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Large and medium-sized mammals of Buenaventura Reserve, southwestern Ecuador

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Abstract
Mammals are the third most threatened group of vertebrates and tropical ones are the most endangered according to recent studies. The Buenaventura Reserve protects 20 km^2 of Montane Tropical forest in the southwestern part of the Ecuadorian Andes. This study estimates the mammal species richness of this reserve by using camera traps and occasional sightings. We recorded 20 species of large and medium-sized mammals in this small protected area, which shows the reserve's important role in the conservation of these species. This study also shows the conservation priority that these forests should have in the western part of the Ecuadorian Andes.

Key words
Neotropical mammals; species inventory; cloud forest; conservation; biodiversity.

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Introduction

Mammals are the third most vulnerable group among vertebrates, with more than 30% of the species in one of the threatened categories according to the IUCN Red List (IUCN 2016). A recent analysis shows that the conservation status of mammal species has declined (Red List Index decrease of 0.8%) between 1996 and 2008, and tropical species are among the most vulnerable (Hoffmann et al. 2010). Mammals exploit a broad range of niches; this is why they play crucial ecological roles that influence community structure and ecosystem functioning (Ripple et al. 2014). The main threats to non-flying terrestrial and arboreal large and medium-sized mammals are habitat destruction, hunting, loss of critical resources, and illegal trade (Schipper et al. 2008). The loss of these mammals can cause an entire series of trophic cascades and alter the ecosystem balance (Estes et al. 2011).

The ecological importance and elevated degree of threats to large and medium-sized mammals (Di Marco et al. 2014) show the need to ensure their protection. It is broadly accepted that mammal conservation begins with accurate, up-to-date information on which species are present in an area (Antos and Yuen 2014). Thus, to include information about this group in inventories and environmental diagnostic studies should be the first step towards conservation (Pardini et al. 2003). Presence–absence data provide baseline information can be acquired with relatively little effort and can be used to

determine the conservation status and distribution of species inhabiting an area (Manel et al. 2001, Guisan and Thuiller 2005). This information is especially important to promote effective wildlife management in protected areas (Tobler et al. 2008, Jenkins et al. 2013).

Ecuador has been the subject of mammal surveys since at least the early 1900s (e.g. Allen 1903, Anthony 1924, Tate 1931), and in the last 2 decades exhaustive studies have been carried out in this country (Albuja 1999, Tirira 2007, Tirira 2008). Forests of the Ecuadorian western subtropics account for 38.4% (147 species) of the total mammal species recorded in Ecuador (Tirira

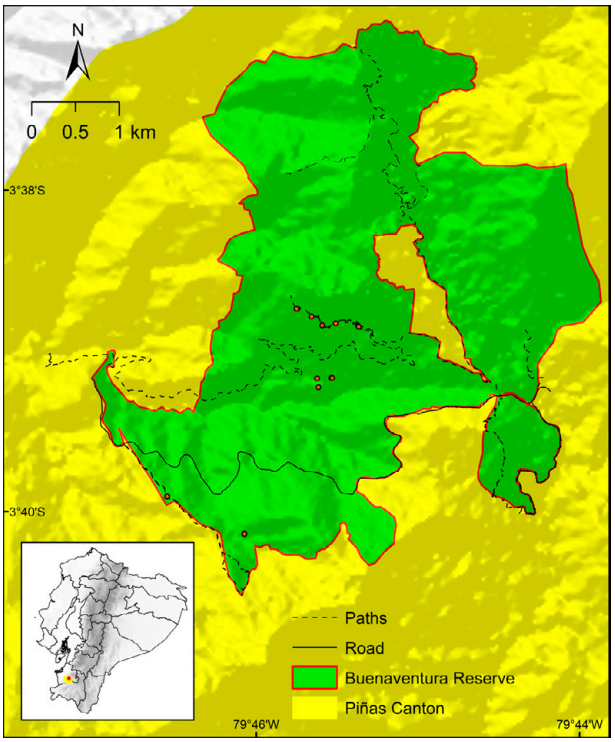


Figure 1. Location of the Buenaventura Reserve, camera traps (red dots) and paths used to detect the large and medium-size mammals. (Insert) Referential position of the study site in Ecuador, shaded areas represent an altitudinal gradient.

