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Non-volant mammals in a protected area on the Central Andes of Colombia: new records for the Caldas department and the Chinchiná River basin

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Abstract: The Chinchiná River basin is located on the western slope of the Colombian Central Andes. This basin provides ecosystem services such as water provision for >500,000 people, but has suffered considerable ecosystem degradation, and the information on its biodiversity is limited. We inventoried the non-volant mammals in the Caldas' Central Hydroelectric (CHEC) Reserve in the Chinchiná River basin, in the Caldas department. We detected 18 species of mammals, present the first record of *Puma yagouaroundi* for the high Chinchiná River basin, the first record of *Leopardus wiedii* for the basin and a new altitudinal record of this felid for the Colombian Central Andes, and we also report a melanistic individual of *Leopardus tigrinus*. We also provide the first record of *Conepatus semistriatus* for Caldas department. We highlight the importance of preserving forests on the Chinchiná River basin such as the CHEC Reserve, since they made serve to connect Andean forest with paramo areas on the National Natural Park Los Nevados, adding possible habitat for movements of *Puma concolor* and other mammals.

Key words: Andean forest, camera-traps, *Conepatus semistriatus, Leopardus wiedii*, melanic oncilla

INTRODUCTION

The Chinchiná River basin is on the western slope of the Colombian Central Andes, on the Caldas department. Because the altitude of the basin ranges from 800 to 5,200 m, it includes tropical ecosystems ranging from rain forest to permanent snowfields (Escobar-Lasso et al. 2013). The basin provides ecosystem services such as water provision for more than 500,000 people (Corpocaldas 2000). Given the high concentration of humans on this region, this zone has suffered significant processes of transformation, including deforestation and fragmentation since the 19th century. However, since the 20th century, there have been reforestation programs, mainly with exotic species such as *Eucalyptus* spp., to protect the basin and its biodiversity, but also for logging (Acosta and Muñoz 2005; Pérez-Arbeláez 1966). To preserve the basin's ecosystem services, it is necessary to protect its biodiversity and in order to do so it is necessary to know which species exist. Therefore, it is important to develop biodiversity inventories that could be used as foundations for research and future conservation and management plans in this zone.

Mammal inventories on the Chinchiná River basin are only limited to Río Blanco Reserve in Manizales (Rodríguez-Posada 2010; Sánchez et al. 2004). Also, Escobar-Lasso et al. (2013) compiled information of mammal records from scientific articles, university theses and specimens deposited in scientific collections for the Chinchiná River basin, showing that some forest fragments on the high portion of the basin are understudied, particularly with respect to medium and large mammals. Here, we present the first inventory of non-flying mammals in the Caldas' Central Hydroelectric (CHEC) Reserve, which is located in the high part of the Chinchiná River basin. In our work, we report mammal species that had not been previously recorded for this river basin and the Caldas department.

MATERIALS AND METHODS

Study site

The CHEC Reserve is 32.9 km² and it includes an altitudinal gradient from 2,400 to 4,000 m above se level (CHEC 2007). This forest connects, in its highest part, with the National Natural Park Los Nevados (CHEC 2007) and its central point is at the following coordinates 04°52′30″ N, 075°24′00″ W (Roncancio-D

and Estéves-V 2007) (Figure 1). Our study was concentrated between 2,400 and 2,730 m, and at that altitude the native canopy forest was dominated by species such as *Faramea flavicans*, *Guettarda hirsuta*, *Guarea kunthiana* and *Rhodostemonodaphne laxa*, while the understory consisted of species such as *Hedyosmum bonplandianum*, *Alsophila erinacea*, *Chamaedorea linearis*, *Geonoma undata*, *Piper archeri*, *Miconia* spp., and *Critoniopsis ursicola*, among others (CHEC 2007). The forest is also abundant in vascular epiphytes represented by families such as Gesneriaceae, Orchidaceae, Araceae y Bromeliaceae. In the 1960s, in order to recover the vegetation on the most degraded zones in the Reserve, plantations of *Eucalyptus* sp., *Acacia* sp., *Pinus* sp., *Cupressus* sp., or *Alnus acuminata*, as the only Neotropical native species, were established (CHEC 2007).

Data collection

PHOTO TRAPPING. We used camera trapping from September 2013 to April 2014. Eight camera traps Bushnell 8MP Trophy Cam HD®, were located 30–40 cm above the ground and programmed to take 20 second videos at intervals of five seconds if the animal remained within capture range (Díaz-Pulido and Payán 2012). During March and April we used sardines at the photo-trapping stations to increase capture probability. The cameras functioned continuously during the study, i.e., a total sampling effort of 2184 cameras × days.

