Mastozoología Neotropical
ISSN: 0327-9383
ISSN: 1666-0536
enrique.lessa@gmail.com
Sociedad Argentina para el Estudio de los Mamíferos
Argentina

Meza-Joya, Fabio Leonardo; Ramos, Eliana; Cediel, Fernando;
Martínez-Arias, Víctor; Colmenares, Javier; Cardona, Diana

PREDICTED DISTRIBUTIONS OF TWO POORLY KNOWN SMALL CARNIVORES IN COLOMBIA: THE GREATER GRISON AND STRIPED HOG-NOSED SKUNK

Mastozoología Neotropical, vol. 25, no. 1, 2018, January-June, pp. 89-105
Sociedad Argentina para el Estudio de los Mamíferos
Argentina

Mastozoología Neotropical, 25(1):89-105, Mendoza, 2018
Versión on-line ISSN 1666-0536

Artículo

PREDICTED DISTRIBUTIONS OF TWO POORLY KNOWN SMALL CARNIVORES IN COLOMBIA: THE GREATER GRISON AND STRIPED HOG-NOSED SKUNK

Fabio Leonardo Meza-Joya[1], Eliana Ramos[1], Fernando Cediel[2], Víctor Martínez-Arias[3], Javier Colmenares[4], and Diana Cardona[1]

[1] Colombia Endémica, Asociación para el Estudio y la Conservación de los Recursos Naturales, Bucaramanga, Colombia. [Correspondence: Fabio Leonardo Meza-Joya <fleonardo78@gmail.com>]
[2] Sociedad Ornitológica del Nororiente Andino (SONORA), Bucaramanga, Colombia.
[3] Grupo de Mastozoología, Universidad de Antioquia, Medellín, Colombia.
[4] Laboratorio de Macroecología, Escuela de Biología, Universidad Industrial de Santander, Bucaramanga, Colombia.

ABSTRACT. Recent contributions have increased our knowledge of the distribution of small carnivores in Colombia, however, geographic ranges of many species remain poorly understood. Species distribution modeling represents a useful tool for predicting the geographic distributions of poorly known species. This paper focuses on updating and modeling the distribution of two small carnivores in Colombia, *Galictis vittata* and *Conepatus semistriatus*, based on reliable historical and new locality records. We used MaxEnt to model the species' potential distributions using presence localities, along with climate variables and elevation. Our results provided strong support for the predictive power of the models, suggesting a broad distribution for these species in Colombia, with 265 063 km^2 and 224 238 km^2 of suitable habitat for *G. vittata* and *C. semistriatus*, respectively. Our models suggest that a greater proportion of the predicted distribution of these species is currently outside protected areas. Based on these results, we highlight the need to increase studies in poorly surveyed regions where these species are predicted to occur and no confirmed records currently exist. Further studies are required to better understand the taxonomic limits, geographic distribution, threats, and conservation status of these and other small carnivores in Colombia.

RESUMEN. Distribución potencial de dos especies poco conocidas de pequeños carnívoros en Colombia: el grisón mayor y el zorrillo rayado. Estudios recientes han incrementado el conocimiento sobre la distribución de los pequeños carnívoros en Colombia, no obstante, la información para muchas especies sigue siendo deficiente. Los modelos de distribución de especies representan una herramienta útil para predecir la distribución geográfica de especies poco conocidas. Este estudio se enfoca en actualizar y modelar la distribución geográfica de dos pequeños carnívoros en Colombia, *Galictis vittata* y *Conepatus semistriatus*, con base en registros históricos y recientes confirmados. Utilizamos MaxEnt para modelar la distribución potencial de estas especies usando datos de presencia, así como variables climáticas y elevación. Nuestros resultados proporcionaron un fuerte apoyo al poder predictivo de los modelos y sugieren una amplia distribución de estas especies en Colombia, identificando 265 063 km^2 y 224 238 km^2 de hábitat adecuado para *G. vittata* y *C. semistriatus*, respectivamente. No obstante, una gran proporción de la distribución predicha para estas especies se encuentra actualmente fuera de áreas protegidas. Con base en estos resultados, resaltamos la necesidad de incrementar muestreos en regiones poco estudiadas donde se prevé que estas especies ocurran y donde actualmente no existen registros confirmados.

Recibido 5 mayo 2017. Aceptado 19 enero 2018. Editor asociado: B Patterson

Estudios adicionales son necesarios para una mejor comprensión de los límites taxonómicos, la distribución geográfica, las amenazas y el estado de conservación de estos y otros pequeños carnívoros en Colombia.

Key words: *Conepatus semistriatus*. Extent of occurrence. *Galictis vittata*. Species distribution models.

Palabras clave: *Conepatus semistriatus*. Extensión de ocurrencia. *Galictis vittata*. Modelos de distribución de especies.

INTRODUCTION

Small carnivores include nine families worldwide, with only three (Mephitidae, Mustelidae, and Procyonidae) occurring in the New World (Schipper et al. 2008; Belant et al. 2009). In Colombia, this group is represented by 18 species, including one mephitid, six mustelids, and 11 procyonids (Ramírez-Chaves & Suárez-Castro 2014), which vary substantially in life-history and ecological traits. Small carnivores represent an important but poorly known component of the terrestrial mammal communities in Colombia (González-Maya et al. 2011). This fact is probably associated with the elusive and secretive nature of some of these species, resulting in low detection probabilities during field work and ultimately difficulty in assessing their rarity (Yensen & Tarifa 2003; Burneo et al. 2009). Information gaps from many geographical regions of Colombia are another key factor limiting knowledge of these taxa in the country (e.g., Ramírez-Chaves & Noguera-Urbano 2010; Castaño-Salazar 2011). Consequently, reliable and verifiable information about the current geographic distribution, ecology, natural history, and conservation status of small carnivores in Colombia remains scarce and scattered (González-Maya et al. 2011).

Recent contributions have increased the knowledge of the distribution of small carnivores in Colombia (e.g., Bornholdt et al. 2013; Helgen et al. 2013; Noguera-Urbano & Ramírez-Chaves 2013; Escobar-Lasso & Guzmán-Hernández 2014; Cardona et al. 2016; Jiménez-Alvarado et al. 2016; González-Maya et al. 2017), but distributional limits for many species remain poorly defined. This fact prevents an adequate understanding of the distributions of all small carnivores in Colombia and the assessment of their current conservation status (González-Maya et al. 2011). Due to a lack of sufficient sampling and associated records, most distribution maps of small carnivores are based on the minimum convex polygon (MCP) method (i.e., the smallest polygon containing all locality records for a given species) in combination with expert opinion (see http://www.iucnredlist.org). Nevertheless, polygon range maps have many drawbacks including overestimation of the size of the species distributional limits and introduction of an unknown amount of commission error, which reduces their reliability for conservation and management applications (Rondinini et al. 2006; Boitani et al. 2011; Rondinini & Boitani 2012).

