Medium and large mammals of the mid Planas River basin, Colombia

Mamíferos medianos y grandes de la cuenca media del río Planas, Colombia

Carlos A. Aya-Cuero ⓘ , **Federico Mosquera-Guerra**ⓘ , **Diego A. Esquivel** ⓘ , **Fernando Trujillo** ⓘ and **Daniel Brooks**ⓘ

Abstract

We describe the diversity of medium and large mammals from an area in the Colombian Orinoco River basin. For three years we systematically used camera traps at 72 sampling stations and walked forest and savanna transects to determine the diversity of medium and large mammals. Relative abundance was documented for 29 native and 2 feral mammals from a sampling effort of 1789 camera-days and 469.5 km walked. Thirty-one species of mammals (9 orders, 19 families) were recorded. Threatened species recorded included the giant armadillo (*Priodontes maximus*), lowland tapir (*Tapirus terrestris*), white-lipped peccary (*Tayassu pecari*), and giant anteater (*Myrmecophaga tridactyla*). The most abundant species were the collared peccary (*Pecari tajacu*) and the common opossum (*Didelphis marsupialis*). We recorded rare species, including the bush dog (*Speothos venaticus*) and the Llano semi-endemic long-nosed armadillo (*Dasypus sabanicola*). The species documented face diverse pressures, including development, hunting for subsistence, and competition with invasive species and livestock. Our results suggest that the surveyed areas are important for the conservation of mammals in the eastern plains of Colombia.

Keywords. Meta. Riparian forest. Savannas. Species composition.

Resumen

Estudiamos la diversidad de mamíferos medianos y grandes en un área no protegida de la Orinoquia Colombiana durante tres años, empleando cámaras trampa en 72 estaciones de muestreo y haciendo recorridos por bosques y sabanas. Con un esfuerzo de 1789 días-cámara y 469.5 km recorridos se documentaron 31 especies de mamíferos (9 órdenes, 19 familias). Se registraron especies amenazadas como ocarro (*Priodontes maximus*), danta (*Tapirus terrestris*), pecarí de labio blanco (*Tayassu pecari*) y hormiguero gigante (*Myrmecophaga tridactyla*). Se registraron especies raras, como el perro vinagre (*Speothos venaticus*) y semiendémicas como el cachicamo sabanero (*Dasypus sabanicola*). Las especies mejor representadas a través del índice de abundancia relativa fueron el pecarí de collar (*Pecari tajacu*) y la zarigüeya (*Didelphis marsupialis*). Las especies registradas se enfrentan a diversas presiones, como cacería para subsistencia, especies invasoras y ganadería. Por lo tanto, los resultados sugieren que las áreas no protegidas son importantes para la conservación de los mamíferos en los Llanos Orientales de Colombia.

Palabras clave. Bosques de galería. Composición de especies. Meta. Sabanas.

Introduction

Colombia is considered the sixth most species-rich country for mammals worldwide, with 528 species (Ramírez-Chaves *et al.*, 2016; Ramírez-Chaves *et al.*, 2019). This diversity is explained in part by its geographic position, and the different climates, altitudes, and ecosystems represented in the country's six biogeographic regions (Andean, Amazon, Caribbean, Guyana, Pacific, and Orinoquia; Trujillo *et al.*, 2018). The Orinoquia, also known as the *Llanos Orientales* (eastern plains), occupies ca. 17 million ha (Rippstein *et al.*, 2001), 18% of the country's land area, and contains multiple ecosystems, including savannas, wetlands, and a variety of forests (e.g., morichal or *Mauritia* swamps, transitional, and gallery forests; Buriticá, 2016). The mammalian fauna of the Orinoco River basin is shaped by Andean, Amazonian, and Guiana Shield elements (Correa *et al.*, 2006), and it is estimated that the largest population concentrations of mammals are located in this biogeographic region (Rodríguez-Mahecha *et al.*, 2006). In contrast, this region harbors a relatively low level of endemism (Rodríguez-Mahecha *et al.*, 2006; Ferrer *et al.*, 2009).

Despite the high biodiversity and studies recently conducted of the region's medium and large mammals (Álvarez & López-Arévalo, 2014; Rodríguez-Bolaños *et al.*, 2015; Olarte-González & Balaguera-Reina, 2015; Mosquera-Guerra *et al.*, 2017; Mosquera-Guerra *et al.*, 2018; Trujillo *et al.*, 2018; Castillo-Figueroa *et al.*, 2019; Pardo *et al.*, 2019), the mammals of the Orinoco River basin are among the least known in Colombia (Hernández *et al.*, 1984; Mosquera-Guerra *et al.*, 2018). The cited studies have a low representatioforest fragmentedn contrast to the size of the Orinoquia and its habitat heterogeneity. Therefore, it is necessary to keep on gathering information on distribution, conservation, and threats (Mosquera-Guerra *et al.*, 2017), since there are still information gaps that hinder the designation of priority zones for mammal conservation.

