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Nota

NATURAL ROOSTS USED BY BATS IN CENTRAL AMAZONIA, BRAZIL

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ABSTRACT. Some bat species use leaves or trees to roost during the day and the Stenodermatinae species are known to build tents in leaves of specific plant species. Tent-roosting bat species and Emballonuridae bats have a widespread geographic distribution in the Amazon region, but it can be difficult to find these bats perched in roosts due to changes in the availability of food and the low durability of the tents. Here, we describe the type of roost, tent architecture and plant species used by *Uroderma bilobatum*, *Mesophylla macconnelli*, and *Saccopteryx leptura* in a fragmented landscape in Brazilian Amazonia.

RESUMO. ABRIGOS NATURAIS USADOS PELOS MORCEGOS NA AMAZÔNIA CENTRAL, BRASIL. Algumas espécies de morcegos usam folhas e árvores para se abrigarem durante o dia e as espécies de Stenodermatinae são conhecidas por construírem tendas em folhas de plantas específicas. Espécies que se abrigam em tendas e os morcegos emballonurídeos tem uma ampla distribuição geográfica na região Amazônica, mas pode ser difícil encontrar estes morcegos empoleirados nos abrigos devido às mudanças na disponibilidade de alimento e a baixa durabilidade das tendas. Nós descrevemos o tipo e a arquitetura do abrigo, e as espécies de plantas usadas por *Uroderma bilobatum*, *Mesophylla macconnelli* e *Saccopteryx leptura* em uma paisagem fragmentada na Amazônia Brasileira.

Key words: Amazon forest, bat roost, Neotropics, tent making.

Palavras-chaves: Abrigo de morcegos, floresta amazônica, Neotrópicos, tendas.

Roosts are fundamental in limiting resources for bats; they spend a large part of their lives in roosts, resting safely and engaging in social, reproductive, and nursing activities (Kunz & Mccracken 1996). In general, bats can use permanent roosts in stable microclimate conditions (e.g., caves, buildings and tree hollows) or ephemeral roosts that are more abundant but less durable (e.g., foliage and tents) (Kunz & Pena 1992). Among ephemeral roosts, bats may use unmodified foliage (i.e., roosting under banana leaves, rolled *Heliconia* leaves, *Cecropia* leaves and palm tree) or build tents by modifying the shape of the leaves, cutting the petioles, midribs or veins with their teeth and splitting them with their thumb pads (Kunz 1982; Rodríguez-Herrera et al. 2007; Velazco et al. 2014). Few species of bats show tent-roosting behavior; it has been observed in only 19 bat species in the Neotropics (Garbino & Tavares 2018). To build the tents, bats usually select plants with large leaves in specific sites with food resources and open access below the tents without adjacent vegetation, allowing them to enter and depart unimpeded (Kunz

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& Mccracken 1996; Rodríguez-Herrera et al. 2018). Because food resources change periodically and the tents may deteriorate over time, it may be difficult to record tents with bats in them (Timm & Lewis 1991; Kunz & Mccracken 1996).

During field expeditions to record the activities of aerial insectivorous bats in Central Amazonia, we actively looked for natural bat roosts to document and describe their roosting ecology. Herein, we provide information about group size, roost type, plant species, tent architecture, habitat type, and canopy closure of some Neotropical bat roosts. We looked for bats roosting under foliage and tents, in exposed tree trunks, in tree hollows, and in the surfaces of lianas. We carried out the surveys in the Biological Dynamics of Forest Fragment Project (BDFFP), approximately 80 kilometers north of Manaus, Brazil (-2.416211°, -59.844159°), during field expeditions conducted in 2018 and 2019 (**Fig**. 1). Our observations along the BDFFP's preexisting trails crossed various habitat types: continuous forests, fragment forests and secondary forests. Whenever possible, we photographed the bats in the roosts. We used the categorization of Kunz et al. (1994) and Rodríguez-Herrera et al. (2007) to describe the tent architecture and estimated the percentage of the canopy closure immediately above the roosts using the average of four spherical densiometer readings.

