

FIRST ASSESSMENT OF THE HERPETOFAUNA OF MUTATÁ, URABÁ SUBREGION, COLOMBIA: A POST-CONFLICT DIVERSITY STUDY

PRIMERA EVALUACIÓN DE LA HERPETOFAUNA DE MUTATÁ, SUBREGIÓN DEL URABÁ, COLOMBIA: UN ESTUDIO DE DIVERSIDAD POSCONFLICTO

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Resumen.— La subregión de Urabá en el noroeste de Colombia cuenta con una diversidad biológica excepcional, atribuible principalmente a su ubicación dentro de la ecorregión Chocó-Darién. No obstante, los esfuerzos por caracterizar esta diversidad se han visto obstaculizados por el conflicto armado colombiano, que afectó gravemente esta región. Con la firma de los acuerdos de paz en el 2016, la mejora en la seguridad incrementó la agroindustria y los asentamientos humanos, exacerbando la fragmentación de bosques. Esta mayor accesibilidad subraya la urgencia de caracterizar la composición de las comunidades para posteriormente generar políticas de conservación. Como un primer paso para lograr esa meta, nuestro estudio tuvo como objetivo identificar especies de herpetofauna en fragmentos del municipio de Mutatá, Urabá. Aquí reportamos 24 especies de anfibios y 30 de reptiles en un esfuerzo de muestreo de 345 horas-persona realizados en ese sitio. A pesar de nuestros esfuerzos, la curva de acumulación de especies indicó que es necesario realizar un esfuerzo de muestreo mayor con el fin de acercarse a la riqueza de especies real. Es imperativo generar acciones ambientales para conservar la herpetofauna de Urabá, particularmente en regiones posconflicto, ya que han experimentado cambios rápidos su uso de suelo. La rapidez con la que desarrollemos esfuerzos de conservación es crucial para mitigar una mayor pérdida de biodiversidad, especialmente en estas áreas vulnerables.

Palabras clave.— Anfibios, Chocó-Darién, conflicto armado colombiano, reptiles, curva de acumulación de especies.

Abstract.— The Urabá subregion in northwest Colombia boasts exceptional biological diversity, primarily attributable to its location within the Chocó-Darién ecoregion. However, efforts to characterize this diversity have been hindered by the Colombian armed conflict, which heavily impacted the region. With the signing of peace accords in 2016, improved security has increased agroindustry and human settlements, exacerbating forest fragmentation. This promoted accessibility underscores the urgency of characterizing the composition of the communities in order to subsequently generate conservation policies. As a first step to achieve this goal, our study aimed to identify herpetofauna species in forest fragments in the municipality of Mutatá, Urabá. Here, we report 24 amphibian and 30 reptile species across a sampling effort of 345 person-hours conducted at that site. Despite our efforts, the species accumulation curve indicated that further sampling is necessary to assess species richness more accurately. Urgent environmental action is imperative for conserving Urabá's herpetofauna, particularly in post-conflict regions experiencing rapid shifts in land use. Agility in conservation efforts is crucial to mitigate further biodiversity loss, especially in these vulnerable areas.

Keywords.— Amphibians, Chocó-Darién, Colombian armed conflict, reptiles, species accumulation curve.

INTRODUCTION

With a land area exceeding 1.14 million km² and its strategic location in the extreme northwest of South America, Colombia is considered one of the countries with the most extraordinary biodiversity. It ranks second and third in amphibian and reptile species worldwide, with 927 and 591 estimated species, respectively (Sistema de Información sobre Biodiversidad de Colombia (SiB Colombia, 2020). This biodiversity parallels the enormous variety of environments present in the country, with more than 98 major ecosystems recognized (Instituto de Estudios Ambientales (IDEAM, 2018).

The plurality of ecosystems and the biological richness that inhabits them have been significantly degraded in recent years, driven by multiple forces. The expansion of the agricultural frontier, grazing areas, and urban infrastructure have fragmented the once impressive natural cover throughout the Colombian landscape (Armenteras et al., 2017). In addition, illegal activities, such as the expansion of illegal crops, mining, and logging, add to the challenges faced by the Colombian's natural heritage (Chadid et al., 2015).

