



Annotated checklist of the amphibians and reptiles of the Santander highland, Colombia

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Abstract

We characterize the amphibian and reptile fauna from four habitats of the Andean region of the department of Santander, Colombia. Eight species were recorded, including four amphibians and four reptiles. The family Hylidae was represented by two species and had the greatest abundance of individuals at 241. Among reptiles, the family with the greatest diversity was the Colubridae, with two species, but the Dactyloidae had the greatest abundance, with seven individuals. The grassland habitat exhibited the greatest diversity, with five species found, and it was the habitat with the greatest abundance of individuals, with 242 individuals obtained. The habitat with the least diversity and abundance was cropland, which had no species recorded.

Keywords

Andean region, ecological aspect, fragmented habitat, herpetofauna, species distribution, taxonomic diversity.

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Introduction

The Andean forests are one of the most important vegetation formations in Colombia due to the ecosystem services they provide. However, they are also among the most threatened ecosystem, due to their changes in land use to productive systems mainly agriculture and livestock (Etter et al. 2006). Endemic species are numerous, and some of their populations are naturally small and fragile due to fragmentation and habitat loss, which has been mainly caused by the development of livestock and agriculture production (Rangel-C. 1997). The fragmentation of these forests affects biodiversity, both positively and negatively; it decreases vegetation cover of the

forest, changes species diversity, population densities, and impacts ecosystem functionality (Rangel-C. 2000).

The herpetofauna of the Colombian Andes is influenced by changes in their habitats and the physiological requirements of species, including thermoregulation characteristics of reptiles (Pough et al. 2001). There have been many investigations on Andean amphibians and reptiles on these topics (Méndez-Narváez 2014). Twenty-one species of amphibians (Ardila-Robayo and Acosta-Galvis 2000; Lynch and Suárez-Mayorga 2002) and 10 species of reptiles (Castaño-Mora et al. 2000) have been reported from the Cordillera Oriental of Colombia.

From the Bogotá savannah, Lynch and Rengifo (2001) and Ariza et al. (2010) recorded 13 amphibian and eight reptile species; Medina-Rangel and López-Perilla (2014) recorded seven species of anuran and three reptile species. However, in large areas of the Cordillera Oriental, mainly the departments of Boyacá and Cundinamarca, there is a lack of studies on the composition, structure, and effects of habitat transformation on the herpetofauna.

As inventories provide basic data, which are useful for decision-making, our goal is to provide an annotated list of the herpetofauna in the Santander highland, north of the Cordillera Oriental, Colombia.

Methods

Study area. The study area, at 2600–2800 m above sea level, was north of the Cordillera Oriental, near the municipality of Sucre, in the department of Santander (Fig. 1). The study area is composed of a mosaic of natural, semi-natural, and anthropogenic elements. The regional climate is bimodal-tetraseasonal, with an average rainfall of 2000–2114 mm (Rangel-C. 1997), and an average temperature of 16–17 °C. The terrain is rough, with steep slopes that exceed 50%. The dominant topography in the study area are grasslands, which are dedicated to cattle grazing. There are also patches of forests, from passive regeneration that has occurred over the last 25 years. Perennial crops, mainly blackberry (*Morus nigra* L.), are also cultivated.

Research and sampling design. We chose four habitats for our study:

1. Large forest fragment (05°51'56"N, 073°54'37"W and 05°51'50"N, 073°54'38"W). This area exceeds 100 ha (Fig. 2A), with a high floristic diversity and complex vegetative structure. Trees exceed 15 m in height, and the canopy is closed. Herbaceous groundcover extends over 20% of the area, shrubs covers 30%, and trees cover 40%. The soil has an uppermost leaf-litter layer, with

80% coverage. The average grass height is 10 cm. Species of Melastomataceae and Clusiaceae are dominant, followed by Myrtaceae, Piperaceae, Rubiaceae, Sapindaceae, and Sapotaceae.

