

Diversity of phyllostomid bats in four caves in the Dominican Republic

Diversidad de murciélagos filostómidos en cuatro cuevas de República Dominicana

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The Dominican Republic is the second country in the Greater Antilles with the widest variety of bats; however, the knowledge we have about these species is precarious, so this research focused on studying the diversity and conservation of the Phyllostomidae family in 4 caves in the country. One sampling was carried out every 3 months between December 2021 and December 2022. Three mist nets measuring 15 m long x 3 m wide were used to capture the bats. Diversity was analyzed through the Margalef, Shannon, Simpson, and Pielou indices. 545 bats of the Phyllostomidae family were captured. According to the Margalef index, the highest richness was recorded in the La Chepa cave (5.81), with 6 of the 7 species with distribution in the country. Los Patos cave presented the highest diversity ($H' = 1.50$), and the abundances of the species were more uniform ($J' = 0.31$). The La Chepa cave presented the highest abundance of bats with 35.2 % of the total captures. The differences in the diversity of bats in the studied caves may be due to the availability of food near the caves and the fragmentation of the surrounding habitat since the good state of the ecosystem is directly related to the presence and abundance of this family.

Key words: Bats; biodiversity; fragmentation; Hispaniola; shelters.

República Dominicana es el segundo país de las Antillas mayores con mayor diversidad de murciélagos; no obstante, el conocimiento que se tiene sobre estas especies es limitado, por lo que esta investigación se centró en estudiar la diversidad de murciélagos de la familia Phyllostomidae en 4 cuevas de República Dominicana. Se realizó 1 muestreo cada 3 meses entre diciembre de 2021 y diciembre de 2022. Se utilizaron 3 redes de niebla de 15 m de largo x 3 m de ancho para capturar a los murciélagos. La diversidad fue analizada a través de los índices de Margalef, Shannon, Simpson, y Pielou. Se capturaron 545 murciélagos de la familia Phyllostomidae. De acuerdo con el índice de Margalef, la riqueza más alta se registró en la cueva La Chepa (5.81) con 6 de las 7 especies con distribución en el país. La cueva Los Patos presentó la diversidad más alta ($H' = 1.50$) y las abundancias de las especies fueron más uniformes ($J' = 0.31$). La cueva La Chepa presentó las abundancias más altas de murciélagos con el 35.2 % del total de las capturas. Las diferencias en la diversidad de murciélagos en las cuevas estudiadas pueden deberse a la disponibilidad de alimento cercanas a las cuevas y a la fragmentación del hábitat circundante, ya que el buen estado del ecosistema se relaciona directamente con la presencia y abundancia de esta familia.

Palabras clave: Biodiversidad; Española; fragmentación; quirópteros; refugios.

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Bats are the second most diverse group of mammals with 1,460 species in the world ([ASM 2023](#)). The Dominican Republic is the country with the second highest richness of Chiroptera in the Caribbean region, with 18 species distributed in 6 families ([Núñez-Novas et al. 2019](#)), within which, the Phyllostomidae family stands out, a group of microchiropterans that occupy diverse niches and present highly specialized adaptations in a diversity of trophic strategies ([Jiménez 2013](#)), which is why it has been recognized as an indicator group of the conservation status of ecosystems ([Torres-Flores et al. 2012](#); [Ramos-Rodríguez et al. 2018](#)). The family Phyllostomidae is distributed in the Neotropical region from the southwestern United States to northern Argentina ([Bracamonte 2018](#)).

In the Dominican Republic, bats represent 90 % of the mammals; however, knowledge about them remains limited. Caves in the Dominican Republic are indispensable refuges for bats, and their study and research are imperative to ensure their conservation and effective management. Several important studies have been conducted, including those of [Núñez-Novas and León \(2011\)](#) who examined 723 collection specimens, with the phyllostomids *Artibeus jamaicensis*, *Macrotus waterhousii* and the molossid *Molossus molossus* being the most abundant. Another notable study of cave bats in the Dominican Republic is that of [Núñez-Novas et al. \(2014\)](#), who evaluated the migratory and seasonal patterns of 12 bat species including 6 of

the 7 phyllostomid species recorded in the country: *A. jamaicensis*, *Brachyphylla pumila*, *Erophylla bombifrons*, *M. waterhousii*, *Monophyllus redmani* and *Phyllonycteris poeyi*. Finally, [Núñez-Novas et al. \(2019\)](#) developed an identification guide to the bats of Hispaniola, which represented a significant advance in the knowledge of the families and species of bats in the study area.