This is the case of the geographical subregion of Urabá, which is located in the megadiverse Chocó-Darién ecoregion (Myers et al., 2000; Ortiz-Yusty et al., 2015). Urabá has been severely impacted by the armed conflict, making it one of the most affected regions in Colombia over the last century. This has resulted in a lack of comprehensive studies on its biodiversity (Suárez & Herrera, 2021). Most research in Urabá and other conflict zones has centered on deforestation processes through landscape ecology analyses (Sánchez-Cuervo & Aide, 2013; Negret et al., 2019), with studies focusing on species communities -including herpetofauna- often overlooked (Ortiz-Yusty et al., 2015). The situation has gradually been reversing, especially due to the positive impact of the peace treaties signed in 2016 on research accessibility. In recent years, improvements in accessibility to these areas have allowed for an intensification of efforts to catalog their enormous diversity. Ironically, as security improves with the peace treaties, new socio-economic developments accelerate forest destruction through increased selective extraction, human settlements, and agribusiness (Clerici et al., 2020).

Because habitat destruction and fragmentation occur rapidly in these post-conflict zones, it is imperative to quickly generate knowledge about diversity and natural history to propose conservation strategies in sites exposed to rapid post-conflict land-use changes. One of these sites is the Mutatá municipality

located in the heart of the subregion of Urabá, which has an area of 1,106 km² and a total population of 13,991 inhabitants as of 2018, and its economy is mainly based on the agricultural production of bananas, cassava and pineapple (Alcaldía de Mutatá – Antioquia, 2012; Departamento Administrativo Nacional de Estadística (DANE, 2018). For these reasons, we set the goal of identifying the herpetofauna species in forest patches in the municipality of Mutatá.

MATERIALS AND METHODS

This study was conducted in the geographical subregion of Urabá in northwestern Colombia, specifically in the municipality of Mutatá. Urabá is an important area in terms of biodiversity because it is located between the Chocó-Darién ecoregion and the Andean piedmont (Myers et al., 2000; Ortiz-Yusty et al., 2015). The high diversity of this locality arises mainly from (1) the uplift of the Andes in diverse and complex orogenic processes, (2) the Great American Exchange that occurred at the closure of the Central American isthmus, (3) Pleistocene climatic fluctuations that contracted and extended climatic zones promoting speciation (Kattan et al., 2004), and (4) the high levels of humidity and rainfall, with up to 7000 mm of rain per year (Casas-Herrera et al., 2018). The complexity of these processes has allowed this area to have extreme indices of endemism (Lynch et al., 1997; Duellman, 1999; Rivas et al., 2021).

Between February 25 and November 30, 2022, we sampled five forest fragments at different sites within Mutatá: two private farms in the vicinity of the community of Pavarandocito (PA) (7° 18' 51" N, 76° 30' 05" W; 7° 19' 31" N, 76° 32' 03" W), the water intake of the town of Mutatá (M) (7° 14' 52" N, 76° 26' 01" W), the water intake of the vereda de Caucheras (C) (7° 20' 26" N, 76° 28' 21" W), and Puenteadero, which is located along the Mutatá River (PU) (7° 14' 35" N, 76° 25' 06" W). The altitude of these sampling sites ranged from 57 (in Pavarandocito) to 300 (in Caucheras) m a.s.l. This region is classified as tropical rain forests (Casas-Herrera et al., 2018) with an average rainfall of 4,300 mm per year (Organización de las Naciones Unidas para la Alimentación y la Agricultura [FAO] & Gobernación de Antioquia, 2018).

Surveys began in the late afternoon, just before nightfall, and extended to midnight. We determined herpetofauna composition using the direct visual encounter method (Heyer et al., 1994) with the number of hours sampled per person (hrs/per) as sampling units. The search was carried out both in the mulch and in the first layer of the understory, up to a

height of approximately 4 m. For amphibians and reptiles other than snakes of medical importance, one individual of each encountered species was captured, photographed, and transferred to the Herpetology Museum of the Universidad de Antioquia (UdeA) in Medellín, Colombia. All venomous snakes found were captured, photographed, and transferred to the UdeA Serpentarium in Medellín, where they were kept for studies on their venoms. Collecting permits were endorsed by Autoridad Nacional de Licencias Ambientales de Colombia under resolution 839-25-07-2014.

