UNIVERSIDAD PEDAGÓGICA Y TECNOLÓGICA DE COLOMBIA
FACULTAD DE CIENCIAS
ESCUELA DE CIENCIAS BIOLÓGICAS-POSGRADO
MAESTRÍA EN CIENCIAS BIOLÓGICAS

DIVERSITY AND SPECIES TURNOVER OF AMPHIBIANS AND REPTILES ASSEMBLAJES AMONG BIOTOPES IN A HIGHLY DISTURBED TROPICAL DRY FOREST LANDSCAPE OF NORTHERN COLOMBIA

Requisito para optar el título de Magister en Ciencias Biológicas

JAVIER ANDRÉS MUÑOZ AVILA

TUNJA
Mayo, 2018

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Mayo, 2018

CERTIFICADO DE ORIGINALIDAD

Jairo Antonio Camacho Reyes, Maestría en Biología. Profesor Universidad Pedagógica y Tecnológica de Colombia.

CERTIFICA: El trabajo de grado realizado bajo mi dirección por **Javier Andrés Muñoz Avila** titulado "**DIVERSITY AND SPECIES TURNOVER IN HERPETOFAUNAL ASSEMBLAJES AMONG BIOTOPES IN A HIGHLY DISTURBED TROPICAL DRY FOREST LANDSCAPE OF NORTHERN COLOMBIA"**, reune las condiciones de originalidad requeridas para obtar el título de Magister en Ciencias Biológicas otorgado por la **Universidad Pedagógica y Tecnológica de Colombia**.

Y para que así conste, firmo la siguiente certificación en ciudad y fecha.

Jairo Antonio Camacho Reyes MSc.
Director
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Grupo de Investigación Manejo Integrado de Ecosistemas y Biodiversidad XIUÂ

NOTAS DE ACEPTACIÓN

Según el acta de sustentación No. ____ para **JAVIER ANDRÉS MUÑOZ AVILA**, fue aprobada y calificada esta tesis de maestría como ___ por la Escuela de Posgrados de la Facultad de Ciencias de la Universidad Pedagógica y Tecnológica de Colombia.

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Dedicatoria:

Para

MAMÁ

Mujer que hace más bonita mi vida

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CHAPTER 1

A BRIEFLY HISTORICAL CONTEXT IN HERPETOFAUNAL ASSEMBLAGES

ABSTRACT

In this chapter, we contextualize the transformation of natural habitats mainly for agricultural and cattle activities and urban growth, how these activities changed the biotic and abiotic conditions of ecosystems, affecting the structure and composition of amphibians and reptile's populations. The forest ecosystems (Tropical Dry Forest) of Cesar and Magdalena departments have been exploited for decades, making them a highly threatened and priority conservation area for Colombia. Amphibians and reptiles have different habitat perceptions depending on the scale they reproduce, behave and interact with environment, making necessary to adapt physiological conditions related to climatic factor and vegetal coverages along the environment gradients. For this reason, amphibians and reptiles play a functional key role in ecosystems and are important, directly or indirectly, for human beings.

Keywords: amphibians, Cesar, coverage, Magdalena, reptiles, transformation.

INTRODUCTION

Researches about herpetofauna of the lowlands of the Cesar and Magdalena departments have been carried out by Castaño (2002), Rueda et al., (2007), Ecopetrol (2010), Berry et al., (2011), Medina et al., (2011), Páez et al., (2012), however, these studies do not include a detailed and quantitative analysis of the patterns of species turnover between plant cover.

In this study, these assemblages are analyzed with recent approaches to measure biological diversity, which control biases of traditional methodologies (Magurran, 2004, Jost, 2006, Chao & Jost 2012, Jost & Gonzales, 2012, Blanco et al., 2013, Paternina et al., 2015, Angarita et al., 2015, Rojas et al., 2016).

Jost & Gonzales (2012) raise the need to use mathematical tools that allow us to study biological diversity and, in turn, the conclusions per se, are adequate to measure, establish and promote conservation criteria and priorities, considering the environmental problems that we are facing nowadays. An integrated sampling allows comparing the richness of species within a community based on sampling conducted in areas with the same coverage instead of sampling with areas of equal size. By comparing these samplings within the same coverage, it is ensured that they are equally complete and that the unregistered species constitute the same proportion of the total individuals of each community (Chao & Jost 2012). Diversity has been confused with the indexes used to measure it (Jost 2006), which can give erroneous interpretations of the diversity of a particular sampled area.

The growth of the human population implies a high demand for resources, promoting transformation of large areas of natural habitats or agricultural production systems, an area that has expanded in the last century (Kattan & Álvarez 1996, Etter et al., 2006, Sánchez et al., 2012). However, the land expansion rate for cattle and agriculture uses has decreased since 1960, the rate of deforestation continues to occur in many tropical countries, including Colombia (Etter et al., 2006).

The vegetal coverage change is the main reason of decline in ecological systems at local and global scales, which causes changes in the microhabitat requirements of individuals, tolerance thresholds, specific environmental dependencies, species dispersal and colonization ability, soil degradation, loss of biodiversity, among others (Bernal 2014), making a high risk in the structure, function and stability of ecosystems (Ehrlich & Ehrlich 1981, Gitay et al., 2002). The last, has direct and indirect effects on local and regional communities such as nonstop habitat loss, microclimatic changes and trophic niches loss (Blanco & Bonilla 2010). Moreover, transformation in the structure and the loss of the forest increase the risks of predation, in birds, amphibians, reptiles and mammals, decreasing the food resource located at a great distance (Grajales et al., 2003, Gutiérrez et al., 2004).

Colombia is one of the most biodiverse countries on the planet, mainly in the categories of plants, mammals, reptiles, amphibians and birds (Chavez & Arango 1998, Myers et al 2000, Orme et al 2005, SIB Colombia 2014). However, the diversity and abundance of fauna has been disturbed by changes in landscapes and vegetal coverages (Lehtinen et al., 2003), from the habitat transformation, change in light intensity, temperature, humidity, availability of microhabitats, wind speed, among others (Pringle 2003). Furthermore, fragmentation processes on the landscape produced by anthropic involvement produce subpopulations that are increasingly separated and more likely to have the strongest effect on populations with low natural dispersion rates, such as: declines in amphibians and reptiles population worldwide, due to their low potential dispersion and availability of different microclimates in microhabitats, where relative humidity is very close to 100%, an important circumstance in the life of these organisms because it determines the rate of water lost (Gutierrez et al., 2004, Begon et al., 2006, Herzog et al., 2011).