Despite the important advances in the knowledge of the bats of the Dominican Republic, much remains to be explored and understood. Therefore, this study presents the diversity of bats of the family Phyllostomidae in 4 caves in the Dominican Republic.

Study area. This research was conducted in the Dominican Republic, located in the central Antilles, in the insular Caribbean, which has a territorial extension of 48,000 km² divided from southeast to northwest by the Cordillera Central. The highest point is located at Pico Duarte, at 3,089 m. The Dominican Republic is marked by valleys and mountain ranges, its geomorphology and different bioclimates favor a great biodiversity of flora and fauna ([MIMARENA 2015](#)). To determine the species diversity of the Phyllostomidae family, we first explored the known refugia in the literature. To do this, a search for reports of occurrence in

GBIF and a search for new refugia sites was conducted. The final set of refugia consisted of 4 caves (Figure 1) which are described below:

1. El Pomier Cave: It is located in the paraje of the same name (18° 28' 0.90" N, 70° 8' 9.60" W) in the foothills of the Cordillera Central, in the province of San Cristóbal. It has an area of 4 km² and is surrounded by subtropical secondary rainforest and riparian forests (Figure 2). The average annual temperature is 25.9 °C and precipitation is 1,756 mm ([MIMARENA 2015](#)). The vascular flora in the area near the cave includes royal palm (*Roystonea regia*), ceiba (*Ceiba pentandra*), saman (*Samanea saman*), mango (*Mangifera indica*), guayuyo (*Piper aduncum*), pringamosa (*Urera baccifera*), almácigo (*Burcea simaruba*), caoba (*Swetenia mahagoni*), savanna (*Petitia domingensis*), cedar (*Cedrela odorata*), coralillo (*Hamelia patens*), guava (*Psidium guajava*) and tabacon (*Solanum rugosum*).

2. Los Patos Cave: It is located in Barahona province (17° 57' 35.05" N, 71° 10' 59.80" W), measures about 290 m in linear extension, has 3 entrances and 8 chambers with heights of 3 and 15 m. The Los Patos River emerges from the flooded area of the cave. Around the cave, there is an altered low montane rainforest (Figure 2) with fruit plants

