Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales.
50(194):111-131, enero-marzo de 2026. doi: https://doi.org/10.18257/raccefyn.3185

Natural Sciences

Original article

Amphibians (Amphibia, Lissamphibia) from the Cordilleras Central and Occidental, Department of Caldas, Colombia: A century of data collection and research

Anfibios (Amphibia, Lissamphibia) de las cordilleras Central y Occidental en el departamento de Caldas, Colombia: un siglo de recolección de datos e investigación

Héctor F. Árias-Monsalve[1,2,*], Erika Alejandra Cardona-Galvis[2,3], L. Santiago Caicedo-Martínez[3], Julián A. Rojas-Morales[1,3,4], Jose J. Henao-Osorio[1,3], Héctor E. Ramírez-Chaves[1,3]

[1] Grupo de Investigación en Genética, Biodiversidad y Manejo de Ecosistemas (GEBIOME), Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Caldas; Centro de Museos, Museo de Historia Natural, Universidad de Caldas, Manizales, Colombia
[2] Maestría en Ciencias Biológicas, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Caldas, Manizales, Colombia
[3] Integrative Zoological Biodiversity Discovery Laboratory, Centro de Museos, Museo de Historia Natural, Universidad de Caldas, Manizales, Colombia
[4] Doctorado en Ciencias, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Caldas, Manizales, Colombia

Abstract

The Andean region of Colombia hosts a high number of endemic amphibian species due to the complex topography of the three main cordilleras and the associated mountain massifs. Located in the Central Andes, the Department of Caldas spans the eastern slopes of the Cordillera Occidental, both slopes of the Cordillera Central, and the middle sections of the Cauca and Magdalena inter-Andean valleys. We compiled and analyzed the amphibian richness and distribution data across Caldas' political and natural subdivisions using information from biological collections, scientific literature, and recent field work. We reported 135 species distributed in 48 genera, 18 families, and three orders (Anura, Caudata, and Gymnophiona), of which 22 species have their type locality within Caldas. Despite the department's high amphibian diversity across its 7,888 km² area, information gaps remain after almost 100 years of research: one of the 27 municipalities lacks data entirely, several are underrepresented, and there are few records and uneven sampling in the western part of Caldas. To fill these distribution and knowledge gaps, we highlight as survey priority areas the Cauca Valley Dry and Montane Forests ecoregions on the eastern slope of Cordillera Occidental.

Keywords: Andes; Anura; Caudata; geographical gaps; Gymnophiona; inter-Andean valleys; species richness.

Resumen

La región andina de Colombia alberga una gran cantidad de especies endémicas de anfibios debido a la topografía compleja formada por las tres cordilleras principales y otros macizos montañosos. Localizado en la parte central de los Andes, el departamento de Caldas abarca las vertientes orientales de la cordillera Occidental, ambas vertientes de la cordillera Central y la parte media de los valles interandinos del Cauca y el Magdalena. Compilamos y analizamos aquí la información sobre la riqueza y la distribución de los anfibios en las subdivisiones políticas y naturales del departamento de Caldas, utilizando datos de colecciones biológicas, de la literatura científica y de actividades de campo recientes. Reportamos 135 especies de 47 géneros, 18 familias y tres órdenes, de las cuales 22 tienen su localidad tipo dentro de Caldas. Aunque en su área de 7.888 km²

Citation: Árias-Monsalve HF, *et al*. Amphibians (Amphibia, Lissamphibia) from the Cordilleras Central and Occidental, Department of Caldas, Colombia: A century of data collection and research. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales. 50(194):111-131, enero-marzo de 2026. doi: https://doi.org/10.18257/raccefyn.3185

Editor: Martha Patricia Ramírez Pinilla

***Corresponding autor:**
Héctor E. Ramírez-Chaves;
hector.ramirez@ucaldas.edu.co

Received: April 1, 2025
Accepted: November 12, 2025
Published on line: January 19, 2026

Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales.
50(194):111-131, enero-marzo de 2026. doi: https://doi.org/10.18257/raccefyn.3185

la riqueza de anfibios del departamento es elevada, aún persisten vacíos de información después de casi 100 años de investigación: uno de los 27 municipios no cuenta con datos, varios muestran una baja representación y hay pocos registros y baja representatividad en la parte occidental de Caldas. Resaltamos la ecorregión de los bosques montanos y los bosques secos del Valle del Cauca como áreas prioritarias para realizar esfuerzos de campo tendientes a llenar estos vacíos de distribución y conocimiento.

Palabras clave: Andes; Anura; Gymnophiona; riqueza; Caudata; valles interandinos; vacíos geográficos.

Introduction

With 903 species, Colombia ranks second in amphibian richness worldwide after Brazil (**Acosta Galvis**, 2025). The amphibian fauna in Colombia exhibits remarkable diversity per unit area, alongside one of the highest levels of endemism globally, with 417 endemic species to date (**Lynch *et al.***, 1997; **Frost**, 2024). The country features contrasting habitats that offer unique niches and microclimates which support distinct amphibian communities, underscoring the importance of conservation strategies across its landscapes (**Saboyá-Acosta & Urbina-Cardona**, 2023). The high diversity of amphibians in Colombia has been assessed to understand the drivers that influence their distribution, abundance, and conservation status (**Lynch *et al.***, 1997; **Bernal & Lynch**, 2008; **Ortiz-Yuzti *et al.***, 2013). Geological, climatic, and ecological drivers shaped the Andean region as the richest in terms of amphibian diversity (**Kattan *et al.***, 2004; **Armesto & Senaris**, 2017; **Herrera-Lopera *et al.***, 2023). In this sense, the presence of three mountain ranges, namely the Occidental, Central, and Oriental cordilleras, inter-Andean valleys, and several natural ecosystems where amphibians inhabit, explains such diversity (**Lynch *et al.***, 1997; **Kattan *et al.***, 2004; **Tobar-Suárez *et al.***, 2022).

Thus, the Colombian Andes play an important role in housing several species with restricted distributions and endemic species, particularly in high-Andean forests and páramo ecosystems (**Lynch *et al.***, 1997; **Tobar-Suárez *et al.***, 2022; **Saboyá-Acosta & Urbina-Cardona**, 2023). During the last four decades, studies conducted in the Andean region have compiled a robust list of amphibians at different scales, from local restricted areas (**Restrepo *et al.***, 2017; **Ovalle-Pacheco *et al.***, 2019) to wider political units such as municipalities (**Lynch**, 2006) and departments (**Castro-Herrera & Vargas-Salinas**, 2008; **Llano-Mejía *et al.***, 2010; **Román-Palacios *et al.***, 2017; **Ramírez-Chaves *et al.,*** 2022, 2023). Despite the continuous efforts to document the diversity and distribution patterns of Andean amphibians, information gaps remain (**Castro-Herrera & Vargas-Salinas**, 2008; **Saboyá-Acosta & Urbina-Cardona**, 2023) as evidenced in poorly or unexplored areas within the region, where undescribed amphibians live.

