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Species composition of bats (Chiroptera) in different land- use mosaics

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ABSTRACT

Bats are an abundant and diverse group of species that can be used as indicators of habitat disturbance and to test the effects of land-use mosaics on an ecosystem. For 11 nights I used mist-nets to sample the bat assemblages in pastures, forest fragments, banana fields and coffee fields on the Finca Santamaría in Cañitas, Monteverde, Costa Rica. The differences between the land-use areas were not significant in the abundance of bats, species richness, species diversity or trophic diversity. However the species that were found, such as *Glossaphaga commissarisi* and *Sturnia ludovici* could be considered indicators of disturbed habitats suggesting the entire area is degraded to a point that only generalist species persist.

RESUMEN

Los murciélagos son abundantes y diversos y pueden ser utilizados como indicadores de la alteración del hábitat y para probar los efectos de los diferentes usos de la tierra sobre los ecosistemas. Por 11 noches yo utilicé redes de niebla para muestrear comunidades de murciélagos en pastos, fragmentos de bosque, cultivos de plátano y café en la Finca Santamaría en Cañitas, Monteverde, Costa Rica. Los sitios muestreados no difirieron en la abundancia de murciélagos, la riqueza de especies, la diversidad de las especies y la diversidad de los grupos tróficos. Sin embargo, *Glossaphaga commissarisi* y *Sturnia ludovici* podrían ser considerados como indicadores de hábitats perturbados lo que sugiere que el área entera está degradada a un punto que solamente los especies generalistas persisten.

INTRODUCTION

Each year the planet loses 13 million hectares of forest and the majority of this forest is being converted into row crops and pasture land (2005 FAO Global Forest Resource Assessment). Some estimates suggest that between 40 and 50% of the Earth's surface has been altered or degraded in some way by humans (Vitousek et al. 1997). Crop lands and pastures create a vast biome that is equal in area to the remaining forests of the world (Foley et al. 2005). If deforestation trends continue at their current rates, many organisms will no longer be able to depend solely on pristine-primary forest. The long term survival of many species will largely depend on their ability to adapt to converted landscapes (Medellín et al. 2000). The impact of transformed land on the natural diversity will become increasingly more important for future conservation efforts.

Certain species or groups of species can be very useful indicators of the effects of different land-use areas on the ecosystem health. To be a good indicator these taxa should be abundant, as well as tropically, geographically and ecologically diverse. They should also have an important role in the ecosystem and respond to changes in that ecosystem in a measurable way (Medellín et al. 2000). In the Neotropics, bats are more abundant than any other group of mammals and are extremely diverse. There are around 220 species of bats in the New World Tropics and they occupy a wide array of niches ranging from primary to tertiary consumers (Medellín et al. 2000). They are also important seed dispersers and pollinators and are thought to be key players in forest regeneration (Nowak 1994). Insectivorous bats control populations of many insects including those that are vectors for disease and that cause agricultural problems (Altringham1996).

It is due the high level of diversity and abundance of bats almost everywhere in the tropics that they are useful indicators of the effects that different land use activities have on the ecosystem. Some species will be sensitive to changes and other opportunistic species will become more abundant, depending on the land use activity (Medellín et al. 2000). Studies conducted in Guatemala, Mexico and Costa Rica showed that many Phyllostomid bats species declined in species richness and abundance after land transformation, however, other species of Phyllostomids such as *Sturnia lilium*, *Carollia perspicillata*/*brevicauda*, and *Desmodus rotundus* tend to become more abundant in disturbed areas (Schulze et al. 2000, Medellín et al. 2000, LaVal 2004).

In this study I aim to examine the species assemblages of bats in different land use areas in Cañitas, Monteverde, Costa Rica. Specifically, to compare the bat communities that frequent banana fields, coffee fields, pastures and forest fragments. I hypothesized that there would be a difference in the community assemblages of bats in the different land-use areas. I predicted that the bat communities in the forest fragment would be more numerous and diverse in comparison to the other land-use types.

METHODS

Study Sites

I conducted this study at the Finca Santamaría in Cañitas, Monteverde, Costa Rica at an elevation of about 1300 m. The Finca Santamaría is a farm that contains areas of open pasture, coffee, banana and other small crop fields bordering several secondary forest fragments. Theses regenerating fragments have been left standing since 1989.