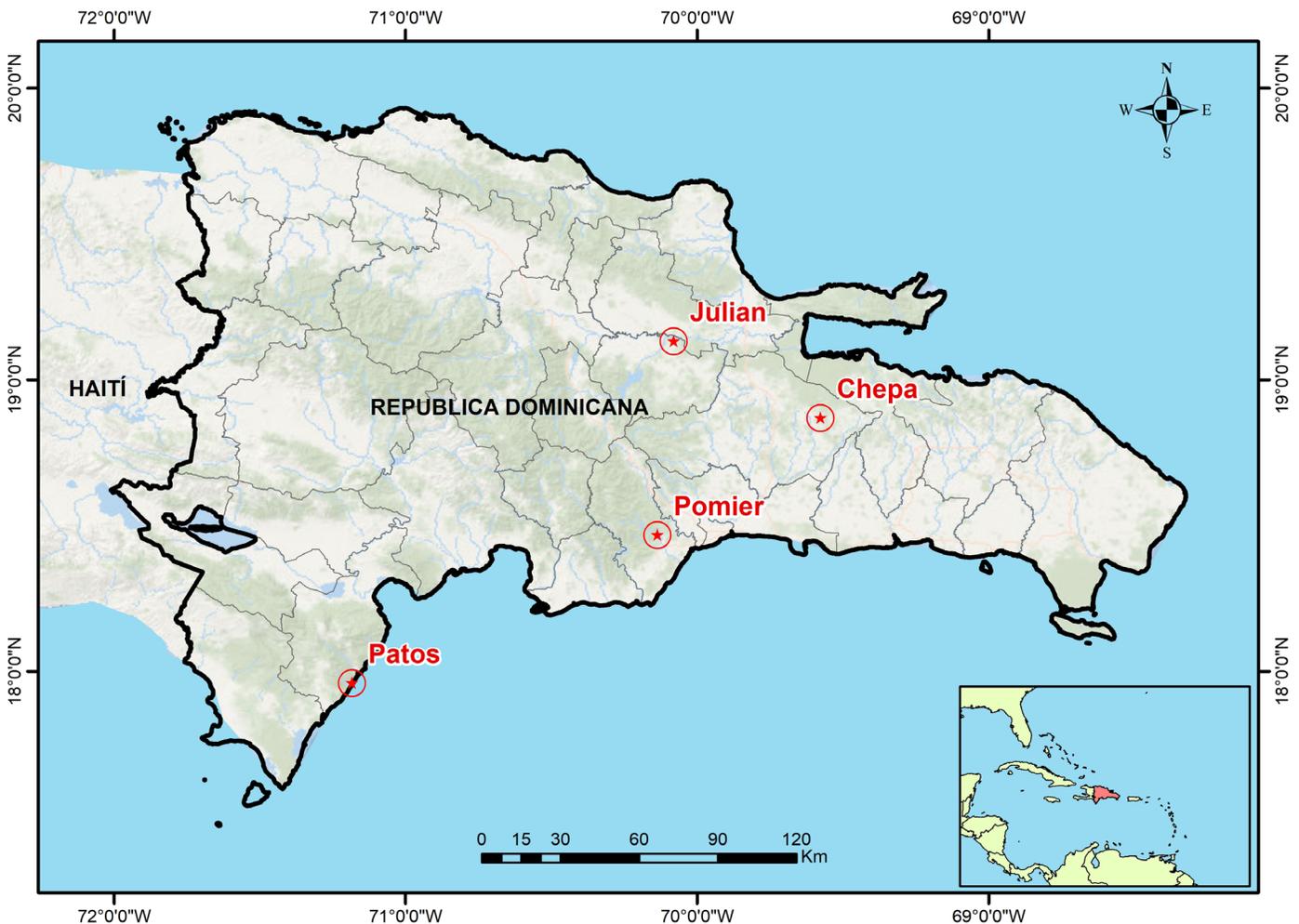


Figure 1. Location map of the 4 caves sampled for phyllostomid bats in the Dominican Republic.

such as guanabana (*Annona muricata*), lemongrass (*Melicoccus bijugatus*) and almond (*Terminalia catappa*).

3. Cueva Honda Julián: Located in the Platanal area (18° 52' 8.80" N, 69° 34' 34.70" W) in Sánchez Ramírez province. The cave is located in the northern part of a karst valley, measures more than 100 m in linear extension, and has 8 chambers and 3 entrances, 2 of which measure approximately 1 m in diameter (Tejedor *et al.* 2005). Around the cave there is a modified subtropical rainforest and pastures used for livestock (Figure 2). Around the cave there is a modified subtropical rainforest and pastures used for cattle grazing. Among the most representative flora species are guacima (*Guazuma tomentosa*), coralillo (*Hamelia patens*) and escobilla (*Sida acuta*).

4. La Chepa Cave: Located in Valle Grande (18° 52' 09" N, 69° 34' 34.70" W) in Bayaguana. The cave is in a karst com-

plex, has a length of 500 m, with areas up to 25 m high. Nearby, several streams from other caves flow into the Comatillo River. In the surrounding area there are riparian forests (Figure 2) dominated by dragon trees (*Pterocarpus officinalis*) and fruit plants.

Data capture and collection methods. The methodology of Bracamonte (2018) was followed for the sampling protocol, which consists of the use of mist nets to capture bats prioritizing their welfare. Each cave was sampled on 4 occasions (every 3 months) between December 2021 and December 2022. In total, 24 hr of sampling were devoted to each cave (1 sampling in each season of the year), adding up to a total sampling effort of 96 hr. In each cave, 3 mist nets 15 m long by 3 m wide were placed at the entrance from 18:00 hr to 24:00 hr. The nets were checked every 15 min and the captured bats were identified with the dichotomous key of



Figure 2. Characteristics of the caves of the Dominican Republic and surrounding vegetation. a) La Chepa Cave; b) vegetation surrounding the La Chepa cave; c) Honda Julián Cave; d) vegetation surrounding the Honda Julián cave; e) vegetation surrounding Los Patos cave; f) vegetation surrounding El Pomier cave.

Núñez-Novas *et al.* (2019). Sex and sexual maturity were determined for each individual. Subsequently, each individual of the family Phyllostomidae was marked on the forearm with a plastic celluloid ring (AVINET, Portland, Maine) with a unique combination code of 2 to 4 digits depending on the species. Finally, the bats were released.