Species distribution modeling has an enormous potential for conservation planning because it offers a potential solution for making predictions about the potential geographic distribution of poorly known species (Raxworthy et al. 2003; Kamino et al. 2012; Kalle et al. 2013). Here, we focused on two small carnivores in Colombia, the Greater Grison *Galictis vittata* (Schreber, 1776) and the striped hog-nosed skunk *Conepatus semistriatus* (Boddaert, 1785). These species, identified as Least Concern by the International Union for the Conservation of Nature (IUCN, Cuarón et al. 2016a, b), have broad distributional ranges from Mexico, through Central America into South America, as far south as northern Argentina for *G. vittata* (Yensen & Tarifa 2003; Bornholdt et al. 2013; Cuarón et al. 2016b); and as far south as Peru with an isolated population in eastern Brazil for *C. semistriatus* (Nowak 2005; Cuarón et al. 2016a). The main goal of this study was to update the knowledge of the distributional range of these species in Colombia using reliable historical and new records in conjunction with predictive species distribution models. We also provide an estimate of these species extent of occurrence and their representation inside the network of protected areas in the country. Lastly, we discuss some possible anthropogenic threats and key research issues that will help ensure the long-term survival of these and other small carnivores in Colombia.

MATERIALS AND METHODS

Field surveys

We conducted field surveys in several areas of Colombia (Atlántico, Bolívar, Casanare, Cesar, La Guajira, and Santander departments) between 2011 and 2017. Fieldwork was conducted using active survey methods (Voss & Emmons 1996) searching for direct observations (e.g., sightings and carcasses) and signs (e.g., footprints, feces, burrows) of mammals. Surveys started in the morning (8:00 h) and night (18:00 h), lasting for 4-6 hours. In several localities in Santander, Casanare, and Cesar departments we also randomly placed between 5 and 10 Bushnell Trophy cameras (model 119435) on trails, near water bodies or where mammalian sign was found. Cameras were set to heights between 30 and 50 cm above the ground, and programmed to take either 10-second videos (720 x 480) or 3 photos per trigger (8 mp). Some cameras were baited with fruits or a mixture of tuna and sardines to increase the likelihood of detection. Cameras were operated between 5 and 15 days, 24 hours per day, and were checked at the end of each field trip. In addition, during field work in La Guajira and Santander departments, we collected opportunistic roadkill data for these species on several roads. The location, geographic coordinates, habitat, and date of each record were taken (**Table 1** and **Table 2**; for additional details see **Supplementary Material S1** and **S2**).

Distributional data

We mapped the species' geographical distribution in Colombia based on confirmed records from our field surveys, well-supported reports from published literature, and data provided by reference collections in Colombia: Colección de Mamíferos of Instituto de Ciencias Naturales at Universidad Nacional de Colombia (ICN), Colección de Mamíferos of Universidad del Valle (UV), Colección Teriológica of Universidad de Antioquia (CTUA), and Colección Zoológica of Universidad de Nariño (PSO-CZ). Additional data from other sources was obtained through Global Biodiversity Information Facility (http://www.gbif.org), Mammal Networked Information System (http://manisnet.org), and SiB Colombia (http://www.sibcolombia.net) on 10 April 2016. Because the target species are easy to identify in the field, we considered "human observation" records with consistent geographic data available to be reliable. Each locality record available was checked to identify uncertainty and mistakes in the geographic information. When locality information was incomplete, it was inferred from Global Gazetteer Version 2.3 (http://www.fallingrain.com) and using Google Earth. When geographical coordinates were incomplete or not available, locality descriptions provided by collectors were georeferenced using the point-radius method (Wieczorek et al. 2004) in Quantum GIS software (http://qgis.osgeo.org). Although we recognize some degree of uncertainty around these coordinates (between 1 and 5 km^2), we expect them to fall near or in the correct pixel of the 30 arc-seconds environmental data (about 1 km^2 resolution; see next paragraph). Records with inconsistent geographic information were excluded from the maps and analyses.

Species distribution modeling

We built models using MaxEnt v. 3.3.3k, a presence-background algorithm that integrates georeferenced occurrence locations with environmental data to model the spatial suitability of a given species (Phillips et al. 2006). Models were generated using 36 and 60 occurrence records from Colombia for *G. vittata* and *C. semistriatus*, respectively (**Supplementary Material S1** and **S2**). We reduced spatial autocorrelation and bias among our records using rarefication via spatial filtering, keeping the maximum number of occurrences that were at least 10 km apart (Anderson & Raza 2010; Boria et al. 2014; **Table 3**). We used 19 bioclimatic variables and elevation data from the WorldClim Project (Hijmans et al. 2005) at a spatial resolution of 30 arc-seconds. To select the variables used in the final models, we followed the process outlined by Warren et al. (2014). For this, we ran a starting model including all variables, and calculated the contribution scores for each variable (percentage contribution and permutation importance). To get alternate estimates of which variables are most important in the model, we also ran a jackknife test. Then, we calculated the spatial correlations (Pearson coefficient) between environmental variables. We

Table 1

Description of the new records of *Galictis vittata* from Colombia reported here. Asterisk (*) denote recent records (2017) not included in the analyses.

Locality (department, municipality, location)	Elevation (m)	Record type	Aggregation	Biogeographic region	Record site, Holdridge's Life Zone
Atlántico, Piojó, Reserva Forestal El Palomar	192	Sightings Video	Couple	Caribbean	Path near to shrub, tropical dry forest
Bolívar, Rioviejo, vereda Pan Coger, El Rabo farm	37	Sightings Photograph	Solitary	Caribbean	Savannah, tropical moist forests
Casanare, Villanueva, vereda la Camarga-Leche Miel*	202	Sightings	Solitary	Orinoquia	Oil palm plantation, tropical moist forest
Santander, Barrancabermeja, vereda Peroles	85	Roadkill Photograph	Solitary	Andean	Road next to pasture, tropical moist forest
Santander, San Vicente de Chucurí, vereda Viscaina, El Comején	134	Sightings Photograph	Solitary	Andean	Pasture near to scrub, tropical moist forests
Santander, San Vicente de Chucurí, corregimiento Yarima, Caño Hondo	143	Sightings Photograph	Couple	Andean	Pasture next to a disturbed forest patch, tropical moist forests
Santander, Girón, near to the dam Hidrosogamoso	320	Camera-trap	Couple	Andean	Pasture adjacent to stream, tropical moist forest

Table 2

Description of the new records of *Conepatus semistriatus* from Colombia reported here. Asterisk (*) denote recent records (2017) not included in the analyses.

Locality (department, municipality, location)	Elevation (m)	Record type	Aggregation	Biogeographic Region	Record site, Holdridge's Life Zone
La Guajira, Uribia, Ipapure	32	Sightings Photograph	Solitary	Caribbean	Disturbed shrub, subtropical thorn woodland
La Guajira, Manaure, Ranchería Mayapo	1	Footprint	Solitary	Caribbean	Disturbed shrub, subtropical thorn woodland
La Guajira, Manaure, Ranchería Cangrejos	0	Footprint	Solitary	Caribbean	Disturbed shrub, subtropical thorn woodland
La Guajira, Manaure, Ranchería Pipamana	2	Footprint	Solitary	Caribbean	Disturbed shrub, subtropical thorn woodland
La Guajira, Riohacha, Route 49, next to La Negrita	26	Roadkill Photograph	Solitary	Caribbean	Road adjacent to disturbed shrub, subtropical thorn woodland
La Guajira, Riohacha, Route 49, near to Los Ángeles	33	Roadkill Photograph	Solitary	Caribbean	Road next to disturbed shrub, subtropical thorn woodland
La Guajira, Riohacha, Route 90, close to corregimiento Camarones	15	Roadkill Photograph	Solitary	Caribbean	Road close to disturbed shrub, subtropical thorn woodland
La Guajira, Riohacha, Route 49, adjacent to comunidad Tiwouya	36	Roadkill Photograph	Solitary	Caribbean	Road near to disturbed shrub, subtropical thorn woodland
La Guajira, Riohacha, Route 90, next to Perico	17	Roadkill Photograph	Solitary	Caribbean	Road adjacent to disturbed shrub, subtropical thorn woodland
La Guajira, Riohacha, Route 90, near to El Ebanal	21	Roadkill Photograph	Solitary	Caribbean	Road near to pasture, tropical very dry forest
La Guajira, Dibulla, Route 90, close to San Salvador bridge	16	Sightings	Solitary	Caribbean	Road next to patch of disturbed riparian forest, tropical dry forest
La Guajira, Riohacha, Route 90, adjacent to San Miguel	51	Roadkill Photograph	Solitary	Caribbean	Road surrounded by pasture, tropical dry forest
La Guajira, Dibulla, corregimiento Palomino, vereda San Salvador	74	Carcass	Solitary	Caribbean	Disturbed riparian forest, tropical dry forests

(Table 2 cont.)