A list of species was generated based on our observations and their taxonomic identity confirmed. We catalogued the conservation status of the species according to the IUCN Red List. We estimated the species accumulation curve to assess whether our sampling effort was sufficient to determine an estimate of the composition of the total herpetofauna. For constructing this curve, we used a sample-size and coverage-based integrations of rarefaction and extrapolation of the Hill number order

$q = 0$, following Chao & Jost (2012) and Hsieh et al. (2016). We used iNEXT package in R Studio (R Core Development Team, 2021) based on an incidence matrix per sampling unit, using a 95 % confidence interval (CI). One of the applications of iNext is the assessment of sample completeness (sample coverage) across multiple samples (Hsieh et al., 2016). Thus, the sample completeness is understood as the probability that an already sampled species would be found if the sample were enlarged by one individual (Chao & Jost, 2012).

RESULTS

We found five orders and 23 families, for a total of 54 species of herpetofauna, of which 24 were amphibians and 30 reptiles (Figs. 1, 2 and 3). The sampling site with the highest species richness was the Caucheras water intake with 35, followed by the farms located in the vicinity of Pavarandocito with 22, Puenteadero with 13, and the Mutatá water intake with 5 (Table 1). Most species, 45, were catalogued as least concerned. Two species,

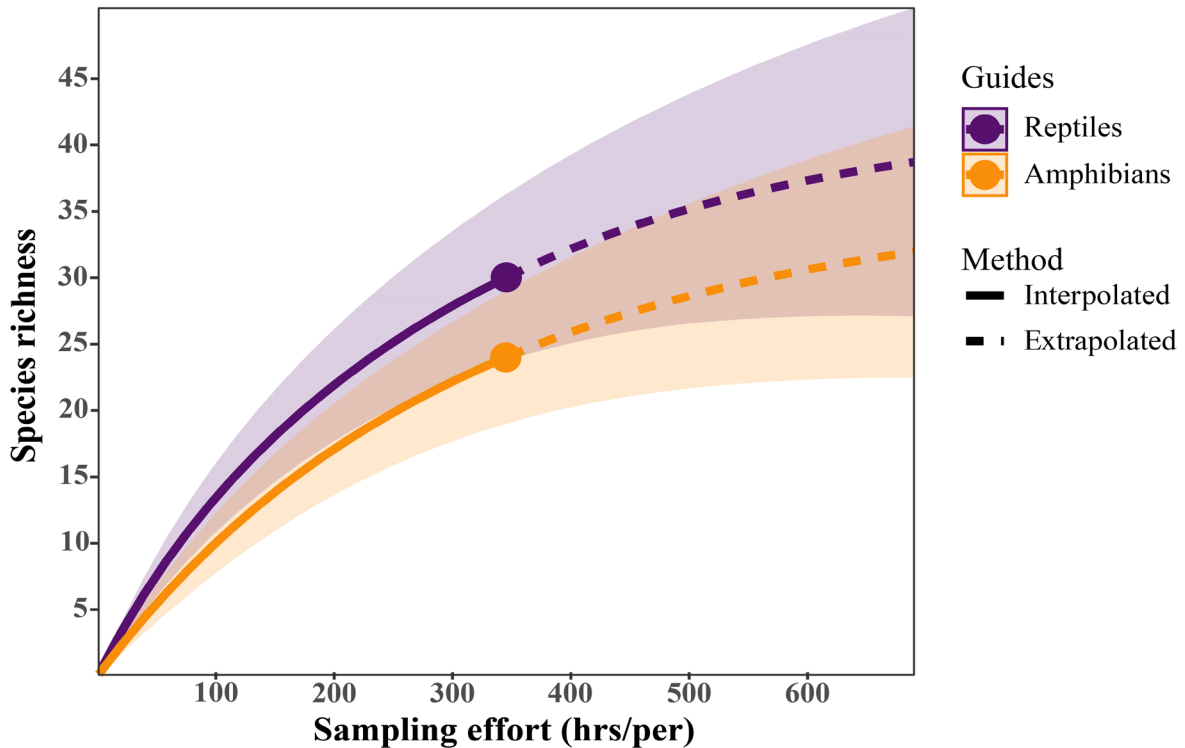


Figura 1. Curva de acumulación de especies de la herpetofauna encontrada en Mutatá, subregión del Urabá, Colombia a partir de un esfuerzo de muestreo de 345 horas por persona. El área sombreada corresponde al intervalo de confianza (IC) al 95 %.