Zones outside protected areas constitute an important aspect in the conservation of large mammals (Payán-Garrido & Escudero-Páez, 2015). Although the total proportion of legally protected areas in Colombia is slightly larger than the global average of 14.7% (UN Environment WCMC, 2018),these reserves alone will not protect most of the biodiversity in the long-term (Rosenzweig, 2003; Brooks *et al.*, 2004; Rodrigues *et al.*, 2004). The protected areas are and will remain too small, isolated and vulnerable to natural and anthropogenic changes (Hales, 1989; Van Schaik *et al.*, 1997; Carroll *et al.*, 2004; DeFries *et al.*, 2005). Forest cover changes in the Orinoco basin have intensified after human activity increased since ca. 1950 (Trujillo & Superina, 2013), and the area has suffered a reduction in the quantity and quality of available habitat. Therefore, further data are necessary to track subsequent changes in species composition and density (Lasso *et al.*, 2011).

Our objective in this study is to describe the diversity of medium and large mammals in the mid Planas River basin, an unprotected area located in Puerto Gaitán, Meta Department. This study was undertaken using 'bycatch' photo-trap data from armadillo conservation projects in the Colombian Llanos (Superina *et al.*, 2019) and autoecological research of the giant armadillo *Priodontes maximus* in Puerto Gaitán (Aya-Cuero *et al.*, 2017).

Materials and methods

Study site. The study area comprises ten private properties (ca. 30 700 ha surveyed) located in the mid Planas River basin (ca. 369 530 ha; Forero, 2017), near the municipality of Puerto Gaitán, Meta, Colombia (4°1'56" N, 71°49'40" W). The Planas River watershed is one of the most extensive forested areas of the municipality, with over 250 tree species, but has suffered a high degree of change in vegetation cover recently (Correa *et al.*, 2006; Forero, 2017). The following types of forest cover have been documented in the region: riparian, *terra firme*, fragmented, freshwater swamp, *morichal* (*Mauritia flexuosa* palm swamps), and secondary tall forest, as well as wooded pasture, and savanna (Forero, 2017). Overall, the area is 90% plains and 10% mountains (Cicery *et al.*, 2005),

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corresponding to high plains without seasonal flooding (Rangel-Ch *et al.*, 1995). Average annual rainfall is 2300 mm, with a bimodal rainfall regime, and temperature renges between 24 and 30 ºC (Cicery *et al.*, 2005). The area is classified as a seasonal tropical savanna pedobiome, characterized by extensive savannas and wooded vegetation restricted to gallery forests (Hernández-Camacho *et al.*, 1992).

Fieldwork. We used 20 Bushnell Trophy Cam, Scout-Guard, Cuddeback Attack, DLC Covert II and Reconyx PC camera traps with active motion detection. The cameras were installed at 72 sampling sites (Figure 1; Table 1) between 2013 and 2015, with the following seasonal effort

per year (season/trap-days): 2013 (rainy - 95, dry - 55), 2014 (rainy- 250, dry- 1209) and 2015 (rainy -180), camera traps were installed 50 cm above the ground, located primarily at armadillo burrows, trails, and watering holes, with inter-camera distances ranging from 500 - 1000 m. Each camera was georeferenced using a global positioning system (GPSMAP® 62sc |Garmin). Camera traps were programed to operate 24 hrs/day with an interval of 3 minutes between each pictures record. Finally, the sampling effort was calculated according to Díaz-Pulido & Payán (2012) and Lira-Torres & Briones-Salas (2012).