Locality (department, municipality, location)	**Elevation (m)**	**Record type**	**Aggregation**	**Biogeographic Region**	**Record site, Holdridge's Life Zone**
La Guajira, Riohacha, Route 49, next to corregimiento Tomarrazón	30 158	Roadkill Photograph	Solitary	Caribbean	Road near to a pasture, tropical dry forest
La Guajira, Albania, Route 88, near to Ojo Caro	213	Roadkill Photograph	Solitary	Caribbean	Road adjacent to disturbed shrub, tropical very dry forest
Cesar, La Loma, Palmeras de Alamosa	54	Camera-trap	Solitary	Caribbean	Undisturbed shrubs, tropical dry forest
Santander, San Vicente de Chucurí, road to Bucaramanga	636	Roadkill Photograph	Solitary	Andean	Road near at pastures and forest patches, tropical moist forest
Santander, Girón, vereda Chocoa	337	Roadkill Photograph	Solitary	Andean	Road near to shrub, tropical dry forest
Santander, San Vicente de Chucurí, road to Bucaramanga	800	Roadkill Photograph	Solitary	Andean	Road next to crops, pastures, and forest patches, tropical moist forest
Santander, San Vicente de Chucurí, vereda La Colorada	1260	Sightings	Solitary	Andean	Agricultural areas and forest patches, premontane rain forest
Santander, Carmen de Chucurí, vereda Manchurrías	1855	Camera-trap	Solitary	Andean	Undisturbed forest, lower montane wet forest
Santander, Betulia, next to Montebello site	352	Camera-trap	Solitary	Andean	Disturbed riparian forest, tropical moist forest
Santander, Zapatoca, road between Zapatoca and Betulia*	1570	Roadkill Photograph	Solitary	Andean	Road surrounded by crops and shrubs, premontane rain forest
Santander, Zapatoca, vereda La Cacica, sector Paramito, Reserva Mama Berta*	2340	Camera-trap	Solitary	Andean	Undisturbed forest, premontane rain forest
Santander, Santa Bárbara, vereda Esparta, Finca La Rinconada*	2323	Carcass Photograph	Solitary	Andean	Agricultural areas and forest patches, montane tropical forest

Table 3

Extent of occurrence (EOO) estimated from the species' distribution models (SDM) along with the number and percentage of national protected areas (categories in parentheses) overlapping. Acronyms: National Park (NP), National Protective Forest Reserve (NPR), Road Park (RP), and Sanctuary (S).

Species	Method	Occurrence number	EOO (km²)	Areas under protection	EOO under protection (%)
Galictis vittata	SDM	32	265 063	21(NP), 28(NPR), 1(RP), 6(S)	3.9
Conepatus semistriatus	SDM	46	224 238	19(NP), 40(NPR), 1(RP), 9(S)	7.3

used contribution scores in conjunction with the scores from correlations to select the final set of environmental variables. First, we eliminated variables with low contribution scores (< 5%) in the starting model. Then, we deleted variables that were highly correlated ($|r| > 0.85$) following Elith et al. (2010), keeping the variables with the highest contribution scores. This selection process resulted in a subset of bioclimatic variables to build the final models for each species (**Table 4**). We used linear plus quadratic (LQ) features to avoid over-parameterization (van Proosdij et al. 2016). Also, as recommended by Phillips et al. (2006), we used default values for convergence threshold (10^{-5}), maximum number of iterations (500), regularization multiplier (1), and maximum number of background points (10^4). To validate the models, we ran 100 bootstrap replicates with calibration datasets (70% random selection of the data) and evaluation datasets (30%). The best model was selected based on the area under the receiver operating characteristic curve (AUC; Fielding & Bell 1997) and the True Skill Statistics (TSS; Allouche et al. 2006) values. Once the best model for each species was selected, we used the cut-off probability value based on the maximum training sensitivity plus specificity threshold to distinguish suitable from unsuitable areas. Lastly, we calculated the extent of occurrence (EOO) for both species using the number of pixels from the binary models (presence/absence).

Table 4

Percentage of contribution and permutation importance of the most important variables used to build final species distribution models for *Galictis vitatta* and *Conepatus semistriatus*. For each species, the four variables with the highest contributions are presented in bold.

Variable	*Galictis vittata*		*Conepatus semistriatus*	
	Percent contribution	Permutation importance	Percent contribution	Permutation importance
Altitude	**11.3**	**13.9**	---	---
Isothermality	---	---	2.8	7.7
Mean diurnal range	14.4	7.8	---	---
Minimum temperature of coldest month	---	---	**6.1**	**10.2**
Precipitation of coldest quarter	11.7	6.0	**82.5**	**58.8**
Precipitation of driest month	**14.9**	**11.7**	**2.9**	**10.4**
Precipitation of warmest quarter	5.1	9.0	---	---
Precipitation seasonality	**15.5**	**12.2**	**5.7**	**12.9**
Temperature seasonality	**27.1**	**39.5**	---	---

RESULTS

Updated distributional data

We compiled 37 reliable locality records for *Galictis vittata* (30 historical and 7 new) in Colombia. The new locality records presented here are distributed in the lowlands of the Caribbean and Orinoquia regions, as well as in the Middle Magdalena Valley (**Fig. 1**, **Table 1**). We recorded ten individuals, nine through sightings and one during roadkill surveys, from Atlántico (Piojó municipality), Bolivar (Rioviejo municipality), Casanare (Villanueva municipality), and Santander departments (Barrancabermeja, Girón, and San Vicente de Chucurí municipalities). These records are distributed in a wide diversity of ecosystems and habitats, including highly disturbed areas such as pastures and oil palm plantations (**Table 1**). Based on these records, we update the distributional range for this species to all natural regions of Colombia, except the Amazonian, with confirmed records from 16 departments: Antioquia, Atlántico, Bolívar, Caldas, Casanare, Cauca, Cesar, Cór-

Fig. 1. Photographic records of some *Galictis vittata* specimens reported in this study. Adult male from vereda Pan Coger, municipality of Rioviejo, Bolívar department (A). Roadkill specimen from National Route 45, vereda Peroles, municipality of Barrancabermeja, Santander department (B). Adult couple from corregimiento Yarima, municipality of San Vicente de Chucurí, Santander department (C and D). Couple of adult specimens recorded by camera trapping from municipality of Girón, Santander department (E). Adult specimen from vereda Viscaina, municipality of San Vicente de Chucurí, Santander department (F).

doba, Cundinamarca, La Guajira, Magdalena, Meta, Nariño, Santander, Tolima, and Sucre (see **Supplementary Material S1**); from sea level to 2200 m elevation (Escobar-Lasso & Guzmán-Hernández 2014) with most records from lowlands below 1000 m (**Fig. 3A**).