2. Small forest fragment (05°51'41"N, 073°54'19"W and 05°51'46"N, 073°54'12"W). This is a linear fragment of forest less than 20 ha, which extends along a creek. The canopy is semi-open (Fig. 2B); groundcover covers 80% of the area, shrubs cover 20%, underbrush covers 40%, and trees cover 30%. Leaf litter covers 30% of the ground, and the average grass height is 5 cm. Dominant families are Adoxaceae, Aquifoliaceae, Aquifoliaceae, Araliaceae, Gesneriaceae, Melastomataceae, Myrtaceae, Clusiaceae, Piperaceae, Rubiaceae, Sapindaceae, and Sapotaceae.

3. Grassland (05°52'20"N, 073°54'39"W and 05°52'27"N, 073°54'10"W) represent the most extensive habitat in the study area (Fig. 2C). Herbaceous groundcover exceeds 90%, with a median height of 10 cm. Isolated trees cover less than 10% of the area.

4. Perennial cropland (05°52'01"N, 073°54'37"W and 05°52'06"N, 073°54'33"W) is represented in the study area by blackberry crops with large expanses of open areas (Fig. 2D). There is no stratification, and the ground is completely bare due to the constant erosion of the soil.

In each of these four habitats, two plots were set out. Each plot was a 100 × 50 m rectangle. Random routes, each 100 m long, were made at each plot, using visual encounter surveys (Crump and Scott 1994; Angulo et al. 2006). Each route visit lasted 160 hours. The sampling effort was 120 hours per person for each habitat (= 480 hours per person).

Between June 2017 and February 2018, surveys were carried out three times, each time during both day and night. Microhabitats were closely examined and included leaf litter, fallen tree trunks, the undersides of rocks, and branches up to 3 m above ground. For each species, several individuals were collected for identification, which

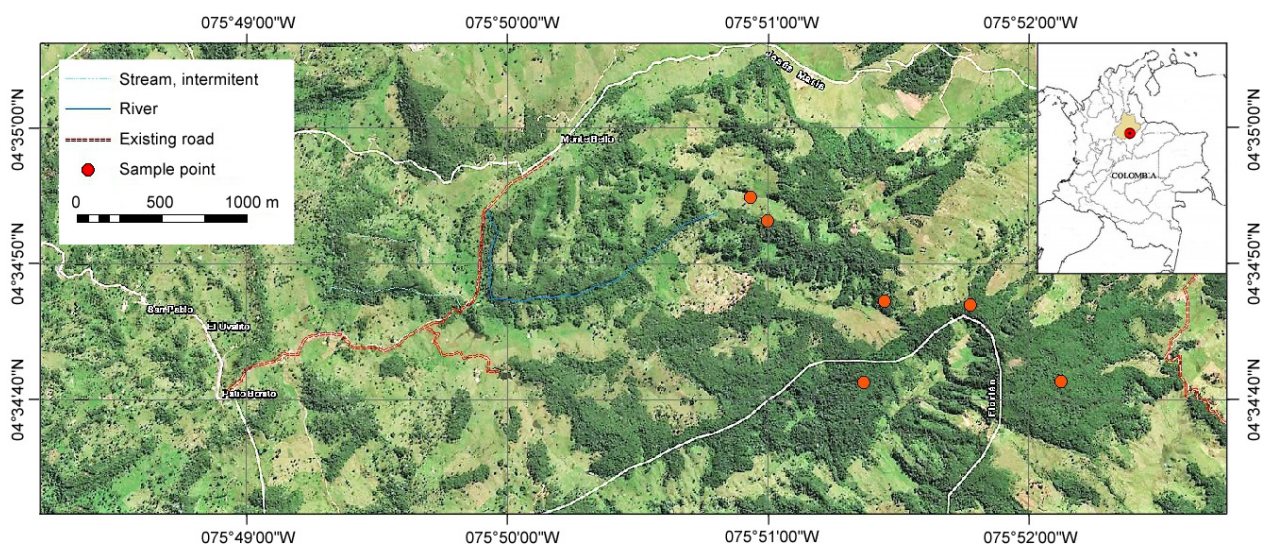


Figure 1. Study area in the municipality of Sucre, department of Santander, Colombia. The study area is north of the Cordillera Oriental at 2600–2800 m a.s.l.