The Department of Caldas is located in the Colombian central-western Andes between the Cordilleras Occidental and Central and the inter-Andean valleys of the Cauca and Magdalena rivers. Its topographic complexity results in environmental heterogeneity along its altitudinal range from 170 to 5,321 m (**INGEOMINAS**, 1993; **Rueda-Almonacid**, 2000; **Ordoñez *et al.***, 2022). Field work in Caldas over the last 30 years has led to the discovery of new species of anurans, salamanders, and caecilians (**Lynch & Rueda-Almonacid**, 1997; **Ruiz-Carranza & Lynch**, 1997; **Acosta-Galvis & Restrepo**, 2001; **Caicedo-Martínez *et al.***, 2024), and natural history observations, for example, diet descriptions of *Dendrobates truncatus* (**Cope**, 1861; **Marín-Martínez *et al.***, 2019) and of advertisement calls of *Leucostethus* aff. *fraterdanieli* (**Rojas-Morales *et al.***, 2021). The scientific efforts to document amphibian diversity in Caldas have been synthesized at different regional scales, with records of up to 133 species (**Ramírez-Chaves *et al.***, 2022) and several areas with well-documented information on local amphibians. For instance, there are studies for protected areas such as the National Natural Park Selva de Florencia (**Rueda-Almonacid**, 2000; **Duarte-Marín *et al.***, 2018), natural reserves (**Acosta-Galvis *et al.***, 2006), and dry forest ecosystems of the inter-Andean Magdalena River valley lowlands (**Burbano-Yandi *et al.***, 2016). However, the best-known areas in terms of amphibian community

composition and diversity are located in the mid and highland Cordillera Central western slope, near the capital city (Manizales) (**Rojas-Morales *et al.***, 2011, 2014; **Rojas-Morales & Marín-Martínez**, 2019).

Furthermore, the description of new species with restricted distribution in Caldas, Risaralda and Quindío neighboring departments (**Cuellar-Valencia *et al.***, 2021; **Montilla *et al.***, 2023; **Caicedo-Martínez *et al.***, 2024) highlights the need for regularly updated checklists of the region's amphibian fauna. Such efforts are also essential to inform and guide conservation programs aimed at protecting threatened species (**Ruiz-Carranza *et al.***, 1996; **Castro-Herrera & Vargas-Salinas**, 2008; **Ovalle-Pacheco *et al.***, 2019). To consolidate the available information on the amphibians distributed in Caldas, we provide here an updated checklist of species, explore distribution gaps, list type localities within the political borders, and include information on the biological collections that hold specimens from this Department.

Materials and methods

Study area

The Department of Caldas (4°48' - 5°46' N and 74°39' - 75°55' W) has an area of 7,888 km^2, where most of the territory is distributed in the narrow strait formed between the Central and Occidental cordilleras (**Figure S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5287). Caldas has two main basins: the Magdalena River in the east and the Cauca River in the west. The Magdalena River basin captures the waters from the Cordillera Central that flow along the eastern slope, while the Cauca River basin receives the rivers draining the western slope of this same cordillera and the eastern slope of the Cordillera Occidental. The elevation gradient varies throughout the Department, with a minimum elevation of 170 m in the municipality of La Dorada, which extends towards the Magdalena River basin. On the western slope, in the Cauca River basin, the lowest elevation point is 580 m at the confluence of the Arma and Cauca rivers in the north of Caldas. The highest point recorded in the department is the Nevado del Ruiz, which reaches 5,321 m (**INGEOMINAS**, 1993; **Rueda-Almonacid**, 2000; **Acosta-Galvis**, 2009; **Ordóñez *et al.***, 2022). Its 27 municipalities (**Figure S1A,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5287) are grouped into six political units to facilitate the political administration: i) Northern region, ii) South-central region, iii) Magdalena Caldense region, iv) Upper Eastern region, v) Upper Western region, and vi) Lower Western region (**Figure S1A,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5287). In ecological terms, Caldas has six ecoregions: i) the Cauca Valley Dry Forests, ii) the Cauca Valley Montane Forest, iii) the Magdalena-Urabá Moist Forests, iv) the Magdalena Valley Dry Forests, v) the Magdalena Valley Montane Forests, and vi) the Northern Andean Páramo (**Dinerstein *et al.***, 2017) (**Figure S1B,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5287).

Species checklist

To update the taxonomic checklist of amphibians in the Department of Caldas and provide data on their distribution across its 27 municipalities, political regions, and natural ecoregions, we used three main sources of information: (1) a comprehensive review of the scientific literature, (2) an examination of specimens housed in two biological collections, and (3) a search for additional records in online databases and digital repositories. From the literature review, we compiled data from 51 scientific publications: **Gaige** (1933), **Dunn** (1942), **Lynch** (1991, 1997, 1999, 2001, 2008), **Ruiz-Carranza *et al.*** (1996), **Ruiz-Carranza & Lynch** (1997), **Lynch & Rueda-Almonacid** (1997, 1998a; 1998b, 1999) **Rueda-Almonacid** (2000, 2004), **Acosta-Galvis** (2000, 2018), **Lynch & Suárez-Mayorga** (2001), **Acosta-Galvis & Restrepo** (2001) **Rueda-Almonacid *et al.*** (2006), **Acosta-Galvis *et al.*** (2006), **Grant & Ardila-Robayo** (2002), **Lynch & Acosta-Galvis** (2004), **Grant** (2007) **Grant *et al.*** (2007), **Tapley & Acosta-Galvis** (2010), **Rojas-Morales *et al.*** (2011, 2014, 2021), **Rivera-Correa & Faivovich** (2014), **Ospina-Sarria**

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50(194):111-131, enero-marzo de 2026. doi: https://doi.org/10.18257/raccefyn.3185

et al. (2015), **Burbano-Yandi *et al.*** (2016), **Escobar-Vargas *et al.*** (2016), **González-Durán** (2016), **Román-Palacios *et al.*** (2016), **Vanegas-Guerrero *et al.*** (2016), **Basto-Riascos *et al.*** (2017), **Gómez-Salazar *et al.*** (2017), **Serna-Botero & Ramírez-Castaño** (2017), **Rada *et al.*** (2017), **Duarte-Marín *et al.*** (2018), **Gómez-Hoyos *et al.*** (2018), **Guevara-Molina *et al.*** (2018), **Marín-Martínez & Serna-Botero** (2019), **Martínez *et al.*** (2019), **Díaz-Ricaurte & Guevara-Molina** (2020), **Rivera-Correa *et al.*** (2021), **Gutiérrez-Cárdenas *et al.*** (2022), **Montilla *et al.*** (2023), **Ramírez-Chaves *et al.*** (2023), and **Caicedo-Martínez *et al.*** (2024). We also included an unpublished document edited by the Corporación Autónoma Regional de Caldas – CORPOCALDAS (**Acosta-Galvis**, 2009), which is not found in conventional search engines. From biological collections, we reviewed specimens housed at the Colección de Anfibios del Museo de Historia Natural, Universidad de Caldas (MHN-UCa-Am), and the Colección Herpetológica, Corporación Universitaria Santa Rosa de Cabal (UNISARC). Finally, we searched records from online databases of biological collections including those of the Museo Herpetológico, Universidad de Antioquia (MHUA-A), Colección de Anfibios, Museo La Salle (MLS-ran), Colección de Anfibios, Instituto de Ciencias Naturales, Universidad Nacional de Colombia (ICN-Anf), Colección de Anfibios, Instituto Alexander von Humboldt (IAvH-Am), Colección de Anfibios, Museo de Historia Natural de la Pontificia Universidad Javeriana (MPUJ_ANFB), and Colección de Herpetología del Museo de Ciencia Naturales de La Salle - Instituto Tecnológico Metropolitano (formerly Museo de Historia Natural del Colegio San José - CSJ-H).