In 2014 different transects were walked daily by one person (occasionally two) between 6:00 and 9:00 hrs.
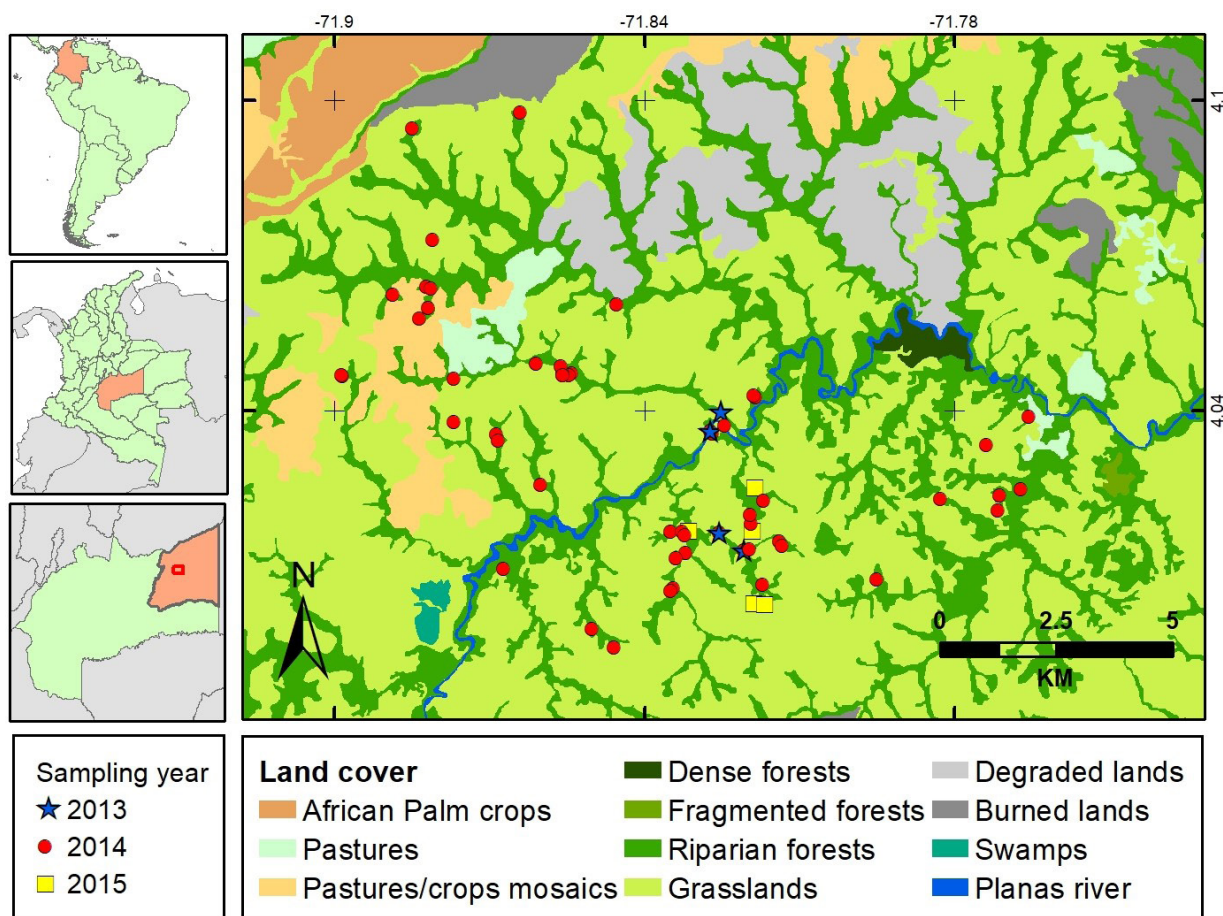

Figure 1. Planas River basin in Puerto Gaitán (Meta, Colombia), with land covers and mammal sampling stations. Stars, 2013 sampling; circles, 2014 sampling: squares, 2015 sampling.

Transect length ranged between 1.5 km (195 repeats) along gallery forests and 0.5 km (254 repeats) along wooded savannas. We recorded direct sightings and indirect evidence of mammals, which were registered, georeferenced, and photographed.

Semi-structured interviews were conducted among 45 local people of Vereda Santa Catalina and Vereda Alto Manacacías between February 8th and August 14th, 2014, to obtain data on uses of fauna and the primary threats to certain species. We asked about uses of the species, considering the following topics for wild mammals: retaliation hunting, protein source, local threats, medicinal and other uses. Interviewees were shown illustrations of Linares (1998) and Emmons & Feer (1997) for species identification.

Specimens found dead or displayed as hunting trophies were collected and deposited at the biological collections of the Museo de Historia Natural de la Universidad Distrital Francisco José de Caldas (MHNUD) and the Museo de La Salle (MLS-BOG). The only reference available for this area, Rodríguez-Bolaños *et al.* (2015), was included to confirm the presence of certain species in the Planas River basin.

Medium and large size mammals were identified using the taxonomic guides of Linares (1998), Gardner (2008), Patton *et al.* (2015), and taxonomy follows Wilson & Reeder (2005), Ramírez-Chaves *et al.* (2019), and specialized papers for each group. To identify the threat category, the National Red List for mammals of Colombia was used (Minambiente, 2017), as well as the IUCN Red List (IUCN, 2019).

Statistical Analysis. Sampling effort was calculated by multiplying the number of camera traps by the number of effective sampling days (1 day = 24 hrs; Lira-Torres & Briones-Salas, 2012). Additionally, the relative abundance index (RAI) was calculated for each species by dividing the number of records per taxon by the total number of camera trap records (Díaz-Pulido & Payán-Garrido, 2012).

Results

A total of 588 records were obtained from a sampling effort of 1789 camera-days (Table 1). These records accounted for 31 species of medium and large mammals (29 natives, 2 feral species) from 19 families in 9 orders (Table 2, Figure 2). IUCN Red-listed species accounted for 23.3% of all identified species, including *Priodontes maximus* (VU), *Tapirus terrestris* (VU), *Myrmecophaga tridactyla* (VU), *Tayassu pecari* (VU), *Dasypus sabanicola* (NT), *Speothos venaticus* (NT), and *Lontra longicaudis* (NT).

The lowest RAI (RAI = 0.001) was for *C. lanatus,* which was found only once during the sampling effort; in contrast, *P. tajacu* (n = 203; RAI = 0.222) and *D. marsupialis* (n = 168; RAI = 0.184) had the highest RAI values (Figure 3).

Table 1. Sampling effort of camera trapping for medium and large mammals at the mid Planas River, Meta, Colombia.