Despite the high biodiversity and natural resources in the national territory, there is still non-consistent information on the use and transformation of the soil (Sánchez et al., 2012), a transformation that in Colombia is not homogeneous, since it varies enormously between different ecological and political regions (Chavez & Arango 1998). However, the transformation of forest cover in Colombia usually begins with the felling of small areas used for subsistence agriculture, then they are replaced by grazing land for livestock and mechanized agriculture (Etter et al., 2006). For Caribbean region, the use of land by livestock represents 48% and another considerable use for agriculture by 14% (Sánchez et al., 2012). The last, implying the search of diversity patterns, of habitat use and others ecological attributes of the biotic assemblages in ecology, taxonomy, conservation among others (Horta et al., 2009).

Some researches referring to the effects of the transformation of vegetal coverage in other groups of fauna are: Fahrig & Merriam (1985), they assessed a species of mouses (*Peromyscus leucopus*) using a dynamic model to simulate the change of sizes of the resident populations in a series of patches of interconnected habitats, finding that the migration is low when a patch is separated from another similar patch, evidencing that in circumstances like this, the probability of survival in the patch is very low. Dunstan & Fox (1996), showed that the richness and abundance of mammalian species decreases significantly with the decrease in the size of the forest remnant and the increase in disturbance. Jokimäki & Suhonen (1998) made a study with 26 different species of winter birds (5155 individuals observed) in Finland, determining that birds recognize their environment by signals or trails with certain features of vegetation and habitat. Whittingham & Evans (2004) conclude that the habitat structure, affects the options of habitats used for foraging and nesting of birds in areas of agricultural use, thus increasing the risk of predation. In terms of amphibians and reptiles, Grajales et al (2003) assessed the richness and distribution of anurans in a region of the Colombian Pacific in three habitats subject to deforestation area (1) highly intervened, (2) moderately intervened and (3) minimally intervened, concluding that the wealth and distribution of amphibians is clearly affected by the procedures of human intervention.

The strongest factors that contribute to the population decrease of amphibians and reptiles is the destruction and alteration of the habitat (Blaustein et al., 1994). Given their condition as ectothermic organisms, they depend on environmental sources for the gain or loss of heat. Many of these organisms regulate their body temperature within relatively narrow ranges, taking advantage of sources such as the sun and warm surfaces arranged in the environment (Vitt & Caldwell 2014), necessary to reduce and/or regulate their temperature; which is why in terrestrial ecosystems, they use a variety of behavioral and physiological mechanisms to control body temperature (Cloudsely 1972, Bartholomew 1982, Vitt & Caldwell 2014). Equally important for these organisms is maintaining a constant range of body temperature as it has a direct effect on most physiological processes, including the locomotion, behavior, and development of amphibians and reptiles (Prech et al., 1973, Wieser 1973, Sousa & Crespo 2003).

RESEARCH QUESTION

How does the structure and composition of the amphibian and reptile's communities vary between biotopes, in some areas of the Cesar and Magdalena departments?

MAIN OBJETIVE

Assess changes in the structure and composition of assemblages of amphibians and reptiles in four biotopes (Forest, swamp border, grassland and Oil Palm Crops), in some areas of the Cesar and Magdalena departments.

SPECIFIC OBJETIVES

- Identify the amphibians and reptiles present in four biotopes, in some areas of the Cesar and Magdalena departments.
- Compare the assembly of amphibians and reptiles in four biotopes, in some areas of the Cesar and Magdalena departments.
- Asses how the richness and diversity of amphibians and reptiles is related to the habitat structure variables.

MATERIALS AND METHODS

Study area

The study area is located in the Colombian Caribbean region, and covers three localities (Fig. 1); two of them in the Cesar department: municipalities of Gamarra – San Alberto and municipality of Chimichagua. A third locality is in the Magdalena department: Aracataca-Tucurinca. The average linear distance between localities is 220 Km. All native vegetal coverage in the localities is transformed mainly for implementation of cattle and agriculture of rice, cassava, and palm oil. The last, implies stream deviation for water irrigation (Armenteras & Rodríguez 2014).

