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Land-cover changes affect the diversity of amphibians and reptiles in a rural landscape of the Colombian Caribbean region

Los cambios en la cobertura del suelo afectan la diversidad de anfibios y reptiles en un paisaje rural de la región Caribe colombiana

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ABSTRACT. Land cover changes resulting from agricultural expansion and cattle ranching are the primary factors influencing the diversity of amphibian and reptile communities. In this study, we assessed the variation in the diversity of amphibians and reptiles across four land-cover types (ponds, grasslands, temporary crops, and secondary vegetation) in a rural landscape in the Colombian Caribbean region. Amphibians and reptiles were sampled through visual encounter surveys between April and August 2018. A total of 19 species of amphibians (frogs and toads) and 23 species of reptiles (14 lizards, 7 snakes, 1 turtle, and 1 alligator) were recorded. Species diversity differed among land covers, for both amphibians and reptiles. Amphibian diversity was higher in ponds and lower in grasslands, whereas reptile diversity was higher in secondary vegetation and lower in temporary crops. Our results suggest that the maintenance of ponds and secondary vegetation could be important for the conservation of herpetofauna in rural landscapes where anthropogenic activities such as agriculture and cattle ranching predominate.

Key words: Agroecosystems; Anthropic disturbance; Anura; Ponds; Tropical Dry Forest

RESUMEN. Los cambios en la cobertura del suelo debido a la expansión agrícola y ganadera son las principales causas que influyen en la diversidad de las comunidades de anfibios y reptiles. En este estudio, evaluamos la variación de la diversidad de anfibios y reptiles en cuatro tipos de cobertura del suelo (jagüeyes, pastizales, cultivos transitorios y vegetación secundaria) en un paisaje rural de la región Caribe colombiana. Los anfibios y reptiles fueron muestreados a través del método de relevamiento por encuentros visuales entre abril y agosto de 2018. Se registró un total de 19 especies de anfibios (ranas y sapos) y 23 especies de reptiles (14 lagartos, 7 serpientes, 1 tortuga y 1 caimán). La diversidad de especies difirió entre las coberturas del suelo, tanto para anfibios como para reptiles. La diversidad de anfibios fue mayor en los jagüeyes y menor en los pastizales, mientras que la de reptiles fue mayor en la vegetación secundaria y menor en los cultivos transitorios. Nuestros resultados sugieren que el mantenimiento de jagüeyes y vegetación secundaria podría ser importante para la conservación de la herpetofauna en paisajes rurales donde predominan actividades antropogénicas como la agricultura y la ganadería.

Palabras clave: Agroecosistemas; Disturbio antrópico; Anura; Jagüeyes; Bosque seco tropical

INTRODUCTION

Changes in land cover resulting from agricultural expansion and livestock production are the primary factors that seriously threaten biodiversity worldwide, altering diversity patterns and species composition (Cushman, 2006; Brum *et al*., 2013; Fulgence *et al*., 2022). Amphibians and reptiles exhibit high density and diversity in tropical regions, where they play important roles as primary, mid-level, and top consumers within ecosystems (Gardner *et al*., 2007). However, these organisms are currently undergoing a widespread global decline, primarily attributed to habitat loss, invasive species, environmental pollution, climate change, and epidemic diseases (Suazo-Ortuño *et al*., 2008; Urbina-Cardona *et al*., 2014).

Although some human activities can decrease the resilience of animal populations and increase the risk of extinction, especially among specialist organisms, other species may benefit from man-made structures (*e.g.,* artificial ponds), which provide potential breeding sites and refuges for amphibians and reptiles (Valdez *et al*., 2021; Díaz-Ricaurte *et al*., 2022). Additionally, fragments of secondary vegetation have been documented as important shelters for the diversity of amphibians and reptiles in human-modified landscapes (Thompson & Donnelly, 2018). In light of these considerations, if habitat structural characteristics influence animal community structure at the local scale, it becomes possible to establish links between species occurrence and key resource utilization variables, such as microhabitat use (Vitt *et al*., 2007; Carvajal-Cogollo *et al*., 2019).

Microhabitat use by amphibians and reptiles is influenced by a combination of ecological and intrinsic (i.e., morphological, behavioral, and physiological) factors. These organisms exhibit specific adaptations that shape their choice of microhabitat (Urbina-Cardona *et al.,* 2006). Morphological characteristics, such as size, shape, and specific anatomical features (e.g., permeable skin in amphibians and scales in reptiles) play an important role in determining their suitability for different microhabitats (Glor *et al*., 2001; Urbina-Cardona *et al*., 2014). Furthermore, the behavioral traits of amphibians and reptiles, including thermoregulatory behaviors and food preferences, guide their selection of specific niches within an environment (Urbina-Cardona & Londoño, 2003; Brüning *et al*., 2018). Environmental variables such as temperature, humidity, and vegetation cover influence microhabitat use (Urbina-Cardona & Londoño, 2003; Urbina-Cardona *et al*., 2006). These ecological factors are important for understanding the distribution and diversity patterns of amphibians and reptiles in response to habitat modifications (Flynn *et al*., 2009; Urbina-Cardona *et al*., 2014; Carvajal-Cogollo & Urbina-Cardona, 2015).