2007). A total of 105 species were recorded in the southern part of the country, distributed among 12 orders and 33 families, equivalent to approximately 25% of mammalian fauna in Ecuador (Narváez et al. 2012). However, private reserves in southwestern Ecuador have received little attention and the diversity of mammals in these areas remains largely unrecorded.

Information on the diversity of medium and large-sized mammals is needed to estimate the conservation status of ecosystems, especially of those which are protected. Presence of certain species could be a preliminary indicator of the conservation success of the management measures applied in protected areas. For that reason, our aim was to sample the species richness of medium and large-sized mammals of the Buenaventura Reserve (BR) of the Jocotoco Foundation.

Methods

Study site. The Buenaventura Reserve is located in the Subtropical Western Zoogeographic zone (Albuja et al. 1980) in southernwestern Ecuador (03°38′40″ S, 079°45′30″ W, 400–1200 m above sea level). It is in the foothills of the Andes mountain range and is part of the Piñas Canton in El Oro Province (Fig. 1). The reserve has an area of 20 km^2. It is covered by recovering Cloud and Tumbesian Forest as a result of reforestation and protection activities developed by the Jocotoco Foundation. This is a private reserve, not included in the Subsystem of Private Protected Areas of the National System of Protected Areas of Ecuador (Ministerio del Ambiente del Ecuador 2009). Mean temperature in the area ranges from 19 to 21 °C, and annual precipitations oscillate around 1569 mm, with a well-marked seasonality (driest and wettest quarter 42.3 mm and 806.8 mm, respectively) (INAMHI 2011).

Data collection. In this study, we considered large and medium-sized mammals as those ranging in size from squirrels (0.45 kg) to mountain lions (100 kg). Two different sampling techniques, camera traps and occasional sightings were used to record the large and medium-sized mammals in the BR. The sampled transects were the paths located in the reserve (Fig. 1). We did not include domestic species in our counts. We conducted our sampling activities from July 2014 to July 2016.

Bushnell® camera traps were used and changed location each month; with this we covered most of the best-preserved western area of the reserve. Cameras were positioned at strategic points, such as near possible tracks without using any bait. During our study we accumulated 669 trap nights (3 traps × 223 nights).

Searches in transects were carried out by direct visual records of animals totaling 75.47 km of trails traversed in 57 days of sampling. We did 4 of these data collections: from 28 July to 11 August 2014, from 29 January to 11 February 2015, from 1 to 14 February 2016, and from 18 to 31 July 2016. The trained reserve staff recorded each occasional mammal sighting from February 2015 to July 2016.

We easily recognized the species recorded by the camera traps and occasional sightings (some of them photographed); however, doubts were clarified with the aid of Tirira (2007).

Data analysis. We performed a species accumulation curve (Soberón and Llorente 1993) to detect the trend of species richness. To eliminate the effect of the order in which data was recorded, we randomized the data 100 times in EstimateS (Colwell 2009). In order to calculate the relative abundance index (RAI) and to avoid autocorrelation due to the proximity in the location of the camera traps, the records of those cameras located at a less distance than 1.5 km (TEAM Network 2008, Ahumada et al. 2011) were grouped, having 2 groups, north and south. We considered as independent each record of each species separated by 24 hours. We have calculated

Table 1. Conservation status of the large and medium-sized mammals species recorded at Buenaventura Reserve in Southwestern Ecuador considering the Red List (RL) of mammals of Ecuador (Tirira 2011), the IUCN Red list (2016) and the CITES Appendices. Record's geographic location (Latitude, Longitude) of the individuals analysed for identification. Methods with which the different species have been recorded throughout the study: Occasional sightings (OS) or Camera traps (CT).