Procedure

I used the forest fragments, coffee, banana, and pasture fields to conduct the experiment. Mist nets were set up during the day in each of the land-use areas, but left closed until dark. Nets for the coffee, banana and pasture were 12 m long and the forest fragments contained two 6 m long nets. The nights for data collection were chosen according to what time the moon is high in the sky (three hours after moonrise until three hours before moonset) and the phase of the moon. Nets were also moved for each night so that the bats would not learn to avoid them.

Just before dark, at around 5:30pm, the nets were opened and checked continuously for two hours, by walking between the four sites and observing what was caught. They were identified to species and sex, and marked by cutting a small patch of hair on their back to notice

in the event of a recapture. The nets were usually closed around 8:00pm each night; data were collected on 11 nights over the course of four weeks.

Statistical Analyses
The Shannon – Wiener index for diversity was used to compare the four different land-use areas. A Chi-Squared test was used to compare the differences in trophic groups between the land-use areas. A Chi-Squared test was also used to compare the differences in over-all abundance of bats between the land-use areas. Due to the overall low number of bats caught, recaptures were included in all calculations and statistics.

RESULTS

Habitat Use by Bats
I caught a total of five species of bats: *Glossaphaga commissarisi, Sturnia ludovici, Carollia brevicauda, Micronycteris microtis* and *Myotis keaysi.* Four of the five species found were of the largest family in Costa Rica, Phyllostomidae, the leaf-nosed bats. These four species are all found in a wide variety of habitats, including disturbed areas. *G. commissarisi* is often associated with agricultural land-use areas in addition to being common to various habitat types. Both *S. ludovici* and *C. brevicauda* are found in a wide variety of habitats but are especially common in early successional forests. Each of the four species of phyllostomid bats belong to different subfamilies. The fifth species, *M. keaysi*, is in the family Vespertilionidae, the world's largest and most widely distributed family of bats (Laval and Rodríguez-H 2002). This species is also found in both disturbed and undisturbed habitats (Table 1).

All except for one of the species captured in this study was listed as either "common" or "abundant" for Monteverde (LaVal and Timm 2000). The species *M. microtis* was reported as "uncommon" to the Monteverde area but can reach elevations of at least 2600 m (Laval and Rodríguez-H 2002).

Patterns of Species Abundance
There were 32 total mist-net captures including five recaptures within the land-use mosaic on the farm. The most bats were captured in the banana field, followed by the forest fragments, then the pasture and finally the coffee field (Table 2).

There was no significant difference in the number of bats caught in the four land-use types when including the recaptures (Chi-squared test, $X^2 = 10.25$; df = 3; $P > 0.05$). The differences were not significant when excluding recaptures as well (Chi-squared test, $X^2 = 9.15$; df = 3; $P > 0.05$).

Patterns in Species Richness
The greatest numbers of species were captured in the forest fragments (Figure 2). *G. commissarisi* and *S. ludovici* were caught in all four the different land-use areas. *C. brevicauda* was captured in both the pasture and banana fields. In the forest fragments two species, *M. keaysi* and *M. microtis,* were found, neither of which was captured anywhere else.

Patterns in Species Diversity

G. commissarisi and *S. ludovici* were caught most frequently on the farm and in each of the land-use areas. The only exception was in the forest fragments where *M. microtis* outnumbered *S. ludovici* (Figure 1).

There was no difference in the diversity between the pasture and the forest ($t = 1.13$; $v = 82.61$; $P > 0.05$), the pasture and the banana field ($t = 0.02$; $v = 13.39$; $P > 0.05$), and the pasture and the coffee field ($t = 0.56$; $v = 91.99$; $P > 0.05$). There was also no difference between the forest and the banana field ($t = 0.44$; $v = 18.33$; $P > 0.05$) and the forest compared the coffee field ($t = 0.57$; $v = 8.61$; $P > 0.05$). Finally there was no difference between the banana and coffee fields ($t = 0.19$; $v = 8.43$; $P > 0.05$) (Figure 1, Table 3).

Patterns in Trophic Diversity

Three groups of trophic guilds were found on the farm (Altringham 1996). Nectarivorous and frugivorous bats visited all four of the land-use areas tested. Insectivorous bats were found only in the forest fragments (Figure 2). Although varied in abundance, the difference between the land-use areas in the diversity of trophic guilds is not significant (Chi-squared test, $X^2 = 113.39$; $df = 6$; $P > 0.05$).

DISUSSION

Many bats from the suborder Microchiroptera, such as all the bats found in this study, can travel up to 10-15 km from their roosts; some can even go as far as 80 km in one night (Nowak 1994). This means that the bats on the farm can move about freely between the different land-use areas. This is consistent with the results of this study. There was no significant difference between the different land-use areas in terms of the number of bats, number of species, diversity of species and diversity of trophic levels.

