

Bat assemblage composition and diversity of the Cusuco National Park, Honduras.

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Introduction

The tropical lowlands of Central and South America are recognized to harbor a remarkably high bat richness and diversity, whereas tropical highlands are less diverse and the species that prefer this habitat represent a small portion of the overall bat richness in the neotropics. Nevertheless, the highland assemblages have been less studied and are currently under extreme anthropogenic pressure due to deforestation for agriculture and cattle (Perez-Torres 2004).

Many nature reserves have been designed to take into account the villages around or within them, so portions of their total area have been allocated for low intensity farming and/or allow firewood extraction. The Cusuco National Park (CNP) in Honduras is an interesting case, the lower half of the park is a buffer zone where farmers grow cash crops and graze cattle, while the upper half, or core zone, is a protected continuous highland forest. Reserve managers in Honduras are interested in measuring the effects of habitat transformation in animal assemblages within the buffer zone, using the assemblages in the core zone as a reference (Coles, Smith and Field 2007).

Since 2004, bat scientists have surveyed the buffer zone and the core zone of Cusuco and they have compiled a database of the bat assemblage in the area, but new survey camps were open in the north side to the CNP after 2006. This created a need to rebalance the sampling efforts to have a better understanding of the whole park and to include more humid forests in the north, which have higher diversity of tropical flora than the pine and oak forest, more abundant in the south side of the park.

The main objective of the bat survey team in the Cusuco National Park during 2007 was to determine differences in the assemblage diversity and composition between the buffer zone and core zone of the park, having a balanced design with similar effort between these two areas. Finally, determine differences in species richness between the north side and south side of Cusuco.

Methodology

Study sites.

Cusuco National Park is located in the Merendón Mountain Range, state of Cortés, Honduras (15°29.8'-15°32.1'N, 88°13'-18°16.3'W). The park covers 23440 km² divided into a core zone (7690 km²) and a buffer zone (15750 km²) and it is considered one of the last enclaves of the Central American Montane Forest (sensu Holdridge 1962) in the region (Brough 1992). The Merendón Mountain Range goes from east to west, dividing the park into two distinct areas, the north slopes covered with wet deciduous forests between 500 and 1500 m, and the south slopes comprised mostly of semi-arid pine forests between an altitudes of 800 to 1700 m. The semi-arid pine forest covers 11000 km² dominated by the genera *Quercus* (Fagaceae) and *Pinus* (Pinaceae), while 100 km² consists of immature plants less than 35 years old. The wet deciduous forest covers 1600 km² in a mixture of pines, oaks and *Liquidambar* (Altingiaceae) (Lennkh 2003). The remaining 13000 km² of broad leaf forest lay within the cloud forest, usually above 1700 meters (Bear 1995) and it is characterized by species from the genera *Guatteria* (Annonaceae), *Geonoma* (Arecaceae), *Clusia* (Clusiaceae), *Ocotea* (Lauraceae) and *Inga* (Fabaceae), among others. A small portion of dwarf forest is present at the hilltops of the park and dominated by the family Ericaceae. A detailed description of the park can be found in Coles, Smith and Field (2007). The buffer zone on the south area is characterized by a mixture of semi-arid pine forest fragments and an agricultural matrix for cash crops, while the north area has a fragmented system of wet deciduous forests and cloud forests remnants, surrounded by pastures.

Surveys

Bat surveys were conducted between June and August of 2007 in 4 survey camps within the buffer zone and the core zone of the park with similar sampling efforts between sites (Table 1). Bats were captured in the forest understorey with regular mist nets of different lengths (6, 9 and 12m X 2.5m). Netting was restricted to two transects per survey camp and around the 100m² main sampling sites but always intending to intersect flight paths to maximize capture success. Full moon and rainy nights were avoided. Captured bats were sexed, weighted and measured following standardized

protocols (Jones 1996). Adults were distinguished from juveniles or sub-adults by the ossification of the epiphysis in the phalange. Field identification was based on Mammals of Central America (Read 1997), A Field Guide to the Bats of Costa Rica (Tim and LaVal 1998) and the key of the bats of México (Medellin et al. 1997).

