Bat community structure in an evergreen forest in western Cuba*

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ABSTRACT: **Bat community structure in an evergreen forest in western Cuba.** The composition and structure of a bat community were examined in an evergreen forest in the Sierra del Rosario Ecological Station, Cuba. Bats were captured using mist nets in the dry and wet seasons. A total of 187 bats, representing 11 species, were captured. The family Phyllostomidae represented the highest species richness. *Artibeus jamaicensis* was the most commonly captured species, followed by *Monophyllus redmani* and *Phyllonycteris poeyi*. In all surveyed months , frugivorous and nectarivorous bats were more abundant than insectivorous species; and their greatest capture rate coincided with peaks in the primary productivity in the area. The bats were classified into six guilds. Analysis of a two-dimensional niche matrix revealed a high niche segregation in the habitat use by members of the same guild in the bat community.

KEY WORDS: Bats, community structure, niche segregation, Sierra del Rosario, Cuba.

INTRODUCTION

Neotropical bats are among the most ecologically diverse vertebrates. The high number of species that can coexist (e.g., Vos and Emmons, 1996) makes bats an ideal group to characterize community structure. An intense debate exists on whether the composition of species of a community is the result of deterministic interactions, such as resource availability, competition, and mutualism, among others, or of stochastic processes, such as dispersal ability of the species and climatic phenomenona, among others (Willig and Moulton, 1989).

Considerable research has been conducted on structure of bat communities in the Neotropic (e. g., Fleming *et al.*, 1972; Bonaccorso, 1979; La Val and Fitch, 1977; Willig *et al.*, 1993; Kalko *et al*., 1996), however, few data are available on dynamics and composition of the populations of bats to the level of local communities of West Indian species (Vaughan and Hill, 1996; Gannon and Willig, 1998). Most work in the Caribbean islands has been limited to supra-community levels (Mac Nab, 1971; Fleming 1986; McFarlane, 1989; Genoways *et al.,* 1998; Rodríguez-Durán and Kunz, 2001) and presuppose the homogeneous use of all of the available habitat.

The main families of highly frugivorous birds and primates, among other terrestrial mammals (Fleming *et al.,* 1987), are absent from the West Indies islands. Therefore, the importance of the fruit-eating phyllostomids as seed-dispersal agents and hence in the successional processes of the forest in the region increases. Little work, however, has been done on the relative contributions of bats to Caribbean ecosystems, nor on the relationship between these mammals and the local flora.

Cuba has the largest bat fauna of the West Indian islands (Koopman, 1989; Rodríguez-Durán and Kunz, 2001). This diversity is favored by the high superficial area, wide habitat complexity, numerous caves, and geographical position (I.C.G.C, 1978). Cuba has 27 extant species, representing more than 40% of those recorded in the Antillean subregion. Five of the eight endemic genera of the Antilles are also represented. One of the characteristics of the Caribbean islands' fauna is the shortage of mammals. In the Cuban Archipelago, bats represent 70% of the native mastofauna and, in some of the Antillean islands, bats are the only autochthonous representatives of the class Mammalia. Although many aspects of the biology of Cuban bats have been studied (Silva-Taboada, 1979), little is known about the interactions of species in local communities. In this paper I examine the composition and structure of the bat community in an evergreen forest in western Cuba.

MATERIAL AND METHODS

Study Site. This study was conducted in the Biosphere Reserve "Sierra del Rosario", in the easternmost portion of the Coordillera de Guaniguanico (82^0 50' to 83^0 10' W, 22^0 45' to 23^0 00' N), with an area of 250.7 km^2. I made five trips to the Sierra del Rosario Ecological Station (SRES) (82^0 57' 41.6'' W, 22^0 50' 22.8'' N), at 470m elevation above mean sea level. The study area at "El Salon" (Fig. 1) is characterized by predominantly tropical evergreen forest (Herrera *et al*., 1988). This forest exhibits two strata: canopy trees 10–20m tall, and a shrub layer, with plants 3–5m tall. The climate is characterized by two seasons: a rainy season, April through November, and a dry season, December to March. The annual average temperature is 24.4^0C and the average annual rainfall is 201.4cm. My samples were made during the wet season (April 1996, July 1996, and September 1996) and the dry season (December 1996 and March 1997).

