New potential distribution and overlap areas of woolly opossum, genus *Caluromys* (Didelphimorphia: Didelphidae), in Colombia

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The woolly opossums of the genus *Caluromys*, despite their wide distribution range, are poorly known species. In Colombia, the presence of *C. derbianus* and *C. lanatus* is recognized, and the presence of *C. philander* has been proposed. This study sought to update the distribution and know overlapping areas of the species of the genus *Caluromys* in Colombia. We modeled the current and potential distribution of *C. derbianus* and *C. lanatus,* and discussed the potential presence of *C. philander*. We extend the distribution range for *C. derbianus* and *C. lanatus* by obtaining new records mainly in the Colombian Caribbean region. For *C. derbianus*, we found that the estimated model area was 177,337 km^2, with the most suitable areas in the Caribbean region in the department of Córdoba and the coast of the department of Sucre, in the north and south of the Pacific region, and in the Andean region on the western mountain range, associated with forest cover. For *C. lanatus*, the estimated model area was 940,007 km^2 with the greatest habitat suitability in the forest cover of the Sierra Nevada de Santa Marta, the central mountain range, the Magdalena River valleys and the Andean-Orinosence piedmont. The areas of occupancy (AOO) and extent of occurrence (EOO) in Colombia are 268 km^2 and 182,741 km^2 for *C. derbianus*, 652 km^2 and 1,036,486 km^2 for *C. lanatus*, with an overlap area of 37,889 km^2. Although we found high uncertainty in the records for *C. philander* in Colombia, we consider that the species probably has representation in the eastern Amazon and Orinoquia regions. This information could be useful to provide new perspectives for the study of the ecological interactions of these Neotropical marsupials, as well as for assessing threats to woolly opossums in Colombia.

Las zarigüeyas lanudas del género *Caluromys* a pesar de su amplio rango de distribución son especies poco conocidas. En Colombia se reconoce la presencia de *Caluromys derbianus* y *C. lanatus*, y se ha propuesto la presencia de *C. philander*. Este trabajo buscó actualizar la distribución y conocer áreas de sobrelapamiento de las especies del género *Caluromys* para Colombia. Modelamos la distribución actual y potencial de *C. derbianus* y *C. lanatus*, y discutimos la presencia potencial de *C. philander*. Ampliamos el intervalo de distribución para *C. derbianus* y *C. lanatus* a partir de la obtención de nuevas localidades de registros principalmente para la región Caribe colombiano. Encontramos para *C. derbianus* un área estimada por el modelo de 177,337 km^2, con áreas más idóneas sobre la región Caribe en el departamento de Córdoba y la costa del departamento de Sucre, al norte y sur de la región Pacífica y en la región Andina sobre la Cordillera Occidental, asociadas a coberturas boscosas. Para *C. lanatus* el área estimada por el modelo fue 940,007 km^2 con mayor idoneidad de hábitat sobre las coberturas boscosas en la Sierra Nevada de Santa Marta, la Cordillera Central, los valles del río Magdalena y el piedemonte Andino-Orinosence. Las áreas de ocupación (AOO) y extensión de ocurrencia (EOO) en Colombia es 268 km^2 y 182,741 km^2 para *C. derbianus*, 652 km^2 y 1,036,486 km^2 para *C. lanatus*, con un área de sobrelapamiento de 37,889 km^2. Aunque encontramos alta incertidumbre en los registros para *C. philander* en Colombia, consideramos que es probable que la especie tenga representación al oriente de las regiones de la Amazonia y Orinoquia. Esta información podría ser útil para brindar nuevas perspectivas para el estudio de las interacciones ecológicas de estos marsupiales Neotropicales, así como poder evaluar amenazas y cambios potenciales en los patrones de distribución para Colombia.

Keywords: Areas of occupancy (AOO); *Caluromys philander*; Colombian Caribbean; extent of occurrence (EOO); range expansion.

Introduction

In Colombia, the order Didelphimorphia is represented by 39 marsupials species grouped in one family and 13 genera that represent 7.2 % of the mammals present in the national territory (Ramírez-Chaves *et al.* 2021). The genus *Caluromys* known as woolly opossum is a lineage of the family Didelphidae characteristic of the New World (Voss and Jansa 2009). This genus is composed of three species, *C. derbianus*, *C. lanatus*, and *C. philander*. They are distributed from the state of Veracruz in México southward in association with forests in Central and South America, including Trinidad and Tobago, to eastern Bolivia, Paraguay, and northeastern Argentina, with an elevational range up to 2,500 m approximately (Gardner 2008; Voss and Jansa 2009). The woolly opossum is arboreal marsupials (rarely descend to the ground), nocturnal, solitary, considered opportunists that consume a wide variety of fleshy fruits, insects, small vertebrates, and flower parts, including nectar, these spe-

cies inhabit primary and disturbed tropical rainforests (Gardner 2008; Astúa 2015).