Although *G. vittata* has been recorded in the Bolivian, Brazilian, Peruvian, and Venezuelan Amazon basin (see Yensen & Tarifa 2003; Bornholdt et al. 2013), no confirmed records have been reported from this region in Colombia. Alberico et al. (2000) reported this species from the Amazonian region ("amz"), but this information is incongruent with the accompanying geopolitical distribution, thus, we consider this conclusion erroneous. A record from the Vichada department in Alberico et al. (2000) and Solari et al. (2013), although supported by two voucher specimens (UV 8105-06) needs verification because coordinates ("5.775, -68.184") and locality data ("Puerto Carreño, La Arama, Hacienda Carimagua") are apparently incongruent or erroneous. During our locality validation, we did not find any locality with the

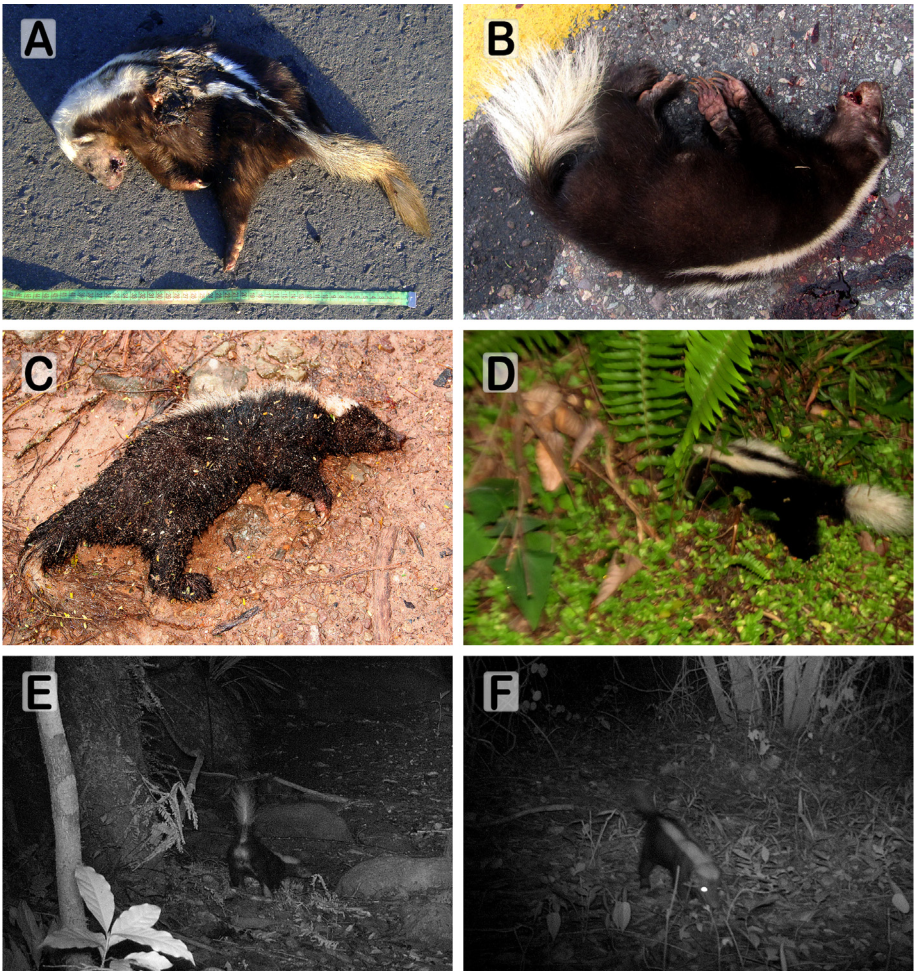

Fig. 2. Photographic records of some *Conepatus semistriatus* specimens reported in this study. Roadkill adult specimens from: municipality of Albania, La Guajira department (A); municipality of Girón, Santander department (B); and municipality of San Vicente de Chucurí, Santander department (C). Adult specimen sighting in municipality of San Vicente de Chucurí, Santander (D). Adult specimens recorded by camera trapping from municipalities of Betulia, Santander department, and La Loma, Cesar department (E and F, respectively).

names "La Arama" or "Hacienda Carimagua" near Puerto Carreño municipality at Vichada department. The closest localities associated to these names are San Juan de Arama municipality and Hacienda Carimagua (Puerto Gaitán municipality), both in the Meta department. The reliability of additional records from the Caribbean (Jiménez-Alvarado et al. 2016) and Pacific (Asprilla-Perea et al. 2013) regions needs confirmation because they are based on interviews of local people and confiscated specimens at Chocó department (but with uncertainty about its origin), respectively. The confirmed distribution of *G. vittata* in Colombia is summarized in **Fig. 3A** (for additional details see **Supplementary Material S1**).

We also compiled 63 reliable locality records for *Conepatus semistriatus* (38 historical and 25 new) in Colombia. The new locality records are distributed in the lowlands of the Andean and Caribbean regions, and in the Middle Magdalena Valley (**Fig. 2**, **Table 2**). A series of 13 roadkill individuals were recorded during 2011-2017 in several roads of La Guajira and Santander departments. In addition, eight individuals were recorded from carcasses (including a fresh individual killed by dogs), footprint signs, and sightings in several areas of La Guajira and Santander departments. Lastly, four individuals were recorded by camera trapping in Cesar and Santander departments. These records are in a wide variety of ecosystems and habitats, including highly disturbed areas such as agricultural lands (**Table 2**). Based on the records gathered here, we update the distributional range for this species to the Andean and Caribbean regions of Colombia, with confirmed records from 10 departments: Antioquia, Caldas, Cesar, Córdoba, Cundinamarca, La Guajira, Magdalena, Nariño, Norte de Santander, and Santander; the latter including the type locality (see **Supplementary Material S2**). These records are distributed from the sea level to 3100 m elevation (Alberico et al. 2000), with most records being at elevations below 1000 m (**Fig. 3B**).