TRACK STATIONS. We recorded the presence of mammals with 24 track stations during August 2013, with a sampling effort of 720 stations × days. We prepared the stations as follows: we removed the vegetation and stones in a meter of diameter, we then homogenized soil with water and finally flattened the resultant mud (Sánchez et al. 2004). Bait made of banana and granola mixture was placed in the center of the station. We checked each station around sunrise (06:00–08:00 h) to identify the presence of footprints or others tracks, e.g., foraging marks, hairs or scents (Sánchez et al. 2004). Subsequently, each station was watered and prepared as described before, and finally we marked three fingers on the station to verify that it was operational.

TRACK SEARCHING. During August 2013, we walked 4 km daily during daytime using available trails on the Reserve, with a cumulative distance of 124 km. From September 2013 to April 2014, we walked twice per month at daytime, covering altitudes from 2,400 m to 2,730 m, and we walked a total of 109.8 km in this period. We recorded every evidence that could be identified from a particular mammal species, e.g., foraging evidences, claw marks, footprints, hairs, dead individuals or burrows. Also, we included the species that we observed directly.

RESULTS

We recorded 19 mammal species distributed in six orders (Table 1). Carnivora was the best represented mammalian order with eleven species, followed by Rodentia with three and Cingulata with two. Didelphimorphia, Soricomorpha and Artiodactyla were represented by only one species each (Table 1). Using indirect methods, such as track searching and track stations, we recorded 12 species, whereas with direct detection methods we recorded 12 species (Table 1 and Figures 3–5).

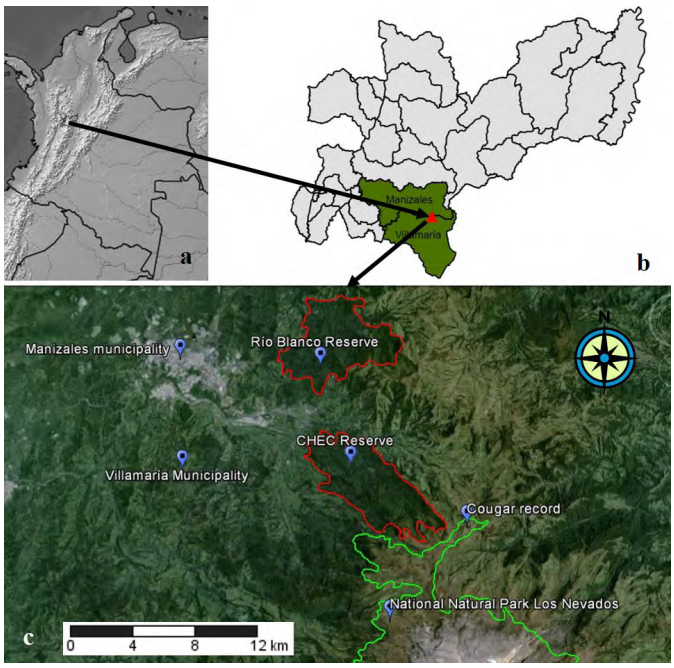

Figure 1. Location of the study zone in Colombia (a) and Caldas Department (b). The satellite image shows the limits of CHEC Reserve, the Río Blanco Reserve and National Natural Park Los Nevados (c). It is signaled a record of cougar in Los Nevados (unpublised data), which is near the CHEC Reserve. The satellite image is edited from Google Earth.

DISCUSSION

The non-flying mammal species composition recorded in our study is similar to that reported on the Río

Figure 2. *Puma concolor* (Linnaeus, 1771) feces recorded at National Natural Parck Los Nevados, on La Laguna village, at the Villamaría municipality and at a 3985 m of altitude in a paramo ecosystem, 04°59.028′ N, 075°20.272′ W (unpublished data).

Table 1. Mammals recorded at the CHEC Reserve. Detection method for each species. TTS: tracking and track stations, PT: Photo-trapping, DA[1]: dead animals. IUCN: conservation status according to IUCN (2014). CCS: Colombian conservation status according to Rodríguez-Mahecha et al. (2006).

