IUCN/SSC Small Carnivore Specialist Group

ORIGINAL CONTRIBUTION

Predicting Greater Grison *Galictis vittata* presence from scarce records in the department of Cordoba, Colombia

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Abstract.

The Greater Grison, *Galictis vittata*, is a poorly known species in Colombia. Throughout its range major knowledge gaps exist regarding its ecology and conservation. To compile and analyse information about the species´ distribution records in the department of Cordoba, Colombia and assess its presence probability according to landscape attributes, we conducted a literature review of all wildlife studies in the region and compiled all possible direct presence records of the species in the department. We generated random location points and characterized each distribution and random location by their distance to landscape attributes and land-cover type and modelled landscape presence using a Multiple Logistic Regression approach. We found 33 records of the species in Cordoba with most of the records distributed in the subregion of Alto Sinú (36%). Higher presence probabilities are localized in areas near forests mostly in the southern parts of the department, showing the species is still related with the largest forest blocks. Grisons appears to potentially tolerate some levels of disturbance but is still dependent to forest. The influence of natural habitats and abundance across the department and other areas of its distribution remain to be evaluated.

Keywords: Carnivora, Multiple Logistic Regression, Mustelidae, Resource Selection Model

Introduction

Small carnivores, generally mustelids, procyonids and mephitids, are among the least studied groups in the Neotropical region, where demographic and life-history information from some countries, such as Colombia, are limited and anecdotal (González-Maya *et al*. 2011). Despite the important role of these species in the ecosystems (Belant *et al.* 2009, González-Maya *et al.* 2009), few researches have been carried out on many basic aspects of their ecology, biology and natural history, and they have been relatively overlooked by science and conservation efforts (Schipper *et al*. 2009). Likewise, among small carnivores, some species (e.g., *Mustela felipei*, *Procyon* spp.) have aroused the interest among biologists, most probably related with distribution range, conservation status, ecosystems function or charismatic appealing (González-Maya *et al*. 2009, Schipper *et al*. 2009).

The Greater Grison, *Galictis vittata* (Schreber 1776), is one of the least known mustelid species in America (Bornholdt *et al.* 2013), with significant information gaps regarding demographic and life-history traits throughout its range (de Oliveira 2009, González-Maya *et al*. 2011). It is an inconspicuous, widely distributed species from Southern

Mexico to Northern Argentina and Southern Brazil (Yensen & Tarifa 2003, Cuarón *et al.* 2016) including some localities from Paraguay (Bornholdt *et al*. 2013). It inhabits tropical lowlands in an elevational range from 0 to 2200 m asl (Escobar-Lasso & Guzmán-Hernández 2014, Cuarón *et al*. 2016). It occupies mainly undisturbed forests and occasionally secondary forests, especially associated to water bodies (Yensen & Tarifa 2003), but there are some reports in disturbed habitats such as coffee and banana plantations, intervened forests and pasturelands (Gallina *et al*. 1996, Gaudrain & Harvey 2003, de la Torre *et al*. 2009). Main threats to Greater Grison are related to deforestation and illegal hunting, mostly as a pest control alternative to poultry predation (Cuarón *et al*. 2016) and for pet-trade (Convention on International Trade in Endangered Species of Wild Fauna and Flora - CITES 2013). The Greater Grison is considered globally as Least Concern by IUCN (Cuarón *et al*. 2016), but few information exists regarding the real conservation status both at local and regional scales, likely product of the generalized low attention to study the species (González-Maya *et al*. 2011).

Currently, most of the available information on the Greater Grison is limited to some incidental reports, without systematic approaches, considering the species probably tolerant to anthropic intervention but occurring at low densities on most of the habitats (Cuarón *et al*. 2016). For Colombia, Alberico *et al.* (2000) described the general distribution of the Greater Grison based on accidental data from few localities, suggesting that this species occur across all over the country. However, recent confirmed reports from Cesar, Sucre (Wieczorek 2001), Antioquia (Cuartas Calle & Muñoz Arango 2003), Caldas (Escobar-Lasso & Guzmán-Hernández 2014), Nariño (Ramírez-Chaves & Noguera-Urbano 2010), Vichada, Meta, Arauca, Caquetá (Ferrer Pérez *et al.* 2009) and Cordoba departments have allowed to draw more precise distribution inferences for the country (Meza-Joya *et al*. 2018). However, ecological information, such as demography, life history, tolerance to disturbed areas or intervention is limited; therefore, assessing its conservation status remains a difficult task.