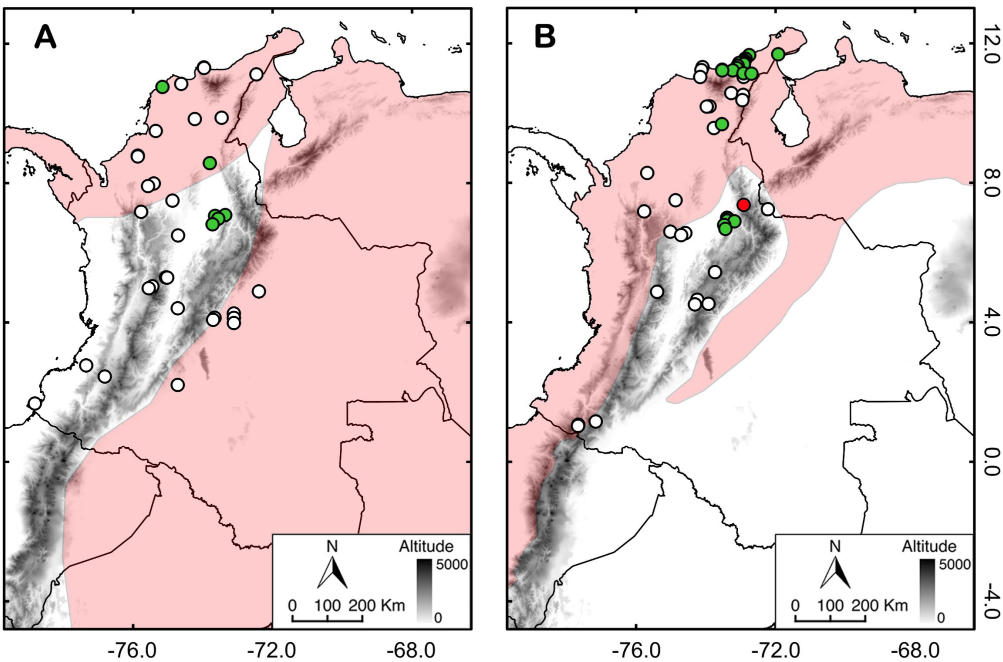

Fig. 3. Distributional maps for *Galictis vittata* (A) and *Conepatus semistriatus* (B) in Colombia, showing historical (white circles) and new records presented here (green circles). Red circle in B denotes the type locality for *C. semistriatus* proposed here (see **Supplementary Material S2**). For additional details see **Supplementary Material S1** and **S2**. The datum used for geographic coordinates is WGS84. Color-shaded areas indicate each species distributional range according to the IUCN.

Among the records of this species from Nariño department in Ramírez-Chaves & Noguera-Urbano (2010), there was erroneously included a specimen housed at Colección de Mamíferos of Universidad del Valle (UV 8103) from Soacha municipality (here corrected as Guerrero municipality) at Cundinamarca department. This species was also incorrectly included as present in Valle del Cauca department by Rojas-Díaz et al. (2012) based on a specimen apparently deposited at UV, however, in this collection there are no voucher specimens of the species from this department (Oscar Murillo, pers. comm.). The record from Boyacá department in González-Maya et al. (2017) needs confirmation because the original source is the Corporación Autónoma Regional del Centro de Antioquia (Corantioquia), thus, this record probably comes from Antioquia department. Andrade-Ponce et al. (2016) reported this species from Tatamá National Natural Park (without precise location) based on data from a technical report (Plan de Manejo Parque Nacional Natural Tatamá). We reviewed this document and found that this record comes from a secondary unspecified source of information that requires confirmation. The reliability of additional records from Reserva Forestal Protectora Montes de Oca at La Guajira department (Galvis et al. 2011) and from Casanare department (Trujillo et al. 2011) needs to be confirmed because the authors list the species but they do not provide any supporting evidence for such records. The confirmed distribution of *C. semistriatus* in Colombia is summarized in **Fig. 3B** (for additional details see **Supplementary Material S2**).

Species distribution modeling

Based on the results from the spatially rarified occurrence analysis, we considered 32 and 46 spatially independent localities to generate the models for *Galictis vitatta* and *Conepatus semistriatus*, respectively (**Table 3**). Environmental data to build the models were reduced to seven variables for *G. vittata* and five variables for *C. semistriatus* (**Table 4**), based on the contribution scores of variable importance and the Pearson correlation test. According to the used validation metrics (AUC and TSS values [± standard deviation]) models have good performance: *G. vittata* (AUC = 0.861 ± 0.031; TSS = 0.76 ± 0.04) and *C. semistriatus* (AUC = 0.924 ± 0.016; TSS = 0.81 ± 0.07). These results indicate that models are informative for the predicted potential suitable habitat for both species.

The jackknife analysis of variable importance shows that temperature seasonality was the most important variable for determining habitat suitability for *G. vittata* (**Table 4**), with highly suitable areas at low temperature variability (standard deviation ≈3 °C). The final logistic distribution models predict areas with high suitability of habitat across the Caribbean and Andean regions in Colombia, including the Inter-Andean valleys (**Fig. 4A**). Areas of low suitability (e.g., Andean highlands, Amazonian lowlands, and most of Chocoan and Orinoquia lowlands) were excluded from the binary model based on the average habitat suitability threshold value (maximum training sensitivity plus specificity threshold = 0.435; **Fig. 4B**). We estimated the total extent of occurrence for *G. vittata* to be 265 063 km^2 from the binary model, of which only a small percentage (ca. 3.9% of EOO, near 10 384 km^2) is predicted to be inside national protected areas under several management categories (**Fig. 4C**; **Table 3**).

For *C. semistriatus*, the jackknife analysis revealed that the most important variables for determining habitat suitability was the precipitation of the coldest quarter (**Table 4**), with highly suitable areas at low total precipitation during the coldest quarter (≈100 mm). The final logistic distribution model predicts areas with high suitability of habitat across Caribbean and Andean regions in Colombia (**Fig. 4C**). Areas of low suitability (e.g., Amazonian and Orinoquia lowlands, as well as most of Chocoan lowlands) were excluded from the binary model based on the average habitat suitability threshold value (maximum training sensitivity plus specificity threshold = 0.189; **Fig. 4D**). When applying this threshold to build the binary model, we estimated the total extent of occurrence for *C. semistriatus* to be 224 238 km^2, of which only a small percentage (ca. 7.3% of EOO, near