Figure 2. The four habitats in the study area. **A.** Large forest fragment. **B.** Small forest fragment. **C.** Grassland. **D.** Blackberry crop.

was achieved using taxonomic keys and other literature (Sánchez-Pacheco et al. 2012; Passos and Lynch 2010). Specimens were captured by hand, euthanized using a lethal dose of anesthetic, preserved in ethanol (70%), and deposited in the vertebrate collection of the Museo de Historia Natural “Luis Gonzalo Andrade”, Universidad Pedagógica y Tecnológica de Colombia. Collections were made under permit number 724/2014 issued by the Autoridad Nacional de Licencias Ambientales. Some individuals were identified, photographed, and immediately released.

The number of specimens collected and the number of times each species was encountered are shown in Table 1. The number of habitats in which each species was found is characterized as wide (≥ 2 habitats) or restricted (< 2 habitats).

Matrices were built to show the composition and abundance of species. The sampling effort for each taxonomic group in the study area was plotted and alpha diversity was calculated from non-parametric estimators using the Jack 1 Mean, which estimates the richness of individuals in heterogeneous habitats, and using the Bootstrap Mean index, which estimates the rich variety of species without overestimating it, as this is not influenced by rare species (Magurran 2004). These analyses were performed using the EstimateS statistical program v. 9.20 (Colwell 2018). To compare the species abundances, rank abundance graphs were made from the base logarithms for eight of the species.

Results

Eight species were recorded: four amphibians and four reptiles. The amphibians belong to two orders, three families, and four genera. The family with the greatest diversity was Hylidae, with two species. The reptiles belong in two orders, three families, and four genera, and the reptilian family with greatest diversity was Colubridae, with two species (Table 1). Grasslands supported the greatest richness with five species (Table 1). The small and large forest fragments each had two species. The most abundant amphibian species was *Dendropsophus molitor* (Schmidt, 1857), with 223 individuals, while the most abundant reptile was *Anolis nicefori* Barbour, 1932, with 10 individuals (Table 1).

Table 1. Richness and abundance of species in four high-elevation habitats in Sucre, Santander department, Cordillera Oriental, Colombia.

Species	Large forest	Small forest	Grasslands	Perennial cropland
<i>Dendropsophus molitor</i> (Schmidt, 1857)	0	0	223	0
<i>Hyloscirtus piceigularis</i> (Ruiz & Lynch, 1982)	0	18	0	0
<i>Pristimantis bogotensis</i> (Peters, 1863)	2	0	0	0
<i>Bolitoglossa adspersa</i> (Peters, 1863)	9	0	0	0
<i>Riama striata</i> (Peters, 1863)	0	0	6	0
<i>Anolis nicefori</i> Barbour, 1932	0	3	7	0
<i>Atractus marthae</i> Meneses-Pelayo & Passos, 2019	0	0	4	0
<i>Erythrolamprus epinephelus</i> (Cope, 1862)	0	0	2	0
Total	11	21	242	0

For amphibians, the sample representativeness exceeded 80%. The species accumulation shows that one or two additional species might be present, according to the Bootstrap and Jack 1 estimators (five and six species, respectively). We deemed species rare if only one or two individuals were found. Only one rare amphibian species, *Pristimantis bogotensis* (Peters, 1863), was found during the survey. For reptiles, the sample representativeness also exceeded 80%, and increased sampling effort might add a few more species. Rare species decreased as sampling increased. The rarest species, *Erythrolamprus epinephelus* (Cope, 1862), was represented by only two individuals found during the entire survey.

The rank abundance graph (Fig. 3) shows that *D. molitor* is more abundant than other species of amphibians, which can be explained by its resistance to stressors caused by anthropogenic activities (Lynch and Rengifo 2001). Conversely, snakes were rare in the study area.

Class Amphibia
Order Anura
Family Hylidae
Subfamily Dendropsophinae
Genus *Dendropsophus* Fitzinger, 1843

Dendropsophus molitor (Schmidt, 1857)

Materials examined. COLOMBIA • 5 adults ♀, 3 adults ♂; Santander, municipality of Sucre, La Pradera, La Playa; 05°52'19"N, 073°54'41"W, 2574 m a.s.l.; 25 Jun. 2017; Juan Carvajal leg.; UPTC-Am 1000 to UPTC-Am 1007 • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Casa Loma; 05°52'00"N, 073°54'36"W, 2574 m a.s.l.; 23 Jun. 2017; María Estupiñán leg.; UPTC-Am 1008 • 5 adults ♂; Santander, municipality of Sucre, La Pradera, Colegio; 05°52'05"N, 073°54'15"W, 2574 m a.s.l.; 25 Jun. 2017; Diego Pérez leg.; UPTC-Am 1009 to UPTC-Am 10091011, UPTC-Am 0971, UPTC-Am 10090973.