We used the following species inclusion and exclusion criteria when reviewing the literature and databases: (i) for literature records, we included only species supported by voucher specimens or reported in peer-reviewed inventories and (ii) from online databases, we excluded species lacking verifiable records, confirmed misidentifications, or taxa with distributions far from the Department of Caldas, and those that could be misidentifications of other species from the same genera. We excluded the species *Pristimantis bellona* (Lynch, 1992), *P. leptolophus* (Lynch, 1980), and *P. orpacobates* (Lynch, Ruiz-Carranza, & Ardila-Robayo, 1994), as their identification requires confirmation, as well as *Allobates brunneus* (Cope, 1887) MLS-ran 436, 560, *Colostethus latinasus* (Cope, 1863) MLS-ran 391, *Leptodactylus mystaceus* (Spix, 1824) MLS-ran 1261, 1354-55, *Pristimantis conspicillatus* (Günther, 1858) MLS-ran 821, *P. cruentus* (Peters, 1873) MLS-ran 361, 366, 371, 373, *P. latidiscus* (Boulenger, 1898) MLS-ran 398, and *P. supernatis* (Lynch, 1979) MLS-ran 318-19, 322-23, 365, 372, 424, 553, 786, 2090 because their distribution is far from the Department of Caldas and there could be a misidentification of related species of the same genera.

All the documented species were contrasted with the threatened category according to the **IUCN** (2025) and Resolution No. 0126 of 2024 (**Ministerio de Ambiente y Desarrollo Sostenible - MADS**, 2024) that listed threatened biodiversity of Colombia as follows: Critically Endangered (CR), Endangered (EN), and Vulnerable (VU). We also included taxa listed as Data Deficient (DD) and listed species whose type locality is within the limits of the Department of Caldas, e.g., *Allobates niputidea* (**Grant *et al.***, 2007) and *Pristimantis carylae* (**Rivera-Correa *et al.*,** 2021).

Taxonomic considerations and species identification

We followed **Frost** (2024) for general taxonomy and nomenclature, including specific taxonomic arrangements at the supra-specific level for some families, such as Aromobatidae (**Grant *et al.***, 2006) and Caeciliidae (**Pyron & Wiens**, 2011). The list also included the exotic but naturalized and ecologically established common bullfrog, *Aquarana catesbeiana* (Shaw, 1802). In addition, we included three undescribed species that have been suggested as new in the literature: (i) *Atelopus* sp. (MHN-UCa-Am 04-05), an unnamed and possibly extinct species (**Rueda-Almonacid**, 2004) recently synonymized with *A. sonsonensis* Vélez-Rodriguez & Ruiz-Carranza, 1997 (**Velázquez-Trujillo *et al.***, 2024) based on limited morphological comparisons, for which we retained the species

herein as *Atelopus* sp. pending additional analyses; (ii) *Pristimantis* sp. (MHN-UCa-Am 1738), and (iii) *Niceforonia* sp. (MHN-UCa-Am 769), which have been morphologically revised but do not match any described species (**Rojas-Morales & Marín-Martínez**, 2019). Furthermore, we updated the identity of *Rhinella* sp., available in a previously published dataset (**Ramírez-Chaves *et al.***, 2022) to *R. kumanday* Caicedo-Martínez, Henao-Osorio, Arias-Monsalve, Rojas-Morales, Ossa-López, Rivera-Páez, & Ramírez-Chaves, 2024 following its recent description (**Caicedo-Martínez *et al.***, 2024), and the record of *Nymphargus griffithsi* (**Goin**, 1961) to *N. pijao* Montilla, Arcila-Pérez, Toro-Gómez, Vargas-Salinas & Rada, 2023 (**Montilla *et al.***, 2023).

Distributional gaps, temporal trends, and collection representativeness of amphibians in Caldas

To assess distributional gaps within Caldas, we conducted a second search using the complete amphibian dataset available from the **Global Biodiversity Information Facility – GBIF** (2024). The GBIF dataset was used solely to analyze the spatial and temporal distribution of amphibian sampling in the department, regardless of species. For records lacking coordinates, we georeferenced localities using tools such as Google Earth. When precise locations were unavailable, we approximated coordinates to the municipality's urban centroids. We carefully reviewed the occurrence database to remove duplicate entries derived from tissue samples and preserved specimens. Using this dataset, we mapped amphibian records across Caldas' municipalities, political regions, and ecoregions to identify areas of high and low representativeness. To illustrate this, we used a Kernel Density Estimation in the QGIS 3.34.6 software (**QGIS Development Team**, 2024). This spatial information is crucial for prioritizing future research efforts. The initial dataset comprised 6,233 records, including preserved specimens and human observations, which were retained to capture overall survey coverage regardless of taxonomic accuracy. We excluded records without precise locality or municipality information (e.g., only labeled "Caldas") and records from the former Gran Caldas Department, which included today's departments of Quindío and Risaralda. Additionally, we updated records for localities that have since been designated as municipalities (Norcasia) to reflect current administrative boundaries. We also corrected discrepancies where recorded municipality or locality names conflicted with coordinates (likely due to GPS errors) by adjusting coordinates to match the collector or observer's reported locality. After this cleaning process, the final dataset comprised 5,587 amphibian records for Caldas (**Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284).

To investigate temporal trends in amphibian collection records in Caldas, we analyzed sampling effort variations over the past decades. Specifically, we used the year of collection or human observation to identify periods of increased field activity, whether through specimen collection or research projects involving field records. Additionally, we examined the distribution of preserved specimens across national and international scientific collections to evaluate the representativeness of Caldas's amphibian fauna in biological repositories.