Bats were captured using mist nets (9 and 12 X 2.5 m), set at ground height. Five or six nets were placed in relatively open areas and inside the forest. In every sampling the nets were opened during fives nights, on average. All nets were open before dusk until 24:00 hours, and checked at 15 minutes intervals. Supplemental collecting from caves, buildings, and bridges, was done to verify that the bat composition was not biased by collecting methods.

For each captured bat, I recorded species, sex, and weight. The reproductive condition for females was determined following Racey (1988). All bats were individual marked with color plastic bands in the forearms and phalanges. Fecal samples were obtained, as well as remains of pollen on the skin of bats.

Assuming that the capture rate is positively correlated with the bat density, I considered the relative abundance for the number of animals captured within the time in which the nets were open. I used data from field observations, as well as data of the literature to categorize species within guilds as proposed by Kalko (1997). To characterize the structure of the bat community, a two-dimensional niche matrix was used. Forearm length was used as indicator of size; each category differed by a factor of 1.16; i. e., the mean of ratios obtained by Willig (1986) in adjacent-sized species of bats in two Brazilian communities.

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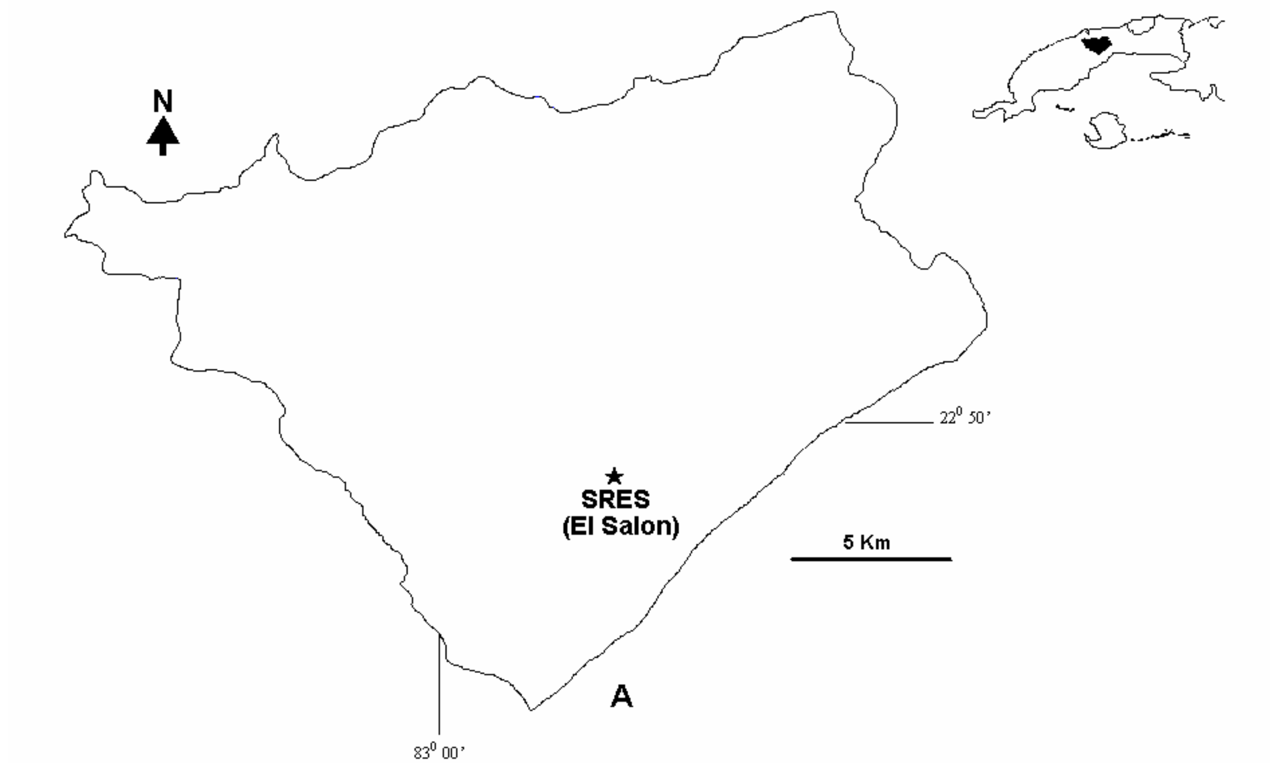