Identification. Our specimens were easily identified as *D. molitor* by the following: distance from nostrils to

end of the snout half the distance from end of snout to eye; eyes small, non-prominent, diameter equal to distance from eye to nostril; tympanum prominent, half the diameter of eye; and relative finger length I<II<IV<III, with fourth finger longer than second (Guarnizo et al. 2014).

Remarks. We found *Dendropsophus molitor* to have the largest populations of any amphibians in the study area. This species was locally restricted to pastures and areas near crops. The preferred microhabitat was grassy areas, near water bodies (Fig. 2C). Specimens varied widely in color, from green to yellow and with mottled tones (Fig. 4). The population in the study area is ideal for studies on thermal tolerances, intrapopulation polymorphisms, and ecology, ethology, and reproduction.

Subfamily Cophomantinae
Genus *Hyloscirtus* Peters, 1882

Hyloscirtus piceigularis (Ruiz & Lynch, 1982)

Materials examined. COLOMBIA • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Tequendama; 05°51'47"N, 073°54'40 W, 2574 m a.s.l.; 23 Jun. 2017; Diego Escamilla leg.; UPTC-Am 1012 • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Peña Bonita river; 05°51'43"N, 073°54'16"W, 2574 m a.s.l.; 20 Aug. 2017; Juan Carvajal leg.; UPTC-Am 0972.

Identification. Our specimens were easily identified as *H. piceigularis* based on: finger webbing extending to base of distal subarticular tubercle of finger IV; ulnar, tarsal and supra-anal folds with red edge, yellow bottom base, and cream top; tympanum covered by skin without modifications; and mental gland present in males (Ruiz-Carranza and Lynch 1982).

Remarks. We recorded 18 individuals, even though the population may be larger, given the auditory record and the capacity of this species for concealment. *Hyloscirtus piceigularis* was found in the small forest fragment, in a ravine (Fig. 2B) and had mossy rocks as their preferred

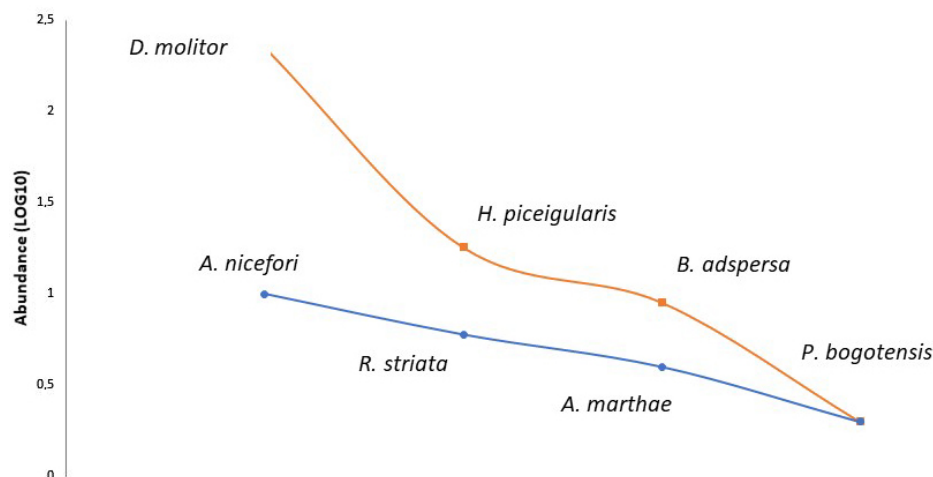


Figure 3. Behavior of the abundance of amphibian and reptile species in high-mountain habitats in the Santander highland, north of the Cordillera Oriental, Colombia.



Figure 4. Color variation of *Dendropsophus molitor*. Scale bar = 9 mm.

microhabitat (Fig. 5). Animals were active both during the day and at night. Tadpoles at various stages were found in backwaters and other lotic waterbodies during the dry season in February. The study area lies between the species' northernmost occurrence, in the municipality of Encino, and its southernmost occurrence, in the department of Cundinamarca. We extend the distribution of the species approximately 100 km, from the type locality in the municipality of Encino.