Results

Based on our search for amphibian records in Caldas, we compiled information on 135 species belonging to 48 genera, 18 families, and three orders (Anura, Caudata, and Gymnophiona) (**Table 1**, **S2,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5285). Most species reported for Caldas are represented by specimens housed at the MHN-UCa-Am collection, with 106 species. Combining these specimens with data from the literature review, we documented the presence of 133 species (including six with type locality within Caldas that lack specimens housed at the MHN-UCa-Am collection) (**Table 2**). Two additional species, *Ctenophryne aterrima* (Günther, 1901) and *Elachistocleis panamensis* (Dunn, Trapido & Evans, 1948), are not included in the literature reviewed but are supported, to the best of our knowledge, by a single

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Table 1. Taxonomic representation of amphibians distributed in the Department of Caldas and the number of species restricted to both the department and Colombia

Order/Family	Genera	Species	Species restricted to Colombia	Species restricted to Caldas
Anura				
Aromobatidae	2	3	3	
Bufonidae	4	9	5	
Centrolenidae	7	20	9	1
Craugastoridae	1	2	1	
Dendrobatidae	5	9	8	1
Eleutherodactylidae	1	1	1	
Hemiphractidae	3	5	3	
Hylidae	7	18	3	
Leptodactylidae	3	6		
Microhylidae	2	3		
Phyllomedusidae	1	1		
Ranidae	2	2		
Strabomantidae	3	44	36	9
Caudata				
Plethodontidae	2	4	3	
Gymnophiona				
Caeciliidae	2	4	4	
Rhinatrematidae	1	2	1	
Siphonopidae	1	1	1	
Typhlonectidae	1	1		
Total	48	135	78	11

specimen housed at the National Museum of Natural History (USNM 152145) and the Colección de Anfibios, Museo de Historia Natural de la Pontificia Universidad Javeriana (MPUJ_ANFB 7163), respectively. These specimens were not directly reviewed by us (marked with an asterisk in **Table S2,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5285, to indicate that their records require further validation). Along with these two species, the occurrence within the department of other taxa such as *Hyalinobatrachium colymbiphyllum* (**Taylor,** 1949), *Leucostethus yaguara* (**Rivero & Serna,** 1991), *Gastrotheca bufona* (**Cochran & Goin,** 1970), *Pristimantis gracilis* (**Lynch,** 1986), and *Microcaecilia pricei* (**Dunn,** 1944) requires further validation. These species were included because they have been reported in both peer-reviewed and grey literature (**Acosta-Galvis**, 2009; **Rojas-Morales *et al.***, 2014), although no verified voucher specimens are currently available. As with *C. aterrima* and *E. panamensis*, we marked these species with an asterisk in **Table S2,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5285, to indicate the need for verification.

Caudata is the least represented order in Caldas, with only four known species: *Bolitoglossa lozanoi* (Acosta-Galvis & Restrepo, 2001)*, B. ramosi* (Brame & Wake, 1972), *B. vallecula* (Brame & Wake, 1963), and *Oedipina complex* (Dunn, 1924), followed by Gymnophiona with seven species. In contrast, Anura concentrates the highest diversity, comprising 41 genera and 122 species, highlighting Strabomantidae with 44 species, of

Table 2. List of amphibian species with type locality within the Department of Caldas, Colombia

Species	Locality	Municipality	Year of description	Elevation	Reference
Diasporus anthrax	Norcasia, Río la Miel II	Norcasia	2001	700	**Lynch** (2001)
Pristimantis actinolaimus	El Estadero, Florencia, Samaná	Samaná	1998	2000	**Lynch & Rueda-Almonacid** (1998a)
Pristimantis carylae	Montebello, Pensilvania, PNN SF	Pensilvania	2021	2390	**Rivera-Correa *et al.*** (2021)
Pristimantis factiosus	El Estadero, Florencia, Samaná	Samaná	1998	2000	**Lynch & Rueda-Almonacid** (1998a)
Pristimantis fetosus	Puerto Suárez, Pensilvania	Pensilvania	1998	2150	**Lynch & Rueda-Almonacid** (1998a)
Pristimantis lemur	El Estadero, Florencia, Samaná	Samaná	1998	1850-1950	**Lynch & Rueda-Almonacid** (1998b)
Pristimantis lichenoides	Puerto Suarez, Pensilvania	Pensilvania	1997	2150	**Lynch & Rueda-Almonacid** (1997)
Pristimantis penelopus	Samaná	Samaná	1999	1375	**Lynch & Rueda-Almonacid** (1999)
Pristimantis stictus	El Vergel, Marulanda	Marulanda	2016	3700	**Gonzáles-Durán** (2016)
Pristimantis suetus	El Estadero, Florencia, Samaná	Samaná	1998	1850-1950	**Lynch & Rueda-Almonacid** (1998b)
Pristimantis torrenticola	El Estadero, Florencia, Samaná	Samaná	1998	1800-2000	**Lynch & Rueda-Almonacid** (1998a)
Pristimantis tribulosus	El Estadero, Florencia, Samaná	Samaná	1997	1950	**Lynch & Rueda-Almonacid** (1997)
Pristimantis uranobates	Hotel Termales, Villamaría	Villamaría	1991	3350-3370	**Lynch** (1991)
Pristimantis veletis	Puerto Suárez, Pensilvania	Pensilvania	1997	2000-2150	**Lynch & Rueda-Almonacid** (1997)
Rhinella kumanday	Torre IV, Manizales	Manizales	2024	2730	**Caicedo-Martínez *et al.*** (2024)
Nymphargus rosada	La Cristalina, Samaná	Samaná	1997	1430-1500	**Ruiz-Carranza & Lynch** (1997)
Nymphargus spilotus	Rancho Quemado, Florencia, Samaná	Samaná	1997	1940	**Ruiz-Carranza & Lynch** (1997)
Allobates niputidea	Riomanso, Norcasia	Norcasia	2007	280	**Grant *et al.*** (2007)
Andinobates daleswansoni	El Estadero, Florencia, Samaná	Samaná	2006	1950	**Rueda-Almonacid *et al.*** (2006)
Gastrotheca nicefori	Pensilvania	Pensilvania	1933	1850-2150	**Gaige** (1933)
Bolitoglossa lozanoi	Vereda Corinto, Victoria	Victoria	2001	500	**Acosta-Galvis & Restrepo** (2001)
Caecilia caribea	Pensilvania*	Pensilvania	1942	NA	**Dunn** (1942)

*"Pensilvania [on the Río Samaná Sur, a tributary of the Río Magdalena] (Cauca valley south of Medellin), [Caldas,] Colombia"

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which 36 are restricted to Colombia and nine to Caldas (**Table 1**). Other notable families include Centrolenidae with 20 species (nine of which are restricted to Colombia and one to Caldas), Hylidae with 18 species (three restricted to Colombia), and Bufonidae with nine species (five restricted to Colombia). Overall, 78 species are restricted to Colombia, and 11 are only known from Caldas. According to the **IUCN** (2025) Red List classifications, two species are listed as Data Deficient (DD): *Caecilia caribea* (Dunn, 1942) and *Pristimantis cabrerai* (Cochran & Goin, 1970). In total, 38 species are listed under a threatened category: seven as Critically Endangered (CR), 13 as Endangered (EN), and 18 as Vulnerable (VU) (**Table S2,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5285). Moreover, categories provided by the Colombian MADS are the same as those from the IUCN, except for *Centrolene buckleyi* (Boulenger, 1882) (VU *sensu* IUCN, not assessed by the MADS).