Data analysis. To analyze diversity in the 4 caves, the indices of 1) Margalef (Margalef 1951) were used to assess species richness in relation to the total number of individuals in the sample; 2) Shannon (H') (Shannon and Weaver 1949) for diversity; 3) Simpson (D) (Simpson 1949) for dominance; and 4) Pielou's Equity (J') (Magurran 1988) to assess evenness in the distribution of abundances. To determine the degree of threat of the bat species, a literature review was conducted on their conservation status in the Red List of Threatened Fauna Species of the Dominican Republic (MIMARENA 2018) and the International Union for Conservation of Nature Red List (IUCN 2020).

A total of 545 individuals of 7 species of the Phyllostomidae family were captured: *A. jamaicensis*, *Brachyphylla nana*, *E. bombifrons*, *M. waterhousii*, *M. redmani*, *P. falcatus* and *P. poeyi*. The season with the most captures was in the summer, with 175 individuals (32.11 % of the total captures; Appendix 1). The highest expected species richness, according to the Margalef index, was in La Chepa (5.81) while the lowest was in Honda Julián (2.78). The highest abundance occurred in La Chepa cave ($n = 196$, 35.9 % of the total catches). *Erophylla bombifrons* was the most abundant species in all caves ($n = 106$, 19.4 % of all individuals captured), followed by *A. jamaicensis* ($n = 100$, 18.3 %) and *M. redmani* ($n = 92$, 16.8 %), while *P. falcatus* was the least abundant species ($n = 3$; Table 1). The Shannon index showed that the highest diversity occurred in Los Patos cave ($H' = 1.50$), while the lowest occurred in El Pomier ($H' = 0.62$; Table 2). The highest value of Simpson's index occurred in Los Patos cave ($D = 0.74$), while the lowest occurred in Honda Julián ($D = 0.55$; Table 2). Pielou's equity index showed that the cave with the most uniform species abundance was Los Patos ($J' = 0.31$), while the least uniform was El Pomier ($J' = 0.12$).

Of the species recorded in this study, 85.7 % are listed as of Least Concern in the IUCN (2020), with the exception of *B. nana*, for which no assessment is available. On the

Table 1. Bat species of the Phyllostomidae family and their abundance in 4 caves in the Dominican Republic.

Species	Los Patos	El Pomier	Honda Julián	La Chepa	Total
<i>Artibeus jamaicensis</i>	19	0	0	81	100
<i>Brachyphylla nana</i>	15	4	0	67	86
<i>Erophylla bombifrons</i>	0	50	39	17	106
<i>Macrotus waterhousii</i>	34	11	0	22	67
<i>Monophyllus redmani</i>	24	0	62	6	92
<i>Phyllotis falcatus</i>	0	0	0	3	3
<i>Phyllonycteris poeyi</i>	3	79	9	0	91
Total	95	144	110	196	545

Table 2. Values of the diversity and equity indices of bats of the Phyllostomidae family in 4 caves in the Dominican Republic.

Caves	Margalef	Shannon	Simpson	Pielou
Los Patos	4.780	1.504	0.742	0.317
El Pomier	3.799	0.625	0.571	0.126
Honda Julián	2.787	0.896	0.550	0.191
La Chepa	5.810	1.327	0.685	0.252

other hand, in the Dominican Republic Red List (MIMARENA 2018), *P. poeyi*, *E. bombifrons* and *B. nana* are classified as Vulnerable (Table 3).

The 7 species of phyllostomid bats recorded in this study had been previously recorded in the Dominican Republic (Núñez-Novas *et al.* 2016). However, the findings of this research reinforce and expand the available information about the diversity of phyllostomid bats. This contribution not only makes it possible to evaluate possible changes in the populations and distributions of these species but also contributes to understanding the factors that influence the distribution of phyllostomid bats in karst environments.

The difference in bat species richness between caves could be influenced by extrinsic factors such as shelter shape, temperature, humidity, airflow, light intensity, safety from predators, and distribution and abundance of food resources (Kunz and Lumsden 2003; Brigham *et al.* 1997; Kerth 2008). Larger, more complexly structured caves have also been observed to provide a wide variety of microhabitats, which influences shelter choice by bats (Barquez *et al.* 2022). In our study, differences in species richness could be attributed to the availability and distribution of food resources, as well as habitat fragmentation and destruction in the vicinity of caves. These factors have a significant impact on the availability of roosts and optimal environmental conditions for bat life.