Fig. 1. Western Cuba, with the enlarged view showing the Sierra del Rosario Ecological Station (SRES) within the Sierra del Rosario Biosphere Reserve.

RESULTS AND DISCUSSION

Community Composition. I captured a total of 187 bats, representing 11 species, 10 genera, and four families, during this study (Table 1). An additional species, *Macrotus waterhousei*, was captured in a diurnal roost. The family Phyllostomidae, with six species, represented the highest species richness and this made up more than 87% of all captures, followed by Mormoopidae (10.1%), Vespertilionidae (1.6%), and Molossidae (1.07%). The captured species represented 46.1% of the species known for Cuba. Only the families Natalidae and Noctilionidae were not represented. All the species detected in the diurnal roosts in other localities of the Reserve were captured. The absence of members of Natalidae, with very gregarious and abundant species in other regions of Cuba, could be related to the absence of resident populations in the Sierra del Rosario.

Artibeus jamaicensis was the most abundant species captured, representing 30.5% of all bats captured, followed by *Monophyllus redmani* (22.4%) and *Phyllonycteris poeyi* (20.8%). The high species diversity, as well as the abundance of phyllostomids, distinguishes the Neotropical communities of bats, including that of the West Indies (Klingener *et al.*, 1978; Vaughan and Hill, 1996; Gannon and Willig, 1998).

The capture data demonstrate that the bat community consists of a few dominant species, along with uncommon and rare species (Fig. 2). Kalko *et al.* (1996) found a similar distribution of species in the bat community of Barro Colorado and, according to Magurran (1988), this distribution is a characteristic of natural communities.

Table 1. Bat species presence and abundance in wet and dry seasons in an evergreen forest in Sierra del Rosario Ecological Station, Cuba.

Family / Subfamily	Species	Number of bats captured: Dry	Wet
Phyllostomidae			
Stenodermatinae	*Artibeus jamaicensis*	21	36
Stenodermatinae	*Phyllops falcatus*	3	7
Glossophaginae	*Monophyllus redmani*	17	25
Brachyphyllinae	*Brachyphylla nana*	10	5
Phyllonycterinae	*Phyllonycteris poeyi*	28	11
Phyllostominae	*Macrotus waterhousei*[1]		
Mormoopidae	*Pteronotus quadridens*	5	4
	Pteronotus parnelli	7	1
	Mormoops blainvillei	1	1
Vespertilionidae	*Eptesicus fuscus*	2	1
Molossidae	*Molossus molossus*	1	0
	Tadarida brasiliensis	1	0

[1]Detected only in the roost.

I grouped the bat species by similar food types, such as fruit, nectar, or insects (Fig. 3). Vegetarian bats (frugivores and nectarivores) were present in higher numbers than insectivorous species in all survey months. The monitoring techniques (mist-netting) I have used under-samples most aerial insectivorous bats; however, the captures reflected the relative numbers I observed in the roosts.