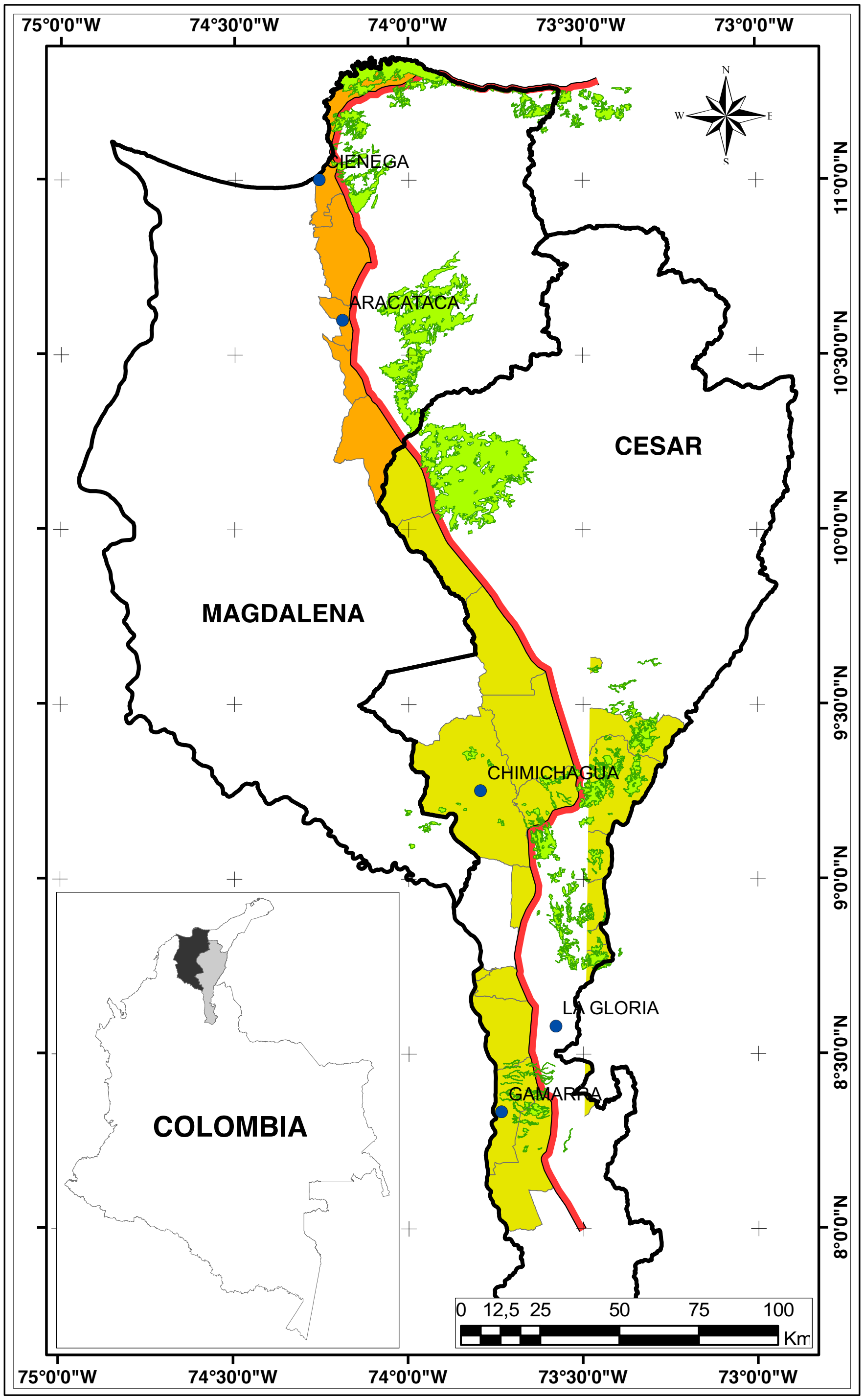

Figure 1. Study area in the departments of Cesar and Magdalena. Colombia. South America.

Fieldwork

In each locality, we sampled four vegetal covers called here biotopes (forest, grassland, swamp borders and oil palm crops); in the Cesar department (Gamarra-San Alberto and Chimichagua) and three (forest, grassland and oil palm crops) in the Magdalena department (Aracataca-Tucurinca) taking into account its high representatively in the landscape. Data were collected twice during the wet season (May - April and August - September 2015) and twice during the dry season (July – December 2015), we made four field trips, each one lasting 11 days, except in July that was nine because we could not have sampled swamp coverage.

For each vegetal cover three transects of 50 x 2 m were set up, one transect was located in the edge and two in the interior of the coverage area. Transects were separated from each other by a minimum distance of 400m. The sampling of amphibians and reptiles was made by four persons during the day (14:00 - 18:00) and at night (18:00 – 22:00). In addition, we also used the constrained visual encounter surveys (Crump & Scott, 1994) in areas out of transects as a complement technique that increased the chances of recording species associated to microhabitat do not represented inside transects. For each individual captured we recorded its body size (snout-vent length), environment temperature and relative humidity (using a USB data logger), time of observation, substrate (leaf litter, roots, trunks, etc). The species identification was based on Cochran & Goin 1970, Medina-Rangel et al. 2011, Narvaes & Trefaut 2009, Peters & Orejas 1970, we also receipt help for specialist; the scientific nomenclature followed Uetz et al. (2014) and Frost (2018). Some of the individuals captured were used as vouchers and are deposited in the Museo de Historia Natural Luis Gonzálo Andrade of the Universidad Pedagógica y Tecnológica de Colombia.

PRODUCTS GENERATED THROUGH THIS THESIS

Bedoya-Cañon M.A, **Muñoz-Avila J.A** y Vargas-Salinas F. 2018. Morphology and natural history of the mud turtle *Kinosternon scorpioides scorpioides* in populations of Northern Colombia. Herpetological Review, en prensa.

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PRODUCTS IN PROCESS

Muñoz-Avila J.A, Vargas-Salinas F, Díaz-Pérez C.N. y Morales Puentes M.E. Editores. Libro. Anfibios y Reptiles en bosques secos tropicales del Norte de Colombia. Universidad Pedagógica y Tecnológica de Colombia.

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CHAPTER 2

DIVERSITY AND SPECIES TURNOVER OF AMPHIBIANS AND REPTILES ASSEMBLAJES AMONG BIOTOPES IN A HIGHLY DISTURBED TROPICAL DRY FOREST LANDSCAPE OF NORTHERN COLOMBIA

ABSTRACT

It is important to record in detail the ecological aspects of biotic assemblages in the tropical dry forest (TDF) of Colombia, as this is one of the most threatened ecosystems in the country and the world. Because amphibians and reptiles are ectothermic vertebrates with little vagility, they are especially susceptible to the high deforestation that has occurred in TDF. Therefore, the ecological role of these vertebrates in the suitable ecosystem functioning of the TDF might be altered. Using modern measurements that control traditional biases in biodiversity measures, we examined the taxonomic diversity of amphibians and reptiles in the four predominant biotopes in the departments of Cesar and Magdalena, north of Colombia: forest remnant, grassland, tropical swamp border and oil palm crops. Between February 2015 and January 2016, four field trips were carried out, each spanning 11 days in the field and covering the dry and the rainy seasons. With a sampling effort of 1408 hours/observer, 21 species of amphibians and 44 of reptiles were registered, four of which are endemic to Colombia, one of which is in Critical Risk (CR) and two of which are classified as Vulnerable (VU). Standardizing the same sampling coverage, the forest remants was the biotope with the greatest diversity of amphibians and reptiles, and the swamp borders were the biotope with the lower diversity. This result implies that

forest remnant should be a priority for conservation areas independent of the size and isolation of the remnant. The results obtained here are expected to provide basic information that helps to optimize management and conservation plans in a highly threatened ecosystem.

Keywords: amphibians, Colombia, diversity, reptiles and Tropical Dry Forest.

INTRODUCTION

The world is in a global biodiversity crisis; the species extinction rate today is 100 times higher than in the past (Ceballos et al., 2015). This crisis is attributed to several non-mutually exclusive causes including invasive species, contamination of water bodies, excessive hunting, and trafficking of species; however, forest deforestation for the commercial of sale of wood and the implementation of agriculture and cattle is considered the most significant threat for biodiversity conservation (Lepers et al., 2005, Etter et al., 2006). Forests cover 31% of the earth's surface (FAO 2012), but 0.12% of that coverage is deforested annually (Etter et al., 2006, Armenteras & Rodríguez 2014). Deforestation has a direct negative effect on species because of habitat loss, as well as the alteration of abiotic conditions such as temperature, humidity, or exposure to air currents (Saunders et al., 1991, Mendoza et al., 2007). It has an indirect negative effect through the alteration of biotic interactions between species because of changes in the structure and composition of assemblages (Saunders et al., 1991).

Tropical Dry Forests (TDF) are among the most threatened ecosystems around the world; at present, only 8% of the original coverage persists (Dirzo et al., 2011, Ceballos et al., 2015) because most of TDF has been deforested for implementing cattle and farming activities (Ceballos et al., 2015). Colombia is one of the countries in the neo-tropics with a large TDF coverage (Pizano & Garcia 2014, Vásquez et al., 2014), but most of such coverage (92%) has been deforested. At present, only isolated forest remnants enveloped by open areas persist; the largest remnants of TDF persist in the Caribbean region of the country (Vásquez et al., 2014). Although traditionally underestimated and considered as a poor ecosystem in comparison with humid forest (Dirzo et al., 2011), the biological diversity in TDF is considerably high and exhibits many distinctive species (Mares, 1992). This implies that extended areas of this ecosystem can disappear without any knowledge about the basic aspects of species composition and the ecology of its associated diversity.