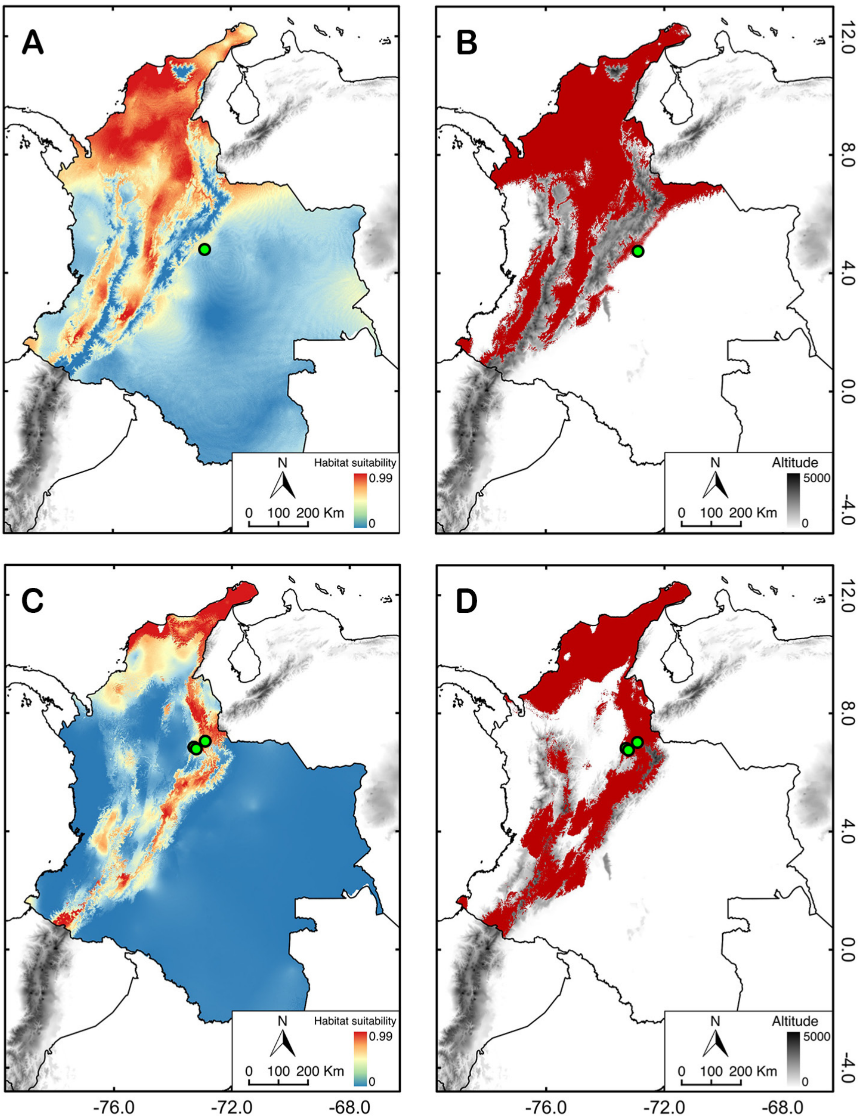

Fig. 4. Species distribution models showing logistic (left) and binary (right) outputs for *Galictis vittata* (A-B) and *Conepatus semistriatus* (C-D) in Colombia. Green circles denote the recent records (2017) not included in the analyses.

16370 km^2) is predicted to be inside national protected areas under several management categories (**Fig. 4D**; **Table 3**).

DISCUSSION

Distributional data and updates

The revision of distributional data reveals that Colombian specimens of these species are underrepresented in national and international scientific collections. Historical records for *Galictis vittata* are supported by only 15 voucher specimens (most of them collected between 1943 and 1985) from the Andean, Caribbean, and Orinoquia regions, whereas recent records are based mainly on sightings and photographs of specimens from Andean, Caribbean, and Orinoquia regions (**Supple-**

mentary Material S1). Similarly, historical records for *Conepatus semistriatus* are supported by 31 voucher specimens (mostly collected between 1899 and 1943) from the Caribbean and Andean regions, while recent ones are based mainly on sightings, roadkill specimens, and camera-trap records from the same natural regions (**Supplementary Material S2**).

The new locality records provided here confirm the occurrence of both species across areas of potential habitat based on the species distributional range provided by the IUCN and fill previous distributional gaps in the Andean, Caribbean, and Orinoquia regions, including the Middle Magdalena Valley (**Fig. 3**). Although to date no confirmed records have been reported for *G. vitatta* from the Colombian Amazon, the presence of this species in the entire Amazon basin has been proposed (see Bornholdt et al. 2013). We anticipate that gaps in the distribution of these species will be filled as more localities are sampled with the appropriate survey methods (e.g., camera-traps surveys and roadkills monitoring). In this sense, further field studies are needed to gather more information on the distribution, abundance, and ecology of these small carnivores.

Species distribution modeling

The predictions of habitat suitability developed here support the wide distributional range for *G. vittata* and *C. semistriatus* in Colombia (265 063 km^2 and 224 238 km^2, respectively), with Caribbean and Andean regions harboring most suitable habitats for these species (**Fig. 4**). This is an unexpected distributional pattern for *G. vittata* because it excludes large areas of the Colombian Amazon basin, a region where this species seems to occur (see Bornholdt et al. 2013). Interestingly, up to now no confirmed records of this species are available from this region in the published literature and mammal collections. However, these results should be considered cautiously because the extent of the study area used to build the models was restricted to Colombia. Further field studies are needed to confirm the presence of this species in the Colombian Amazon.

During surveys in early 2017, an additional *G. vittata* (**Table 1**; **Supplementary Material S1**) and three *C. semistriatus* (**Table 2**; **Supplementary Material S2**) were recorded in Casanare and Santander departments, respectively. Given that these records were documented after most of the analysis and manuscript had been completed, we did not include them in the species distribution modeling. However, these locality records overlap with areas of intermediate and high habitat suitability predicted by the models in the Andean and Orinoquia regions (**Fig. 4**), highlighting the importance of this methodological approach for making predictions about distribution of poorly known species. Although most of the suitable habitat identified in our models come from unprotected areas, the potential presence of these species in some protected areas is a positive signal for their conservation (**Table 3**). Further studies are needed to generate more robust SDMs and improve the understanding of the extent of occurrence and conservation status for these species.

Anthropogenic threats

Human-caused habitat fragmentation is expected to represent a minor threat for these small carnivores because of their ability to occupy highly human-modified landscapes and even areas near to human settlements (Kasper et al. 2009; Cuarón et al. 2016a, b). During our field work, these species were recorded in diverse habitats, including highly disturbed areas with recurrent human activities (**Table 1** and **2**), suggesting that in such areas these species do not appear to be restricted to native vegetation areas (e.g., forested areas) but they may explore the whole landscape. However, the magnitude of the ecological impacts of habitat loss and fragmentation are often exacerbated because other forms of disturbance co-occur (e.g., hunting, roadkills, and domestic dogs) and are likely to increase and have synergistic effects as habitat loss and fragmentation increase (Ewers & Didham 2006).

In recent human-occupied areas of our country, some small carnivore species are the target of hunting for pest-control (González-

Maya et al. 2011). This fact was evident in all areas where field work was conducted, in which people consider *G. vittata* as a pest; therefore, it is a target of incidental hunting. Although not directly hunted, *C. semistriatus* is often killed by cars on roads throughout its distributional range (Timm et al. 1989; Kasper et al. 2009). This situation was also observed during our study, with specimens of both species recorded as killed by vehicles on roads (**Table 1** and **2**), however, the impact of roadkills on their populations is unknown. Domestic dogs (*Canis familiaris*) represent another latent threat for native mammals (see Vanak & Gompper 2010; Vanak et al. 2014). This is true for some areas where local people have free-ranging and hunting dogs, which occasionally attack native mammals. In fact, we recorded an attack of domestic dogs on *C. semistriatus* in a rural area in Santander department. In this sense, the impact of domestic dogs on populations of small carnivore species is another topic that warrants further investigation.

Illegal wildlife trade has also been recognized as an additional threat for *G. vittata* in Colombia, which is recognized as one of the most confiscated species during wildlife trade controls (Cuarón et al. 2016b), despite this fact, the species has not been included in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Although apparently not related to illegal wildlife trade in Colombia, all the species of the genus *Conepatus* have been proposed to be included in the CITES Appendix II to prevent threatened species from being traded under the name of unprotected ones (Cuarón et al. 2016a). While during our field work, evidence of illegal wildlife trade of these species or their parts was not recorded, further actions aimed to assess the impact of these activities on wild populations are necessary to see whether these species need to be included in any of the CITES appendices.

Taxonomic remarks

Although Colombian skunks have been usually referred as *Conepatus semistriatus* (Cadena et al. 1998; Alberico et al. 2000; Solari et al. 2013), some authors have suggested that specimens from the Andes of southwestern Colombia and central and northern Ecuador represent a morphologically distinct species (Ramírez-Chaves & Noguera-Urbano 2010). This hypothesis is apparently based on the observations by Voss (2003), who examined a single specimen from Cerro Antisana (AMNH 66719), northern Ecuador, near to Colombia, and referred it as *Conepatus* cf. *semistriatus*, arguing an urgent need for a revision of the genus in South America. However, morphological analyses of specimens referred as *C. semistriatus* from Central and South America, including the Ecuadorian specimen examined by Voss (2003), showed that these are referable as *C. semistriatus* (Dragoo et al. 2003). Based on results from this work we considered skunks from Colombia as *C. semistriatus*, but recognize the need for further studies aimed to clarify the taxonomic status of specimens from northern South America. For this purpose, future research efforts must focus on careful examination of specimens housed at museums and the collection of new individuals and their associated information (e.g., tissues for DNA extraction), in order to gather enough quality morphological and molecular data to accurately delimit taxonomic boundaries in *Conepatus*.