Year	Date	# traps/stations	Sampling days	Effort (trap-days)
2013	5 - 23 August	5/5	19	95
	1 - 11 March	5/5	11	55
2014	10 February - 8 August	10/50	133	1335
	2 - 30 November	6/6	20	124
2015	23 July – 23 August	6/6	30	180
	TOTAL	42/72	213	1789

Table 2. Medium-sized to large mammals recorded in mid Planas River basin, Meta, Colombia. Records to genus are not included in the species count. Conservation status follows IUCN Red List (2018) and Rodríguez *et al.* (2006): LC, Least Concern; NT, Near Threatened; VU, Vulnerable. Type of records: Ct, camera trap; Ho, human observation; In, interview; Ir, indirect record; Li, literature; Pa, parts of dead animals. RAI, relative abundance index. Forest Cover: Gf, gallery forest; M, *Morichal;* Sa, high-plain savannas. *Species recorded by Rodríguez-Bolaños *et al.* (2015).

Species	Voucher	Conservation status		Records				Forest cover
		IUCN	MIN-AMBIENTE (2017)	2103	2014	2015	RAI	
DIDELPHIMORPHIA								
Didelphidae								
*Didelphis marsupialis**	[MHNUD-795]: skull and skin	LC	-	Ct (6)	Ct (149), Pa(1), In (28)	Ct (13), Li (1)	0.187	Gf
Caluromys lanatus		LC	-	Ct (1)			0.001	Gf
*Metachirus nudicaudatus**		LC	-	Ct (1)	Ct (3)	Li (1)	0.004	Gf
CINGULATA								
Dasypodidae								
*Dasypus novemcinctus**		LC	-	Ct (1)	Ct (7), Pa (6), In (19)	Ct (3), Li (1)	0.014	Gf, M
Dasypus pastasae	[MHNUD- 807]: carapace; [MLS-2430]: skull	LC	-	Ct (5)	Ct (84), Pa (2), Ir (3), In (26)	Ct (2)	0.101	Gf, Sa
*Dasypus sabanicola**	[MHNUD-796]: skin; [MHNUD-806]: skin	NT	-	Ho (1), Ct (2)	Ct (6), Ho (2), Pa (2), In (35)	Li (1)	0.009	Sa, Gf, M
Dasypus spp.		-	-	Ct (8)	Ct (45)		0.059	Gf, Sa, M
Chlamyphoridae								
*Priodontes maximus**	[MHNUD-810]: carapace; [MLS-1844]: skull; [MHNUD-808]: carapace	VU	EN	Pa (1), Ct (3),	Ct (85), Ho (3), Pa (2), In (17)	Ct (1), Li (1)	0.099	Gf, Sa
PILOSA								
Myrmecophagidae								

*Tamandua tetradactyla**	Not Collected	LC	-	Ct (2)	Ho (2), Ct (11), Pa (2), (In 32)	Ct (2), Li (1)	0.017	Gf
Myrmecophaga tridactyla		VU	VU	Ct (2)	Ct (12), Ho (2), In (41)		0.016	Gf, Sa
CARNIVORA								
Felidae								
*Leopardus pardalis**		LC	-	Ct (4)	Ct (5), Pa (16)	Li (1)	0.010	Gf
Puma concolor	Not Collected	LC	-	Ct (3)	Ct (3), In (14)	Pa (1)	0.007	Gf
Canidae								
Speothos venaticus		NT	-	Ct (2)	Ct (1)		0.003	Gf
Cerdocyon thous	[MHNUD-802]: skull; [MHNUD-803]: skull	LC	-	Ct (1)	Ct (8), Ho (3), Pa (2), In (43)		0.010	Gf, Sa
Canis familiaris		-	-		Ct (3)		0.003	Gf
Mustelidae								
*Eira barbara**		LC	-		Ct (7), Ho (3)	Ct (2), Li (1)	0.010	Gf
Lontra longicaudis		NT	VU		Ho (1), In (17)		-	Gf
PERISSODACTYLA								
Tapiridae								
Tapirus terrestris	[MHNUD- sn]: skull	VU	-	Ct (2)	Ho (1), Ir (7), In (13)	Pa (1)	0.002	Gf, M
ARTIODACTYLA								
Tayassuidae								
Pecari tajacu	[MHNUD-798]: skull; [MHNUD-804]: skull	LC	-	Ct (8)	Ct (183), Ho (3), Pa (2), In (45)	Ct (12)	0.226	Gf, M
Tayassu pecari		VU	-			Ct (5)	0.006	Gf
Suidae								
Sus scrofa		LC	-		Ct (2), In (5), Ir (3), In (8)		0.002	Gf, Sa

