico vehicular afectan negativamente a las poblaciones de fauna silvestre, como los mamíferos, que intentan cruzar las vías por recursos, como alimentos, agua, refugios, entre otros, lo que resulta en su atropellamiento en las vías. Los mamíferos terrestres son vulnerables a este tipo de amenazas, lo que hace necesario evaluar el efecto de estos impactos en sus poblaciones. Este problema sucede en las afueras de la ciudad de Guayaquil, en la provincia de Guayas y en la denominada vía a la Costa, que conecta con la provincia de Santa Elena. Esta carretera conecta con diversas zonas turísticas, productivas y urbanas, en donde existen remanentes de matorrales, bosques seco y humedales que acogen a estas especies. En el presente estudio evalué la mortalidad de mamíferos silvestres por efecto de atropellamiento en las vías a la Costa E40 y Colectora Posorja E489, entre las poblaciones de Guayaquil, General Villamil, Posorja y Chanduy. La fase de campo la llevé

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a cabo entre julio de 2021 y junio de 2022, con un total de 42 recorridos. Identifiqué y georreferencié los mamíferos atropellados en la vía. El trayecto de estudio lo dividí en cuatro tramos: 1) Chongón, 2) Progreso, 3) Posorja y 4) Chanduy. Las diferencias entre las medianas de los tramos y los grupos taxonómicos y las diferencias en las frecuencias de los atropellamientos entre hábitos diurno, nocturno, crepuscular y catemeral las determiné mediante la prueba no paramétrica de Kruskall-Wallis. Calculé la tasa de atropellamiento total y por tramos; determiné zonas de alta incidencia de atropellamiento por medio de mapas de calor. Obtuve 156 registros de mamíferos silvestres correspondientes a 15 especies, nueve familias y seis órdenes. Las especies con mayor frecuencia relativa de atropellamiento fueron la zarigüeya común (*Didelphis marsupialis*) (n = 125), el hormiguero de occidente (*Tamandua mexicana*) (n= 6) y el ocelote (*Leopardus pardalis*) (n= 4). La tasa de atropellamiento total fue de 0,024 individuos/día/km; identifiqué nueve puntos de alta incidencia de atropellamientos; encontré diferencias significativas entre los tramos estudiados, siendo mayor en el tramo de Progreso, pero esto no fue así entre hábitos, pues no mostraron diferencias estadísticas. En cuanto a las especies amenazadas, según la *Lista Roja de los mamíferos del Ecuador* (2021), se encuentran los murciélagos *Eptesicus innoxius* y *Rhogeessa velilla*, así como *L. pardalis* y *T. mexicana*. Recomiendo la señalización de las vías estudiadas y la instalación de reductores de velocidad, así como la implementación de franjas de vegetación para la mitigación de estos impactos.

Palabras clave: *Didelphis marsupialis*, *Eptesicus innoxius*, *Leopardus pardalis*, impactos, mapas de calor.

Keywords: *Didelphis marsupialis*, *Eptesicus innoxius*, *Leopardus pardalis*, impacts, heatmaps.

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RESUMEN DE TESIS

Mortalidad de mamíferos por atropellamiento en la vía Salitre-Palestina (Guayas, Ecuador)

Mammals mortality due roadkill on Salitre-Palestina highway (Guayas, Ecuador)

Stuart Martín Aldaz Cedeño

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Las carreteras provocan impactos ambientales, como la fragmentación de ecosistemas, reducción de las poblaciones de especies de flora y fauna nativas, cambios del ciclo hidrológico, alteraciones microclimáticas, producción de material particulado, ruido, contaminación del agua y del suelo, entre otros. En Ecuador, específicamente en la zona de los municipios de Salitre, Daule y Palestina, en la provincia de Guayas, existen vías de alta recurrencia y que cruzan áreas rodeadas por humedales, arrozales y urbanizaciones, las que provocan colateralmente la pérdida de hábitats y afectan a la fauna nativa, entre ella, la de mamíferos. Estos vertebrados presentan amplia distribución y cumplen diversos roles dentro de los ecosistemas, como depredador o presa, sirven como controladores biológicos y, algunas especies, como los murciélagos, son polinizadoras, dispersoras de semillas o cumplen un papel importante en el reciclaje de nutrientes; debido a esto, los mamíferos son elementos clave en los ecosistemas tropicales y en la recuperación de áreas degradadas. En el presente estudio evalué la mortalidad de mamíferos por efecto