Distribution of amphibian richness across Caldas' political units

Based on our dataset of voucher-supported species records and specialized literature, Caldas' amphibian species have been documented in 26 municipalities (**Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). The municipality with the highest amphibian richness is Samaná with 87 species. Other municipalities with significant but less species richness include Norcasia (52 species), Pensilvania (49), Manizales (39), Victoria (38), and La Dorada (36) (**Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). The municipality of Marquetalia exhibits a single voucher of *Pristimantis taeniatus* (Boulenger, 1912; MHN-UCa-Am 1154). Riosucio (two species: *Pristimantis ptochus* (Lynch, 1998), and *P. uranobates* (Lynch, 1991)), San José, and Risaralda (three species each), and Filadelfia, Supía, and Viterbo (four species each) (**Table S2,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5285). No species were recorded for La Merced. The type locality of 22 species is within Caldas' borders (**Table 2**). The municipality of Samaná stands out with the highest number of type localities for 10 valid described species, followed by Pensilvania with six, Norcasia with two, and Manizales, Marulanda, Victoria, and Villamaria with one species each. A summary of the species richness and records is presented in **Table 3**.

Distributional gaps, temporal trends, and collection representativeness of amphibians in Caldas

We obtained a final dataset of 5,587 records (human observations and collected specimens) from 26 of the 27 municipalities, the six political regions, and the six ecoregions that lay within the Department of Caldas (**Figures 1-2**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). The density of the records was heterogeneous along the units evaluated (**Table 3**). Samaná was the municipality with the highest number, with 1,311, followed by Norcasia, Manizales, Pensilvania, and La Dorada, with 910, 633, 621, and 559 records, respectively (**Figure 1**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). These five municipalities accounted for 72.2% of the total records for Caldas (**Table 3**). In contrast, La Merced was the only municipality without records, as no preserved specimens or human observations were reported. The records available on **GBIF** (2024) for this municipality correspond to Pácora, according to the locality provided. Four municipalities had fewer than ten records each (Marquetalia, Risaralda, San José, and Supía), while another four had fewer than 50 amphibian records (Viterbo, Chinchiná, Riosucio, and Marmato) (**Figure 1**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284; **Table 3**). Together, all these municipalities accounted for 1.6% of the total records. Moreover, the relationship between the number of records and the extension of each municipality was low, with less than one individual recorded per square km for most of the municipalities assessed (**Table 3**); thus, even for the most surveyed municipalities of the department there are few records regarding their area of extension (e.g., Norcasia with 4.31 records/km^2; Pensilvania with 1.17 records/km^2) suggesting that there are still large areas with knowledge gaps even in

Table 3. Data of amphibians related to the municipalities of the department of Caldas. S: Species richness recorded for each municipality. N: Number of amphibian records for each municipality. %N: Percentage of records from each municipality. Record density: Relation between the number of records and the extension of each municipality as records/Km^2

Municipality	S	N	%N	Record density
Aguadas	14	115	2.06	0.24
Anserma	7	27	0.48	0.13
Aranzazu	8	43	0.77	0.25
Belalcázar	10	62	1.11	0.59
Chinchiná	7	15	0.27	0.13
Filadelfia	4	31	0.55	0.16
La Dorada	36	559	10.01	0.97
La Merced	0	0	0.00	0.00
Manizales	39	633	11.33	1.11
Manzanares	9	36	0.64	0.17
Marmato	5	22	0.39	0.54
Marquetalia	1	2	0.04	0.02
Marulanda	17	34	0.61	0.09
Neira	25	232	4.15	0.66
Norcasia	52	910	16.29	4.31
Pácora	6	45	0.81	0.19
Palestina	12	26	0.47	0.22
Pensilvania	49	621	11.12	1.17
Riosucio	2	18	0.32	0.04
Risaralda	3	6	0.11	0.06
Salamina	15	216	3.87	0.54
Samaná	87	1311	23.47	1.72
San José	3	7	0.13	0.13
Supía	4	8	0.14	0.07
Victoria	38	400	7.16	0.79
Villamaría	24	194	3.47	0.43
Viterbo	4	14	0.25	0.08

the best represented municipalities.

In the case of other political regions, the Magdalena Caldense region (3,180 records) has been the most surveyed, accounting for 56.9% of records (**Figure 2A**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284), followed by the South-Central and the Upper Eastern regions with more than 1,100 and 693 records, respectively (**Figure 2A**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). In the South-central region, Manizales contributed with more than half of the records (633), while in the Upper Eastern region, Pensilvania contributed with 621 records. The political regions with a lower number of records were the Northern region with 419, the Lower Western region with 116, and the Upper Western region with 79 records (**Figure 2A**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). Together, these

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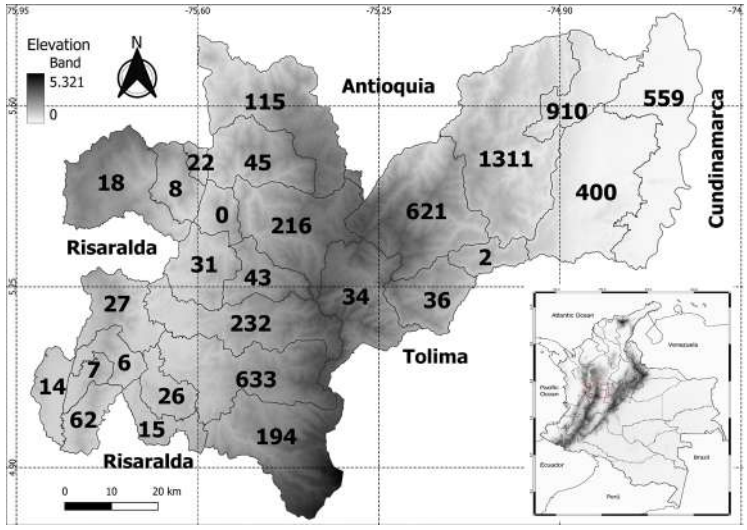

Figure 1. Amphibian records for the Department of Caldas' municipalities based on literature research, human observation, and collected specimens