In the Colombian Caribbean lowlands, the primary biome is the Seasonally Dry Tropical Forest (SDTF). However, human activities such as agriculture and cattle ranching have replaced native vegetation with crops and pastures for livestock. Consequently, the landscape in this region is predominantly characterized by agroecosystems (IDEAM, 2010; Pizano & García, 2014). Despite the significant reduction in the extent of the native vegetation cover, some remnants of secondary vegetation persist within the agroecosystems of the Colombian Caribbean region. These remnants have served as crucial refuges for local herpetofauna (Carvajal-Cogollo & Urbina-Cardona, 2008; Thompson & Donelly, 2018).

Unfortunately, the effects of land-cover changes on the diversity of amphibians and reptiles remain poorly documented in Colombia (Cordier *et al*., 2021). Therefore, the main goal of this study was to assess the diversity of amphibians and reptiles across different land covers in a rural landscape of the Colombian Caribbean region. Additionally, we aimed to assess the microhabitat associations of amphibian and reptile species recorded in the study area.

MATERIALS AND METHODS

The study area included the villages of Las Palmas (9°16' 07" N, 75° 20' 06" W) and San José de Piletas (9°15' 58" N, 75°19' 05" W), located in the municipalities of Sincelejo and Corozal, respectively, in the Department of Sucre, Colombia. The study area is a rural landscape typical of the lowlands of the Caribbean region of Colombia, characterized by scattered patches of secondary vegetation and high anthropogenic disturbance primarily driven by agricultural and livestock activities. The replacement of native vegetation has resulted in a rural landscape predominantly comprised of pastures, shrubs, and isolated trees, where many plant species tend to shed their leaves due to prolonged periods of drought (Pizano & Garcia, 2014; Mercado-Gomez *et al*., 2021).

To determine the composition and distribution of the herpetofauna, we focused on the main four predominant land cover types in the study area. The characterization of land cover types was based on descriptions of similar ecosystems in the Colombian Caribbean region (Rangel-Ch, 2012; Pizano & Garcia, 2014; Acuña-Vargas, 2016; Díaz-Perez *et al*., 2019). The selected land cover categories were as follows:

Temporary crops (TS). This category encompasses crops with a vegetative cycle of less than a year or just a few months. After harvest, these crops must be replanted to sustain production (Fig. 1A). The study area was primarily dominated by monocultures of cassava, beans, corn, and eggplant.

Grasslands (GL). These are extensive areas of pasture and paddocks, with few trees or shrubs scattered along their entire extension, with herbaceous vegetation dominating (Fig. 1B).

Secondary vegetation (SV). These are small fragments or patches of dry forest in various stages of ecological succession. They typically consist of a sparse population of large trees, predominantly comprising shrubs and bushes, with a thin layer of leaf litter covering the ground (Fig. 1C).

Ponds (PN). Characterized as artificial formations, these ponds have emerging or floating vegetation covering all or part of the water surface. They also exhibit herbaceous vegetation along their edges and are surrounded by a limited number of trees or shrubs. During certain climatic seasons, water levels decrease, revealing strips of dry land, which are also encompassed within this category (Fig. 1D). During the sampling phase, the ponds were sampled up to 5 m from the edge.