Family Craugastoridae

Subfamily Ceuthomantinae

Genus *Pristimantis* Jiménez de la Espada, 1870

***Pristimantis bogotensis* (Peters, 1863)**

Materials examined. COLOMBIA • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Fontibón; 05°

51'53" N, 073°54'37" W, 2574 m a.s.l.; 23 Jun. 2017; Diego Escamilla leg.

Identification. Our specimens were identified as *P. bogotensis* based on the characters given by Werner (1916): tympanum transparent, half the diameter of the eye; supratympanic fold distinct; toe webbing basal.

Remarks. This is a rare species; we recorded only two individuals, both from the interior of the large forest fragment (Fig. 2A). The preferred microhabitat of *P. bogotensis* was low branch, close to the ground. This species was nocturnal.

Order Caudata

Family Plethodontidae

Subfamily Hemidactyliinae

Genus *Bolitoglossa* Duméril, Bibron & Duméril, 1854

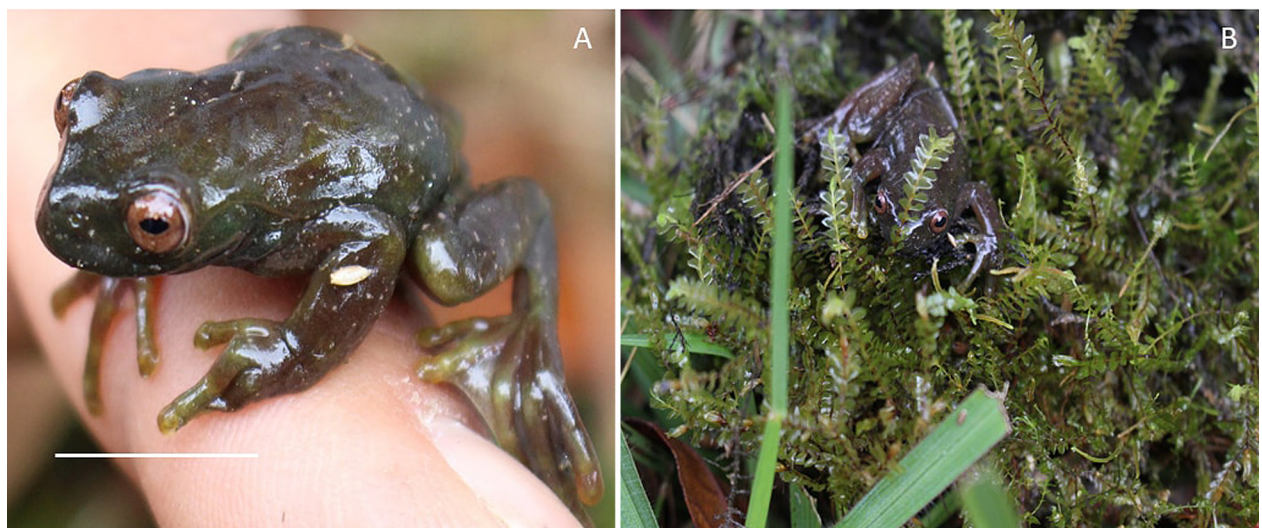


Figure 5. *Hyloscirtus piceigularis*. **A.** Male individual, scale bar = 14 mm, head length. **B.** Camouflage in moss.

***Bolitoglossa adspersa* (Peters, 1863)**

Materials examined. COLOMBIA • 4 adults ♂; Santander, municipality of Sucre, La Pradera, Fontibón; 05°51'53" N, 073°54'37" W, 2574 m a.s.l.; 23 Jun. 2017; Diego Pérez leg.; UPTC-Am 1013 to UPTC-Am 1016.

Identification. Our specimens were identified as *B. adspersa* based on size of the males and females (snout-vent length 47 mm and 54 mm, respectively), about three times the distance from tip of snout to gular fold; limbs short, not meeting when adpressed; fingers and toes very short and broad, truncate, and webbed, with the tips free; carpal or tarsal tubercles absent; and tail cylindrical, shorter than total length of the body.