In Colombia, there are confirmed records of the species *C. derbianus* and *C. lanatus* (Solari *et al.* 2013), and the presence of *C. philander* has been proposed (Alberico *et al.* 2000). *C. derbianus* has been reported for the Pacific region and on the western cordillera in the Andean region, between 0 and 2,600 masl (Solari *et al.* 2013), and more recently for the Caribbean region (Chacón-Pacheco *et al.* 2022a, b). While *C. lanatus* for the Amazon, Andean, and Caribbean regions, up to 2,000 m (Solari *et al.* 2013), and some occasional records for the Orinoquia region (Fonseca and Astúa 2015). Despite this, for the species of the genus for the country there are gaps in information, the main antecedents date from condensed reports in general lists of mammals (Ramírez-Chaves and Noguera-Urbano 2010; Ramírez-Chaves and Pérez 2010; Rojas-Diaz *et al.* 2012; Solari *et al.* 2013; Chacón-Pacheco *et al.* 2022a, b), and even more unknown about its possible sympatry in areas where there is potential overlapping.

Due to aspects related to their habits and the lack of knowledge that human communities have about their importance for ecosystems, opossums are stigmatized and little appreciated (Flórez-Oliveros and Vivas-Serna 2020). Ecosystems in Colombia are favorable scenarios for interactions between organisms in the Neotropics, which are only possible if there is a certain overlap in their geographic distributions. This is little studied in marsupials, which makes it difficult to understand several ecological dynamics related to the energy flow in ecosystems (Kuhnen *et al.* 2017). The use of environmental and biotic variables and their correlations with species occurrence points can contribute to know overlapping areas of potential species distribution (Rödder and Engler 2011). The aim of this study is present new information on the current and potential distribution and overlap areas of the species of the genus *Caluromys* in Colombia. We update their distribution, indicate areas with possible sympaty in the country and present new information that contributes to determine the conservation status of the species of the genus in Colombia. We also discuss the presence of *C. philander* in the country based on the records revision.

Materials and methods

To know the current and potential distribution and overlap areas of *Caluromys* species in Colombia, was used the Ecological Niche Modeling (ENM) approach using the Maximum Entropy Algorithm Maxent 3.4.3 (Phillips *et al.* 2006) and estimated the area of occurrence extension (EOO) and area of occupancy (AOO) in Colombia. Occurrences (Figure 1) were obtained from: 1) specimens captured or observed in the field during the years 2011 to 2019. 2) Biological col-
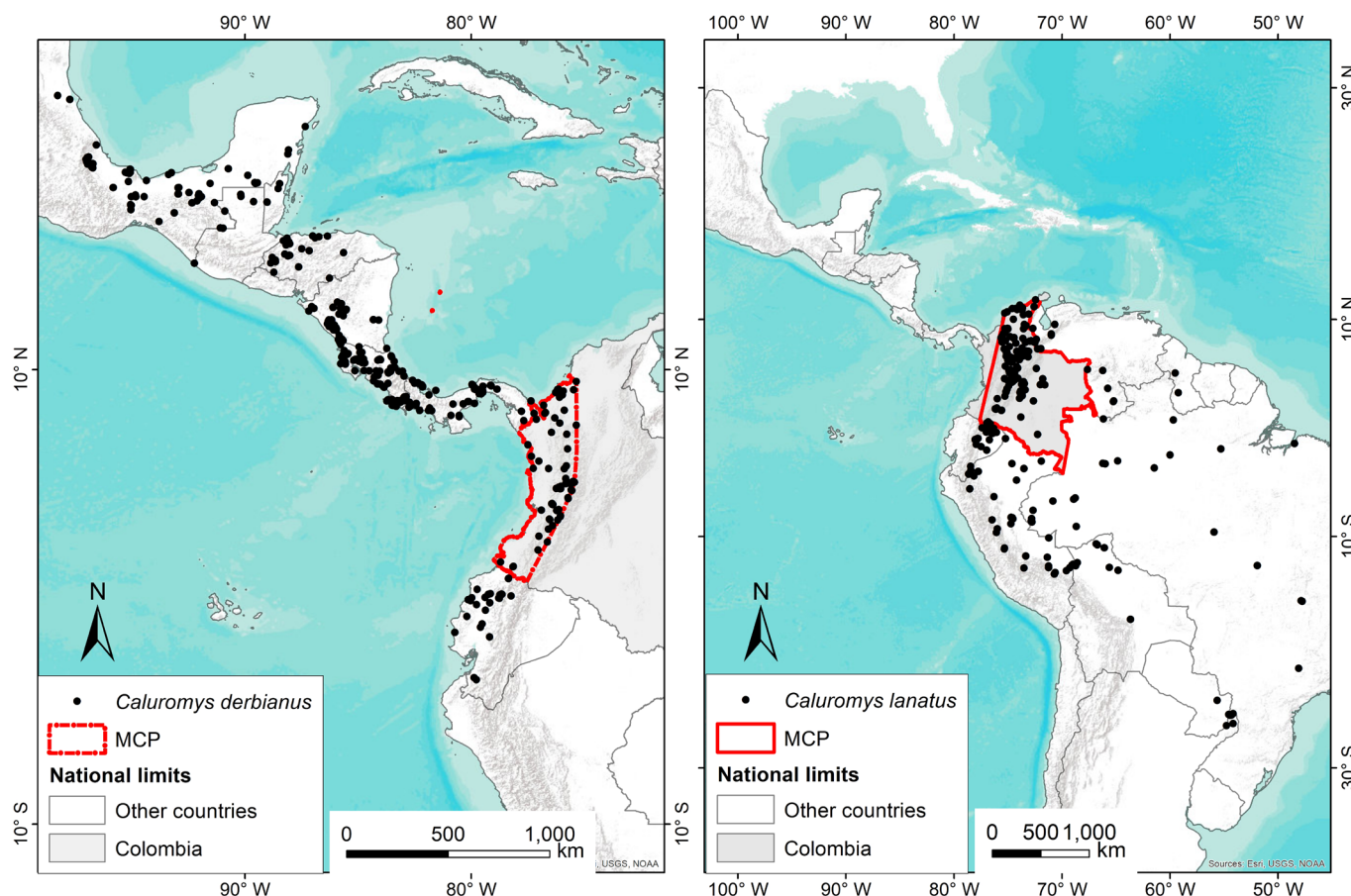