Data analysis

Species richness was compared between the core zone and the buffer zone using rarefaction methods and calculating 95% confidence intervals (Moreno 2001; calculated with the software EcoSim Gotelli and Entsminger 2001). Same procedure was used to compare wetter and dryer camps, which would be the north slopes versus de south slopes of the CNP, respectively. To determine inventory completeness for the species ensemble (sensu Fauth et al. 1996) in Cusuco, as well as for the buffer and core zone, a non-parametric species richness estimator (Michaelis-Menten 1 Mean) was compared with a species accumulation curve to obtain a percentage of completeness (calculated with the software EstimateS Colwell 2005). The chosen species richness estimator has proved to be reliable of mobile organisms such as bats (Brose and Martinez, 2004). Randomizations for the estimations were set to 1000.

Results

A total of 568 individuals were captured and identified during the 2007 field season in Cusuco, comprising 35 species within 5 families. Phyllostomidae was the most abundant and diverse family, followed by Vespertilionidae, Mormoopidae, Molossidae and Natalidae, respectively. The new species for the park are *Mormoops megalophylla*, *Molossus ater*, *Natalus stramineus*, *Phyllostomus hastatus* and *Vampyressa pusilla*. This constitutes a remarkable progress of the monitoring program in the CNP, not only for the number of species but also for the high capture success. The methodology that has been standardized corroborates that increasing netting efforts include rare and/or seasonal species (Table 2).

Certain trends can be extracted from the data. Animalivorous species (insectivorous and carnivorous sensu Giannini and Kalko 2004) were rare and mostly collected in the core zone. For example, *Trachops cirrhosus* was exclusively captured in the core zone, also in previous surveys in CNP. Other animalivorous species like *Bauerus dubiaquercus*, *Myotis albescens*, *Natalus stramineus* and *Micronycteris schmidtorum*, the latter another new species for the park, were also captured exclusively in the core zone. Within Phyllostomidae, the subfamily Stenodermatinae was the most abundant, expressed in the highest percentage of captures. *Artibeus jamaicensis*, *Artibeus toltecus*, *Sturnira ludovici* and *Sturnira lillium*, all frugivorous, were the most abundant species in this subfamily and responsible for the percentage difference between the subfamilies of Phyllostomidae (Figure 1).

The number of captures and species captured in the buffer zone was higher than in the core zone (Table 2), however, species richness was not statistically different between the two areas (Figure 2). Data sorted by precipitation showed that richness between dry sites and humid sites were no statistical different (Figure 2). The percentage of completeness of the survey was high; 81% for the core zone, 87% for the buffer zone and 92% for the pooled data.

Discussion

Altitude is a strong confounding factor in Cusuco, therefore it is unfeasible to make a clear cut interpretation when the core zone and the buffer zone want to be compared. Never the less, the steeper curve at an abundance of 160 captures, together with the percentage of completeness, indicates that more species are expected to be found in the core zone in comparison to the buffer zone, regardless of the altitude. This may be due to the habitat heterogeneity of the core zone, an ecotone where pine and oak forest is intertwined with tropical cloud forest. The 2007 survey reflects the mixture of the two ensembles and differs from other studies that have shown lower richness at higher altitudes (Muñoz-Arango 1990 for Colombia; Patterson et al. 1996 for Perú and Sanchez-Cordero 2001 for México).

From the conservation stand point; the core zone can serve as source to replenish the bat populations that inhabit forest fragments around the national park, especially for those species that prefer the tropical cloud forest than the pine and oak or the tropical lowland forests. Even though it was not possible to show that the core zone is richer in species than the buffer zone, the complementarity between the two areas suggests that both areas are important for conservations purposes and need to be preserved.

We recommend that future surveys follow the specific guidelines that have been set in Cusuco National Park, standardized long term methodologies in tropical cloud forests are scarce. We are not aware of any study in bat ecology, except maybe for Sanchez-Cordero (2001), that has been done in such an important ecosystem ecotone, where species from tropical Central America share foraging grounds with species from boreal forest. Besides short term projects, no doubt fruitful, is imperative to

continue the monitoring program that started in 2004. Finally, it is always desirable to count with researchers acquainted with tropical bat taxonomy due to the complexity of the ensemble present in Cusuco, this will ensure that the data set keeps its good quality.

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Table 1. Number of bat species and survey efforts in four survey camps in Cusuco National Park, Honduras.