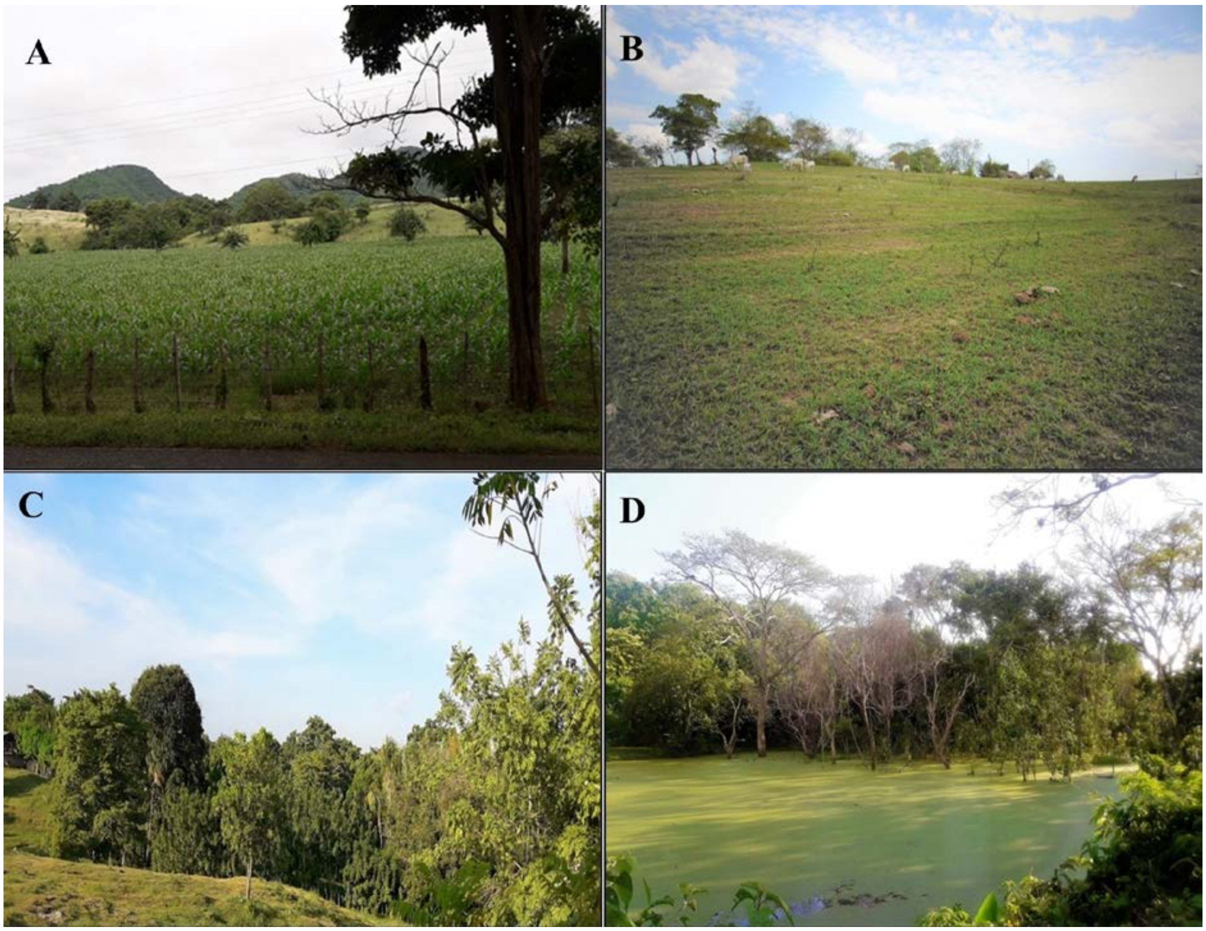

Figure 1. Land covers sampled in the rural landscape of the department of Sucre, Colombia: (**A**) Temporary crops, (**B**) Grasslands, (**C**) Secondary vegetation, (**D**) Ponds.

Herpetofauna surveys

Amphibians and reptiles were surveyed during ten field trips from April to August 2018 (except July). These specific months were chosen because they coincide with the onset of the first rainfall in the study area, a period during which the herpetofauna tends to be more active (Urbina-Cardona *et al*., 2014). Additionally, these months align with the planting and harvesting periods of monocultures in the study area. We conducted surveys of the herpetofauna in each of the four defined land covers, resulting in 10 independent sample units per land cover during the entire sampling period. Each sample unit involved a two-hour survey of amphibians and reptiles, one during the daytime (between 09:00 – 13:00 h) and another at nighttime (between 19:00 – 23:00 h), employing the Visual Encounters Surveys method (Crump & Scott, 1994).

We recorded the specific microhabitat where each amphibian and reptile were initially sighted, and its taxonomic identification was performed *in situ*. Each specimen was classified to the lowest possible taxonomic category using taxonomic keys, field guides, and species descriptions (Peters & Orejas, 1970; Acosta-Galvis, 2012; Romero-Martínez & Lynch, 2012; Mendoza & Gómez, 2014).

Data analysis

We assessed sampling completeness in the study area using non-parametric estimators of species richness, specifically Chao 1 (abundance-based) and Chao 2 (incidence-based). Additionally, we calculated the sample coverage estimator as a complementary measure of sampling completeness (Chao & Jost, 2012). This estimator ranges from 0 to 1, with values closer to 1 indicating higher sampling completeness. These analyses were performed using the SpadeR package (Chao *et al*., 2016).

To compare the richness of amphibians and reptiles across different land covers, we employed 84% confidence intervals, following the methodology proposed by MacGregor-Fors and Payton (2013). The advantage of this method is that the 84% confidence intervals mimic robust statistical tests with P (α) = 0.05; therefore, significant differences are indicated by non-overlapping confidence intervals (MacGregor-Fors & Payton, 2013).