We found six roosts occupied by two species of Phyllostomidae and one species of Emballonuridae, and observed two occupied tents in modified leaves of *Potalia amara* (Loganiaceae) (**Fig**. 2**C**). These tents were conical types with several leaves bitten at the petiole and folded down, forming a single tent (white arrow in **Fig**. 2**C**). The folded leaves were 1.2 m high and had a diameter of 43 cm. We observed several *Uroderma bilobatum* individuals using these tents during rainy seasons (February and March 2018). The first tent (78.5% of canopy closure above the tent) was found in a secondary forest and had two individuals in it (**Fig**. 2**B**); the other tent (89.7% of canopy closure) was found in the continuous forest and occupied by a group of twelve bats (**Fig**. 2**C**). *Uroderma bilobatum* often roosts under large, modified leaves in groups composed of up to 60 individuals (Kunz & Mccracken 1996). This fruit-eating bat species has been found using tents made from leaves of native plants in primary and secondary forests in Costa Rica such as *Carludovica palmata*, *Philodendron fragrantissimum* (Kunz et al. 1994), *Sabal mauritiiformi*, and *Attalea rostrata* (Timm 1987), and from exotic plants (*Cocos nucifera* and *Musa acuminata* (Sagot et al. 2013). The use of *P. amara* tents has been previously reported only for *Artibeus* spp. (Lopez & Vaughan 2007). *Uroderma bilobatum* has been found roosting in conical tents of plants from the genus *Potalia (P. turbinata*) in Costa Rica (Villalobos-Chaves et al. 2016).

According to our observations, *U. bilobatum* individuals appear to have low roosting fidelity, as they left the tents and did not return in the next three days. We also visited the tents every two months over a one-year period, and the tents remained in good condition, but unoccupied. Rodríguez-Herrera et al. (2007) suggested that *U. bilobatum* uses these tents sporadically. Over a 6-day period when *U. bilobatum* were observed in six tents of Costa Rica, Timm & Lewis (1991) noticed that none of these tents were continuously occupied suggesting the ability of changing roosts after a disturbance. Longer monitoring period could be a good opportunity to understand the dynamics of roost use by bats in the Amazon, including roost fidelity and seasonality. Ultrasound recorders and camera traps can be employed to monitor the bats.

We also found three tents in the terminal blades of pinnae of the *Astrocaryum sciophilum* palm (**Fig**. 2**D**). These were bifid tents with V-shaped cuts along both sides of the midrib of the pinnae, in such way that the apex of the leaves folded together to form a cavity serving as a roosting space (Kunz et al. 1994). This type of tent has only been found in plants of the families Arecaceae and Cyclanthaceae and is relatively more common in continuous forests (Rodríguez-Herrera et al. 2007). Indeed, we only found bifid tents in immature individuals of the palm *A. sciophilum* in a continuous forest (**Fig**. 1). We observed *Mesophylla macconnelli* individuals roosting in two bifid tents during the rainy season (May 2019). One of these tents (87% of canopy closure) had five individuals (**Fig**. 2**E**), and the other tent (82.3% of canopy closure) had three bats (**Fig**. 1**D**). Individuals of the species *M. macconnelli* have light-colored fur and were positioned close to the ribs on the underside of the leaf, a behavior hypothesized to provide protection against visually oriented predators (Koepcke 1984). Roosting *M. macconnelli* groups have been reported to contain up to eight individuals under the same tent, including lactating females and nursing young (Foster 1992). We found a third tent with four individuals (91.1%of canopy closure), but the bats left quickly, before we could take pictures or identify them properly.

Mesophylla macconnelli is known to shelter exclusively in foliage (Voss et al. 2016; Garbino & Tavares 2018) and previous observations of *M. macconnelli* roosting under modified *A. sciophilum* leaves have been