Figure 1. Occurrence records of the woolly opossums *Caluromys derbianus* (left) and *C. lanatus* (right). The minimum convex polygon (MCP) used to calculate the extent of occurrence (EOO) and area of occupancy (AOO) of the species in Colombia.

lections, national and departmental mammal lists were reviewed. 3) Literature databases such as Google Scholar, Scopus, and ScienceDirect were consulted using keywords, ("*Caluromys*" OR "*Caluromys derbianus*" OR "*Caluromys lanatus*" OR "*Caluromys philander*") AND "Colombia". 4) Also were obtained records shared by other researchers and citizen science (iNaturalist; https://www.inaturalist.org/). And, 5) in addition, complementary records for the species *C. derbianus* and *C. lanatus* for Colombia and records for another countries where these species are distributed were obtained from the biodiversity platforms, Species Link (https://specieslink.net/) and the Global Biodiversity Information Facility (GBIF; https://doi.org/10.15468/dl.bxauh6, https://doi.org/10.15468/dl.3wpryf, https://doi.org/10.15468/dl.caktxu). The search for records of the species *C. philander* was restricted to Colombia, due to the uncertainty of the presence of the species in the country (see records https://github.com/jchacon-bio/Ocurrences_Caluromys). Individuals recorded in fieldwork and from citizen science were identified based on external characteristics such as woolly fur; long, prehensile tail, lacking long, dense fur for 1/3 or more of distal length; large, naked ears; dark, conspicuous medial facial stripe (Gardner 2008).

To understand the potential distribution of woolly opossums, *C. derbianus* and *C. lanatus*, were used bioclimatic variables from WorldClim 2.0 (Fick and Hijmans 2017) for recent climates (~2000 years) at 2.5 minutes (~4.5 km) resolution. Were excluded variables with combined precipitation and temperature information (bio8: Mean temperature of the wettest quarter; bio9. Mean temperature of the driest quarter; bio18: Precipitation of the warmest quarter; bio19: Precipitation of the coldest quarter) because they show spatial anomalies in the form of discontinuities between adjacent pixels (Booth 2022). The models were calibrated in a hypothetical area where the species has been able to explore and potentially colonize using the minimum convex polygon with a buffer of 1 km from the centroid calculated from all occurrences. Was used the random kfolds method, 10,000 background points. Were used different responses (Linear, Quadratic, Linear-Quadratic, Hinge, Linear-Quadratic-Hinge), and different regularization multipliers [RM] (0.1 to 4, growing to 0.5), and three sets of environmental variables (six PC; Muscarella *et al.* 2014; Radosavljevic and Anderson 2014).

Within the known distribution range for *C. derbianus* and *C. lanatus*, 598 occurrence records were obtained (80 records from citizen science in Colombia). For *C. derbianus* 348 (67 in Colombia) and 250 for *C. lanatus* (145 in Colombia) after spatial filtering (~4.5 km²). Were generated 32 candidate models for each species (*C. derbianus* and *C. lanatus*) that were evaluated by partitioning the records using the random kfold method, into 50 % training data and 50 % test data. A three-step framework was used to evaluate and choose an automated model in the R environment (R Core Team 2022) and the Wallace v2.0 package that allow the work with multiple species in the same session (Kass *et*

al. 2023). At first, in order to evaluate models performance, was estimated the partial area under the curve (AUC) of the receiver operating characteristic (pROC; Peterson *et al.* 2008). Second, was calculated the statistical significance of the models with omission rates (5 %; Peterson *et al.* 2011; Muscarella *et al.* 2014), and, finally, were selected models with low complexity and good fit to the underlying data, was used the corrected Akaike information criterion (AICc; Burnham *et al.* 2011; Muscarella *et al.* 2014). From the final model for each species, we selected the logistic output of each model and converted the suitability map into a binary map using the 10P (tenth percentile) cutoff threshold value. This approach was selected because it assumes that 10 % of the records do not occur in representative regions of the general habitat of the species and should therefore be omitted (Babich-Morrow 2019).