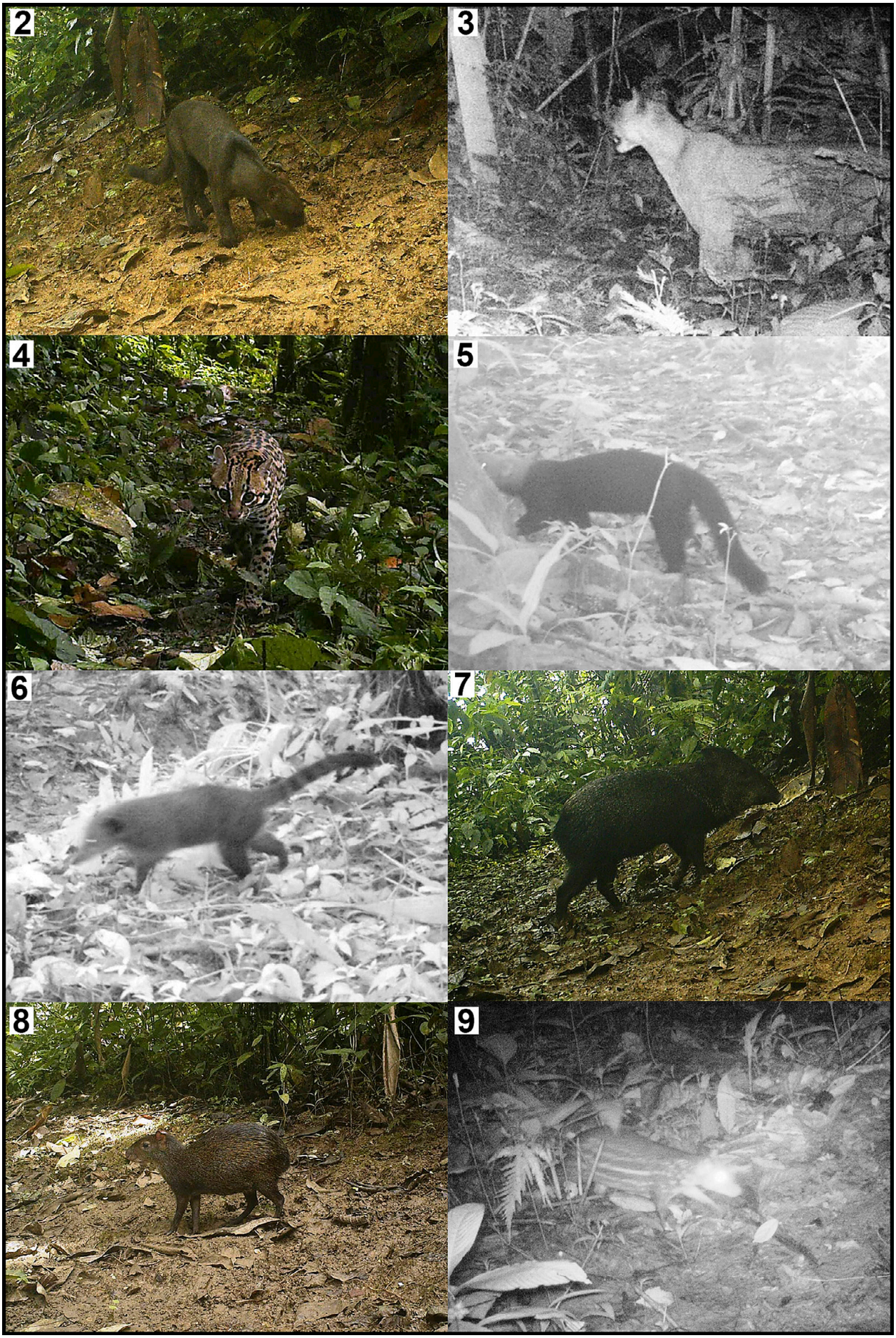
Taxon	RL	IUCN	CITES	Latitude	Longitude	Method
Carnivora						
Canidae						
Lycalopex culpaeus	VU	LC	Appendix II	03°38′32″	079°44′57″	OS
Felidae						
Herpailurus yagouaroundi	NT	LC	Appendix II	03°39′54″	079°46′33″	CT
Puma concolor	VU	LC	Appendix II	03°38′44″	079°45′45″	CT
Leopardus pardalis	NT	LC	Appendix I	03°38′50″	079°45′22″	CT
Mustelidae						
Eira barbara	LC	LC	Appendix III (Honduras)	03°39′54″	079°46′33″	CT
Lontra longicaudis	VU	NT	Appendix I	03°65′37″	079°74′27″	OS
Procyonidae						
Nasua narica	DD	LC	Appendix III (Honduras)	03°39′11″	079°45′57″	CT/OS
Potos flavus	LC	LC	Appendix III (Honduras)	03°39′14″	079°46′05″	OS
Artiodactyla						
Tayassuidae						
Pecari tajacu	NT	LC	Appendix II	03°38′44″	079°45′45″	CT/OS
Cingulata						
Dasypodidae						
Dasypus novemcinctus	LC	LC	—	03°39′12″	079°45′59″	CT/OS
Didelphimorphia						
Didelphidae						
Didelphis marsupialis	LC	LC	—	03°38′50″	079°45′22″	CT
Pilosa						
Myrmecophagidae						
Tamandua mexicana	VU	LC	Appendix III (Guatemala)	03°39′39″	079°46′38″	CT/OS
Bradypodidae						
Bradypus variegatus	LC	LC	Appendix II	03°38″04″	079°45′06″	OS
Megalonychidae						
Choloepus hoffmanni	VU	LC	Appendix III (Costa Rica)	03°38′55″	079°45′57″	OS
Primates						
Atelidae						
Alouatta palliata	EN	VU	Appendix I	03°38′58″	079°45′28″	OS
Cebidae						
Cebus aequatorialis	CR	CR	Appendix I	03°39′13″	079°46′03″	OS
Rodentia						
Cuniculidae						
Cuniculus paca	NT	LC	Appendix III (Honduras)	03°39′13″	079°45′37″	CT
Dasyproctidae						
Dasyprocta punctata	LC	LC	Appendix III (Honduras)	03°38′58″	079°45′13″	CT/OS
Sciuridae						
Notosciurus granatensis	LC	LC	—	03°38′57″	079°45′13″	OS
Simosciurus stramineus	LC	LC	—	03°39′18″	079°46′20″	OS