To compare the diversity of amphibian and reptile communities among land covers, we calculated the exponential of the Shannon´s entropy index (Jost, 2006), with its associated 95% confidence intervals using the SpadeR package (Chao *et al*., 2016). Non-overlapping confidence intervals indicated significant differences.

To compare the similarity in species composition of both amphibians and reptiles among land covers, we used the Chao-Jaccard abundance-based similarity index (Chao *et al*., 2005, 2006). This index ranges from 0 to 1, where values closer to 1 signify high similarity in species composition. Importantly, the Chao-Jaccard index accounts for the influence of unobserved shared species among land covers, thereby addressing potential under-sampling bias (Chao *et al*., 2005, 2006). We calculated this index using the SpadeR package (Chao *et al*., 2016).

To assess species association with one or more microhabitats, we performed an Indicator Species Analysis (Dufrêne & Legendre, 1997; De Cáceres *et al*., 2010). For this analysis, we categorized microhabitats based on the substrate in which we recorded each individual, including ground, herbaceous vegetation, rock, water, leaf litter, and tree trunk (Afonso & Eterovick, 2007; Román-Palacios *et al*., 2016). This method calculates the indicator value (IndVal) for each species, considering its specificity (exclusivity within a particular microhabitat) and fidelity (the frequency of occurrence within a particular microhabitat). IndVal values close to 100 indicate a high association of a species with a particular microhabitat or group of microhabitats. To determine the statistical significance of these associations, we conducted 999 Monte Carlo permutations. This analysis was performed using the indicspecies package (De Cáceres, 2013). We performed statistical analyses using R, version 4.2.2 (R Core Team, 2022).

RESULTS

We recorded 441 individuals representing 19 amphibian species, and 281 individuals representing 23 reptile species (Table 1). The representativeness of the inventory was equal to or greater than

88% for both amphibians and reptiles. According to the sampling coverage estimator, inventories were more than 95% complete (Table 2).

Table 1. Composition and abundance of amphibian and reptile species in the rural landscape studied in Department Sucre, Colombia. **SV**: secondary vegetation, **PN**: ponds, **GL**: grasslands, **TC**: temporary crops.

TAXA	**Land-covers**			
CLASS AMPHIBIA	**SV**	**PN**	**GL**	**TC**
Order Anura				
Family Bufonidae				
Rhinella horribilis (Wiegmann, 1833)	30	28	9	21
Rhinella humboldti (Gallardo, 1965)	4	26	33	6
Family Ceratophryidae				
Ceratophrys calcarata Boulenger, 1890	1	5	3	3
Family Hylidae				
Boana pugnax (Schmidt, 1857)	2	9	1	3
Boana platanera (Escalona, La Marca, Castellanos, Fouquet, Crawford, Rojas-Runjac, Giaretta, Señaris, Castroviejo-Fisher, 2021)	1	0	0	1
Dendropsophus microcephalus (Cope, 1886)	1	12	0	6
Pseudis paradoxa (Linnaeus, 1758)	0	1	0	0
Scinax rostratus (Peters, 1863)	0	12	0	0
Scinax ruber (Laurenti, 1768)	0	0	0	3
Scinax x-signatus (Spix, 1824)	1	1	0	0
Family Leptodactylidae				
Engystomops pustulosus (Cope, 1864)	36	10	0	3
Leptodactylus fragilis (Brocchi, 1977)	7	10	4	0
Leptodactylus fuscus (Schneider, 1799)	3	17	9	4
Leptodactylus insularum Barbour, 1906	2	9	0	1
Leptodactylus poecilochilus (Cope, 1862)	5	1	0	1
Pleurodema brachyops (Cope, 1869)	0	4	21	2
Pseudopaludicola pusilla (Ruthven, 1916)	15	44	8	0
Family Microhylidae				
Elachistocleis panamensis (Dunn, Trapido & Evans, 1948)	1	0	0	0
Elachistocleis pearsei (Ruthven, 1914)	0	0	1	0
Order Squamata				
Family Anolidae				
Anolis auratus Daudin,1802	8	6	33	50
Anolis tropidogaster Hallowell,1856	2	0	0	0
Anolis sp.	2	0	0	0
Family Geckonidae				
Hemidactylus frenatus Duméril & Bribron, 1836	1	0	1	0
Family Gymnophthalmidae				
Loxopholis rugiceps Cope, 1869	7	2	0	0
Family Iguanidae				
Iguana iguana (Linnaeus, 1758)	0	1	0	0