The resulting models were trimmed following the national limits of Colombia and the terrestrial ecoregions (Olson *et al.* 2001) where there was no evidence for each of the species were extracted. For *C. derbianus* were extracted the terrestrial ecoregions, Eastern Cordillera real montane forests, Cordillera Oriental montane forests, Magdalena Valley dry forests, Magdalena Valley montane forests and Napo moist forests. While for *C. lanatus* ecoregions were excluded Northern Andean paramo, Cauca Valley dry forests, Cauca Valley montane forests, Western Ecuador moist forests, Northwestern Andean montane forests and Chocó-Darién moist forests.

Later, the overlapping area of the species was estimated as the intersection of the distribution ranges of the two species. For the estimation of the extent of occurrence (EOO) in Colombia we used a minimum convex polygon joining the extreme records of the species. The area of occupancy (AOO) was calculated by adding the area of the grid where the species is known (we used grid of 2 km² as recommended in IUCN 2012) within Colombia using the GeoCat tool (Bachman *et al.* 2011).

Results

For Colombia, we obtained 222 occurrence records for the genus *Caluromys*, 67 for *C. derbianus*, 145 for *C. lanatus*, three for *C. philander*, and seven undetermined records (Figure 1).

We confirm the presence of *C. derbianus* for the Andean and Pacific regions and extend its distribution to the Caribbean region in the departments of Córdoba and Sucre (Figure 2). While for *C. lanatus* its distribution range extends to the Colombian Caribbean in all the continental departments of the region (Atlántico, Bolívar, Cesar, Córdoba, La Guajira, Magdalena, and Sucre), and we confirm its presence in the Andean region in the departments of Antioquia, Boyacá, Caldas, Cauca, Cundinamarca, Huila, Norte de Santander, Santander, Tolima, and Valle del Cauca (Figure 2). We also confirm its distribution in the Orinoquia region in the department of Meta, and for Amazon region, in the departments of Amazonas, Caquetá, Guaviare, and
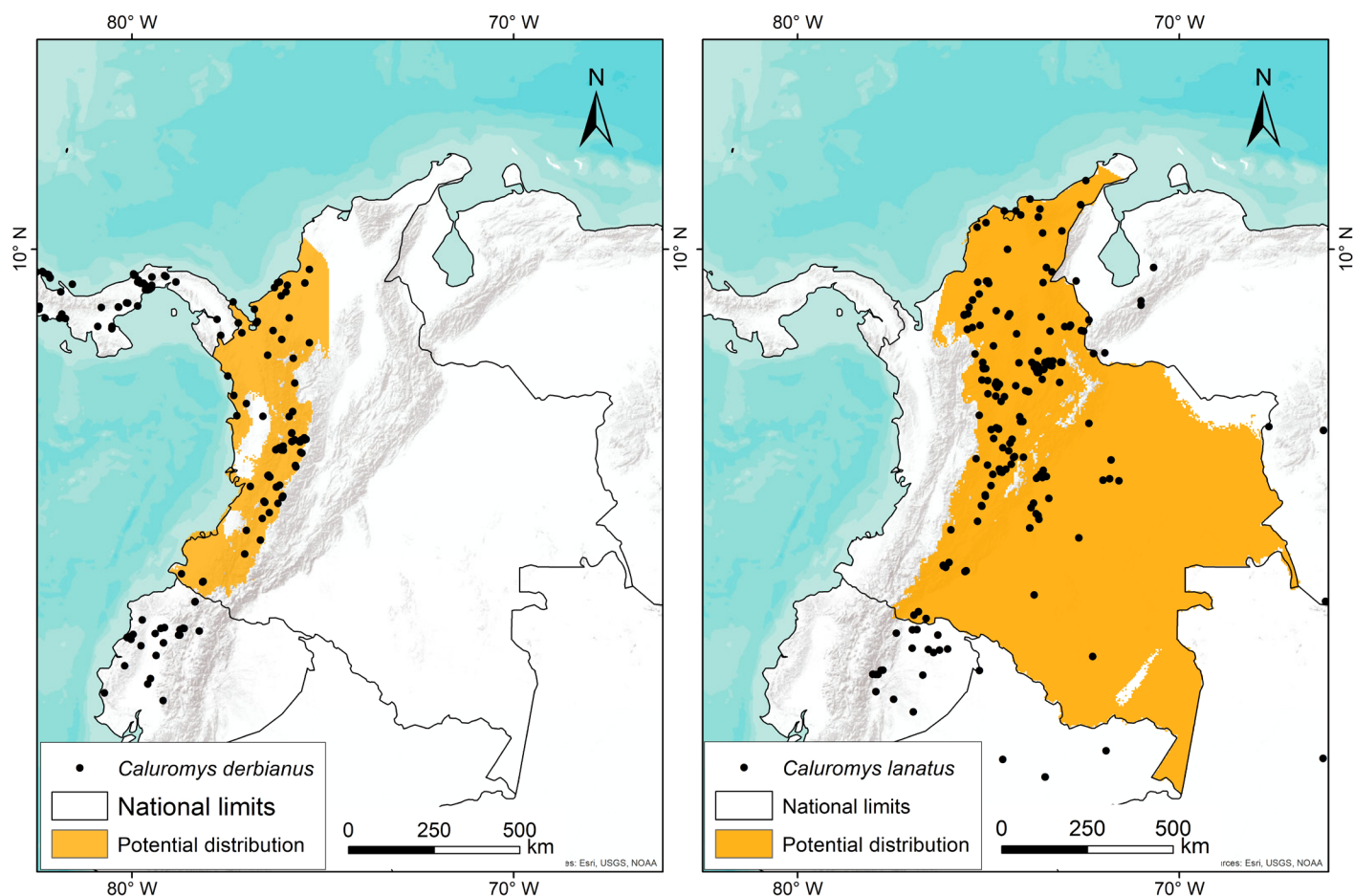
Figure 2. Potential distribution for *Caluromys derbianus* (left) and *C. lanatus* (right) in Colombia based on the Maximum Entropy (Maxent) algorithm model. The binary map (orange) was created using the threshold cut-off of the tenth percentile.