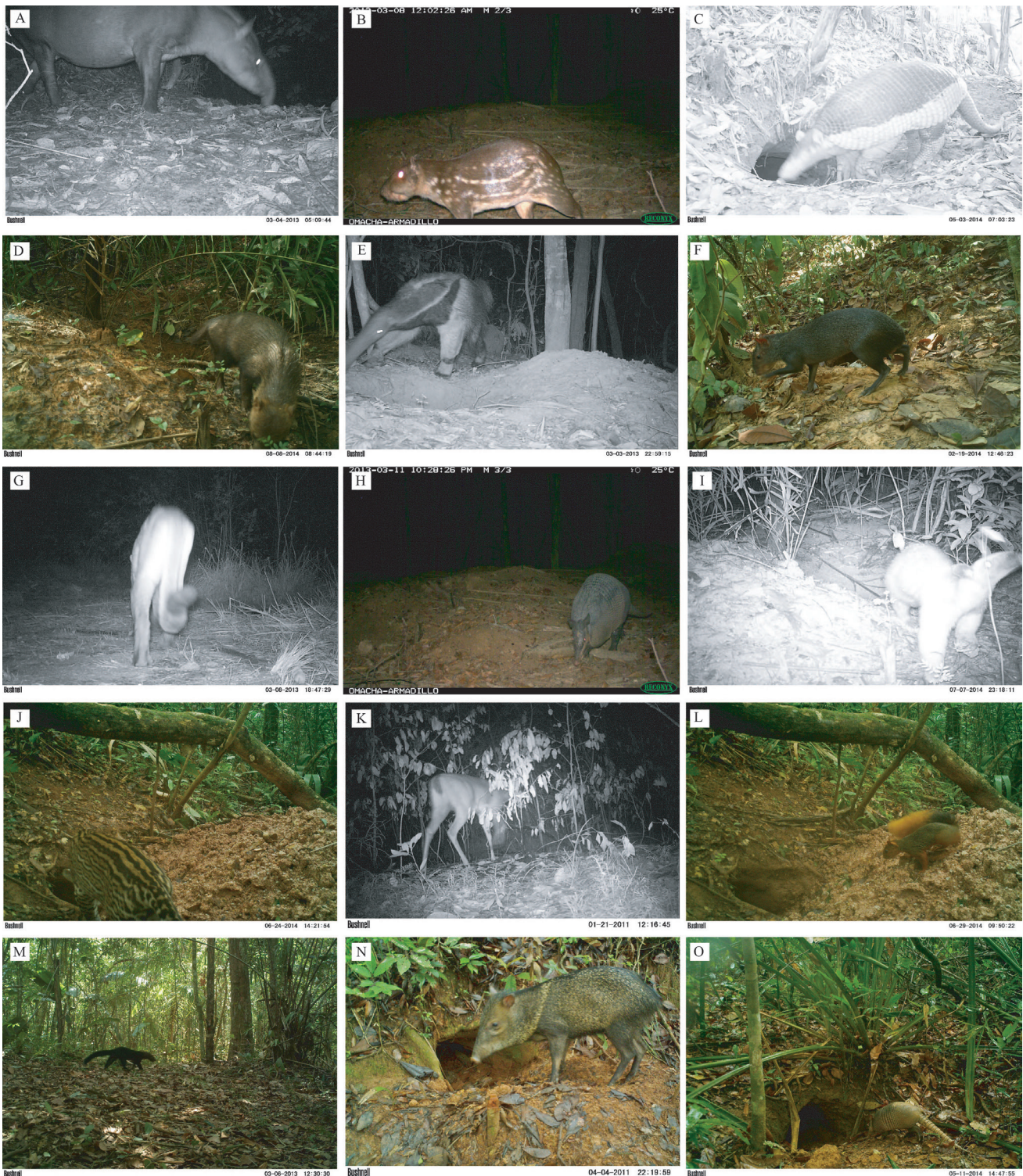|								
Cervidae								
Odocoileus cariacou	[MHNUD-800]: skull	-	CR	Pa (1)	Ct (4), Ho (3), In (25)		0.004	Gf, Sa
LAGOMORPHA								
Leporidae								
Sylvilagus brasiliensis		LC	-	Ho (1)	Ho (5), In (32)		-	Sa
PRIMATES								
Atelidae								
Alouatta seniculus		LC	-		Ho (4), Ir (8)		-	Gf
Cebidae								
Cebus albifrons	[MHNUD- sn]: skull	LC	-		Pa (1)	Ho (2)	-	Gf
*Sapajus apella**		LC	-		In (6)	Li (1)	-	Gf
Saimiri cassiquiarensis		LC	-		Ca (1), Ho (3)			Gf
RODENTIA								
Sciuridae								
Notosciurus cf. *granatensis*		LC	-		Ct (25), Ho (8), In (23)	Ho (2)	0.031	Gf
Caviidae								
Hydrochoerus hydrochaeris	Not collected	LC	-		Ho (2), Pa (1), In (6)		-	Gf, M
Cuniculidae								
*Cuniculus paca**	[MHNUD-799]: skull; [MHNUD-805]: skull	LC	-	Ct (9)	Ct (72), Ho (2), In (45)	Ct (17)	0.109	Gf
Dasyproctidae								
*Dasyprocta fuliginosa**	[MHNUD-797]: skin and skull; [MHNUD-809]: skull; [MHNUD-801]: skull	LC	-	Ct (12)	Ct (45), Pa (3), In (38)	Ct (3)	0.067	Gf
Erethizontidae								
*Coendou prehensilis**		LC	-		In (6)	Li (1)	-	Gf