Family Phyllodactylidae				
Thecadactylus rapicauda (Houttuyn, 1782)	0	0	3	0
Family Sphaerodactylidae				
Gonatodes albogularis (Duméril & Bibron, 1836)	18	2	4	1
Lepidoblepharis sanctaemartae (Ruthven, 1916)	16	4	0	3
Family Teiidae				
Cnemidophorus gaigei Ruthven, 1915	10	2	10	55
Ameiva bifrontata Cope, 1862	0	0	1	0
Ameiva praesignis (Baird & Girard, 1852)	0	1	1	0
Holcosus festivus (Lichtenstein & Martens, 1856)	1	0	0	0
Tupinambis cf. *cryptus* (Linnaeus, 1758)	2	0	0	0
Family Colubridae				
Leptodeira ashmeadii (Hallowell, 1845)	0	2	0	2
Pseudoboa neuwiedii (Duméril, Bibron & Duméril, 1854)	0	0	1	1
Tantilla melanocephala (Linnaeus, 1758)	2	0	0	0
Family Dipsadidae				
Helicops danieli Amaral, 1938	0	3	0	0
Dryophylax sp.	0	0	2	0
Erythrolamprus melanotus (Shaw, 1802)	1	0	0	0
Micrurus dissoleucus Cope, 1860	0	0	1	0
Order Crocodylia				
Family Alligatoridae				
Caiman crocodilus (Linnaeus, 1758)	0	9	0	0
Order Testudines				
Family Testudinidae				
Chelonoidis carbonarius (Spix, 1824)	10	0	0	0

Table 2. Sampling completeness (%), according to the species richness estimators and the sample coverage estimator.

Amphibians	No. species (95% CI)	% Sampling completeness
Observed richness	19	
Chao 1	21 (19.27 – 38.00)	90
Chao 2	21 (19.45 – 25.20)	90
Sample coverage estimator	0.99 (0.99 – 1.00)	99
Reptiles	No. species (95% CI)	% Sampling completeness
Observed richness	23	
Chao 1	25 (23.23 – 33.44)	92
Chao 2	26 (23.52 – 37.58)	88
Sample coverage estimator	0.98 (0.97 – 0.99)	98

Amphibian species richness varied among land cover types, with 15 observed in ponds, 14 in secondary vegetation, 12 in temporary crops, and nine in grasslands. Statistical analysis did not reveal any significant differences in amphibian richness between ponds, secondary vegetation, and temporary crops. However, there were significant differences between the grasslands and all other land cover types (Fig. 2A). The diversity of amphibians was significantly higher in ponds than in secondary vegetation and grasslands (Fig. 2B).

Additionally, we recorded two amphibian species in the secondary vegetation from San José de Piletas village (Monte Firme locality): *Dendrobates truncatus* and *Scarthyla vigilans*. These species were recorded during a field trip conducted in 2022 (after the sampling period of this study) and were not included in from the statistical analysis (Appendix).

Regarding reptiles, the total richness was 13 species in secondary vegetation, while ponds and grasslands each had 10 species, and temporary crops had six species. Significant differences in reptile species richness were found only between secondary vegetation and temporary crops (Fig. 3A). Additionally, reptile diversity was significantly higher in secondary vegetation and ponds than in grasslands and temporal crops (Fig. 3B).

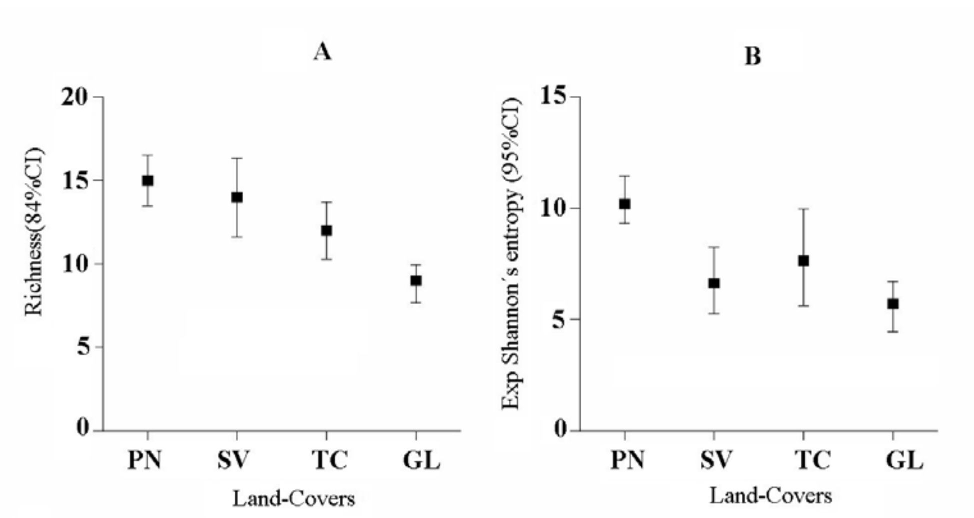

Figure 2. Comparisons of richness (**A**), and diversity (**B**) of amphibians among land covers. **PN**, ponds, **SV**, secondary vegetation, **TC**, temporary crops, **GL**, grasslands.