Putumayo. We found overlapping of species, *C. derbianus* and *C. lanatus*, in the Andean and Caribbean region, for the departments Antioquia, Bolívar, Córdoba and Sucre, with an area 37,889.48 km^2 (Figure 3).

For *C. derbianus* the model predicted that the most suitable areas for the species were the department of Córdoba, the coastal region of the department of Sucre, the north and south of the Pacific region, and the Western Cordillera, associated with forest cover (Figure 4). The EOO was 182,741.51 km^2 and AOO was 268 km^2 (Figure 1). The estimated area with the model was 177,337.01 km^2 (Linear + Quadratic 0.50; AUC test = 0.70; AUC train = 0.73; 10 percentile = 0.10). On the other hand, the regions with the most suitable habitat for *C. lanatus* are shown over forest cover in the Sierra Nevada de Santa Marta, the Cordillera Central, the Magdalena River valleys and the Andean-Orinosence foothills (Figure 4). The EOO was 1,036,485.97 km^2 and AOO was 652.00 km^2 (Figure 1). The estimated area with the model was 940,007.40 km^2 (linear 0.5; AUC test = 0.77; AUC trainning = 0.78; 10 percentile = 0.12).

For *C. philander* we discarded a record for the Corregimiento de Arusí in Nuquí municipality, Chocó department, that probably refers to *C. derbianus* given the observed distribution. For the Meta department, a report was recovered as part of a study of *Leptospira* reservoirs

(Aycardi *et al.* 1980), however, there is no specimen or material to verify its determination. In eastern Colombia there are two records, one associated with a specimen deposited in the Museum of the Rancho Grande Biological Station, Venezuela (EBRG 2166; 01°51'N, 67°03'W), and another recorded in machine observation by the Fundación Puerto Rastrojo-Colombia (FPR-Colombia 63750; 1°55'N, 67°04'W), both georeferenced for Guainía department, but which refer to collections made at Caño Ardabo in San Carlos de Río Negro, Amazonas state, Venezuela (Figure 3).

Discussion

The results obtained extend the distribution of the species *C. derbianus* and *C. lanatus* to northern Colombia and despite uncertainty about the occurrence records of *C. philander* in the country we consider that the species probably has representation in the eastern Amazon and Orinoquia regions in the departments of Guainía, Guaviare and Vichada, where it is likely to show sympatry with *C. lanatus*. We found overlap areas for *C. derbianus* and *C. lanatus* for the departments of Antioquia, Bolívar, Córdoba and Sucre (Solari and Lew 2015; Costa *et al.* 2021), where may exist coexistence interactions given the functional roles of these two species, know for their habits omnivorous (Astúa 2015). However, it is necessary know how these species utilize their environment and resources.
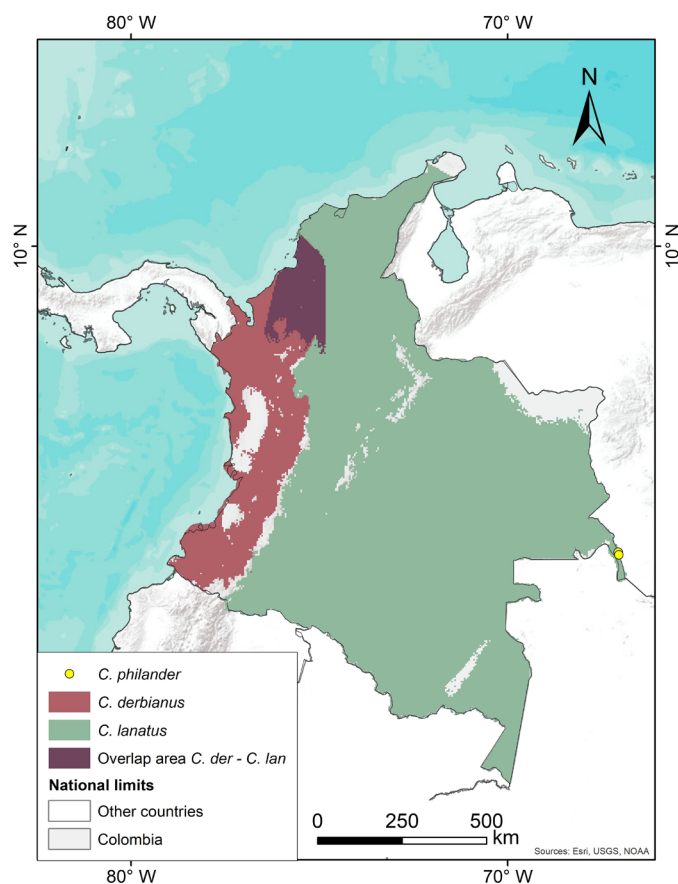
Figure 3. Predicted current area of distributions and overlap (purple) of *C. derbianus* (red) and *C. lanatus* (green) in Colombia (gray) under current climatic condition. Yellow circles represent the records of *C. philander* georeferenced for Guainía department, but which refer to collections made at Caño Ardabo in San Carlos de Río Negro, Amazonas state, Venezuela (EBRG 2166; 01°51'N, 67°03'W and FPR-Colombia 63750; 1°55'N, 67°04'W).