The highest rate of capture of nectarivorous (*Monophyllus redmani*, *Phyllonycteris poeyi*, and *Brachyphylla nana*) species was in the dry season and coincided with peaks in flowering (Herrera *et al.*, 1988), although this tendency was not significant (Fig. 3). The high number of nectarivorous bats captured in an evergreen forest in Sierra del Rosario Ecological Station, as well as in other Cuban woody ecosystems (C. Mancina, pers. observ.), could be related to the high aggregations and wide food spectrum that characterizes the species of this group (see Silva-Taboada, 1979). Evidence suggests that species with a wide feeding niche breadth are numerically dominant inside a community (Magurran, 1988). The abundance of *Hibiscus elatus* (Malvaceae), with its wide flowering period, could be an essential factor in the maintenance of high populations of nectarivorous bats year-round. All species of the group were captured carrying pollen of this plant.

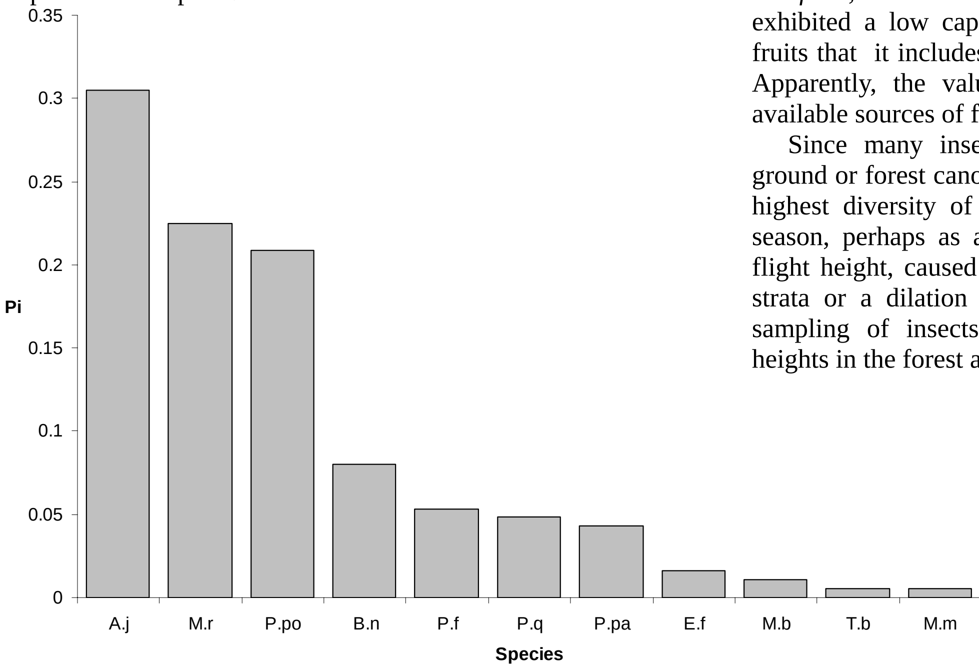

Fig. 2. Relative capture rate[1] among bat species assemblages from an evergreen forest in Sierra del Rosario Ecological Station, Cuba. Aj = *Artibeus jamaicensis*; Mr = *Monophyllus redmani*; Ppo = *Phyllonycteris poeyi*; Bn = *Brachyphylla nana*; Pf = *Phyllops falcatus*; Pq = *Pteronotus quadridens*; Ppa = *Pteronotus parnelli*; Ef = *Eptesicus fuscus*; Mb = *Mormoops blainvillei*; Tb = *Tadarida brasiliensis*; Mm = *Molossus molossus*.

[1]Pi=number of captured individuals of particular species/ total number of captured bats regardless of taxonomic identity.