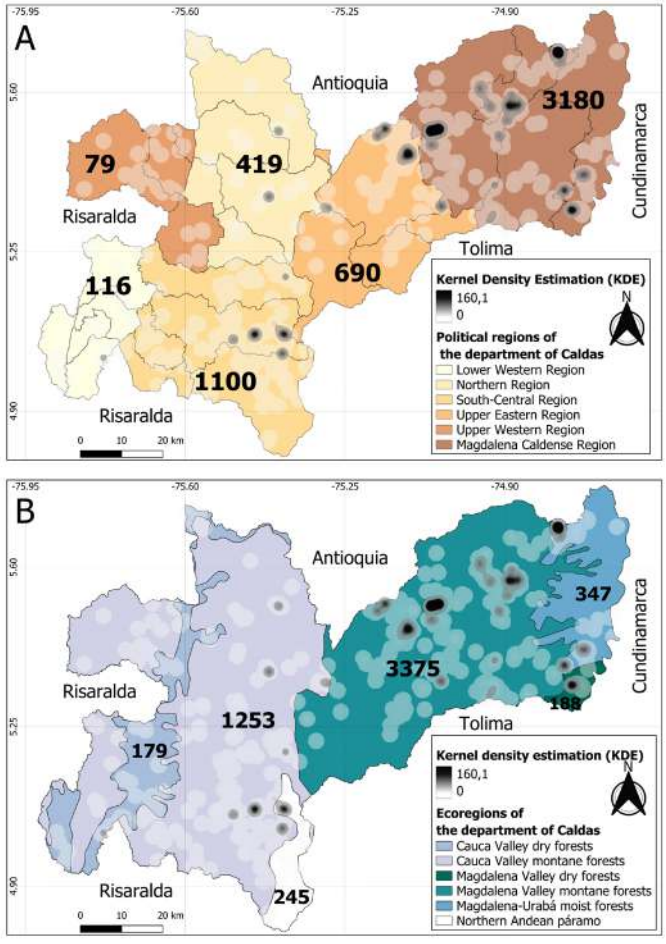

Figure 2. Kernel density estimations and number of records for amphibians in the Department of Caldas. **A.** Amphibian records for each political region of the Department of Caldas. **B.** Number of amphibian records in each ecoregion within the Department of Caldas (*sensu* **Dinerstein *et al.***, 2017)

regions contributed around 11% of the total records for the Department of Caldas. Within these three political regions, there are six of the eight municipalities with the lower number of records (Marmato, Riosucio, Risaralda, San José, Supía, and Viterbo) (**Figures 1-2A**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284).

As for the ecoregions, the Magdalena Valley Montane Forests are the most surveyed in the Department of Caldas, with 3,375 records (60.4% of total records), followed by the Cauca Valley Montane Forests with 1,253 records (22 %), accounting with 82.8% of the total records for both ecoregions in the Department of Caldas (**Figure 2B**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). The Magdalena-Urabá Moist Forests, with 347 (6.2% of the records), the Northern Andean Páramo, with 245 (4.4% of the records), the Magdalena Valley Dry Forest, with 188 (3.4%), and the Cauca Valley Dry Forest, with 179 records (3.2%), were the ecoregions with the smaller number of records (**Figure 2B**; **Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284).

Of the 5,587 amphibian occurrence records compiled, 5,221 included the year of the event (either specimen collection or human observation), while 370 lacked this information (**Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284). Among the dated records, 1994 stood out as the year with the highest number of records, with 440 preserved specimens, representing 8.3% of all the records with known dates (**Figure 3A**). In contrast, the least represented years were 1927 (the earliest known collection record, almost a century ago), 1931, 1933, 1945, 1965, and 1978, each with a single record. Most records were concentrated in the late 20th and early 21st centuries (**Figure 3A**). Years 2000 to 2009 had the highest number of records (1,908), followed by the 2010s (1,562) and the 1990s (1,103) (**Figure 3B**). Although the current decade is still ongoing, it already surpasses all decades before 1990, with more than 400 records up to 2024 (**Figure 3B**). The least documented decades were the 1920s, 1930s, and 1940s, with only one, two, and one record, respectively (**Figure 3B**).

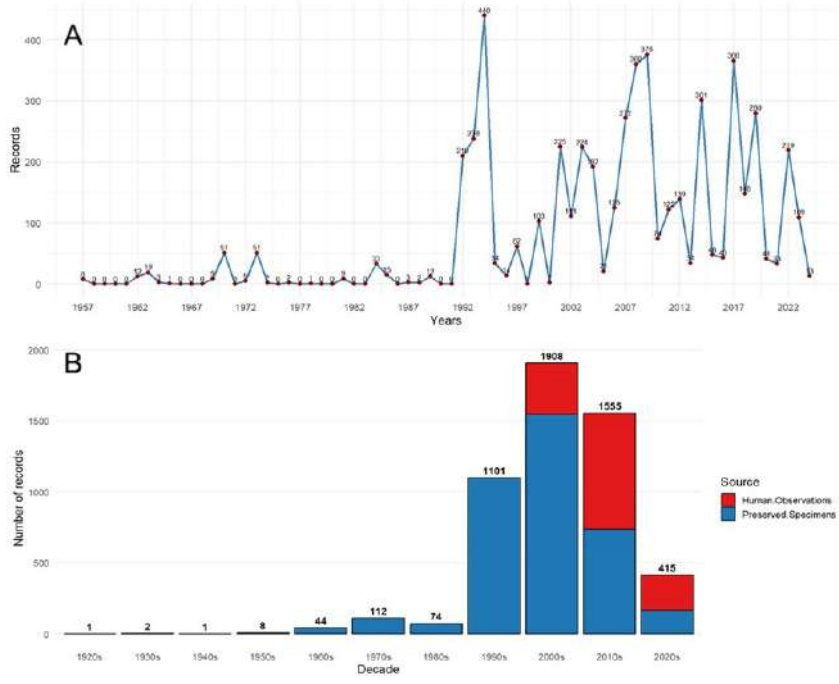

Figure 3. Amphibian records for the Department of Caldas across the years. **A.** Total of records per year since 1957. **B.** Amphibian records from human observations (in red) and preserved specimens (in blue) per decade since the first known record from 1927

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Of the 4,222 records from Caldas supported by vouchers in biological collections, 3,852 included the year of the event. The collection of specimens followed a similar temporal pattern: the 2000s had the highest number of preserved specimens (1,546), followed by the 1990s (1,103), and the 2010s (744). These specimens are distributed among various scientific collections, both international (University of Michigan Museum of Zoology, Museum of Comparative Zoology at Harvard University, University of Kansas Herpetology Collection) and national institutions. However, the vast majority (4,087 specimens, 96.8% of the total) are housed in Colombian collections. The national collections with the highest numbers of preserved specimens from Caldas (**Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284) are: (1) MHN-UCa-Am: 1,262 specimens (29.9%); (2) MPUJ_ANF: 1,011 specimens (23.9%); (3) ICN-Anf: 782 specimens (18.5%); (4) IAvH: 544 specimens (12.9%), (5) MHUA-A: 297 specimens (7.0%); (6) MLS: 125 specimens (2.9%); (7) CSJ-H: 64 specimens (1.5%), (8) UV-C: 1 specimen (0.024%), and (9) UNISARC: 1 catalogued specimen (0.024%).

Discussion

Amphibian diversity in Caldas

The amphibians in Caldas are a heterogeneous and diverse group, representing 14.95% of the country's known diversity (**Acosta-Galvis**, 2025) in an area equivalent to only 0.69% of the nation's territory (**Figure 4**). Our results confirm the high amphibian biodiversity despite Caldas' comparatively small size, as it is the fifth smallest department in Colombia.