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de atropellamientos en la vía Salitre-Palestina, en zonas de urbanizaciones, humedales y arrozales de la provincia de Guayas. El área de estudio la dividí en dos tramos y la monitoreé con la ayuda de un vehículo particular o una bicicleta, en recorridos semanales entre septiembre de 2022 y febrero de 2023. Para determinar las especies con mayor frecuencia de atropellamientos usé curvas de rango-abundancia; posteriormente, procedí con la verificación del supuesto de la normalidad, mediante la prueba de Ryan-Joiner (RJ = 0,960; N = 70; $p < 0{,}010$); la que, al ser descartada, desarrollé frecuencias por tramos mediante Mediana (IQ) en gráficos de caja. Para determinar diferencias significativas entre los tramos apliqué una prueba de U de Mann-Whitney; para determinar las diferencias de atropellamiento entre hábitos (diurno, nocturno, catemeral y crepuscular) empleé la prueba no paramétrica de Kruskall-Wallis. Adicionalmente, estimé la tasa de atropellamientos por tramo y por día. Finalmente, generé puntos de alta incidencia de atropellamientos a través de mapas de calor en base a los puntos de atropellamientos tomados en campo. En este trabajo, registré un total de 116 mamíferos nativos pertenecientes a nueve especies, nueve géneros, ocho familias y cinco órdenes. La especie *Didelphis marsupialis* fue la más afectada, con 80 atropellamientos (62 %), seguida de *Molossus molossus*; también registré a *Eptesicus innoxius* (n = 3), especie categorizada como Vulnerable según la *Lista Roja de los mamíferos del Ecuador* (2021). En los atropellamientos entre los tramos no encontré diferencias significativas ($p = 0{,}222$), mientras que en relación con los hábitos las diferencias sí fueron significativas ($p < 0{,}01$), con predominancia de los mamíferos nocturnos. Determiné que la tasa de atropellamientos fue de 0,045 individuos/día/km. Generé 11 puntos de alta incidencia, con predominio de los sitios cercanos a urbanizaciones, humedales y arrozales. Recomiendo intervenir en estas zonas con la implementación de fotorradares, reductores de velocidad, zonas de amortiguamiento entre las vías y la vegetación y señaléticas que indiquen que estas áreas son sensibles para los mamíferos.

Palabras clave: *Eptesicus innoxius*, mapas de calor, murciélagos, reductores de velocidad.

Keywords: *Eptesicus innoxius*, heat maps, bats, speed bumps.

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RESUMEN DE TESIS

Patrones de actividad y frecuencia relativa de mamíferos grandes y medianos en la Reserva Ecológica Manglares Churute, Guayas, Ecuador

Activity patterns and relative frequency of large and medium-sized mammals in the Manglares Churute Ecological Reserve, Guayas, Ecuador

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Los mamíferos grandes y medianos cumplen con roles ecológicos importantes, por lo que su pérdida representaría impactos negativos para el ecosistema. Aunque los estudios en la Costa de Ecuador enfocados en este grupo se han incrementado en los últimos 10 años, las investigaciones sobre sus patrones de actividad son escasos, pues predominan los reportes de diversidad y abundancia. En este contexto, la Reserva Ecológica Manglares Churute es un importante espacio natural para la supervivencia de varias especies de mamíferos; sin embargo, esta fauna no ha sido estudiada de forma sistemática a pesar de que soporta fuertes presiones directas, como la cacería, el tráfico de vida silvestre, los incendios forestales, las retaliaciones por conflicto humano-fauna, o los atropellamientos. El objetivo del estudio que presento fue evaluar los patrones de actividad y frecuencia relativa de mamíferos