the RAI by dividing the number of captures of a species by the total number of captures of all species (Liu et al. 2013).

We identify the conservation status of each species based on the IUCN Red List (IUCN 2016), the Red Book of mammals of Ecuador (Tirira 2011), and the CITES Appendices.

Results

In total, 20 large and medium-sized mammals were recorded, distributed among 7 orders and 17 families (Table 1, Figs 2–15). Of this total, 11 species were recorded by camera traps, 5 of these also by occasional sightings and the other 9, mainly arboreal ones, such as squirrels (*Notosciurus granatensis, Simosciurus stramineus*), sloths (*Bradypus variegates, Choloepus hoffmanni)*, monkeys (*Alouatta palliate, Cebus aequatorialis*) and kinkajou (*Potos flavus*) but also the Neotropical Otter (*Lontra longicaudis*), the Culpeo (*Lycalopex culpaeus*) and the Common Opossum (*Didelphis marsupialis*) were recorded only by occasional sightings. According Tirira (2011), 19 species of the BR are Threatened, whereas the IUCN Red List (IUCN 2016) categorizes 20 species as at risk. Only 4 of all species are not included in the CITES Appendices (Table 1). The species accumulation curves did not reach an asymptote (Fig. 16). The richness estimate generated by the Chao 2 method ($n = 21.42$) was somewhat higher than the observed richness curve for the study area (Fig. 16). The relative abundance index of camera traps shows that of all 250 individuals recorded, the 2 most abundant species (i.e., dominant species) are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Figures 10–15. Some of the large and medium-sized mammals detected as occasional sightings at Buenaventura Reserve in southwestern Ecuador. **10.** *Bradypus variegatus*. **11.** *Choloepus hoffmanni*. **12.** *Dasypus novemcinctus*. **13.** *Potos flavus*. **14.** *Alouatta palliata*. **15.** *Cebus aequatorialis*.

Dasyprocta punctata and *Pecari tajacu*, which together account for more than 70% of the captures. The rarest species were *Tamandua mexicana* (0.80%) and *Herpailurus yagouaroundi* (1.20%) (Fig. 17).

Family Canidae

Lycalopex culpaeus Molina, 1782

Lycalopex culpaeus Molina 1782—Tirira 2007, Lucherini 2016.

Pseudalopex culpaeus—Molina 1782.

◄ **Figures 2–9.** Large and medium-sized mammals detected by the camera traps at Buenaventura Reserve in southwestern Ecuador. **2.** *Herpailurus yagouaroundi*. **3.** *Puma concolor*. **4.** *Leopardus pardalis*. **5.** *Eira barbara*. **6.** *Nasua narica*. **7.** *Pecari tajacu*. **8.** *Dasyprocta punctata*. **9.** *Cuniculus paca*.