In Colombia, there is few information on the ecosystems occupied by species of the genus *Caluromys*. According to the recovered records and the model projection, we recognize the presence of the species in various ecosystems and vegetation cover, mainly associated with primary and secondary forests and cultivated areas with greater cover such as banana (*Musa* spp), in humid and dry tropical forests for *C. derbianus* and for *C. lanatus* additionally in sub-Andean forests and gallery forests towards the Orinoquía. In addition, in urban areas, as electrocution records in the Caldas, Quindío and Valle del Cauca departments (Sánchez and Alvear 2003; Saavedra-Rodríguez *et al.* 2013; Bastidas-Domínguez *et al.* 2021). Congruent with the models presented for México by Ortiz-Acosta (2022), showing *C. derbianus* is associated with dry and moist forests, for the regions of Chiapas and the Yucatán Peninsula. Likewise, this is consistent for *C. lanatus* that is considered one of the tropical marsupial species most associated with moist and dense forests (Cáceres *et al.* 2022).

The fact these species are found in diverse environments with varying degrees of anthropic disturbance reflects its relatively good tolerance to habitat transformation (Astúa 2015; Solari and Lew 2015; Brito *et al.* 2021; Costa *et al.* 2021). Also, for being generalist species, omnivorous that consume a high variety of resources from fruits, insects, nectar, invertebrates, small vertebrates to carrion (Astúa 2015), they are able to occur in areas where humans may consider them an annoyance. Although these species have rarely been associated with conflict with humans, with few hunting reports to avoid damage to crops and poultry (Marineros *et al.* 2016).
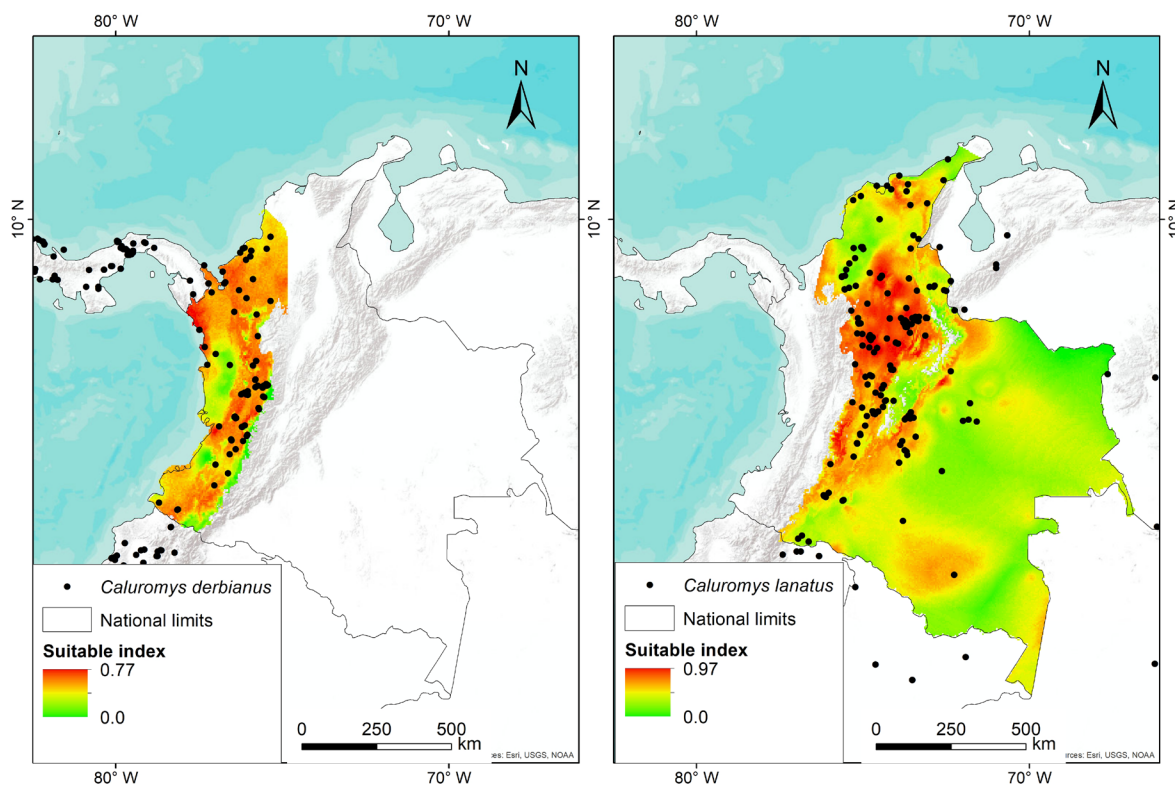