Figure 1. Species accumulation curve of herpetofauna found in Mutatá, Urabá subregion, Colombia from a sampling effort of 345 person hours. The shaded area corresponds to the 95 % confidence interval (CI).

both dendrobatids, are endangered; while *Agalychnis terranova* is near threatened. Finally, two dipsadids are not evaluated (Table 1).

The total sampling effort during the months of the study was 345 hrs/per, in which the asymptote in the species accumulation curve was not reached for either amphibians or reptiles (Fig. 1).

Tabla 1. Primera lista de especies de herpetofauna encontradas en fragmentos de bosque en Mutatá, subregión del Urabá, Colombia. Los sitios de muestreo dentro de Mutatá se abreviaron como: PA = comunidad de Pavarandocito, M = toma de agua del poblado de Mutatá, C = toma de agua de la vereda de Caucheras y PU = Puenteadero. Categorías de la Lista Roja de la UICN: LC = Preocupación Menor, EN = En Peligro, NT = Casi Amenazado, and NE = No Evaluado.

Table 1. First list of herpetofauna species found in forest fragments in Mutatá, Urabá subregion, Colombia. Sampling sites within Mutatá were abbreviated as PA = community of Pavarandocito, M = Mutatá city's water intake, C = Cauchera's water intake, and PU = Puenteadero. IUCN Red List categories: LC = Least Concern, EN = Endangered, NT = Near Threatened, and NE = Not Evaluated.

Species	PA	M	C	PU	IUCN
CLASS AMPHIBIA					
Order Anura					
Family Bufonidae					
<i>Rhaebo haematiticus</i>				X	LC
<i>Rhinella horribilis</i>			X		LC
<i>Rhinella humboldti</i>	X				LC
Family Centrolenidae					
<i>Sachatamia ilex</i>	X	X			LC
Family Craugastoridae					
<i>Craugastor fitzingeri</i>				X	LC
<i>Craugastor raniformis</i>	X		X	X	LC
<i>Pristimantis cf. taeniatus</i>	X		X	X	LC
Family Dendrobatidae					
<i>Andinobates victimatus</i>			X		EN
<i>Colostethus imbricolus</i>			X		EN
<i>Dendrobates truncatus</i>	X		X		LC
Family Eleutherodactylidae					
<i>Diasporus gularis</i>	X		X	X	LC
Family Hemiphractidae					
<i>Gastrotheca spp.</i>			X		
Family Hylidae					
<i>Dendropsophus microcephalus</i>				X	LC
<i>Hyloscirtus palmeri</i>			X		LC

Tabla 1 (cont.). Primera lista de especies de herpetofauna encontradas en fragmentos de bosque en Mutatá, subregión del Urabá, Colombia. Los sitios de muestreo dentro de Mutatá se abreviaron como: PA = comunidad de Pavarandocito, M = toma de agua del poblado de Mutatá, C = toma de agua de la vereda de Caucheras y PU = Puenteadero. Categorías de la Lista Roja de la IUCN: LC = Preocupación Menor, EN = En Peligro, NT = Casi Amenazado, and NE = No Evaluado.

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Species	PA	M	C	PU	IUCN
<i>Scinax boulengeri</i>	X				LC
<i>Scinax elaeochroa</i>	X				LC
<i>Smilisca phaeota</i>	X		X	X	LC
Family Leptodactylidae					
<i>Engystomops pustulosus</i>	X			X	LC
<i>Leptodactylus fragilis</i>	X			X	LC
<i>Leptodactylus fuscus</i>	X				LC
<i>Leptodactylus savagei</i>				X	LC
Family Phyllomedusidae					
<i>Agalychnis terranova</i>				X	NT
Order Caudata					
Family Plethodontidae					
<i>Bolitoglossa spp.</i>	X		X		
Order Gymnophiona					
Family Caeciliidae					
<i>Caecilia spp.</i>			X		
CLASS REPTILIA					
Order Crocodylia					
Family Alligatoridae					
<i>Caiman crocodilus</i>	X				LC
Order Squamata					
Suborder Sauria					
Family Corytophanidae					
<i>Basiliscus basiliscus</i>		X			LC
Family Dactyloidae					
<i>Anolis lyra</i>	X		X		LC