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grandes y medianos en esta reserva. Entre noviembre de 2022 y junio 2023 establecí cinco estaciones de muestreo con cámaras trampa, con una separación entre cámaras de 1,5 km. Las imágenes que obtuve fueron procesadas considerando registros independientes bajo los siguientes criterios: (1) fotografías de diferentes especies captadas de manera continua, (2) fotografías de la misma especie captada de manera consecutiva, pero con al menos una hora de diferencia y (3) fotografías no sucesivas de la misma especie. Las especies con mayor frecuencia de eventos de fototrampeo las determiné con el Índice de Abundancia Relativa (IAR) y elaboré histogramas de frecuencia de horas para determinar los patrones de actividad. En total, gistraré 14 especies nativas; las más frecuentes fueron *Dasyprocta punctata* (IAR = 12,1), con actividad diurna (entre 06:00–17:00 h); *Nasua nasua* (IAR = 4,9), diurna (05:00–17:00 h); *Sylvilagus daulensis* (IAR = 1,8), catermeral (18:00–05:00 y 13:00 h); y *Leopardus pardalis* (IAR= 1,4), una especie nocturna (22:00–05:00 h); también registré dos especies introducidas: *Bos taurus* y *Canis lupus familiaris*. Las frecuencias de estas especies mostraron niveles bajos a los reportados en otros estudios en la Costa ecuatoriana, mientras que los patrones exhibidos concuerdan con los registros en el Neotrópico. Por otro lado, me preocupa la presencia de las especies introducidas, pues pueden ocasionar afectaciones a las poblaciones nativas de mamíferos, como transmisión de enfermedades y la competencia por los recursos. La presencia de las especies introducidas es un reflejo de la ampliación de la frontera agrícola y podría explicar la ausencia de carnívoros grandes, como jaguar o puma en la reserva. Propongo continuar con estos monitoreos e investigar aspectos ecológicos importantes para el manejo in situ de las especies silvestres, como la selección y el uso de hábitat que ocupan en la reserva.

Palabras clave: *Dasyprocta punctata*, especies introducidas, fototrampeo, *Leopardus pardalis*, *Nasua nasua*.

Keywords: *Dasyprocta punctata*, introduced species, photo-trappig, *Leopardus pardalis*, *Nasua nasua*.

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RESUMEN DE TESIS

Mamíferos grandes y medianos del recinto El Mamey (Santa Elena, Ecuador)

Large and medium-sized mammals from El Mamey (Santa Elena, Ecuador)

Santdy Roxana Farro Terán

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La provincia de Santa Elena mantiene remanentes de bosques secos con múltiples desafíos de conservación, pues su alta valoración productiva produce un acelerado cambio en el uso de suelo, lo que provoca una reducción de hábitat y fragmentación ecológica; estos impactos afectan directamente a los mamíferos grandes y medianos, que son escasamente estudiados en la provincia. Bajo estas perspectivas, llevé a cabo un estudio para caracterizar la mastofauna en los remanentes de bosque del recinto El Mamey en busca de determinar su abundancia, frecuencia, amenazas, usos y prioridades de conservación. Para este fin, realicé observaciones directas mediante transectos, de 1 a 1,5 km de largo y 5 m de ancho, lo que recorrí durante el día (08:00–11:00 h) y la tarde (13:00–17:00 h) en un bosque de 20 ha de extensión; el muestreo lo complementé con la búsqueda de huellas, excrementos y restos óseos. El estudio lo efectué durante ocho semanas, entre mayo y julio de 2023, para un total de 112 horas de trabajo efectivo. De forma adicional, coloqué siete cámaras-trampa al azar, distanciadas entre 1 y 1.5 km

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entre una y otra, con revisiones quincenales y activadas durante 24 horas. Las imágenes que obtuve las procesé bajo estos criterios: (1) fotografías de distintas especies continuas, (2) fotografías de la misma especie consecutivas, con al menos una hora de diferencia y (3) fotografías no sucesivas de la misma especie. La frecuencia la determinada mediante el índice de Abundancia Relativa (IAR). También llevé a cabo entrevistas no estructuradas a 20 moradores adultos mayores que han vivido gran parte de su vida en el lugar; con esto busqué conocer sobre las actividades económicas, las especies presentes en el área, la frecuencia de avistamientos, los registros históricos y los conflictos. En total, registré cuatro especies nativas por métodos directos e indirectos: *Leopardus pardalis*, *Procyon cancrivorus*, *Odocoileus virginianus peruvianus* y *Sylvilagus daulensis*; mediante fototrampeo añadí cinco especies: *Didelphis marsupialis*, *Tamandua mexicana*, *Eira barbara*, *Dicotyles tajacu* y *Leopardus wiedii*, para un total de nueve especies. Los mayores valores de abundancia relativa los registré para *O. v. peruvianus* (IAR = 9,1), *L. pardalis* (8,6) y *D. tajacu* (6,6). Entre las actividades económicas registradas, el comercio ilegal de vida silvestre presentó una mayor ocupación (40 %), seguida de la agricultura (30 %) y la ganadería (30 %); las especies sujetas a comercio ilegal fueron *Leopardus* spp. y *O. v. peruvianus*. Los pobladores también refirieron conflictos con felinos medianos y cánidos, pues depredan animales de corral; entre registros históricos, mencionaron a la presencia de *Cuniculus paca* y *Dasypus novemcinctus*, especies que ya no se observan hoy en día; entre los usos de estas especies, se mencionó a *O. v. peruvianus* (alimentación, medicinal, artesanal, superstición, decoración) y *L. pardalis* (decoración). Para evitar el avance de la defaunación recomiendo desarrollar un plan de manejo del área con los residentes a fin de hallar alternativas al comercio ilegal de especies.