		No. of Species	Unique Species ¹	Survey Time ²	Nets used ³	Effort ⁴	Capture ratio ⁵
Buffer Zone	Buenos Aires	23	8	42.5	892.5	37931.25	0.656
	Santo Tomas	16	4	53.65	915	49089.75	0.507
Core Zone	Base Camp	14	3	51.3	855	43861.5	0.567
	Cortesito	15	4	53	810	42930	0.58
	TOTAL	35		200.45	3472.5	696062.625	0.816

¹ Number of species found only in this survey camp.

² In hours.

³ In square meters.

⁴ Square meters of nets deployed * Survey time.

⁵ Total number of individuals captured / Effort

Table 2. Bat species list with total captures for the buffer zone and core zone of Cusuco National Park, Honduras, 2007 field season.

Family	Subfamily	Species	Buffer Zone		Core Zone		TOTAL
			Buenos Aires	Santo Tomas	Base Camp	Cortesito	
Mormoopidae		<i>Mormoops megalophylla</i>			1		1
		<i>Pteronotus parnellii</i>			2	3	5
Phyllostomidae	Carollinae	<i>Carollia brevicauda</i>	14	28	4	9	55
		<i>Carollia castanea</i>		2			2
		<i>Carollia perspicillata</i>	3	9	2		14
	Desmodontinae	<i>Desmodus rotundus</i>	17	4		1	22
		<i>Diphylla ecaudata</i>	2				2
	Glossophaginae	<i>Anoura geoffroyi</i>		1			1
		<i>Glossophaga commissarisi</i>	1	19		14	34
		<i>Glossophaga soricina</i>	10	2	1	4	17
		<i>Hylonycteris underwoodi</i>				2	2
	Phyllostominae	<i>Micronycteris schmidtorum</i>				1	1
		<i>Phyllostomus hastatus</i>	1				1
		<i>Trachops cirrhosus</i>				1	1
	Stenodermatinae	<i>Artibeus intermedius</i>	1				1
		<i>Artibeus jamaicensis</i>	32	14	1	29	76
		<i>Artibeus lituraus</i>		3			3
		<i>Artibeus phaeotis</i>	1				1
		<i>Artibeus toltecus</i>	35	2	26	23	86
		<i>Artibeus watsoni</i>		17			17
		<i>Centurio senex</i>	9		14	1	24
		<i>Chiroderma salvini</i>	2			1	3
		<i>Chiroderma villosum</i>	2				2
		<i>Enchisthenes hartii</i>			1		1
		<i>Platyrrhinus helleri</i>	3	1			4
		<i>Sturnira lilium</i>	64	22	3		89
		<i>Sturnira ludovici</i>	19	9	14	7	49
		<i>Uroderma bilobatum</i>	3				3
	<i>Vampyressa pussila</i>	3	3			6	
	<i>Vampyrodes caraccioli</i>	2				2	
Natalidae		<i>Natalus stramineus</i>				1	1
Vespertilionidae		<i>Bauerus dubiaquercus</i>	1		1		2
		<i>Myotis albescens</i>			2		2
		<i>Myotis kaeyssi</i>	3	3	8	3	17
Molossidae		<i>Molossus ater</i>	21				21
		TOTAL	249	139	80	100	568