Figure 4. Suitability areas in climatic environment in Colombia of *Caluromys derbianus* (left) y *C. lanatus* (right).

Among the field records, we found the corpses of four specimens (one female and her three young) that were stoned to death associated with banana crops.

Due to the considerable knowledge gap on the species of the genus, our results serve as a basis for further analysis that involves aspects of their ecology and conservation status. The distribution range reports provided in this study constitute a basis for obtaining novel information on local populations of the genus in the country, considering the high deforestation rates in the Caribbean and Andean regions (Correa-Ayram *et al.* 2020), where population monitoring and confirmation of species sympatry through field studies is recommended, contributing to defining conservation and management areas common for these species. Thus, it is necessary new perspectives on the ecology studies of these two Neotropical marsupials, such as the association of different but complementary methods (*i. e.,* diet overlap and temporal segregation) that allow a more complete understanding of resource partitioning and species coexistence (Kuhnen *et al.* 2017).

Furthermore, although these species are recognized as tolerant to ecosystem changes and models indicate a continuous distribution, new efforts should be considered to resolve aspects of their taxonomy, especially for *C. lanatus*, which in Colombia could be another taxonomic entity different from those distributed in southern South America, according to reported variations in color and cranial morphology (López-Fuster *et al.* 2008; Fonseca and Astúa 2015). Likewise, it is important to study aspects of their life history in the different areas of the country where the woolly opossums occur, according to their habitat requirements, ecological characteristics and their interactions with human communities.

Acknowledgments

Literature cited

ALBERICO, M. A., *ET AL*. 2000. Mamíferos (Synapsida: Theria) de Colombia. Biota Colombiana 1:43–75.

ASTÚA, D. 2015. Didelphidae. Pp. 70–186, in Handbook of the mammals of the world (Wilson, D. E., and R. A. Mittermeier, eds.). Lynx Edicions. Barcelona, Spain.

AYCARDI, E. R., D. M. MYERS, AND B. TORRES. 1980. A New Leptospiral Serovar in the Tarassovi Serogroup from Colombia. Zentralblatt für Veterinärmedizin Reihe B 27:425–428.

BABICH-MORROW, C. 2019. Thresholding species distribution models. Github. https://babichmorrowc.github.io/post/2019-04-12-sdm-threshold. Consulted 24 July 2023.

BACHMAN, S., *ET AL*. 2011. Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. ZooKeys 150:117–126.

BASTIDAS-DOMÍNGUEZ, M. C., *ET AL*. 2021. Primeros registros del género *Caluromys* (Didelphimorphia: Didelphidae) para el departamento del Quindío, y aclaraciones sobre los registros de Colombia. Mammalogy Notes 7:218.

BOOTH, T. H. 2022. Checking bioclimatic variables that combine temperature and precipitation data before their use in species distribution models. Austral Ecology 47:1506–1514.

BRITO, D., *ET AL*. 2021. *Caluromys philander* (amended version of 2015 assessment). The IUCN Red List of Threatened Species 2021. http://www.iucnredlist.org. Consulted 21 May 2023.

BURNHAM, K. P., D. R. ANDERSON, AND K. P. HUYVAERT. 2011. AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology 65:23–35.

CÁCERES, N. C., *ET AL*. 2022. Movement, Habitat Selection, and Home Range of American Marsupials. Pp. 1–27, *in* American and Australasian Marsupials (Cáceres, N. C., and C. R. Dickman, eds.). Springer International Publishing. Cham, Switzerland.

CHACÓN-PACHECO, J. J., G. A. SALCEDO-RIVERA, AND D. A. ZÁRRATE-CHARRY. 2022. Mamíferos del departamento de Sucre, Colombia. Biota Colombiana 23:e1022.

CHACÓN-PACHECO, J. J., *ET AL*. 2022. Actualización de la lista de mamíferos silvestres del departamento de Córdoba, Colombia. Biota Colombiana 23:e966.

CORREA-AYRAM, C. A., *ET AL*. 2020. Spatiotemporal evaluation of the human footprint in Colombia: Four decades of anthropic impact in highly biodiverse ecosystems. Ecological Indicators 117:106630.

COSTA, L. P., *ET AL*. 2021. *Caluromys lanatus* (amended version of 2015 assessment). The IUCN Red List of Threatened Species 2021. http://www.iucnredlist.org. Consulted 21 May 2023.