ACKNOWLEDGMENTS

Logistic and financial support was provided by Asociación Colombia Endémica, Corporación Autónoma Regional de La Guajira, Conservación Internacional Colombia, Asociación Selva, Fundación Botánica y Zoológica de Barranquilla, and Celsia S.A. E.S.P. We are very grateful to Sergio Solari from Universidad de Antioquia, who kindly allowed us to use an unpublished locality record of *C. semistriatus*. We also thank John Tulcan, Oscar Murillo, and Sergio Solari for their help obtaining information from the Colección Zoológica of Universidad de Nariño, Colección de Mamíferos of Universidad del Valle, and Colección Teriológica of Universidad de Antioquia, respectively. Carlos Cáceres and Sebastián Jiménez kindly assisted us georeferencing records of *C. semistriatus* from Tamá National Natural Park and included in González-Maya et al. (2017), respectively. We also thank Carlos Hernández for reviewing the English. The manuscript was greatly improved by comments from Sergio Solari and two anonymous reviewers.

LITERATURE CITED

Alberico, M., A. Cadena, J. Hernández-Camacho, & Y. Muñoz-Saba. 2000. Mamíferos (Synapsida: Theria) de Colombia. Biota Colombiana 1:43-75.

Allouche, O., A. Tsor, & R. Kadmon. 2006. Assessing the accuracy of species distribution models: prevalence, kappa and the true skill statistic (TSS). Journal of Applied Ecology 43:1223-1232.

Anderson, R. P., & A. Raza. 2010. The effect of the extent of the study region on GIS models of species geographic distributions and estimates of niche evolution: preliminary tests with montane rodents (genus *Nephelomys*) in Venezuela. Journal of Biogeography 37:1378-1393.

Andrade-Ponce, G. P., S. M. Montaño-Salazar, L. M. Riveros-Loaiza, H. E. Ramírez-Cháves, & A. F. Suárez-Castro. 2016. Estado del conocimiento y prioridades de investigación sobre las familias Canidae, Mephitidae y Procyonidae (Mammalia: Carnivora) en Colombia. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 40:500-513.

Asprilla-Perea, J., J. E. Serna-Agudelo, & Y. Palacios-Asprilla. 2013. Diagnóstico sobre el decomiso de fauna silvestre en el departamento del Chocó (Pacífico Norte Colombiano). Revista U.D.C.A Actualidad & Divulgación Científica 16:175-184.

Belant, J. L., J. Schipper, & J. Conroy. 2009. The conservation status of small carnivores in the Americas. Small Carnivore Conservation 41:3-8.

Boitani, L. et al. 2011. What spatial data do we need to develop global mammal conservation strategies? Philosophical Transactions of the Royal Society of London B 366:2623-2632.

Boria, R. A., L. E. Olson, S. M. Goodman, & R. P. Anderson. 2014. Spatial filtering to reduce sampling bias can improve the performance of ecological niche models. Ecological Modelling 275:73-77.

Bornholdt, R., K. Helgen, K. Koepfli, L. Oliveira, M. Lucherini, & E. Eizirik. 2013. Taxonomic revision of the genus *Galictis* (Carnivora: Mustelidae): species delimitation, morphological diagnosis, and refined mapping of geographical distribution. Zoological Journal of the Linnean Society 167:449-472.

Burneo, S. F., J. F. González-Maya, & D. G. Tirira. 2009. Distribution and habitat modelling for Colombian weasel *Mustela felipei* in the Northern Andes. Small Carnivore Conservation 41:41-45.

Cadena, A., P. Rivas-Pava, & R. Anderson. 1998. Colombian mammals from the Chocoan slopes of Nariño. Occasional Papers Museum of Texas Tech University 180:1-15.

Cardona, D., F. L. Meza-Joya, & J. Colmenares. 2016. New Olingo records (genus *Bassaricyon*) from the Colombian Andes. Small Carnivore Conservation 54:12-18.

Castaño-Salazar, J. H. 2011. Mamíferos de Caldas: un análisis de vacíos de información. Boletín Científico Centro de Museos. Museo de Historia Natural 16:101-119.

Cuarón, A., K. Helgen, & F. Reid. 2016a. *Conepatus semistriatus*. IUCN Red List of Threatened Species. www.iucnredlist.org.

Cuarón, A., F. Reid, J. González-Maya, & K. Helgen. 2016b. *Galictis vittata*. IUCN Red List of Threatened Species, Version 2015.4. www.iucnredlist.org.

Dragoo, J., R. L. Honeycutt, & D. J. Schmidly. 2003. Taxonomic status of white-backed hog-nosed skunks, genus *Conepatus* (Carnivora: Mephitidae). Journal of Mammalogy 84:159-176.

Elith, J., M. Kearney, & S. Phillips. 2010. The art of modelling range-shifting species. Methods in Ecology and Evolution 1:330-342.

Escobar-Lasso, S., & C. F. Guzmán-Hernández. 2014. El registro de mayor altitud del hurón mayor *Galictis vittata*, con notas sobre su presencia y conservación dentro del departamento de Caldas, en la región Andina de Colombia. Therya 5:567-574.

Ewers. R. M., & R. K. Didham. 2006. Confounding factors in the detection of species responses to habitat fragmentation. Biological Review 81:117-142.

Fielding, A. H., & J. F. Bell. 1997. A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation 24:38-49.

Galvis, P. A., A. Mejía, & J. V. Rueda (Eds.). 2011. Fauna silvestre de la reserva forestal protectora Montes de Oca, La Guajira, Colombia. Primera Ed. Corporación Autónoma Regional de La Guajira - CORPOGUAJIRA, La Guajira.

González-Maya, J. F., A. A. Cepeda, J. L. Belant, D. A. Zárrate-Charry, S. Balaguera-Reina, & A. Rodríguez-Bolaños. 2011. Research priorities for the small carnivores of Colombia. Small Carnivore Conservation 44:7-13.

González-Maya, J. F. et al. 2017. First confirmed record of the striped hog-nosed skunk *Conepatus semistriatus* from peri-urban Bogotá, Colombia. Small Carnivore Conservation 55:91-96.

Helgen, K. M. et al. 2013. Taxonomic revision of the Olingos (*Bassaricyon*), with description of a new species, the Olinguito. ZooKeys 324:1-83.

Hijmans, R. J., S. E. Cameron, J. L. Parra, G. Jones, & A. Jarvis. 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25:1965-1978.

Jiménez-Alvarado, J. S. et al. 2016. Analysis of the distribution of the grison (*Galictis vittata*) (Carnivora: Mustelidae) in the Colombian Caribbean. Therya 7:179-186.

Kalle, R., T. Ramesh, Q. Qureshi, & K. Sankar. 2013. Predicting the distribution pattern of small carnivores in response to environmental factors in the Western Ghats. PLoS ONE 8:E79295.