Species	TTS	PT	DA[1]	IUCN	CCS	Common name at the site
Order Didelphimorphia						
Didelphis pernigra (J.A. Allen, 1900)		X		LC	LC	Chucha
Order Cingulata						
Dasypus novemcinctus (Linnaeus, 1758)	X	X		LC	LC	Armadillo nueve bandas
Cabassous centralis (Miller, 1899)	X			DD	NT	Armadillo cola de trapo
Order Soricomorpha						
Cryptotis sp.			X	-	-	Musaraña
Order Rodentia						
Cuniculus taczanowskii (Stolzmann, 1865)	X	X		NT	LC	Güagüa de páramo
Coendou sp.	X			-	-	Erizo
Sciurus granatensis (Humboldt, 1811)	X	X		LC	LC	Ardilla
Order Artiodactyla						
Mazama rufina (Pucheran, 1851)	X	X		VU	LC	Venado
Order Carnivora						
Canidae gen. et sp. indet.	X			-	-	Zorro
Nasua nasua (Linnaeus, 1766)	X	X	X	LC	LC	Cusumbo solino, coatí
Nasuella olivacea (Gray, 1865)	X	X		DD	LC-NT[2]	Cusumbo mocoso, coatí
Eira Barbara (Linnaeus, 1758)		X		LC	LC	Tayra
Mustela frenata (Lichtenstein, 1831)	X	X		LC	LC	Comadreja
Conepatus semistriatus (Boddaert, 1785)	X			LC	LC	Zorrillo, mofeta
Leopardus wiedii (Schinz, 1821)		X		NT	NT	Margay
Leopardus tigrinus (Schreber, 1775)		X		VU	VU	Oncilla
Leopardus sp.		X		-	LC	Tigrillo
Puma concolor (Linnaeus, 1771)		X		LC	NT	Puma
Puma yagouaroundi (É. Geoffroy Saint-Hilaire, 1803)		X		LC	LC	Yaguarundí

[1] The dead animals were not collected because of the CHEC Reserve authorities' policies.
[2] Conservation status for Colombia according to Balaguera-Reina et al. (2009).

Blanco Reserve (Sánchez et al. 2004), which is near the CHEC's Reserve (Figure 1c). However, in our study, we did not detect *Leopardus pardalis* (Linnaeus, 1758), *Sylvilagus brasiliensis* (Linnaeus, 1758), and *Dinomys branickii* (Peters, 1873), which were reported for Río Blanco (Sánchez et al. 2004). In addition, we did record *Puma concolor* (Linnaeus, 1771), *Puma yagouaroundii* (É. Geoffory Saint-Hilaire, 1803), *Leopardus wiedii* (Schinz, 1821) and *Conepatus semistriatus* (Boddaert, 1785) that have not been registered for Río Blanco Reserve (Figures 3 and 4).

Cougars, *P. concolor*, had already been reported previously for the Caldas department (Castaño et al. 2003; Castaño 2011; Escobar-Lasso et al. 2013). However, our record is important because CHEC Reserve connects, on its south-eastern portion, with the National Natural Park Los Nevados (CHEC 2007) (Figure 1c). In Los Nevados, on La Laguna village, at the Villamaría municipality and at a 3985 m of altitude in a paramo ecosystem, we found on January 2013 feces that, based on size and shape (Aranda 2012), corresponded to cougar (unpublished data) (Figure 2). On Los Nevados cougars have been recorded before (Lotero-Echeverri et al. 2010) and it is likely that Los Nevados is where the cougars registered on the CHEC Reserve are originally from. Indeed, the CHEC Reserve has 38.9 km^2 and since the reported home ranges for cougars vary between 31.8–1,031 km^2 (Caso et al. 2008; Elbroch and Wittmer 2012), it is very unlikely that the CHEC Reserve can sustain more than one individual and it is probably used as a corridor by cougars and they do not live permanently at the Reserve (Figure 3g, h).

Escobar-Lasso et al. (2013) reported the presence of *P. yagouaroundi* for the lower part of the Chinchiná River basin at 1,212 m of altitude. We recorded this species at 2,453 m of altitude at the coordinates 05°01.148′ N, 075°25.022′ W (Figure 3i), and this constitutes the highest record for the Caldas Department (Escobar-Lasso et al. 2014). Additionally, we made the first record of *L. wiedii* for the Chinchiná River basin (Castaño Salazar 2011; Escobar-Lasso et al. 2013). This felid has been previously recorded on Caldas but at the Samaná municipality, at 1,493 m of altitude in the National Natural Park Selva de Florencia (Payan-Garrido and Soto-Vargas 2012). Ours is the highest altitudinal record of *L. wiedii* on the Colombian Central Andes (Figure 3b), 2,700 m, and the second highest of the country, since it has been previously recorded at 2,845 m of altitude in the Cundinamarca department, Colombian Eastern Cordillera (Valderrama-Vásquez 2013). Also, we recorded a melanistic individual of *Leopardus tigrinus* (Schreber, 1775) at an altitude of 2,730 m (Figure 3f). There are few reports of this condition in Colombia, and with the increase in the use of camera traps probably we will have