Figure 2. Mammals recorded with camera traps at the mid Planas River basin, Puerto Gaitán, Meta, Colombia. A) *Tapirus terrestris*, B) *Cuniculus paca*, C) *Priodontes maximus*, D) *Speothos venaticus*, E) *Myrmecophaga tridactyla*, F) *Dasyprocta fuliginosa*, G) *Puma concolor*, H) *Dasypus pastasae*, I) *Tamandua tetradactyla*, J) *Leopardus pardalis*, E) *Odocoileus cariacou*, L) *Notosciurus* cf. *granatensis*, M) *Eira barbara*, N) *Pecari tajacu*, and O) *Dasypus sabanicola*.
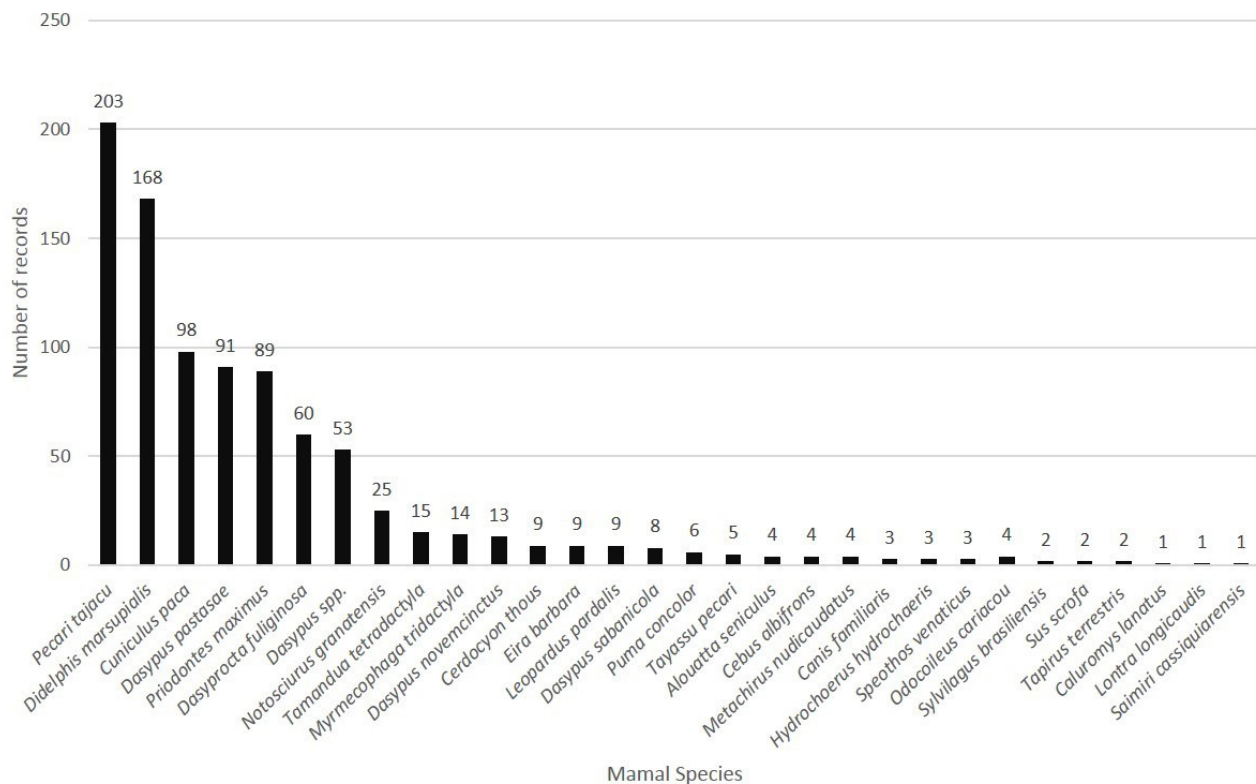
Figure 3. Number of records obtained with camera traps for medium and large mammals in the mid Planas River basin, Meta, Colombia.

The local community uses mammals in various ways: 52% consume wild mammals as a source of protein for subsistence, 40% have medicinal uses for different animal parts, 5% hunt for recreation, and 3% keep some mammals as pets. Most interviewees (82%) identified armadillos (*Dasypus* spp.) and paca (*C. paca*) as the most important species for food consumption. In addition, local people recognize ungulates such as the lowland tapir, deer and peccaries as the most hunted mammals a decade ago. Nonetheless, people perceive that the number of mammals has decreased in recent years, the causes being identified by the community as hunting (30%), dog kills (29%), environmental pollution (19%), wildlife-vehicle collisions (15%), and fire (7%).

During our fieldwork between February and August 2014, we recorded multiple evidence of mammals being used as a source of protein, hunting trophies, and pets.

We recorded the following species: *D. pastasae* (1), *D. sabanicola* (5), *P. maximus* (2), *T. terrestris* (1), *D. fuliginosa* (2), *H. hydrochaeris* (1), *C. paca* (3) *C. albifrons* (1) *and O. cariacou* (2). Other mammals were hunted because they posed a threat to livestock and poultry, including *P. concolor* (1) and *D. marsupialis* (1).