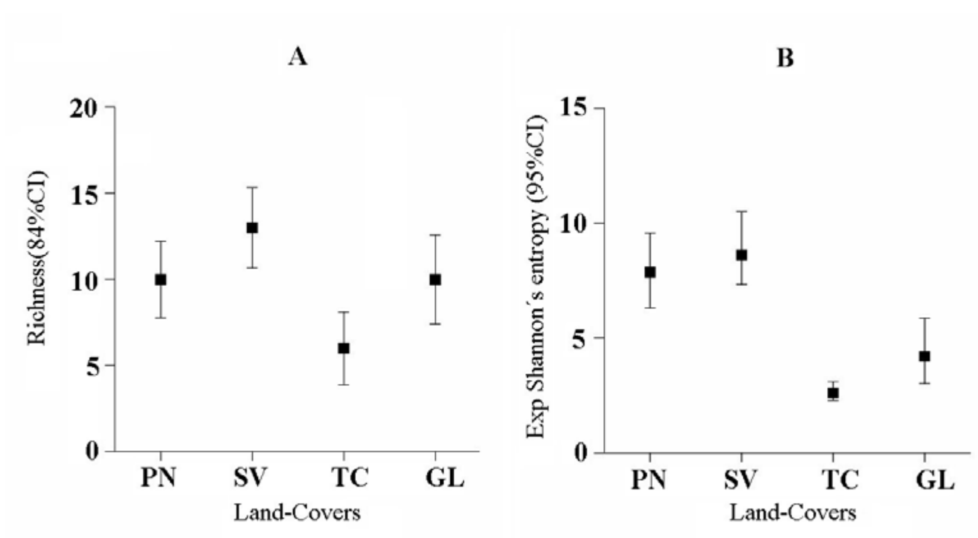

Figure 3. Comparisons of richness (**A**), and diversity (**B**) of reptiles among land covers. **PN**, ponds, **SV**, secondary vegetation, **TC,** Temporary crops, **GL**, grasslands

We also observed variations in species composition among different land cover types for both amphibians and reptiles. Land covers of secondary vegetation, ponds, and temporary crops form a group indicating greater similarity in species composition (Fig. 4A). Conversely, for reptiles, two distinct groups emerged. One group comprised temporary crops and grasslands, indicating high similarity in species composition, whereas the other group included ponds and secondary vegetation, showing a lower similarity in species composition compared with the group of grasslands and temporary crops (Fig. 4A).

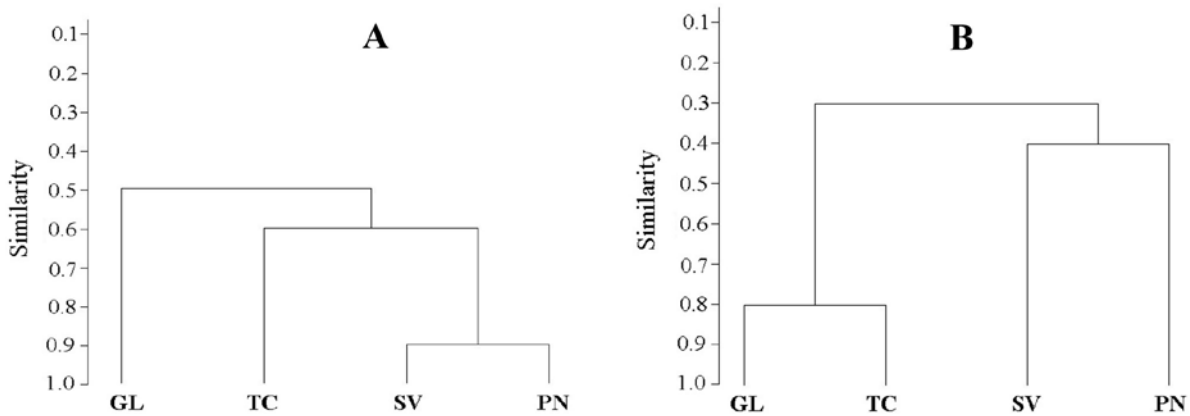

Figure 4. Chao-Jaccard similarity dendrogram between land covers for (**A**) amphibians, and (**B**) reptiles. **PN**, Ponds; **SV**, secondary vegetation **TC**, temporary crops, **GL**, grasslands

Eleven amphibian species were associated with one or two specific microhabitats. Some of them were strongly associated with the ground, such as *Leptodactylus fragilis*, *Pleurodema brachyops*, and *Rhinella humboldti* (Table 2). *Dendropsophus microcephalus* was associated with herbaceous vegetation, whereas *Rhinella horribilis* and *Leptodactylus poecilochilus* were associated with both ground and water. Similarly, *Engystomops pustulosus* was associated with both ground and leaf litter (Table 3).