Figure 3. Mammal images from videos of camera-traps on the CHEC Reserve. (**a**) *Sciurus granatensis* (Humboldt, 1811). 2,493 m altitude, 05°01.162′ N, 075°24.869′ W. (**b**) *Leopardus wiedii* (Schinz, 1821). 2,700 m altitude, 05°01.699′ N, 075°24.825′ W. (**c**) *Eira Barbara* (Linnaeus, 1758). 2,473 m altitude, 05°01.135′ N, 075°24.937′ W. (**d**) *Nasua nasua* (Linnaeus, 1766). 2,484 m altitude, 05°01.117′ N, 075°24.897′ W. (**e**) *Mazama rufina* (Pucheran, 1851). 2,494 m altitude, 05°01.101′ N, 075°24.878′ W. (**f**) Melanic *Leopardus tigrinus* (Schreber, 1775). 2,730 m altitude, 05°01.008′ N, 075°23.774′ W. A video is available by writing to the principal author; an edited version of the video can be viewed at https://www.youtube.com/watch?v=MddWRklQu9c (**g**) *Puma concolor* (Linnaeus, 1771). First individual recorded at the Reserve, the red arrow show a scar in the left ear of the animal. 2,596 m altitude, 05°01.803′ N, 075°24.733′ W. (**h**) *P. concolor*. Second individual recorded at the Reserve, this animal have no a scar in the left ear. 2,730 m altitude, 05°01.008′ N, 075°23.774′ W. (**i**) *Puma yagouaroundi* (É. Geoffroy Saint-Hilaire, 1803). 2,453 m of altitude, 05°01.148′ N, 075°25.022′ W. A video is available by writing to the principal author; an edited version of video can be viewed at https://www.youtube.com/watch?v=fgG3zlCwpYg.

a better understanding of the distribution of the mutation in this species (Schneider et al. 2012) throughout the Andes. Finally, our *C. semistriatus* report constitutes the first in the Caldas department (Castaño et al. 2003; Castaño 2011; Escobar-Lasso et al. 2013) (Figure 4a). The four Carnivora species, *P. yaguarondi*, *L. wiedii*, *L. tigrinus* and *C. semistriatus*, are expected to have a wide distribution in Colombia, but we still have a limited idea