Remarks. This species was restricted to the large forest fragment (Fig. 2A) and occurred in several microhabitats, but especially on leaves. One or two individuals were sighted per leaf (Fig. 6).

Class Reptilia
Order Squamata
Infraorder Iguania
Family Dactyloidae

Genus *Anolis* Daudin, 1802

***Anolis nicefori* Barbour, 1932**

Materials examined. COLOMBIA • 1 adult ♂; Santander, municipality of Sucre, La Pradera, La Playa; 05°52'19"N, 073°54'41"W, 2574 m a.s.l.; 25 Jun. 2017; María Estupiñán leg.; UPTC-R 0599 • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Peña Bonita river; 05°51'43"N, 073°54'16"W, 2574 m a.s.l.; 20 Aug. 2017; Juan Carvajal, Diego Pérez, Diego Escamilla and María Estupiñán leg.; UPTC-R 0590.

Identification. Our specimens were identified as *A. nicefori* based on: small dorsal scales, in 21–34 rows; small head plates, with interparietal scale much shorter than width of head between orbits; and subdigital lamellae 16–20 (Lazell 1969).

Remarks. This species occurred in the small forest fragment and in the grassland. Individuals were observed at night, for the first time, resting on leaves and small branches. Specimens varied in color, being various shades of green, yellow, and blue (Fig. 7). This variability in color has not been previously reported for this species.



Figure 6. *Bolitoglossa adspersa*. Scale bar (on left) = 13 mm.



Figure 7. Color variation of *Anolis nicefori*. Scale bar (on right) = 20 mm.

Infraorder Scincomorpha
 Family Gymnophthalmidae
 Subfamily Cercosaurinae
 Genus *Riama* Gray[†], 1858

***Riama striata* (Peters, 1863)**

Materials examined. COLOMBIA • 3 adults 1♂ 2♀, 3 juveniles; Santander, municipality of Sucre, La Pradera, Peña Bonita river; 05°51'43"N, 073°54'16"W, 2574 m a.s.l.; 20 Aug. 2017; Juan Carvajal leg.; UPTC-R 0589, UPTC-R 0595 to 0598, UPTC-R 0600 • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Colegio; 05°52'05"N, 073°54'15"W, 2574 m a.s.l.; 25 Jun. 2017; Diego Pérez, leg; UPTC-R 0601 • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Antenas; 05°51'20"N, 073°54'14"W, 2574 m a.s.l.; 20 Aug. 2017; Diego Escamilla and leg.

Identification. Our specimens were identified as *R. striata* based on: mental scales in three pairs; scales 32–37 around midbody; dorsal scales striated, rectangular, in 33–39 transverse rows; lateral scales in 0–3 rows; ventral scales quadrangular, in 22–25 transverse rows and 10–12 longitudinal rows (Burt and Burt 1931).

Remarks. *Riama striata* occurred in the grassland, where it was found under logs, rocks, and moss. No individuals were detected outside of this habitat, but cryptic movements may make them difficult to detect in other habitats. We noted intra-sex differences, with males white to intense yellow ventrally (Fig. 8) and varying in size as adults; females are generally smaller than males.

Superfamily Colubroidea
 Family Colubridae

Subfamily Dipsadinae
 Genus *Atractus* Wagler[†], 1828

***Atractus marthae* Meneses-Pelayo & Passos, 2019**

Materials examined. COLOMBIA • 1 adult ♂; Santander, municipality of Sucre, La Pradera, Fontibón; 05°51'53"N, 073°54'37"W, 2574 m a.s.l.; 03 Feb. 2018; María Estupiñán leg.; UPTC-R 0594 • 3 adults ♀; Santander, municipality of Sucre, La Pradera, Colegio; 05°52'05"N, 073°54'15"W, 2574 m a.s.l.; 23 Jun. 2017; Juan Carvajal leg.; UPTC-R 0591 to UPTC-R 0592, UPTC-R 0602.

Identification. *Atractus marthae* was identified by: dorsal scale rows 17/17/17, smooth; postoculars two, loreal long, temporals 1 or 2; and hemipenis moderately bilobed, with lobe size equivalent to the capitulum length, semicapitated and semicalyculated (Meneses-Pelayo and Passos 2019).