Specimens from the study area used as hunting trophies included ocelot (*Leopardus pardalis*) pelts, giant armadillo (*P. maximus*) carapaces, tails and carapaces of armadillos (*Dasypus* spp.), paca (*C. paca*) skulls, Coues' white-tailed deer (*O. cariacou*) antlers, and jaguar (*P. onca*) bones. The Jaguar bones came from the department of Vichada (bordering to the east) and they are used to treat burns and wounds.

Another threat documented in the study area was wildlife-vehicle collisions; 15% of the local communities

have observed mammals involved in roadkills on tertiary roads in this area. During the field work three mammals were found dead along the Puerto Gaitán-Rubiales tertiary road: *C. thous* (1), *D. pastasae* (1) and *T. tetradactyla* (2). Also, stray or feral species such as dogs (*C. familiaris*; n = 3 events) and pigs (*S. scrofa*; n = 2) present a threat from the hunting of wild species and competition for resources. Moreover, local people hunted with dogs, as evidenced for the following species: *C. paca*, *D. marsupialis*, *Dasypus* spp., *T. terrestris*, and *P. concolor*. Additional threats recognized by the local communities and the literature include African oil palm (*Elaeis guineensis*) crops, extensive livestock farming, changes in native forest cover, and habitat destruction through deliberate burning of savannas.

Discussion

Our study detected 57% more species of the native medium-sized to large terrestrial mammals compared to a study carried out in the same area by Rodríguez-Bolaños *et al.* (2015). Comparing with other non-protected areas of the Orinoco basin, we obtained 55% more than that reported in others three types of savannas (Castillo-Figueroa *et al.*, 2019), 45% more than the African oil palm plantation, 21% more than forest (Pardo *et al.* 2019), and 13% more than the *morichales* (Trujillo *et al.*, 2017). This indicates that the gallery forest is important as a biological corridor among the savannas and pastures; the probability of occurrence in these forests is considerably greater than in other types of forest cover. In addition, long-term studies are more effective for understanding species diversity in a non-protected area. However, in La Macarena National Natural Park, relatively close to our study area in the same department, Díaz-Pulido *et al.* (2016) recorded all the species found in our study, and 27% more, with a minor sampling effort. Nevertheless, according to Trujillo *et al.* (2018) the characteristics and landscape in that location are different, more closely associated with the Guianan region.

In general, the protected areas in the Orinoquia region are few (Romero *et al.*, 2017). La Macarena, El Tuparro, and the flooded savannas of Cinaruco, in Arauca, are the only national protected areas in the Orinoquia and constitute a small portion of this important biogeographical region. It is questionable whether these protected areas in the Orinoquia region provide effective protection to medium and large mammals. At present, no protected biological corridors have been established between these protected areas. Therefore, there is no guarantee of quality or quantity of long-term habitat for wildlife conservation.

The association of giant armadillo burrows by wildlife in savanna ecosystems is an important topic. Aya-Cuero *et al.* (2017) documented different groups of vertebrates associated with *P. maximus* burrows at this same study area, among them 13 species of mammals, including *P. tajacu* and *C. paca*. These two species had high RAI values compared to other studies in the same region (e.g., Castillo-Figueroa *et al.*, 2019; Pardo *et al.*, 2019), probably due to their foraging and subterranean habits. The savanna ecosystem has few shelters compared to others ecosystems. Nonetheless, these ecosystems are home to keystone species and habitat engineers, such as large carnivores (*P. concolor* and *L. pardalis*; Garrote *et al.*, 2017; Mosquera-Guerra *et al.*, 2017), perissodactyls (*T. terrestris*), artiodactyls (*T. pecari* and *O. cariacou*), and xenarthrans (*P. maximus* and *M. tridactyla*; Muñoz-Saba *et al.*, 2016; Aya-Cuero *et al.*, 2017; Mosquera-Guerra *et al.*, 2017).

The adequate identification of species from camera trap records is vital to avoid underestimating or overestimating the abundance of some species. Different studies have used camera traps to obtain data on medium and large mammals, during which *D. pastasae* was documented (Tobler *et al.*, 2008; 2015; Aya-Cuero *et al.*, 2017). It should be noted that nine-banded armadillo (*D. novemcinctus*) and greater long-nosed armadillo (*D. pastasae*) tend to be pooled as *Dasypus* spp., due to difficulties in differentiating the two species based on camera trap images (Aya-Cuero *et al.*, 2019). Similarly, *D. pastasae* also inhabits areas where other members of the genus *Dasypus* can be found, such as the llano

long-nosed armadillo *D. sabanicola*, of the Eastern Plains, which likely indicates that armadillo abundance in other biological surveys of the Orinoco basin has been under-reported or misrepresented.

Local uses for different species reduce mammal populations. Of the 30 species recorded, only 10 (33%) are used by local communities. Among such uses, bushmeat is most common and comprises an activity focused on finding food. Although hunting is not practiced intensively, the populations of some species may be affected in the midterm, for species such as *P. maximus* and *T. terrestris* with intrinsically low rates of reproduction (Brooks & Eisenberg, 1999). Most rural communities in this area live in poverty and economic margination, and their priorities are therefore focused on subsistence and use of natural resources, although often unsustainably (Bolkovic, 1999, Lorenzo-Monterrubio *et al.*, 2007).