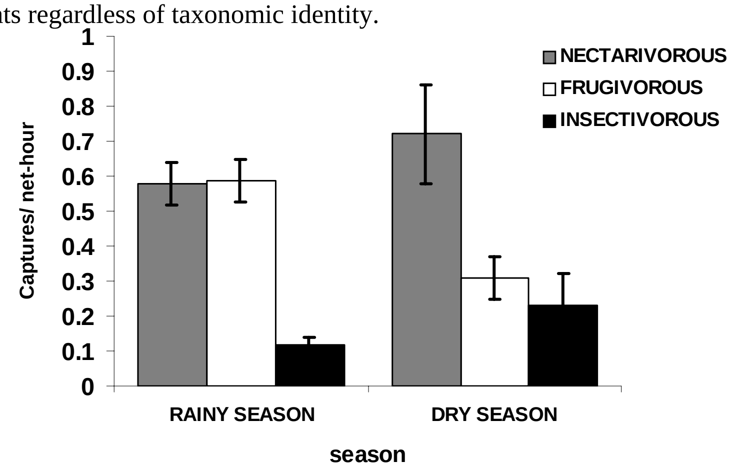

Fig. 3. Capture rates/food type in bats of an evergreen forest in Sierra del Rosario Ecological Station, in rainy and dry seasons. Vertical bars represent one standard error.

The greatest difference in capture rate occurred among the frugivorous bats (*Artibeus jamaicensis* and *Phyllops falcatus*). In the rainy season, when fruit resources were more available (Herrera *et al*., 1988), 64.2% of the total frugivorous bats were captured. Compared to continental neotropical communities, fruit-eating phyllostomids in the West Indies exhibit low diversity and high dominance of *Artibeus jamaicensis* (see Klingener *et al*., 1978; Vaughan and Hill, 1996; Gannon and Willig, 1998). In the Sierra del Rosario Biosphere Reserve, the more-often used plants by *A. jamaicensis* were *Cecropia scheberiana*, *Solanum sp*., *Muntingia calabura, Ficus* sp., *Syzygium jambos*, *Guazuma ulmifolia*, and *Callophyllum antillanum. Phyllops falcatus* exhibited a low capture rate and little is known about the fruits that it includes in its diet (Mancina and García, 2000). Apparently, the values of abundance are related to the available sources of foods.

Since many insectivorous bats forage high above the ground or forest canopy, this guild was underrepresented. The highest diversity of insectivorous bats was during the dry season, perhaps as a result of two factors: decrease in the flight height, caused by the shortage of insects in the upper strata or a dilation in feeding areas. However, year-round sampling of insects using light traps placed at different heights in the forest are necessary for better conclusions.

Guilds and Community Structure. Based on diet, feeding mode, and habitat use, I categorized bats in the following guilds: aerial insectivore in uncluttered space (*Molossus molossus* and *Tadarida brasiliensis*), aerial insectivore in background - cluttered space (*Pteronotus quadridens*, *Eptesicus fuscus*, and *Mormoops blainvillei*), aerial insectivore in highly cluttered space (*Pteronotus parnelli*), gleaning insectivore in highly cluttered space (*Macrotus waterhousei*), gleaning nectarivore in highly cluttered space (*Phyllonycteris poeyi*, *Brachyphylla nana*, and *Monophyllus redmani*), and gleaning frugivore in highly cluttered space (*Artibeus jamaicensis* and *Phyllops falcatus*). Based on wing morphology, I developed a trivariate distribution of species (Fig. 4). A general vision evidences a remarkable separation in the wing shape; this variation can be correlated to different foraging strategies (Norberg and Rayner, 1987).

To examine the functional structure of the community, a two-dimensional niche matrix (see McNab, 1971; Fleming *et al*., 1972; La Val and Fitch, 1977; Willig, 1986) was constructed (Table 2). If the matrix reflected the niche segregation of habitat use by members of the same guild within the bat community, I could predict that it is well structured. Of the 11 used cells, 10 are occupied by only one species. The only cell occupied by two species belongs to aerial insectivores in background cluttered space (*Eptesicus fuscus* and *Mormoops blainvillei*), both uncommon species were using a space that potentially could produce the greatest values of insects biomass.