In light of enormous gaps on the ecology, distribution and threats knowledge of the Greater Grison, and the need for quality data that supports conservation status assessment in Colombia, here we provide new data for the Caribbean region of Colombia. Specifically, we perform a spatial modelling approach to explore the tolerance of the Greater Grison to disturbed areas using a presence probability scheme.

Materials and methods

Study area

Cordoba department is located within the Caribbean region of Colombia (09°25', 07°15'N and 75°26', 75°10'W; Figure 1; González-Maya *et al*. 2013). The department extends through 25,000 km^2, including approximately 1,220 km of rivers, 100 km^2 of wetlands, and 165 km of shorelines. The topography is dominated by plains with isolated mountains, with an elevation gradient from 0 to 1250 m asl. Mean annual precipitation ranges from 1,400 to 2,300 mm, mean annual temperature of 28º C and humidity over 80%. The typical vegetation is mangroves, estuarine areas, savannas, tropical dry and rain forests (Marín Ramírez 1992). Geographic regions division includes six subregions: High, Mid and Lower Sinú River, Costanera (coast), Sabanas (savannas) and San Jorge River. Historically, the department have suffered of unsustainable land and resource use, where current predominant land-use is degraded pasturelands and agriculture/cattle production areas, with isolated forest patches and the largest remaining forests mostly restricted to the southern portion of the department (González-Maya *et al.* 2013).

Range distribution database

We compiled information from technical reports and fauna inventories from multiple sources such as thesis, scientific papers, research reports, and semi-popular articles, in order to collect all recent available (2000-present) presences records for the Greater Grison in the department of Córdoba. Technical reports from the Universidad de Córdoba, and the regional environmental authority – Corporación Autónoma Regional de los Valles del Sinú y del San Jorge (CVS and UNAL 2005, Ballesteros *et al.* 2009, Centenaro & Ballesteros 2002, Centenaro & Ballesteros 2004, Centro de Investigaciones Ambientales y de Ingeniería 2001, Consultores-Unidos & Gercon 1997, Consultoría Colombiana 2000, Consultoría del Caribe 1998, Cuervo-Maya *et al*. 2000, De la Ossa 1993, Franco-C 2000, Jiménez 2000, Luna 2000, Montoya-Bohorquez 1993, Noriega-M & Mejia-A 1993, Nuñez-D 2005, Racero-Casarrubia & Hernández 2010, Universidad de Córdoba & Fundación Neotrópicos 1996). We also consulted Museum specimens from national and international collections and public electronic databases including the Instituto de Ciencias Naturales (ICN)- National University of Colombia (Instituto de Ciencias Naturales 2011), and validation assessments (Suárez-Castro & Ramírez-Chaves 2015), VertNet (http://www.vertnet.org) and the Biodiversity Information System in Colombia (Instituto Alexander von Humboldt 2011). In addition, we included first-hand records collected by the Grupo de Biodiversidad of the Universidad de Cordoba between 2006 and 2011 (Ballesteros *et al.* 2006, Ballesteros com. pers.), and monitoring activities of the Parque Nacional Natural Paramillo (PNN Paramillo) by the park staff.