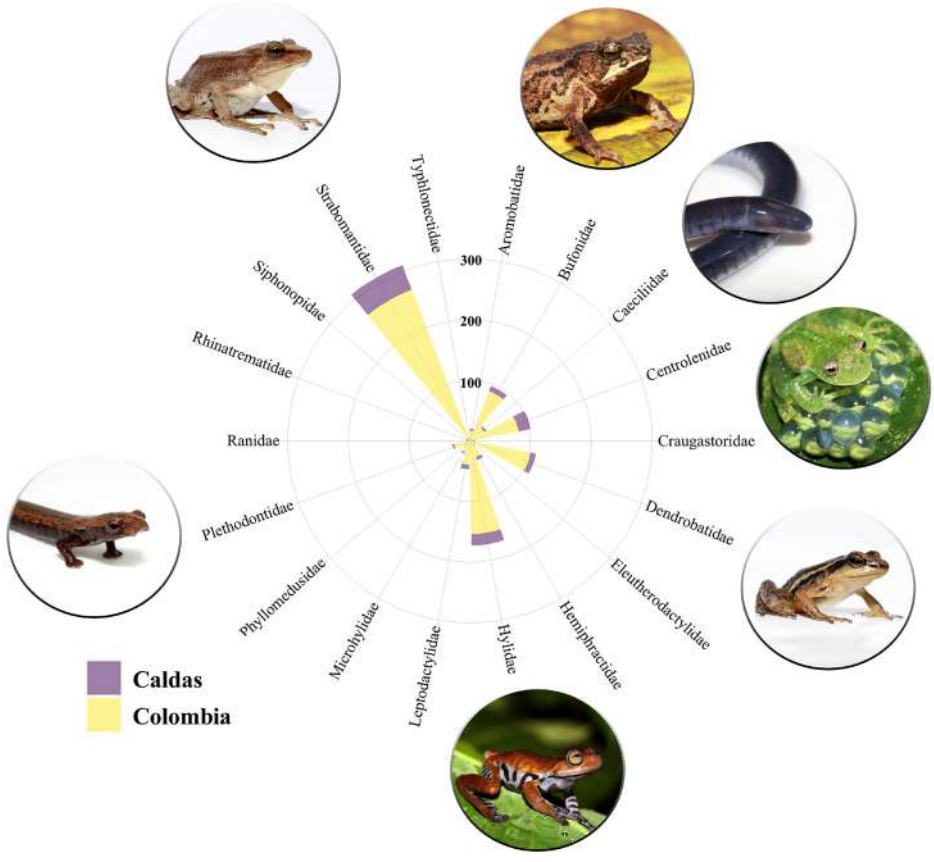

Figure 4. Number of amphibian species from families registered in the Department of Caldas expressed as a proportion of Colombia's total. Data of Colombian amphibians obtained from **Acosta-Galvis** (2025)

We documented 135 amphibian species, placing it seventh in national species richness, surpassed by Antioquia (235), Valle del Cauca (181), Amazonas (150), Chocó (155), Cauca (148), and Caquetá (140), all of which have a greater territorial extension (**Acosta-Galvis**, 2025). Caldas' richness is associated with its location within Colombia, encompassing two cordilleras (the eastern slope of the Cordillera Occidental and both slopes of the Central), two inter-Andean valleys, and the high elevation páramo ecosystems, which implies a high number of climatic conditions and, therefore, different life zones and ecoregions (**Dinnerstein *et al.***, 2017). This ecological heterogeneity promotes the settlement of a high diversity of amphibians, ranging from the warmer lowlands to the montane forests and high-elevation grasslands, in both the Central and Occidental cordilleras of Caldas (**Lynch *et al.***, 1997; **Lynch & Rueda-Almonacid**, 1999).

During the almost 100 years elapsed since the collection of the first specimens in the Department of Caldas (to the best of our knowledge MLS-ran: 479 collected in 1927) and the 91 years since the first amphibian species was described for Caldas (*Gastrotheca nicefori* Gaige, 1933), several studies have contributed to the consolidation of the current amphibian list (**Lynch**, 1991; **Lynch & Rueda-Almonacid**, 1997, 1998a, 1998b, 1999; **Ruiz-Carranza & Lynch**, 1997; **Rojas-Morales *et al.***, 2014; **Rivera-Correa *et al.***, 2021; **Caicedo-Martínez *et al.***, 2024). The increasing knowledge of Caldas' amphibians in the last 30 years, when specimens' collection and field observation has peaked, is the result of a combination of scientific field exploration, the use and curatorial process of biological collections, and the analysis of biodiversity in taxonomic, ecological, behavioral, and, recently, molecular and biogeography aspects (**Lynch & Rueda-Almonacid**, 1997; **Ramírez-Chaves *et al.***, 2023; **Caicedo-Martínez *et al.***, 2024). Caldas' eastern region has been historically a key site for species descriptions (e.g., *Gastrotheca nicefori* and *Caecilia caribea*). The region has been relevant for the development of herpetological research in Caldas, particularly due to the seminal work conducted in the late 1990s by José Vicente Rueda-Almonacid and John D. Lynch. In the 1990s, several descriptions of rain frogs (genus *Pristimantis*) and glass frogs (Centrolenidae) in the eastern flank of Caldas led to the identification of one of the most amphibian-rich areas in Colombia and the world: the Selva de Florencia National Natural Park (**Lynch & Rueda-Almonacid**, 1997; **Rueda-Almonacid**, 2000). Field surveys conducted there since the 1990s also led to the description of several Caldas-endemic species, including *Nymphargus spilotus* (**Ruiz-Carranza & Lynch**, 1997), *Pristimantis actinolaimus*, *P. fetosus, P. lichenoides, P. torrenticola, P. tribulosus*, and *P. veletis* (**Lynch & Rueda-Almonacid**, 1997, 1998a), and other Colombia-endemic species such as *Nymphargus rosada* (**Ruiz-Carranza & Lynch**, 1997), *Pristimantis factiosus, P. lemur*, *P. penelopus*, and *P. suetus* (**Lynch & Rueda-Almonacid**, 1998b, 1999). Subsequent discoveries, including *Andinobates daleswansoni* (**Rueda-Almonacid *et al.*,** 2006) and the recently described *Pristimantis carylae* (**Rivera-Correa *et al.***, 2021), both endemic to Caldas (**Figure S2,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5287), underscore the importance of this protected area as a zone of high diversity and endemism. Nineteen of the 22 amphibian species described with type localities in Caldas originate from this eastern region. Of these, 16 are found exclusively within the municipalities of Pensilvania and Samaná. Moreover, the descriptions of *Allobates niputidea* from Norcasia, *Bolitoglossa lozanoi* (**Acosta-Galvis & Restrepo**, 2001) from Victoria, and *Pristimantis stictus* (**González-Durán**, 2016) from Marulanda further highlight the significance of the eastern region in terms of amphibian endemism and species discovery.