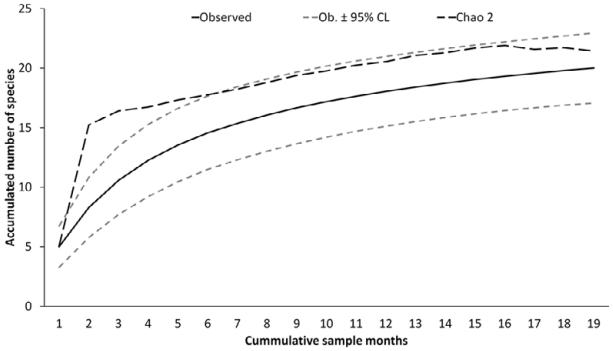

Figure 16. Accumulative mammal species curve for Buenaventura Reserve in southwestern Ecuador, data collected from July 2014 to July 2016.

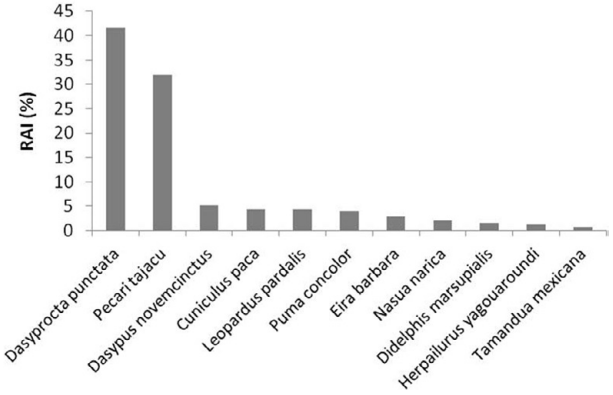

Figure 17. Relative abundance index of camera traps for each species for the Buenaventura Reserve in southwestern Ecuador.

Material examined: Table 1.

Long and thick pelage; blackish back with gray color and scarce reddish hair intermixed; the ventral region is of cream and pale orange color; head and face broad and well pronounced, triangular in appearance; conspicuous, straight and triangular ears; it has a distinctive reddish orange pattern on the face, cheeks, back face of the ears, limbs and inner face of the tail; short tail, blackish and densely haired (Tirira 2007).

Family Felidae

Herpailurus yagouaroundi (Geoffroy Saint-Hilaire, 1803): Figure 2

Felis yagouaroundi Geoffroy Saint-Hilaire 1803.

Herpailurus yagouaroundi — Tirira 2007, Caso et al. 2015.

Material examined: Table 2.

Short, uniform and spotless pelage, brown, grayish brown, reddish brown, fawn yellow or black; the belly is slightly paler; small and flat head, with small rounded ears; short snout and elongated neck; uniform tail color, long and thin (exceeds 60% of the length of head and body combined) (Tirira 2007).

Puma concolor **(**Linnaeus, 1771): Figure 3

Felis concolor Linnaeus 1771.

Puma concolor — Tirira 2007, Nielsen et al. 2016.

Material examined: Table 1.

Short uniform pelage, grayish brown, fawn brown or dark reddish brown, no spots; the ventral region is pale, almost white; relatively small head, snout and ears short; pale face, with whitish spots around the muzzle and on the throat; long tail (exceeds 60% of head and body length) with black tip (Tirira 2007).

Leopardus pardalis Linnaeus, 1758: Figure 4

Leopardus pardalis Linnaeus 1758 — Tirira 2007, Paviolo et al. 2016.

Material examined: Table 1.Short and soft pelage, sometimes slightly rough; it shows a color between yellow-brown and yellow-off almost all over the body, covered with well-defined black spots; on the back and flanks, some spots open in the shape of a rosette, or appear as blackish longitudinal lines, revealing a pale brown color on the inside, the ventral region is white with black spots (Tirira 2007).

Family Mustelidae

Eira barbara (Linnaeus, 1758): Figure 5

Mustela barbara Linnaeus 1758.

Eira barbara— Tirira 2007, Cuarón et al. 2016a.

Material examined: Table 1; Figure 5.

Short, thick and glossy pelage; dorsum dark brown to blackish, including limbs and tail; the ventral region is dark brown, with a yellow orange stain on the throat; head and neck may be yellowish brown, cream or cinnamon, a coloration that contrasts strongly with the rest of the body; middle face, naked and blackish snout, and large eyes; small ears and rounded and of the same color of the head; long tail (reaches 60% of the length of head and body together) and black (Tirira 2007).

Lontra longicaudis Olfers, 1818.

Lontra longicaudis Olfers 1818 — Tirira 2007, Rheingantz and Trinca 2015.