Tabla 1 (cont.). Primera lista de especies de herpetofauna encontradas en fragmentos de bosque en Mutatá, subregión del Urabá, Colombia. Los sitios de muestreo dentro de Mutatá se abreviaron como: PA = comunidad de Pavarandocito, M = toma de agua del poblado de Mutatá, C = toma de agua de la vereda de Caucheras y PU = Puenteadero. Categorías de la Lista Roja de la UICN: LC = Preocupación Menor, EN = En Peligro, NT = Casi Amenazado, and NE = No Evaluado.

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Species	PA	M	C	PU	IUCN
<i>Anolis princeps</i>			X		LC
Family Gymnophthalmidae					
<i>Echinosaura palmeri</i>	X				LC
Family Hoplocercidae					
<i>Enyalioides heterolepis</i>	X		X		LC
Family Phyllodactylidae					
<i>Thecadactylus rapicauda</i>		X			LC
Suborder Serpentes					
Family Boidae					
<i>Boa imperator</i>		X			LC
<i>Corallus annulatus</i>			X		LC
<i>Epicrates maurus</i>			X		LC
Family Colubridae					
<i>Chironius grandisquamis</i>			X		LC
<i>Oxybelis brevirostris</i>			X		LC
<i>Spilotes pullatus</i>		X	X		LC
Family Dipsadidae					
<i>Geophis brachycephalus</i>			X		LC
<i>Imantodes cenchoa</i>	X		X		LC
<i>Imantodes inornatus</i>			X		LC
<i>Leptodeira ornata</i>	X		X		NE
<i>Lygophis lineatus</i>			X		LC
<i>Ninia atrata</i>	X			X	LC
<i>Ninia teresitae</i>				X	NE
<i>Oxyrhopus petolarius</i>			X		LC

Tabla 1 (cont.). Primera lista de especies de herpetofauna encontradas en fragmentos de bosque en Mutatá, subregión del Urabá, Colombia. Los sitios de muestreo dentro de Mutatá se abreviaron como: PA = comunidad de Pavarandocito, M = toma de agua del poblado de Mutatá, C = toma de agua de la vereda de Caucheras y PU = Puenteadero. Categorías de la Lista Roja de la UICN: LC = Preocupación Menor, EN = En Peligro, NT = Casi Amenazado, and NE = No Evaluado.

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Species	PA	M	C	PU	IUCN
<i>Pliocercus euryzonus</i>			X		LC
<i>Pseudoboa newwiedii</i>			X		LC
<i>Siphlophis compressus</i>			X		LC
<i>Urotheca fulviceps</i>			X		LC
Family Elapidae					
<i>Micrurus dumerilii</i>	X		X		LC
Family Tropidophiidae					
<i>Trachyboa boulengeri</i>			X		LC
Family Viperidae					
<i>Bothriechis schlegelii torvus</i>			X		LC
<i>Bothrops asper</i>	X		X		LC
<i>Porthidium lansbergii</i>			X		LC

For amphibians, the effort made suggest a sample completeness of 68 % (0.684) [CI = 0.526 – 0.841] and the number of expected species to be 36 [CI = 26 – 56]. For reptiles, the effort made suggest a sample completeness of 71 % (0.714) [CI = 0.635 – 0.866] and the number of expected species at 42 [CI = 45 – 61].

DISCUSSION

There is no available count of species present in the Mutatá region, although the Sistema de Información sobre Biodiversidad de Colombia report the species expected from biological records in all Colombia. Based on this information, the number of species expected in the municipality of Mutatá is close to 27 species of amphibians and 52 species of reptiles (Sistema de Información sobre Biodiversidad de Colombia (SiB Colombia), 2020). If we take these values as a reference, our combined effort represents 88.9 % of amphibians and 57.7 % of reptiles inhabiting the municipality.