Remarks. This species occurred in the grassland habitat, where it was found under rocks (Fig. 9D). No individuals were detected in other habitats (Fig. 2C), which would make their detection difficult. We observed much variation in color intrapopulation, with the ground color blackish (Fig. 9A, B) to reddish with dark longitudinal lines (Fig. 9C). In February 2018, we observed eggs and hatchlings under a fallen tree trunk, which is the first observation of reproduction for this species.

Genus *Erythrolamprus* Wagler[†], 1830

***Erythrolamprus epinephelus* (Cope, 1862)**

Materials examined. COLOMBIA • 2 adults ♀; Santander, municipality of Sucre, La Pradera, La Playa; 05°52'19"N, 073°54'41"W 2574 m a.s.l.; 24 Jun. 2017; Diego Pérez leg.; UPTC-R 00025.



Figure 8. *Riama striata*. **A, B.** Females (scale bar in A = 12 mm). **C.** Ventral coloration of a female. **D.** Ventral coloration of a male.



Figure 9. *Atractus marthae*. **A, B.** Black phase (scale bar in B = 8 mm. **C.** Red phase. **D.** Preferred habitat under a stone in grassland.

Identification. Our specimen was identified as *E. epinephelus* based on: ventral scales 182, subcaudals 54, venter immaculate, and scale pits present.

Remarks. We found this species in the grassland habitat, where it was under rocks (Fig. 10B), near cultivated areas with evidence of the use of agrochemicals. As an escape strategy from predators, this species can flatten the body by contracting transverse muscles (Fig.10A).

Discussion

The amphibians and reptiles that we recorded in our study area follows the ecogeographic and phylogenetic pattern identified for Colombia, where elevation and corresponding temperature and relative humidity influence the occurrence of species, mainly in Hylidae and Craugastoridae for amphibians, and Colubridae, Dactyloidae, and Gymnophthalmidae for reptiles (Castaño-Mora et al. 2000; Lynch and Rengifo 2001). These families show patterns of higher richness values within assemblages, both in highlands and in lowlands, as well as in intact and transformed habitats (Lynch 1999).

Lynch and Rengifo (2001) and Vargas-Ríos and Pedraza (2003) have reported a greater number of

species in other studies in the Andean region. The transition from natural habitats to pasture and crops in the Andes may reduce species diversity, leaving only a relictual fauna, as has been documented in other high mountain (Medina-Rangel and López-Perilla 2014) and lowland regions (Carvajal-Cogollo and Urbina-Cardona 2008, 2015; Paternina-Hernández et al. 2013).

The abundance graph (Fig. 3) shows that most species, except for *Dendropsophus molitor*, were not abundant in the study area. Lüddecke (1997) this species was abundant due to its preferential habitats, wide food spectrum, and year-round reproduction (Guarnizo et al. 2014). These abundance patterns are characteristic of relictual assemblages for various taxa, such as mammals and amphibians (Bovendorp et al. 2018; Whiles et al. 2006). The shape of the curves shows us a hierarchy in the structure for amphibians, but for reptiles the assembly structure does not show a hierarchical pattern. The amphibians, show a general pattern to make use of resources in a differential manner (Magurran 1988, 2004).

This study is the first to document the ecology and natural history of the Endangered *Hyloscirtus piceigularis* (IUCN 2019) since its description by Ruiz and Lynch (1982). This species' cryptic habits and microhabitats are



Figure 10. *Erythrolamprus epinephelus* and its preferred microhabitat. Scale bar (on left) = 14 mm.

limiting factors, and habitat loss due to agriculture and livestock production is a serious threat to the survival of the species. We contribute to the ecological knowledge of *Atractus marthae*, the first since this species was described (Meneses-Pelayo and Passos 2019); oviposition occurs in the same microhabitat used by for concealment. This species exhibits intrapopulation variation in color pattern, which merits further study.

We recommend management strategies to conserve herpetofaunal habitats, including the maintenance of forest fragments and the stopping of agricultural and livestock expansion, which have proven to be effective in the the Santander highland, north of the Cordillera Oriental.

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Authors' Contributions

DAPR, DEQ, MFET, and JECC conceived the study and performed the fieldwork. DAPR and JECC wrote the text, confirmed the identification of all specimens, and analyzed the data.

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