There are some studies about the faunal diversity in TDF of Colombia, but our knowledge is still poor about ecological processes in those assemblages. For instance, there are checklists of species and analyses of assemblage structure for ants, dung beetles, spiders, and termites in altered landscapes (Escobar, 1997, Escorcia et al., 2012, Abadía et al., 2013, Arenas et al., 2013), mymercofauna comparison between forest relicts (Armbrecht, 1995, Armbrecht 1999, Arenas et al., 2013), microhabitat use by scorpions (Álvarez et al., 2013), and habitat preferences by caddisfly larvae in watersheds (Vásquez et al., 2014). With respect to vertebrates, there are studies about distribution of birds (Ayerbe et al., 2008, Losa & Molina 2011, Lara et al., 2012), and diversity patterns of mammals (Adler et al., 1997, Solari et al., 2013). Some of previous studies have found that species diversity increases with size of the forest remnant, but this also depends of the matrix characteristics (Arenas et al., 2013). For amphibians and reptiles, there are numerous inventories and distribution reports of species in the TDF of Colombia (Acosta, 2000, Urbina et al., 2015, Acosta, 2012., Romero & Lynch 2012., Blanco et al., 2013, Paternina et al., 2015, Angarita et al., 2015, Rojas et al., 2016), but just few of them examine ecological processes such as edge effects in diversity and species composition finding amphibians and reptiles responding to that effect, mainly in the abundance of the species in the interior forest at distance of 250-408 m (Carvajal & Urbina 2008, Carvajal & Urbina 2015, Pizano & García 2014, Schneider-Maunoury et al., 2016, Suazo-Ortuño et al., 2018).

Moreover, for the total sampled area and according to Rangel (2012), a high or low diversity obey a series of factors acting individually or synergistically. For TDF mainly of northern Colombia, the water gradient presented by the altitudinal changes associated with the presence of the Sierra Nevada de Santa Marta (Aracataca – Tucurinca municipalities) and the Serrania de Perijá, (Gamarra - San Alberto – Chimichagua municipalities) and the ecological gradient associated with the dissimilar types of vegetation present in the floodplains of the Zapatosa Swamp and the Cesar River, mold the biotic assemblages present in this departments of Colombia.

The last, implies a necessity to encourage a deeper knowledge of the ecology of assemblages of amphibians and reptiles in TDF of Colombia and also is important given that first, those vertebrates are especially susceptible to habitat fragmentation because of their ectothermic condition and low vagility (Lehtinen et al., 2003), and second, because they are abundant predators and prey with an important role in the trophic web energy flow, and hence, in ecosystem functioning (Wells, 2007). Therefore, unbiased measures of species diversity in amphibian's and reptile's assemblages will help to establish conservation strategies, particularly in threatened ecosystems such as TDF (Mares, 1992, Carvajal & Urbina, 2008, Pizano & García 2014). Here, we quantify and analyze the species diversity using modern metrics that control sampling bias present in traditional measures of diversity (e.g. Chao & Jost 2012, Colwell et al., 2012, Chao et al., 2014).

MATERIALS AND METHODS

Study area

The study area is in the Colombian Caribbean region, and covers three localities (Fig. 2). Two localities are in the Cesar department: municipalities of Gamarra-San Alberto (8°26'1.72"N 73°43'31.83"W), and the municipality of Chimichagua (9°17'52.00"N 73°46'31.79"W); the third locality is in the Magdalena department: municipalities of Aracataca-Tucurinca (10°36'41.90"N 74° 4'41.60"W). The mean annual temperature in the study area exceeds the 24°C, and the precipitation level is between 250 – 2000 mm/year, there is a bimodal climatic regimen with two long periods of drought (First period - December, February and March. Second period – June and July) and two short periods with highly rains (First period - April, May and June. Second period - August, September and November) (Rangel-Ch, 2007). Most of the forested vegetal coverage in the study area has been transformed mainly for the implementation of cattle and agriculture activities; the last one implying deviation of the streams natural course for water irrigation of rice, cassava, and oil palm crops (Armenteras & Rodríguez 2014). Therefore, nowadays the landscape is composed of few gallery dry forest remnants in a matrix dominated by grasslands and crops.

Field work

In each of the three localities of study, I selected four biotopes: forest (F), grassland (G), swamp borders (SB) and oil palm crops (OP) (Fig. 2); however, in the locality of Aracata-Tucurinca was not possible to doing sampling in SB because restricted access to private lands. Four fieldtrips, each one lasting 11 days, were made to the study area between May 2015 and January 2016. For each biotope located in each locality there were two samplings in dry seasons and two samplings in rainy seasons.

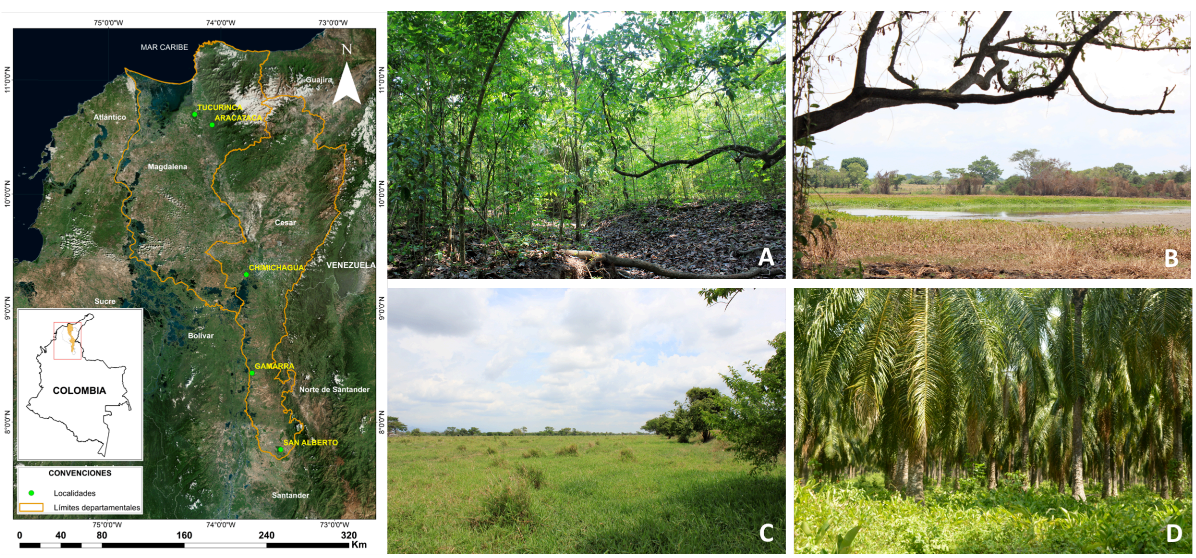

Figure 2. Geographic position of the study areas (3 localities: Gamarra-San Alberto, Chimichagua, and Aracataca-Tucurinca) in four biotopes: (A). Forest (B). Swamp borders (C). Grassland and (D). Oil palm crops. Departments of Cesar and Magdalena of Colombia (department delimited by the yellow line).