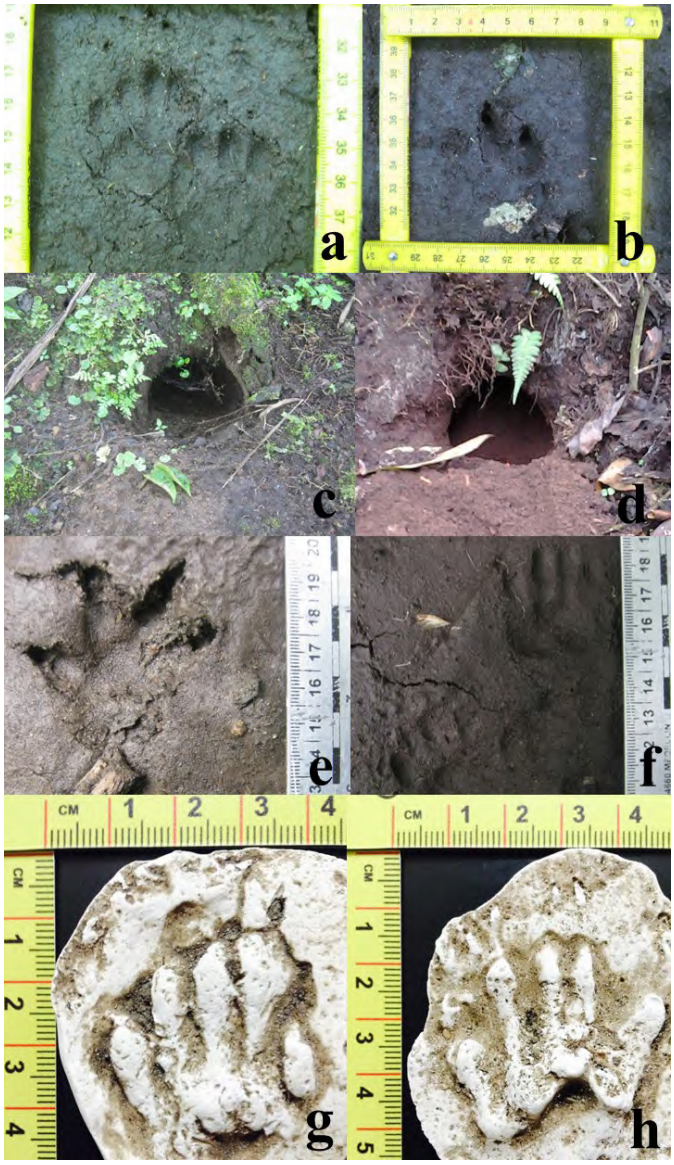

Figure 4. Tracks and plasters molds of mammals on the CHEC Reserve. (**a**) *Conepatus semistriatus* (Boddaert, 1785) footprint, recorded on *Eucalyptus grandis* reforestation at the Reserve, 2,484 m altitude, 05°01.116′ N, 075°24.893′ W. (**b**) *Dasypus novemcinctus* (Linnaeus, 1758), right hand footprint. 2,476 m altitude, 05°01.158′ N, 075°24.857′ W. (**c**) *Cabassous centralis* (Miller, 1899), foraging evidence; the hole is wider than it is tall, 2,512 m altitude, 05°01.663′ N, 075°24.755′ W. (**d**) *D. novemcinctus*, foraging evidence; the hole is taller than it is wide, 2,489 m altitude, 05°1.510′ N, 075°24.762′ W. (**e**) *Cuniculus taczanowskii* (Stolzmann, 1865) hand footprint. 2,473 m altitude, 05°01.135′ N, 075°24.937′ W. (**f**) *Cryptotis* sp. 2,482 m altitude, 05°01.143′ N, 075°24.864′ W. *Nasuella olivacea* (Gray, 1865), plaster mold of left hand (**g**) and right foot (h) footprints. 2,484 m altitude, 05°01.116′ N, 075°24.893′ W.

on what particular regions they are still present in the Colombian Andes (Alberico et al. 2000; Solari et al. 2013). Indeed, our findings show how little we know about the distribution of mammal species in the Chinchiná River basin, the Caldas department, and the Colombian Andes in general. We consider that this type of information is important when considering managing strategies for either particular patch-forests or landscapes in Caldas.

In the neighboring forests of the Río Blanco Reserve two canids, *Cerdocyon thous* (Linnaeus, 1766) and *Urocyon cinereoargenteus* (Schreber, 1775) have been reported (Sánchez et al. 2004). Since we could not identify the genus and species of canid, we classified these tracks as "undetermined Canidae" (Table 1). It is necessary to make additional efforts to identify the canid species at the CHEC Reserve. Moreover, because one of the small spotted cats recorded could not be clearly photographed, we identified it only to genus level, *Leopardus* sp., leaving the possibility of more than two *Leopardus* species being present at the CHEC Reserve.

Nine of the species we found are not categorized as Threatened using the international classification (IUCN 2014) (Table 1). *Cabassous centralis* (Miller, 1899) and *Nasuella olivacea* (Gray, 1865) are cataloged as Data Deficient, whereas *Cuniculus taczanowskii* (Stolzmann, 1865) and *L. wiedii* are Near Threatened (IUCN 2014) (Table 1). According to the Colombian Red List of Threatened Species (Rodríguez-Mahecha et al. 2006), *C. centralis* (Miller, 1899), *L. wiedii* and *P. concolor* are Near Threatened (Table 1), and Balaguera-Reina et al. (2009) proposed categorizing *N. olivacea* as Near Threatened in Colombia (Table 1). All this confirms the importance of the CHEC Reserve as a refuge for species that are Near Threatened and others, such as *Mazama rufina* (Pucheran, 1851) and *L. tigrinus* (Figure 3e and f), which are categorized as Vulnerable (IUCN 2014). Particularly, as habitat loss and poaching continues as a regular practices in Caldas, the negative effects of those processes could be mitigated by keeping, or ideally increasing, forested areas in the department. In addition, the restoration and preservation of forests might also reduce the possible future negative effects associated to climate change (Cuesta et al. 2009). Therefore, the Andean forest fragments such as those in the CHEC Reserve, which also connects with bigger protected areas, such as Los Nevados, could be crucial for mammal species persistence through time.

Finally, our results confirm the limited knowledge that we have about the terrestrial mammals in some Chinchiná River basin forests and the need to continue research into the wildlife that survives there. We hope that the results presented here will be used as a basis for understanding the species' biology in the Chinchiná River basin, and as an example for developing research about how different species respond to the human modification of habitats and thus serve to develop plans for their conservation.

Figure 5. Porcupine tracks and dead shrew found at CHEC Reserve. (**a**) *Coendou* sp. spines, 2,512 m altitude, 05°01.663′ N, 075°24.755′ W. Dead *Cryptotis* sp. (**b**) and (**c**). 2,596 m altitude, 05°01.803′ N, 075°24.733′ W.

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Author's contribution statement:
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