All of the species found in the nets are habitat generalists (Table 1). *S. ludovici* and *C. brevicauda*, which were found on the farm, are particularly common to early stages of successional growth (Laval and Rodríguez-H 2002). The forest on the farm is only about 17 years old and is still in the early phases of regeneration. Both these frugivorous bats specialize on *Piper* fruits (Laval and Rodríguez-H 2002). This also supports the data because there are 42 species of *Piper* in the Monteverde area and it is an early succession plant that was prevalent on the farm (Haber 2000). *G. commissarisi* is a nectivarous bat that forages on the flowers of bananas and *Macuna*. This is consistent with the fact that there was a fairly large plot of bananas on the farm and *G. commissarisi* was the most common bat caught and more bats were caught in the banana nets than the other three land-use areas (Table 2, Figure 1). *M. keaysi* is often abundant in premontane and lower montane habitats, such as the farm. It has been noted that this species forages over trails and openings within the forest (Laval and Rodríguez-H 2002). This is exactly where the mist-nets were set up in the forest sites. *M. microtis* is noted to specialize on butterflies, specifically *Morpho peleides*, which was observed frequently on the farm during the study (Laval and Rodríguez-H 2002).

The differences in species abundance, species richness, species diversity and trophic diversity between land-use areas were not significant. It is possible that this is because overall disturbance of the entire area. Phyllostomid species can be used as indicators of disturbance in tropical areas because they are sensitive to habitat changes (Medellín et al. 2000). This could explain the absence of other species of phollostomids and the persistence of those found. Medellín et al. (2000) and Schulze et al. (2000) found that the abundance of *Sturnia lilium* and

Carollia perspicillata was an indicator of disturbance. Closely related are *S. ludovici* and *C. brevicauda* respectively, were both found on the farm. This could mean that the species found on the farm are just the generalist species that prosper in habitat fragmentation and land-use mosaics.

Despite the non-significant differences between the land-use types, the data has some similarities to past studies that did show significant differences between land-use types. Medellín et al. (2000) showed that forest nets caught less bats overall than nets set up in agriculture areas. Another parallel between this study and Medellín et al. (2000) is that the greatest number of species was found in the forest but the greatest number of bats was found in the agricultural areas (Table 2 and Figure 1). Medellín et al. (2000) also observed *G. commissarisi* in every habitat that they tested, again similar to this study. These similarities could imply that the sample sizes in this study are just too small to show significance. For future studies, longer and more extensive trails should be conducted. To further test the impacts of habitat disturbance and land use mosaics on bat assemblages, areas further and closer to primary forest should be studied as well such areas with more extensive agricultural productions taking place.

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Table 1: Bat species found at Finca Santamaría in Cañitas, Monteverde, Costa Rica, along with family, subfamily and common habitat taken from Laval and Rodríguez-H (2002).

Species	**Family**	**Subfamily**	**Common Habitat**
Glossophaga commissarisi	Phyllostomidae	Glossophaginae	Found in a variety of habitats, including agricultural lands, lowlands and elevations as high as 3000m
Sturnira ludovici	Phyllostomidae	Stenodermatinae	Both primary and various disturbed habitats, very common to early successional growth, mid elevations 600-2600m
Micronycteris microtis	Phyllostomidae	Phllostominae	Both forested and disturbed habitats up to a least 2600m
Carollia brevicauda	Phyllostomidae	Carollinae	Both primary and various disturbed habitats, very common to early stages of regenerating forest, lowlands up to 1500m
Myotis keaysi	Vespertilionidae		Premontane and lower montane habitats and disturbed areas, 1400- 1800m

Table 2: The number of bats captured on the farm including and excluding recaptures for each of the given land-use areas.

Land-Use Type	Total (n)	Total (ex-recaps)
Pasture	6	6
Forest	7	5
Bananas	15	13
Coffee	4	3
Total	32	27

Table 3: Diversity values (H'), H'max and evenness values (J') for each land-use type. Habitats were tested in pair-wise comparisons using the Shannon- Weiner Index for Diversity. There was no significant difference between the habitats.