For each biotope in each locality, I randomly located three lineal transects, each one of 50 x 4 m; these transects were separated from each other by a minimum distance of 400m. The three transects were sampled by four people for amphibians and reptiles in a same day (14:00 - 18:00 h) and a same night (18:00 – 22:00 h). We implemented a time-constrained visual encounter surveys (Crump & Scott, 1994) we recorded biotope of observation, body size (snout-vent length, SVL), sex if possible, environment temperature, relative humidity (using a USB data logger), time of observation, type of substrate (leaf litter, roots, trunks, etc), and the presence or absence of bodies of water. In addition, daytime and nighttime visits were made outside the transect area to increase the probability of observing species associated to microhabitats not present inside transects.

The species identification was based on possible presence of the species in the area, previously knowledge, and morphological descriptions by Cochran & Goin (1970), Medina-Rangel et al., (2011), Narvaes & Trefaut (2009), Peters & Orejas (1970). In this study, I followed the taxonomic nomenclature by Cochran & Goin (1970), Medina-Rangel et al., (2011), Narvaes & Trefaut (2009), Peters & Orejas (1970). Some individuals were collected and slaughtered according to standard procedures (McDiarmid 1994., Simmons & Muñoz-Saba 2005), and deposited in the Museo de Historia Natural Luis Gonzálo Andrade of the Universidad Pedagógica y Tecnológica de Colombia, Tunja, Boyacá.

Analysis of data

Because our records inside and outside of transects were based on visual encounters of individuals and there was no differentiation of the species composition, for the analyses of both types of records were grouped according to the recommendations of Colwell et al., (2012). To compare the diversity of amphibians and reptiles among the four biotopes a sampling coverage analysis was performed (sensu Chao & Jost 2012, Colwell et al., 2012, Chao et al., 2014) using the iNEXT package (Hsieh et al., 2014) on the R platform v. 3.2.2 (R Core Team, 2015). In these diversity analyzes, different levels of sensitivity to the relative abundance of the species are used (q=0, 1, and 2). When q= 0, the diversity calculations ignore the difference in the relative abundance of individuals per species and the value of diversity obtained is equal to the value of species richness. When q=1, the species are weighted according to their relative abundance and a calculation corresponding to the exponential of the Shannon-Wienner index is obtained. When q= 2, the diversity calculations are mainly influenced by the most abundant species and the value obtained corresponds to the inverse of the Simpson index (Jost 2006, Jost & Gonzalez-Oreja 2012, Chao et al., 2014).

We calculated Beta (β) diversity among biotopes based on the guidelines proposed by Jost (2006, 2007) at two scales of analysis: at the level of all the coverages (i.e. gathering data from all the locations), and at location level. However, given that β diversity can reflects two different and antithetic processes (nestedness: species of sites with smaller richness are subsets of the species at richer sites [βNES], or spatial turnover: replacement of some species by others [βSIM]) (Baselga, 2010), we calculated βSIM and βNES indexes in the package betapart (Baselga & Orme, 2012). On the other hand, to compare species composition among biotopes, we used the similarity index by Chao-Jaccard (Chao et al., 2005, Chao et al., 2006), which was calculated in Estimates 9.0 (Colwell, 2013) and was charted in a dendrogram using PAST 3.0 (Hammer et al., 2001).

RESULTS

Species recorded

With an effort of 384 person-hours for each biotope of F, G, and OP, and 256 person-hours for SB (1408 person-hours in total), we recorded 21 species of amphibians (883 individuals, Table 1), and 44 species of reptiles (739 individuals, Table 2). We observed 19 species of amphibians in the biotope F, 17 in G, 9 in SB, and 16 species in OP (Table 1). The frog *Leptodactylus fuscus* was the most abundant amphibian and it was present in the four biotopes; *Ceratophrys calcarata* was the less abundant species with just nine individuals recorded in the biotopes F and G. With respect to reptiles, we recorded 33 species in the biotope F, 25 in G, 20 in SB, and 27 in OP (Table 2). The lizard *Anolis auratus* was the most abundant reptile and it was present in the four biotopes; the snake *Boa constrictor* was the less abundant reptile with just one individual recorded in the biotope F.

Table 1. Species of amphibians recorded in each biotope: Forest (F), Grassland (G), Swamp Border (SB) and Oil Palm Crop (OP), and threat status.

FAMILY/SPECIE	Coverage				Threat status	
	F	G	SB	OP	IUCN	Red Books
BUFONIDAE						
Rhinella humboldti	17	6	6	12	LC	
Rhinella marina	3	0	3	2	LC	LC
CERATOPHRYIDAE						
Ceratophrys calcarata	3	6	0	0	LC	
DENDROBATIDAE						
Dendrobates truncatus	9	7	0	0	LC	
HYLIDAE						
Dendropsophus microcephalus	0	5	31	18	LC	
Boana boans	31	4	0	0	LC	
Boan xerophylla	30	10	0	5	LC	
Boana pugnax	11	4	1	38	LC	

Phyllomedusa venusta	5	0	0	0	LC	
Scinax rostratus	3	18	0	6	LC	
Trachycephalus typhonius	6	3	0	2	LC	
LEIUPERIDAE						
Pleurodema brachyops	18	10	2	38	LC	
Pseudopaludicola pusilla	4	41	0	4	LC	
LEPTODACTYLIDAE						
Engystomops pustulosus	46	8	0	29	LC	
Leptodactylus fragilis	18	4	17	35	LC	
Leptodactylus fuscus	14	8	16	195	LC	
Leptodactylus insularum	30	2	9	3	NA	
Leptodactylus poecilochilus	3	2	0	3	LC	
MYCROHYLIDAE						
Elachistocleis panamensis	0	1	0	0	LC	
Elachistocleis pearsei	2	0	0	1	LC	
RANIDAE						
Lithobates vaillanti	2	0	2	13	LC	

Table 2. Species of reptiles recorded in each biotope: Forest (F), Grassland (G), Swamp Border (SB) and Oil Palm Crop (OP) and threat status.