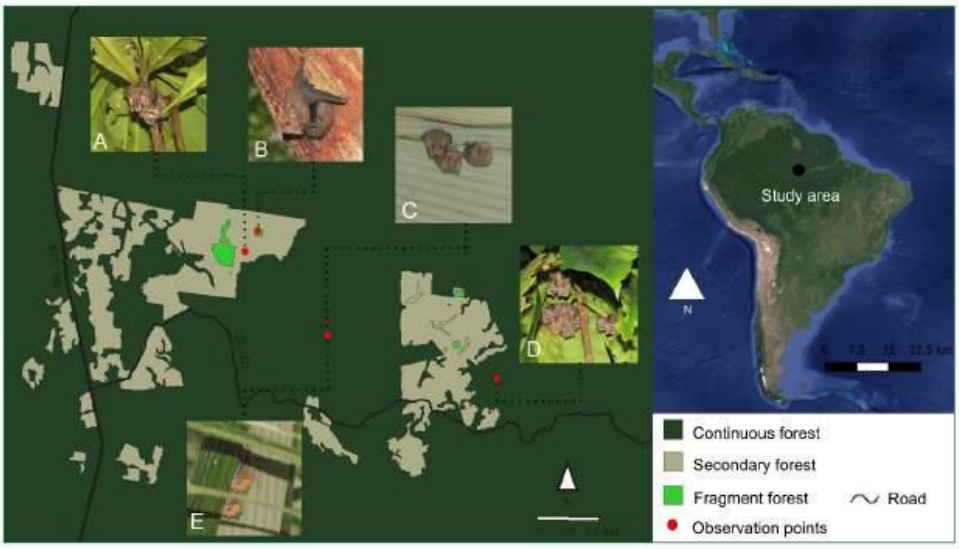

Fig. 1. Geographic distribution of bat roosts in Biological Dynamics of Forest Fragment Project (BDFFP), Central Amazon, Brazil. Our roost locations are represented by red circles. (A) *Uroderma bilobatum* in *Potalia amara* leaves; (B) *Saccopteryx leptura* in a woody liana; (C) *Mesophylla macconnelli* in *Astrocaryum sciophilum*; (D) *U. bilobatum* in *P. amara*; (E) *M. macconnelli* in *A. sciophilum*. All photos by G. Appel.

registered in the continuous forests of Peru (Foster 1992) and French Guyana (Charles-Dominique 1993). Our findings are consistent with the suggestion that this species is commonly found in lowland forests with numerous palms (Kunz & Pena 1992). Other bat species reported to use tents of *A. sciophilum* in Amazonia are *Artibeus cinereus* and *Rhinophylla pumilio* (Kunz et al. 1994; Simmons & Voss 1998). The change of roosts and use of several tents within a few days appear to be a recurrent behavior of *M. macconnelli*, and it has been reported that females often switch tents (Kunz & Pena 1992). When we returned two months later, these tents remained empty, similar to the findings by Foster (1992), in which the bats had not returned to the *A. sciophilum* tents six days after being disturbed.

Among the nine bat families in the Amazonian region, Phyllostomidae uses the largest variety of roosts, followed by the aerial insectivorous bats from the Emballonuridae family (Voss et al. 2016). We found three Emballonuridae individuals (*Saccopteryx leptura*) roosting 1-2 m high on the surface of a liana trunk along a trail inside the 10-ha fragment forest (90.1% canopy closure) (**Fig**. 2**F**). This behavior of exposing the body is typical for *Saccopteryx* species, which roost almost on surfaces of tree trunks (Voss et al. 2016) and in the walls of artificial roosts, such as houses (e.g. Tavares & Anciães 1998). This is the second report of an emballonurid bat (*S. leptura*) roosting in a climbing woody vine (Goodwin & Greenhall 1962), and we suggest that this use may be related to the high abundance of woody lianas in the fragments of the BDFFP trails (Laurance & Williamson 2001). *Saccopteryx leptura* can use a wide variety of roosting surfaces, including trees in secondary forests (Simmons & Voss 1998) and urban buildings (Nogueira et al. 2002). However, *S. leptura* usually occupies sites that are partly protected by some minor concavity (Bradbury & Vehrencamp 1976).

Our records are consistent with the previous observations on social groups of *S. leptura*, which usually consist of one pair of adults and their offspring, ranging from one to nine individuals (Bonaccorso 2019). We found an adult female carrying a young individual in April 2019 (**Fig**. 2**F**). The birth probably occurred in mid-April, as females carry their young for 10-15 days (Yancey et al. 1998). Breeding information about this species in South America is scarce (Bonaccorso 2019). In the Brazilian Atlantic forest, *S. leptura* is pregnant around March, during the onset of the rainy season (Nogueira et al. 2002). In the Central Amazon, the rainy season occurs from November to May (Laurance 2018), indicating that *S. leptura* probably follows the pattern of breeding near the end of the rainy season.