FICK, S. E., AND R. J. HIJMANS. 2017. WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37:4302–4315.

FLÓREZ-OLIVEROS, F. J., AND C. VIVAS-SERNA. 2020. Zarigüeyas (Chuchas Comunes) Marmosas y Colicortos en Colombia. Fundación Zarigüeya – FUNDZAR. Medellín, Colombia.

FONSECA, R., AND D. ASTÚA. 2015. Geographic variation in *Caluromys derbianus* and *Caluromys lanatus* (Didelphimorphia: Didelphidae). Zoologia (Curitiba) 32:109–122.

GARDNER, A. L. 2008. Mammals of South America, Volume 1. Marsupials, Xenarthrans, Shrews, and Bats. The University of Chicago Press. Chicago and London, U.S.A.

KASS, J. M., *ET AL*. 2023. wallace 2: a shiny app for modeling species niches and distributions redesigned to facilitate expansion via module contributions. Ecography 2023:e06547.

KUHNEN, V. V., *ET AL*. 2017. Diet overlap and spatial segregation between two neotropical marsupials revealed by multiple analytical approaches. Plos One 12:e0181188.

LÓPEZ-FUSTER, M. J., R. PÉREZ-HERNÁNDEZ, AND J. VENTURA-QUEIJA. 2008. Morphometrics of genus *Caluromys* (Didelphimorphia: Didelphidae) in northern South America. Orsis 23:97–114.

MARINEROS, L. E., *ET AL*. 2016. Notas y nuevos sitios de encuentro de *Caluromys derbianus* (Marsupialia: Didelphidae) en Honduras. Revista Biodiversidad Neotropical 6:77.

MUSCARELLA, R., *ET AL*. 2014. ENMeval: An R package for conducting spatially independent evaluations and estimating optimal model complexity for Maxent ecological niche models. Methods in Ecology and Evolution 5:1198–1205.

Olson, D. M., *et al*. 2001. Terrestrial ecoregions of the world: a new map of life on Earth. BioScience 51:933–938.

Ortiz-Acosta, M. A. 2022. Distribución potencial de los marsupiales (Didelphimorphia: Didelphidae) en México bajo diferentes escenarios de cambio climático. Maestría en Ciencias en Ecología y Biotecnología, Instituto de Biotecnología y Ecología Aplicada, Universidad Veracruzana, Xalapa, México.

Peterson, A. T., *et al*. 2011. Ecological niches and geographic distributions. Princeton University Press. Princeton, U.S.A.

Peterson, A. T., M. Papes, and J. Soberón. 2008. Rethinking receiver operating characteristic analysis applications in ecological niche modeling. Ecological Modelling 213:63–72.

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

R Core Team. 2022. R: A language and environment for statistical computing. Vienna, Austria. https://www.R-project.org.

Radosavljevic, A., and R. P. Anderson. 2014. Making better Maxent models of species distributions: complexity, overfitting and evaluation. Journal of Biogeography 41:629–643.

Ramírez-Chaves, H. E., and 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., and W. A. Pérez. 2010. Mamíferos (Mammalia: Theria) del departamento del Cauca, Colombia. Biota Colombiana 11:141–171.

Ramírez-Chaves, H. E., *et al*. 2021. Lista de cotejo de los mamíferos (Mammalia) de Colombia. Mammalogy Notes 7:253.

Rödder, D., and J. O. Engler. 2011. Quantitative metrics of overlaps in Grinnellian niches: advances and possible drawbacks. Global Ecology and Biogeography 20:915–927.

Rojas-Diaz, V., M. Reyes-Gutierrez, and M. S. Alberico. 2012. Mamíferos (Synapsida, Theria) del Valle del Cauca, Colombia. Biota Colombiana 13:99–116.

Saavedra-Rodríguez, C. A., Á. Lizcano, and J. D. Corrales. 2013. Incidentes de fauna silvestre en líneas de energía en zona rural del Valle del Cauca, Colombia. Revista Biodiversidad Neotropical 3:85–89.

Sánchez, F., and M. Alvear. 2003. Comentarios sobre el uso de hábitat, dieta y conocimiento popular de los mamíferos en un bosque andino en el departamento de Caldas, Colombia. Boletín Científico, Museo de Historia Natural, Universidad de Caldas 7:121–144.

Solari, S., and D. Lew. 2015. *Caluromys derbianus*. The IUCN Red List of Threatened Species 2021. http://www.iucnredlist.org. Consulted 5 May 2023.

Solari, S., *et al*. 2013. Riqueza, endemismo y conservación de los mamíferos de Colombia. Mastozoología Neotropical 20:301–365.

UICN. 2012. Directrices para el uso de los Criterios de la Lista Roja de la UICN a nivel regional y nacional: Versión 4.0. UICN Gland, Suiza y Cambridge. Gland, Suiza y Cambridge, U.K.

Voss, R., and S. Jansa. 2009. Phylogenetic relationships and classification of didelphid marsupials, an extant radiation of New World metatherian mammals. Bulletin of the American Museum of Natural History 322:1–177.