Material examined: Table 1.

Short, dense and shiny pelage; back dark brown to uniform brown cinnamon dark uniform; upper lip, lower cheeks, throat and ventral region whitish, cream or pale brown; head rounded, small and flat, short and wide snout; the nasal cushion totally or partially naked, with thick and rigid vibrisas; long tail, thick, fully furry and cylindrical, broad at base and thin at tip; legs short and robust, fingers with interdigital membranes (Tirira 2007).

Family Procyonidae

Nasua narica (Linnaeus, 1766): Figure 6

Viverra narica Linnaeus 1766.

Nasua narica — Tirira 2007, Cuarón et al. 2016b.

Nasua nelsoni Merriam 1901.

Material examined: Table 1.

Short and dense pelage; back dark brown to brown cinnamon; ventral region brown to yellowish cream colored, with whitish breast that joins the white throat; head elongated and grayish brown, the muzzle is long and mobile; chin and throat whitish; nose slightly rigid upward, black and damp in appearance; long tail (reaches 75 to 100% of the length of head and body together), densely haired and thinning toward the tip, dark brown with rings usually inconspicuous (Tirira 2007).

Potos flavus (Schreber, 1774): Figure 13
Lemur flavus Schreber 1774.
Potos flavus—Tirira 2007, Helgen et al. 2016.

Material examined: Table 1; Figure 13.

Dense, soft and short pelage; back is reddish to smoky brown gray, usually with a darker stripe in the middle of the back; ventral pelage between yellow and pale orange; round head, short but pronounced muzzle; brown nose, large, round, brown eyes, relatively spaced apart; prehensile tail, slightly longer than head and body together (Tirira 2007).

Family Tayassuidae

Pecari tajacu (Linnaeus, 1758): Figure 7
Sus tajacu Linnaeus 1758.
Tayassu tajacu Linnaeus 1758.
Pecari tajacu—Tirira 2007, Gongora et al. 2011.
Pecari maximus M. van Roosmalen et al. 2007.

Material examined: Table 1.

Back color blackish gray uniform, usually with numerous hairs with white tips, which give it a fleshy appearance; presents a strip of cream-colored hair that is pale to white, like a necklace, which starts on the lower part of the cheeks extending back through the neck, and ends at the top of the shoulders (Tirira 2007).

Family Dasypodidae

Dasypus novemcinctus Linnaeus, 1758: Figure 12
Dasypus novemcinctus Linnaeus 1758—Tirira 2007, Loughry et al. 2014.

Material examined: Table 1.

Back covered by a bone armor, generally with nine (possibly 8 to 11) moving bands or rows of osseous plaques in the middle part of the body; the plates are small and of rounded shape, except in the movable bands, where they have the shape of narrow triangles; the head has a shield armored in the forehead, formed by polygonal plates; snout long, narrow and slightly raised at the tip; narrow ears almost touching the base; tail covered with plates, slightly shorter than the head and body combined, with 12 to 15 differentiated rings; forelegs with four toes and hind legs with five (Tirira 2007).

Family Didelphidae

Didelphis marsupialis Linnaeus, 1758
Didelphis marsupialis Linnaeus 1758—Tirira 2007, Astua de Moraes et al. 2016.

Material examined: Table 1.

Dorsal pelage consists of two types of hair, one abundant, short, soft, woolly and clear, and another long and rough, black or white, which appears intermixed with small hairs; its dorsal coloration is black to gray; head yellowish-black to dirty white, sometimes with a black line not well-defined extending from the crown to the height of the eyes; tail a little longer than head and body combined, nude, black at the base and white towards the tip (Tirira 2007).

Family Mymercophagidae

Tamandua mexicana Saussure, 1860
Myrmecophaga tamandua Saussure 1860.
Tamandua mexicana—Tirira 2007, Ortega Reyes et al. 2014.

Material examined: Table 1.

The pelage is dense, short and uniform, has a large black stain, like a waistcoat, which starts on the shoulders and extends from the back and the belly towards the base of the tail; the rest of body, including the head, the upper third of the back and the extremities is of a golden yellow color, intense or pale, depending on the individuals; the ventral region is black, similar to the flanks; medium ears, well separated and protruding; tail thick, long, prehensile, with furry base and bare tip (Tirira 2007).