FAMILY/SPECIE	Coverage				Threat status	
	F	**G**	**SB**	**OP**	**IUCN**	**Red Books**
ALLIGATORIDAE						
Caiman crocodilus	8	0	0	1	LC	LC
BOIDAE						
Boa constrictor	1	0	0	0	NA	LC
Epicrates maurus	1	2	1	0	NA	LC
Corallus ruschenbergerii	13	0	7	5	NA	LC
CHELIDAE						
Mesoclemmys dahli	2	0	0	0	CR	EN
COLUBRIDAE						
Chironius carinatus	0	0	0	4	DD	LC
Helicops danieli	0	1	0	0	LC	LC
Imantodes cenchoa	0	1	0	3	NA	LC
Leptophis ahaetulla	2	0	0	0	NA	LC
Mastigodryas pleei	1	3	1	3	NA	LC
Oxybelis aeneus	1	0	0	0	NA	LC
Pseudoboa neuwiedii	0	5	2	1	NA	LC
Spilotes pullatus	0	0	1	0	NA	LC
CORYTOPHANIDAE						

Basiliscus basiliscus	29	2	2	27	LC	LC
DACTYLOIDAE						
Anolis auratus	14	8	24	125	NA	LC
Anolis tropidogaster	15	0	0	3	NA	LC
DIPSADINAE						
Enulius flavitorques	2	1	0	0	NA	LC
Leptodeira septentrionalis	2	0	3	1	NA	LC
Lygophis lineatus	0	1	0	2	LC	LC
Phimophis guianensis	1	0	1	0	NA	LC
Thamnodynastes gambotensis	2	1	0	1	LC	LC
EMYDIDAE						
Trachemys callirostris	0	0	5	0	NA	VU
GEKKONIDAE						
Hemidactylus frenatus	1	4	0	4	LC	
GYMNOPHTHALMIDAE						
Bachia bicolor	1	2	0	0	NA	LC
Gymnophthalmus speciosus	1	0	0	6	NA	LC
Leposoma rugiceps	1	2	0	4	LC	LC
Tretioscincus bifasciatus	2	11	9	18	NA	LC
IGUANIDAE						
Iguana iguana	2	2	7	4	NA	LC
KINOSTERNIDAE						
Kinosternon scorpioides	10	4	4	2	NT	LC
PHYLLODACTYLIDAE						
Thecadactylus rapicauda	8	1	6	1	NA	LC
POLICHROTIDAE						
Polychrus marmoratus	6	0	0	0	NA	LC
SCINCIDAE						
Mabuya sp	7	2	0	6	LC	LC
SPHAERODACTYLIDAE						
Gonatodes albogularis	34	16	18	28	NA	LC
Lepidoblepharis sanctaemartae	29	4	0	0	LC	LC
Sphaerodactylus heliconiae	5	3	0	3	NA	DD
TEIIDAE						
Ameiva ameiva	6	5	7	4	NA	LC
Holcosus festivus	0	0	6	0	LC	LC
Cnemidophorus lemniscatus	21	0	25	18	NA	
Tupinambis teguixin	0	0	5	3	LC	LC
TESTUDINIDAE						
Chelonoidis carbonarius	0	5	0	3	NA	VU
TROPIDURIDAE						

Stenocercus erythrogaster	8	0	0	0	LC	LC
VIPERIDAE						
Bothrops asper	6	1	0	5	NA	LC
Crotalus durissus	2	0	0	0	LC	LC
Porthidium lansbergii	0	2	1	0	NA	LC

Microhabitat

The most used substrate by the amphibians was the soil, followed by leaves and branches of herbaceous vegetation and leaf litter. There was a difference in the tendency among families to the use of a particular kind of substrate; for instance, the species of the family Hylidae most of the time were observed on herbaceous vegetation, frogs of the family Mycrohylidae exclusively under soil, while the use of substrate in the family Leptodactylidae was diverse (Fig. 3). The most used substrate by the reptiles was the soil, however, on branches of herbaceous vegetation was frequently to observe lizards sleeping at night, such as individuals of *Basiliscus basiliscus*, *Anolis auratus*, and *Hemidactylus frenatus*. Others species of reptiles were observed mainly in leaf litter and trees (Fig. 3).

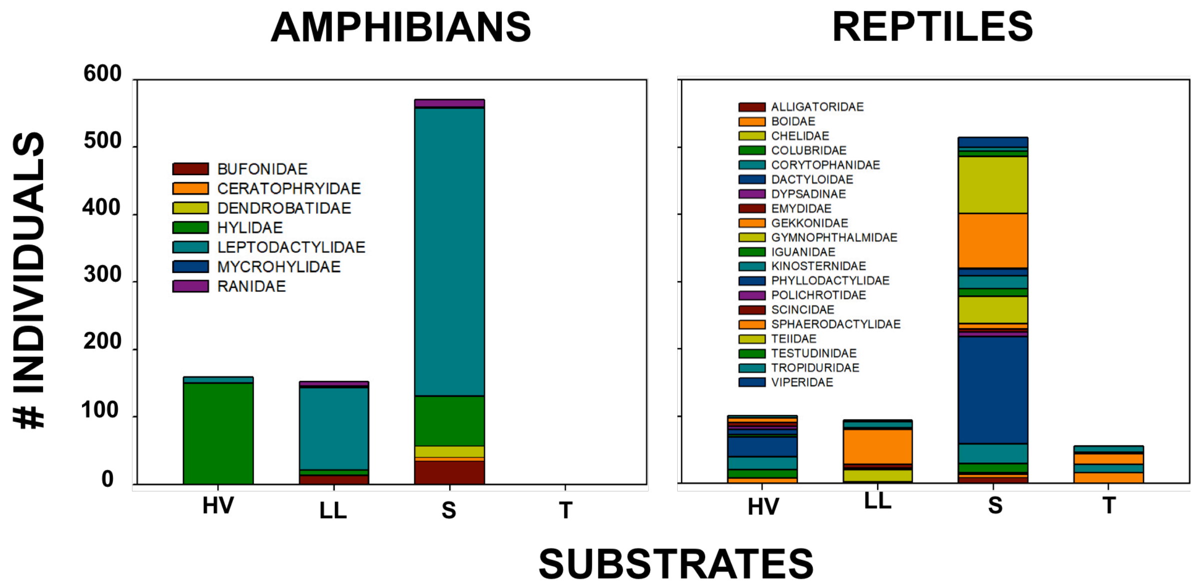

Figure 3. Substrate use for amphibians and reptiles in TDF at the departments of Magdalena and Cesar. Colombia. **HV**. Herbaceous vegetation **LL**. Leaf litter **S**. Soil, sand and dirt. **T**. Trees.