	H'	H'max	J'
Pasture	0.38	0.48	0.79
Forest	0.55	0.60	0.92
Bananas	0.38	0.48	0.8
Coffee	0.30	0.30	1

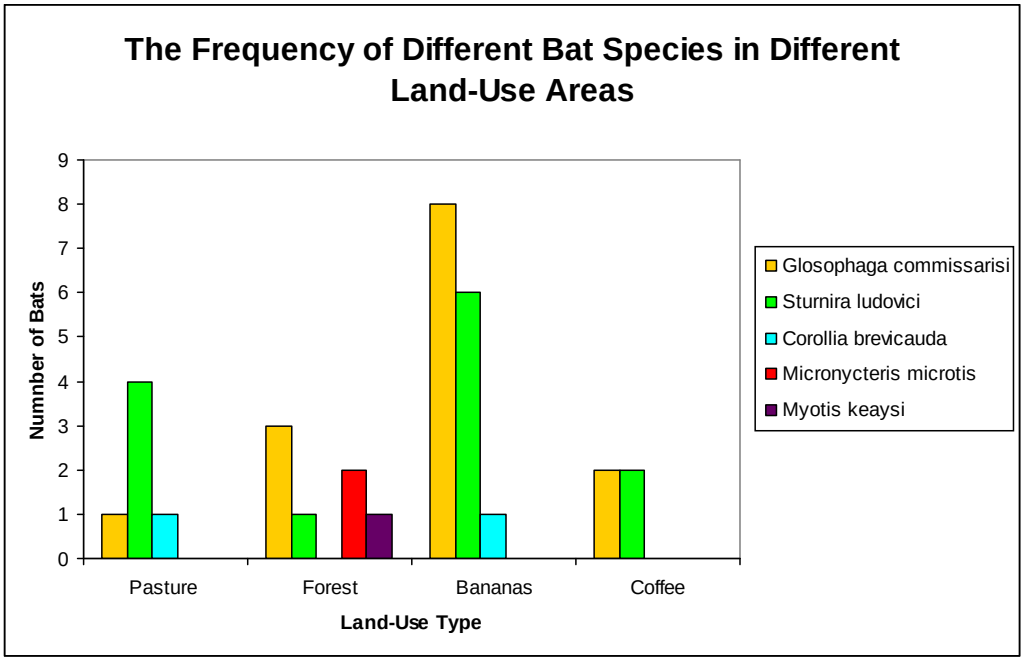

Figure 1: The number of each species of bat captured in the different land-use areas. This data is including the recaptures in the totals. There was no significant difference between land-use areas (Shannon – Wiener index).

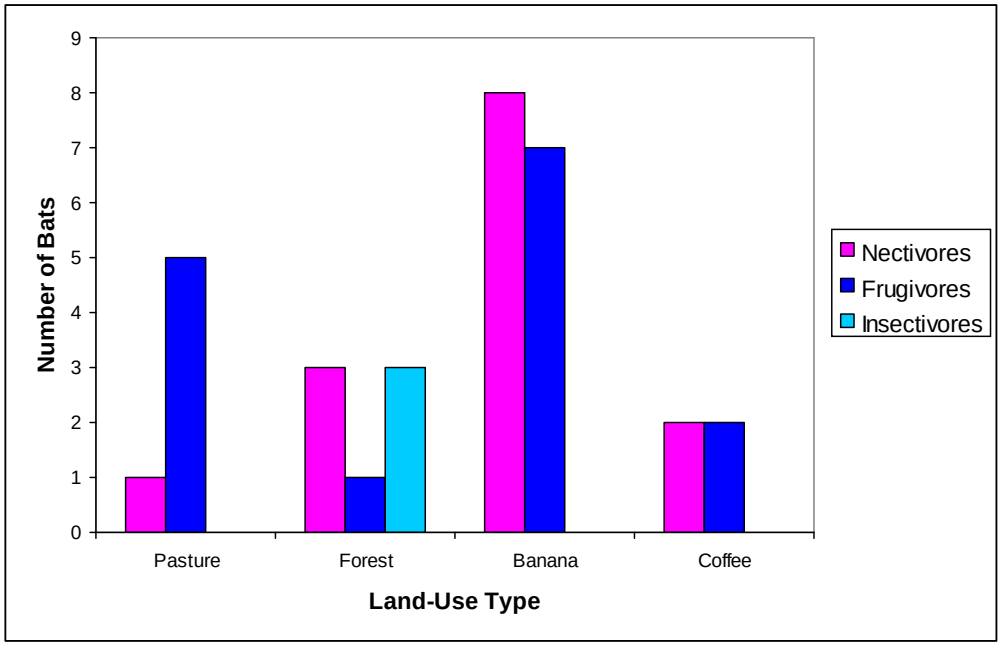

Figure 2: The frequency of bats belonging to different trophic guilds in the different land-use areas. Recaptures are included in the totals.