Normally, when diversity studies compare the observed species against the expected species reported, the values range around

40 % to 60 %, while the sample completeness is higher (e.g. Acuña-Vargas, 2016). Here, we found that pattern with reptiles but no with amphibians. We attribute this result to the limited information available on amphibian species in the area as a result of the armed conflict. Because the SiB Colombia platform bases its reports on this limited information, the number of amphibians reported by them is very similar to that reported by us. We believe that as more diversity studies are conducted in this area, the data presented by SiB Colombia will increase for both amphibians and reptiles.

The combined effects of various phenomena could have influenced the number of species found being lower than the expected. First, the secretive nature of many herpetofauna groups makes their detection difficult (Doan, 2003), so as sampling efforts increase, more of these animals would appear. Second, sampling in this study was crepuscular and nocturnal. A large number of species have diurnal peaks of activity, which could explain why groups that are normally diverse, such as dendrobatids and lizards, were poorly observed in this study (Ortiz-Yusty et al., 2015). Finally, we focused our sampling on



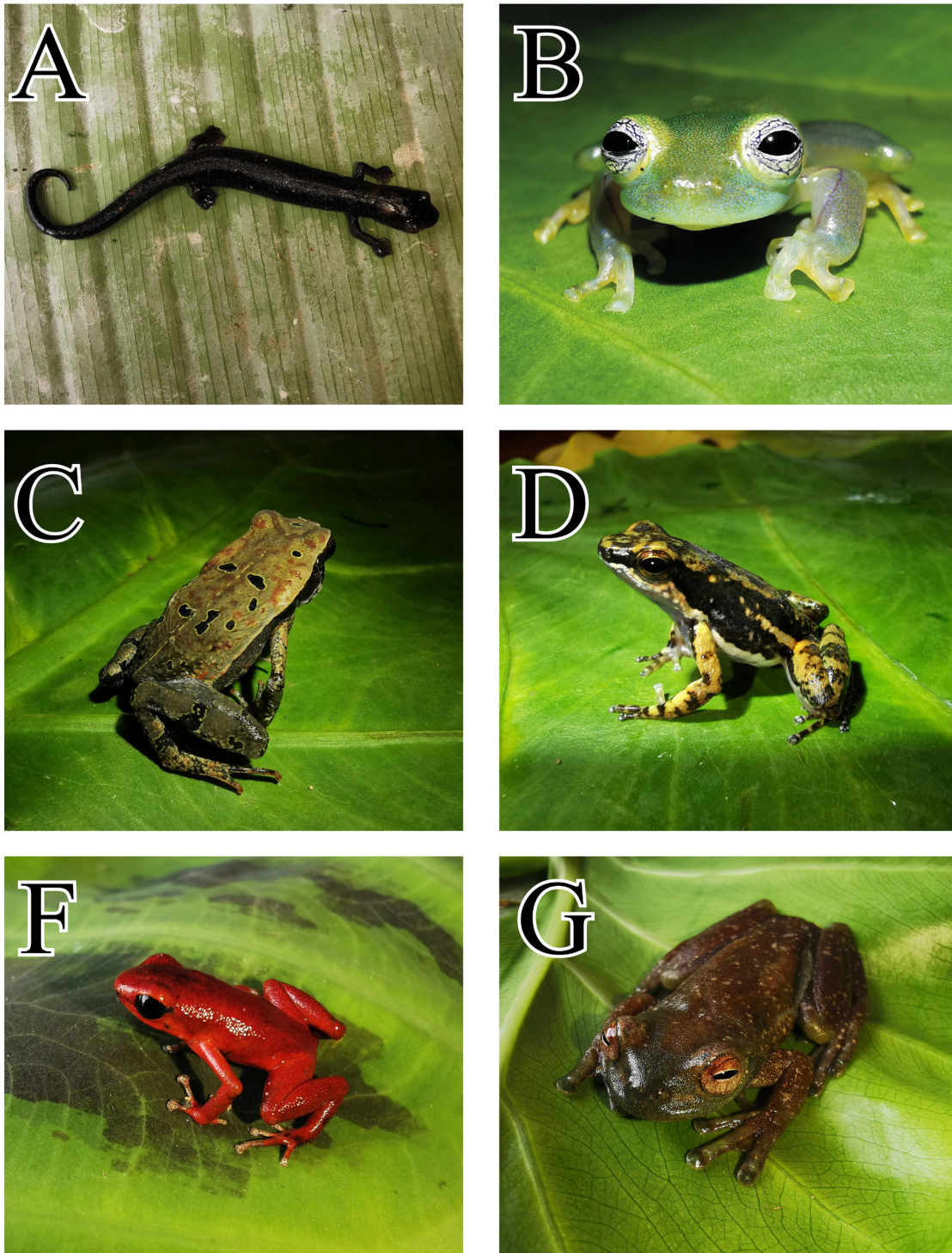


Figura 2. Ejemplares de algunas especies de anfibios encontradas en Mutatá, subregión del Urabá, Colombia. A) *Bolitoglossa* sp., B) *Sachatamia ilex*, C) *Rhaebo haematiticus*, D) *Colostethus imbricolus*, E) *Andinobates victimatus* y G) *Hyloscirtus palmeri*. Fotos: Felipe Triana.

Figure 2. Specimens of some amphibian species found in Mutatá, Urabá subregion, Colombia. A) *Bolitoglossa* sp., B) *Sachatamia ilex*, C) *Rhaebo haematiticus*, D) *Colostethus imbricolus*, E) *Andinobates victimatus*, and G) *Hyloscirtus palmeri*. Photos: Felipe Triana.



Figura 3. Ejemplares de algunas especies de reptiles encontradas en Mutatá, subregión del Urabá, Colombia. A) *Enyalioides heterolepis*, B) *Micrurus dumerilii*, C) *Bothriechis schlegelii* torvus, D) *Bothrops asper*, F) *Geophis brachycephalus* y G) *Pliocercus euryzonus*. Fotos: Felipe Triana.

Figure 3. Specimens of some reptile species found in Mutatá, Urabá subregion, Colombia. A) *Enyalioides heterolepis*, B) *Micrurus dumerilii*, C) *Bothriechis schlegelii* torvus, D) *Bothrops asper*, F) *Geophis brachycephalus*, and G) *Pliocercus euryzonus*. Photos: Felipe Triana.

leaf-litter and understory; therefore, we report few species of the canopy and river. With this in consideration, the sample completeness of 68 % and 71 % for amphibians and reptiles, respectively, effectively corresponds to the percentage of species found in the specific habitats where we sample.