Alpha diversity (α)

Our records for the four biotopes (F, G, SB and OP), suggest that the amphibians and reptile's richness (diversity q=0) shows a similar tendency; for amphibian's G and F are statistically different from the other biotopes. In reptile's F and OP were the coverages with the most species diversity compared with SB and G. Similar tendency's show the diversities indexes q=1 and q=2 (Fig. 4).

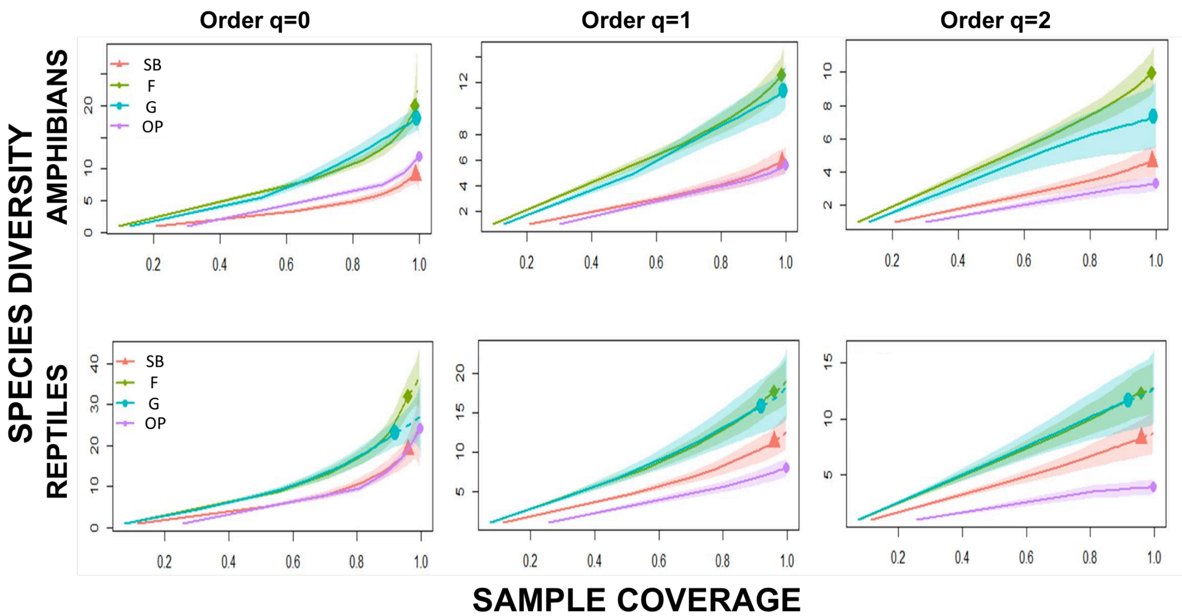

Figure 4. Amphibians and reptile's richness comparison (q=0), diversity (q=1), diversity (q=2). Biotopes. (F). Forest (G). Grassland (SB). Swamp border and (OP). Oil Palm Crop. 'q' values indicate the sensibility level of the diversity calculate relative species abundance. Shaded areas belong to the confidence intervals of 95% for each biotope.

Species turnover between biotopes (β diversity)

When we analyzed β diversity at location level (i.e. comparing biotopes – F, G, SB and OP), the highest turnover of amphibians and also in reptiles were observed in OP. However, the species similarity among biotopes showed a similar pattern between amphibians and reptiles but, for amphibians, the grouping pattern suggests that the species similarity would co-varies with the level of OP coverage: G and SB, tend to be more similar among each other than with respect to F. In reptiles, it was noted that OP tend to make up a separate entity from the group conformed by G, SB and F.

The amphibians and reptile's species turnover between biotopes were very similar and the species similitude showed a similar patron between amphibians and reptiles (Fig. 5). The assemblage pattern suggests that the species similitude co-varies with the level of OP. G share some species with SB and F that tend to be similar between them. In all the biotopes sampled, the amphibians and reptile's species turnover was higher in the OP coverage.

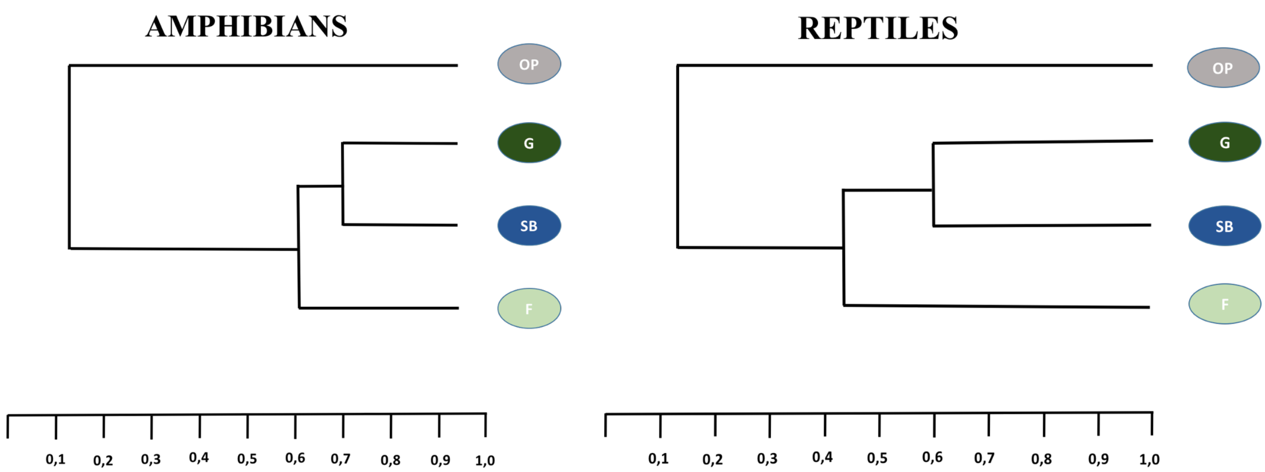

Figure 5. Chao – Jaccard Similitude index, between four biotopes presents in the departments of Cesar and Magdalena. Colombia. Analysis based on the amphibians and reptile's species similitude and relative abundance of individuals. **F**. forest **G**. grassland **SB**. swamp border **OP**. oil palm crops.

Discussion

The Caribbean Region physiography is different in the plains, which are interrupted by mountainous areas like the Sierra Nevada de Santa Marta, Macuira in Guajira, San Lucas and San Jacinto in Bolívar, and the Perijá in Cesar and Guajira (Rangel, 2012), affecting the climate and rainy performance between these topographies areas.