Regarding the documentation of Caldas' amphibians at the territorial level, the first compiling study documented 108 species and mentioned nine more unidentified (**Acosta-Galvis**, 2009). This number increased to 133 species recently (**Ramírez-Chaves *et al.***, 2022), particularly due to new geographic records and, to a lesser extent, the description of new species (**González-Durán**, 2016; **Rojas-Morales & Marín-Martínez**, 2019; **Ramírez-Chaves *et al.***, 2022, 2023; **Caicedo-Martínez *et al.***, 2024). Our study updates

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the list of amphibians provided for Caldas (135 *vs*. 133 species in **Ramírez-Chaves *et al.***, 2023) by including new records of species (**Table S1,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5284) and the taxonomic status of previously unnamed taxa (*Rhinella kumanday*; **Caicedo-Martínez *et al.***, 2024) (**Figure 5**). However, several information gaps remain. For example, two species included in this updated checklist are supported by specimens housed in collections we did not directly examine (e.g., MPUJ), but one of them was reported by **Acosta-Galvis** (2009), who indicated that these identifications were validated through direct examination of specimens (including MPUJ

Figure 5. Some species reported in Caldas. **A.** *Rhinella kumanday*. **B.** *Andinobates daleswansoni.* **C.** *Andinobates bombetes.* **D.** *Niceforonia latens.* **E.** *Pristimantis simoterus.* **F.** *Pristimantis uranobates*

that we did not review). We are aware that a limitation of our study is that 23 species were not directly verified by us, and there may be errors or outdated taxonomic classifications in the sources consulted. Such inaccuracies can only be identified and corrected through a detailed review of the specimens upon which the records are based, a circumstance which may persist even when they appear geographically plausible or are already cited in the scientific literature.

Distributional gaps, temporal trends, and collection representativeness of Caldas' amphibians

Despite Caldas' high amphibian diversity (**Figure 5**), large areas of the department remain poorly surveyed. Our research indicates that extensive portions of the department's Cordillera Central, as well as the cloud forests in the Cordillera Occidental, have yet to be studied, and likely harbor undescribed species or relictual populations of threatened and endemic species, for example, *Atelopus quimbaya* **Ruiz-Carranza & Osorno-Muñoz**, 1994, and *Atopophrynus sintomopus* **Lynch & Ruiz-Carranza**, 1982. Our assessment of the different units of the Department of Caldas (political units and ecoregions) suggested that the western zone (upper and lower western political regions and the Cauca Valley Dry and Montane Forest ecoregions on the eastern slope of Cordillera Occidental) would be a survey priority area to fill the distribution and knowledge gaps in amphibian diversity. The headwaters of the Arma, Guarinó, and Samaná rivers and their tributaries are also priority areas for future field studies. Similarly, the upper-western and lower-western political regions, along with the Cauca Valley Dry Montane Forests, are significantly underrepresented in amphibian records. These regions are only minimally documented, with a few records from municipalities such as Filadelfia, La Merced, Marmato, Risaralda, Riosucio, San José, and Viterbo. The low sampling in key ecoregions, particularly the Cauca Valley Dry Forest, may be attributed to ongoing habitat fragmentation caused by agricultural expansion and other economic activities along the lowlands of the Cauca River. This pattern of degradation is consistent with broader threats to dry forests across Colombia (**Correa-García *et al.***, 2018). Recent studies reporting new records for common species at the national level underscore the region's priority research needs (**Arias-Monsalve *et al.***, 2023). Expanding research in these understudied areas could significantly enhance our understanding of amphibian diversity in Caldas and support the development of conservation programs targeting key ecoregions and political units where threatened species may occur. Achieving this, however, will require new and comprehensive field surveys focused on these priority areas.

The high amount of records for the eastern part of the Department of Caldas (municipalities of La Dorada, Victoria, Norcasia, Pensilvania, and Samaná), composed by the Magdalena Caldense and the Upper Eastern political regions, the Magdalena Valley Montane and Dry Forests, and the Magdalena-Urabá Moist Forest ecoregions, are explained by the continuous monitoring of the amphibian fauna in compensation for enterprises' economic activities and the efforts of scientists to document the diversity in this zone within protected areas and remnant forests (**Rueda-Almonacid**, 2000; **Acosta-Galvis *et al.***, 2006; **Burbano-Yandi *et al.***, 2016; **Duarte-Marín *et al.***, 2018). A similar case is that of the portion of the Cauca Valley montane forests that lie on the western slope of the Cordillera Central in the south-center region of Caldas, where research efforts and the presence of small protected areas have helped to document the amphibian diversity (**Rojas-Morales *et al.***, 2011, 2014; **Rojas-Morales & Marín-Martínez**, 2019; **Arias-Monsalve *et al.***, 2023). This explains the increasing number of records, both from human observation and preserved specimens, since the 1990s. It is important to note that the increasing number of records from human observation since the beginning of this century is also explained by a higher interest from local people and students to report the diversity of their towns and rural areas, along with the development of digital tools such as iNaturalist to document it.

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We recommend exploring areas within Caldas with significant information gaps and reviewing specimens in biological collections that require taxonomic clarification. For example, the *Epicrionops* record (ICN-Anf 41234; **Lynch**, 1999) and other anuran species (*Niceforonia* sp., *Pristimantis* sp.) listed at the genus level need taxonomic confirmation or formal description (**Table S3,** https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5286). The *Epicrionops* specimen is particularly crucial for reassessing the presence of caecilians in the department, as they remain largely undocumented. A detailed revision using molecular and morphological analyses could clarify its taxonomic status and the distribution patterns of this group in the region.

Given the increasing anthropogenic pressures in some regions of Caldas, particularly the Cauca and Magdalena valleys' Dry Forests, future research should prioritize amphibian populations in these areas. Assessing the impact of habitat fragmentation, agricultural expansion, and deforestation on amphibian diversity is essential to developing conservation actions tailored to the department's ecological dynamics. Conservation initiatives should focus on strengthening protected areas and establishing biological corridors to connect fragmented habitats, ensuring long-term amphibian population persistence. Our findings also highlight the need for continuous taxonomic updates and monitoring to track population trends and potential declines. Recent discoveries of new species and records suggest that Caldas's amphibian diversity remains underestimated. Systematic surveys and long-term monitoring programs, especially in unexplored or under-sampled regions such as páramos that exhibit critical shortfalls in taxonomy, spatial information, and conservation actions (**Saboyá Acosta & Urbina-Cardona,** 2023), should be encouraged to refine our understanding of this biodiversity.

Author contributions

Authors contributed equally to the conceptualization, data curation, formal analysis, and manuscript writing, revision, and editing, as well as to funding acquisition.

Conflicts of interest

The authors declare no personal, financial, or institutional conflicts of interest.

Acknowledgments

We thank the Alcaldía de Manizales, Corpocaldas, and the Universidad de Caldas, who sponsored this study (interadministrative agreement 2110200953), and the curators of the following collections reviewed: MLS, Julieth Stella Cardenas Hincapie; UNISARC: Vanessa Serna; IAvH-Am: Sandra Galeano; ICN: Mauricio Rivera; ITM: Danny Zurc and Esteban Garzón Franco, and Gustavo González for helping with some identifications. We also want to thank the Mohamed Bin Zayed Fund (projects No. 222529372 and 230530964) for supporting our field work activities in the Andes of Colombia; the Central Hidroeléctrica de Caldas S.A. E.S.P. (CHEC) for the support provided in gathering information on the species present in their conservation areas in Caldas, and to Sebastián Cortés Gallo for providing photographs of a *Caecilia* specimen from Caldas.

Supplementary material

See the supplementary material in https://www.raccefyn.co/index.php/raccefyn/article/view/3185/5287

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