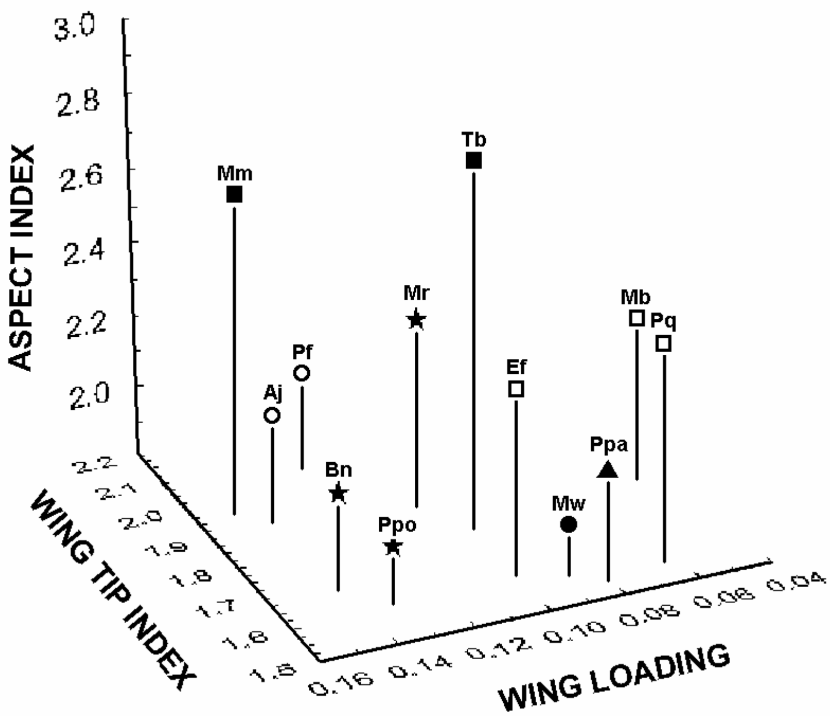

Fig. 4. Trivariate distribution of bat species assemblages from an evergreen forest in Sierra del Rosario Ecological Station, according to the wing indexes (Findley *et al*., 1972). Species abbreviations as in Fig. 2. ■ aerial insectivore in uncluttered space, □ aerial insectivore in background cluttered space, ● gleaning insectivore in highly cluttered space, ▲ aerial insectivore in highly cluttered space, ○ gleaning frugivore in highly cluttered space, and ★gleaning nectarivore in highly cluttered space. Data were redrawn from Mancina (1999).

Table 2. Two dimension niche matrix for the bat community from an evergreen forest in Sierra del Rosario Ecological Station, Cuba.

Guild	**Number of species distributed by forearm length (mm)**			
	34–38	**39–44**	**45–52**	**>53**
Aerial insectivore in uncluttered space		1	-	-
Aerial insectivore in background cluttered space	1	-	2	-
Aerial insectivore in highly cluttered space	-	-	-	1
Gleaning insectivore in highly cluttered space	-	-	1	-
Gleaning nectarivore in highly cluttered space	-	1	1	1
Gleaning frugivore in highly cluttered space	-	-	1	1

The guild with greatest diversity, assuming both species richness and capture rate, was gleaning nectarivore in highly cluttered space. In spite of their dietary preference of nectar and pollen, the examination of feces demonstrated that species within the guild frequently consume fruits; most fruits consumed were from shrubs and small trees, including *Piper aduncun*, *Muntingia calabura*, *Solanum* sp., and *Cecropia schreberiana*, among others not identified. *Phyllonycteris poeyi* and *Monophyllus redmani* are among the more abundant and gregarious species in the Sierra del Rosario Ecological Station. Between them, differences exist in wing morphology (this could be related to different foraging modes; e.g., hovering) and activity patterns, that could facilitates coexistence of both species (Mancina, 1998).

Apparently, the availability of food resources determines, in great measure, the composition of the fauna of bats at the Sierra del Rosario Ecological Station. The highest rates of capture, at least for phyllostomids, coincided with peaks in the production of fruits and flowers. Given the diversity and abundance of roost types in Sierra del Rosario, these habitat characteristics should not be limiting factors. Competitive interactions could be a cause of the absence of species such as *Erophylla sezekorni*, *Pteronotus macleayi* and *Natalus* spp., that are gregarious and abundant in other forest localities of the Cuban Archipelago (C. Mancina, pers. obs.).

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