In contrast, only six reptile species exhibited associations with specific microhabitats. *Cnemidophorus gaigei* and *Leptodeira ashmeadi* were associated with the ground, *Caiman crocodilus* and *Helicops danieli* with the water, *Gonatodes albogularis* with tree trunks, and *Lepidoblepharis sanctaemartae* with leaf litter (Table 3). Table 3 shows only significant results for both amphibians and reptiles.

DISCUSSION

Our findings reveal a significant variation in species richness among the land covers evaluated in the study area. These findings are consistent with prior research conducted in agricultural systems in the Colombian Caribbean lowlands (Angarita *et al*., 2015; Acuña-Vargas, 2016). These results support the idea that different land covers exert a discernible influence on the distribution and abundance of amphibians and reptiles. This influence is likely shaped by the structural characteristics inherent to each land cover, which, in turn, provide suitable environmental conditions aligned with the ecological requirements of amphibians and reptile species (Urbina-Cardona & Londoño, 2003; Brüning *et al*., 2018).

Table 3. Associations of amphibian and reptile species with microhabitats, according to the Indicator Species Analysis (only the species that showed a stronger association with the microhabitat are presented).

Species	Microhabitat association	%IndVal	*P* value
Amphibians			
Leptodactylus fragilis	Ground	98	0.001
Pleurodema brachyops	Ground	95	0.001
Rhinella humboldti	Ground	89	0.001
Ceratophrys calcarata	Ground	80	0.001
Pseudopaludicola pusilla	Ground	72	0.001
Leptodactylus insularum	Ground	68	0.003
Dendropsophus microcephalus	Herbaceous vegetation	59	0.011
Leptodactylus fuscus	Ground and rocks	63	0.002
Rhinella horribilis	Ground and water	74	0.001
Leptodactylus poecilochilus	Ground and water	55	0.010
Engystomops pustulosus	Ground and leaf litter	60	0.014
Reptiles			
Cnemidophorus gaigei	Ground	71	0.001
Leptodeira ashmeadii	Ground	55	0.024
Caiman crocodilus	Water	55	0.018
Helicops danieli	Water	55	0.026
Gonatodes albogularis	Tree trunk	75	0.001
Lepidoblepharis sanctaemartae	Leaf litter	66	0.002

Considering the persistent anthropic pressure exerted on land covers for agricultural and livestock purposes, such as grasslands and temporary crops, it is important to note that these areas tend to be structurally more homogeneous. Consequently, the composition and diversity of amphibian and reptile species are likely to be dominated by those species that can tolerate the specific conditions offered by these land covers (Glor *et al*., 2001; Angarita *et al*., 2015; Acuña-Vargas, 2016). As we observed in the present study, generalist species such as *C. gaigei*, *A. auratus*, *P. brachyops*, and *R. humboldti*, are expected to be dominants in these types of land covers (Blanco-Torres & Bonilla-Gómez, 2010; Angarita *et al*., 2015).

In this study, we found that the diversity of amphibians and reptiles was higher in ponds and secondary vegetation, similar to that found in a previous study in agroforestry systems in the department of Magdalena, Colombia (Angarita *et al*., 2015). The high diversity observed in these particular land covers can be attributed to their capacity to provide more stable environmental conditions, high resource availability, and wetter microhabitats, which are essentials for the physiological requirements and reproduction of these organisms (Blanco-Torres & Bonilla-Gómez, 2010; Rojas-Murcia *et al*., 2016). We consider that the results of our study have important implications for biodiversity conservation in the Colombian Caribbean lowlands. The preservation of these land covers would be crucial to maintaining the diversity of amphibians and reptiles (Carvajal-Cogollo *et al*., 2007). This leads to the need for future research for the creation of biological corridors and promoting sustainable management practices across agriculture and other productive activities, especially in the study region where the dry forest is severely degraded and only remnants of secondary vegetation persist in different stages of ecological succession (García *et al*., 2014; Galván-Guevara *et al*., 2015).