Spatial modelling approach

We georeferenced and characterized each Greater Grison record according to distance to different landscape attributes and types of land cover where the record was obtained. The attributes used included distance to roads, human settlements and rivers, elevation and land-use types (*i.e.*, primary and secondary forest, crops, managed pastures and succession; CVS 2006). To assess if the distribution of the records was random or responded to landscape or human variables, and to estimate presences probabilities we used a logistic regression modelling approach (Pearce & Ferrier 2001). We generated 110 random additional points throughout the department; each random point was also characterized by its land-use and distance to the landscape attributes. We generated Multiple Logistic Regression Models (MLRM) using the distances to landscape (continuous) and land-use of the record variables (discrete as dummy) as independent regression variables, and the confirmed records as the dependent variable (*i.e.*, presence; Imam & Kushwaha 2013). To estimate the presences probabilities and influence of the variables we built the MLRM; the best model was selected based on the Akaike Information Criterion (AIC), and we used the model adjustment, the products odd-ratio of each variable and the likelihood algorithm for the selected model. To analyse the presences probabilities spatially, a grid of 0.03 x 0.03 degrees' cells was created over the department. We calculated the probability derived from the model's function (0-1), and assigned this probability values to each of the grid's cell to generate a presences probability maps for the department. All the analyses were performed using Infostat Software® (Di Rienzo *et al.* 2011).

Results

We found 33 confirmed, georeferenced records of the Greater Grison, distributed in all geographic department sub-regions (Table 1). The localities varied from highly intervened areas, such as the capital city of the department (Montería) or the University campus, to highly preserved forests in the higher parts of the Sinú and San Jorge Rivers.

Table 1. Confirmed records of *Galictis vittata* in the department of Cordoba, Colombia

Sub-region	Municipality	District	Long	Lat	Locality
Upper Sinú	Tierralta	-	76°09'45.00"	07°58'12.00"	Quebrada Tay
			75°57'12.00"	08°23'41.00"	Hacienda Currayao
			76°02'04.00"	08°16'39.60"	Finca Walterra
			75°58'00.00"	07°59'04.00"	East sector Cerro Murrucucú *
			75°58'42.00"	08°00'23.00"	
			75°58'48.00"	07°52'26.00"	
			75°56'16.00"	07°52'40.00"	
			75°57'51.00"	07°55'59.00"	
		Cerro Murrucucú	76°03'31.80"	07°59'17.52"	El Silencio
		Volador	75°59'07.00"	08°19'33.10"	Hacienda Monaco
	Valencia	Villanueva	76°04'16.00"	08°20'15.00"	Hacienda Las Tangas
		Volador	76°03'55.00"	08°18'04.30"	Hacienda Jaraguay
Mid Sinú	Montería	-	75°51'53.30"	08°47'28.10"	Universidad de Córdoba
			75°51'55.13"	08°46'03.02"	Barrio La Castellana
		Betancí	75°49'55.00"	08°22'44.00"	Ciénaga de Betancí
		Loma Verde	76°11'42.00"	08°31'11.50"	Agua Viva
		Martinica	75°59'45.00"	08°43'29.00"	Ciénaga de Martinica
	San Pelayo	Sabana Nueva	75°51'01.10"	09°02'24.70"	Ciénaga La Pacha
Lower Sinú	Lorica	Cotocá	75°50'23.00"	09°07'14.40"	Finca Nueva Colombia
		Pantano Bonito	72°53'47.00"	09°09'49.93"	Ciénaga de Pantano Bonito
Coast	Canalete	-	76°19'16.00"	08°44'28.08"	Hacienda Chimborazo
	Los Córdobas	Santa Rosa de la Caña	76°19'32.00"	08°45'30.00"	Reserva Forestal Campo Alegre
	Moñitos	Río Cedro	76°11'01.00"	09°08'13.52"	Reserva Natural Viento Solar
	Puerto Escondido	Cristo Rey	76°12'17.00"	09°05'37.10"	Finca Leticia
	San Antero	El Molino	75°51'00.00"	09°20'12.00"	Agrosoledad
Sabana	Pueblo Nuevo	-	75°19'28.00"	08°20'28.00"	Hacienda Praga
San Jorge	Ayapel	Los Pájaros	74°52'11.40"	08°19'34.50"	Caño Canchila
	Buenavista	-	75°32'05.70"	08°11'15.90"	Hacienda Betanci-Guacamayas
	Montelíbano	-	75°32'41.20"	07°54'46.20"	Complejo minero – Cerro Matoso
			75°34'14.49"	07°55'05.44"	Sector Balsillas Cerro Matoso
			75°30'48.50"	07°59'16.70"	Las parcelas
		Town	75°24'25.72"	07°59'31.25"	Ecoparque
	San José de Uré	-	75°38'30.84"	07°38'12.86"	Alto Río Uré