It is well known that forest loss and fragmentation processes are among the greatest threats to tropical biodiversity (Hanski, 2011; Kehoe et al., 2015; Laurance et al., 2018). Consequently, even with the low number of species found, our study provides a valuable baseline for understanding the herpetofauna of the forest patches of Mutatá during the post-conflict era, especially considering that this is the first list of amphibians and reptiles in the region. Moreover, from the conservation status of the species we found, it can be inferred that the ecosystems where they are distributed have provided a safe environment for the stability of their populations until now. Identifying species in an area that is classified as a hotspot of diversity and has been facing enormous urban and agro-industrial development in recent years is fundamental for developing conservation strategies. This is especially true when working with groups of animals that are feared, marginalized, and persecuted by humans, such as many groups of amphibians and reptiles.

Unfortunately, if environmental action is not taken in an agile manner, especially in the regions that were most affected by the armed conflict in Colombia and which are now experiencing strenuous human development, the herpetofauna diversity we know today could disappear faster than expected. Defining municipal conservation areas in the region would increase forest connectivity and support biodiversity conservation (Brumberg et al., 2024). Considering the results obtained in this study with herpetofauna and the proximity to the Paramillo National Natural Park, Caucheras and Puenteadero are two sites that could be considered for this purpose. Studying the diversity of other groups of living beings in these sites is essential to reaching conclusions; however, this study could be used as a first step.

CONCLUSIONS

In this preliminary assessment of the herpetofauna of the Mutatá forest patches, we identified a total of 24 amphibian and 30 reptile species in 345 hrs/per. Despite having observed fewer species than expected, this study represents an important step in the knowledge of the diversity of the Urabá region, especially considering that there is no record documenting this subject in this region. In addition to this problem, the recent sociocultural context of Mutatá has led to the reduction of forest areas in favor of industrial and urban development, despite being located in one of the most biodiverse areas in the world. This exacerbated

loss of habitat increases the pressure to conserve nature, and to do so, as our study suggest, further studies are urgently needed to inform the scientific and local communities about the diversity of both herpetofauna and other living beings in post-conflict regions, such as Mutatá.

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