The effects of deforestation and the conversion of the tropical dry forest for agricultural purposes have resulted in reduced habitat availability for several species, leading to a decline in biodiversity (Urbina-Cardona *et al*., 2014). The structure and distribution of land covers might influence the composition of amphibians and reptiles. Consequently, this relationship could also be attributed to the gradual replacement of native species by others with broader distribution ranges that exhibit greater tolerance to land cover changes (Blanco-Torres & Bonilla-Gómez, 2010; Acuña-Vargas, 2016). However, it is challenging to thoroughly assess this aspect with the present study because of the centuries-long history of agricultural activities causing changes in the tropical dry forest in the Caribbean region, coupled with the scarcity of historical records on the local biota. Furthermore, the diversity patterns of amphibians and reptiles can be more comprehensively understood by evaluating the microhabitat use of different species (Blanco-Torres *et al*., 2017). Consequently, the microhabitat preferences of species can provide valuable insights into the ecology of amphibians and reptiles, particularly in the context of changing land cover. Identifying specific microhabitat preferences by certain species highlights their adaptability and specialization in response to environmental variations (Urbina-Cardona *et al*., 2006; Blanco-Torres & Bonilla-Gómez, 2010). Our findings suggest that certain species show a marked preference for microhabitat types. Therefore, it becomes increasingly necessary to document the use and preference of microhabitats by amphibians and reptiles and to relate these patterns to the response of individuals to environmental filters, based on their ecological characteristics and functional traits (Carvajal-Cogollo *et al*., 2019).

Some species recorded in our study, such as *R. horribilis,* and *R. humboldti*, are typically found in dry areas and a little away from water bodies, because these species have high ecological adaptability and can tolerate highly degraded environments, even benefiting from human activities (Blanco-Torres & Bonilla-Gómez, 2010; Angarita *et al*., 2015).However, species belonging to the Hylidae family, such as *D. microcephalus*, consistently inhabit herbaceous vegetation within or along the periphery of ponds (Muñoz-Guerrero *et al*., 2007). Some amphibians have developed strategies to cope with the temporal variations in the evaporation rates characteristic of the Colombian Caribbean lowlands. These strategies include morphological adaptations such as reduced skin permeability, skin waterproofing through waxes, and mechanisms that enhance water uptake (Ortega-Chinchilla *et al*., 2019). However, within the current Anthropocene context, rapid changes in land cover have resulted in a scarcity of humid microhabitats that can modulate the structure and composition of communities, often favoring the presence and abundance of species with greater capacity to locate water sources (Urbina-Cardona *et al*., 2014).

On the other hand, defining specific microhabitat preferences for reptiles poses challenges due to their high vagility (Garda *et al*., 2013; Carvajal-Cogollo *et al*., 2019). The presence of these reptilian species is determined by their natural history attributes and the availability of niches within each land cover (Vitt *et al*., 2007). In this study, we observed that species such as *C. crocodilus*, and *H. danieli* were more commonly associated with wetter microhabitats, which were prevalent in the ponds, aligning with the findings of Angarita *et al*. (2015). Conversely, species such as *G. albogularis* exhibited a stronger association with tree trunks, as this is favorably linked with an increased tree stratum (Medina-Rangel & Cardenas-Árevalo, 2015), while *L. sanctaemartae* displayed a greater association with leaf litter because this species requires a layer of leaf litter that provides humidity and limits light penetration through the canopy, necessary for passive thermoregulation (Angarita *et al*., 2015; Atencia-Gandara *et al*., 2020). These microhabitats or substrates were more frequently observed in secondary vegetation, where these species were abundant. Although the structure of the vegetation cover in the studied rural landscape varies in its components, it allows several species to co-exist due to differences in their habitat and microhabitat preferences. These differences include factors such as proximity to water bodies, stratum height, substrate type, and activity patterns (Muñoz-Guerrero *et al*., 2007; Blanco-Torres & Bonilla-Gómez, 2010; Acuña-Vargas, 2016; Rojas-Murcia *et al*., 2016).

We conclude that changes in land cover at the local scale influence the species diversity of amphibians and reptiles in the study area. This observed trend could represent a common pattern in the lowlands of the Colombian Caribbean, where extensive agricultural and livestock activities are driving substantial anthropogenic impacts. We consider that ponds and secondary vegetation are important elements for the survival and maintenance of local herpetofauna in the rural landscape of the Colombian Caribbean region, and they should be considered in future management and conservation plans for local biodiversity.

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Appendix.
Some species of amphibians and reptiles found in the rural landscape in the department of Sucre, Caribbean region of Colombia. (a) *Boana pugnax*, (b) *Scinax rostratus,* (c) *Scarthyla vigilans,* (d) *Dendrobates truncatus*, (e*) Ceratophrys calcarata*, (f) *Rhinella horribilis,* (g) *Leptodactylus fragilis*, (h) *Pleurodema brachyops*, (i*) Gonatodes albogularis*, (j) *Anolis tropidogaster*, (k) *Anolis auratus,* (l) *Leptodeira ashmeadi*.