Palabras clave: conflicto humano-fauna, *Leopardus pardalis*, *Odocoileus virginianus peruvianus*, fototrampeo, uso de la fauna.

Keywords: human-fauna conflict, *Leopardus pardalis*, *Odocoileus virginianus peruvianus*, photo-trapping, wildlife use.

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Language:	We publish papers in Spanish and English.
Edition:	Full color
Cost:	OJS (Open Journal System), no cost for authors or readers.
Offprints:	PDF offprints of each published article are provided for free circulation.
Diffusion:	The complete journal and offprints are disseminated through the official website of the journal, the page

- NOTAS CIENTÍFICAS
(hasta 1000 palabras).
Los manuscritos son arbitrados por el Comité editorial.

- RESÚMENES DE TESIS
(hasta 500 palabras más referencias).
Los resúmenes no son arbitrados, pero la pertinencia de su publicación es decidida por el Comité editorial.

- REVISIONES DE LIBROS
(hasta 1000 palabras).
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- ARTÍCULOS DE OPINIÓN
(hasta 3000 palabras).
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- ESTADOS DEL ARTE
(hasta 3000 palabras).
Los textos no son arbitrados, pero la pertinencia de su publicación es decidida por el Comité editorial.

3. Formato de publicación

Formato:	Digital
Frecuencia:	Publicación continua (publicamos un artículo en prensa tan pronto es aceptado).
Volúmenes:	De momento publicamos un volumen por año (en diciembre).
Tamaño:	ISO B5 (17,6 x 25 cm)
Idioma:	Publicamos trabajos en español e inglés.
Edición:	Full color
Costo:	Sistema OJS (*Open Journal System*), sin costo para autores ni lectores.
Separatas:	Se entregan separatas en PDF de cada artículo publicado de libre circulación.
Difusión:	La revista completa y por separatas se difunde a través del portal oficial

of the Asociación Ecuatoriana de Mastozoología and our social networks.

DOI: All articles, notes and other sections that we publish have DOI.

4. Taxonomy

We suggest that manuscripts follow the official taxonomy proposed by the Asociación Ecuatoriana de Mastozoología for the mammals of Ecuador. Follow the most updated version, which can be found at the following link.

You may use a different taxonomy, but it must be justified.

5. Manuscript Submission

For a manuscript to be considered within Mammalia æquatorialis it must include, in addition to the text and supporting files of your publication, a digital letter from the main author or correspondence in which:

- Requests publication of your manuscript in the journal *Mammalia æquatorialis*.
- Indicate that the article or scientific note is unpublished and has not been published or submitted to another journal, book or book chapter.

You must also sign the Submission preparation checklist.

If you have additional questions, please contact

editor@mammalia-aequatorialis.org

More details on how to submit a manuscript can be found on our official website: *Mammalia æquatorialis*.

de la revista, de la página de Asociación Ecuatoriana de Mastozoología y de nuestras redes sociales.

DOI: Todos los artículos, notas y demás secciones que publicamos cuentan con DOI.

4. Taxonomía

Sugerimos que los manuscritos siga la taxonomía oficial que para los mamíferos del Ecuador propone la Asociación Ecuatoriana de Mastozoología. Siga la versión más actualizada que la encuentra en el siguiente enlace.

Puede usar una taxonomía diferente, pero debe ser justificada.

5. Envío de manuscritos

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- Indique que el artículo o nota científica es inédito y no ha sido publicado o sometido a otra revista, libro o capítulo de libro.

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Más detalles sobre cómo someter un manuscrito los encuentra en nuestro sitio oficial: *Mammalia æquatorialis*.

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