Family Bradypodidae

Bradypus variegatus Schinz, 1825: Figure 10
Bradypus variegatus Schinz 1825—Tirira 2007, Moraes-Barros et al. 2014.

Material examined: Table 1.

Long, dense, thick and wavy pelage (except on the face), inverted from the belly to the back, the back is grayish, yellowish gray or pale grayish brown, marbled, and with prominent whitish stains; small and round head; face whitish to grayish brown; ears not visible covered by pelage; dark lips that simulate a slight smile; limbs very long and hairy, the former somewhat more than the hind limbs; each ending in three long, curved claws, in the form of a hook and creamy yellowish color; tail short thick and truncated, covered by abundant pelage (Tirira 2007).

Family Megalonychidae

Choloepus hoffmanni Peters, 1858: Figure 11
Choloepus hoffmanni Peters 1858—Tirira 2007, Plese and Chiarello 2014.

Material examined: Table 1.

The coat is long, thick and wavy; the back is brown, slightly greenish as a result of the symbiotic relationship with algae; the ventral region is of the same coloration of the dorsal part, but contrasts clearly with the throat which is much paler; round head, often paler than the body; long limbs, light brown to dark, with long, curved claws, two on the front legs and three on the hind legs; tail not visible externally (Tirira 2007).

Family Atelidae

Alouatta palliata (Gray, 1849): Figure 14.
Mycetes palliataus Gray 1849.
Alouatta palliata— Tirira 2007, Cuarón et al. 2008.

Material examined: Table 1.

General coloration of the black body, except the flanks that have a fringe or mantle of long hairs of yellowish white, pale yellow, gold yellow or off-brown, which contrasts with the rest of the animal; large head, bare and blackish face; chin with long beards, more evident in the male; throat of inflated appearance, much more noticeable in the male (Tirira 2007).

Family Cebidae

Cebus aequatorialis Allen, 1914: Figure 15

Cebus aequatorialis Allen 1914 — Tirira 2007, Cornejo and de la Torre 2015.

Cebus albifrons aequatorialis Allen 1914 — Hershkovitz 1949.

Material examined: Table 1.

General pelage is grayish brown to yellowish brown; the head has a dark brown stain on the wedge-shaped crown, which extends forward; the face is pink, bordered with silvery white; prehensile tail, color from silvery-yellow to creamy (Tirira 2007). Molecular genetic analyses by Lynch Alfaro et al. (2010) and Boubli et al. (2012) indicated that *Cebus albifrons aequatorialis* should be considered a distinct species.

Family Dasyproctidae

Dasyprocta punctata Gray, 1842: Figure 8

Dasyprocta punctata Gray 1842 — Tirira 2007, Emmons 2016a.

Material examined: Table 1.

Medium-sized; the back is reddish brown to uniform yellowish brown; the chin and inguinal region are pale orange, while the rest of the belly is pale yellow; back slightly curved; short, hairy and inconspicuous tail (Tirira 2007).

Family Cuniculidae

Cuniculus paca (Linnaeus, 1766): Figure 9

Agouti paca Linnaeus 1766.

Cuniculus paca— Tirira 2007, Emmons 2016b.

Material examined: Table 1.

Short pelage, copious and somewhat rough; dorsum reddish brown to uniform dark brown, with abundant white spots from the neck to the hips, arranged in four lateral lines not very defined on each side of the back; cheeks, throat, chest and belly, creamy white; large square head, bulging cheeks; eyes large and well separated; short ears and long vibrisas; tiny tail, naked and hidden among the pelage (Tirira 2007).

Family Sciuridae

Notosciurus granatensis (Humboldt, 1811)

Sciurus granatensis Humboldt 1811 — Tirira 2007, Koprowski et al. 2008.

Notosciurus granatensis— Patton et al. 2015, Tirira 2016.

Material examined: Table 1.

The back and head vary between olive greenish, blackish, and dark reddish brown, often the crown and the midline of the back are darker; large ears, stand out prominently on the crown; long and voluminous face, blackish at the base, but orange-red in most of its extension; legs red to pale orange (Tirira 2007).

Simosciurus stramineus (Gervais, 1841)

Simosciurus simosciuru Gervais 1841.

Simosciurus stramineus — Patton et al. 2015; Tirira 2016.

Sciurus stramineus Eydoux and Souleyet 1841 — Tirira 2007, Duckworth and Koprowski 2008.

Material examined: Table 1.