The medium and large orders of mammals are preferred sources of protein by local communities. Our study found that the mammals used as a protein source were Artiodactyla, Cingulata and Rodentia. Similarly, the orders Artiodactyla and Rodentia are the most used (for their high biomass) by two indigenous communities in El Tuparro Biosphere Reserve (Martínez *et al.*, 2016). Similarly, the species we found most desired by hunters are similar to those reported for other Sikuani indigenous communities in the department of Vichada (Plata, 2006). Concordant with Martínez *et al.* (2016), we found primate consumption infrequent, and only a single hunting incident involving one specimen (*C. albifrons*) by Sikuni indigenous communities was found. Systematic research of subsistence hunting is necessary in our study area, to understand the effect of this activity on the potential decrease of mammal populations.

A rare species recorded in our study is *S. venaticus*, photographed on 8 August 2014 at 08:44:19 h. Additional records of this species at the same locality are documented in detail by Rodríguez-Castellanos *et al.* (2017). In contrast, a rare species we did not record in this region is the short-eared dog (*Atelocynus*

microtis) which was found in the same department, near Restrepo, on the Río Ariari (Ayure & González-Maya, 2014) and recently in La Macarena (Díaz-Pulido *et al.*, 2016). For species recorded, our results are concordant with Castillo-Figueroa (2019), with the exception of *Herpailurus yaguaroundi*, which we did not record.

Three Near threatened species, *D. sabanicola*, *S. venaticus*, and *L. longicaudis*, have not yet been evaluated at the national level for Colombia (Rodríguez-Mahecha *et al.*, 2006; Minambente, 2017). However, the semi-endemic *D. sabanicola* yielded one of the lowest RAI (0.009). Considering that it is one of the few Orinoquia endemics and in light of its relatively small area of distribution, it seems to be seriously affected by the constant changes to its habitat, which has resulted in a population decrease. For this reason, it has recently been reevaluated by IUCN and classified as Near Threatened (NT; Superina *et al.*, 2014). We consider that future studies in this region can estimate population density of cryptic, semi-endemic and rare species such as *P. maximus*, *D. sabanicola* and *S. venaticus*.

Various threats reduce mammal populations in the Orinoquia region, and our study identified hunting as one of the principal threats for mammals, concordant with a study in El Tuparro Biosfere Reserve (Martínez *et al.*, 2016). This activity is a potential factor that contributes to the reduction of mammal populations globally. For the endangered giant armadillo (*P. maximus*), Rodríguez-Mahecha *et al.* (2006) mentioned that it is easy prey for hunters because it cannot hide quickly, especially in open habitats. We found a high preference of *P. maximus* in riparian forest rather than savannas (Aya-Cuero *et al.*, 2017), which may be a mechanism for this species to avoid being hunted. Perhaps the same is true with other species (e.g., *D. sabanicola*, *P. tajacu*, *O. cariacou*, and *T. terrestris*). Behavioral studies analyzing these patterns are needed to identify the responses of the different species in their adaptation process and ecological importance.

An emerging threat in the study area is the presence of feral animals, primarily dogs and pigs. Other studies have demonstrated the negative impact these species

have as they disproportionately predate and unbalance native faunal population densities (Cruz-Reyes, 2009). Plant populations are also affected; for example, in the Mauritia palm swamps, pigs predate the palm fruits and prevent seedlings from developing (Trujillo & Mosquera-Guerra, 2016). These two domestic mammals are also competing with wildlife for resources such as food and habitat.

This study emphasizes the importance of private lands and non-protected areas as natural corridors for mammals, and as tools for faunal conservation in Meta department, as pointed out in studies conducted in the departments of Amazonas (Payán-Garrido & Escudero-Páez, 2015) and Vichada (Mosquera-Guerra *et al.*, 2017). Colombia has one of the highest proportions of protected areas with land and forest degradation (Leisher *et al.*, 2013), with 4.9% of its protected areas subjected to intense human pressures (Jones *et al.*, 2018). This is especially true in the Orinoco basin since it is one of the regions of Colombia with the least amount of protected areas (Romero *et al.*, 2017). We recommend the promotion of private natural reserves, focusing on goals and activities related to conservation of key species such as *P. maximus*, *S. venaticus* and *T. terrestris.*

Acknowledgements

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Carlos A. Aya-Cuero

Fundación Kurupira

Bogotá, Colombia

ekatenkes24@gmail.com

https://orcid.org/0000-0002-4884-4347

Federico Mosquera-Guerra

Fundación Omacha

Bogotá, Colombia

afederico.mosqueraguerra@gmail.com

https://orcid.org/0000-0002-6915-8602

Diego A. Esquivel

Fundación Kurupira

Bogotá, Colombia

diegodaem@gmail.com

https://orcid.org/0000-0001-7098-4517

Fernando Trujillo

Fundación Omacha

Bogotá, Colombia

fernando@omacha.org

https://orcid.org/0000-0002-5327-8618

Daniel Brooks

Houston Museum Natural History

Houston, USA

dbrooks@hmns.org

https://orcid.org/0000-0003-1316-690X

Medium and large mammals of the mid Planas River basin, Colombia