On the other hand, it has been mentioned that disturbance and fragmentation of forests and conversion to pasture to feed cattle have a negative effect on the presence of bat species (Núñez-Novas *et al.* 2016). In our study, La Chepa was the cave that presented the highest species richness and abundance, which may be directly related to the location and availability of food, since the surrounding area of the cave is dominated by rainforest where there is a great variety of fruit plants that serve as food for these species. The richness results of this study are similar to those obtained by Núñez-Novas *et al.* (2016), who also found the highest diversity in La Chepa cave.

In contrast, the Honda Julián cave had the lowest species richness and the lowest Shannon diversity for the Phyllostomidae family. In 2021, this cave was certified as a Site of Importance for the Conservation of Bats (SICOM). The low diversity of bats in this cave could be due to the change in land use that the area surrounding the cave has undergone, as the forest has been converted to pasture fields where the availability of fruits, on which phyllostomid spe-

Table 3. Conservation status of bat species of the Phyllostomidae family in 4 caves in the Dominican Republic. N/A: None.

Species	Category according to the IUCN Red List	Category according to the Red List of the Dominican Republic
<i>Artibeus jamaicensis</i>	Least Concern	N/A
<i>Brachyphylla nana</i>	Least Concern	Vulnerable
<i>Erophylla bombifrons</i>	Least Concern	Vulnerable
<i>Macrotus waterhousii</i>	Least Concern	N/A
<i>Monophyllus redmani</i>	Least Concern	N/A
<i>Phyllops falcatus</i>	Least Concern	N/A
<i>Phyllonycteris poeyi</i>	Least Concern	Vulnerable

cies feed, could be lower. These results coincide with those reported by [Oporto et al. \(2015\)](#) who mention that the low diversity of fruit bats they found in secondary forests in Tabasco, México could be due to the loss of conserved forests or the lack of forest fragments close to the sampling sites. Previously, it has been mentioned that conserved forest fragments play an important role in biodiversity conservation as they function as a source for colonizing other fragments ([Bennett 1998](#); [Numa et al. 2005](#)).

The high abundances of *E. bombifrons* and *A. jamaicensis* are not noteworthy, since it is known that they are species that frequently take refuge in caves and tend to form groups of several dozen individuals ([Silva-Taboada 1979](#)). In the case of *P. falcatus*, only 3 individuals were captured in La Chepa cave during the spring, and it was absent in the rest of the caves. The low abundance may be due to the fact that during the day this species seeks refuge in the dense foliage of broad-leaved trees, where they gather in compact clusters in the shadiest areas ([Silva-Taboada 1979](#)).

Current knowledge about bats in the Dominican Republic shows great gaps in information, especially about their ecology, habitat, distribution patterns and the conservation status of their populations, so it is necessary to understand and know the requirements of these organisms in relation to their habitat, which is key to guaranteeing their conservation. It has already been shown that the decline of bat populations results in serious consequences on the interaction networks they form, so conservation measures must be a priority, not only because they are essential for the reproductive success of many plants that contribute to our food and economy, but also because of their key role in ecosystems.

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Appendix 1

Number of individuals captured in 4 caves in the Dominican Republic. Sp: spring; Su: summer, F: fall; W: winter.

Phyllostomidae Family	Los Patos				El Pomier				Honda Julián				La Chepa			
	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W
<i>Artibeus jamaicensis</i>	2	9	7	1	0	0	0	0	0	0	0	0	15	28	23	13
<i>Brachyphylla nana</i>	11	4	0	0	0	3	1	0	0	0	0	0	11	31	19	5
<i>Erophylla bombifrons</i>	0	0	0	0	12	21	11	6	16	7	10	6	0	5	12	0
<i>Macrotus waterhousii</i>	11	9	7	7	0	3	5	3	0	0	0	0	6	2	11	3
<i>Monophyllus redmani</i>	5	10	2	6	0	0	0	0	14	19	20	9	0	0	4	2
<i>Phyllops falcatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
<i>Phyllonycteris poeyi</i>	0	3	3	0	17	21	23	18	6	0	0	3	0	0	0	0
Total	29	35	19	14	29	48	40	27	36	26	30	18	36	66	69	23