Back with black hairs at the base and gray to white at the tips, which give it a cryptic and notoriously frosty appearance; thighs and base of the tail with hairs of an opaque orange color, intense or faint, with black hairs intermixed; ventral region gray, opaque brown or faintly reddish brown; head dark gray to blackish; long tail with black hairs at its base, but with white tips; legs black to whitish (Tirira 2007).

Discussion

Although various surveys on mammal diversity have been realized in Ecuador, there are few of these studies in the Andean Forests of Southern Ecuador. Buenaventura Reserve host at least 20 large and medium-sized mammals which represent 16% of mammals of the Subtropical Western zoogeographical zone (Albuja 2011), and about 50% of the mammals listed by Narváez et al. (2012) in Loja and El Oro provinces. A similar study in Machalilla National Park (area: 120 km^2), which is located in the western region of Ecuador (Tropical Northwest and Tropical Southwest zones), reported 18 species but the sample effort was 900 trap nights (Cervera et al. 2016). In another study in Santa Lucía Community Reserve, in the northwestern Ecuadorian Andes, 13 species of mammals were recorded with 2,700 trap nights (Cueva et al. 2010). The BR shares 16 species with Machalilla National Park and 9 with Loja and El Oro provinces. The shorter durations of other studies and their location in other zoogeographical zones could be the main reasons of why fewer species were found in those studies. All of the shared species have large distribution ranges.

Other studies have been made in the eastern foothills of the Andes. For example, Arcos (2010) recorded 31 species of mammals in 3 localities in 3 zoogeographic zones (Eastern Subtropical, 21 spp.; Temperate, 12 spp.; and High Andean, 10 spp.). In the temperate forests of eastern slope of Sumaco volcano, Lee et al. (2008) found 17 species of mammals, and in an inventory in the Andean forest remnants of the Guandera Biological Reserve in the High Andean zoogeographical zone of northern Ecuador, Titrira and Boada (2009) detected 30 species. Although these studies are less comparable with ours because they are located on the other side of the Andes in the Amazon basin, the BR shares 8 species with the study of Arcos (2010), 9 species with Lee et al. (2008), and 2 with Tirira and Boada (2009). The greatest differences between studies in the western region of the Andes may be related to where these studies were located and kinds of survey methods used.

Most species in the present study have geographic ranges that include the study site, but this study confirms for the presence of these species in the BR for the first time. The IUCN distribution maps of *Choloepus hoffmanni, Cuniculus paca, Dasyprocta punctata and Notosciurus granatensis* (IUCN 2016) do not include these species in the study site, expanding its ranges towards the south in the western Andes.

The presence of *Cebus aequatorialis* in the BR is a reintroduction project carried out in 2010. We are uncertain about the presence of this species before the

reintroduction; however, previous studies reported *C. aequatorialis* at nearby Cerro Azul, 12 km more north of the BR (Jack and Campos 2012). Priority regions conservation of this species were proposed by Campos and Jack (2013), and the BR is about 20 km from the fourth priority area.

We report 20 species located at various levels in the trophic chain, which signals good equilibrium of the BR ecosystem. For example, predators can play a vital role in ecosystem restoration as ecological engineers (Ritchie et al. 2012), and by their predation-driven direct effects or fear-driven indirect effects on communities and ecosystems (Ray et al. 2005, Roemer et al. 2009). Herbivores are an important part of the nutrient cycle, by diffusing nutrients in the ecosystem (Wolf et al. 2013). Frugivores are important role shaping the structure of plant communities and maintaining plant diversity because they can disperse seeds (Guimarães et al. 2008, O'Farrill et al. 2013). Finally, mammals that intermittently disturb soil incorporate organic matter into the soil, aerate it, improve the infiltration of water, and spread mycorrhizal fungi and seeds (Martin 2003).

The species richness and the relative abundance found in this study, and the benefits to the health of this protected area that these species represent, suggest that the BR is important for preservation of the environment. However, studies on population dynamics and community structure are needed to contribute to the conservation of the BR mammals. The role of this well-protected reserve as a refuge is crucial to species under threat of hunting and illegal trade, which occur in surrounding areas. With more information on the diversity, natural history, and ecology of species in the BR, better management is likely, which would ensure the equilibrium of the reserve's ecosystem.

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Authors' Contributions

JTP and JMS collected the data, and MEC, JTP, JMS and NA wrote the text.

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