*Buffer Zone of Paramillo National Natural Park

Most of records are located in the High Sinú river (36%), followed by Mid-Sinú and San Jorge rivers (21%), Coast (12%), Lower Sinú (6%) and Sabanas (3%). Records of the species increased since 2000 (6%) to 2007 (36%), decreasing by 2010 (24%). Most of the records were located in Managed Pastures (45%), followed by Secondary Forests (19%), Crops (16%), Succession (13%) and Primary Forests (6%). Mean elevation of the records was 302.00 ± 521.78 m, and mean distance to rivers was 5.6 ± 18.7 km, 6.4 ± 20.2 km to roads and 46.17 ± 20.50 km to towns (Table 2).

Table 2. Distribution of confirmed records of *G. vittata* (Schreber, 1776) according to distance (km) to human and landscape variables in Cordoba, Colombia.

Variable (km)	Mean ± SD	Ranges		Records	Rel. Freq.
		Lower	Higher		
Rivers	5.6 ± 18.7	0.14	21.87	32	0.97
		21.88	43.61	0	0.00
		43.62	65.35	0	0.00
		65.36	87.08	0	0.00
		87.09	108.82	1	0.03
Roads	6.4 ± 20.2	0.01	23.46	32	0.97
		23.47	46.93	0	0.00
		46.94	70.39	0	0.00
		70.40	93.86	0	0.00
		93.87	117.32	1	0.03
Towns	46.17 ± 20.50	14.52	35.24	8	0.24
		35.25	55.96	14	0.42
		55.97	76.67	10	0.30
		76.68	97.39	0	0.00
		97.40	118.11	1	0.03
Elevation (m)	302.00 ± 521.78	1	491	26	0.79
		491	981	4	0.12
		981	1471	2	0.06
		1471	1961	0	0.00
		1961	2451	1	0.03

The best performance of MLRM showed significant effect of presence in Secondary Forests and Crops, and distance to towns and roads (Table 3). For town distance, crops and secondary forests the effect was positive, meaning that presence probability increases when distance to towns increase and in areas with crops and secondary forest. For road distance the effect was negative, meaning that presence probability increases when approaching main roads. Spatially, we found higher presence probabilities for the southern portion of the department, coinciding with those areas in lower intervention status (*i.e.*, High Sinu and Paramillo National Natural Park; See Figure 1).

According to our model, there are no areas within the department with zero presence probabilities of the Greater Grison (lower percentage value= 24). The model map indicated a mean probability value per cell of 47.64 ± 13.15, with the highest number of cells in the 38-52% range (47% of cells).

Table 3. Logistic regression model adjusted to selected variables explaining the occurrence of *G. vittata* (Schreber, 1776) records in department of Cordoba, Colombia (AIC=2530). Model: y= -12.67+8.39 (land-use=crops) + 6.25 (land-use secondary forest) + 0.0005 * (dist. Towns) – 0.0005 (dist. Roads).

Parameters	Estimate	Standard error	Odd ratio	*p*
Intersect	-12.67	4.62	<0.001	0.0062
Land-use: Secondary forest	6.25	2.61	3.08	0.0168
Land-use: Crops	8.39	4.22	4430.47	0.0465
Distance to Roads	-0.0005	0.0001	0.99	0.0177
Distance to Towns	0.0005	0.0002	1	0.0115