Kamino, L. H. Y., M. F. de Siqueira, A. Sánchez-Tapia, & J. R. Stehmann. 2012. Reassessment of the extinction risk of endemic species in the Neotropics: how can modelling tools help us? Natureza & Conservação 10:191-198.

Kasper, C. B. et al. 2009. Recent advances in the knowledge of Molina's hog-nosed skunk *Conepatus chinga* and striped hog-nosed skunk *C. semistriatus* in South America. Small Carnivore Conservation 41:25-28.

Noguera-Urbano, E. A., & H. E. Ramírez-Chaves. 2013. Confirmation of the presence of crab-eating raccoon *Procyon cancrivorus* (Procyonidae) in the Colombian Amazon, hypothesis of distributional area, and comments on juvenile specimens. Small Carnivore Conservation 52-53:84-92.

Nowak, R. M. (Eds.). 2005. Walker's carnivores of the world. The Johns Hopkins University Press, Baltimore and London.

Phillips, S. J., R. P. Anderson, & R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modelling 190:231-259.

Ramírez-Chaves, H. E., & E. A. Noguera-Urbano. 2010. Lista preliminar de los mamíferos (Mammalia: Theria) del departamento de Nariño, Colombia. Biota Colombiana 11:117-140.

Ramírez-Chaves, H. E., & A. F. Suárez-Castro. 2014. Adiciones y cambios a la lista de mamíferos de Colombia: 500 especies registradas para el territorio nacional. Mammalogy Notes 1:223-235.

Raxworthy, C. J. et al. 2003. Predicting distributions of known and unknown reptile species in Madagascar. Nature 426:837-841.

Rojas-Díaz, V., M. Reyes-Gutiérrez, & M. S. Alberico. 2012. Mamíferos (Synapsida, Theria) del Valle del Cauca, Colombia. Biota Colombiana 13:99-116.

Rondinini, C., & L. Boitani. 2012. Mind the map: trips and pitfalls in making and reading maps of carnivore distribution. Carnivore ecology and conservation: a handbook of techniques (L. Boitani & R. Powell, eds.). Oxford University Press, New York.

Rondinini, C., K. A. Wilson, L. Boitani, H. Grantham, & H. P. Possingham. 2006. Tradeoffs of different types of species occurrence data for use in systematic conservation planning. Ecology Letters 9:1136-1145.

Schipper, J., M. Hoffmann, & J. Conroy. 2008. The 2008 IUCN red listings of the world's small carnivores. Small Carnivore Conservation 39:29-34.

Solari, S., Y. Muñoz-Saba, J. V Rodríguez-Mahecha, T. R. Defler, H. E. Ramírez-Chaves, & F. Trujillo. 2013. Riqueza, endemismo y conservación de los mamíferos de Colombia. Mastozoología Neotropical 20:301-365.

Timm, R., D. Wilson, B. Clauson, R. La Val, & C. Vaughan. 1989. Mammals of the La Selva-Braulio Carrillo complex, Costa Rica. North American Fauna:1-153.

Trujillo, F. et al. 2011. Mamíferos de Casanare. Biodiversidad del Casanare: Ecosistemas Estratégicos del Departamento (J. Usma & F. Trujillo, eds.). Gobernación de Casanare - WWF Colombia, Bogotá D.C., Colombia.

Van Proosdij, A. S. J., M. S. M. Sosef, J. J. Wieringa, & N. Raes. 2016. Minimum required number of specimen records to develop accurate species distribution models. Ecography 39:542-552.

Vanak, A. T., & M. E. Gompper. 2010. Interference competition at the landscape level: the effect of free-ranging dogs on a native mesocarnivore. Journal of Applied Ecology 47:1235-1232.

Vanak, A. T., C. R. Dickman, E. A. Silva-Rodríguez, J. R. A. Butler, & E. G. Ritchie. 2014. Top-dogs and under-dogs: competition between dogs and sympatric carnivores. Free-Ranging Dogs and Wildlife Conservation (M. E. Gompper, ed.). Oxford University Press, Oxford, UK.

Voss, R. S. 2003. A new species of *Thomasomys* (Rodentia: Muridae) from eastern Ecuador, with remarks on mammalian diversity and biogeography in the Cordillera Oriental. American Museum Novitates 3421:1-47.

Voss, R. S., & L. Emmons (Eds.). 1996. Mammalian diversity in Neotropical lowland rainforests: a preliminary assessment. Bulletin of the American Museum of Natural History 230:1-115.

Warren, D. L., A. N. Wright, S. N. Seifert, & H. B. Shaffer. 2014. Incorporating model complexity and spatial sampling bias into ecological niche models of climate change risks faced by 90 California vertebrate species of concern. Diversity and Distributions 20:334-343.

Wieczorek, J., Q. Guo, & R. J. Hijmans. 2004. The point-radius method for georeferencing locality descriptions and calculating associated uncertainty. International Journal of Geographical Information Science 18:745-767.

Yensen, E., & Y. Tarifa. 2003. *Galictis vittata*. Mammalian Species:1-8.

SUPPLEMENTARY ONLINE MATERIAL

Supplement 1

Table S1. Confirmed locality records for *Galictis vittata* in Colombia. Acronyms: Asociación de Becarios de Casanare, Colombia (ABC), Colección de Mamíferos of Universidad del Valle, Colombia (UV), Field Museum of Natural History, USA (FMNH), Instituto de Ciencias Naturales of Universidad Nacional de Colombia, Colombia (ICN), Instituto de Investigaciones Ambientales del Pacifico John Von Neumann, Colombia (IIAP), Museo de Historia Natural of Universidad de Caldas, Colombia (MHN-UC), United States National Museum, USA (USNM, now Smithsonian Institution National Museum of Natural History). Record type: specimen observation (sighting), roadkill specimen (roadkill), sign records (footprint, odor, and feces), digital record (photo, video), camera-trap capture (camera-trap), capture but not collected specimen (spe), and preserved specimen (voucher number). Asterisk (*) denote recent records (2017) not included in the analyses. Geographic coordinates are provided in decimal degrees in the WGS-84 datum.
https://www.sarem.org.ar/wp-content/uploads/2018/06/SAREM_MastNeotrop_25-1_Meza-sup1.xlsx

Supplement 2

Table S2. Confirmed locality records for *Conepatus semistriatus* in Colombia. Acronyms: American Museum of Natural History, USA (AMNH), Colección de Mamíferos of Universidad del Valle, Colombia (UV), Colección Zoológica of Universidad de Nariño (PSO-CZ), Field Museum of Natural History, USA (FMNH), Instituto de Ciencias Naturales of Universidad Nacional de Colombia, Colombia (ICN), Museum of Comparative Zoology, USA (MCZ), United States National Museum, USA (USNM, now Smithsonian Institution National Museum of Natural History). Record type: specimen observation (sighting), roadkill specimen (roadkill), sign records (footprint, odor, and feces), digital record (photo, video), camera-trap capture (camera-trap), capture but not collected specimen (spe), and preserved specimen (voucher number). Asterisk (*) denote recent records (2017) not included in the analyses. Geographic coordinates are provided in decimal degrees in the WGS-84 datum.
https://www.sarem.org.ar/wp-content/uploads/2018/06/SAREM_MastNeotrop_25-1_Meza-sup2.xlsx