The 21 amphibians and 44 reptile's species, we observed in our study the sampling biotope analysis shows that we reported the 90% of the species in the lowlands of the departments of Cesar and Magdalena (Acosta, 2000, Medina-Rangel et al., 2011, Moreno & Medina, 2007, Moreno et al., 2009, Romero & Lynch, 2012, Carvajal et al., 2012, Carvajal et al., 2013, Paternina et al., 2013). This successful record of amphibian and reptile's species, is due to the high intensity of sampling (a sampling effort of 1408 hours/observer), climatic seasons comparison, as well as sampling in the four more prevalent coverages throughout the assessed area (F, SB, G and OP).

Overall, the four biotopes sampled in the study have suffered a high transformation of anthropogenic origin. This could explain why the communities of amphibian and reptile's species turnover in the vegetal coverages is high and also are mostly composed of tolerant habitat disturbed species that can also remain in small forest fragments. For example, some amphibian species *Rhinella humboldti*, *Boana pugnax*, *Pleurodema brachyops*, *Leptodactylus fragilis*, *Leptodactylus fuscus* and *Leptodactylus insularum* were recorded in the four vegetal coverages. Meanwhile, other species *Ceratophrys calcarata*, *Dendrobates truncatus*, *Phyllomedusa venusta*, *Elachistocleis panamensis* and *Elachistocleis pearsei*, species with the less abundance, were recorded only in one or two vegetal coverages. In respect of reptiles, the species *Mastigodryas pleei*, *Basiliscus basiliscus*, *Anolis auratus*, *Tretioscincus bifasciatus*, *Iguana iguana*, *Kinosternon scorpioides scorpiodes*, *Thecadactylus rapicauda*, *Gonatodes albogularis* and *Ameiva ameiva* were recorded in the four vegetal coverages. Meanwhile, other species like *Boa constrictor*, *Mesoclemmys dahli*, *Chironius carinatus*, *Helicops danieli*, *Leptophis ahaetulla*, *Oxybelis aeneus*, *Spilotes pullatus*, *Anolis tropidogaster*, *Trachemys callirostris*, *Polychrus marmoratus*, *Holcosus festivus*, *Stenocercus erythrogaster* and *Crotalus durissus* were recorded only in one or two vegetal coverages.

Although amphibians and reptiles present a generalist use of the different habitat resources in the TDF (Carvajal-Cogollo et al., 2012), the distribution and abundance of amphibians and reptiles is directly related to the availability of the water resource, the relationship increases the resource supply and prey availability. The rainy and dry seasons fluctuation in the TDF, regulates and modifies the behavior of both, predators and preys (Angilletta, 2009, Begon et al., 2006, González et al., 2011). Enhanced to the above, in the oil palm coverage, rivers and streams near are diverted to keep the crops irrigated, so we believe that was the main reason we found more amphibians and reptile's species records. For example: for amphibians, except for some species that were recorded only in one or two coverages (*Ceratophrys calcarata*, *Dendrobates truncatus*, *Boana boans*, *Phyllomedusa venusta* and *Elachistocleis panamensis*), all the others were recorded in a highly transformed ecosystem (OP), and not in the other vegetal cover (e.g. forest coverage). For reptiles, only *Boa constrictor, Mesoclemmys dahli*, *Chironius carinatus*, *Helicops danieli*, *Leptophis ahaetulla*, *Oxybelis aeneus*, *Spilotes pullatus* and *Trachemys callirostris* were found in just one vegetal coverage, the others had a wide record distribution.

The habitat, such as an aspect with environmental resources and factors relating, makes steady conditions, very helpful for amphibians and reptiles physiology requirements (González et al., 2011). So, right there is the importance for microhabitats and the preference substrate used for each specie (Gysel & Lyon, 1980, Morrison et al., 1998) and sort of the place where the species develops its metabolic function (Heyer, 1994). Furthermore, it should be taken into account the strong influence of the temperature for the development, life, and behavior (Grant & Dunham, 1990, Adolph & Porter, 1993) is an imperative parameter related to the thermal ecology (Huey, 1982, Sinervo & Adolph, 1994), as well the recorded temperatures for us, almost 45^{0}C at 14:00 hours in a OP coverage, changing the heat assimilation either by solar thermal energy or thermal conduction (Pianka & Vitt, 2003).

The ecophysiology characteristics of amphibians and reptiles make them good indicators of environments health (Pouhg, 1980, Zug et al., 2001). The last is true, in our context and the data results shows a hard panorama about that, because the forest cover treat and the water resource applied for example to crops (OP), change the water supply and demand and thereby the ecophysiology behavior, quality and survival of amphians and reptiles (Pereira & Daily, 2006). That are also generated and empowered for the forest anthropic transformation estimated in 65% and 78% for the Caribbean Region (MAS 2015) and more than 95% in the TDF forest covers (Carvajal-Cogollo, 2014). This data implies that forest remnant should be a priority for conservation areas independent of the size and isolation of the remnant. We expected that public polices about conservation helps to optimize management and conservation plans in these highly threatened ecosystems.

The structure in complexity and vegetation heterogeneity of the vegetal coverages sampled, is negatively affected due to the low, resulting from a process of transforming large sections of native vegetation into fragments of habitat, becoming an aggressive matrix for amphibians and reptiles, because it restricts the dispersion of species, increasing edge effects such as the exposed by Gascon et al., (1999), Laurance et al., (2002), Grajales et al., (2003), Carvajal-Cogollo 2014 & Paternina-Hernández (2014). Furthermore, the abundance of resources on which the animals depend, the different vegetal coverage they use, the food and the habitats, change drastically due to the soil transformation (Mills et al., 1989), affecting its physiology and does not reacting to these microenvironmental conditions.

Finally, amphibians and reptiles are especially sensitive to changes in their environment, which results in local extinctions. Here we contribute in part to the high historical rate of TDF habitat transformation, because the changing configuration of the landscape, leaving a mosaic of natural coverages immersed in a matrix of anthropogenic coverings. These landscapes using mainly for cattle and farms activities present highly variable conditions of temperature, precipitation and plant structure, imposing environmental filters that shape the observed patterns of diversity of these groups at present. The diversity and use of resources, whether food or habitats, are because environmental filters that can be evidenced at different multitemporal scales. It is important to go deeper in the relationship between the functional features about the reproductive performance in amphibians and reptiles, responding to environmental filters and its role in ecosystem processes. In scenarios of global change, these relationships could be affected and therefore, it is expected that changes in the coverage, use and management of land in the tropical dry forest, impose changing environmental filters homogenizing amphibian and reptile assemblages.

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