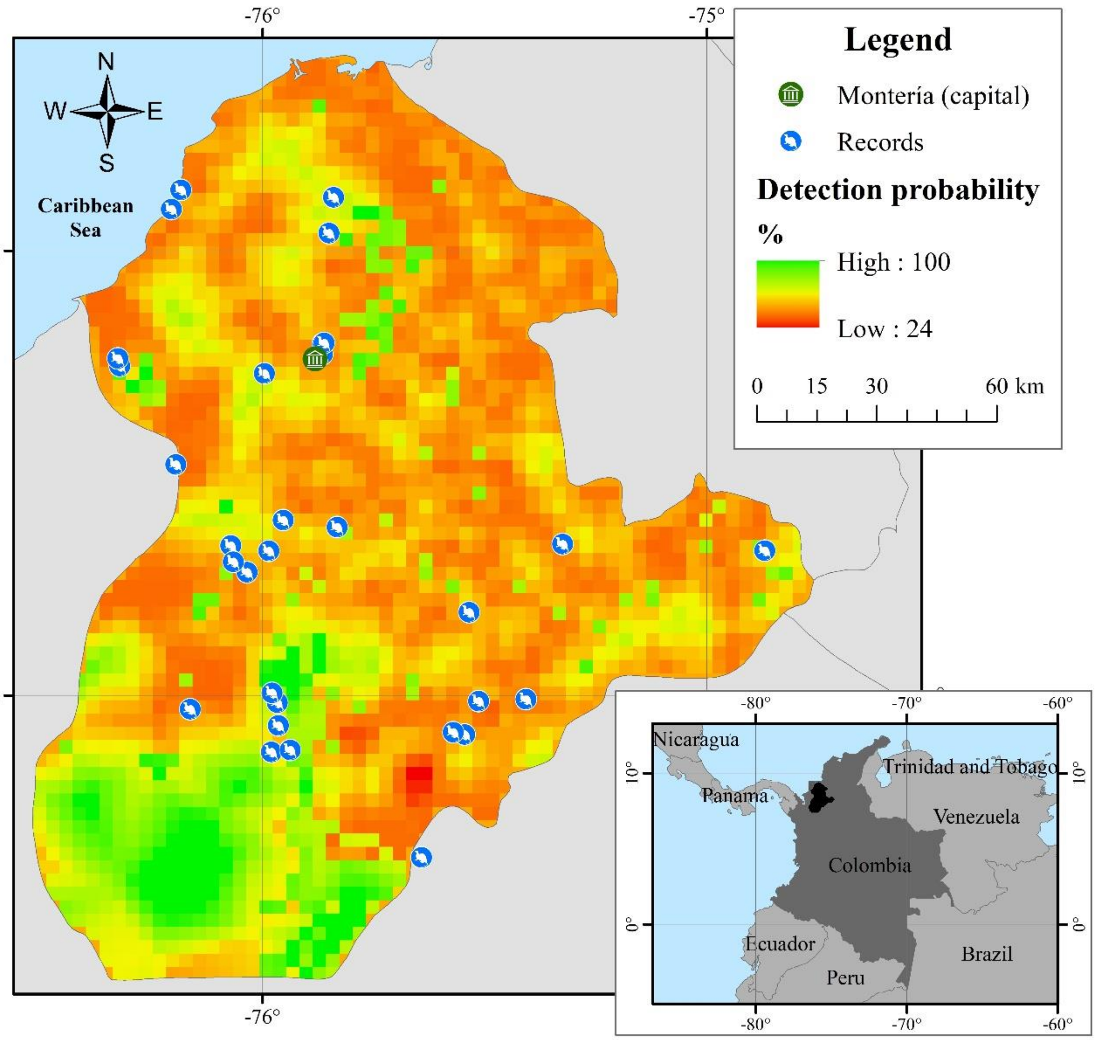

Figure 1. The extrapolated model of presences probabilities for *G. vittata* (Schreber, 1776) and compiled records for department of Cordoba, Colombia (Insert: location of department of Cordoba (black) in Colombia).