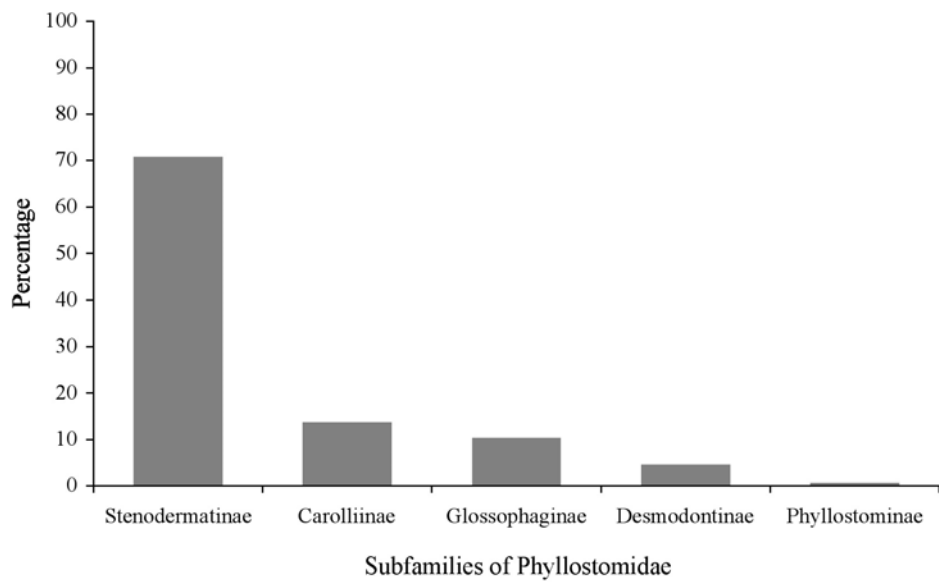


Figure 1. Percentage of total captures among the subfamilies of Phyllostomidae.

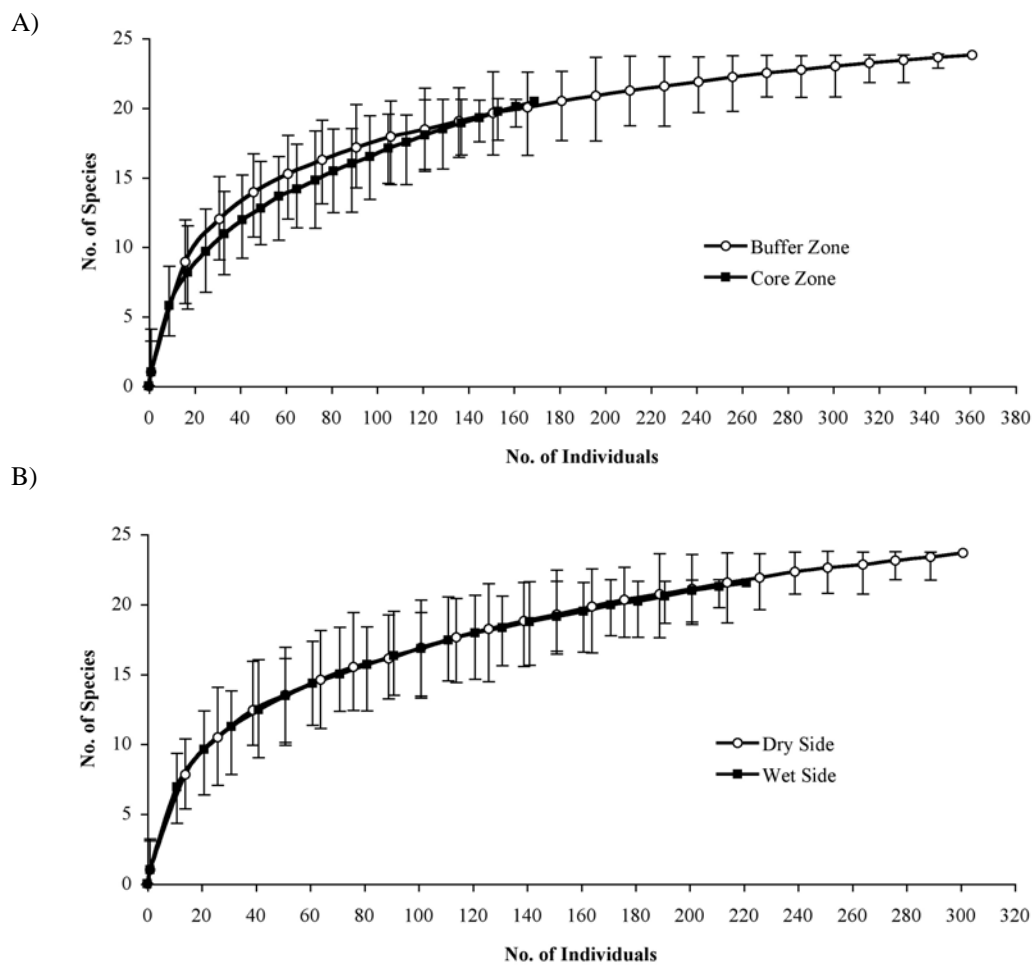


Figure 2. Species rarefaction curves: A) Buffer zone and core zone, B) Dry side (south) and wet side (north) of Cusuco National Park. Bars indicate 95% confidence intervals.