The roosting ecology of bats is still poorly understood (Garbino & Tavares 2018). Available information about Amazonian bats' roosts has been compiled recently by Voss et al. (2016), but our study

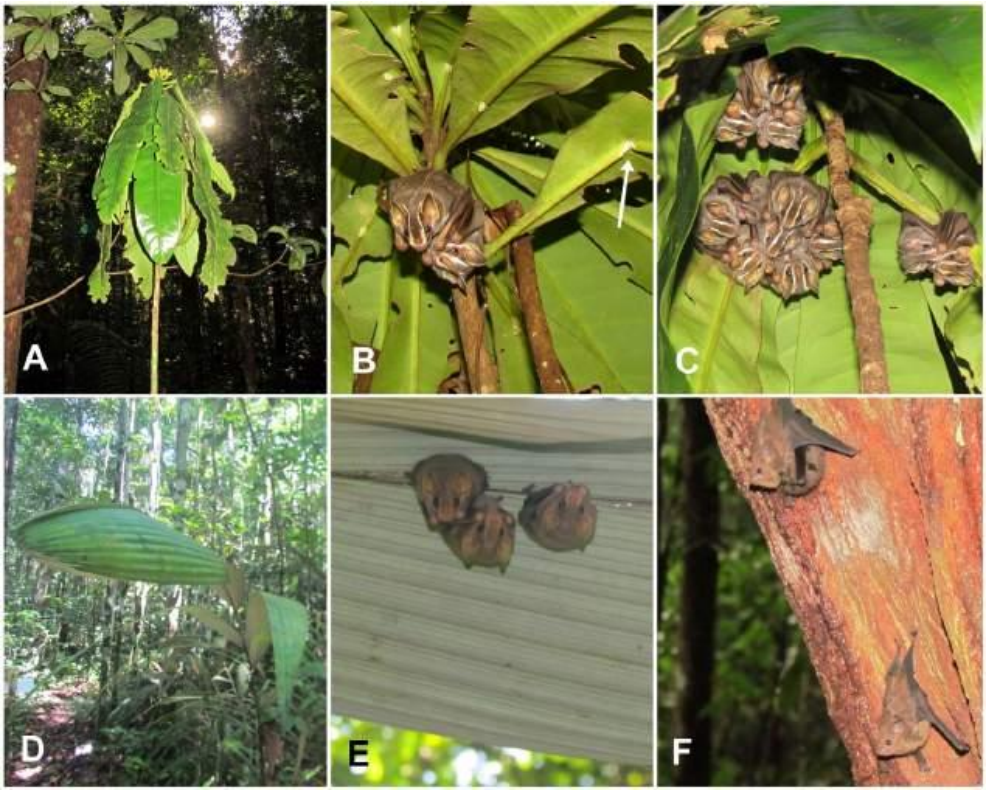

Fig. 2. Roosts found in continuous, fragment and secondary forests of the BDFFP, Central Amazon, Brazil. (A) Conical tent in *Potalia amara* leaves observed in continuous forest; (B) *Uroderma bilobatum* in *P. amara* tent recorded in secondary forest, detail for the cut in the petiole of the leaf (white arrow); (C) *Uroderma bilobatum* in *P. amara* tent recorded in continuous forest; (D) Bifid tent in *Astrocaryum sciophilum* observed in continuous forest; (E) *Mesophylla macconnelli* in *A. sciophilum* leaf in continuous forest; (F) Three individuals of *S. leptura* located in a woody liana recorded in fragment forest. All photos by G. Appel.

is the first data available on tent-roosting bats in Central Amazonia. This is also the first record of tent-making bat *U. bilobatum* using *P. amara* leaves to roost in South America. Patterns of tent use need to be further investigated, such as how they are influenced by seasonality and how human-modified landscapes, such as fragments and secondary forests, affect the availability of roosts.

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