Discussion

To our knowledge, this is among the first studies using a spatial modelling approach to evaluate the distribution and presence probabilities of the Greater Grison, the first at landscape scales, and to assess its relative tolerance to different habitat types and disturbed areas, as has been suggested for the species (Gaudrain & Harvey 2003, Yensen & Tarifa 2003, de la Torre *et al*. 2009). Among the most interesting results is the wide variety of records of the Greater Grison from undisturbed to man-made habitats which are relevant for conservation. Our spatial analysis identified the influence of secondary forest and the distance from towns as main explanatory variables of higher record probabilities, followed by the distance to roads and crops which also influenced the model. Although records could be biased by differential sampling efforts and potential visibility nearby human infrastructure, our results have some ecological and conservation implications. These results suggested certain tolerance and ecological plasticity of Greater Grison to altered environments, which supports the idea that Greater Grison may use and move between less conserved and disturbed areas towards more conserved habitats to find specific and available preys (de la Torre *et al.* 2009).

Spatially, our model indicated that Greater Grison is mostly related with forested habitats and areas with lower influence of human settlements, with overall higher presence probabilities for southern Cordoba department along Paramillo National Natural Park and buffer zones. It is important to highlight that for the department of Córdoba the coverage of industrialized crops is low with small-scale and multi-specific crop areas (CVS 2006). These crop areas could improve the availability of small prey and even parts of the crops could be potentially consumed by the species. The presence of Greater Grison in disturbed areas could mean that even when individuals venture into those areas, the species is still likely related with natural habitats for certain aspects of their ecology and natural history, being tolerant to ecotones for resources but still depending on natural forest (de la Torre *et al*. 2009, Pineda-Guerrero *et al*. 2015). Likewise, given the source of the records, for instance, the high percentage associated with towns could be related with the probability of the species to be sighted in open areas (*i.e.*, detection by humans), and not necessarily reflects habitat preference or availability; the best-conserved areas of the department still need systematic efforts to assess presence and occupancy, distribution and ideally population parameters.

In addition, most of the natural ecosystems in the Caribbean region are heavily transformed, mostly for intensive agriculture and cattle production (González-Maya *et al.* 2013). The long-term human intervention on ecosystems have pushed some species (low tolerant) towards natural cover relicts, while other species (high tolerant) are common due to the adaptability or ecological plasticity for landscape matrix use (Andren 1994). It is yet unclear the impact of land use changes over Greater Grison population parameters; thus, it is important to bear in mind that our model only identifies the potential variables that increase presence probabilities, not necessarily indicating population status or any other viability-related parameters. Systematic efforts are needed to estimate demographic and life-history parameters between natural and disturbed habitats to draw more precise conclusions concerning demographic tendencies.

Future work should focus in addressing localities not sampled so far; most of the records come from recent sampling efforts in hydropower dam building projects or locations that were not available for surveys for instance due to violence or presence of illegal groups (Consultores-Unidos & Gercon 1997, Universidad de Córdoba & Fundación Neotrópicos 1996). This also influences the increase in the number of records towards more recent years; however, for the purposes of our analyses the time-frame was adequate to assess the current dynamic land-use types and its influence on the presence of the species. Our data can also be incorporated into future conservation assessments, providing new insights into the species ecology and could be used to direct future studies for the species across its range.

In sum, our study provides new records for the Greater Grison in Colombia and a preliminary approach to its distribution at regional scale in an important portion of the Caribbean region. Our results are also an additional step to support regional assessments for the species. These kind of models as well as other approaches like site-occupancy models (e.g. Kéry *et al*. 2010) and habitat suitability models (e.g. Singh *et al*. 2009) can be used for new field-survey efforts design to identify at local or regional scales areas with the potential presence of the species (and other species).

Finally, our spatial modelling approach is valuable on one hand for exploratory distribution analyses with scarce base information (records) and using geographic information generally available at national or regional scales, being a proxy to potential distribution at regional levels, and to assess how effective could be to detect the effect of landscape variables on species' occurrence; on the other hand, these models represent a useful tool for designing specific studies of poorly-known species and could contribute and be applied in decision making process when applying management and conservation planning at regional scales.

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